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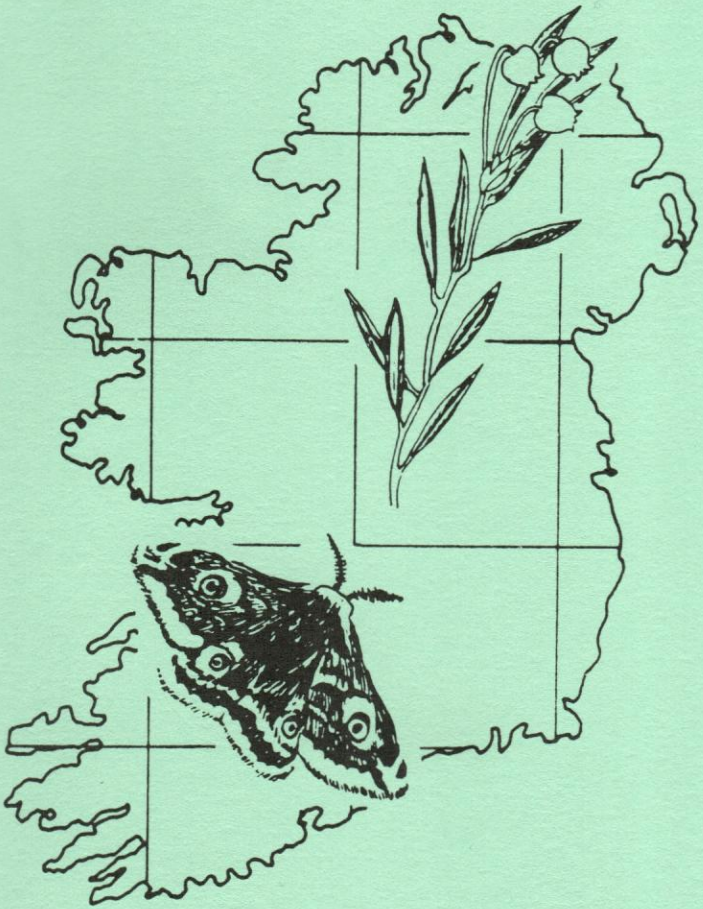

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BULLETIN OF THE IRISH BIOGEOGRAPHICAL SOCIETY

Number 21

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Bull. Ir. biogeog. Soc. No. 21 (1998)

EDITORIAL

To celebrate the publication of the twenty first volume of its *Bulletin*, the committee of the Society decided to produce two issues in 1998. Number 21 is a special one devoted to a survey of the flora and fauna of Irish coastal lagoons. Funding for the study was provided by the National Parks and Wildlife Service as part of the EU funded BioMar project. The work was co-ordinated by Dr Brenda Healy of the Department of Zoology, University College, Dublin. In addition, Dr Healy organized the submission of the papers to the *Bulletin* and provided the cover. The Society is very grateful to the National Parks and Wildlife service and the Department of the Environment for sponsoring this special issue. *Bulletin* No. 22 is now also in production and will be published shortly after No. 21. Both bulletins will be sent to all 1998 subscribers.

On behalf of the Irish Biogeographical Society, I wish to thank our authors especially Dr Healy, the referees and all those who helped with *Bulletin* No. 21. A special word of thanks is due to Mr J. M. C. Holmes who provided his usual invaluable assistance with the production of this *Bulletin*.

J. P. O'Connor
Editor
2 November 1998

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AQUATIC VEGETATION OF IRISH COASTAL LAGOONS

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Abstract

Twenty coastal lagoons on south and west coasts of Ireland from Wexford to Donegal were sampled for aquatic vascular plants, charophytes, and other macrophytic algae as part of a survey of Irish coastal lagoons in 1996. Sampling of aquatics was confined to water of wading depth and those areas that lay within reach of a hand-thrown grapnel. Salinity was measured and substrate type recorded. *Ruppia* spp occurred at 19 sites and were reliable indicators of brackish conditions. Charophytes were present at 11 sites. *Chara baltica*, which was common in L. Aconeera, Co. Galway, is a new Irish record. Two new localities were identified for *Lamprothamnium papulosum*, and two for *Chara canescens*, both Red Data Book species. Thirty-three species of macrophytic algae were recorded, mainly from euhaline sites with rocks.

Introduction

This paper presents the results of a survey of the aquatic flora of 20 coastal lagoons. Marginal vegetation is not included in this account. Surveyed species include vascular plants, charophytes, and other macrophytic algae. A survey of this type has not previously been carried out in Ireland although the scattered records of aquatic plants in brackish waters include a number of species considered rare for Britain and Ireland. The Characeae are of particular interest as they are vulnerable to habitat degradation and populations of brackishwater species are declining throughout western Europe (Stewart and Church, 1992).

The sites surveyed were selected following a rapid inventory of lagoons on the coast of the Irish Republic in 1996 (Healy *et al.*, 1997a, b) and were chosen as outstanding representatives of the types identified. The background to the survey, definitions of the lagoon types, and descriptions of the study sites are given in Healy *et al.* (1997a, c) and Healy and Oliver (1998).

The 20 selected sites were distributed along south and west coasts from Wexford to Donegal (Table 1). The term "lagoon" was interpreted broadly to include not only shallow lakes separated from the sea by sedimentary barriers of sand, gravel, or cobbles, which are geomorphologically classified as true lagoons, but also saline lakes in peatland, karstic limestone and glacial drift. A few were deep, and two were artificial formations. The range of environmental conditions was thus very broad. Some of the lagoons were tidal, remaining euhaline, i.e. with a salinity >30‰, throughout most of the year, or undergoing rapid and wide fluctuations in salinity if there was a substantial inflow of freshwater. Others were mesohaline or polyhaline (Venice system, 1958) and in a few cases the salinity did not exceed 5‰ (oligohaline).

An account is given of each vascular plant and charophyte species recorded, including its distribution, salinity range, and notes on abundance, growth form, and national status. Macrophytic algae are listed. Particular attention was paid to species which are lagoonal specialists in Britain i.e. characteristic of brackish waters with a limited tidal range (Barnes, 1989; Davidson *et al.*, 1991; Bamber *et al.*, 1992; Smith and Laffoley, 1992; Downie, 1996) (see also Healy and Oliver, 1998). An attempt is made to identify plant communities where enough information is available. The communities are primarily defined by species composition and relative abundance of species and are related to environmental factors such as salinity and lagoon type.

Methods

The lagoons were surveyed during the period July-early October 1996. Sampling procedures included estimates of cover/abundance within quadrats placed along transects, as well as intensive searches of both aquatic and marginal vegetation, but only the observations on aquatic flora are reported here. The entire shore of all but the largest lakes was walked, and marginal and aquatic vegetation recorded along with changes in salinity and substrate. Salinity was measured with a hand-held refractometer accurate to 1ppt. A grapnel was used to dredge for aquatics in some areas where depth precluded wading, but in most lagoons the deep regions were not sampled. Aquatic communities were identified in water of wading depth only. Identification of algae was carried out on paper-mounted specimens. Some of the material was

in poor condition, and some filamentous forms could not be identified to species.

Nomenclature of vascular plants is according to Stace (1997) and that of charophytes is after Stewart and Church (1992).

Results

The main features of the lagoons are shown in Table 1. The total number of taxa identified (54) comprised 14 vascular plants, seven charophytes and 33 other algae (Tables 2, 3). The greatest diversity was in euhaline lagoons where marine algae were dominant. Vascular plants and charophytes were most diverse in the larger lagoons where a variety of substrates, and the existence of salinity gradients between freshwater inflows and the sites of seawater incursions, provided a wide range of environments. Few species were found in meso-polyhaline lagoons (Venice System, 1958) with regular tidal flow, except in the inlets where marine algae had colonised the rocky substrate.

(a) Vascular plants (Table 2)

The most characteristic plants of brackish lagoons are *Ruppia* species. One or two species of *Ruppia* were present at all but one of the sites (Aughinish L. which becomes hypersaline), and five sites held both species. In tidal lagoons, *Ruppia* was often the only vascular plant found. Both species are considered to be lagoonal specialists (Davidson *et al.*, 1991; Smith and Laffoley, 1992; Bamber, 1997) and their regular occurrence in Irish lagoons (Table 2) makes them reliable indicators of lagoonal conditions i.e. shallow brackish water with limited tidal flow. *Ruppia* samples could not be determined to species at two sites visited in early summer before the plants were fruiting. In meso-oligohaline waters, *Ruppia* was joined by *Potamogeton pectinatus* which became increasingly dominant as the salinity decreased, sometimes growing in great profusion. In low salinity lagoons, several other species occurred, and near the mouths of freshwater streams a suite of freshwater species sometimes existed side by side with species characteristic of brackish water. *Zostera marina* was found at only two sites with high salinity.

(b) Characeae (Table 2)

Charophytes occurred at 11 sites, covering a salinity range of 0-37‰. Three of the recorded species are lagoonal specialists: *Chara baltica*, *C. canescens*, and *Lamprothamnium papulosum*.

Generally, only one species was recorded, but two species were present in mixed stands in L. Murree and Roonah L., and three in Durnesh L. *Lamprothamnium papulosum* characterised the more saline waters while only *Chara* spp occurred in salinities below about 15‰. Charophytes were not recorded from the smaller lagoons subject to frequent fluctuations in salinity resulting from tidal flow or overwash (Farranamanagh L., Lissagriffin L., Cloonconeen Pool, Mill L., Corragaun L.). Charophytes were recorded from Corragaun L. in the past (Verhoeven, 1980) but conditions at the time were probably different.

(c) Non-charophyte macrophytic algae (Table 3)

Collections of algae were made at all the sites (except where only *Cladophora* and *Enteromorpha* occurred) but no prolonged searches were carried out and it is probable that some species were overlooked at the more marine sites.

Macrophytic algae occurred at ten sites. They were most abundant and diverse in euhaline lagoons where there was a rocky substratum for attachment e.g. in Aughinish L. and Lettermullen Pool. In lagoons with silled inlets (Farranamanagh L., Drongawn L., Mill L.), algae were common in the rapids where large fucoids were often present. *Cladophora* and *Enteromorpha* were present at all sites and the latter was a good indicator of brackish conditions.

Among 33 taxa (28 spp) identified, only two are consistently confined to brackish waters. *Fucus ceranoides*, which also occurs in estuaries and salt marshes, was present at sites where the salinity was <30‰, at least for part of the time, and where there were rocks for attachment. *Chaetomorpha mediterranea* is a lagoonal specialist confined to non-tidal brackish waters where it grows unattached and often forms large, floating masses e.g. in Bridge L. The species appears in lists of lagoonal specialists (e.g. Davidson *et al.*, 1991) as *C. linum*, but Guiry (pers. comm.) believes that *C. mediterranea* and *C. linum* are part of a complex which should be considered as one species. As *C. linum* was originally described as *C. mediterranea*, the latter name should take priority.

Ecology of the species

The most frequently occurring species appear to tolerate a wide range of salinities (Table 4). In fact, the incidental values recorded during the survey probably underestimate the full range

experienced by the plants in their respective lagoons as both lower salinities (due to high rainfall) and sudden exceptional increases (due to storm surges and overwash) are likely to occur in winter. *Ruppia maritima* appears to prefer lower salinity than *R. cirrhosa* but both species were recorded throughout the range 0-37‰. The upper salinity limit of *P. pectinatus* was 24‰. *Lamprothamnium* was not recorded at salinity <13‰. Its preference for high salinity is well documented but the reported upper limit of 30‰ (Stewart and Church, 1992) was exceeded at two of the four sites where it occurred. At Lettermullen, it grew at salinities of 35-37‰.

Ruppia maritima and *P. pectinatus* showed no discernible substrate preferences (Table 5). *Ruppia cirrhosa* was most frequent at peaty, stony sites. However, its low frequency in sandy lagoons may be a consequence of other environmental factors. For example, the sandiest lagoons were typically shallow waters of low salinity. Verhoeven (1979) considered *R. cirrhosa* to be substrate indifferent. *Potamogeton pectinatus* showed no discernible substrate preferences (Table 5). *Lamprothamnium* was not recorded from sand and all records of *Chara canescens* are from coarse, gravelly substrates.

The shore-based nature of this survey means that water depth cannot be considered here. Size of water body does not seem to be a factor limiting species distribution, with the more frequent species occurring in a wide range of lagoon sizes. Species richness, however, is at least partly related to lagoon size.

Species records

Angiospermae

***Ruppia maritima* L.** Beaked tasselweed

Present at 13 sites, salinity 0-36‰. Plants were low growing, often in single-species stands in shallow, sandy, low salinity lagoons (L. Gill, L. Donnell, Corragaun L., Roonah L., Durnesh L.), but formed dense beds in high salinity, rocky or peaty sites (Cloonconeen Pool, L. Tanaí). In L. Tanaí, this species grew with *R. cirrhosa* and *Zostera marina* in dense beds.

Ruppia maritima is listed as a specialist lagoonal species for Britain by Davidson *et al.* (1991) and Smith and Laffoley (1992). As *R. cirrhosa* is not specifically mentioned in these lists, it is assumed that *R. maritima sensu lato* is intended, i.e. to include *R. cirrhosa*. Preston and Croft

(1996) consider that there is little evidence of decline of *R. maritima* in Britain, but it was recorded at only nine out of 175 English lagoon-like sites during a national lagoon survey (Smith and Laffoley, 1992).

***Ruppia cirrhosa* (Petagna) Grande**, synonym *R. spiralis* Dum. Spiral tasselweed

Present at nine sites, salinity 0-37‰. Forming dense stands in high salinity, rocky or peaty lagoons (Drongawn L., Lettermullen Pool, L.Tanaí, Mill L.). In Lettermullen and L. Tanaí, it grew with *Zostera marina* (and with *R. maritima* in L. Tanaí) in dense beds below a narrow algal belt. It is known to tolerate higher salinities than *R. maritima* (den Hartog, 1971; Verhoeven and van Vierssen, 1978; Verhoeven, 1979; Preston and Croft, 1996).

Recognized as a lagoonal specialist in Britain (see under *R. maritima*). Said to have declined in Britain (Preston and Croft, 1996); reported from 15 out of 175 lagoon-like sites in England (Smith and Laffoley, 1992).

***Potamogeton pectinatus* L.** Fennel pondweed

Present at eight sites, salinity 0-24‰. Growing in dense, single-species stands in <10‰ (Lady's Island L. - an isolated pool, and Kilkeran L.), and in dense beds with *Ruppia* in medium salinity (L. Murree, L. Aconeera).

This is not a lagoonal specialist but tolerates brackish conditions and seems to be characteristic of certain types of medium to low salinity lagoon. It starts to grow earlier in the year than *Ruppia* spp (Verhoeven, 1979), producing dense beds reaching the surface in late June, e.g. in Kilkeran L.

***Potamogeton pusillus* L.** Lesser pondweed

Only in Tacumshin L., where it was restricted to low salinity (0-4‰) channels in reed-swamp.

***Zostera marina* L.** Eelgrass

Recorded at two sites, Lettermullen Pool and L. Tanaí, salinity 29-37‰. Growing with *Ruppia* in dense beds in peaty substrates among rocks, lying beyond a narrow algal belt. Some fragments found at other high salinity sites (Drongawn L., Mill L.).

A plant of the intertidal and shallow sub-littoral; its occurrence in these lagoons seems to indicate conditions of more or less constant high salinity.

***Zannichellia palustris* L.** Horned pondweed

Recorded at two sites, Tacumshin L. and L. Gill, salinity 0-5‰. Locally abundant in sheltered areas of L. Gill, growing with *Ruppia maritima* and *Potamogeton pectinatus*. Recorded at Tacumshin L. in brackish channels amongst swamp vegetation.

Typically a species of fresh to mildly brackish conditions.

***Myriophyllum spicatum* L.** Spiked water-milfoil

Recorded at three sites, Tacumshin L., L. Gill, Durnesh L., salinity 0-5‰. Growing in occasional dense beds in L. Gill (western half only where most freshwater enters), and in Tacumshin L. in brackish channels amongst reed-swamp only. At Durnesh L., recorded only in the vicinity of the major freshwater inflow.

Commonly found in freshwaters, but tolerating mildly brackish conditions.

***Littorella uniflora* (L.) Asch.** Shoreweed

Recorded at two sites, Furnace L. and Durnesh L., salinity 0-5‰. Associated with *Eleocharis palustris* stands at Furnace L. - occasional. Recorded in the northernmost region of Durnesh L. in the vicinity of the outlet pipe. The species is not usually found in brackish waters.

***Ranunculus baudotii* Godron** Brackish water-crowfoot

Only in Tacumshin L., salinity 0-4‰, restricted to low salinity channels in reed- swamp. The absence from other low salinity lagoons is interesting as the species is restricted to coastal situations which are often brackish. It was recorded from several lagoons, in salinities of 0-5‰, during the initial field inventory which preceded this survey (Healy *et al.*, 1997a, b).

***Polygonum amphibium* (L.) Gray** Amphibious bistort

Only in Kilkeran L., salinity 1-2‰, occasional along sheltered shores. Generally a freshwater or terrestrial species associated with fluctuating water levels.

Characeae

Chara aspera* Deth. ex Willd. var. *aspera Rough stonewort

Present at four sites (Kilkeran L., L. Gill, Furnace L., Durnesh L.), salinity 0-5‰. Widely distributed in L. Gill and Durnesh L.; dredged from the vicinity of the outlet channel at Kilkeran L. These three lagoons are sandy, more or less shallow sites. Recorded in Furnace L. at two stations. Low-growing (< 10cm) at all sites. *Chara aspera* was present in Corragaun L.

in the 1970s, together with *C. contraria* and *Tolypella glomerata* (Verhoeven, 1980), but it is known that conditions in the lough were very different at that time (M. Viney, pers. comm.).

This charophyte is tolerant of both fresh and mildly brackish waters. It has a widespread distribution in Ireland but is not regarded as common. It occurs in Britain and most countries of continental Europe and is restricted to the northern hemisphere (Moore, 1986).

***Chara baltica* Bruz.** Baltic stonewort

Only in L. Aconeera, salinity range 5-14‰. Occurring frequently within 10m of the shore and in abundance at the western end of the lagoon in the vicinity of the major freshwater inflow.

This is the first confirmed Irish record (confirmed by N. F. Stewart) although there is an unconfirmed record from Co. Sligo (J. Ryan, pers. comm.). It is a Red Data Book species in Britain (Stewart and Church, 1992), where its status is 'Vulnerable' (recorded at only four sites since 1970). It has been found in all northern coastal countries of Europe, most frequently in the brackish waters of the Baltic Sea. It also occurs in Greenland and Bolivia (Stewart and Church, 1992).

Chara baltica is a lagoonal specialist. It probably requires at least a hint of salinity and can tolerate levels up to 18‰ (Stewart and Church, 1992). It is not known whether the Irish plants are perennial or summer annuals.

***Chara canescens* Desv. and Lois.** Bearded stonewort

Present at three of the survey sites (Tacumshin L., L. Murree, Durnesh L.), salinity 5-20‰. Also recorded in Shannon Airport lagoon, salinity 13‰. At Durnesh L., it was found only in the vicinity of the outlet pipe, where salinity was highest (5‰), growing amongst an open cover of emergent *Schoenoplectus tabernaemontani* on a stony substrate. Growing sparsely in Tacumshin L. in a northern landward bay and a channel among reedswamp. In L. Murree, it occurred frequently with *Lamprothamnium papulosum* among mixed *Ruppia* and *Potamogeton pectinatus* beds to at least 20m out from the southern shore on a substrate of mud and stones, and occasionally along the western shore. It was sampled by grapnel only at Shannon Airport.

Chara canescens is generally confined to brackish waters of a high pH (not measured during this survey) and is characteristic of low to medium salinities. This lagoonal specialist had been recorded at six Irish sites since 1970. Of these, three were included in this survey and it was

re-found at two (Tacumshin L. and L. Murree). It was not relocated at Lady's Island L. Durnesh Lake and Shannon Airport lagoon are new localities.

The species is considered 'Vulnerable' in Ireland (Stewart and Church, 1992) and is a declining species in Britain where sites have been lost to water pollution, salinity changes and infilling, and only one known site (inland) remains (Stewart and Church, 1992). It occurs along the northern coasts of Europe and in Asia, Africa and North America (Stewart and Church, 1992).

***Chara virgata* (Kutz.) R.D.Wood** Delicate stonewort, and

***Chara virgata* var. *annulata* (Liljeblad) J. A. Moore**

In Roonah L. only, in 0-2‰ salinity. Both varieties grew sparsely on sandy substrate with sparse *Ruppia maritima* in the vicinity of the major freshwater inflow.

Chara virgata is known to tolerate mildly brackish conditions but is more commonly found in freshwaters (Moore, 1986, as *C. globularis* var. *virgata*). It is widely distributed and frequent in Ireland and in Europe as a whole. No reference has been found to the occurrence of var. *annulata* in brackish conditions. It has a wide distribution in Ireland but its European status is not clear (Moore, 1986).

***Chara hispida* var. *major* (Hartm.) R. D. Wood**

In Durnesh L. only, in 5‰ salinity. Recorded growing with *C. aspera* in an area of open water in *Schoenoplectus tabernaemontani* swamp on a silty substrate. .

C. hispida (aggregate taxon) is known from many types of aquatic habitat, including brackish waters (Olsen, 1944). It has a widespread distribution in Ireland and throughout Europe (Moore, 1986).

***Lamprothamnium papulosum* (Wallr.) J.Groves** Foxtail stonewort

Present at four sites (Lady's Island L., L. Murree; Lettermullen Pool, L. Tanaí), salinity 13-37‰. In Lady's Island L., it was recorded at the western end of the barrier and in the north east corner of the lagoon in 23‰ on coarse sand, and in 14‰ on silty mud respectively. In the Lettermullen Pool, low-growing *Lamprothamnium* (< 10cm) was locally abundant in small, shallow, sheltered bays (34-37‰); it was also sampled by grapnel from deeper water where *Zostera* and *Ruppia cirrhosa* grew in dense beds. These two species also formed extensive beds with *R. maritima* at L. Tanaí (29-34‰) where *Lamprothamnium* grew among them. It was

frequent around most of the shoreline and locally abundant in places. At L. Murree, it was occasional along the western shore and abundant along the south east shore on a stony substrate (10-24‰). In both cases it was low-growing, often colourless to the point of transparency, and covered by a dense surface layer of filamentous green algae. It was much taller at the southern end of the site, where it was locally abundant, with *Chara canescens*, among dense, extensive beds of *Ruppia* (both species) and *Potamogeton pectinatus*. Substrate here was silt and stones. Salinity was 13‰ at the time of sampling.

This lagoonal specialist was known from only three sites before this survey and was re-discovered at two of these (Lady's Island L., L. Murree), but not at Tacumshin L. Lettermullen Pool and L. Tanaí are new localities. Both are high salinity lagoons. *Lamprothamnium* was recorded at salinities even higher than the upper limit of 30‰ given by Moore (1986) and Stewart and Church (1992). It is a Red Data Book species for Britain and Ireland (Stewart and Church, 1992) with a 'Vulnerable' status in both regions. In Britain, it has declined due to loss of habitat but was recorded at five stations in the south of England by Smith and Laffoley (1992) and Bamber (1997). It also occurs along the northern coasts of Europe, in the western Mediterranean, Cyprus, the Black Sea and in southern Africa (Stewart and Church, 1992).

Aquatic Plant Communities

Assemblages are described only for those sites which were felt to be adequately surveyed for this purpose. The descriptions given below are limited by the nature of the survey (see Methods). More detailed survey work would need to be carried out before communities could be described in any greater detail.

Single species *Ruppia* stands

These stands occurred over a wide range of salinities (0-36‰), at six sites: Lissagriffin L., Farranamanagh L., Cloonconeen Pool, L. Donnell, Corragaun L. and Roonah L. *Ruppia* was the only vascular plant species at Lissagriffin L. and L. Donnell, occurring at more or less sparse to patchy cover and typically low-growing. Both sites are very shallow (< 1m), low salinity lagoons (0-8‰ during sampling) with sandy substrates. *R. maritima* occurred at L. Donnell; samples from Lissagriffin L. were not identified to species. Single species *R. maritima*

beds were also recorded at Corragaun L. and Roonah L., both shallow, sandy lagoons of low salinity at the time of the survey. In the temporarily higher salinities of Farranamanagh (1-27‰ on a stony substrate) and at Cloonconeen (30-36‰ on peat), both slightly deeper lagoons, *Ruppia* formed single-species stands in sheltered areas.

***Ruppia* and *Potamogeton pectinatus* in mixed stands with lagoonal charophytes**

These stands were identified at only two sites, L. Murree and L. Aconeera, with a salinity range of 0-18‰. *Potomageton pectinatus* and *R. cirrhosa* (with *R. maritima* at L. Murree) were each locally dominant in tall, dense, extensive beds. *P. pectinatus* was typically dominant in sheltered areas. Associated charophytes, all of which are lagoonal specialists, were frequent to locally abundant: *Lamprothamnium papulosum* and *Chara canescens* at L. Murree, *C. baltica* at L. Aconeera. The presence of *P. pectinatus* may indicate that salinity fluctuations are confined to low to medium levels, at least in the short term.

***Ruppia* and *Potamogeton pectinatus* with vascular plants and charophytes typical of low salinities**

These stands were identified at two sites, L. Gill and Durnesh L., with a salinity range of 0-7‰. *Ruppia* and *P. pectinatus* were typically low-growing with *Myriophyllum spicatum* and other vascular species of fresh to mildly brackish waters. The associated charophytes, *Chara aspera* (both sites) and *C. hispida* var. *major* (Durnesh only) are not lagoonal specialists. Both sites are shallow, sandy, sedimentary lagoons. Species composition suggests that salinity levels are likely to be lower than those of the previous community and that salinity fluctuations are probably small at these sites.

Ruppia* and *Zostera marina* with *Lamprothamnium papulosum

This community type was identified from two sites, Lettermullen Pool and L. Tanaí, with a salinity range of 28-37‰. *Zostera* and *Ruppia cirrhosa* (with *R. maritima* at L. Tanaí) grew in dense, extensive mixed and single-species stands. *Ruppia* was typically dominant with more or less frequent to locally abundant *Zostera*. *Lamprothamnium* growing among these species was frequent to locally abundant but was also present in monodominant stands in shallow sheltered bays. Along rocky shores, the shoreward edge of this community was marked by a zonation with marine algae which formed a narrow belt of 1-2m width. In the tidal L. Tanaí (28-34‰), the belt was mainly composed of *Fucus ceranoides*, but in Lettermullen Pool (34-37‰), a non-

tidal rock lagoon, this algal belt consisted largely of non-fucoid species more often associated with the open coast. Filamentous green algae formed a second, more or less distinct belt of c.1m width above this zone, at and just below the water line. The presence of a well developed zonation involving marine algae indicates that salinity levels at these sites are probably consistently high.

This community may be restricted to high salinity, rocky lagoons and is possibly unique to the Connemara region.

Zostera fragments were found at Drongawn L. and Mill L., both of which are high salinity tidal lagoons with *Ruppia cirrhosa* and marine algae. A similar community to that described above may be indicated, but further investigations would be necessary to establish its nature.

Macrophytic marine algae: non-fucoid species dominant

Such assemblages were present at the two most saline sites, Aughinish L. and Lettermullen Pool, with a salinity range of 31-40‰. At Aughinish L., a tidal lagoon with frequent hypersalinity, a fairly species-rich community grew on submerged rocks and boulders. No vascular plants grew at this sites. At Lettermullen, a non-tidal lagoon, a similarly rich community, of different composition (Table 3), formed a narrow belt (1-2m) along bedrock shores, between a zone of *Ruppia* and *Zostera* below and a zone of filamentous green algae above. Of the 14 taxa identified at each site, only five occurred at both sites.

Macrophytic marine algae: fucoid species dominant

This community was present at six sites; Farranamanagh L., Drongawn L., L. Tanaí, L. Aconeera, Mill L. and Furnace L. with a salinity range of 14-34‰. The algae occurred in species-poor belts along rocky shores in the vicinity of a tidal channel connecting with the sea and on the bed of silled inlets. Like the previous one, this community is limited to rocky areas.

Discussion

The low species diversity in lagoons compared with freshwater lakes is a characteristic feature which is generally explained by environmental variability and the relatively short history of the habitats. Many of the specialist lagoonal species recorded during the survey are common in this habitat but as the total area of lagoons in Ireland is estimated to be no more than about 3000 ha, they must be considered relatively rare for the country as a whole. The most frequently

occurring species can be found in lagoon-like habitats throughout western Europe from the Baltic to the Mediterranean but these habitats are becoming rare as coastal wetlands continue to be drained and reclaimed, and those that remain are threatened by pollution and flood protection schemes. Charophytes are said to be extinct in *Ruppia* communities in The Netherlands (Verhoeven, 1980). The EU Habitats Directive has designated coastal lagoons as a priority for conservation in an effort to protect their unique communities of plants and animals.

The chief interest of lagoons for the botanist lies in the presence of species unique to this habitat and the occurrence of rare and endangered species, chiefly charophytes. All but two of the lagoonal specialists listed for Britain (Davidson *et al.*, 1991; Smith and Laffoley, 1992) were recorded during the present survey. The absentees are *Chara connivens*, which has been recorded from the South Slob, Co. Wexford, but has not been seen in Ireland since 1959 and may survive at only three localities in England, and *Tolypella nidifica* which has not been recorded in Ireland and may be extinct in England (Stewart and Church, 1992). The high constancy of *Ruppia* in Irish lagoons contrasts with Britain where the genus was only reported from 30 out of 175 lagoons sampled (Smith and Laffoley, 1992). An emphasis on fauna by the British surveillance teams, composed mainly of marine biologists, only partly explains the apparent scarcity of *Ruppia* in British lagoons. In contrast, another lagoonal specialist, *Chaetomorpha mediterranea*, was recorded at 33 British sites compared with only four out of the 20 in the present survey.

The records of charophytes are important as indicating healthy environments. The species require clear water and are vulnerable to nutrient enrichment which causes phytoplankton blooms and encourages the growth of epiphytic and filamentous algae which can blanket the plants. Six of the study sites contained Red Data Book charophyte species. Three of these, Lettermullen Pool, L. Tanaí and L. Aconeera, are in fairly remote regions and are not immediately threatened, but the other three showed evidence of eutrophication and will need to be monitored. In L. Murree, a dense growth of *Enteromorpha* in shallow water during the summer of 1996 indicated dangerous levels of nutrients, probably from agricultural sources. Deteriorating conditions in Lady's Island L. have been causing concern for over a decade and are probably due to eutrophication rather than the harmful effects of salinity fluctuations caused by more or less regular annual breaching of the barrier. Breaching has been carried out for

centuries and both flora and fauna appear to be resilient in spite of periodic pseudoextinctions (Healy, 1997). The chief threat to Tacumshin L. is from drainage and the consequent reduction in water area and depth, and the expansion of reed and sedge beds.

The small number of sites sampled, and the restriction of surveys to shallow water, do not allow environmental preferences and tolerances of the species to be defined with any confidence. The incidental summer salinity values, in particular, can only be considered as guidelines since winter salinities are likely to fluctuate more widely. In general, the trends observed correspond to those reported in Britain (Moore, 1986; Preston and Croft, 1996) and The Netherlands (den Hartog, 1971; Verhoeven and van Vierssen, 1978; Verhoeven, 1979). Examples are the greater tolerance of *R. cirrhosa* to high salinity in comparison with *R. maritima*, an upper salinity limit of about 25‰ for *P. pectinatus*, and the restriction of *Lamprothamnium* to high salinity. A wider salinity range for *Lamprothamnium* than that reported in Moore (1986) and Stewart and Church (1992) has also been reported for the south of England where salinities up to 42‰ were recorded (Bamber, 1997). The occurrence of *Lamprothamnium* on blanket bog peat in L. Tanaí appears to be unusual.

The 20 sites sampled include most of the well-known localities for rare brackishwater plants in Ireland, but a number of other lagoons and lagoon-like habitats are known to contain well-developed aquatic vegetation and some are known localities of rare species. The present investigation has produced one new Irish record and has added two new localities to the three previously known for *Lamprothamnium*, and two to the six known sites for *C. canescens* (based on information in Stewart and Church, 1992). Investigation of further examples of this neglected habitat can be expected to add to the catalogue of valuable sites.

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TABLE 1. Main features of the study sites. Rock formations in brackets do not appear at the surface at the lagoon. Salinities are for July-October 1996 only. Emergent vegetation: ex. - extensive beds; loc. - localised beds; *Ph - Phragmites australis*; *Sc - Bolboschoenus maritimus*; *Sch - Schoenoplectus tabernaemontani*.

	Area (ha)	Landscape	Geology	Substrate	Salinity (‰)	Emergents
Lady's Island Lake	450	farmland	granite, glacial till	silt, sand, stones	4-26	loc. *Ph,Sch,Sc*
Tacumshin Lake	450	farmland	glacial till	silt, sand	0-19	ex.*Ph,Sc,Sch*
Kilkeran Lake	16	dunes, woods	(sandstone) sand	silt, sand	1-5 (15)	ex.*Ph,Sc,Sch*
Lissagriffin Lake	12	sandhills, peatland	(sandstone, slate)	sand, some silt	4-8(30)	loc.*Ph,Sc,Sch*
Farranamanagh Lake	5	rocky peatland	sandstone, peat	sand, stones, peat	1-27	loc.*Sc,Sch*
Drongawn Lough	20	rocky peatland	sandstone, peat	rock, peat	10-34	loc.*Ph*
Lough Gill	160	sandhills	(limestone) sand	firm sand	0-5	ex.*Ph*,loc.*Sc,Sch*
Cloonconeen Pool	4	peatland	peat	peat	30-36	loc.*Ph,Sc*
Lough Donnell	20	farmland	glacial till	sand, silt, stones	0-6	ex.*Ph.Sc,Sch*
Lough Murree	15	farmland	karst limestone	rock, sand, silt etc	10-24	loc.*Sc*
Aughinish Lagoon	10	farmland	karst limestone	rock, sand, silt	31-40	none
Bridge Lough	5	farmland	karst limestone	rock, silt	30-38	loc.*Sch*
Lettermullen Pool	1	rocky peatland	granite, peat	rock, stones, silt	(26)34-37	none
Loch Tanaí	12	rocky peatland	granite, peat	peat, rock	28-32	none
Lough Aconeera	28	rocky peatland	granite, peat	rock, sand, peat	0-14	loc.*Ph,Sch*
Mill Lough	5	rocky peatland	granite, peat	rock, sand, peat	2-34	loc.*Ph,Sch*
Corragaun Lough	7	rocky peatland	metamorphic, peat	sand, silt, peat	0-32	loc.*Ph,Sc,Sch*
Roonah Lough	50	machair, farmland	(metamorphic), peaty	sand (peat, silt)	0-2	loc.*Sc,Sch*
Furnace Lough	125	mixed	metamorphic, peat	stones, peat, silt	1-22	loc.*Ph*
Durnesh Lake	70	drumlins	stoney till	sand (stones, silt)	0-7	ex.*Ph,Sch*

TABLE 2. Occurrence of vascular plants and charophyte species in 20 coastal lagoons in 1996. Asterisks denote lagoonal specialists.

	Lady's Island L.	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanai	L. Aconeera	Mill L.	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.	**Total sites**
Vascular plants																					
**Ruppia maritima*	+	+	+				+	+	+	+		+		+			+	+	+	+	**13**
**Ruppia cirrhosa*	+					+				+			+	+	+	+			+	+	**9**
**Ruppia* sp.				+	+																**2**
Potamogeton pectinatus	+	+	+				+			+					+				+	+	**8**
Potamogeton pusillus		+																			**1**
Zostera marina													+	+							**2**
Ranunculus baudotii		+																			**1**
Myriophyllum spicatum		+					+													+	**3**
Zanichellia palustris		+					+														**2**
Polygonum amphibium			+																		**1**
Callitriche hermaphroditica							+														**1**
Callitriche stagnalis																				+	**1**
Lemna minor	+						+													+	**3**
Littorella uniflora																			+	+	**2**
Charophyta																					
Chara aspera var. *aspera*			+				+												+	+	**4**
**Chara baltica*															+						**1**
**Chara canescens*		+								+										+	**3**
Chara virgata																		+			**1**
Chara virgata var. *annulata*																		+			**1**
Chara hispida var. *major*																				+	**1**
**Lamprothamnium papulosum*	+									+			+	+							**4**
Total species	5	7	4	1	1	1	7	1	1	5	0	1	3	4	3	1	1	3	5	10	**21**

TABLE 3. Records of non-charophyte algae from 20 lagoons.

Chlorophyta	
Chaetomorpha mediterranea (Kütz):	Farranamanagh, Cloonconeen, Bridge, Lettermullen.
Cladophora rupestris (L.):	Murree, Bridge, Lettermullen.
Cladophora sp.:	All sites.
Codium fragile (Sur.) Hariot:	Drongawn.
Codium sp.:	Aughinish, Lettermullen.
Enteromorpha sp.:	All sites except Cloonconeen.
Ulva sp.:	Lissagriffin, Aughinish.
Ulothrix flacca Thur.:	Lettermullen.
Phaeophyceae	
Ascophyllum nodosum Le Jol.:	Drongawn, Tanaí.
Chorda filum Lam.:	Faranamanagh, Drongawn.
Cystoseira foeniculacea Grev.:	Aughinish.
Dictyota dichotoma Lam.:	Aughinish.
Fucus ceranoides L.:	Lissagriffin, Farranamanagh, Bridge, Tanaí, Aconeera, Mill.
F. serratus L.:	Drongawn, Aughinish.
F. spiralis L.:	Lissagriffin.
F. vesiculosus L.:	Drongawn, Tanaí.
Rhodophyta	
Ceramium nodulosum (Lightf.) Ducl.:	Aughinish.
Ceramium sp.:	Farranamanagh.
Chondrus crispus Lyngb.:	Lettermullen.
Corallina officinalis L.:	Lettermullen.
Cystoclonium purpureum (Huds.) Batt.:	Aughinish, Lettermullen.
Gracilaria sp.:	Lettermullen.
Griffithsia corallinoides (Turn.) Mart.:	Lettermullen.
Lomentaria clavellosa Gaill.:	Lettermullen.
Laurencia obtusa Lam.:	Aughinish, Lettermullen.
Mastocarpus stellatus (Stackh.) Guiry:	Murree.
Osmundia hybrida (de Cand.) K.Lam.:	Aughinish.
Palmaria palmata (Grev.):	Drongawn, Aughinish.
Phyllophora pseudoceranoides (S. G. Gmel.):	Tanaí.
Plocamium cartilagineum (L.) Dixon:	Aughinish.
Polysiphonia elongata (Huds.) Spreng.:	Aughinish, Lettermullen.
Polysiphonia sp.:	Lissagriffin, Aughinish.
Pterocladia capillacea (S. G. Gmel.) Born. & Thur.:	Lettermullen.

TABLE 4. Salinity range of key species and number of sites of high, medium, and low salinity (‰) at which the species occurred.

	Range	0-10	10-30	>30
Ruppia cirrhosa	0-37	3	4	3
Ruppia maritima	0-36	7	3	4
Potamogeton pectinatus	0-24	5	2	0
Lamprothamnium papulosum	13-37	0	2	2
Chara canescens	5-13	1	2	0

TABLE 5. Distribution of key species in relation to substrate (number of sites in which the species occurred.

	sand	gravel	peat/rock
Ruppia cirrhosa	0	3	6
Ruppia maritima	5	4	4
Potamogeton pectinatus	2	3	2
Lamprothamnium papulosum	0	2	2
Chara canescens	0	3	0

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COASTAL LAGOON SHORES AS A HABITAT FOR STAPHYLINIDAE AND CARABIDAE (COLEOPTERA) IN IRELAND

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Abstract

Nineteen coastal lagoons or saline lakes, and one freshwater beach lake, were sampled for Staphylinidae and Carabidae on the south and west coasts of Ireland during 1996. A total of 145 species of staphylinid and 64 species of carabid were recorded, of which eleven and five species, respectively, were considered indicators of ecologically well-developed shoreline habitats (i.e., containing many local or rare specialist species). *Brundinia meridionalis* (Mulsant and Rey) (Staphylinidae) is recorded for the first time from Ireland. Sites where such habitats were indicated as occurring were Lady's Island Lake (Co. Wexford), Kilkeran Lake (Co. Cork), Lough Gill (Co. Kerry), Cloonconeen (Co. Clare), Lough Donnell (Co. Clare), Lough Murree (Co. Clare), Lough Tanaí (Co. Galway) and Durnesh Lake (Co. Donegal). Most indicator species were freshwater riparian, shoreline and marsh species. Coastal lagoons provide four types of habitat of potential conservation value: inflow marshes, lagoon shores with a vegetation structure different to that of freshwater lakes, stagnant saline silty shores with dense algal growth, and lagoon outflow beach sandflats.

Introduction

Coastal lagoons are shallow saline water-bodies with fluctuating water salinity, formed behind barriers of shingle, sand or rocks (Romão, 1996), but they can also be interpreted more widely to include bayhead saline lakes with narrow sea inlets, and artificial saline lakes (Healy and Oliver, 1998). Saline lagoons can usually be distinguished from coastal freshwater lagoons (to which they often evolve (Barnes, 1991)), and salt-marsh with a regular tidal influence, by the feature of irregular seawater inflow, often only at spring-tides or during seasonal storm or artificial breaches of the sedimentary barrier.

Lagoons typically have a brackish-water fauna which includes halotolerant aquatic Coleoptera

and Hemiptera (Barnes, 1989; Foster *et al.*, 1992; Nelson, 1995). However, the processes involved in maintaining coastal lagoons create microhabitats not only for aquatic fauna, but also for ecotonal shoreline fauna. This fauna comprises both 'aquatic' species (e.g. Hydrophilidae and Hydraenidae) and 'terrestrial' species (e.g. Staphylinidae and Carabidae), although these species are better termed ecotonal in both cases. There are many species of both shoreline and halophilous staphylinid and carabid beetles, but little is known about the assemblages that occur in the shoreline habitats of coastal lagoons in Ireland, and what they indicate about these habitats. The results of a survey of the staphylinid and carabid fauna of coastal lagoon shorelines on the south and west coasts of Ireland is reported here.

Methods

Nineteen coastal lagoons or saline lakes were sampled in 1996. An overview of Irish lagoons, with descriptions of the lagoon sites mentioned in this paper, is given in Healy and Oliver (1998), including data on salinity and hydrology. The rock lagoon near Lettermullen was not sampled, because the margins of this small site had insufficient sedimentary habitat to make sampling worthwhile. In addition, a freshwater beach lagoon at Doovilra (Co. Mayo) was also sampled briefly by ground search and flotation. The sampled areas were generally those most influenced by seawater, because the emphasis of the survey was marine. These areas were mostly associated with the barrier and outer parts of the lagoon or lake shores; the inflow marshes were not sampled.

Details of sites and sampling are summarized in Table 1 and 3 (see also Healy and Oliver, 1998). Four sampling methods were used : (1) Suction sampling using a Stihl® BR 400 suction apparatus, mounted on the operator's back. This machine (referred to as an 'S-vac' to distinguish it from the 'D-vac' suction sampler) has a suction pipe of 58mm diameter (0.0026m^2 surface area). Six subsamples within a defined vegetation type of 100 x 1.5 sec. 'sucks' per subsample were taken at each site, resulting in a total area of 1.56m^2 covered. Because the hand-held pipe was shaken when the apex of the pipe was in the vegetation, a larger area (c. 2m^2) was effectively sampled. (2) Two sets of six plastic cup pitfall traps with undiluted ethylene glycol (commercial anti-freeze) as preservative. Many of the species expected to occur in shoreline habitats are adapted to climbing to escape flooding, so these

traps were fitted with plastic funnels to hinder their escape. (3) Ground search turning cobbles (n = 30/sample). (4) Flotation of beetles in sand or soil in a bucket of water, in areas of potentially suitable *Bledius* habitat (16 samples of c. 100 cm^2 x 8cm depth) (see Good, in press a). An equivalent sampling effort was used at each site, except where suitable microhabitats were not available for ground search or flotation.

Species were selected as indicators of well-developed habitat if: (1) they have a restricted habitat preference to the types of microhabitat associated with the lagoon shores; **and**, (2) they are reported in the literature as being local or rare, from which it is assumed that they are less likely to survive in historically degraded ecosystems. By 'well-developed habitat' it is meant that the ecosystem is sufficiently undisturbed by human activity to allow it to retain many local or rare stenotopic species. The presence of two or more indicator species, likely to breed in the shoreline habitats sampled, is considered an indication of habitat quality (see Good and Speight, 1991).

Nomenclature of Coleoptera follows Booth (1988), Lucht (1987), Lohse and Lucht (1989), Muona (1990) and Good (in press b), with the exception of *Agonum thoreyi* Dejean (= *pelidnum* (Paykull) *sensu* Lohse and Lucht (1989)), and *Carabus clatratus* L. (= *clathratus* L. *sensu* Lohse and Lucht (1989)). Plant nomenclature follows Webb *et al.* (1996). Voucher specimens of *Brundinia meridionalis* and several other species have been deposited in the National Museum of Ireland, and other species have been retained in the senior author's collection.

Salinity measurements were taken using a portable salinity refractometer, calibrated using distilled water.

Results

In total, 145 species of staphylinid and 64 species of carabid were recorded from the twenty sites sampled. Eleven species of staphylinid, and five species of carabid were considered indicators of well-developed habitat (Table 2). Sites were divided into five types of lagoon or saline lake, based on the geomorphology of the barrier and the type of shore substrate (Table 3). These were: (1) sand barrier lagoons/saline lakes, (2) shingle barrier lagoons, (3) peat shore lagoons/saline lakes, (4) karst lagoons/saline lakes, and (5) drumlin lagoons/saline lakes. An

additional category of (6) beach sandflats is also included for sites with lagoon outflows on sandy beaches. Results for each site are given under these categories below. Sites considered to have better developed habitats for ecotonal soil fauna are considered in detail.

1. SAND BARRIER LAGOONS/SALINE LAKES

Lady's Island Lake in Co. Wexford is one of the best known examples of an Irish coastal lagoon with a sand and gravel barrier (Healy *et al.*, 1982; Carter *et al.*, 1984; Healy, 1997). Four other examples also occur on the south-east and south-west coasts, three of which (Tacumshin Lake, Co. Wexford; Kilkeran Lake, Co. Cork; Lough Gill, Co. Kerry) are lagoons, and one (Lissagriffin Lake, Co. Cork) is a saline lake. All five sites have sandy shores, with extensive reedbeds on inland shores.

1.1. Lady's Island Lake (Co. Wexford)

At the seaward end of the lake, the shore is formed from coarse sand, gravel, cobbles and boulders, in places with nutrient and organic matter enrichment from breeding, roosting and loafing birds. Marginal vegetation includes *Bolboschoenus maritimus* L., *Juncus gerardii* Lois., *Glaux maritima* L. and *Salicornia* sp. The inner margin of the barrier was not sampled because few Coleoptera occurred in the dry coarse sand (1991 samples; J. A. Good, unpublished). The sampled areas (Table 1) were located within 1-4m from the waters edge, avoiding the drier free-draining sand further up the exposed shore. Water salinity off the shore of the eastern sampling area was 23‰ (22 August 1996), and varied from 4-26‰ throughout the lake (Healy and Oliver, 1998). *Bledius* burrow casts were not located, nor were any *Bledius* found in 12 flotation subsamples in one of the sampled areas.

In total 36 species of staphylinid and 13 species of carabid were recorded (Tables 4 and 5), the following three of which are regarded as indicator species.

Atheta gyllenhali (Thomson) was recorded only from Lady's Island Lake in this survey (a single male from *Juncus gerardii* dominated vegetation on the east shore). Although this species is not listed by Hyman and Parsons (1994) as being rare or notable in Great Britain, it appears to be local or rare throughout Europe (Palm, 1970; Benick and Lohse, 1974). Johnson and Halbert (1902) cite two Irish records. The species is stenotopic, restricted to marshes, alder carr and bogs (Koch, 1989).

There is one previous Irish record of *Atheta liliputana* (Brisout) (Pollardstown Fen, Co. Kildare; Good, 1994), which was also recorded only from from Lady's Island Lake during this survey (one female from *Juncus gerardii* dominated vegetation on the east shore). It is cited as rare in Scandinavia and Central Europe (Palm, 1970; Benick and Lohse, 1974). The species is described as a stenotopic woodland species by Koch (1989), and may be associated with birds (carrion, faeces, etc.) (see Koch, 1989). The species may possibly be associated with the tern colony at Lady's Island Lake. It has also been recorded in Denmark from saline soil (a grassy salt meadow) by Hansen *et al.* (1991).

Gabrius keysianus Sharp, recorded from Lady's Island Lake, Kilkeran Lake and Lough Gill, is a stenotopic ripicolous species known only from coastal areas of western Europe (Horion, 1965; Koch, 1989). It is widespread but local in England and Wales (Hyman and Parsons, 1994), and generally local and mostly rare in western Europe (Horion, 1965). It has been previously recorded in Ireland, between Cloghane and Lough Gill (Tomlin and Joy, 1914). Although Koch (1989) describes *G. keysianus* as halobiont, it has also been recorded from freshwater pond and lake margins (Hyman and Parsons, 1994); its description as halotolerant is probably more correct. A male and two females were recorded from *Juncus gerardii* dominated vegetation on the east shore of Lady's Island Lake.

These three species indicate an ecologically well-developed site, with both halotolerant and marsh soil species. However, halobiont species were not recorded from Lady's Island Lake.

1.2. Kilkeran Lake (Co. Cork)

Kilkeran Lake has an extensive sandy shore along the outlet channel and inside the sand dune barrier. This is colonised by emergent plants, especially *Phragmites australis* (Cav.). The water is generally of low salinity (Healy and Oliver, 1998), and the outlet channel was dominated (at least in 1996) by freshwater outflow rather than inward percolation. This part of the south coast is characterised by few winter frost-days (Rohan, 1986).

Two areas were sampled at Kilkeran Lake (Table 1). The first was a small area (c. 100m^2) of *Bolboschoenus maritimus* with *Triglochin maritima* L. grading into *Potentilla anserina* L. and grass, on sand immediately behind stable dunes. The *Bolboschoenus* was flooded at high spring tide, and the salinity of the near-shore water in the adjacent channel was 2‰ on 11 September 1996. The second area contained lake shore beds of *Phragmites australis* on sand with a litter

and organic layer, and was situated near the lake outflow channel. This graded into *Elymus atherica*-dominated vegetation on floodplain sand.

In total 17 species of staphylinid and eight species of carabid were recorded from Kilkeran Lake (Tables 4 and 5), two of which are considered indicator species: *Gabrius keysianus* and *Philonthus fumarius* (Gravenhorst). This pair of species were also the only indicator species recorded from Lough Gill, although three times as many species were recorded from there (54 species of staphylinid and 20 species of carabid, Tables 4 and 5).

The single male of *Gabrius keysianus* was captured by suction sampling from the *Bolboschoenus maritimus* sward in the most saline (water salinity 2‰) part of the lagoon. *Philonthus fumarius*, in contrast, was recorded only from the *Phragmites* stand.

P. fumarius appears to be widespread but local in Ireland (Johnson and Halbert, 1902; Lott and Bilton, 1991) and Great Britain (Hyman and Parsons, 1994). It is not rare in Central Europe, but rather rare elsewhere (Horion, 1965). The species occurs in marshes and muddy freshwater shores (Horion, 1965; Koch, 1989) and especially in coastal marshes in Britain (Hyman and Parsons, 1994).

The presence of two indicator species indicates an ecologically well-developed site, but in comparison to Lady's Island Lake the extent of non-reedbed habitat is very small.

1.3. Lough Gill (Co. Kerry)

Like Kilkeran Lake, Lough Gill has a shore habitat with an organic-rich sandy substrate with reedbeds and generally low water salinity. One of the areas sampled (see Table 1) was a reed-bed containing *Phragmites australis* with grasses, *Mentha aquatica* L., etc., on an organic soil between a zone of *Phragmites* in standing water and an *Iris pseudacorus* L. wet pasture zone. The near-shore water salinity was low (2‰ on 15.ix.1996). The second area (see Table 1) was a c. 2m wide sandy beach uncovered by water, with a dried algal mat covering most of the sand, with *Phragmites australis*, *Schoenoplectus lacustris* L. ssp. *tabernaemontani* Gmelin, *Typha* sp. and *Nymphaea alba* L. in standing water. A dune herb-rich grassland lay above a c. 0.3m cliff from this beach. Leeches (Hirudinea) were common under the mat.

In total 54 species of staphylinid and 20 species of carabid were recorded (Tables 4 and 5), two of which are considered indicators of well-developed coastal shoreline habitat. A male and female of *Gabrius keysianus* were recorded by ground search under the algal mat, and a total of

eleven *Philonthus fumarius* occurred at both sampled subsites. A single individual of *Bembidion normannum* Dejean, which could have been vagrant, was the only halobiont species recorded.

The water salinity of Lough Gill would be higher if the sluice doors at Trench Bridge did not restrict seawater inflow. If restoration of the lagoon to a mesohaline (> 5‰) condition was to be considered, would this affect the habitats of ecotonal fauna? *Gabrius keysianus* is the only halotolerant species of those recorded and likely to breed at Lough Gill. The absence of *Philonthus fumarius* from Lady's Island Lake (mesohaline), and its occurrence at Kilkeran Lake (oligohaline), suggest that non-halotolerant species might be restricted to breeding in the wetlands of the freshwater inlet streams. For the ecotonal soil fauna at Lough Gill it is likely that freshwater or oligohaline conditions are of more importance than mesohaline conditions.

Other sites

Twenty-seven species of staphylinid and eleven species of carabid were recorded from Tacumshin Lake (Co. Wexford) (Tables 4 and 5), one of which is regarded as an indicator species: *Stenus nigritulus* Gyllenhall. This species was also recorded at Lough Murree (q.v.). In the determination of the single *Acupalpus* specimen as *parvulus* (Sturm) (Table 5), it was not possible to adequately separate the specimen from *A. elegans* (Dejean), a halobiont species listed as extinct in Britain (Koch, 1989; Hyman and Parsons, 1992). Further sampling at Tacumshin is necessary to obtain more specimens of this species-group, to check for the occurrence of *A. elegans*.

The presence of only one individual of one indicator species does not demonstrate well-developed habitat at the coastal barrier area at this site. However, this is a large site, and sampling priority was given to the coastal barrier. It is possible that the large amount of disturbance due to dewatering (see Aalen, 1997, Fig. 22) may render the coastal barrier part an unsuitable habitat, and the indicator species (*Stenus nigritulus*) may have its core population in the more marshy interior parts of the site. The interior reedbeds and marshes may contain further indicator species. The occurrence of the local hydrophilid *Enochrus halophilus* Bedel at Tacumshin (Oliver and Healy, 1998) suggests further investigation would be worthwhile.

Seventeen species of staphylinid and five species of carabid were recorded from Lissagriffin Lake (Tables 4, 5 and 15), one of which is regarded as an indicator species: *Carabus clatratus* L. Three staphylinid species were recorded outside the barrier (Table 15), and are discussed

below under the heading of beach sandflats. *Carabus clatratus* is a stenotopic species occurring in dense vegetation on peat soils, from bogs, lake shores and also salt-meadows (Koch, 1989; Hyman and Parsons, 1992). It occurs across the Palaearctic (Freude, 1976), but is very local in Great Britain (Hyman and Parsons, 1992), and appears to be local in Ireland. The single individual was recorded from the marshy meadow, but may have orginated in the nearby reedbeds.

The staphylinid assemblage recorded from the marshy meadow was low in diversity, with most species being eurytopic or tolerant of disturbance. The high numbers of the myrmecophile species *Drusilla canaliculata* (Fabr.) from a slightly higher part of the shore indicate dry surface soil conditions (c.f. Good and Wistow, 1997), which change rapidly to flooded conditions (as above). A well-developed ecotonal habitat was not, therefore, shown to occur at this site.

2. Shingle barrier lagoons

The development of shingle barriers is a characteristic of North Atlantic lagoons, and has been attributed to the high energy, macrotidal sea in combination with offshore glacial deposits (Barnes, 1991). Generally, the shingle barriers have been created over different deposits: over sand at Lough Donnell in Co. Clare and Roonah Lough in Co. Mayo; over peat at Cloonconeen in Co. Clare; and across a rocky inlet at Farranamanagh, Co. Cork. The cobble or boulder barrier substrate provides a very poor habitat because it is excessively drained, so it is the underlying deposits which define the staphylinid and carabid assemblages present.

2.1. Lough Donnell (Co. Clare)

An extensive area (c. 0.6ha) of exposed aerobic and anaerobic sandflat occurred in 1996 inside the large cobble barrier. The inland shores of sand and loam were abutted by cattle pasture and contained large stands of *Bolboschoenus lacustris*, *Schoenoplectus lacustris* ssp *tabernaemontani* and *Phragmites australis*, the latter two which which extended upstream. Lough Donnell is fed by the Innageeragh River, with a catchment area of c. 40km^2, and the annual rainfall exceeds 1000mm (Rohan, 1986). Considerable freshwater flooding, therefore, is likely to occur after heavy rainfall. The salinity of the lagoon water in 1996 was low (0-6‰; Healy and Oliver, 1998). Sampling areas are given in Table 1.

In total 22 species of staphylinid and five species of carabid were recorded (Tables 6 and 7), two of which are regarded as indicator species: *Cypha punctum* (Motschulsky) and *Bembidion bipunctatum* (L.).

Cypha punctum appears to be rare in Europe, with a predominantly atlantic distribution (Horion, 1967). There is one published Irish record (moss in dunes, Co. Down, Allen (1975)) and another unpublished Co. Kildare record from *Cladium* and *Carex* in a fen spring (J. A. Good, unpublished). The species has also been recorded from stream banks, wet meadows and coastal cliff flushes (Horion, 1967; Koch, 1989).

Bembidion bipunctatum is a halotolerant shore species, occurring inland and in coastal shingle and by brackish water pools (Koch, 1989; Hyman and Parsons, 1992). It is widespread but local in Great Britain (Hyman and Parsons, 1992), and recorded from Ireland (Speight *et al.*, 1982). It occurs from North Africa to west Siberia, and is common at least in northern Germany, although it is rarer further west (Freude, 1976).

These two species indicate that the site contains well-developed habitat: *Bembidion bipunctatum* has been associated with shingle and brackish water habitats, and *Cypha punctum* with wet coastal soils. However, the latter species, which was represented by only one individual may breed in the freshwater marsh upstream from this lagoon.

More intensive sampling (ground search and flotation) was carried out on the exposed unvegetated sandflats inside the barrier (as opposed to the sandy shores). This habitat appeared superficially suitable for *Bledius* and *Dyschirius*. However, only three individuals of three species were recorded (*Atheta elongatula* (Gravenhorst), *Platystethus cornutus* (Gravenhorst) and *Stenus impressus* Germar). This suggests that disturbance by rapidly fluctuating water levels may inhibit the establishment of burrowing beetle communities in this type of interior lagoonal sandflat.

2.2. Cloonconeen (Co. Clare)

This small coastal lagoon was formed by sea-water flooding partially cut peat. Salt-marsh vegetation (*Festuca rubra* L., *Juncus* spp., *Aster tripolium* L., *Plantago maritima* L., etc.) occurs on peat, which is saturated at the surface after spring tides (water salinity 30-36‰ (Healy and Oliver, 1998)). The site contains occasional peat cuttings isolated from the lagoon margin with c. 1m high cliff walls, flooded at spring tide. A small (c. 250m^2) overwash fan of

cobbles and coarse sand occured behind the barrier, which had extensive filamentous algal growth near the water margin, and surface deposits of seaweed debris from the overtopping sea. For sampling areas see Table 1.

In total five species of staphylinid and five species of carabid were recorded (Tables 6 and 7), two of which are regarded as indicator species: *Bembidion aeneum* Germar and *Brundinia meridionalis* (Mulsant and Rey).

Bembidion aeneum is a stenotopic halotolerant riparian and shoreline species, recorded from turloughs in Ireland (Lott and Bilton, 1991). It is also recorded from the salt spray zone above the upper shore and near brackish pools on the North Sea coast, where it is regarded as halobiont by Heydemann (1963) and Koch (1989). Although it is not listed as rare or notable in Great Britain (Hyman and Parsons, 1992), and is listed as Irish without annotation by Speight *et al.* (1982), it is local in Britain and Ireland according to Lindroth (1974). The habitat and distribution of *Brundinia meridionalis* is summarized under Lough Murree (q.v.).

Although the staphylinid assemblage recorded from the *Festuca rubra* area had low numbers of species, most of these were halophilous or occur in sea shore habitats. Of the five carabid species (Table 7), three *Bembidion* are halophilous, and another (*Bembidion assimile* Gyllenhal) is stenotopic, occurring in marshy shores and flooded meadows (Koch, 1989).

The presence of two indicator species indicates well-developed habitat, especially when the following are also considered: (1) the majority of the non-indicator species are halophilous or breed in sea-shore habitats; (2) regularly salt-saturated peat is a difficult habitat for terrestrial soil insects, so few non-specialised species would be expected to occur; (3) the site is small and, unlike other peat sites in this survey, is not connected to semi-natural peatland, but to marine littoral and pasture biotopes, so peatland species are likely to be infrequent.

Other sites

The two other west coast sites (Roonah Lough and Farranamanagh Lake) were similar to Lough Donnell in possessing barriers restricting water outflow and having large inflow catchments.

Roonah Lough (Co. Mayo) has a natural sand and shingle barrier breached by an outflow stream through shingle. There was a small internal sandflat near the outflow. Fifteen species of staphylinid and nine species of carabid were recorded from Roonah Lough (Tables 6 and 7),

one species of which is regarded as an indicator species (*Bembidion bipunctatum*). Lough Donnell was the only other site from which this species was recorded. No staphylinids, carabids or even amphipods were observed during a cobble search of the outflow shingle, indicating frequent disturbance.

Thirty-five species of staphylinid and thirteen species of carabid were recorded from Farranamanagh Lake (Tables 6 and 7), none of which are regarded as indicator species. Like Lissagriffin (q.v.), high numbers of *Drusilla canaliculata* indicate a overdrained suface just above the regularly flooded area, with little suitable ecotonal habitat.

3. Peat shore lagoons/saline lakes

There are many areas on the west coast of Ireland where marine transgression into peat has occurred, although the means whereby this has been brought about is not always clear (Mitchell, 1976). At several saline lakes and one coastal lagoon (Lough Tanaí, Lough Aconeera, Mill Lough (all in Co. Galway), Drongawn Lough (Co. Kerry) and Roonah Lough (Co. Mayo)), as a result, the rather unusual microhabitat of brackish-water peat shores has developed.

3.1. Lough Tanaí (Co. Galway)

Lough Tanaí is a bayhead saline lake with c.7 m wide inlet, surrounded by heath (including *Pteridium aquilinum* Kuhn) and blanket bog on glacial deposits with rock outcrops and boulders. The lake shore consists of exposed granite rock, boulders, cobbles and gravel, peat cliffs and sheltered lake-bay peat-flats dominated by *Juncus maritimus* Lam. and grass/sedge/*Juncus* swards. Several hectares of *Juncus maritimus* dominated vegetation occur north of Lough Carafinla, and east of Lough Atawny, along another bayhead inlet near this site. Water salinity in 1996 varied from 28-32% (Healy and Oliver, 1998). Sampling areas are given in Table 1.

In total 17 species of staphylinid and three species of carabid were recorded at Lough Tanaí (Tables 8 and 9), two of which are regarded as indicator species: *Philonthus fumarius* and *Stenus opticus* Gravenhorst.

The habitat and distribution of *Philonthus fumarius* has already been described (see under Kilkeran Lake). There are two Irish records of *Stenus opticus* (Anderson, 1984; 1987), and the

species is listed by Hyman and Parsons (1994) as very local in Great Britain. It is not rare in northern or north-eastern Europe, but local in western Europe (Horion, 1963). The species is restricted to marshes, alder carr and bogs, occurring in *Sphagnum* and *Carex* (Horion, 1963; Koch, 1989).

The staphylinid assemblage in the sedge/grass/*Juncus* area was characterized by the association of most species with bogs or marshy shores (Table 10). The presence of two indicator species, plus a majority of staphylinid species associated with bogs and wetlands, indicates ecologically well-developed habitat. The diversity of wetland species and large numbers of *Stenus incrassatus* Erichson, a eurytopic but local species (Anderson, 1984), indicate that this assemblage is at least seasonally associated with the habitat sampled, and not occasionally vagrant from the surrounding bog. Many of these species have been recorded from wet *Sphagnum* in bogs, and may benefit from a high water table maintained at the lagoon shore during the summer.

Other sites

Thirteen species of staphylinid and nine species of carabid were recorded at Lough Aconeera (Tables 8 and 9), one of which is regarded as an indicator species. This species, *Agonum nigrum* Dejean, was recorded from the *Juncus maritimus* area.

Agonum nigrum is a widespread but local species in Great Britain (Hyman and Parsons, 1992), and has been recorded from Ireland (Speight *et al.*, 1982). It occurs on the shores of standing water (freshwater and brackish) and in bogs (Koch, 1989), and its range is restricted to western Europe and the Mediterranean (Freude, 1976).

The presence of one indicator species at Lough Aconeera is insufficient to indicate well-developed habitat. Furthermore, this area, dominated by *Juncus maritimus*, is small relative to other lagoon and bayhead sites (cf. Lough Tanaí). Also, the very low number of staphylinid individuals and species found here (Table 8) suggests that the area is frequently disturbed by flooding. The lake and inlet lack shallow margins to any great extent (cf. Lough Tanaí), and the lake itself has a margin disturbed by wave action, where, for the most part, it appears that the terrestrial fauna abuts the aquatic fauna with little ecotonal habitat.

Fourteen species of staphylinid, seven species of carabid, and also one species of heterocerid (a colony of *Heterocerus flexuosus* Stephens in the sandflat), were recorded from Corragaun

Lough (Tables 8 and 9), none of which are regarded as indicator species. This site had a number of halobiont species, as a result of the tidal incursions.

Ten species of staphylinid and six species of carabid were recorded from Drongawn Lough (Tables 8 and 9), none of which are regarded as indicator species.

Only five species of staphylinid and a single species of carabid were recorded from Mill Lough (Tables 8 and 9), none of which are regarded as indicator species.

4. Karst lagoons/saline lakes

The karst limestone region of north Clare and south-east Galway includes several examples of lagoons, the best known of which is Lough Murree (Pybus and Pybus, 1980). This site is compared to two other types of karst lagoon in this region: Aughinish Island (Co. Clare), with an open surface channel allowing entry to spring tides; and Bridge Lough (Co. Galway), with an artificial causeway barrier.

4.1. Lough Murree (Co. Clare)

In addition to receiving salt-water by percolation through the sedimentary shingle barrier, Lough Murree also appears to receive salt-water though subterranean channels in the karst limestone rock (Pybus and Pybus, 1980). This water movement is slow, so that even at high spring tides when the sea level outside the land and cobble barrier is above the water level of the lagoon, there is a delayed increase of only several mm in the lagoon water level (Pybus and Pybus, 1980). The lagoon is also fed by small intermittent freshwater springs arising from underground limestone channels, and not by surface streams. As a result of the restricted water movement and shallow nature of the lagoon, the water is particularly susceptible to nutrient enrichment. Extensive algal blooms occur (Pybus and Pybus, 1980; Healy and Oliver, 1998), and the shores are covered in dense filamentous algal growth during the summer.

The main sampling area was at the shore of the south-western corner of the lagoon (see Table 1). This area was selected because it was nearest to the shingle barrier, and had well developed shore habitats. These included a bare silty sand shore with cobbles covered in bleached filamentous algae (with many gammarids and some *Ligia oceanica* (L.)), and a dense stand (c. 100m^2) of *Bolboschoenus maritimus* in c. 7cm organic soil over shelly sand.

In total 26 species of staphylinid and 15 species of carabid were recorded from Lough Murree

(Tables 11 and 12), two of which are considered indicators of well-developed habitat: *Brundinia meridionalis* and *Stenus nigritulus*. Both these species occurred in the *Bolboschoenus* area nearest the barrier. The selection of this area as being representative of the more saline shores of the lough was confirmed by measurements taken on the morning of 29 September 1996, after a spring tide and onshore gale the previous night. The recorded shallow water salinity c. 1m offshore was 22‰, compared to 11‰ near the south-eastern shore. Water marks from wave overtopping of the barrier were observed, but the quantity of water appeared small and had not reached the lagoon shore. The saltwater may have percolated through the barrier sediments; this was observed to occur at Aughinish Island lagoon.

Brundinia meridionalis occurred in abundance in the *Bolboschoenus maritimus* area (Table 11). The species has not been previously recorded from Ireland. Although it is not listed in Hyman and Parsons (1994) as rare or notable in Great Britain, it appears to be rare or local in many parts of Europe (Porta, 1926; Palm, 1970; Benick and Lohse, 1974; Mahler, 1987; Koch, 1989). *B. meridionalis* is a halophilous species, recorded from tidal refuse and silty soils on the coast and also on inland saline soils in Austria and other countries (Steel, 1953; Koch, 1989). Tidally undisturbed lagoons with stagnant water appear to be favoured by this species; relatively large populations were also recorded on organic-rich soils with dense algal growth at two other lagoons (Bridge Lough and Cloonconeen Lagoon). Lough Murree was the only one of these three lagoons where the congeneric halobiont species *Brundinia marina* was also recorded (Table 11).

Stenus nigritulus is known only in Ireland from two records (Anderson, 1984; 1987), although it was also found at Tacumshin Lake (q.v.). It is very local and declining in Britain according to Hyman and Parsons (1994), and scattered and rare in France (Horion, 1963). However, it is not rare in Fennoscandia, and is common in eastern Central Europe (Horion, 1963). The species is restricted to marshy shores, including flooded meadows (Horion, 1963), riverbanks and salt-marshes (Hyman and Parsons, 1994). It was recorded in oligohaline but not mesohaline conditions by Heydemann (1963).

The occurrence of two indicator species of staphylinid, plus a group of dominant/intermediate abundance ripicolous and halophilous species, indicates an ecologically well-developed ecotonal habitat at Lough Murree.

Both *Stenus nigritulus* and the local stenotopic hydrophilid *Enochrus halophilus* (Bedel) were recorded from Tacumshin (Table 3 and Oliver and Healy (1998), respectively) and Lough Murree (Table 11 and Pybus and Pybus (1980), respectively). Neither species was recorded at any other site during this survey (Oliver and Healy, 1998).

Other Sites

Twenty-eight species of staphylinid and eleven species of carabid were recorded from Bridge Lough (Tables 11 and 12), one of which is regarded as an indicator species: *Brundinia meridionalis* (see above). This site cannot be considered to possess well-developed habitat, despite the presence of *Brundinia meridionalis*. This is not only because of the lack of further indicator species, but also because of the occurrence of an assemblage of disturbed-soil species (such as *Bembidion lampros* (Herbst), *Gyrohypnus angustatus* (Stephens), *Philonthus carbonarius* (Gravenhorst), *P. laminatus* (Creutzer), and *Tachyporus nitidulus* (Fabr.)) which are frequent in agricultural soils with high nutrient applications (Good and Giller, 1990, 1991) (Tables 11 and 12). This assemblage was absent from Lough Murree, where a halophilous ripicolous assemblage (*Atheta vestita* (Gravenhorst), *Bembidion assimile* Gyllenhal, *Brundinia marina* (Mulsant and Rey), *Dicheirotrichus gustavi* Crotch, *Halobrecta puncticeps* (Thomson) and *Omalium laeviusculum* Gyllenhal) predominated.

The high numbers of *Amischa nigrofusca* (Stephens) from Bridge Lough are remarkable. This species has been recorded from eutrophic agricultural soils in Ireland, but never in such abundance (Good and Giller, 1990; J. A. Good, unpublished). The diet of the genus *Amischa* is apparently unknown (Good, 1995). Paulian (1941) lists several *Atheta* (a related genus) as feeding on *Protococcus* algae, and larvae of the *Atheta/Aloconota/Amischa* group from agricultural soil in the Netherlands contained ingested soil particles in their guts (J. A. Good, unpublished). Larvae of *Bledius*, which feed on interstitial algae, also ingest sand and soil particles (Paulian, 1941). It is possible that *A. nigrofusca* larvae are similarly feeding on interstitial algae exploiting the eutrophic organic margin at Bridge Lough.

Only four species were recorded from Aughinish Island lagoon (Tables 11 and 12), all of which are halophilous and frequent on coasts. Extremely disturbed conditions occur on the shore at this site, which is completely flooded by sea-water during spring tides, and dries out, due to the sandy nature of the soil, during neap tides.

5. Drumlin lagoons and saline lakes

Coastal drumlin landscapes are particularly well developed in Ireland at Clew Bay, Co. Mayo, and at Donegal Bay, Co. Donegal (see Mitchell, 1976, p. 60). Two brackish-water lakes occur in these landscapes: Furnace Lough in Co. Mayo, and Durnesh Lake in Co. Donegal. Durnesh Lake has a much more extensive shore marsh zone than Furnace Lough, and is connected to a large area of freshwater reedbeds to the south.

5.1. Durnesh Lake (Co. Donegal)

Durnesh Lake contains extensive *Schoenoplectus lacustris* ssp. *tabernaemontani* stands, reed beds and large areas of marsh along its shore. Due to high water levels at the time of sampling, an upper shore zone above the flooded area was sampled (see Table 1), characterised by *Schoenus nigricans* L., *Filipendula ulmaria* Maxim., *Parnassia palustris* L., *Briza media* L., *Centaurea nigra* L., etc. It is assumed that at least some of the water margin species migrated into this flooded grassland zone with rising water. The salinity of the flood water was 5‰ (15 August 1996).

In total 26 species of staphylinid and eight species of carabid were recorded from Durnesh Lake (Tables 13 and 14), two of which are regarded as indicator species: *Philonthus furcifer* Renkonen and *Schistoglossa gemina* (Erichson). A further six species, including another indicator species (*Diglotta sinuaticollis* (Mulsant and Rey)), also occurred at this site on the beach sandflat outside the barrier (see under beach sandflats).

There are few Irish records of *Philonthus furcifer*, a species not recorded from Great Britain (Lott and Foster, 1990; Lott and Bilton, 1991). It is rare in Europe, and occurs on marshy shores including those on sea coasts (Horion, 1967).

Schistoglossa gemina is widespread but local in Great Britain (Hyman and Parsons, 1994), and widespread but rare in Central Europe and Scandanavia (Benick and Lohse, 1974; Palm, 1970). There are at least four previous records from Ireland (O'Mahony, 1929). The habitat of the species is marshy lake shores, wet meadows and marshes including wet ditches in sand dunes (Koch, 1989; Hyman and Parsons, 1994).

The presence of two indicator species indicates an ecologically well-developed shoreline community at Durnesh Lake. However, these species can breed in freshwater wetlands, and their occurrence at this site may be due to the large area of reedbeds and marshes adjoining the

lake (e.g., towards Rossnowlagh), although the salinity of the lake was generally low (Healy and Oliver 1998).

Other sites

Twenty-one species of staphylinid and twelve species of carabid were recorded from Furnace Lough (Tables 13 and 14), none of which are regarded as indicator species. The lack of an extensive marsh zone at the margin of the lake, and regular flooding by spring tides, probably restrict the development of the shoreline fauna.

6. Beach sandflats

The specialist staphylinid and carabid fauna of unvegetated intertidal sandflats in Ireland has been previously described (Good, in press a). However, sandflats can also be created by coastal lagoonal processes, where bare areas of sand are maintained by water inflow and outflow to and from lagoons, and the Coleoptera fauna of such habitats in Ireland is not known. At Doovilra, near the mouth of Killary Harbour in Co. Mayo, a small (c. 0.3 ha) freshwater (salinity $< 1‰$) lake occurs at the back of a beach-flat which is rarely reached by storm or low pressure spring tides (landowner, pers. comm.; high spring tide did not reach the lake on 28 September 1996). The sandflat is probably also maintained by freshwater outflow from the lake, which in turn is fed by streams from the Mweelrea mountains (Corragaun Lough, several kilometres north of Doovilra, is a lagoon with water exchange with the sea at high tide, and an extensive sandflat through which the sea inlet meanders. The sandflats at this site were not sampled). Extensive sandflats with a tidal influence also occur behind dunes at Lissagriffin Lake (q.v.). A further small example is provided at the mouth of the water exchange channel, above the beach, at Durnesh Lake (q.v.). For location of sampling areas see Table 1.

Eight species of staphylinid and two species of carabid were recorded at the three sites sampled (Table 15), two of which were indicator species: *Dyschirius impunctipennis* Dawson and *Diglotta sinuaticollis* (see Good, in press a). These are small samples for any one site, and more intensive sampling of sandflats at these sites would be necessary to obtain a more complete account of the fauna. However, taken together, the two indicator species show that a well-developed beach sandflat habitat can be created by lagoonal processes.

Discussion

In a discussion of the conservation of British coastal lagoons, Barnes (1991) pointed out that a typical aquatic lagoonal fauna is not dependant on natural lagoons as a geomorphological/ physiographic feature, and could, equally well, occur in artificially created lagoons. This also appears to be the case for the shoreline fauna of Irish coastal lagoons, in that the assemblages recorded in this survey are more typical of coastal wetlands, than of natural lagoons per se. Nevertheless, some of the best examples of natural geomorphological lagoons in the present survey also possessed well-developed shore habitat (i.e. likely to contain many local or rare specialised species, based on indicator species recorded). These are Lady's Island Lake, Kilkeran Lake, Lough Gill, Cloonconeen, Lough Donnell, Lough Murree and Durnesh Lake. There were exceptions to this, in that lagoons with poorly developed sedimentary inner shores (i.e. not the barrier shore) (Farranamanagh Lake), and those sites susceptible to rapid drying of a coarse-textured sediment (Aughinish and Tacumshin Lake), did not have many indicator species.

A predominantly coastal freshwater-ecotonal fauna was recorded at most lagoon sites, and typical halobiont assemblages (with *Bledius*, *Dyschirius*, several aleocharine genera, etc. (cf. Doyen, 1976; Moore and Legner, 1976)), were noticeably under-represented in this survey. The exceptions to this were sites with relatively small volumes of freshwater inflow (Lough Murree, Aughinish and Cloonconeen). Where freshwater inflow volume is high, regular tidal cycles appear to be essential to support a salt-adapted ecotonal soil fauna. The large Venetian Lagoon in the north Adriatic Sea has a tidal range of c. 1.5m, and tidal circulation has been encouraged for its 'vivification' or prevention of its transformation into a freshwater marsh (Sacchi, 1979). As a result of this tidal influence, a large proportion of the staphylinid and carabid fauna was halobiont or halophilous (Ratti, 1979), including many species occurring in salt marshes. A further factor likely to increase the suitability of Irish lagoon shore habitats to freshwater, rather than saline, soil species, especially on the west coast of Ireland, is the regular flushing of sodium ions through the soil profile by rainwater percolation, and the relatively low levels of evapotranspiration. However, the shoreline fauna also appears to be restricted by large temporal fluctuations in salinity due to regular flushing by seawater. No indicator species were recorded from the six sites (Lough Aconeera, Corragaun Lough,

Farranamanagh Lake, Furnace Lough, Lissagriffin Lake, Mill Lough) with moderate to large temporal ranges in salinity (see Healy and Oliver, 1998).

Lough Tanaí in Connemara was the only saline lake indicated as having well-developed shore habitat. The gently sloping peat shore forms an unusual ecotone of blanket bog/low tidal amplitude euhaline water. This ecotone, also found at similar bayhead *Juncus maritimus* habitat in the vicinity, may provide an unusual type of shoreline habitat. The saline peat shore has a different vegetation structure to a freshwater peat shore because of flooding by salt-water, which inhibits non-halotolerant vegetation. As a result, a different type of shore habitat may be available to immigrating peatland species in summer. The tidal action on the peat shore may maintain a higher summer watertable than would be the case in a similar (non-tidal) freshwater lake. While these comments are speculative, further investigation of this type of shore habitat is certainly worthwhile.

Natural lagoons can usually be divided into three zones: (1) the water body and its benthos; (2) the barrier and associated lagoon shores; (3) the inflow marsh. Each of these will have their own characteristic fauna, and in many cases their value as faunal habitats will not be correlated. This survey concentrated on the staphylinid and carabid fauna of one of these zones, the barrier and lagoon shore habitats. It is not possible to conclude whether the inflow marshes hold well-developed habitats in addition to that found downstream, because they were not sampled. However, the hydrology of lagoons allows greater flooding than would be the case in the absence of a barrier, and many of the indicator species recorded are likely to have large populations in these inflow marshes. Coastal lagoon processes, therefore, may also have conservation value for shoreline fauna by creating coastal freshwater wetland habitat.

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TABLE 1. Details of sites and sampling of coastal lagoons. Vegetation refers to species dominant in the areas sampled, with the following exceptions (asterisked): At Cloonconeen *Phragmites australis* formed a sparse but characteristic stand; at Lissagriffin it was also sparse but near dense stands. Generic abbreviations: J. - *Juncus*; B. - *Bolboschoenus*. Separate dates are given for two sets of S-vac subsamples from Lady's Island Lake due to an engine fire on the first date. Each sampling area is identified by a grid reference.

Site	Grid ref.	Vegetation	Method	Sampling date
Aughinish	M286134	*Salicornia*	S-vac	4 August 1996
(Co. Clare)			Pitfall traps	4 August - 8 September 1996
			Ground search	4 August 1996
Bridge Lough	M339129	*J. gerardii*	S-vac	3 July 1996
(Co. Galway)			Pitfall traps	23 June - 3 July 1996
		Rough pasture	Pitfall traps	8 - 28 September 1996
Cloonconeen	Q834496	*Festuca rubra*	S-vac	4 September 1996
(Nr Kilcredaun Pt)			Pitfall traps	4 - 21 September 1996
(Co. Clare)		Peat cliffs	Flotation	21 July 1996
	Q835495	Inflow fan	Ground search	21 July 1996
	Q835495	*Phragmites**	Pitfall traps	4 - 21 September 1996
Corragaun Lough	L748699	*J. maritimus*	S-vac	13 August 1996
(Co. Mayo)			Pitfall traps	13 August - 27 September 1996
				28 September - 17 October 1996
		Sandy peat	Flotation	13 August 1996
		Sandflat	Flotation	13 August 1996
Doovilra	L7567	Sandflat	Ground search	13 June 1996
(Co. Mayo)			Flotation	13 June 1996
Drongawn Lough	V730638	*J. maritimus*	S-vac	19 September 1996
(Co. Kerry)			Pitfall traps	1 - 19 September 1996
	V727638	*J. maritimus*	Pitfall traps	19 September - 19 October 1996
	V731639	Rocky shore	Ground search	1 September 1996

TABLE 1 (Continued)

Site	Grid ref.	Vegetation	Method	Sampling date
Durnesh Lake	G871696	*Schoenus*	S-vac	26 September 1996
(Co. Donegal)			Pitfall traps	15 August - 26 September 1996
	G872697	*Iris*/grass	Pitfall traps	26 September - 17 October 1996
	G874698	Sandflat	Flotation	15 June 1996
			Ground search	15 June 1996
Farranamanagh Lake	V831376	*J. maritimus*	S-vac	19 September 1996
(Co. Cork)			Pitfall traps	28 August - 19 September 1996
	V829377	Grass bank	Pitfall traps	28 August - 19 September 1996
	V830376	Stony shore	Ground search	12 July 1996
Furnace Lough	L966965	*Alnus* shore	S-vac	14 August 1996
(Co. Mayo)			Pitfall traps	14 August - 27 September 1996
	L966964	Grass bank	Pitfall traps	27 September - 17 October 1996
	L965967	Stony shore	Ground search	14 August 1996
Kilkeran Lake	W337339	*B. maritimus*	S-vac	11 September 1996
(Co. Cork)			Pitfall traps	18 August - 11 September 1996
	W338340	*Phragmites*	Pitfall traps	11 September - 5 October 1996
Lady's Is. Lake	T100049	*J. gerardii*	S-vac	17 July 1996, 12 September 1996
(Co. Wexford)			Pitfall traps	23 July - 3 August 1996
	T099053	*J. gerardii*	Pitfall traps	22 August - 13 September 1996
	T082053	*Salicornia*	Ground search	18 July 1996
Lissagriffin	V772262	*Agrostis*	S-vac	30 August 1996
(Co. Cork)			Pitfall traps	30 August - 3 October 1996
	V772265	*Phragmites**	Pitfall traps	30 August - 3 October 1996
	V772263	Sandy shore	Ground search	13 July 1996
	V774263	*B. maritimus*	Ground search	13 July 1996
	V766260	Sandflat	Flotation	30 August 1996
Lough Aconeera	L878367	*J. maritimus*	S-vac	7 September 1996
(Co. Galway)			Pitfall traps	7 - 28 September 1996
	L878368	*Festuca rubra*	Pitfall traps	7 - 28 September 1996

TABLE 1 (Continued)

Site	Grid ref.	Vegetation	Method	Sampling date
Lough Donnell	R001704	*P. anserina*/grass	S-vac	5 September 1996
(Co. Clare)			Pitfall traps	5 - 21 September 1996
	R002704	Pasture	Pitfall traps	5 - 21 September 1996
	R001706/9	Sandflat	Flotation	20 July 1996
	Scattered	Sandy shore	Ground search	21 July 1996
Lough Gill	Q614141	*Phragmites*	S-vac	15 September 1996
(Co. Kerry)			Pitfall traps	15 September - 12 October 1996
	Q605144	Algal mat	Pitfall traps	28 July - 15 September 1996
			Ground search	28 July 1996
Lough Murree	M252118	*B. maritimus*	S-vac	4 August 1996
(Co. Clare)			Pitfall traps	7 July - 4 August
				4 August - 29 September 1996
		Cobble shore	Ground search	7 July 1996
	M257119	*B. maritimus*	Ground search	7 July 1996
Mill Lough	L755328	*J. maritimus*	S-vac	6 September 1996
(Co. Galway)			Pitfall traps	6 - 28 September 1996
	L755329	*J. gerardii*	Pitfall traps	6 - 28 September 1996
	L755328	Stony shore	Ground search	6 September 1996
Roonah Lough	L749760	*P. anserina*/grass	S-vac	13 August 1996
(Co. Mayo)			Pitfall traps	13 August - 27 September 1996
	L748764	Pasture	Pitfall traps	27 September - 17 October 1996
	L749765	Sandflat	Flotation	13 August 1996
Tacumshin Lake	T033054	*Agrostis*	S-vac	13 September 1996
(Co. Wexford)			Pitfall traps	13 September - 8 October 1996
	T056054	Halophytes	Pitfall traps	23 August - 13 October 1996
	T028053	Bare sand	Ground search	18 July 1996
Lough Tanaí	L950306	Grass/*Carex*	S-vac	16 August 1996
(Co. Galway)			Pitfall traps	6 July - 16 August 1996
	L952304	*J. maritimus*	Pitfall traps	16 August - 28 September 1996
	L952305	Stony shore	Ground search	6 July 1996

TABLE 2. Indicator species recorded from coastal lagoons and saline lakes. Soil salinity preference/tolerance derived from Horion (1963-67), Koch (1989) and Hyman and Parsons (1994); see text also. 'Freshwater' refers to habitat in association with freshwater; 'terrestrial' to species not generally associated with water margins; 'coastal, halotolerant' to species which occur on both saline and non-saline soils, but restricted to the coast.

Species	Total no.	Sites	Soil salinity preference/tolerance
STAPHYLINIDAE			
Atheta gyllenhali (Thomson)	1	Lady's Island	Freshwater
Atheta liliputana (Brisout)	1	Lady's Island	Terrestrial, halotolerant
Brundinia meridionalis (Mulsant & Rey)	121	Bridge L., Cloonconeen, L. Murree	Halophilous
Cypha punctum (Motschulsky)	1	L. Donnell	Freshwater
Diglotta sinuaticollis (Mulsant & Rey)	1	Durnesh	Halobiont
Gabrius keysianus Sharp	6	Kilkeran, Lady's Island, L. Gill	Coastal, halotolerant
Philonthus fumarius (Gravenhorst)	17	Kilkeran, L. Gill, Tanaí	Freshwater
Philonthus furcifer Renkonen	2	Durnesh	Freshwater
Schistoglossa gemina (Erichson)	1	Durnesh	Freshwater
Stenus nigritulus Gyllenhall	4	L. Murree, Tacumshin	Freshwater, halotolerant
Stenus opticus Gravenhorst	4	Tanaí	Freshwater
CARABIDAE			
Agonum nigrum Dejean	2	L. Aconeera	Freshwater, halotolerant
Bembidion aeneum Germar	2	Cloonconeen	Freshwater, halophilous
Bembidion bipunctatum (L.)	10	L. Donnell, Roonah	Freshwater, halotolerant
Carabus clatratus L.	1	Lissagriffin	Freshwater, halotolerant
Dyschirius impunctipennis Dawson	3	Doovilra	Coastal, halotolerant

TABLE 3. Types of coastal lagoon and saline lake based on barrier and shore substrate characteristics. See Healy and Oliver (1998) for general classification and definitions of lagoons and saline lakes. Shore substrate refers to representative substrate sampled, and does not cover all substrates present at a site.

Site	Barrier	Shore substrate	Lagoon shore class
Aughinish	Narrow inlet	Coarse sand	Karst lagoon
Bridge Lough	Causeway/karst	Silt/peat	Karst saline lake
Cloonconeen	Cobble (on peat)	Peat	Cobble barrier lagoon
Corragaun Lough	Narrow inlet	Peat/sand	Peat shore lagoon
Drongawn Lough	Narrow inlet	Peat	Peat shore saline lake
Durnesh Lake	Sand/sluice	Loam	Drumlin lagoon
Farranamanagh Lake	Cobble/gravel/sand	Coarse sand/peat	Cobble barrier lagoon
Furnace Lough	Narrow inlet	Loam	Drumlin saline lake
Kilkeran Lake	Coarse sand/gravel	Coarse sand	Sand barrier lagoon
Lady's Island Lake	Coarse sand/gravel	Coarse sand	Sand barrier lagoon
Lissagriffin	Causeway	Sand	Sand saline lake
Lough Aconeera	Narrow inlet	Peat	Peat shore saline lake
Lough Donnell	Cobble/boulder	Sand/loam	Cobble barrier lagoon
Lough Gill	Sand/sluice	Sand	Sand barrier lagoon
Lough Murree	Shingle/karst	Silt/sand	Karst lagoon
Lough Tanaí	Narrow inlet	Peat	Peat shore saline lake
Mill Lough	Narrow inlet	Peat	Peat shore saline lake
Roonah Lough	Cobble/gravel/sand	Sand/peat	Cobble barrier lagoon
Tacumshin Lake	Sand	Sand	Sand barrier lagoon

TABLE 4. Staphylinidae from sand-barrier lagoons at Lady's Island Lake (Co. Wexford), Tacumshin Lake (Co. Wexford), Kilkeran Lake (Co. Cork), Lough Gill (Co. Kerry) and Lissagriffin Lake (Co. Cork). The same sampling techniques and effort were used at each site, with the exception of Kilkeran where ground search was not possible. Indicator species are marked with an asterisk.

	Lady's Is.	Tacumshin	Kilkeran	Lough Gill	Lissagriffin
Alianta incana (Er.)	1	-	-	-	-
Aloconota gregaria (Er.)	29	1	-	1	-
Amischa decipiens (Sharp)	4	-	-	-	-
Astenus longelytratus Palm	1	-	-	-	-
Atheta amplicollis (Muls. Rey)	9	18	13	28	8
Atheta atramentaria (Gyll.)	5	-	-	-	-
Atheta elongatula (Grav.)	13	-	-	7	3
Atheta fungi (Grav.)	2	3	1	16	-
Atheta graminicola (Grav.)	19	43	6	3	8
Atheta gyllenhali (Thoms.)*	1	-	-	-	-
Atheta liliputana (Bris.)*	1	-	-	-	-
Atheta volans (Scriba)	15	11	-	1	-
Calodera aethiops Grav.	1	-	-	-	-
Carpelimus corticinus (Grav.)	1	-	-	17	1
Cypha laeviuscula (Mannh.)	1	-	-	-	-
Gabrius keysianus Sharp*	3	-	1	2	-
Gabrius nigritulus (Grav.)	1	-	-	-	-
Gnypeta carbonaria (Mannh.)	8	1	-	-	-
Megarthrus depressus (Payk.)	1	-	-	-	-
Ocypus olens (Müll.)	5	6	-	-	-
Paederus fuscipes Curt.	12	18	-	-	-
Philonthus carbonarius (Grav.)	1	1	-	-	-
Philonthus cognatus (Steph.)	1	-	-	3	-
Philonthus laminatus (Creutz.)	5	-	-	5	-
Philonthus quisquiliarius (Gyll.)	1	2	-	12	-
Quedius tristis (Grav.)	1	-	-	-	-
Sepedophilus nigripennis (Steph.)	1	-	4	1	-
Stenus boops Ljungh	4	16	-	-	15
Stenus canaliculatus Gyll.	69	3	-	-	-

TABLE 4 (Continued)

	Lady's Is.	Tacumshin	Kilkeran	Lough Gill	Lissagriffin
Stenus clavicornis (Scop.)	1	1	-	1	-
Stenus juno (Payk.)	32	10	5	7	-
Stenus melanopus (Marsh.)	3	4	-	1	-
Tachyporus chrysomelinus (L.)	6	29	1	-	-
Tachyporus hypnorum (F.)	1	5	-	-	-
Tachyporus nitidulus (F.)	21	-	-	-	-
Tachyporus pusillus Grav.	3	2	3	2	-
Aleochara bipustulata (L.)	-	3	-	-	-
Atheta melanocera (Thoms.)	-	4	-	-	-
Bledius gallicus (Grav.)	-	6	-	2	-
Gabrius pennatus Sharp	-	1	-	4	3
Gabrius subnigritulus (Reitt.)	-	1	-	-	-
Ischnopoda atra (Grav.)	-	2	-	3	-
Philonthus micans (Grav.)	-	3	1	1	-
Philonthus varians (Payk.)	-	1	-	-	-
Stenus nigritulus Gyll.*	-	1	-	-	-
Anotylus rugosus (F.)	-	-	1	8	-
Atheta clientula (Er.)	-	-	1	7	-
Philonthus fumarius (Grav.)*	-	-	6	6	-
Stenus cicindeloides (Schall.)	-	-	2	10	-
Stenus picipennis Er.	-	-	1	-	-
Tachinus signatus Grav.	-	-	1	3	1
Tachyporus dispar (Payk.)	-	-	2	7	1
Xantholinus longiventris Heer	-	-	1	4	-
Acrotona aterrima (Grav.)	-	-	-	1	-
Amischa analis (Grav.)	-	-	-	1	-
Atheta luteipes (Er.)	-	-	-	1	-
Atheta orbata (Er.)	-	-	-	3	-
Carpelimus elongatulus (Er.)	-	-	-	6	-
Carpelimus rivularis (Motsch.)	-	-	-	5	-
Cordalia obscura (Grav.)	-	-	-	16	-
Lathrobium brunnipes (F.)	-	-	-	1	-

TABLE 4 (Continued)

	Lady's Is.	Tacumshin	Kilkeran	Lough Gill	Lissagriffin
Lathrobium geminum Kr.	-	-	-	1	-
Lathrobium quadratum (Payk.)	-	-	-	1	2
Lesteva sicula Er.	-	-	-	8	-
Mycetoporus splendidus (Grav.)	-	-	-	1	-
Myllaena dubia (Grav.)	-	-	-	7	-
Myllaena infuscata Kr.	-	-	-	4	-
Olophrum fuscum (Grav.)	-	-	-	3	-
Rugilus erichsoni (Fauv.)	-	-	-	1	-
Staphylinus dimidiaticornis Gem.	-	-	-	1	-
Stenus bimaculatus Gyll.	-	-	-	11	1
Stenus brunnipes Steph.	-	-	-	1	-
Stenus formicetorum Mannh.	-	-	-	3	-
Stenus fulvicornis Steph.	-	-	-	1	-
Stenus nitidiusculus Steph.	-	-	-	2	-
Stenus pallitarsus Steph.	-	-	-	1	-
Stenus similis (Hbst.)	-	-	-	2	-
Tachyporus obtusus (L.)	-	-	-	3	-
Tachyporus pallidus Sharp	-	-	-	1	-
Tachyporus solutus Er.	-	-	-	1	-
Atheta vestita (Grav.)	-	-	-	-	2
Drusilla canaliculata (F.)	-	-	-	-	141
Othius laeviusculus Steph.	-	-	-	-	1
Philonthus addendus Sharp	-	-	-	-	1
Quedius nigriceps Kr.	-	-	-	-	1

TABLE 5. Carabidae from sand-barrier lagoons at Lady's Island Lake (Co. Wexford), Tacumshin Lake (Co. Wexford), Kilkeran Lake (Co. Cork), Lough Gill (Co. Kerry) and Lissagriffin Lake (Co. Cork). The same sampling techniques and effort were used at each site, with the exception of Kilkeran where ground search was not possible. Indicator species are marked with an asterisk.

	Lady's Is.	Tacumshin	Kilkeran	Lough Gill	Lissagriffin
Agonum marginatum (L.)	7	1	-	2	1
Bembidion varium (Ol.)	21	28	-	-	-
Bradycellus harpalinus (Serv.)	1	-	1	-	-
Broscus cephalotes (L.)	2	-	-	-	-
Calathus fuscipes (Goeze)	4	-	-	-	-
Dyschirius globosus (Hbst.)	60	4	-	11	-
Dyschirius luedersi Wagn.	7	11	-	-	-
Elaphrus cupreus Duft.	11	1	-	-	-
Harpalus rufipes (Geer)	1	-	-	29	-
Loricera pilicornis (F.)	5	-	-	-	-
Pterostichus diligens (Sturm)	2	-	-	-	-
Pterostichus niger (Schall.)	4	1	108	39	1
Pterostichus nigrita (Payk.)	1	-	1	65	-
Acupalpus parvulus (Sturm)	-	1	-	-	-
Agonum thoreyi Dej.	-	14	2	5	1
Bembidion assimile Gyll.	-	4	12	-	-
Bembidion guttula (F.)	-	1	-	-	-
Pterostichus melanarius (Ill.)	-	1	-	3	-
Abax parallelipedus (Pill.Mitt.)	-	-	3	-	-
Blethsia multipunctata (L.)	-	-	1	-	-
Dromius linearis (Ol.)	-	-	3	1	-
Agonum muelleri (Hbst.)	-	-	-	1	-
Bembidion lampros (Hbst)	-	-	-	2	-
Bembidion mannerheimi Sahlb.	-	-	-	44	-
Bembidion normannum Dej.	-	-	-	1	-
Bembidion tetracolum Say	-	-	-	3	-
Carabus granulatus L.	-	-	-	13	-
Demetrias atricapillus (L.)	-	-	-	7	-
Dyschirius thoracicus (Rossi)	-	-	-	1	-
Nebria brevicollis (F.)	-	-	-	16	-
Poecilus versicolor (Sturm)	-	-	-	1	1
Pterostichus minor (Gyll.)	-	-	-	1	-
Trichocellus placidus (Gyll.)	-	-	-	1	-
Carabus clatratus L.*	-	-	-	-	1

TABLE 6. Staphylinidae from shingle barrier lagoons at Lough Donnell (Co. Clare), Roonah Lough (Co. Mayo), Farranamanagh Lake (Co. Cork) and Cloonconeen (Co. Clare). The same sampling techniques and effort were used at each site. Indicator species are marked with an asterisk.

	L. Donnell	Roonah	Farranamanagh	Cloonconeen
Aloconota gregaria (Er.)	1	-	-	-
Amischa analis (Grav.)	1	-	1	-
Atheta amplicollis (Muls. Rey)	4	-	12	-
Atheta celata (Er.)	3	-	-	-
Atheta elongatula (Grav.)	27	3	-	-
Atheta graminicola (Grav.)	17	8	-	-
Atheta volans (Scriba)	22	3	-	-
Bledius gallicus (Grav.)	1	-	-	-
Carpelimus bilineatus (Steph.)	1	-	-	-
Carpelimus corticinus (Grav.)	1	-	-	-
Cypha punctum (Motsch.)*	1	-	-	-
Gabrius pennatus Sharp	3	-	2	-
Gabrius subnigritulus (Reitt.)	2	1	-	-
Gnypeta carbonaria (Mannh.)	5	-	-	-
Ischnopoda atra (Grav.)	1	1	-	-
Philonthus cognatus (Steph.)	8	-	-	-
Philonthus marginatus (Ström)	2	-	-	2
Quedius schatzmayri Grid.	1	-	1	-
Stenus canaliculatus Gyll.	14	-	-	3
Tachyporus chrysomelinus (L.)	1	-	-	-
Tachyporus dispar (Payk.)	2	6	2	-
Tachyporus pusillus Grav.	3	2	-	-
Atheta melanocera (Thoms.)	-	3	-	-
Bledius fergussoni Joy	-	15	-	-
Bledius longulus Er.	-	14	-	-
Euaesthetus laeviusculus Mannh.	-	1	-	-
Ocypus aeneocephalus (Geer)	-	5	-	-
Othius melanocephalus (Grav.)	-	2	-	-
Quedius semiaeneus (Steph.)	-	14	-	-
Xantholinus linearis (Ol.)	-	1	-	-

TABLE 6 (Continued)

	L. Donnell	Roonah	Farranamanagh	Cloonconeen
Anotylus rugosus (F.)	-	-	14	-
Atheta fungi (Grav.)	-	-	8	-
Calodera aethiops Grav.	-	-	1	-
Cordalia obscura (Grav.)	-	-	1	-
Dinaraea angustula (Gyll.)	-	-	4	-
Drusilla canaliculata (F.)	-	-	56	-
Encephalus complicans Steph.	-	-	1	-
Geostiba circellaris (Grav.)	-	-	1	-
Lathrobium brunnipes (F.)	-	-	2	-
Lesteva sicula Er.	-	-	1	-
Metopsia retusa (Steph.)	-	-	1	-
Ocypus olens (Müll.)	-	-	1	-
Omalium excavatum Steph.	-	-	1	-
Oxypoda elongatula Aubé	-	-	2	-
Philonthus varians (Payk.)	-	-	1	-
Quedius nigriceps Kr.	-	-	1	-
Quedius tristis (Grav.)	-	-	3	-
Rugilus erichsoni (Fauv.)	-	-	5	-
Sepedophilus nigripennis (Steph.)	-	-	9	-
Stenus bimaculatus Gyll.	-	-	8	-
Stenus brunnipes Steph.	-	-	7	-
Stenus cicindeloides (Schall.)	-	-	1	-
Stenus clavicornis (Scop.)	-	-	22	-
Stenus fulvicornis Steph.	-	-	17	-
Stenus impressus Germ.	-	-	1	-
Stenus juno (Payk.)	-	-	19	-
Stenus lustrator Er.	-	-	5	-
Stenus ossium Steph.	-	-	2	-
Tachinus signatus Grav.	-	-	4	-
Xantholinus longiventris Heer	-	-	2	-
Brundinia meridionalis (Muls. Rey)*	-	-	-	22
Ocypus ater (Grav.)	-	-	-	7
Polystomota grisea (Kr.)	-	-	-	1

TABLE 7. Carabidae from shingle barrier lagoons at Lough Donnell (Co. Clare), Roonah Lough (Co. Mayo), Farranamanagh Lake (Co. Cork) and Cloonconeen (Co. Clare). The same sampling techniques and effort were used at each site. Indicator species are marked with an asterisk.

	L. Donnell	Roonah	Farranamanagh	Cloonconeen
Agonum marginatum (L.)	2	-	1	-
Agonum thoreyi Dej.	1	2	1	-
Bembidion bipunctatum (L.)*	9	1	-	-
Nebria brevicollis (F.)	3	-	-	-
Pterostichus strenuus (Panz.)	1	-	1	-
Bembidion pallidipenne (Ill.)	-	2	-	-
Calathus fuscipes (Goeze)	-	87	-	-
Calathus melanocephalus (L.)	-	7	-	-
Calathus micropterus (Duft.)	-	1	-	-
Calathus ochropterus (Duft.)	-	1	-	-
Dyschirius politus (Dej.)	-	1	-	-
Pterostichus niger (Schall.)	-	1	6	1
Abax parallelipedus (Pill. Mitt)	-	-	4	-
Agonum gracile (Gyll.)	-	-	1	-
Anisodactylus binotatus (F.)	-	-	1	-
Bembidion mannerheimi Sahlb.	-	-	15	-
Dromius linearis (Ol.)	-	-	1	-
Dromius melanocephalus Dej.	-	-	2	-
Platynus albipes (F.)	-	-	1	-
Pterostichus vernalis (Panz.)	-	-	1	-
Trechus obtusus Er.	-	-	6	-
Bembidion aeneum Germ.*	-	-	-	2
Bembidion assimile Gyll.	-	-	-	1
Bembidion minimum (F.)	-	-	-	3
Bembidion varium (Ol.)	-	-	-	5

TABLE 8. Staphylinidae from saline lake peat shores with *Juncus* and grasses at Lough Tanaí (Co. Galway), Lough Aconeera (Co. Galway), Drongawn Lough (Co. Kerry), Corragaun Lough (Co. Mayo) and Mill Lough (Co. Galway). The same sampling techniques and effort were used at each site, with the exception of Aconeera where ground search was not possible. Indicator species are marked with an asterisk.

	L. Tanaí	Aconeera	Drongawn	Corragaun	Mill Lough
Amischa analis (Grav.)	1	-	-	-	-
Atheta volans (Scriba)	1	-	-	-	-
Drusilla canaliculata (F.)	3	-	8	1	-
Erichsonius cinerascens (Grav.)	2	-	-	-	-
Euaesthetus ruficapillus Bois. Lac.	7	-	-	-	-
Lathrobium quadratum (Payk.)	1	-	-	-	-
Lathrobium terminatum Grav.	3	-	-	-	-
Lesteva sicula Er.	1	1	-	-	-
Paederus fuscipes Curt.	2	-	34	-	-
Philonthus fumarius (Grav.)*	1	-	-	-	-
Philonthus nigrita (Grav.)	1	-	-	-	-
Stenus brunnipes Steph.	1	1	1	-	-
Stenus canaliculatus Gyll.	1	-	-	-	-
Stenus fuscipes Grav.	5	-	-	-	-
Stenus incrassatus Er.	76	-	-	-	-
Stenus nitidiusculus Steph.	2	-	-	1	1
Stenus opticus Grav.*	4	-	-	-	-
Cryptobium fracticorne (Payk.)	-	1	2	1	-
Geostiba circellaris (Grav.)	-	8	-	-	-
Ocypus olens (Müll.)	-	1	-	1	3
Quedius fuliginosus (Grav.)	-	1	-	-	-
Quedius molochinus (Grav.)	-	1	-	1	-
Quedius semiaeneus (Steph.)	-	1	-	-	-
Rugilus erichsoni (Fauv.)	-	1	-	-	-
Staphylinus dimidiaticornis Gem.	-	1	-	-	-
Stenus clavicornis (Scop.)	-	3	-	-	-
Stenus impressus Germ.	-	1	-	-	-
Stenus lustrator Er.	-	1	7	-	-

TABLE 8 (Continued)

	L. Tanaí	Aconeera	Drongawn	Corragaun	Mill Lough
Atheta vestita (Grav.)	-	-	1	14	-
Gabrius pennatus Sharp	-	-	1	-	-
Stenus juno (Payk.)	-	-	1	-	-
Stenus nitens Steph.	-	-	1	-	-
Zyras limbatus (Payk.)	-	-	1	-	-
Bledius fergussoni Joy	-	-	-	6	-
Bledius limicola Totth.	-	-	-	9	-
Carpelimus corticinus (Grav.)	-	-	-	1	-
Diglotta mersa (Hal.)	-	-	-	1	-
Ocypus ater (Grav.)	-	-	-	7	-
Sepedophilus nigripennis (Steph.)	-	-	-	5	-
Tachinus laticollis Grav.	-	-	-	1	-
Xantholinus longiventris Heer	-	-	-	3	-
Atheta melanocera (Thoms.)	-	-	-	-	1
Lathrobium brunnipes (F.)	-	-	-	-	1
Philonthus politus (L.)	-	-	-	-	1

TABLE 9. Carabidae from saline lake peat shores with *Juncus* and grasses at Lough Tanaí (Co. Galway), Lough Aconeera (Co. Galway), Drongawn Lough (Co. Kerry), Corragaun Lough (Co. Mayo) and Mill Lough (Co. Galway). The same sampling techniques and effort were used at each site, with the exception of Aconeera where ground search was not possible. Indicator species are marked with an asterisk.

	L. Tanaí	Aconeera	Drongawn	Corragaun	Mill Lough
Agonum gracile (Gyll.)	1	-	-	-	-
Elaphrus cupreus Duft.	1	-	-	-	-
Pterostichus niger (Schall.)	3	7	6	2	13
Abax parallelipedus (Pill.Mitt.)	-	3	-	-	-
Agonum nigrum Dej.*	-	2	-	-	-
Bembidion mannerheimi Sahlb.	-	6	6	1	-
Dromius linearis (Ol.)	-	1	-	-	-
Notiophilus palustris (Duft.)	-	3	-	-	-
Pterostichus diligens (Sturm)	-	2	-	-	-
Pterostichus strenuus (Panz.)	-	1	-	-	-
Trechus obtusus Er.	-	1	-	-	-
Agonum fuliginosum (Panz.)	-	-	1	-	-
Agonum muelleri (Hbst.)	-	-	2	-	-
Dyschirius globosus (Hbst.)	-	-	5	-	-
Notiophilus biguttatus (F.)	-	-	1	-	-
Dyschirius politus (Dej.)	-	-	-	2	-
Leistus fulvibarbis Dej.	-	-	-	1	-
Loricera pilicornis (F.)	-	-	-	1	-
Nebria brevicollis (F.)	-	-	-	1	-
Notiophilus aquaticus (L.)	-	-	-	1	-

TABLE 10. Staphylinid assemblage from sedge/grass/*Juncus* area, Lough Tanaí (Co. Galway) (S-vac suction sample and pitfall traps combined). Biotope data are from Anderson (1984), Horion (1963-67), Koch (1989), and other literature.

Abundance	Species	No.	Main biotope
Dominant	*Stenus incrassatus*	76	Eurytopic, wet soils including bogs
Intermediate	*Drusilla canaliculata*	2	Heaths, bogs and grassland
	Erichsonius cinerascens	2	Eurytopic, wet soils including bogs
	Euaesthetus ruficapillus	7	Marshes, also bogs
	Lathrobium terminatum	3	Marshes, also bogs
	Stenus fuscipes	5	Mesotrophic/eutrophic marshes, riparian
	Stenus nitidiusculus	2	Eurytopic, including blanket bogs
	Stenus opticus	4	Flooded soils, also blanket bogs
Present	*Amischa analis*	1	Eurytopic, including disturbed agricultural land
	Atheta volans	1	Marshy shores including upper sea shores
	Lathrobium quadratum	1	Marshes, also bogs
	Lesteva sicula	1	Marshes, also bogs
	Philonthus fumarius	1	Marshes and marshy shores
	Philonthus nigrita	1	Bogs
	Stenus brunnipes	1	Woods and grassland including freshwater shores
	Stenus canaliculatus	1	Eurytopic, including muddy sea shores and bogs

TABLE 11. Staphylinidae from karst lagoons at Lough Murree (Co. Clare), Bridge Lough (Co. Galway) and Aughinish Island (Co. Clare). The same sampling techniques and effort were used at each site, with the exception of Bridge Lough, where cobble search was not possible. Indicator species are marked with an asterisk.

	L. Murree	Bridge L.	Aughinish Is.
Aleochara lanuginosa Grav.	2	-	-
Anotylus rugosus (F.)	5	-	-
Atheta amplicollis (Muls. Rey)	1	11	-
Atheta elongatula (Grav.)	8	1	-
Atheta fungi (Grav.)	6	-	-
Atheta graminicola (Grav.)	2	-	-
Atheta melanocera (Thoms.)	1	-	-
Atheta vestita (Grav.)	56	-	-
Atheta volans (Scriba)	2	-	-
Brundinia marina (Muls. Rey)	3	-	-
Brundinia meridionalis (Muls. Rey)*	112	34	-
Carpelimus corticinus (Grav.)	5	1	-
Cordalia obscura (Grav.)	1	-	-
Euaesthetus bipunctatus (Ljungh)	1	-	-
Gabrius pennatus Sharp	1	-	-
Gnypeta carbonaria (Mannh.)	1	-	-
Halobrecta puncticeps (Thoms.)	2	-	-
Ocypus ater (Grav.)	3	-	-
Ocypus olens (Müll.)	2	-	-
Omalium laeviusculum Gyll.	11	1	-
Stenus canaliculatus Gyll.	3	-	-
Stenus ossium Steph.	1	8	-
Stenus nigritulus Gyll.*	6	-	-
Tachinus signatus Grav.	2	1	-
Tachyporus dispar (Payk.)	1	25	-
Xantholinus longiventris Heer	1	1	-
Aleochara bipustulata (L.)	-	1	-
Amischa analis (Grav.)	-	28	-
Amischa nigrofusca (Steph.)	-	168	-
Gyrohypnus angustatus (Steph.)	-	5	-

TABLE 11 (Continued)

	L. Murree	Bridge L.	Aughinish Is.
Ischnopoda atra (Grav.)	-	1	-
Mycetoporus splendidus (Grav.)	-	1	-
Philonthus carbonarius (Grav.)	-	2	-
Philonthus laminatus (Creutz.)	-	5	-
Sepedophilus nigripennis (Steph.)	-	4	-
Stenus clavicornis (Scop.)	-	1	-
Stenus fuscipes Grav.	-	3	-
Tachyporus chrysomelinus (L.)	-	3	-
Tachyporus hypnorum (F.)	-	1	-
Tachyporus nitidulus (F.)	-	7	-
Tachyporus obtusus (L.)	-	1	-
Tachyporus pusillus Grav.	-	1	-
Tachyporus tersus Er.	-	1	-
Tinotus morion (Grav.)	-	1	-
Xantholinus glabratus (Grav.)	-	1	-
Halobrecta flavipes Thoms.	-	-	2

TABLE 12. Carabidae from karst lagoons at Lough Murree (Co. Clare), Bridge Lough (Co. Galway) and Aughinish Island (Co. Clare). The same sampling techniques and effort were used at each site, with the exception of Bridge Lough, where cobble search was not possible. Indicator species are marked with an asterisk.

	L. Murree	Bridge L.	Aughinish Is.
Agonum marginatum (L.)	4	2	-
Bembidion assimile Gyll.	249	-	-
Bembidion mannerheimi Sahlb.	1	4	-
Bembidion varium (Ol.)	20	2	-
Broscus cephalotes (L.)	1	-	-
Carabus granulatus L.	2	-	-
Dicheirotrichus gustavi Crotch	5	-	47
Dyschirius globosus (Hbst)	4	3	-
Elaphrus cupreus Duft.	1	-	-
Harpalus rufipes (Geer)	3	-	-
Loricera pilicornis (F.)	6	-	-
Platynus albipes (F.)	10	-	-
Pterostichus melanarius (Ill.)	2	-	-
Pterostichus niger (Schall.)	2	-	-
Pterostichus nigrita (Payk.)	5	1	-
Bembidion guttula (F.)	-	1	-
Bembidion lampros (Hbst)	-	2	-
Bembidion obtusum Serv.	-	1	-
Calathus melanocephalus (L.)	-	1	-
Nebria brevicollis (F.)	-	1	-
Pterostichus madidus (F.)	-	1	-
Bembidion minimum (F.)	-	-	1
Pogonus chalceus (Marsh.)	-	-	6

TABLE 13. Staphylinidae from brackish-water lake shores at Durnesh Lake (Co. Donegal) and Furnace Lough (Co. Mayo). The same sampling techniques and effort were used at each site. Indicator species are marked with an asterisk.

	Durnesh Lake	Furnace Lough
Anotylus rugosus (F.)	1	1
Atheta amplicollis (Muls. Rey)	1	-
Carpelimus corticinus (Grav.)	1	-
Cypha laeviuscula (Mannh.)	4	-
Drusilla canaliculata (F.)	2	-
Euaesthetus ruficapillus Bois. Lac.	1	-
Gyrohypnus angustatus (Steph.)	2	-
Lathrobium brunnipes (F.)	1	-
Metopsia retusa (Steph.)	1	-
Myllaena infuscata Kr.	1	-
Ocypus olens (Müll.)	23	1
Oxypoda elongatula Aubé	2	3
Philonthus furcifer Renk.*	2	-
Quedius curtipennis Bernh.	1	-
Quedius fuliginosus (Grav.)	1	1
Quedius nigriceps Kr.	1	-
Schistoglossa gemina (Er.)*	1	-
Sepedophilus nigripennis (Steph.)	1	-
Staphylinus dimidiaticornis Gemm.	1	-
Stenus brunnipes Steph.	2	1
Stenus fuscipes Grav.	6	-
Stenus juno (Payk.)	2	10
Stenus lustrator Er.	2	-
Stenus nitens Steph.	4	-
Stenus ossium Steph.	1	-
Tachinus signatus Grav.	3	6
Atheta elongatula (Grav.)	-	1
Atheta volans (Scriba)	-	2
Deubelia picina (Aubé)	-	2
Lesteva sicula Er.	-	1
Philonthus carbonarius (Grav.)	-	1
Philonthus cognatus (Steph.)	-	3
Quedius molochinus (Grav.)	-	1
Stenus bifoveolatus Gyll.	-	15
Stenus canaliculatus Gyll.	-	1
Stenus fulvicornis Steph.	-	1
Stenus nitidiusculus Steph.	-	13
Stenus similis (Hbst.)	-	3
Stenus tarsalis Ljungh	-	1
Tachyporus dispar (Payk.)	-	1

TABLE 14. Carabidae from brackish-water lake shores at Durnesh Lake (Co. Donegal) and Furnace Lough (Co. Mayo). The same sampling techniques and effort were used at each site. Indicator species are marked with an asterisk.

	Durnesh Lake	Furnace Lough
Agonum fuliginosum (Panz.)	4	1
Agonum thoreyi Dej.	7	14
Badister sodalis (Duft.)	1	-
Bembidion mannerheimi Sahlb.	8	-
Dromius linearis (Ol.)	2	-
Leistus terminatus (Hellw.)	1	-
Pterostichus niger (Schall.)	13	16
Pterostichus nigrita (Payk.)	1	3
Agonum gracile (Gyll.)	-	5
Agonum viduum (Panz.)	-	1
Elaphrus cupreus Duft.	-	7
Loricera pilicornis (F.)	-	3
Nebria brevicollis (F.)	-	23
Platynus albipes (F.)	-	14
Pterostichus diligens (Sturm)	-	2
Pterostichus melanarius (Ill.)	-	5

TABLE 15. Staphylinidae and Carabidae from beach sandflats outside lagoon barriers at Doovilra (Co. Mayo), Durnesh (Co. Donegal) and Lissagriffin (Co. Cork). Indicator species are marked with an asterisk.

	Doovilra	Durnesh	Lissagriffin
Bembidion pallidipenne (Ill.)	3	11	-
Bledius fergussoni Joy	11	16	-
Dyschirius impunctipennis Daws.*	3	-	-
Anotylus maritimus Thoms.	-	1	-
Atheta vestita (Grav.)	-	3	-
Bledius subniger Schneid.	-	3	18
Diglotta sinuaticollis (Muls. Rey)*	-	1	-
Phytosus balticus Kr.	-	1	-
Diglotta mersa (Hal.)	-	-	1
Othius laeviusculus Steph.	-	-	1

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RECORDS OF AQUATIC FAUNA FROM COASTAL LAGOONS IN IRELAND

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Abstract

Records of aquatic fauna are reported from 20 coastal lagoons on south and west coasts of Ireland from Wexford to Donegal. The total number of taxa recorded is 248 (220 identified to species), the number at each site varying between 14 and 70 depending on the relative degree of marine and freshwater influence, the extent of salinity fluctuations, and the presence of rocks. The fauna was diverse in comparison with English lagoons, with a high proportion of aquatic Coleoptera, Heteroptera and fish, but poor representation of Annelida. A provisional list of lagoonal specialists for Ireland is given for use as bioindicators of lagoonal conditions.

Introduction

The European Union Habitats Directive (92/43/EEC) identifies coastal lagoons as a priority habitat for conservation. Within the United Kingdom, coastal brackish lagoons are the only marine priority habitat type (Bamber, 1997). All member states are obliged by European law to evaluate the lagoons within their national territories and protect those deemed worthy of conservation within Special Areas of Conservation. Governments of Member States are also required under Article 17 of the Habitats Directive to report on the conservation status of the SACs via an ongoing monitoring programme.

Many studies of coastal lagoons have been carried out in Britain over the past two decades (e.g. Waterston *et al.*, 1979; Barnes and Heath, 1980; Barnes, 1987, 1989; Sheader and Sheader, 1989; Bamber *et al.*, 1992; Smith and Laffoley, 1992; Davidson *et al.*, 1992; Downie, 1996; Bamber, 1997; Covey *et al.*, 1998; Thorpe, 1998) but far less attention has been paid to this habitat in Ireland. Until 1996, there was no comprehensive account of coastal lagoons in Ireland and they have not been included in recent coastal surveys. Only a small

number of those known had been described (Parker, 1977; Pybus and Pybus, 1980; Healy *et al.*, 1982; Galvin, 1992; Healy, 1997) although some information was available for those of ornithological or geomorphological interest.

The following records are the result of a survey carried out on behalf of the National Parks and Wildlife Service during 1996, together with some additional records relating to the sites investigated. The main study was carried out in 20 lagoons, selected from a total of 56 identified during 1996 (Healy *et al.*, 1997a, b, c; Healy and Oliver, this volume).

Study sites

Sites are situated on south and west coasts from Wexford to Donegal. Some details of the localities are given in Table 1. For further details of the survey, selection of the 20 sites, and descriptions of the lagoons studied see Healy and Oliver (this volume).

Methods

Preliminary samples were taken in June and the first week of July, 1996; the main sampling period was late July-beginning of October, 1996. A number of stations were selected in each lagoon according to size, habitat diversity, and ease of access. The position of sampling areas was determined using a GPS Personal Navigator (Global Positioning Satellite, Garmin GPS 45). At each sampling station the depth of water and substrate type were recorded, salinity was measured using a hand-held salinity refractometer (precision 1 ppt.) and tidal exchange estimated. A photographic record was made of the site and local information sought concerning background and recent history.

Faunal samples were collected by a combination of sweep-netting (0.5mm mesh), sieving of sediment (1mm mesh) and close inspection of stones and vegetation for approximately one hour at each station. Faunal samples were preserved in 70% alcohol and stored for subsequent sorting and identification. Examples of certain species, e.g. hydrobiids and anemones, were kept alive to aid identification. Light-traps were left submerged in water overnight at certain stations. These consisted of a perspex box (25x25x25cm) containing a chemical light and were constructed according to the model described by Holmes and O'Connor (1988). Fyke nets were used at certain stations at all but two of the sites (Tacumshin L., due to lack of water, and

Bridge L., due to problems of access). Standard procedure was that followed by Moriarty (1975) and Poole (1994). The nets used are referred to as summer fyke nets and consist of two 3m traps, facing each other, joined by a 6m leader net, mesh size 16mm. The trap at each end consists of two chambers and a cod end, with knot-to-knot mesh sizes of 16, 12 and 10mm, respectively. Nets were generally placed at right angles to freshwater inflows or tidal inlets in order to trap fish swimming from either direction, although this was not always possible due to either strong winds or tidal flows. Unless the water body was particularly small, and the likelihood of trapping otters (*Lutra lutra*) was considered high, nets were set in the evening, left overnight, and retrieved the following morning. A maximum of four nets was used on a maximum of two consecutive days in each lake. A small number of fish were retained for identification purposes and some were damaged or killed as a result of trapping, but all other individuals were returned alive immediately following retrieval of the nets.

Unless otherwise stated, nomenclature and general information concerning distribution and habitat for most of the marine fauna are according to Hayward and Ryland (1995).

Results

Table 2 lists the 248 taxa (220 species) of aquatic fauna recorded at the 20 selected sites. Further details of abundance and distribution within each site and within Ireland are given in the text. "Lagoonal specialist" refers to the list of species, based on that given by Barnes (1989), subsequently modified, for coastal lagoons in Britain (see Healy and Oliver, this volume). Table 3 lists the number of taxa recorded during the survey, and lagoonal specialists, at each site, together with area, presence of rock and salinity range. Table 4 lists the most frequently occurring species in the 20 lagoons.

Porifera

***Halichondria panicea* (Pallas)** Breadcrumb sponge

On rocks near the inlet in Drongawn L. Marine species.

Cnidaria

***Actinia equina* (L.)** Beadlet anemone

In Bridge L. only, where it was abundant, although it is known to be tolerant of brackish

conditions. An interesting feature of these specimens was that the column and acrorhagi were almost black.

***Anemonia viridis* (Forskål)** Opelet or snakelocks anemone

Several specimens recorded in Aughinish L.

***Aurelia aurita* (L.)** Moon jellyfish

Occasional specimens in Farranamanagh L., Lettermullen Pool, L. Tanaí and Furnace L.

***Chrysaora hysoscella* (L.)** Compass jellyfish

Several in Drongawn L. and Aughinish L.

***Cordylophora caspia* (Pallas)**

Very abundant in Durnesh L. attached to *Potamogeton pectinatus* and *Ruppia* in 0-2‰. Also recorded in Rostellan L., Co. Cork, during an earlier part of the survey and previously at Lady's Island L. (Healy *et al.*, 1982). Found in shallow brackish to nearly fresh water. According to Arndt (1984) "appears to be an excellent bioindicator for eutrophic brackish water in the horohaline zone." Widespread and likely to occur all around British coasts; status in Ireland uncertain. A possible lagoonal specialist.

***Dynamena pumila* (L.)**

A few colonies on fucoid algae in Aughinish L. and Mill L. Marine species.

***Laomedea angulata* Hincks**

Common on *Zostera* in Lettermullen Pool. The species is always associated with eel grasses and is known to have declined following the wasting disease of *Zostera* in the 1930s. Known today from the south coast of England southwards, but 19th century records ranged north to Isle of Man. Current status in Ireland unclear but probably widespread on *Zostera* (B. Picton, pers. comm.).

***Sagartiogeton undatus* (Müller)**

Common on and under rocks in Drongawn L. in 30-32‰, specimens mostly small, about 1cm in diameter. The species is typically found buried in sand but can occur among rocks where specimens tend to be smaller (Manuel, 1980). Marine species.

Turbellaria

Present, but not identified, in L. Aconeera and Furnace L.

Nemertea

Unidentified nemerteans were frequent in Drongawn L. and Lettermullen Pool and were also recorded in L. Murree and L. Tanaí.

Polychaeta

***Amphitrite edwardsi* (Quatrefages)**

Abundant among mussels at the inlet of Drongawn L. Marine species.

***Arenicola marina* agg.** Lugworm

Presence was generally detected by casts only and few specimens were collected, but all are believed to be *A. marina*. At nine of the 20 sites, especially in the north-west from North Clare to Mayo but also in Drongawn L. and Lady's Island L. Salinity range 10-37‰, and temporarily in 0-2‰. Known to tolerate reduced salinity.

***Capitella capitata* (Fabricius)**

Frequent in one region of Aughinish L. Marine species.

***Hediste diversicolor* (O. F. Müller)** Ragworm

Recorded at eight of the sites. Common at most of the more saline sites, salinity range 4-35‰. A common brackish and marine intertidal species.

***Janua pagenstecheri* (Quatrefages)**

Occasional specimens on stones and shells in Drongawn L. and Lettermullen Pool. Marine species.

***Lepidonotus squamatus* (L.)**

Occasional specimens in Aughinish L. Marine species.

***Platynereis dumerili* (Audouin and Milne Edwards)**

Frequent among mussels near the inlet in Drongawn L. Marine species.

***Pomatoceros triqueter* (L.)**

Occasional specimens in Drongawn L. and Aughinish L. Marine species.

***Spirorbis rupestris* Gee and Knight-Jones**

A few in Drongawn L., on rocks and shells. Marine species.

Other unidentified polychaetes were recorded in Drongawn L., Aughinish L. and L. Tanaí. Several polychaete species (*Platynereis*, *Amphitrite*, spirorbids) were found only in Drongawn, Aughinish or Lettermullen, reflecting the strong marine influence at these sites.

Clitellata

***Clitellio arenarius* O. F. Müller**

Occasional in L. Gill and L. Murree.

***Tubificoides benedii* (d'Udekem)**

Occasional in Lettermullen Pool. Marine-brackish species.

***T. heterochaeta* (Michaelsen)**

Identified, with some hesitation, from specimens in Cloonconeen Pool.

One other unidentified tubificid was recorded at L. Tanaí. Unidentified leeches and naidids were present in L. Gill.

Cirripedia

***Balanus balanus* (L.)**

A few on stones in Aughinish L. Marine species.

***Balanus improvisus* Darwin**

Abundant on rocks in Lady's Island L., a single specimen in Lettermullen Pool. A brackishwater species occurring frequently in estuaries and ports.

***Semibalanus balanoides* (L.)**

On rocks in Drongawn L. and Aughinish L. Marine species with some tolerance of reduced salinity.

***Verruca stroemia* (O. F. Müller)**

On the undersides of rocks and stones in Drongawn L. Marine species.

Cumacea

Unidentified cumaceans were recorded in Lettermullen Pool.

Tanaidacea

***Tanais dulongii* (Audouin)**

Three specimens in light-traps in Lettermullen Pool. Marine species.

Mysidacea

***Hemimysis lamornae* (Couch)** Midge shrimp

Several specimens in Drongawn L. Marine species.

***Leptomysis lingvura* (G. O. Sars)**

One specimen in Mill L. Marine species.

***Mysidopsis gibbosa* (G. O. Sars)**

Two specimens in Aughinish L. Marine species.

***Neomysis integer* (Leach)**

Widespread, and often very abundant, at all but five western poly-euhaline sites (Cloonconeen P., Aughinish L., Bridge L., Lettermullen P. and L.Tanaí) where it was replaced by *Praunus flexuosus*. Salinity range 0-26‰, exceptionally 30‰. A common species of the upper reaches of estuaries and in brackish, freshwater or hypersaline pools; rarely on the open coast. A useful indicator of marine influence in freshwaters. Said to need 20°C to reproduce, and to be better adapted to resist high temperatures and low salinities than other mysid species (Vlasblom and Elgershuizen, 1977). A possible lagoonal specialist in Ireland.

***Praunus neglectus* (G. O. Sars)**

One specimen in Aughinish L. Strictly marine and found in deeper water than *P. flexuosus*.

***P. flexuosus* (O. F. Müller)** Chameleon shrimp

Found at seven of the more marine sites, salinity range 25-40‰. Often common but rarely as abundant as *Neomysis*. Tolerant of salinity variations, but larvae less tolerant of high temperatures than *Neomysis* (Vlasblom and Elgershuizen, 1977) and therefore may be outcompeted by the latter in shallow, lagoonal habitats.

***Siriella jaltensis* Czerniavsky**

Three specimens in Lettermullen Pool. Marine species.

Isopoda

***Asellus* sp.**

At the northern end of Tacumshin L. in 0‰. Freshwater species.

***Eurydice pulchra* Leach**

A single specimen taken in Corragaun L. A species of exposed sandy beaches.

***Idotea baltica* (Pallas)**

A few specimens in Aughinish L. and Lettermullen P., and one in Durnesh L. Previously recorded from Lady's Island L. (Healy *et al.*, 1982). A common species in European lagoons and in the Baltic, but apparently only an occasional transient invader of Irish lagoons.

***I. chelipes* (Pallas)**

Frequent to common among vegetation in Lady's Island L., Lettermullen P., and L. Tanaí;

abundant in Bridge L., salinity range 11-37‰. A frequent lagoonal specialist in Britain.

***Jaera albifrons* Leach**

A few specimens in Furnace L. Marine species tolerating reduced salinity.

***J. forsmani* Bocquet**

A single male was identified from under stones in Drongawn L. in 28-30‰, where the species was possibly common but most individuals collected were females for which identification could not be confirmed. The least tolerant *Jaera* of reduced salinity. The only other Irish record of the species located is for L. Hyne, Co. Cork (Holmes, 1981).

***J. ischiosetosa* Forsman**

Common under stones in L. Murree and a few in Furnace L., salinity 10-22‰. The species is said to be very tolerant of reduced salinity and is locally common on most British coasts, but appears to occur only patchily in Ireland.

***J. nordmanni* Rathke**

Frequent-common under stones at water's edge at eight oligo-mesohaline sites in the south-west and west. Salinity range 0-22‰. Apparently absent from Co. Wexford.

Very tolerant of reduced salinity. A thriving population exists in L. Errul, Cape Clear, Co. Cork, where it appears to be the only brackish species in a freshwater lake receiving sea spray. In Britain it is found on south and west coasts only, locally common.

***Lekanesphaera hookeri* (Leach)**

Present at eight sites with a wide range of salinity, 1-34‰. Found patchily in lagoons and brackish ditches along most coasts of England except the south-east. The species sometimes occurs sympatrically with *L. rugicauda* (Bamber, 1997) which is principally a salt marsh species and is known to be capable of hybridizing with it. A lagoonal specialist.

***Ligia oceanica* (L.)** Sea slater

At the water's edge at seven sites. Marine supralittoral species.

Amphipoda

Specimens were identified by J. O'Brien and J. M. C. Holmes. Nomenclature and Irish distribution are according to Costello *et al.* (1989).

***Allomelita pellucida* (Sars)**

Recorded at the three sites in Co. Cork, and also in Furnace L.; salinity range 2-8‰.

The only previous Irish records are for L. Hyne and Glengariff in Co. Cork and Furnace L. A brackishwater species. According to Costello *et al.* (1989) the few records for this species may reflect the little attention that has been devoted to its habitat in Ireland, which appears to be amongst decaying leaves in sheltered fresh water connected to the sea at high tides. A possible lagoonal specialist.

***Ampithoe ramondii* Audouin**

Recorded only from Drongawn L. All records in Britain are in the south-west (Lincoln, 1979). Previously recorded in Cork and Mayo. Marine species.

***Caprella acanthifera* Leach**

Recorded in Drongawn L. and L. Tanaí, salinity 28-32‰. All British coasts, possibly more frequent in the north.

***Corophium volutator* (Pallas)**

Recorded at six sites from Kerry to Mayo, salinity range 10-30‰ (exceptionally 0‰). A common coastal species, usually in estuaries, but appears to be less frequent in lagoons in Ireland than in Britain (Smith and Laffoley, 1992).

***Dexamine spinosa* (Montagu)**

Taken at four euhaline sites in Co. Galway, salinity 34-37‰. Recorded from most parts of the Irish coast (Costello *et al.*, 1989).

***Echinogammarus marinus* (Leach)**

Taken only in L. Murree. Tolerates reduced salinities (Lincoln, 1979). Recorded from most parts of the Irish coast (Costello *et al.*, 1989).

***Erichthonius difformis* Milne Edwards**

Recorded only in Drongawn L. Up to and including the review of this genus (Myers and McGrath, 1984) there was only one positive record of *E. difformis* in Ireland (Kinsale, Co. Cork).

***Gammarus chevreuxi* Sexton**

A single specimen taken in Aughinish L. in 40‰, but extremely abundant, and the only gammarid recorded, in Durnesh L., salinity 0-5‰. Previously recorded from "N. E. Ireland, (rarely)" by Spooner in the Plymouth Marine Fauna (1957) and subsequently from Ireland by Pinkster (1978), but confirmation of these records is desirable (Costello *et al.*, 1989). In Britain

it is said to be locally common (Lincoln, 1979) and is regarded as a lagoonal specialist but was recorded only in one British lagoon during a recent national survey (Smith and Laffoley, 1992).

***G. duebeni* Liljeborg**

Recorded at 12 sites but not in Wexford or Donegal or several sites on the coast. Salinity range 0-30‰. The dominant freshwater amphipod in Ireland but a subspecies (*G. d. duebeni*) occurs in brackish water (Holmes, 1978; Costello *et al.*, 1989). Given the salinity range of the present records, it is possible that the present records include both subspecies. Recorded from a similar salinity range (1-35‰) in inland waters of the Outer Hebrides (Waterston *et al.*, 1979).

***G. locusta* (L.)**

Cloonconeen Pool and Aughinish L. A common coastal species in Ireland.

***G. ?salinus* Spooner**

Specimens from Tacumshin L., tentatively identified as this species but awaiting confirmation. Salinity 3-18‰. Previously recorded from Dublin Bay, Kenmare R., Galway Bay, Donegal Bay and L. Foyle (Costello *et al.*, 1989). A brackishwater species, usually in more saline conditions than *G. zaddachi*.

***G. zaddachi* Sexton**

Recorded at seven sites, well distributed around the coast, salinity range 0-34‰. A mainly brackishwater, north European species (Pinkster, 1978).

***Hyale* sp.**

Recorded only in L. Murree.

***Lembos longipes* Liljeborg**

Recorded in Drongawn L. and Furnace L., both deep sites with silled, tidal inlets. Previous records from Counties Down and Kerry, and Galway Bay (Costello *et al.*, 1989).

***Leptocheirus pilosus* Zaddach**

A few taken near the south end of Furnace L. in 0-10‰. A brackishwater species. The only other known Irish localities are the south side of Wexford Harbour (Costello *et al.*, 1989) and a brackish channel on the North Slob, Co. Wexford (Galvin, 1992).

***Melita palmata* (Montagu)**

Recorded at seven sites on west and south-west coasts, salinity 0-37‰. A species of marine and brackish waters tolerating a very wide salinity range (Lincoln, 1979). Recorded from most

parts of the Irish coast.

***Orchestia gammarellus* (Pallas)**

Recorded from the water's edge at 11 sites in 2-37‰, well distributed around the coast. The most widespread and abundant upper shore amphipod around Ireland (Costello *et al.*, 1989).

***Talitrus saltator* (Montagu)**

At Aughinish L. only. A common species of open coast strandline and dunes.

(*Gammarus insensibilis* Stock and *Corophium insidiosum* Crawford occur in lagoons in southern Britain where they are regarded as lagoonal specialists. A single specimen of the former was taken in L. Hyne (Kitching and Thain, 1983), which is not considered to be a lagoonal habitat. The latter has not been recorded for Ireland.)

Decapoda

***Carcinus maenas* (L.)** Shore crab, green crab

One of the most widespread and abundant species, found in sixteen sites. Salinity range 0-40‰, but not recorded in some of the more isolated lagoons i.e. Tacumshin L., Kilkeran L., L. Gill and L. Murree. *Carcinus* comprised 32% of the total number of individuals in fyke net catches. Both adults and juveniles are known to be tolerant of reduced salinity.

***Crangon crangon* (L.)** Common shrimp

Recorded at eight sites, including Furnace L., salinity range 1-40‰. A marine species of the shallow sublittoral with some tolerance of reduced salinity.

***Macropodium rostrata* (L.)** Long-legged spider crab

Several specimens recorded among algae, especially *Cystoclonium*, in Aughinish L. A marine species of the shallow sublittoral.

***Pagurus bernhardus* (L.)** Hermit crab

In Aughinish L. only. Marine species.

***Palaemon elegans* Rathke**

Recorded at six sites with tidal inlets along the west coast, salinity 6-37‰.

***P. longirostris* Milne Edwards**

One in Drongawn L. Considered to be an estuarine and brackishwater species. On south and east coasts only in Britain.

***P. serratus* (Pennant)** Common prawn

Recorded in five sites with tidal inlets scattered along the south-west and west coasts, salinity range 2-40‰. Marine species.

***Palaemonetes varians* (Leach)**

Recorded at all sites except L. Gill, Aughinish L., Lettermullen Pool and Roonah L., often extremely abundant, salinity range 0-34‰. Present in Lettermullen in 1990 when the salinity was 26‰ (BH). A brackishwater species occurring also in salt-marshes, ditches, and upper estuaries but considered in Britain to be a lagoonal specialist.

***Hippolyte varians* Leach** Chameleon prawn

Two specimens recorded in Aughinish L. Marine species.

***Thoralus cranchii* (Leach)**

A single specimen in Aughinish L. Marine species.

Arachnida

An unidentified spider taken in net sweeps in several lagoons deserves further investigation. Hydracarina were present at some sites.

Pycnogonida

A single, very small, unidentifiable specimen in Drongawn L.

Thysanura

***Petrobius* sp.**

Upper shore of Lissagriffin L. Supralittoral species, usually on rocks, probably overlooked at many other sites with rocky shores.

Ephemeroptera

***Cloeon dipterum* L.**

Recorded in Kilkeran L. and and Durnesh L., salinity 0-2‰. Freshwater species.

***C. simile* Eaton**

Recorded in L. Gill and Roonah L., salinity 0‰. Freshwater species.

***Procloeon bifidum* Bengtssen**

Recorded in L. Gill, salinity 0‰. Freshwater species.

Odonata

***Ischnura elegans* (Linden)**

Nymphs recorded in ten of the lower salinity sites, maximum salinity 18‰ in Tacumshin L. A common species of brackish lagoons but also widespread and abundant at freshwater sites and therefore not considered a lagoonal specialist.

Plecoptera

Small, unidentified nymphs present in Kilkeran L., L. Gill, Roonah L. and Durnesh L.

Trichoptera

No larvae were found, but empty cases were recorded at six sites.

Heteroptera

Nomenclature is according to Savage (1989) and all specimens were identified by M. C. D. Speight.

***Arctocorisa germari* (Fieber)**

One in L. Gill, one in Durnesh L. A freshwater species occurring at scattered sites in Ireland (Nelson, 1995).

***Callicorixa praeusta* (Fieber)**

Recorded in Lady's Island L., Tacumshin L., L. Gill, Roonah L. and Durnesh L., maximum salinity 18‰, and previously in Kilkeran L. by Galvin (1992). A widely distributed freshwater species favouring some degree of organic enrichment. The species is said to have a great facility for migration and is often the first species to colonize a new or temporary habitat (Southwood and Leston, 1959) and is therefore likely to occur spasmodically in lagoons.

***Corixa panzeri* (Fieber)**

Frequent and sometimes abundant at most of the lower salinity sites, and in low salinity areas of large lagoons: Lady's Island L., Tacumshin L., Kilkeran L., L. Gill., Roonah L., and Durnesh L., salinity 0-18‰.

A predominantly coastal, freshwater species in Britain and continental Europe (Nelson, 1995), sometimes in low salinities, but seldom abundant (Southwood and Leston, 1959). There are only two recent records from Northern Ireland, both from coastal sites (Nelson, 1995).

***C. punctata* (Illiger)**

Occasional in Tacumshin L. and L. Gill. A common freshwater species. Adults are sometimes

found in brackish water, but above 5‰ eggs fail to hatch (Southwood and Leston, 1959).

***Cymatia bonsdorffi* (Sahlberg)**

One specimen in Roonah L. A common species of lowland freshwaters.

***Gerris lacustris* L.**

One specimen in Furnace L. in 0-10‰. The commonest pondskater in Irish freshwaters (Nelson, 1995).

***G. odontogaster* (Zetterstedt)**

Several specimens in Tacumshin L. in 18‰. Present near the outfall of Durnesh Lake in 1996 (B. Nelson, pers. comm.). A common freshwater species in Ireland.

***G. thoracicus* Schummel**

One specimen in Tacumshin L. at 18‰. A common inhabitant of coastal ponds and saltmarshes in Ireland (Nelson, 1995). Not recorded during British lagoon surveys.

***Hesperocorixa linnaei* (Fieber)**

Found at only two sites: one specimen in Tacumshin L., relatively common in Durnesh L., salinity range 0-18‰. Scattered records throughout Ireland (Leston, 1958); in stagnant habitats with emergent vegetation. Can tolerate mild salinity but it is not known if the eggs are viable (Southwood and Leston, 1959).

***Hydrometra gracilenta* Horvath**

Three specimens were found in an earlier collection taken in Kilkeran L. in 1991 by Galvin (1992). This appears to be the first record of the species in Ireland. It is rare in England where, according to Macan (1965), it was confined to Barton and Sutton Broads, Norfolk and a New Forest locality, but has recently been discovered on Pevensey Levels in Sussex "amongst mixed marginal vegetation including sedges and rushes along a well-vegetated drainage ditch in grazing levels" (Kirby, 1992). Specimens are deposited in the National Museum of Ireland.

***H. stagnorum* L.** Water measurer

One specimen taken in Kilkeran L. and two in Furnace L., salinity 2-10‰. A common freshwater species.

***Nepa cinerea* L.**

One specimen in L. Gill in 5‰. Present near the outfall of Durnesh Lake in 1996 (B. Nelson, pers. comm.). A common freshwater species.

***Notonecta glauca* L.** Water boatman

Several specimens in Tacumshin L. and Kilkeran L., and one in a small pool adjoining Furnace L., salinity 2-18‰. A common freshwater species.

***N. viridis* Delcourt**

Common in Lady's Island L., Tacumshin L., Kilkeran L., and occasional in L. Donnell, salinity 2-18‰, and earlier in the year at the North Slob, Co. Wexford.

A rare brackishwater species in Ireland. According to Southwood and Leston (1959), it was recorded only for Wexford and North Kerry. It has since been recorded in Lady's Island L. (Healy *et al.*, 1982) and in Lady's Island L. and the North Slob by Galvin (1992). Considered by Halbert (1935) to be a Lusitanian species. Not recorded during a recent Northern Ireland survey (Nelson, 1995). In England it is found mainly in brackish water (but not from lagoons in recent surveys), but also inland. A possible lagoonal specialist in Ireland.

***Plea leachi* McGregor and Kirkaldy**

Recorded in Tacumshin L. only, where it was abundant in salinities up to 18‰, but is a very small species and could be overlooked. Abundant in a brackish pool near the Cull Inlet, Co. Wexford in 1991 (Galvin, 1992). Halbert (1935) recorded it (as *P. minutissima*) from L. Gill, Co. Kerry, and described it as widespread but local, usually in stagnant water near the coast. The species was not recorded during a recent survey in Northern Ireland (Nelson, 1995). A possible lagoonal specialist in Ireland.

***Sigara dorsalis* (Leach)**

One of the most abundant species in seven mainly oligohaline lagoons, but several specimens were collected in a light-trap near a freshwater inflow in Drongawn L. at a salinity of at least 10‰. A freshwater species considered by Halbert (1935) to be the commonest corixid in Ireland. Reported in one coastal lagoon in Britain (Smith and Laffoley, 1992).

***S. falleni* (Fieber)**

Recorded only in Durnesh L., salinity 0‰, where it was relatively common. A common species of lowland lakes but said to be a poor coloniser of new sites (Southwood and Leston, 1959).

***S. concinna* (Fieber)**

Only recorded in this survey on the south coast. Abundant in Lady's Island L. and Kilkeran

L., frequent in Tacumshin L., in salinities up to 18‰. Regarded by Southwood and Leston (1959) as rare in Ireland but recently recorded at 14 sites in Northern Ireland, only three of which were coastal (Nelson, 1995). One record for the west coast: a well, almost confluent with a brackish lagoon, on Inishmore, Co. Galway (Reynolds, 1985).

Although considered to be a lagoonal specialist in England, this species may be of limited use as an indicator of brackish conditions in Ireland.

***S. semistriata* (Fieber)**

One specimen recorded in Roonah L., 0‰. A freshwater species described by Southwood and Leston (1959) as fairly common and widely distributed in Ireland. Nelson (1995) adds a further record from Bunduff L., Co Sligo, a former lagoon which was freshwater in June 1996.

***S. stagnalis* (Leach)**

One of the most widespread and abundant species, recorded at nine sites in salinities 0-30‰, and in L. Murree by Lansbury (1965). A brackishwater species occurring in coastal situations throughout Britain but also at a few inland sites; not recorded for Ireland by Halbert (1935). Its osmoregulatory mechanism allows the species to live in waters from 5-18‰ but although it is often in found in waters with a higher salinity than this, it is unable to breed in them (Southwood and Leston, 1959). A lagoonal specialist.

Sigara selecta (Fieber) is listed as a lagoonal specialist for Britain (Barnes, 1989) and can tolerate even higher salinities than *S. stagnalis*, but there is only one record for Ireland, from brackish pools at Ventry on the Dingle Peninsula where *S. stagnalis* also occurs, but the two species were segregated (McCarthy and Walton, 1980). *Corixa affinis* Leach and *S. lateralis* (Leach) are both listed by Southwood and Leston (1959) as occurring in at least slightly brackish water but neither was recorded at any of the sites covered by this survey. However, *Corixa affinis* was present in a karstic lagoon on Inishmore, Co. Galway (Reynolds, 1985), and *S. lateralis* was recorded at four brackishwater sites in Northern Ireland (Nelson, 1995).

Coleoptera

Many of the following aquatic species were collected from shore habitats using various methods (see Good and Butler, this volume). All specimens were identified by G. N. Foster. Nomenclature is according to Anderson *et al.* (1997). Species regarded as scarce in Britain, but not falling within Red Data Book categories, are listed by Hyman and Parsons (1992) as either

Notable A (thought to occur in 30 or fewer 10km squares of the national grid of Great Britain, or, for less well-recorded groups, within seven or fewer vice-counties), or Notable B (thought to occur in 31-100 10km squares, or 8-20 vice-counties).

***Agabus conspersus* (Marsham)**

This lagoonal specialist was recorded in Lady's Island L. by Healy (1997). Pre-1950 records exist for most coastal counties in the east and south and from Co. Clare, but the species appears to have become rare. It was not found during the recent survey in Northern Ireland and there are only two other recent Irish records: from a salt marsh in Co. Meath, and at Dundalk Harbour, Co. Louth (Nelson *et al.*, 1997).

***A. montanus* (Stephens) nec. *A. melanocornis* Zimmermann**

One tentative identification from a pitfall-trap at Roonah L.

***A. nebulosus* (Förster)**

One specimen from L. Murree in a limestone fissure, salinity 13‰. A typical pond species found in a range of habitats including brackish sites. A rapid colonizer of artificial sites (Nelson *et al.*, 1997).

***Anacaena globulus* (Paykull)**

One specimen in a pitfall-trap at Durnesh L. and one in an S-vac sample on the shore at Farranamanagh L.

***A. lutescens* (Stephens)**

One female specimen in Kilkeran L., 1-2‰.

***Cercyon littoralis* (Gyllenhal)**

One specimen in a pitfall-trap at Bridge L. and one collected by S-vac at Mill L. A strandline species capable of withstanding high salinities. Only two recent 10km square records in Ireland (Foster *et al.*, 1992).

***C. marinus* Thomson**

One specimen in Kilkeran L. 1-2‰, and two other *Cercyon* sp. too teneral for identification. A rather rare species in Ireland (Foster *et al.*, 1992).

***C. sternalis* (Sharp)**

One male specimen under an algal mat on the sandbank of the outflow channel at the north end of L. Gill, near Trench Bridge. There are only three previous Irish records: Kerry

(Bullock, 1935), and more recently L. Gash, Co. Clare and Portumna, Co. Galway (Owen, 1997). Listed as Notable B by Hyman and Parsons (1992).

***Colymbetes fuscus* (L.)**

One specimen among marginal *Juncus maritimus* at Lady's Island L., and three in a deep channel in Tacumshin L., 3-5‰. A stagnant water species, common but with gaps in the records.

***Dryops luridus* (Erichson)**

One among stones at the base of the barrier at L. Donnell.

***Elmis aenea* (Müller)**

One in Roonah L., 0‰.

***Enochrus bicolor* (Fabricius)**

Found at six sites of varying salinity 4-35‰, often very abundant (Lady's Island L., Cloonconeen P., L. Murree, Bridge L., Lettermullen P., L. Tanaí). Previously recorded in Lady's Island L. by Healy (1997). For some time regarded as a subspecies of *E. maritimus*. Appears to be limited to parts of the coast of Britain and Ireland and confined to brackish water where it can be common. Recorded from only one 10km square in Ireland by Foster *et al.* (1992). A lagoonal specialist. Listed as Notable B in Hyman and Parsons (1992).

***E. halophilus* Bedel**

Two male specimens in Tacumshin L. in 8‰. Recorded in L. Murree by Pybus and Pybus (1980). No other recent Irish records (Foster *et al.*, 1992; Nelson *et al.*, 1997). A lagoonal specialist in Britain. Listed as Notable A in Hyman and Parsons (1992).

***E. testaceus* (Fabricius)**

One specimen at the north end of L. Gill near the tidal channel, 2‰.

***Graptodytes granularis* (L.)**

One male in a pitfall at Lady's Island L. and three specimens in pitfalls at Durnesh L. In Britain this species is now only common in East Anglia, having declined in much of its range (Foster, 1983), but it was recorded from 16 10km squares in Northern Ireland (Foster *et al.*, 1992). Listed as Notable B in Hyman and Parsons (1992).

***Gyrinus aeratus* Stephens**

One female in Durnesh L., 0‰. A species of still water, not halophilous. Rather rare and

listed as Notable B in Hyman and Parsons (1992).

***G. caspius* Ménétriés**

Nine in Tacumshin L., two in Kilkeran L., one in L. Donnell (pitfall) and one in L. Aconeera, salinity range 2-13‰. In Britain its distribution is almost exclusively coastal (Foster, 1985) but in Northern Ireland it occurs widely inland (Nelson *et al.*, 1997).

***Haliplus confinis* Stephens**

Recorded only in L. Gill, where it was very common, especially in light-traps (0‰). A freshwater species. The larvae feed on charophytes (Nelson *et al.*, 1997).

***H. flavicollis* Sturm**

One specimen in L. Donnell (5‰). Sometimes found in brackish pools ("up to 238 grains/gallon") but this is not its normal habitat (Balfour-Browne, 1950).

***H. fulvus* (Fabricius)**

Six specimens collected from light-traps in L. Gill (0‰). A relatively common species which tends to avoid brackish water.

***H. lineatocollis* Marsham**

Two in Farranamanagh L., one in a light-trap in L. Gill, two in a light-trap in L. Donnell, and three in light traps in Roonah L., salinity range 0-6‰. A common freshwater species in Ireland (Foster *et al.*, 1992).

***H. ruficollis* De Geer**

Two specimens in L. Donnell (one in a light-trap) and two males in Furnace L., salinity range 0-10‰. A stagnant water species, less common in peaty or brackish water.

***H. wehnckei* Gerhardt**

Five in light-traps in L. Donnell (2-6‰), 28 in Roonah L. (0‰, mostly in light-traps) and three in light-traps in Drongawn at a salinity of 30‰. A clear water species, widespread in Britain and Ireland.

***Helophorus brevipalpis* Bedel**

Twenty in Kilkeran L. (1‰), three in L. Donnell (2-6‰), and one in a pitfall at Durnesh L. A common species which frequently flies and sometimes swarms.

***Hydrobius fuscipes* L.**

Only one specimen collected from the north end of Tacumshin L. in 0‰. A detritus- and

brackish-pond species.

***Hydroporus angustatus* Sturm**

Seven in a pitfall at Kilkeran L. and two in pitfalls at Durnesh L. A relatively common species, especially in the east of Ireland, but local (Balfour-Browne, 1950).

***H. gyllenhalii* (Schišdte)**

Three in pitfalls among *Shoenoplectus* at Durnesh L. Common in most districts of Ireland (Balfour-Browne, 1950).

***H. incognitus* Sharp**

One male in a pitfall among *Schoenoplectus* at Durnesh L.

***H. memnonius* Nicolai**

Recorded at three shore sites in the northwest: Roonah L (in 0‰ and 1 in a pitfall), Furnace L. (4 in pitfalls), Durnesh L. (3 in pitfalls among *Schoenoplectus*). Widespread in Ireland, especially in coastal counties, occasionally in brackish pools, but generally not common.

***H. palustris* (L.)**

Six in pitfalls at Kilkeran L. and 18 at Durnesh L. in 0‰. One of the commonest Hydropori found in freshwater marshes, ditches and ponds.

***H. planus* (Fabricius)**

One specimen on the shore at Tacumshin L. and in Durnesh L. (0‰). Widespread and relatively common in both fresh and brackish waters.

***H. pubescens* (Gyllenhal)**

Two in Durnesh L. in 0‰. One of the commonest Irish water beetles, equally at home in peaty, brackish or fresh water.

***H. striola* (Gyllenhal)**

Four in pitfall-traps at Durnesh L. Widespread and common, primarily in fens.

***H. umbrosus* (Gyllenhal)**

Five in pitfall-traps among *Schoenoplectus* at Durnesh L. A relatively common species.

***Hygrotus impressopunctatus* (Schaller)**

One specimen in Tacumshin L. (8‰) and three at Durnesh L. (one in a light-trap, 0‰, and 2 in pitfalls). It appears to be common in coastal areas and tolerates brackish conditions.

***H. inaequalis* (Fabricius)**

One in Tacumshin L., eight in L. Gill, (some in light-traps), two in light-traps in L. Donnell, and 19, mostly in pitfalls, at Durnesh L., salinity range 0-5‰. A widespread and often abundant freshwater species.

***Ilybius fuliginosus* (Fabricius)**

One in a light-trap in L. Gill, one in Roonah L., salinity range 0-2‰. Widespread in a wide range of habitats including brackish water.

***Laccobius biguttatus* Gerhardt**

Three in L. Gill (in terrestrial weed).

***L. minutus* (L.)**

Two in light-traps in L. Gill and six in Roonah L., 0‰ at both sites.

***Laccophilus minutus* (L.)**

One in the south channel of Tacumshin L., one in a light-trap in L. Gill, two specimens in Durnesh L. (one in a light-trap), salinity range 0-5‰.

***Megasternum obscurum* (Marsham)**

One in a pitfall at Furnace L. Rather rare in Ireland (Foster *et al.*, 1992).

***Nebrioporus depressus* (Fabricius)**

Two in a light-trap at L. Gill, ten in light-traps in Roonah L., and five in a light-trap in Furnace L., salinity range 0-10‰.

***Noterus clavicornis* (De Geer)**

One in Lady's Island L., nine in Tacumshin L., two in L. Donnell, and two in Durnesh L., salinity range 0-10‰. More generally distributed in Ireland than in Britain.

***Ochthebius marinus* Paykull**

Not taken during the survey, but previously recorded in Lady's Island L. in 1978 (Healy *et al.* (1982) and 1991 (Healy, 1997). Recorded from only one 10km square in Ireland by Foster *et al.*, (1992). A lagoonal specialist regarded as scarce in Britain. Listed as Notable B by Hyman and Parsons (1992).

***Rhantus frontalis* (Marsham)**

Four in Tacumshin (two in light-traps), salinity 3-18‰. Somewhat rare and local in Ireland. Listed as Notable B in Hyman and Parsons (1992).

Diptera

Chironomidae

Unidentified chironomid larvae and pupae were recorded at all sites except Aughinish L., but in relatively low numbers, except in Durnesh L. where they were extremely abundant, especially in light-traps.

Tipulidae

Occasional tipulid larvae were found in L. Gill and Corragaun L.

Ephydridae

Few larvae or pupae were recorded. Occasional specimens were found in Lady's Island L. and L. Donnell.

Culicidae

Occasional larvae in L. Donnell and L. Murree.

Syrphidae

A few larvae in L. Murree.

Polyplacophora

***Lepidochitona cinereus* (L.)**

Present in Drongawn L., Aughinish L., Lettermullen Pool, and a single small specimen on floating *Fucus* in L. Gill. Marine species.

Prosobranchia

***Bittium reticulatum* (da Costa)** Needle whelk

Common on algae in Drongawn (height reaching 19 mm) and on algae and *Zostera* in Lettermullen Pool, occasional in Aughinish L. A marine species particularly associated with *Zostera*.

***Gibbula umbilicalis* (da Costa)** Flat top shell

Occasional in Drongawn L. and Lettermullen Pool, frequent but localised in Aughinish L. Marine intertidal species.

***Hinia incrassata* (Ström)** Thick lipped dog whelk

A few in Lettermullen Pool. A marine species of rocky shores and the shallow sublittoral.

***Hydrobia ulvae* (Pennant)** Laver spire shell

Recorded in lagoons with frequent incursions of seawater: Lissagriffin L., Cloonconeen Pool,

L. Tanaí and Mill L., salinity range 14-34‰. A common species of estuaries and open coasts.

***H. ventrosa* (Montagu)**

Seven sites along the south and west coasts, mainly mesohaline lagoons, salinity range 10-37‰. Very common in L. Murree. Present in Lettermullen Pool in 1990 (BH). Occurs in more brackish waters than the previous species, preferring isolated lagoons and ditches to the open coast. A lagoonal specialist.

(*Hydrobia neglecta* Muus, which is a lagoonal specialist, is known to occur in Ireland (Seaward, 1982) but was not found.)

***Littorina littorea* (L.)** Common periwinkle

Very common in Aughinish L.; also recorded in Drongawn Bridge L., and Lettermullen Pool and one specimen in Cloonconeen Pool. Intertidal species, tolerant of reduced salinity.

***L. obtusata* (L.)** Flat periwinkle

Present in Drongawn L. and Mill L. An intertidal species associated with fucoid algae. Some tolerance of reduced salinity.

***L. saxatilis* (Olivi)** Rough periwinkle

Occasional in Drongawn L. and Aughinish L. Common on the north shore of L. Murree and in nearby tidal springs and seeps in grassland. Upper shore species.

***L. "tenebrosa"* (Montagu)** Lagoon periwinkle

The status of this taxon is still under dispute. Reid (1996) considers it to be no more than a variety of *L. saxatilis*. It is, however, morphologically and ecologically distinct and is listed as a lagoonal specialist for Britain. Barnes (1993) has suggested that it be recognised as a distinct variety inhabiting lagoons and has suggested the name *L. saxatilis* var. *lagunae*, but as no type specimen has been designated, this name cannot yet be considered valid (see also Bamber, 1997).

Very abundant on weed in Lettermullen Pool; common on weed and rocks, sometimes above water level, in L. Tanaí, salinity 14-37‰. The only *Littorina* in the pool near L. Murree in 1997, but not present in the lagoon itself (E. Gosling, pers. comm.). Recorded on the North Slob during the earlier part of the survey and by Galvin (1992). These are the only known Irish localities.

***Nucella lapillus* (L.)** Dog whelk

Single specimen recorded in Lettermullen Pool. Avoids low salinity.

***Onoba semicostata* (Montagu)**

Occasional in Drongawn L. and L. Tanaí. A rocky shore species extending into the Baltic.

***O. aculeus* (Gould)**

Recorded in 1997 in Lettermullen Pool (S. Smith, pers. comm.). Listed as a lagoonal specialist for Britain (Barnes, 1989) although Graham (1988) gives its habitat as similar to that of *O. semicostata* but more frequent in brackish water. Recorded from several sites in Mulroy Bay, mainly intertidally (Nunn, 1996).

Patella ulyssiponensis* Gmelin syn. *P. aspera China limpet

A few in Aughinish L. A common species of exposed shores, avoiding extreme shelter and low salinities.

***P. vulgata* L.** Common limpet

Recorded in Drongawn L. and Lettermullen P. Tolerant of low salinity but generally confined to habitats >25‰.

***Potamopyrgus antipodarum* (Gray)** Jenkins' spire shell

Present, and usually abundant, at all but the more saline sites i.e. Drongawn L., Cloonconeen Pool, Aughinish L., Bridge L., Lettermullen Pool and L. Tanaí. Common in freshwater and, according to Graham (1988), in brackish water <16‰, but the salinity range in the present survey was 0-18‰.

***Rissoa inconspicua* Alder**

One in Lettermullen Pool in 1997 (S. Smith, pers. comm.).

***R. parva* (da Costa)**

One in Lettermullen Pool in 1997 (S. Smith, pers. comm.).

***R. parva* var. *interrupta* (da Costa, *partim*)**

Common in Lettermullen Pool.

***Rissotomia membranacea* (J. Adams)**

Abundant on algae in Drongawn L. and Lettermullen P., frequent in L. Tanaí, salinity 14-37‰. The species has been divided into varieties by some authors on the basis of shell characters and different degrees of tolerance of reduced salinity, but the above populations did

not fit easily into any of the varieties listed by Hayward and Ryland (1995).

***Skeneopsis planorbis* (Fabricius)**

Common in Lettermullen Pool. Marine species tolerating brackish conditions. Reported from salinity as low as 20‰ in the Outer Hebrides (Waterston *et al.*, 1979).

Pulmonata

Nomenclature follows Kerney (1979).

***Anisus leucostoma* (Millet)**

Occasional in Tacumshin L. Freshwater species.

***Aplexa hypnorum* (L.)**

Occasional in Roonah L. Freshwater species.

***Hippeutis complanatus* (L.)**

Occasional in L. Gill, Roonah L. and Durnesh L., salinity 0-2‰. Freshwater species.

***Lymnaea palustris* (Müller)** Marsh snail

Occasional in Tacumshin L. and Roonah L., maximum salinity 5‰. Freshwater species.

***L. peregra* (Müller)** Wandering snail

Frequent in Tacumshin L. and Roonah L., occasional in L. Gill and Durnesh L., maximum salinity 5‰. Freshwater species. Found in mildly brackish water in the Outer Hebrides, salinity 3‰ (Waterston *et al.*, 1979).

***Planorbarius corneus* (L.)**

Occasional in Durnesh L. in 0‰. Freshwater species.

Opisthobranchia

***Acanthodoris pilosa* (Abilgaard)**

One specimen in Lettermullen Pool in 1997 (BH). Marine species.

***Aeolidia papillosa* (L.)**

Occasional in Aughinish L. Marine species.

***Akera bullata* (Müller)**

Very common in L. Tanaí in June-August 1996, absent in April 1997. Reported as occurring in and on soft, fine mud, in sheltered bays formerly favoured by *Zostera* (Hayward and Ryland, 1995). In L. Tanaí, *Zostera* was present but the substrate was peat.

***Elysia viridis* (Montagu)**

Among algae in Drongawn L., Aughinish L. and Lettermullen Pool. Marine species.

***Limapontia depressa* (Alder and Hancock)**

Occasional in Bridge L. among *Chaetomorpha*, salinity 37‰. Marine-brackishwater species, usually on saltmarshes where it feeds on *Vaucheria*.

***Scaphander lignaris* (L.)**

Common in Drongawn in July-September 1996, absent in September 1997. Marine species.

Bivalvia

***Abra* sp.**

A single, small specimen recorded in Furnace L.

***Anomia* sp.**

Small specimens on the underside of rocks in Drongawn L.

***Cerastoderma edule* (L.)** Common cockle

A few large specimens in Aughinish L. Marine-estuarine species, tolerant of salinities as low as 10‰ (Hayward and Ryland, 1995).

***C. glaucum* (Poiret)** Lagoon cockle

At seven sites: Drongawn L., Cloonconeen P., and five of the six sites in Co. Galway, salinity range 2-34‰. Previously recorded in Lady's Island L. (Boyden and Russell, 1972; Healy *et al.*, 1982), Tacumshin L. (Boyden and Russell, 1972; BH), and at several sites in Cork, Clare and Galway, including Toormore, Co. Cork, Aughinish L., and Salt Lake, Co. Galway (Boyden and Russell, 1972). Adult specimens were found during the early part of the survey in the first week of July, 1996 at three sites in Co. Cork (White's Marsh and Beamish's Lagoon near Clonakilty, and Toormore, near Schull); all were large specimens but all were dead or dying from unknown causes.

Generally found in brackish water, but overlapping the distribution of *C. edule*. A lagoonal specialist.

***Chlamys varia* (L.)** Variegated scallop

Occasional specimens under rocks in Drongawn L. Marine species.

***Modiolarca tumida* (Hanley)** Marbled crenella

A few in Aughinish L. Marine species.

***Musculus discors* (L.)** Green crenella

A few in L. Tanaí, salinity 28-34‰. Marine species.

***Mya arenaria* (L.)** Sand gaper

Small specimens found in sandy areas of L. Aconeera in 10‰. Marine-brackishwater species. Formerly present in Lady's Island L. (Healy *et al.*, 1982).

***Mytilus edulis* (L.)** Common mussel

Often abundant at sites with a strong tidal influence: Drongawn L., Aughinish L., Lettermullen Pool, L. Tanaí and at the inlet of Furnace L., salinity 10-40‰.

***Ostrea edulis* L.** Flat oyster

Large specimens found in Drongawn L. and Aughinish L., salinity 26-38‰.

***Parvicardium ovale* (Sowerby)**

A single specimen in Drongawn L. Marine species.

***Pisidium* sp.**

Frequent in L. Gill. Freshwater species.

***Sphaerium* sp.**

Frequent in L. Gill. Freshwater species.

***Venerupis* sp.**

Small unidentified specimen in Drongawn L., shells only in Aughinish L.

Bryozoa

***Alcyonidium gelatinosum* (L.)**

On algae in Aughinish L. Marine species.

***Bowerbankia gracilis* Leidy**

Occasional in Drongawn L., Aughinish L., and Lettermullen Pool. Marine species with some tolerance of brackish conditions. Reported from brackish waters with a salinity 14.5-30‰ in the Outer Hebrides (Waterston *et al.*, 1979).

***Conopeum seurati* (Canu)**

Common on algae, stones and rocks in Lady's Island L., Lettermullen P., L. Tanaí, Aconeera L., Mill L. and Furnace L., salinity 4-35‰. A lagoonal specialist which can withstand salinities as low as 1‰. The species is not listed in a review of Irish marine Bryozoa (Wyse Jackson, 1991) thus these may be the only recorded Irish localities.

***Cryptosula pallasiana* Moll**

Common on algae, stones and shells in Drongawn L. and Aughinish L. and in a number of other high salinity lagoon-like systems visited during the early part of the survey, especially in Co. Cork. A common species of open coast shores, but capable of living in brackish water (Hayward, pers. comm.).

***Flustrellidra hispida* (Fabricius)**

On fucoids near the inlet in Mill L. Marine species.

***Fredericella sultana* (Blumenbach)**

Tentative identification. A few colonies on sedge rhizomes in Kilkeran L. Freshwater species.

***Plumatella repens* (L.)**

Occasional colonies found in Kilkeran L., Lissagriffin L., L. Gill and Roonah L. Freshwater species.

***Walkeria uva* (L.)**

Occasional on algae in Lettermullen Pool.

Echinodermata

***Amphipholis squamata* Delle Chiaje**

Under rocks in Drongawn L., Aughinish L., and Lettermullen Pool. A marine species capable of withstanding some reduction in salinity. Reported from a polder drainage channel adjacent to the Ballyteige dunes, Co. Wexford (Galvin, 1992).

***Asterias rubens* L.** Common starfish

Occasional in Drongawn L. Marine species.

***Luidia ciliaris* (Philippi)**

One specimen in Lettermullen Pool. Common on the open coast in the region.

***Paracentrotus lividus* (Lamarck)** Purple sea urchin

One specimen in Lettermullen Pool. Common on the open coast in the region.

Tunicata

***Ciona intestinalis* (L.)**

Common in L. Tanaí. Marine species.

***Ascidiella aspersa* (O. F. Müller)**

Frequent to common in Drongawn L., Aughinish L., and Lettermullen Pool. Together with

the following species, it was common at several other euhaline lagoons visited, sometimes attached to peat. Marine species.

***A. scabra* (O. F. Müller)**

Frequent to common in Aughinish L., Lettermullen Pool, L. Tanaí, and Mill L. (see above). Marine species.

***Botryllus schlosseri* (Pallas)**

Occasional on fucoids in Aughinish L. and Lettermullen Pool. Marine species.

***Clavelina lepadiformis* (O. F. Müller)**

Occasional in Drongawn L., Aughinish L., Lettermullen Pool, and L. Tanaí. Marine species.

***Dendrodoa grossularia* (Van Beneden)**

Small colonies in Drongawn L. Marine species.

***Diplosoma listerianum* (Milne Edwards)**

Occasional colonies in Aughinish L. Marine species.

Teleostei

A total of 21 species of fish was recorded, of which 14 were caught in fyke nets, including six trout (*Salmo trutta*) and one bass (*Dicentrarchus labrax*). The remaining seven species were taken in sweep nets or light traps. Eels comprised 51% of the total number of individual fish caught, flounder 32% and mullet 9.8%; the remaining 7.2% was made up of 11 fish species.

***Anguilla anguilla* (L.)** Eel

At all sites where fyke nets were used except Lettermullen Pool; not recorded at Tacumshin L. or Bridge L. where fyke nets could not be used. Widespread and, at certain sites (e.g. L. Gill), very numerous.

***Atherina presbyter* (Cuvier)** Sand smelt

Shoals of juveniles recorded in Drongawn L. Known to occur inshore, including estuaries, particularly on south and west coasts.

***Ciliata mustela* (L.)** Five-bearded rockling

A single specimen in a fyke net in Aughinish L.

***Conger conger* (L.)** Conger eel

A single specimen in a fyke net, about 1m in length, in Lettermullen Pool. Marine-estuarine species, sometimes found in brackish water (Kennedy, 1954).

***Crenilabrus melops* (L.)** Corkwing wrasse

Seven in fyke nets in Drongawn L.

***Ctenolabrus rupestris* (L.)** Goldsinny

One in a fyke net in Lettermullen Pool.

***Dicentrarchus labrax* (L.)** Bass

A single juvenile (20 cm) in a fyke net near the river inlet in L. Donnell, salinity 3-4‰.

***Gasterosteus aculeatus* L.** Three-spined stickleback

At all sites except Aughinish L., ranging from freshwater through brackish to seawater. The most widespread and abundant species recorded. Often taken in large numbers in light- traps.

***Gobius niger* L.** Black goby

One large specimen in a fyke net in Drongawn L.

***Labrus bergylta* Ascanius** Ballan wrasse

One in a fyke net in Mill. L., salinity 31‰.

***Molva molva* (L.)** Ling

A single specimen (40cm) in a fyke net in Lettermullen Pool.

Mugilidae Grey mullet

All specimens are assumed to be *Chelon labrosus* Risso (thick-lipped) but only the largest were positively identified. Taken in fyke nets at eight sites. Juveniles were particularly susceptible to gill-netting in the 16mm mesh leader net.

***Pleuronectes flesus* (L.)** Flounder

Recorded at 13 sites. Mostly juveniles, which were abundant, but specimens up to 40cm were taken in fyke nets, salinity 0-30‰.

***Pollachius pollachius* (L.)** Pollack

Taken in fyke nets in Lady's Island L. (3), Aughinish L. (6), and Lettermullen Pool (4), salinity 26-40‰.

***Pomatoschistus microps* (Krøyer)** Common goby

Recorded at 13 sites, often abundant, salinity 2-40‰.

***Pungitius pungitius* (L.)** Nine- or ten-spined stickleback

A single specimen in Tacumshin L. in 3-5‰. Also taken previously in Lady's Island L. (Healy *et al.*, 1982). Listed in the Irish Red Data Book as "a near threatened species needing to

be closely monitored" (Whilde, 1993). Freshwater species.

***Salmo trutta* L.** Trout

Taken in fyke nets in L. Gill (5) and Durnesh L. (1), salinity 0-2‰.

***Spinachia spinachia* (L.)** Fifteen-spined stickleback

A single specimen in Lady's Island L.

***Sprattus sprattus* (L.)** Sprat

A single large specimen (15cm) in a fyke net in Lady's Island L., salinity 4-15‰.

***Syngnathus acus* L.** Greater pipe fish

A single specimen in Lady's Island L., salinity 26‰.

***S. typhle* L.** Deep-nosed pipe fish

A single specimen in L. Tanaí, salinity 28-32‰. A somewhat rare species (Douglas, 1989).

Discussion

Ireland possesses a wide range of lagoon types, many of which are in a relatively natural state. Of the 56 sites identified as lagoons or saline lakes during the inventory, 19 were sedimentary lagoons, 3 were rock lagoons, 14 were natural saline lakes and 20 were artificial saline lakes (Healy and Oliver, this volume). The list is incomplete as insufficient time was available to visit and sample all potential sites. Some of the geomorphological types are believed to be limited to Ireland and Scotland and are therefore rated highly for their conservation value within the EU (see Healy and Oliver, this volume). They tend to be larger than those identified in England where few of the 176 sampled were larger than 10ha and over 25% were < 1ha (Smith and Laffoley, 1992). Of the 20 sites selected for more intensive sampling, size varied from a little under 1ha (Lettermullen) to 450ha (Lady's Island and Tacumshin) with a mean area of 73ha (Table 1). Lagoons in Northern Ireland cover a total of 41ha, only one of which is natural (unpublished reports). The majority of lagoons investigated in England were less than 4ha (Bamber *et al.*, 1992) and the total area of 166 English lagoons is estimated to be only around 1300ha (Bamber, 1997) while in Scotland and the Inner Hebrides the estimated area of 33 lagoons is only 300ha (Covey *et al.*, 1998), compared with a total of approximately 1465ha for the 20 lagoons reported here, and a probable total for the country of about around 3000ha. This important resource in the Republic had not previously been

investigated.

Lagoon fauna

The number of taxa recorded is 248 including 17 Annelida, 51 Crustacea, 77 Insecta, 47 Mollusca, and 21 fish. Only one new Irish record is reported (*Hydrometra gracilenta*), but a number of the species are believed to be rare in Ireland although for some groups the scarcity of records may be due to under-recording. Species which probably are rare include *Jaera forsmani*, *Gammarus chevreuxi*, *Erichthonius difformis*, *Lembos longipes*, *Leptocheirus pilosus*, *Notonecta viridis*, *Sigara concinna*, *Agabus conspersus*, *Enochrus halophilus*, *Graptodytes granularis*, *Gyrinus aeratus*, *Ochthebius marinus*, *Rhantus frontalis* and *Littorina "tenebrosa"*. *Cordylophora caspia* and *Laomedea angulata* may be under-recorded.

A comparison between a list of the most commonly occurring species in Irish lagoons (Table 4) and those recorded in a directory of 176 lagoon-like systems sampled in England (Smith and Laffoley, 1992) shows that certain species appear to be much less frequent in Ireland, particularly *Hydrobia ventrosa*, *Idotea chelipes* and *Corophium volutator*, while more annelid species have been recorded in English lagoons. Species apparently more frequent in Ireland are *Neomysis integer*, *Potamopyrgus antipodarum*, *Jaera* spp, *Anguilla anguilla*, *Gasterosteus aculeatus* and *Pleuronectes flesus*. Many more insects and fish were recorded than in Britain but this may be due partly to under-recording during the British survey and partly to differences in methodology. No trapping methods appear to have been used in Britain and few aquatic insects were recorded, but Sheader and Sheader (1989) admit that in the majority of surveys of individual sites insects were ignored so their actual frequency is unknown. Only four species of beetle were identified from 166 sites in Britain (Bamber *et al.*, 1992). Some beetles were only taken in pitfall-traps during this survey and submerged light-traps may have attracted some species which are not normally present in lagoon waters, but all of the heteropterans, and 28 out of 45 beetles, were taken, somewhere, in net-sweeps. It seems probable, therefore, that insects are genuinely more frequent in Irish lagoons, perhaps because the milder winter climate enables them to overwinter more successfully and hypersaline conditions may be relatively rare (Foster, pers. comm.). Insects were relatively infrequent in *Ruppia* communities in The Netherlands and Finland where winters are more severe (Verhoeven, 1980). Eleven of the 21 species of fish recorded were only taken in fyke nets, presumably not used in the English

surveys.

Species occurrence and environmental factors

Isolation and variation in environmental conditions result in species presence in lagoons tending to vary temporally and spatially both within and between sites. Only a small number of species occurred regularly in a high proportion of the sites sampled, and most of these have wide tolerances. The small number of sites investigated, and the broad range of conditions, make classification of habitats difficult, and no attempt is made to designate suites of species which are characteristic of given sets of environmental features, as proposed by Covey and Thorpe (1994) for Scottish sites. It is the experience of some other workers (e.g. Verhoeven, 1980; Barnes, 1989) that faunal assemblages do not generally appear to be directly related to salinity nor to any historical, topographic or biotic factors, probably because the element of chance in dispersal and colonization processes is important and the liability to extinction unpredictable (Verhoeven, 1980; Barnes, 1987; Bamber *et al.*, 1992). The time lag in response of the community to rapid environmental changes, and the different reponse rates of the species, may also contribute to the lack of relationship (Healy, 1997).

Despite the above limitations, certain species or groups appear to be associated with aspects of the more conspicuous features of the environment, notably salinity, physical properties of the substrate, and vegetation. Further investigations are needed to clarify the ecological limits and preferences of lagoonal species in Ireland.

Species richness

Characteristically, all brackish waters are poor in species compared with marine or freshwater systems. In general, the concept of the "horohalinicum" (Remane, 1934), a critical salinity of about 5-8‰ at which a minimum number of species occurs, applies to lagoonal faunas, although its validity is sometimes disputed e.g. Deaton and Greenberg (1986). Results of this survey based on only 20 sites suggest that three main factors determine species richness: salinity regime, habitat diversity and size of the water body. The number of species at each site ranged from 14 at Cloonconeen to 70 at Drongawn (Table 3). Highest numbers of species were found in those sites with highest salinity (>30‰) indicating frequent incursions of seawater and easy access for colonists from the sea, *together with* an abundance of rocky substrates for the attachment of sessile species (i.e. Drongawn L., Aughinish L., Lettermullen Pool).

On the other hand, the number of species also tended to be high at very low salinity (5‰ or less) where freshwater groups, especially insects, were diverse (Tacumshin L., Kilkeran L., L. Gill, and Durnesh L.). Aquatic insects, chiefly aquatic Coleoptera and Heteroptera, were recorded at all but one site (Aughinish L.). Heteropterans were present at 11 of the 20 sites sampled, and aquatic beetles were present in all but three, with a total of 45 species. A total of 17 species of aquatic beetle was identified from L. Durnesh alone. This is in sharp contrast to British lagoons where insects other than chironomid larvae appear to be relatively infrequent. In a survey of English lagoons and saline "ponds" in which 176 were sampled for fauna, Coleoptera (none identified to species) were recorded at only 21 sites and Heteroptera at 28 (Smith and Laffoley, 1992).

Lagoonal specialists

"Lagoonal specialists" are distinctly more characteristic of lagoon-like habitats than of freshwater, estuarine or marine waters (Barnes, 1989). The category described as "species of blocked brackish waters" for *Ruppia* communities in The Netherlands, Finland and the Mediterranean (Verhoeven, 1980) is broadly equivalent. However, many of the listed species can also be found in saltmarsh pools, brackish drainage ditches, and supralittoral rock pools, especially near the upper tidal limits where conditions are similar to those in lagoons, and further information on the ecological requirements of these species is needed. Some of the species are rare or vulnerable in Europe, and in Britain several are protected by the Wildlife and Countryside Act (1981) (Bamber, 1997). Lists of lagoonal specialists vary according to the nature and geographic location of surveys, and opinions of the authors, and this has created some confusion (see Healy and Oliver, this volume). For example, the list compiled by Barnes (1989) comprises 34 faunal species, whereas that presented by Bamber (1997) for true lagoons in southern England omits all heteropteran and coleopteran species, together with a cnidarian and a polychaete, but includes two additional cnidarians and a crustacean to give a total of only 21 faunal species. Thirty one faunal species were listed by Smith and Laffoley (1992), nineteen by the Joint Nature Conservation Committee (1996) and seventeen for brackish water lagoons in Great Britain (Bamber *et al.*, 1992). A composite list of lagoonal specialists in the United Kingdom is given by Healy and Oliver (this volume).

In total, 13 of the lagoonal specialists on recent British lists were recorded during this survey,

and a further two were reported during previous studies. The number per lagoon varied between one and eight with the lowest proportion in very high or very low salinity (Table 3). Of the 34 listed by Barnes (1989), 12 are regarded as rare or were not recorded during the British National Survey and one is presumed extinct (*Edwardsia ivelli*). Of the remaining 20 species, several are rare or may not occur in Ireland. None of the cnidarians or annelids on the British list was recorded during this survey although the smaller species may have been overlooked. Of the crustaceans, *Gammarus insensibilis* is very rare in Ireland, *Corophium insidiosum* is not recorded, and *Gammarus chevreuxi* is known certainly only for the two sites identified during this survey. Of the three heteropteran species, *Sigara selecta* is very rare, and *Sigara concinna* was recorded at only three southern sites during the survey and has been widely reported from inland sites, and therefore may not be a useful indicator of lagoonal conditions in Ireland as a whole. *Sigara stagnalis* was recorded at most of the less saline sites but also in salinities up to 30‰. In the United Kingdom, *S. selecta* is found at higher salinities than *S. stagnalis* and in the absence of competition it is possible that the latter species may survive in higher salinity in Ireland. Only four of the 11 species of Coleoptera listed as lagoonal specialists in Britain were recorded during the British National Survey (Bamber *et al.*, 1992) (*Agabus conspersus*, *Enochrus bicolor*, *E. halophilus* and *Ochthebius marinus*) although very few of the participants recorded this group at all. Of the other groups, *Hydrobia neglecta* was not found during the present survey, and although *Victorella pavida* was previously recorded from Kilkeran L. (Galvin, 1992), it may have been misidentified.

The aquatic fauna of Irish lagoons resembles that of British lagoons but differences in the occurrence of faunal species between Britain and Ireland, and some apparent differences in their ecology, mean that none of the British lists of lagoonal specialists are wholly appropriate for Ireland. Table 5 gives a list of species that might be regarded as lagoonal specialists in Ireland. This list is included as further information on the ecological distribution of these species in Ireland is needed and it may encourage other biologists to take a greater interest in this previously largely neglected habitat.

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TABLE 1. Location, size, and lagoon type of the 20 sites sampled.

Site	County	Grid ref.	Area (ha)	Lagoon type
Lady's Island Lake	Wexford	T009065	450	sedimentary lagoon
Tacumshin Lake	Wexford	T050065	450	sedimentary lagoon
Kilkeran Lake	Cork	W338344	16	sedimentary lagoon
Lissagriffin Lake	Cork	V775265	12	artificial saline lake
Farranamanagh Lake	Cork	V830378	5	sedimentary lagoon
Drongawn Lough	Kerry	V731640	20	natural saline lake
Lough Gill	Kerry	Q606142	160	sedimentary lagoon
Cloonconeen Pool	Clare	Q836497	4	sedimentary lagoon
Lough Donnell	Clare	R002707	20	sedimentary lagoon
Lough Murree	Clare	M255119	15	rock lagoon
Aughinish Lagoon	Clare	M286134	10	sedimentary lagoon
Bridge Lough	Galway	M342128	5	artificial saline lake
Lettermullen Pool	Galway	L827213	1	rock lagoon
Loch Tanaí	Galway	L950305	12	natural saline lake
Lough Aconeera	Galway	L875369	28	natural saline lake
Mill Lough	Galway	L755331	5	natural saline lake
Corragaun Lough	Mayo	L748698	7	sedimentary lagoon
Roonah Lough	Mayo	L755765	50	sedimentary lagoon
Furnace Lough	Mayo	L965975	125	natural saline lake
Durnesh Lough	Donegal	G878695	70	sedimentary lagoon

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TABLE 2. Faunal species recorded in 20 lagoons.

(+) = additional record: see text.

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanai	L. Aconeera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
Porifera	*Halichondria panicea*						+														
Cnidaria	*Actinia equina*												+								
	Anemonia viridis											+									
	Aurelia aurita					+								+	+					+	
	Chrysaora hysoscella						+					+									
	Cordylophora caspia																				+
	Dynamena pumila											+					+				
	Laomedea angulata													+							
	Sagartiogeton undatus						+														
Turbellaria																+				+	
Nemertea							+				+			+	+						
Annelida																					
Polychaeta	*Amphitrite edwardsi*						+														
	Arenicola marina	+					+					+	+	+	+	+	+	+			
	Capitella capitata											+									
	Hediste diversicolor	+	+		+						+	+		+	+		+				
	Janua pagenstecheri						+							+							
	Lepidonotus squamatus											+									
	Platynereis dumerili						+														
	Pomatoceros triqueter						+					+									
	Spirorbis rupestris						+														
	Nereidae						+														
	Polychaeta indet.											+			+						
	Spirorbidae indet.						+					+		+							
Clitellata	*Clitellio arenarius*						+				+										
	Tubificoides benedii													+							
	T. heterochaeta								+												
	Hirudinea							+											+		
	Naididae							+													
	Tubificidae indet.														+						
Crustacea																					
Ostracoda								+													+
Copepoda								+						+							+
Cirripedia	*Balanus balanus*											+									
	Balanus improvisus	+												+							
	Semibalanus balanoides						+					+									
	Verruca stroemia						+														
Cumacea														+							
Tanaidacea	*Tanais dulongi*													+							
Mysidacea	*Hemimysis lamornae*						+														
	Leptomysis lingvura																+				
	Mysidopsis gibbosa											+									
	Neomysis integer	+	+	+	+	+	+	+		+	+					+	+	+	+	+	+

TABLE 2 (Continued)

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanai	L. Aconeera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
Mysidacea	cont.																				
	Praunus flexuosus	+					+					+	+	+	+		+				
	P. neglectus											+									
	Siriella jaltensis													+							
Isopoda	*Asellus sp.*		+																		
	Eurydice pulchra																	+			
	Idotea baltica	(+)										+		+							+
	Idotea chelipes	+											+	+	+						
	Jaera albifrons																			+	
	J. forsmani						+														
	J. ischiosetosa										+									+	
	J. nordmanni				+	+				+						+	+	+		+	+
	Lekanesphaera hookeri	+	+					+	+						+	+	+			+	
	Ligia oceanica		+		+	+	+			+	+				+						
Amphipoda	*Allomelita pellucida*			+	+	+														+	
	Ampithoe ramondi						+														
	Caprella acanthifera						+								+						
	Corophium volutator						+								+	+	+	+		+	
	Dexamine spinosa											+	+	+	+						
	Echinogammarus marinus										+										
	Erichthonius difformis						+														
	Gammarus chevreuxi											+									+
	G. duebeni			+	+	+	+			+	+	+				+	+	+	+	+	
	G. locusta								+			+									
	G. ?salinus		+																		
	G. zaddachi	+				+		+								+	+	+		+	
	Hyale sp.										+										
	Lembos longipes						+													+	
	Leptocheirus pilosus																			+	
	Melita palmata				+		+	+			+	+		+	+						
	Orchestia gammarella	+		+	+		+		+	+	+		+	+	+			+			
	Talitrus saltator											+									
Decapoda	*Carcinus maenas*	+			+	+	+		+	+		+	+	+	+	+	+	+	+	+	+
	Crangon crangon	+			+	+				+		+						+		+	+
	Macropodium rostrata											+									
	Pagurus bernhardus											+									
	Palaemon elegans				+		+					+		+			+			+	
	P. longirostris						+														
	P. serratus				+		+					+					+	+			
	Palaemonetes varians	+	+	+	+	+	+		+	+	+		+	(+)	+	+	+	+		+	+
	Hippolyte varians											+									
	Thoralus cranchii											+									
Arachnida																					
Hydracarina								+							+						

TABLE 2 (Continued)

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanai	L. Aconeera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
Pycnogonida							+														
Insecta																					
Thysanura	*Petrobius sp.*				+																
Ephemeroptera	*Cloeon dipterum*			+																	+
	C. simile							+											+		
	Procloeon bifidum							+													
Odonata	*Ischnura elegans*	+	+	+				+		+	+					+			+	+	+
Plecoptera				+				+											+		+
Trichoptera	(cases)							+		+	+					+			+		+
Heteroptera	*Arctocorisa germari*							+													+
	Callicorixa praeusta	+	+	(+)				+											+		+
	C. panzeri	+	+	+				+											+		+
	Corixa punctata		+					+													
	Cymatia bonsdorffi																		+		
	Gerris lacustris																			+	
	G. odontogaster		+																		(+)
	G. thoracicus		+																		
	Hesperocorixa linnaei		+																		+
	*Hydrometra gracilenta**			(+)																	
	H. stagnorum			+																+	
	Nepa cinerea							+													(+)
	Notonecta glaucum		+	+																+	
	Notonecta viridis	+	+	+						+											
	Plea leachi		+					(+)													
	S. concinna	+	+	+																	
	Sigara dorsalis	+	+	+			+	+		+									+		+
	S. falleni																				+
	S. semistriata																		+		
	S. stagnalis	+	+	+	+				+	+	(+)							+	+		+
Coleoptera	*Agabus conspersus*	(+)																			
	A. montanus																		+		
	A. nebulosus										+										
	Anacaena globulus					+															+
	A. lutescens			+																	
	Cercyon littoralis												+				+				
	C. marinus			+																	
	C. sternalis							+													
	Colymbetes fuscus	+	+																		
	Dryops luridus									+											
	Elmis aenea																		+		
	Enochrus bicolor	+							+		+		+	+	+						
	E. halophilus		+								(+)										

TABLE 2 (Continued)

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanai	L. Aconeera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
Coleoptera	cont.																				
	E. testaceus							+													
	Graptodytes granularis	+																			+
	Gyrinus aeratus																				+
	G. caspius		+	+						+						+					
	Haliplus confinis							+													
	H. flavicollis									+											
	H. fulvus							+													
	H. lineatocollis					+		+		+									+		
	H. ruficollis									+										+	
	H. wehnckei						+			+									+		
	Helophorus brevipalpis			+						+											+
	Hydrobius fuscipes		+																		
	Hydroporus angustatus			+																	+
	H. gyllenhalli																				+
	H. incognitus																				+
	H. memnonius																		+	+	+
	H. palustris			+																	+
	H. planus		+																		+
	H. pubescens																				+
	H. striola																				+
	H. umbrosus																				+
	Hygrotus impressopunctatus		+																		+
	H. inaequalis		+					+		+											+
	Ilybius fuliginosus							+											+		
	Laccobius biguttatus							+													
	L. minutus							+											+		
	Laccophilus minutus		+					+													+
	Megasternum obscurum																			+	
	Nebrioporus depressus							+											+	+	
	Noterus clavicornis	+	+							+											+
	Ochthebius marinus	(+)																			
	Rhantus frontalis		+																		
Diptera	Chironomidae	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+
	Tipulidae							+										+			
	Ephydridae	+								+											
	Culicidae									+	+										
	Syrphidae										+										
Mollusca																					
Polyplacophora	*Lepidochitona cinerea*						+	+				+		+							
Prosobranchia	*Bittium reticulatum*						+					+		+							
	Gibbula umbilicalis						+					+		+							
	Hinia incrassata													+							

TABLE 2 (Continued)

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanai	L. Aconeera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
	Hydrobia ulvae				+				+						+		+				
	H. ventrosa	+	+				+		+		+		+	(+)	+						
	Littorina littorea						+					+	+	+							
	L. obtusata						+										+				
	L. saxatilis						+				+	+									
	L. "tenebrosa"													+	+						
	Nucella lapillus													+							
	Onoba aculeus													(+)							
	O. semicostata						+								(+)						
	Patella ulyssiponensis											+									
	Patella vulgata						+							+							
	Potamopyrgus antipodarum	+	+	+	+	+		+		+	+					+	+	+	+	+	+
	Rissoa inconspicua													(+)							
	R. parva													(+)							
	R. p. var. interrupta													(+)							
	Rissostomia membranacea						+							+	+						
	Skeneopsis planorbis													+							
Pulmonata	*Anisus leucostoma*		+																		
	Aplexa hypnorum																		+		
	Hippeutis complanata							+											+		+
	Lymnaea palustris		+																+		
	L. peregra		+					+											+		+
	Planorbarius corneus																				+
Opisthobranchia	*Acanthodoris pilosa*													(+)							
	Aeolidia papillosa											+									
	Akera bullata														+						
	Elysia viridis						+					+		+							
	Limapontia depressa												+								
	Scaphander lignarius						+														
Bivalvia	*Abra sp.*																			+	
	Anomia sp.						+														
	Cerastoderma edule											+									
	C. glaucum	(+)	(+)				+		+				+	+	+	+	+				
	Chlamys varia						+						(+)								
	Modiolarca tumida											+									
	Musculus discors														+						
	Mya arenaria	(+)														+					
	Mytilus edulis						+					+		+	+					+	
	Ostrea edulis						+					+									
	Parvicardium ovale						+														
	Pisidium sp.							+													
	Sphaerium sp.							+													
	Venerupis sp.						+														

TABLE 2 (Continued)

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanaí	L. Aconeera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
Bryozoa	*Alcyonidium gelatinosum*											+									
	Bowerbankia gracilis						+					+		+							
	Conopeum seurati	+												+	+	+	+			+	
	Cryptosula pallasiana						+					+									
	Flustrellidra hispida																+				
	Fredericella sultana?			+																	
	Plumatella repens			+	+			+											+		
	Walkeria uva													+							
Echinodermata	*Amphipholis squamata*						+					+		+							
	Asterias rubens						+														
	Luidia ciliaris													+							
	Paracentrotus lividus													+							
Tunicata	*Ascidiella aspersa*						+					+		+							
	A. scabra											+		+	+		+				
	Botryllus schlosseri											+		+							
	Ciona intestinalis														+						
	Clavelina lepadiformis						+					+		+	+						
	Dendrodoa grossularia						+														
	Diplosoma listerianum											+									
Teleostei	*Anguilla anguilla*	+		+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+
	Atherina presbyter						+														
	Ciliata mustela											+									
	Conger conger													+							
	Crenilabrus melops						+														
	Ctenolabrus rupestris													+							
	Dicentrarchus labrax									+											
	Gasterosteus aculeatus	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+
	Gobius niger						+														
	Labrus bergylta																+				
	Molva molva													+							
	Mugilidae	+			+			+		+					+		+	+			+
	Pleuronectes flesus	+		+	+		+	+		+					+	+	+	+	+	+	+
	Pollachius pollachius	+										+		+							
	Pomatoschistus microps	+		+	+	+	+	+		+	+	+	+			+	+			+	
	Pungitius pungitius		+																		
	Salmo trutta							+													+
	Spinachia spinachia	+																			
	Sprattus sprattus	+																			
	Syngnathus acus	+																			
	S. typhle														+						

TABLE 3. Number of taxa of aquatic fauna and lagoonal specialists recorded during the survey (previous records in brackets) in relation to lagoon area, presence of tidal inlet/outlet, rock (* - few or localised, ** - abundant), and salinity range (survey period only).

Site	Area (ha)	Inlet/outlet	Rocks	Sal. range (‰)	Taxa	Lag. spec.
Lady's Island Lake	450	barrier artificially breached	*	4-26	38	8 (3)
Tacumshin Lake	450	artificial outlet, unsluiced		0-19	37	6 (1)
Kilkeran Lake	16	temporary, natural or artificial		1-5	35	3
Lissagriffin Lake	12	artificial outlet, unsluiced		4-30	24	2
Farranamanagh Lake	5	permanent natural inlet		1-27	17	1
Drongawn Lough	20	silled inlet, tidal	**	10-34	70	3
Lough Gill	160	artificial outlet, sluiced		0-5	47	1
Cloonconeen Pool	4	barrier overtopped		30-36	14	6
Lough Donnell	20	artificial outlet, unsluiced		0-6	32	2
Lough Murree	15	rock fissures	**	10-24	25	3 (2)
Aughinish Lagoon	10	natural inlet, tidal	**	31-40	56	1
Bridge Lough	5	artificial outlet, sluiced	*	30-38	17	5
Lettermullen Pool	1	barrier overtopped	**	34-37	52	5 (3)
Loch Tanaí	12	tidal channel	*	28-32	38	7
Lough Aconeera	28	silled inlet, tidal	**	0-14	22	4
Mill Lough	5	silled inlet, tidal	*	2-34	30	4
Corragaun Lough	7	tidal channel		0-32	20	2
Roonah Lough	50	tidal channel		0-2	32	1
Furnace Lough	125	silled inlet with weirs	*	0-22	34	3
Durnesh Lake	70	artificial outlet, sluiced		0-7	48	3

TABLE 4. The most frequently occurring taxa in 20 lagoons (number of lagoons in which they occurred). Lag. spec - lagoonal specialist.

Gasterosteus aculeus	19		*Corixa dorsalis*	8	
Chironomidae (larvae)	19		*Jaera nordmanni*	8	
Anguilla anguilla	17		*Lekanesphaera hookeri*	8	lag spec.
Palaemonetes varians	16	lag spec.	*Crangon crangon*	8	
Carcinus maenas	16		Mugilidae	8	
Neomysis integer	15		*Hydrobia ventrosa*	7	lag spec.
Potamopyrgus antipodarum	14		*Cerastoderma glaucum*	7	lag spec.
Pleuronectes flesus	13		*Ligia oceanica*	7	
Pomatoschistus microps	13		*Gammarus zaddachi*	7	
Gammarus duebeni	12		*Melita palmata*	7	
Orchestia gamarella	11		*Enochrus bicolor*	6	lag spec.
Ischnura elegans	10		*Conopeum seurati*	6	lag spec.
Sigara stagnalis	9	lag spec.	Trichoptera (larval cases)	6	
Arenicola marina	9		*Corixa panzeri*	6	
Hediste diversicolor	8		*Corophium volutator*	6	

Table 5. A proposed list of lagoonal specialists for Ireland. (?) - possible candidate, needing confirmation of ecological distribution in Ireland; * - species not on British lists; † - not recorded during the present survey.

Cnidaria
- **Cordylophora caspia*

Crustacea
- **Neomysis integer*
- *Idotea chelipes*
- **Jaera nordmanni (?)*
- *Lekanesphaera hookeri*
- **Allomelita pellucida (?)*
- *Gammarus chevreuxi*
- **Leptocheirus pilosus (?)*
- *Palaemonetes varians*

Insecta
- **Notonecta viridis*
- *Sigara selecta* †
- **Plea leachi*

Insecta (cont.)
- *S. stagnalis*
- *Agabus conspersus* †
- *Enochrus bicolor*
- *E. halophilus*
- *Hygrotus impressopunctatus (?)*
- *Ochthebius marinus* †

Mollusca
- *Hydrobia ventrosa*
- *Littorina "tenebrosa"*
- *Onoba aculeus*
- **Rissoa membranacea* vars. *(?)*
- *Cerastoderma glaucum*

Bryozoa
- *Conopeum seurati*

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IRISH COASTAL LAGOONS: SUMMARY OF A SURVEY

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Abstract

A survey of coastal lagoons in the Irish Republic, carried out in 1996, is summarized. Among 56 sites identified in the national inventory, 19 were lagoons with sedimentary barriers, three were rock lagoons, 14 were natural saline lakes and 20 were artificial saline lakes. Examples in peat or karst are unusual for Europe. The sites are mainly situated on south and west coasts from Wexford to Donegal. Twenty were selected for more intensive study of aquatic vegetation and fauna, and selected shoreline fauna. Aquatic fauna and flora appear to be rich in comparison with other regions of western Europe. Charophytes and insects in particular were well represented. Records include 53 species of plants (including algae), 220 species of aquatic fauna (invertebrates and fish), and 209 Carabidae and Staphylinidae collected from lagoon shores. A list of lagoonal specialist species is given.

Introduction

Coastal lagoons are a neglected habitat in Ireland and prior to the present survey relatively little was known of their flora and fauna. The need for more information became a matter of some urgency following the listing of lagoons as a priority for conservation in the EU Habitats Directive (92/43/EEC). Although a few Irish lagoons were relatively well known and were already receiving a degree of protection, most had never been investigated and there was no national inventory of lagoon sites. In 1996, therefore, the authors carried out a survey of lagoons on the coast of the Irish Republic with a view to assessing their value for conservation (Healy *et al.*, 1997a, b, c). A rapid inventory showed that Ireland possesses a wide range of lagoon types in a relatively natural state and 20 were selected for special study and scientific evaluation. The species of flora and fauna listed in this volume (Hatch and Healy, 1998; Oliver

and Healy, 1998; Good and Butler, 1998) were recorded from these 20 sites.

There are differing opinions about what constitutes a lagoon. The classification of biotopes in the revised Interpretation Manual of European Union Habitats (Version EUR 15, April 1996) defines lagoons as: "Expanses of shallow coastal salt water, of varying salinity or water volume, wholly or partially separated from the sea by sand banks or shingle, or, less frequently, by rocks. Salinity may vary from brackish water to hypersalinity depending on rainfall, evaporation and through the addition of fresh sea water from storms, temporary flooding by the sea in winter or tidal exchange. With or without vegetation from *Ruppietea maritimae*, *Potametea*, *Zostereteа* or *Charetea*" (CORINE 91: 23.21 or 23.22) (Romão, 1996). This definition is somewhat broader than the usual textbook description of a lagoon since it includes those with rock barriers. It appears to exclude deeper lakes with natural, silled inlets which are frequent in the west of Ireland, and also in Scotland where they are called "obs" (Smith, 1984). Other enclosed brackish waters which do not fit the definition include those with peat barriers and Baltic lagoons derived from bays as a result of recent land uplift. It is the opinion of many environmentalists, including the present authors, that these lagoon-like systems have their own intrinsic value and should be included with lagoons in the stricter sense for conservation purposes. The CORINE classification of marine habitats is currently under review.

Conservation of habitats is generally concerned with natural systems. However, most natural lagoons in Europe have probably been modified in some way by human interference, and many lagoon-like systems have been created artificially, often unintentionally. Barnes (1987), for example, estimated that all but three out of 26 brackish lagoons in East Anglia owed their origin directly or indirectly to man. It seems reasonable, therefore, to consider as candidates for conservation those which were created by construction of causeways carrying roads or railways, or which owe their brackish nature to artificial structures designed to control flooding such as sluices and culverted outlets. There is, in fact, no essential difference between the environmental conditions and biota of natural lagoons and those of artificial ones. Artificial saline lakes can act as reservoirs of characteristic lagoonal species and may even be important refuges for rare species. In England, some entirely artificial sites are now protected for their flora and fauna (Smith and Laffoley, 1992; Bamber, 1997). Lagoons also deserve protection for their geomorphology alone.

Characteristics of lagoons

All lagoons and lagoon-like systems, whatever their origin, have features in common which distinguish them from tidal brackish waters such as estuaries and salt marsh pools.

Barriers. Sedimentary lagoons lie behind barriers of sand, gravel, cobbles, or cobbles and boulders, depending on the amount of local wave energy and sediment supply. Lagoons on north-east Atlantic coasts are unusual from a world perspective in that their barriers are generally composed of shingle or cobble instead of sand and have formed on meso- or macrotidal coasts. The barriers allow lagoon water to percolate seawards and seawater to percolate into the lagoon, according to the relative levels of sea and lagoon water. Where only small amounts of lagoon water are able to exit by percolation, an outlet channel may form, which can be temporary or permanent, and which allows seawater to enter at high tides. In a true lagoon the tidal range is always small, however, and no large expanses of the substratum are uncovered at low tide.

Other kinds of barrier, composed of peat, rock, glacial till, or combinations of these, are generally impervious and seawater enters through narrow inlet/outlets, or occasionally by overtopping the barrier during storms. An exception is found in limestone regions where seawater may enter coastal lakes by way of subterranean rock fissures.

Water level. Unless the system has an open inlet, water levels tend to undergo seasonal fluctuations according to variations in precipitation and evaporation, rising in winter and falling in summer. In order to prevent flooding of surrounding land, artificial outlets have been installed through the barrier at many sites, usually with flap sluices or manually controlled gates to prevent the entry of seawater. Sedimentary barriers are sometimes breached, naturally or artificially, resulting in a rapid fall in water level. The breach would eventually seal by natural processes.

Salinity. Seawater may enter through open inlets, by overtopping the barrier, by percolation through sedimentary barriers, and through leaky sluices and artificial outlet pipes. Small, but significant amounts of salt may be derived from sea spray. Salinity in most lagoons is highly variable, both spatially and temporally, and steep gradients between freshwater and seawater inflows are typical. Localized areas of higher salinity may be caused by percolation or overtopping or by evaporation in shallow water. It is not uncommon for salinities from 0-36‰

to exist in different parts of the same lagoon. Higher salinity may occur in summer in shallow lagoons due to evaporation but in low salinity lagoons an increase in salinity is more likely to occur in winter as a result of seawater incursions during storms.

Fauna and flora. Substrate type and salinity regime are probably the most important environmental factors limiting the occurrence of plant and animal species in lagoons. Burrowing invertebrates will only be common where there is soft sediment, and sessile forms need hard substrates for attachment. Similarly, rooted vascular plants and charophytes (stoneworts) are favoured by soft bottoms, and attached algae by an abundance of hard surfaces. Many euryhaline species can survive in the full range of salinities from freshwater to full strength seawater, but may not reproduce in extreme conditions and the majority show preference for a limited salinity range. In the notes which accompany the species records, the Venice System for the classification of brackish waters (Venice System, 1958) is sometimes used to indicate the preferred salinity range of a species as follows: <0.5‰ - limnic, 0.5-5‰ - oligohaline, 5-18‰ - mesohaline, 18-30‰ - polyhaline, and 30-40‰ - euhaline. A critical level between 5 and 8‰ generally separates fauna and flora which are typically limnic, with a high diversity of insects and vascular plants, from those which are more marine in character, containing a variety of crustaceans, molluscs, and algae. At some sites identified during the present survey, there was no measurable amount of salt at the time of sampling (meter accurate to 1‰) but the fauna and flora were indicative of a saline influence, emphasizing the limitations of single samples when attempting to assess salinity regimes.

A characteristic feature of lagoons is the degree of difference in species composition between apparently similar systems. A species may be abundant in one lagoon but absent in a neighbouring one where conditions appear similar. This is usually attributed to random colonization processes and a vulnerability to extinction resulting from drastic changes in environmental conditions which characterize many lagoon systems.

Lagoonal specialists. A number of species are confined to lagoons or are distinctly more frequent in them than in other kinds of brackish water such as estuaries and salt marsh pools. They characterize brackish waters receiving only small volumes of tidal water where water currents are slow. In Britain, 43 species of invertebrate, algae, vascular plant and charophyte have been listed as lagoonal specialists by various authors (Barnes, 1989; Sheader and Sheader,

1989; Davidson *et al.*, 1991; Bamber *et al.*, 1992; Smith and Laffoley, 1992; Bamber, 1997) (Table 1). A recent reassessment of specialist lagoonal species has resulted in exclusion of many species widely found in brackish ditches or other non-lagoonal habitats (Joint Nature Conservation Committee, 1996; Downie, 1996) but we have not followed this trend (see Discussion). Not all of the species listed in Table 1 have been recorded in Ireland but most of those that occur appear to have a similar ecological distribution here although some are rare while others are distinctly more frequent.

Classification of lagoons

Four types of lagoon are recognized in this survey:-

Sedimentary lagoons lie behind sedimentary barriers. Usually there is some landward percolation of seawater. The sea may also enter through a temporary or permanent inlet, or through an artificial outlet, or by overtopping.

Rock lagoons lie behind rock barriers and receive seawater by overtopping, through inlet/outlets, or, in the case of karst, through subterranean rock fissures.

Natural saline lakes have barriers composed of peat, glacial till or material of mixed origin. Seawater enters through an outlet which is of natural origin but usually modified and frequently sluiced. Many saline lakes are silled at their outlet and some are quite deep.

Artificial saline lakes originated either by isolation of a sea bay or inlet behind a causeway, or by construction of a sea wall during land reclamation. Many date from the middle of the last century. Artificial lakes are sometimes created as reservoirs for firefighting e.g. Shannon Airport, or as an amenity.

In this paper, and often in the scientific literature, the term "lagoon" is sometimes used to include all the above types.

Threats to lagoons

True, i.e. sedimentary, lagoons are transient features which could in time evolve into freshwater lakes and eventually fill in by siltation or wind-blown sand, landward transgression of the barrier, and succession of the vegetation. Alternatively, they might become fully tidal if the barrier is partially destroyed or if the sea-level rises. Some changes to lagoons which may

be perceived as threats are thus caused by natural phenomena, but human activities can accelerate or alter natural trends. Any project which alters sedimentation patterns, such as sand or gravel extraction, pier extension or coastal protection schemes, may have far-reaching consequences for sedimentary lagoons in the area. Some of the commonest threats to lagoons are from land reclamation and flood control schemes. A number have been drained in recent years and others are likely to be significantly altered by changes to the barrier or the outlet/inlet. The commonest form of pollution is nutrient enrichment, mostly from fertilizer or slurry application on surrounding land, overflowing slurry tanks, silage effluent, and septic tanks, with the additional stress caused by toxic contaminants in industrial or domestic effluents. Even grazing cattle can cause significant enrichment in small water bodies.

Outline of the survey

Identification of sites. Potential sites were identified from maps and aerial photographs or on the advice of colleagues. In an initial phase of the survey during June and early July 1996, we examined all types of enclosed, or semi-enclosed, brackish waters with a limited tidal range which were easily accessible, both natural and artificial. Water bodies less than 0.75ha were not considered, and sites where extensive areas of the bed are exposed at low tide e.g. Broad Lough, Co. Wicklow were excluded. As far as we know, Lough Hyne, Co. Cork shows no evidence of significant freshwater influence and was therefore not investigated.

(a) *An isolated lake*, i.e. without visible connection to the sea, was considered to be a lagoon or saline lake if the salinity was 1‰ or more *or* if certain indicator species were present. Indicators of former seawater incursion in waters which were fresh at the time of sampling were:

Algae: *Enteromorpha*.

Plants: *Ruppia* spp, *Ranunculus baudotii*, *Bolboschoenus maritimus*, and salt-marsh plants on the shore. The presence in the main body of the lake of salt-sensitive species such as water-lilies (*Nymphaea alba*), water lobelia (*Lobelia dortmanni*) and *Callitriche* spp (water starworts) was taken to indicate permanent freshwater.

Fauna: *Hediste diversicolor*, *Neomysis integer*, *Lekanesphaera hookeri*, *Palaemonetes varians*, crabs.

(b) *Tidal lakes* were considered to be lagoons or saline lakes if the salinity was <33‰ *or* if certain indicators of brackish conditions were present. Indicators of freshwater influence in waters of 33‰ or more at the time of sampling were:

Algae: *Chaetomorpha mediterranea*, *Fucus ceranoides*.

Plants: *Ruppia* spp, charophytes, *Phragmites*.

Fauna: *Cerastoderma glaucum*, Heteroptera, Coleoptera.

(c) Fully saline waters, i.e. with a salinity of 34‰ or more, were included even when no brackish species could be found if they displayed the topographical features of a true lagoon, namely shallow water, a sedimentary barrier, and restricted tidal flow. Brackish conditions may develop temporarily in these during long periods of rainfall.

Preliminary sampling. At each site identified as a lagoon or saline lake, the salinity was measured at several shore locations, the nature of the substrate noted and, where possible, the positions of seawater and freshwater inflows noted. The dominant aquatic and emergent plants were identified, samples taken of aquatic fauna, and suitable shore habitats for future sampling of Coleoptera investigated. Further details of methods are given in Healy *et al.* (1997a). An inventory of the sites identified, including some not sampled, contains a summary of the observations and some information obtained from other sources (Healy *et al.*, 1997b).

Selection of sites for further study. Following the initial inventory, 20 sites were chosen for more intensive study based on their potential value as Special Areas of Conservation (SACs) (Table 3). Those selected were considered to be good examples of a representative range of lagoon types. They are distributed in seven counties and include 11 sedimentary lagoons, two rock lagoons, five natural saline lakes and two artificial saline lakes (Fig. 1, Table 2).

Site surveys. Three categories of living organisms were investigated independently: aquatic and marginal vegetation, aquatic fauna, and marginal (ecotonal) beetles. Sampling took place from July to October, 1996, and in all cases was qualitative or semi-quantitative. Details of sampling methods are given in Hatch and Healy (1998), Oliver and Healy (1998) and Good and Butler (1998). Scientific evaluation criteria were those in general use for conservation assessment, including lagoons (e.g. Mitchell, 1987; Barnes, 1989; Sheader and Sheader, 1989), but greater emphasis was placed on geomorphology than is usual for other habitats.

Summary of the lagoon inventory

Among 99 sites visited in 1996, 50 were identified as lagoons or saline lakes and a further six are known to qualify (Healy *et al.*, 1997a, b). At least 50 further sites over 1ha are considered worthy of investigation. Among the 56 sites identified, 19 are sedimentary lagoons, 3 are rock lagoons, 14 are natural saline lakes and 20 are artificial saline lakes (Table 2).

There are distinct regional differences in the number and type of lagoons (Table 2) which are related to coastal topography, land use, and the level of urbanization. No natural lagoons or saline lakes were found on the east coast north of Wexford. If they existed in the past, they have disappeared as a result of land reclamation, road or railway construction, or flood control schemes. Contrary to popular belief, Irish lagoons are not concentrated in the south-east although two of the most important are situated there. The main concentrations of lagoons and lagoon-like habitats are, in fact, in Co. Cork, where road construction on a highly indented coastline has created many artificial saline lakes, and Connemara, where some of the many lakes in the area lie near the coast and are subject to marine influence. Unusual geomorphological types in Ireland include karstic lakes in the Burren which receive seawater through limestone fissures, and lagoons with peat barriers.

Summary of the site surveys

Environmental factors. The lagoons investigated presented a wide range of sizes, depths, salinity regimes, substrate types and degrees of human interference. The most important factor limiting species occurrence was undoubtedly the salinity regime which was determined chiefly by hydrological processes governing the relative amounts of seawater and freshwater entering the lagoon, and the frequency of seawater incursions. Salinities from 0 to 40‰ were recorded (Tables 3, 4). Twelve of the 20 lagoons had open inlets, either natural or artificial, which allowed seawater to enter either at each high tide (Lissagriffin L., Mill L., Corragaun L.) or mainly at springs. Sometimes the tidal influence was small, however, because the amount of freshwater entering the system was sufficient to flush out the seawater before significant mixing occurred (Farranamanagh L., L. Donnell, Corragaun L., Roonah L.). Eight lagoons remained more or less isolated from the sea for most of the time and received seawater by percolation through the barrier (Tacumshin L.), by waves overtopping the barrier during storms

(Tacumshin L.) or at spring tides (Cloonconeen Pool), through subterranean rock fissures (L. Murree), by natural or artificial breaching of the barrier (Lady's Island L., Kilkeran L.), or through leaking sluices, e.g. when jammed open by stones (Bridge L., L. Gill, Durnesh L.). In some lagoons the salinity fluctuated widely according to tide cycles, storm surges, rainfall, and evaporation, and where fluctuations were frequent and of high amplitude they exerted a strong limiting influence on fauna and flora (Farranamanagh L., Mill L., Corragaun L.). In most systems, however, there were persistent salinity gradients which allowed species with different preference and tolerance ranges to survive in different parts of the lagoon.

Other factors which contributed to species richness, or which limited species distribution, included substrate type and diversity (rock, stones, sand, silt, peat), and the extent of a shallow littoral zone which determined the development of emergent vegetation and aquatic plants.

Species records. Faunal and floral records include 54 taxa (53 species) of aquatic plants, 248 taxa (220 species) of aquatic fauna, and 209 species of shore beetles (Table 4). Three are new records for Ireland: one charophyte (*Chara baltica*), one hemipteran (*Hydrometra gracilis*), and one beetle (*Brundinia meridionalis*), while a number of others are rare in Ireland. Many of the records extend the known geographic range of the species and much new information on the ecology of brackish species in Ireland is provided, particularly in relation to salinity.

Vegetation. Records of aquatic plants include 13 vascular plants, 7 charophytes and 33 other algae (Hatch and Healy, 1998). Collections of the latter were not fully identified and green algae in particular merit further study as they may prove to be useful indicators of lagoon environments. *Ruppia* spp were present at all but one of the sites (Aughinish which becomes hypersaline) and appear to be reliable indicators of brackish conditions, being more frequent here than in Britain (Smith and Laffoley, 1992; Bamber, 1997). Records of charophytes include three species listed in the Red Data Book for Britain and Ireland (Stewart and Church, 1992): *Chara baltica*, which is a new Irish record, and *C. canescens* and *Lamprothamnium papulosum* for which new localities have been found. All three, together with the *Ruppia* spp, and *Chaetomorpha mediterranea* (*C. linum*), a filamentous green alga, are lagoonal specialists (Table 1). The remaining species are either typical of euhaline-polyhaline conditions e.g. *Zostera marina* and most macrophytic algae, or freshwater plants associated with coastal habitats and tolerating various degrees of saline influence. Some typically freshwater species

were restricted to areas near the mouth of streams or rivers.

Fauna. A total of 248 aquatic faunal taxa includes 17 Annelida, 51 Crustacea, 77 Insecta, 47 Mollusca, and 21 fish (Oliver and Healy, 1998). A large proportion of the species are marine, or euryhaline marine, and colonize lagoons which are open to the sea and where salinity remains high. A number of these are associated with rock and could not be expected to occur in sedimentary lagoons unless rock was present. Another large contingent consists of freshwater species with varying degrees of tolerance of saline conditions. A change in dominance from crustaceans and molluscs to insects occurred at salinities between 10 and 5‰. Coleoptera and Hemiptera were particularly abundant and diverse compared with similar habitats in Britain and Continental Europe. Only 13 of the 35 lagoonal specialists listed for Britain (Table 1) were recorded (Table 5) although another two species are known to occur in Irish lagoons. Some are distinctly more common here than in England while others are relatively rare.

Marginal Coleoptera. Records of non-aquatic beetles from lagoon shores include 64 Carabidae and 145 Staphylinidae (Good and Butler, 1998). Fifteen Coleoptera were identified as indicator species, characterizing well-developed habitat sufficiently undisturbed by human activity to allow it to retain many local or rare stenotopic species. However, only nine of these are known to be halophilous or halotolerant. The species were, on the whole, more characteristic of freshwater wetland than saline soils, with many halobiont species not recorded, indicating that soil salinity is not aways a limiting factor. It is suggested that winter flooding by freshwater may have more impact than seawater flooding in western areas, especially at sites within large watersheds.

Species richness. The number of aquatic species/lagoon (fauna and flora) varied between 17 in Cloonconeen Pool and 76 in Drongawn L. with a mean of 41.8 (Table 4). Three determinants of faunal richness are apparent: area, habitat diversity, and salinity regime. These factors are, to a large extent, interrelated because large lagoons generally contain persistent salinity gradients and a wider range of habitats than small ones. A species-area relationship for aquatic fauna could be demonstrated for most lagoons with the exception of Drongawn L., Aughinish L., and Lettermullen Pool for which a combination of high salinity and abundant rocks provided conditions favouring many common sessile invertebrates and algae of the open coast (Healy *et al.*, 1997a). The importance of these two factors is illustrated by Lettermullen

Pool, the smallest site, for which 70 species (52 faunal species) are recorded.

The lowest number of taxa was recorded in Cloonconeen Pool, a small, peat lagoon with low habitat diversity and a soft substrate not favoured by invertebrates. Relatively few species were found at sites experiencing large and frequent fluctuations in salinity due to extensive tidal flow (Lissagriffin L., Farranamanagh L., Corragaun L.). The low number for Bridge L. is partly explained by limited access to the site and a lower sampling effort. A below average number of taxa in L. Aconeera, an unspoilt, medium-sized lagoon with rocks, is possibly explained by its salinity range. The range throughout most of the lake during the sampling period was 10-14‰ but average levels may be lower. If the characteristic value for the lagoon falls between 5 and 10‰, this would correspond to the level at which a species minimum in brackish waters is expected to occur (Remane, 1934; Kinne, 1971). None of the other lagoons investigated showed a widespread salinity within this range.

Lagoonal specialists and indicator species. The total number of lagoonal specialists recorded was 19, comprising 6 plant species and 13 aquatic invertebrates (Table 5). The maximum recorded during the survey was 11 at Lady's Island L. (Table 4), confirming this site as an exceptional example of a classical lagoon (a further four species were recorded from the site during previous studies). Other sites with a high proportion of lagoonal specialists were L. Tanaí (10), Tacumshin L. (8) and, surprisingly, Cloonconeen Pool (8), which had the lowest number of total species. There is, in fact, no relationship between the number of lagoonal specialists and the number of taxa (Table 4). As expected, the fewest specialist species (1-2) were found in lagoons with very high or very low salinity (Aughinish L., L. Gill, and Roonah L.).

Among shore Coleoptera, 10 species of Staphylinidae and four species of Carabidae were recognized as indicators of well-developed habitat (Table 5). Three indicator species were found at Lady's Island L. and Durnesh L. and one or two at 11 other sites, while none were recorded at seven sites (Table 4). The shores of Lettermullen Pool did not include areas of suitable shore habitat and the lagoon was not sampled. Doovilra L., Co. Mayo, a small lake lying behind a low sand bank, was sampled in the survey of shore beetles (Good and Butler, 1998), but is not considered to be a lagoon and is not included in this analysis.

Lagoon descriptions

Locations of the lagoons are shown in Fig. 1, and the main features summarized in Tables 3 and 4. Names are as shown on the Ordnance Survey 1:50 000 maps (Discovery Series). In the following descriptions, lagoonal specialists are aquatic species only, but indicator shore species are listed. Comments on the scientific value of the sites are the opinions of the authors.

Lady's Island Lake. A large, natural, sedimentary, percolating lagoon in an agricultural landscape, with a dune barrier of sand and gravel. There is no natural outlet but the barrier is breached in spring of most years to lower the water level. Salinity during the sampling period was 4-15‰ at the north end where a stream enters and 23-26‰ in the rest of the lake. Depth 1-3m, reaching 5m in winter. Substrate grades from soft, sandy mud to coarse, sandy gravel with stones, and there are granite rocks in the south-east. An area in the south-west, Bunargate Pool (or Scallan's Pool), becomes isolated in summer when it has a lower salinity than the rest of the lake (6-10‰ during the survey). Aquatic vegetation patchy, but dense in some previous years. Some small stands of reeds and sedges occur in sheltered bays.

The typical lagoonal community comprised euryhaline-marine, brackish and limnic species. It is subject to wide variation in species composition due to breaching of the barrier (Hurley, 1997, 1998; Healy, 1997). Aquatic taxa recognized - 44, 11 lagoonal specialists (and a further four on previous occasions). **Notable species**: *Lamprothamnium papulosum*, *Notonecta viridis*, *Atheta gyllenhali*, *A. liliputana*, *Gabrius keysianus* (*Chara canescens*, *Agabus conspersus*, *Ochthebius marinus* and *Cerastoderma glaucum* on previous occasions).

Scientific value of the site - exceptional, for its rich and interesting fauna and flora, including rare species; recognized as perhaps the best example of a percolating lagoon in Europe. The lake is a Special Protection Area for birds.

The lake and its fauna and flora are described by Healy *et al.* (1982), Hurley (1997, 1998) and long-term variations in salinity and biota by Healy (1997). The geomorphological characteristics of the barrier are described in a number of papers e.g. Carter and Orford (1980, 1982) and Orford and Carter (1982).

Tacumshin Lake. A large, natural, sedimentary, percolating lagoon, with a dune barrier of sand and gravel. A natural outlet sealed naturally in the mid 1970s since when there have been several attempts at drainage. Outlet pipes were installed during the summer of 1996 and the

water level was low during the sampling period. The salinity was 0‰ in the most northerly arm of the lake, 8-5‰ in the north-east, 3-5‰ in an artificial channel in the south-west, 19-35‰ on the south shore where there is extensive percolation and occasional overwash, and 18‰ in the extreme south-west. The lake is very shallow, <1m except in artificial channels, and extensive areas dry out in summer. Substrate is soft, sandy mud with gravel near the barrier. Aquatic vegetation sparse. Reed and sedge beds occupy a large proportion of the total lake area.

The community characterized a closed, low salinity system and was dominated by oligohaline and limnic species. Aquatic taxa recognized - 47, eight lagoonal specialists (and a further two on previous occasions). **Notable species**: *Chara canescens*, *Gammarus salinus*, *Sigara concinna*, *Notonecta viridis*, *Plea leachi*, *Enochrus halophilus*, *Rhantus frontalis*, *Stenus nigritulus*, *Pungitius pungitius* (*Lamprothamnium papulosum*, *Cerastoderma glaucum*, *Mya arenaria* and *Zostera* sp. on previous occasions).

Scientific value of the site - exceptional, for its interesting geomorphology and typical lagoonal flora and fauna including rare species. The lake is a Special Protection Area for birds.

The geomorphological characteristics of the barrier are described in a number of papers, particularly Carter and Orford (1982) and Orford and Carter (1982).

Kilkeran Lake. A natural sedimentary lagoon with a broad dune barrier of sand and gravel. A natural outlet forms periodically, generally in winter, and the barrier is also breached occasionally by the local Council. There was no opening to the sea during the sampling period. Salinity remains low throughout the year except when an outlet forms naturally or the barrier is breached artificially. Salinity was 0-2‰ throughout the lake during the main sampling period but reached 5‰ in early July. Depth was <3m. Substrate mainly sand, with a deep covering of organic mud. *Potamogeton pectinatus* abundant, in dense beds. Reed and sedge beds occupied most parts of the shore.

The community was typical of a low salinity lagoon and was dominated by oligohaline and limnic species. Aquatic taxa recognized - 40, four lagoonal specialists. *Neomysis integer* and corixids were exceptionally abundant. **Notable species**: *Hydrometra gracilenta* (new Irish record), *Notonecta viridis*, *Sigara concinna* (abundant), *Cercyon marinus*, *Gabrius keysianus*, *Philonthus fumarius*, *Plumatella repens*.

Scientific value of the site - high, as a good example of a sedimentary lagoon containing some rare species. A water quality and phytoplankton survey was carried out on behalf of the National Parks and Wildlife Service in 1993-94.

Lissagriffin Lake. An artificial saline lake formed by construction of a causeway across a tidal inlet in Barley Cove. An unsluiced outlet allows entry of seawater on all tides and there are several outlet pipes through the causeway but a salinity gradient from the causeway inland is maintained by freshwater from two streams. Salinity near the causeway was 28‰ during a flowing tide and 6‰ at low tide, while near the shores it remained at 0-8‰. Depth was mostly < 1m and substrate was sand with softer muds in sheltered areas. Aquatic vegetation sparse and low-growing. Reed beds were present in the north, sedges and rushes on the south shore and a salt marsh near the causeway.

The community typified a brackish water system with medium to high salinity and open access to the sea. Aquatic taxa recognized - 31, three lagoonal specialists. **Notable species**: *Carabus clathratus*.

Scientific value of the site - low.

Farranamanagh Lake. A natural sedimentary lagoon with a cobble barrier and a permanent, natural sea inlet. Seawater probably enters on spring tides only and input from freshwater streams generally maintains a low salinity although wide fluctuations can occur. Salinity was 1-6‰ on one sampling occasion and 16-29‰ on another. Maximum depth 2m. Substrate is gravelly silt with peat in places and cobbles near the barrier. Aquatic vegetation sparse and patchy. Reed and sedge beds were present on parts of the lake shore.

The community was species-poor, probably limited by wide fluctuations in salinity. Aquatic taxa recognized - 23, three lagoonal specialists. **Notable species**: *Chaetomorpha mediterranea*.

Scientific value of the site - high, based on geomorphology and its unspoilt situation.

Drongawn Lough. A deep, natural saline lake with a narrow, silled inlet, surrounded by rocky peatland. The inlet is very shallow and seawater enters mainly at spring tides. Brackish conditions are probably maintained by slow release of freshwater from the surrounding peat. Salinity was 26-30‰ in the main body of the lake, but reached 34‰ near the inlet and 10‰ near the outlet of a small stream. Depth reaches at least 18m. Substrate mainly sandstone rock with stones and peat. Shores are steep and emergent vegetation scarce. Aquatic vegetation

consisted of marine algae and some *Ruppia*.

The species-rich community was dominated by marine-euryhaline species but with 18% of brackish species. Aquatic taxa recognized - 76, four lagoonal specialists. **Notable species**: *Sagartiogeton undatus*, *Jaera forsmani*, *Erichthonius difformis*, an ephemeral population of *Scaphander lignarius*.

Scientific value of the site - high, for its rich fauna and natural setting.

Lough Gill. A large, natural sedimentary lagoon on a sand tombolo, with a long, artificial, sluiced outlet (The Trench). The lake is surrounded by dune grassland. Little seawater enters and salinity was generally $<1‰$ except near the outlet, but 5‰ was measured in June at one site on the east shore. Depth was only 30-40cm in most regions. Substrate mainly firm sand. Aquatic vegetation dense. Extensive reed beds and some sedge beds fringe most of the shoreline.

A species-rich community was dominated by limnic species but with a significant element of brackish species. Aquatic taxa recognized -56, two lagoonal specialists. **Notable species**: *Cercyon sternalis*, *Gabrius keysianus*, *Philonthus fumarius*, *Salmo trutta* (the lake is an important trout fishery).

Scientific value of the site - high, as a example of a species rich lagoon evolving to a freshwater lake. The survival of brackishwater species depends on management policy.

Cloonconeen Pool (near Kilcredaun Point). A small lagoon in a peat-floored depression (probably an old peat cutting), with a low cobble barrier. The barrier lies on a peat platform which extends into the intertidal zone where there is a drowned forest. Seawater washes over the barrier at spring tides and the whole area is subject to flooding. Some freshwater enters by way of drainage ditches but the salinity remained $>30‰$ throughout the survey period. Depth about 80cm. Substrate soft peat. Aquatic vegetation patchy. The pool is bordered by a mainly narrow zone of sedges and rushes.

The low-diversity, species-poor system was dominated by euryhaline species. Aquatic taxa recognized - 17, eight lagoonal specialists. **Notable species**: *Chaetomorpha mediterranea*, *Brundinia meridionalis* (new Irish record), *Bembidion aeneum*. A population of *Cerastoderma glaucum* was dominated by juveniles.

Scientific value of the site - high, as an unusual lagoon type with a typical lagoonal fauna, but

an exceptionally high number of lagoonal specialists in a small area.

Lough Donnell. A natural sedimentary lagoon with a high cobble barrier and an artificial, unsluiced outlet pipe. Seawater enters through the outlet at high tides and by substantial percolation through the barrier, but a small river (Innageeragh R.) maintains low salinity except near the barrier. Salinity was 2-6‰ in all parts of the lake but 25‰ was measured in seepage water in patches of saltmarsh between the lake and the barrier. Depth only exceeded 1m in the region of the river mouth. Substrate is sand with stones near the barrier. Aquatic vegetation patchy and low-growing. Reed, sedge, and salt-marsh communities line the shore.

The community comprised euryhaline, oligohaline and limnic species. Aquatic taxa recognized - 35, three lagoonal specialists. **Notable species**: *Notonecta viridis*, *Cypha punctum*, *Bembidium bipunctatum*, *Dicentrarchus labrax* (bass).

Scientific value of the site - average. The site is notable for the height of the cobble barrier.

Lough Murree. A natural rock lagoon, separated from the sea by karstic limestone and farmland, fronted by a cobble barrier. Seawater enters through subterranean limestone fissures and, according to Pybus and Pybus (1980), the lake is fed by two freshwater springs. Salinity was 10-24‰ near the main seepage inflow, 13-15‰ in other parts of the lake, and 20-27‰ in an isolated pool between the lake and the sea. Depth 2m or less. Substrate is rock with deep deposits of sand, mud and gravel. Emergent vegetation sparse. Extensive beds of charophytes and *Ruppia* were present. A dense growth of *Enteromorpha* indicated nutrient enrichment.

The community was typical of a medium salinity lagoon without direct contact with the sea. Aquatic taxa recognized - 34, seven lagoonal specialists (and two further species recorded by Lansbury (1974). **Notable species**: *Chara canescens*, *Lamprothamnium papulosum*, *Jaera ischiosetosa*, *Brundinia meridionalis* (new Irish record), *Stenus nigritulus* (*Enochrus halophilus* on a previous occasion (Lansbury, 1974).

Scientific value of the site - high/exceptional, as an unusual lagoon in karst, containing vulnerable charophytes and a high proportion of lagoonal specialists.

An account of the fauna and flora and the salinity regime is given by Pybus and Pybus (1980).

Aughinish Lagoon. A natural sedimentary lagoon in karstic limestone with a cobble barrier and natural tidal inlet, formerly bridged. Spring tidal range in lagoon estimated to be about 50cm.

No freshwater inflows were apparent and the salinity remained close to that of seawater, or hypersaline, during the sampling period. Depth was mostly <2m. Substrate is bedrock with rocks, cobbles and soft sediments. Areas of saltmarsh were present around the lagoon, emergent vegetation absent. Aquatic vegetation consisted of algae only.

The fauna and flora were almost entirely marine, and characteristic of a tidal system. Brackishwater species were absent because the karst landscape severely limits the supply of surface freshwater. Aquatic taxa recognized - 71, one lagoonal specialist (single specimen), and a further one on a previous occasion. **Notable species**: *Cystoseira foeniculacea*, *Gammarus chevreuxi*. *Cerastoderma glaucum* was recorded by Boyden and Russell (1972).

Scientific value of the site - high, as an example of a tidal lagoon in karst.

Bridge Lough. A shallow, artificial saline lake in karst, formed by construction of a causeway across a sea inlet. Seawater enters through a sluiced outlet and possibly also through limestone fissures. Salinity was 31-38‰ during two sampling visits. Depth mostly <1m. Substrate consists of bedrock with rocks and cobbles, covered by a thick layer of organic mud. There were small areas of saltmarsh on the shoreline but no emergents. Aquatic vegetation consisted of dense masses of unattached *Chaetomorpha* and some *Ruppia*. There were signs of nutrient enrichment from surrounding farmland.

The community consisted of marine and euryhaline species. Aquatic taxa recognized - 24, seven lagoonal specialists (the lagoon was undersampled). **Notable species**: *Chaetomorpha mediterranea* (very abundant), *Limapontia depressa*, *Actinia equina* (melanic form), *Idotea chelipes* (very abundant), *Brundinia meridionalis* (new Irish record), *Cerastoderma glaucum*.

Scientific value of the site - low, due to nutrient enrichment and poor prospects for amelioration (a proper evaluation was not possible due to restricted access).

Lettermullen Pool. A small rock lagoon, separated from the sea by a granite sea shore, receiving seawater at spring tides and by overwash during storms. Freshwater enters from a small stream and from runoff from the surrounding peatland. Salinity remained close to that of seawater during the sampling period but 26‰ was recorded in a previous year (BH). Depth reaches 4m. Substrate mainly bedrock with patches of organic, silty sand. Aquatic vegetation in dense zones and patches with beds of *Zostera*, *Ruppia*, charophytes and marine algae.

The species-rich community comprised an unusual mix of marine and brackishwater species.

Aquatic taxa recognized - 71, eight lagoonal specialists (and a further three on other occasions). **Notable species**: *Chaetomorpha mediterranea*, *Lamprothamnium papulosum*, *Zostera marina*, *Laomedea angulata*, *Littorina "tenebrosa"*, *Onoba aculeus*, *Cerastoderma glaucum*, *Conger conger*, *Molva molva* (ling).

Scientific value of the site - exceptional, as a completely natural system containing a diverse fauna and flora including some rare species and a high number of lagoonal specialists.

Loch Tanaí (Loch Nacrimina). A natural, or possibly man-made, saline lake in rocky peatland with a long tidal inlet. The lake may have formed in a former peat cutting and the channel may then have been cut for drainage. Seawater enters at spring tides but tidal fluctuations are small. Freshwater enters from one permanent stream and drains from the surrounding peat, but salinity remained high during the sampling period; 28-32‰ was measured throughout most of the lake and 14-27‰ in the south-west where a small stream enters. Depth was 50-120cm. Substrate is unconsolidated peat with rocks. The aquatic vegetation was diverse with *Zostera*, *Ruppia*, fucoid algae and abundant charophytes. Emergent vegetation sparse.

The community consisted of marine and brackishwater species characterizing high salinities. Aquatic taxa recognized - 46, ten lagoonal specialists. **Notable species**: *Chaetomorpha mediterranea*, *Lamprothamnium papulosum*, *Littorina "tenebrosa"*, *Akera bullata* (ephemeral population), *Cerastoderma glaucum*, *Philonthus fumarius*, *Stenus opticus*, *Syngnathus typhle*.

Scientific value of the site - exceptional, as an unusual lagoon type with a high proportion of lagoonal specialists and rare species.

Lough Aconeera. A natural saline lake in rocky peatland with a bridged, natural (?) tidal inlet. Seawater enters on all tides but brackish conditions are maintained by a freshwater stream and by drainage from the surrounding peat. The salinity varied with tides but remained between 10 and 14‰ during the sampling period and there was evidence of stratification. Depth mostly 1-1.5m but reaches 5m. Substrate mainly granite bedrock with boulders and patches of sand, silt, and unconsolidated peat. The aquatic vegetation consisted of fucoid algae, *Ruppia* and charophytes. Reed and sedge beds occupied parts of the margin.

The somewhat species-poor community typified meso-euhaline waters. Aquatic taxa recognized - 28, six lagoonal specialists. **Notable species**: *Chara baltica* (new Irish record), *Agonum nigrum*, *Mya arenaria*, *Cerastoderma glaucum*.

Scientific value of the site - exceptional for flora, otherwise moderate. A good example of a western saline lake.

Mill Lough. A natural saline lake in rocky peatland with a natural, but modified, tidal inlet. Seawater probably enters on all tides, and freshwater enters from a stream. The salinity varied widely according to tide cycle from 2-5‰ on one occasion to 20-31‰ on another. Water near the stream mouth remained at 2-6‰. Depth mostly 1-2m. Substrate is granite bedrock with patches of sand and unconsolidated peat. Aquatic vegetation was sparse except near the inlet where there were fucoid algae. Patches of rushes and reeds present on the shore.

The community typified a brackishwater lagoon with a tidal inlet and medium to high salinity. Aquatic taxa recognized - 34, five lagoonal specialists. **Notable species**: *Cerastoderma glaucum*.

Scientific value of the site - low to moderate, a typical lagoonal community without special features.

Corragaun Lough. A natural sedimentary lagoon with a long, natural tidal inlet. The lake lies behind a low sand bank and seawater enters on most tides. A small river enters at the head of the lake. Salinity undergoes wide fluctuations according to tides; 0-1‰ was measured at the seaward end of the lake in June and 15-32‰ in September. Depth was 20-70cm and substrate mainly sand with some silt, and unconsolidated peat especially at the east end. Aquatic vegetation scarce. Salt marsh and stands of rushes were found on the shore and a reed bed was present at the river mouth. The topography of the lagoon has changed since the 1970s when a diverse aquatic flora was described (Bekkers *et al.*, 1976; Verhoeven, 1980).

The community was species-poor and dominated by euryhaline species. Aquatic taxa recognized - 23, three lagoonal specialists. **Notable species**: none.

Scientific value of the site - low, interesting for its history and geomorphology but species-poor. The site is of value, however, as one of a series of lagoons in the area in different successional stages.

Roonah Lough. A natural sedimentary lagoon in dune grassland, with a cobble barrier and a natural, but artificially repositioned, outlet. Seawater enters through the outlet at spring tides but freshwater from two rivers maintains a low salinity which remained close to 0‰ during the sampling period. Depth mostly 25-80cm. Bed sandy with some silt and unconsolidated peat.

Aquatic vegetation sparse with green algae, low-growing *Ruppia*, and charophytes. Wide sedge beds occupied parts of the shoreline.

The community was dominated by limnic species, typifying a low salinity system. Aquatic taxa recognized - 37, two lagoonal specialists. *Neomysis integer* very abundant. **Notable species**: none.

Scientific value of the site - low as a lagoon, with few lagoonal specialists or species of interest (but see Corragaun L.).

Furnace Lough. A large, deep, natural saline lake in a drumlin landscape, with a natural, but modified, tidal inlet. Seawater flows in at high tides but is impeded by two weirs, and freshwater enters from streams and from L. Feeagh. The salinity varies spatially and the water is permanently stratified. Salinity was 10-22‰ near the weirs and 0-15‰ near the north end. A small pool connected by a narrow channel, with a salinity of about 3‰, was included in the survey. Depth is mostly 1-9m but reaches 21m. Substrate consists of rocks, sand, organic silt and some peat. Aquatic vegetation was sparse with *Ruppia*, *Potamogeton*, green algae and some charophytes. There were few emergents.

The community comprising marine, brackish and freshwater species reflected the combined effects of open access from the sea and a substantial freshwater inflow. Aquatic taxa recognized - 41, five lagoonal specialists. **Notable species**: *Leptocheirus pilosus*, *Lembos longipes*, *Jaera ischiosetosa*.

Scientific value of the site - high, as a large, deep saline lake with salinity gradients and interesting hydrology.

The lake and its fauna were described by Parker (1977), Parker and West (1979) and Poole (1994).

Durnesh Lake. A natural sedimentary lagoon behind a high barrier of dunes formed on drumlins, fronted by cobbles, with an artificial, sluiced outlet. Seawater appeared to enter through the outlet only and the salinity remained between 0-7‰ throughout the lake except near the outlet pipe where 19‰ was measured on one occasion. Depth generally < 1.5m. Substrate mainly sand with stony and muddy shores. Aquatic vegetation well developed and diverse with *Ruppia*, *Potamogeton*, and charophytes. There were extensive beds of reeds and sedges.

The species-rich community typified an isolated lagoon with small marine influence, dominated by limnic species, including 17 species of aquatic Coleoptera and four charophyte taxa. Aquatic taxa recognized - 60, six lagoonal specialists. **Notable species**: *Chara canescens*, *Cordylophora caspia*, *Gammarus chevreuxi* (abundant), *Gyrinus aeratus*, *Diglotta sinuaticollis*, *Philonthus furcifer*, *Schistoglossa gemina*.

Scientific value of the site - high, as a species-rich, low salinity lagoon containing some species which are rare in Ireland.

Discussion

The diversity of geological landforms which make up the Irish coastline has resulted in the formation of a wide range of lagoon types, both natural and artificial. Compared with England, Ireland has a greater number of large, natural, or nearly natural, lagoons, and some types such as karstic lagoons which may be unique to this country. Others like peat lagoons and deep, silled lakes also occur in Scotland (Waterston *et al.*, 1979; Smith, 1984; Covey *et al.*, 1998; Thorpe, 1998), while some artificial drainage systems of south-east Wexford and Donegal have their counterparts in The Netherlands. The total area of Irish lagoons, relative to the length of the coastline, cannot easily be compared with Britain where a high proportion of the those surveyed, including several designated for conservation, are less than 1ha in size (Barnes, 1989; Sheader and Sheader, 1989; Smith and Laffoley, 1992; Bamber, 1997) whereas systems less than 0.75ha in area were ignored during the present survey. The total area of Irish lagoons is estimated to be around 3000ha compared with approximately 1300ha in England (including The Fleet at around 470ha). Lagoons in mainland Scotland and the inner Hebrides total less than 300ha but this inventory may be incomplete. An estimated lagoon area of 1310ha for Orkney and Shetland includes Britain's largest lagoon, the Loch of Stenness, measuring 860ha. Estimates for other European countries are not available. The comparatively high level of "naturalness" of lagoons in Ireland reflects the country's history of late urbanization and the persistence of traditional rural practices. Coastal lagoons are under threat throughout Europe, especially from land reclamation schemes, thus those in Ireland are valuable remaining examples of habitats which were formerly more widespread.

Only 20 out of a probable total of between 80-100 lagoons and lagoon-like systems have been

properly investigated, thus it may be premature to generalize about the characteristics of Irish lagoon communities, but preliminary sampling in 30 others indicates that the 20 sites analysed are broadly representative. The total number of aquatic species recorded is surprisingly high, lagoons being generally poor in species in comparison with freshwater lakes and tidal estuaries. This is in spite of the short time available for sampling of individual sites, and limitations such as the vegetation survey being confined to shallow water, most sampling of aquatic fauna carried out in summer when some insect larvae are absent or too small to be identified, and the failure to identify some groups, particularly some filamentous algae and all Nemertea and dipteran larvae. A total of 248 taxa of aquatic fauna (220 identified to species), with a maximum per site of 70 and a minimum of 14 (Table 4), far exceeds the numbers recorded during most comparable surveys in other regions of western Europe, e.g. a total of 44 species and a maximum of 17 in 26 East Anglian lagoons (Barnes, 1987), a total and maximum of 47 in 166 British lagoon-like systems (excluding The Fleet) (Bamber *et al.*, 1992), a total of 58 and a maximum of 36 in 14 *Ruppia* communities in The Netherlands (Verhoeven, 1980) and a total of 77 and a maximum of 25 in 18 *Ruppia* communities in the Camargue and Corsica (Verhoeven, 1980). Only in The Fleet (southern England), a tidal, linear lagoon, intensively studied, especially for algae (150 spp) and molluscs (57 spp), and in Scotland where lagoonal systems remain largely natural and where topography apparently limits the supply of freshwater so that salinities are generally high (Covey *et al.*, 1996), does species richness approach that of Irish lagoons. Totals of 216 faunal spp (33 sites) for mainland Scotland and the Inner Hebrides (Covey *et al.*, 1998), and 207 spp (34 sites) in Orkney and Shetland (Thorpe, 1998), include no insects other than chironomid larvae. The aquatic vegetation of Irish lagoons is also species-rich in comparison with lagoons elsewhere where charophytes in particular have succumbed to pollution; charophytes have completely disappeared from enclosed brackish waters in The Netherlands as a result of eutrophication (Verhoeven, 1980). As lagoons are particularly subject to variations in species composition from year to year, longer studies could be expected to extend lists for most Irish sites. In Lady's Island Lake, 98 species were recorded over a period of 17 years (Healy, 1997) but only 45 species were identified during this survey.

One reason for the apparent richness of Irish lagoons may be the large size of those selected for study in comparison with lagoons surveyed elsewhere. For example, the majority of lagoons

investigated in Britain were less than 4ha (Bamber *et al.*, 1992) and only one in England and one in Scotland exceeded 50ha. In contrast, only one of the 20 lagoons reported here is less than 4ha and six are 50ha or more. In The Netherlands and in Mediterranean regions, many of the sites sampled were small ponds or ditches. The species area relationship holds for most of the sites studied in the present survey but where rocks were present, sessile and cryptic species contributed to exceptionally rich faunas and macrophytic algae extended the floral lists. Other factors contributing to the apparent richness of Irish lagoons are the inclusion of sites on rocky coasts (rare elsewhere except in Scotland) where rocky shore species invade through inlets, the inclusion of oligohaline sites, largely excluded by British survey teams (none of the Norfolk Broads, where salinity can reach 8‰ (Moss, 1994) were considered to be lagoons), a number of fish taken in fyke nets which are not normally used in such studies, and a high proportion of aquatic insects (over 30% of all taxa), some of which may not be permanent inhabitants of the systems investigated. In the majority of British surveys, aquatic insects were generally ignored or not identified to species (Sheader and Sheader, 1989) so it is not possible to make a direct comparison. It seems likely, however, that aquatic insects are indeed more frequent in Irish lagoons and their presence, and wider tolerance limits, may be due to the mild climate (Foster, 1998).

The occurrence of lagoonal specialists, i.e. species found only in lagoons or distinctly more frequent in them than in other brackish habitats, is a useful criterion for the scientific evaluation of lagoons because the vulnerability of such species is implicit in the designation of lagoons as a priority for conservation in Europe. However, deciding what constitutes a lagoonal environment, and therefore which species should be recognized as lagoonal specialists, is subject to different interpretations. A number of species on the British list are very rare, some known only from single sites, and their potential ecological range is thus unknown. Barnes' list (1989), which was broadly equivalent to Verhoeven's (1980) category of species occurring in "blocked brackish waters" in The Netherlands, included a number of species known to be frequent in salt marshes and sheltered regions of estuaries. Some of these were subsequently removed and a recent reassessment of the list (Joint Nature Conservation Committee, 1996) resulted in exclusion of many species widely found in brackish ditches and other "non-lagoonal habitats", including all but one insect (*Paracymus aeneus*). We have taken the view that all

types of sheltered brackish waters are vulnerable to degradation and reclamation, therefore all species which characterize them deserve protection wherever feasible. Such species are most likely to survive where they form large populations in the larger lagoons. By restricting the list of lagoonal specialists to those which only inhabit lagoons, more widespread species might be in danger of being undervalued and their decline go un-noticed.

Many of the lagoonal specialists are widespread, occurring in Europe from the eastern Baltic to the Mediterranean (Verhoeven, 1980), but others have a more restricted distribution. Among the 43 species of lagoonal specialist identified for Britain (mainly England), 15 are rare there, often recorded from single sites, and two (*Edwardsia ivelli* and *Tolypella nitida*) may already be extinct (Table 1). The evaluation of lagoons in Britain has centred around the occurrence of these rare lagoonal specialists which are especially prone to extinction, although some may be common in other parts of Europe, e.g. *Chara baltica* which is widespread in the Baltic. The number of lagoonal specialists recorded in Irish lagoons (20, including two previous records) compares favourably with British surveys, e.g. Bamber (1997) recorded 11 lagoonal specialists in a survey of 43 sedimentary lagoons in the south of England. Only two of the eight specialist plant species, one of which may be extinct in England and has never been recorded in Ireland, were not found during the present survey and most of the others are distinctly more frequent here. Oliver and Healy (1998) make tentative suggestions for a revised version of the list of faunal specialists for Ireland.

There are few published records of flora and fauna from Irish lagoons and most of those which exist provide little information on the environment. In many publications, the locality of aquatic species is often described by a vague term such as "coastal" and it is not known if the waters sampled were measurably saline. Salinity is, in fact, rarely measured by recorders of brackishwater species and the brackish nature of low-salinity systems in particular frequently goes unnoticed (it was also unrecognized, or ignored, by coastal surveyors and many Irish lagoons are coloured "fresh" on marine charts). Consequently, the salinity ranges of plant and animal species in Ireland are largely unknown. Salinity meters are admittedly expensive but the human tongue is a sensitive instrument and even a "tasting" can provide useful information.

Brackish waters are traditionally studied by marine biologists and this has imposed a bias in Britain towards the study of marine groups and an emphasis on highly saline lagoons selected

for conservation (Sheader and Sheader, 1989). The tolerance of reduced salinity by marine euryhaline species, which form a significant component of high salinity lagoons, is therefore quite well documented. In contrast, much less attention has been paid to the ability of freshwater species to withstand salt, and salinity tolerance limits are known for only a few. There is evidence from this survey that some species may tolerate higher salinities in Ireland, or have wider tolerance limits, than in Britain. This is suggested by the widespread occurrence of hemipterans and beetles in brackish waters, sometimes at salinities approaching that of seawater, and the close association in some lagoons of charophytes and *Ruppia* with diverse communities of marine algae. Further investigations are needed to determine whether Irish populations are indeed more tolerant or whether there is some feature of the lagoon environments in Ireland which enable them to survive over a wider range here.

The continuing loss of lagoon-like habitats is probably inevitable in the face of natural infilling processes, rising sea level and expanding urban developments. Most of the sites where natural lagoons might have formed are now protected by coastal defences, therefore there can be few new ones to replace those lost. In terms of area, lagoons are one of the most restricted habitats in Ireland. They form part of highly dynamic coastal systems which are subject to far-reaching and sometimes rapid changes as a result of ongoing coastal processes, storms, or human interference, as well as more gradual changes due to infilling and succession. Brackish lagoons can, gradually or almost overnight, become transformed into tidal sea inlets or freshwater lakes. Special strategies are therefore required to conserve lagoonal species and communities. A protected network of lagoons is needed, in different evolutionary stages, if the full range of diversity is to be maintained. To ensure the long-term integrity of the network, it is essential that lagoons currently in a freshwater phase be conserved as part of the network. Monitoring programmes should be concerned with hydrology and geomorphology as well as water quality and biota if change is to be predicted and appropriate action taken. Where already vulnerable species are further threatened, creation of suitable artificial systems might be considered.

A number of lagoonal specialists are now believed to be rare in western Europe and their range and populations are declining as a result of pollution and drainage of their habitat. Even species which are currently widespread are considered vulnerable. It is for this reason that

lagoons have been designated as a priority habitat for conservation in the EU Habitats Directive. Ireland is fortunate in possessing a wide range of lagoon-like habitats which are not under immediate threat and are potentially important refuges for endangered species. Several authors e.g. Williams (1973) and Nelson *et al.* (1997) have stressed the importance of identifying existing populations of vulnerable lagoonal species in order that they might be monitored and protected. It is our wish that more specialists will turn their attention to this neglected habitat in Ireland.

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TABLE 1. Specialist lagoonal species in Britain (species distinctly more characteristic of lagoon-like habitats than of freshwater, estuarine brackish waters or the sea). Species present only in the larval phase omitted. After Barnes (1989), with the addition of *Ruppia* spp, and two species added by Bamber (1997), and modification to the list of beetles according to Foster (1998). (For species recorded during the survey, see Table 5)

Cnidaria
- *Clavopsella navis* [B]
- *Gonothyrea loveni*
- *Edwardsia ivelli* [†]
- *Nematosella vectensis*

Polychaeta
- *Armandia cirrhosa* [r]
- *Almaria romijni*

Crustacea
- *Paramysis nouveli* [B]
- *Lekanesphaera hookeri*
- *Idotea chelipes*
- *Gammarus chevreuxi*
- *G. insensibilis*
- *Corophium insidiosum*
- *Palaemonetes varians*

Mollusca
- *Hydrobia neglecta*
- *H. ventrosa*
- *Onoba aculeus*
- *Littorina tenebrosa*
- *Cerastoderma glaucum*
- *Tenellia adspersa* [r]

Insecta
- *Sigara concinna*
- *S. stagnalis*
- *S. selecta*

Insecta (cont.)
- *Agabus conspersus* [r]
- *Berosus fulvus* [r]
- *Hygrotes parallelogrammus* [r]
- *Dytiscus circumflexus* [r]
- *Enochrus bicolor*
- *E. halophilus*
- *E. melanocephalus* [x]
- *Haliplus apicalis* [r]
- *Ochthebius marinus* [r]
- *O. punctatus* [r]
- *Paracymus aeneus* [r]

Bryozoa
- *Conopeum seurati*
- *Victorella pavida* [r]

Algae
- *Chaetomorpha linum*

Charophyta
- *Chara canescens* [r]
- *C. baltica* [r]
- *C. connivens* [r]
- *Lamprothamnium papulosum*
- *Tolypella n. nidifica* [†]

Angiospermae
- *Ruppia maritima*
- *R. cirrhosa* [a]

[B] Species added by Bamber (1997)

[r] Rare species, or not recorded during the British national survey (Barnes, 1989). They may be more widespread in Ireland however.

[†] Now believed to be extinct.

[a] Some versions of this table list either *R. maritima*, *Ruppia* spp or *Ruppia*. It is assumed that *R. cirrhosa* is also considered to be a lagoonal specialist.

[x] Not believed by coleopterists to be a lagoonal specialist.

TABLE 2. Distribution of the four main lagoon types (sedimentary lagoon, rock lagoon, natural saline lake and artificial saline lake) in eight regions of the coastline.

	Sed. lagoon	**Rock lagoon**	**Nat. sal. lake**	**Artificial sal. lake**	**Total**
Dublin-Wexford	2	0	0	4	6
Cork	4	0	0	11	15
Kerry	1	0	1	0	2
Clare	3	2	0	1	6
Galway	3	1	8	1	13
Mayo	4	0	1	1	6
Sligo	1	0	0	0	1
Donegal	1	0	4	2	7
TOTAL	**19**	**3**	**14**	**20**	**56**

Table 3. Location, type, size and salinity range of the lagoons sampled. Grid references refer to the centre of the lagoon. Salinity ranges are for the period June-October 1996 only. Lagoon types: sed. lag. - sedimentary lagoon, rock lag. - rock lagoon, nat. sal. - natural saline lake, art. sal. - artificial saline lake.

Name	County	Nearest town or village	OS Grid Reference	Lagoon type	Area (ha) (approx.)	Salinity range ‰
Lady's Island Lake	Wexford	Rosslare	T099065	sed. lag	450	4-26
Tacumshin Lake	Wexford	Rosslare	T050065	sed. lag	450	0-35
Kilkeran Lake	Cork	Rosscarbery	W338344	sed. lag	15	0-5
Lissagriffin Lake	Cork	Crookhaven	V775265	art. sal.	12	4-30
Farranamanagh Lake	Cork	Kilcrohane	V830378	sed. lag	5	1-27
Drongawn Lough	Kerry	Sneem	V731640	nat. sal.	20	10-34
Lough Gill	Kerry	Castlegregory	Q606142	sed. lag	160	0-5
Cloonconeen Pool	Clare	Carrigaholt	Q836497	sed. lag	5	33-35
Lough Donnell	Clare	Quilty	R002707	sed. lag	20	0-6
Lough Murree	Clare	Ballyvaughan	M255119	rock lag	20	10-27
Aughinish Lagoon	Clare	Kinvarra	M286134	sed. lag	10	31-40
Bridge Lough	Galway	Kinvarra	M342128	art. sal.	5	31-38
Lettermullen Pool	Galway	Lettermullen	L827213	rock lag.	1	34-37
Loch Tanaí	Galway	Costelloe	L950305	nat. sal.	12	28-34
Lough Aconeera	Galway	Kilkieran	L875369	nat.sal.	28	0-14
Mill Lough	Galway	Carna	L755331	nat.sal	5	2-34
Corragaun Lough	Mayo	Killadoon	L748698	sed. lag	7	0-32
Roonah Lough	Mayo	Killadoon	L755765	sed. lag	50	0-2
Furnace Lough	Mayo	Newport	L965975	nat.sal	125	2-22
Durnesh Lake	Donegal	Ballintra	G878695	sed. lag	30	0-7

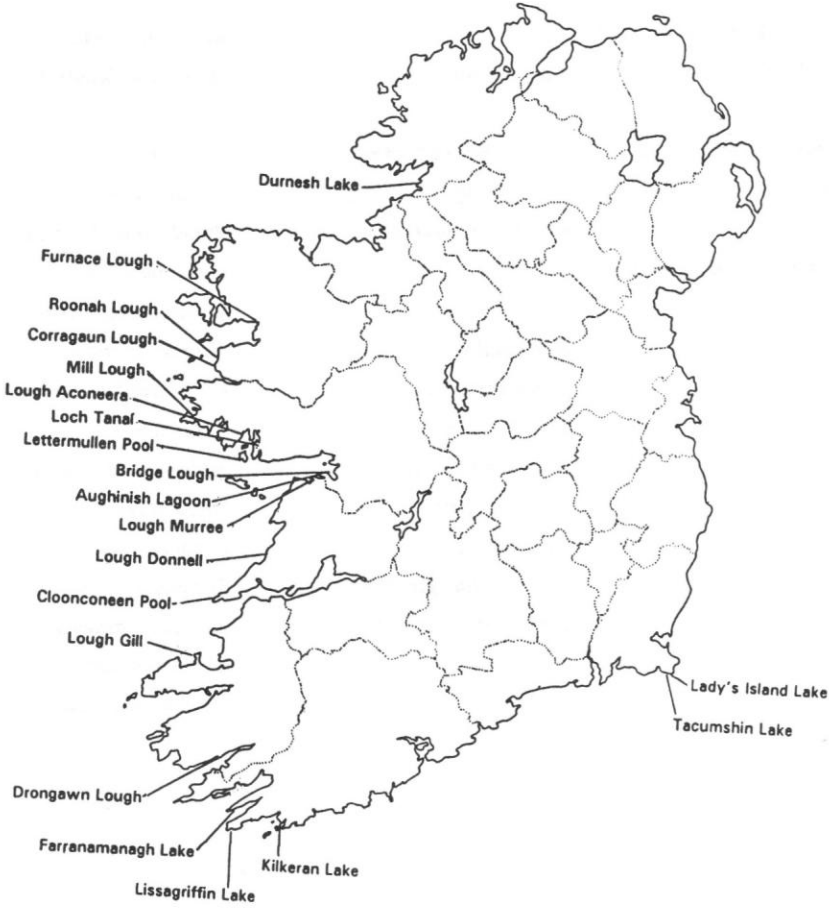
TABLE 4. Number of taxa of aquatic flora (angiosperms and charophytes + non-charophyte algae), aquatic fauna, and lagoonal specialists (flora + fauna + coleopteran indicator species) in relation to lagoon area, presence of rock, and salinity regime (range, spatial and temporal variation).

	Flora	Fauna	Lag. spec.	Area (ha)	Rock	Sal. range	Spatial var.	Temp. var.
Lady's Island Lake	5+2	38	3+8+3	450	*	4-26	large	small
Tacumshin Lake	7+2	37	2+6+1	450		0-19	large	small
Kilkeran Lake	4+2	35	1+3+2	16		1-5	med.	small
Lissagriffin Lake	1+6	24	1+2+1	12		4-30	large	large
Farranamanagh Lake	1+5	17	2+1+0	5		1-27	small	large
Drongawn Lough	1+5	70	1+3+0	20	**	10-34	small	small
Lough Gill	7+2	47	1+1+2	160		0-5	small	small
Cloonconeen Pool	1+2	14	2+6+2	4		30-36	small	small
Lough Donnell	1+2	32	1+2+2	20		0-6	small	small
Lough Murree	5+4	25	4+3+2	15	**	10-24	small	small
Aughinish Lagoon	0+15	56	0+1+0	10	**	31-40	small	small
Bridge Lough	1+5	17	2+5+1	5	*	30-38	small	small
Lettermullen Pool	3+15	52	3+5 (-)	1	**	34-37	small	small
Loch Tanaí	4+5	39	3+7+2	12	*	28-32	small	small
Lough Aconeera	3+3	22	2+4+1	28	**	0-14	med.	med.
Mill Lough	1+3	30	1+4+0	5	*	2-34	med.	large
Corragaun Lough	1+2	20	1+2+0	7		0-32	small	large
Roonah Lough	3+2	32	1+1+0	50		0-2	small	small
Furnace Lough	5+2	34	2+3+0	125	*	0-22	large	med.
Durnesh Lake	10+2	48	3+3+3	70		0-7	small	small

TABLE 5. Lagoonal specialists (aquatic flora and fauna) and indicator species (shore Coleoptera) recorded during the survey of 20 Irish lagoons.

Lagoonal specialists		**Indicator species**
Aquatic flora	**Aquatic fauna**	**of shore Coleoptera**
Chaetomorpha mediterranea	*Lekanesphaera hookeri*	*Atheta gyllenhali*
Chara baltica	*Idotea chelipes*	*A. liliputana*
C. canescens	*Gammarus chevreuxi*	*Brundinia meridionalis*
Lamprothamnium papulosum	*Palaemonetes varians*	*Cypha punctum*
Ruppia cirrhosa	*Sigara concinna*	*Diglotta sinuaticollis*
R. maritima	*S. stagnalis*	*Gabrius keysianus*
	Enochrus bicolor	*Philonthus fumarius*
	E. halophilus	*P. furcifer*
	Hydrobia ventrosa	*Schistoglossa gemina*
	Littorina "tenebrosa"	*Stenus nigritulus*
	Onoba aculeus	*S. opticus*
	Cerastoderma glaucum	*Agonum nigrum*
	Conopeum seurati	*Bembidion aeneum*
		B. bipunctatum
		Carabus clathratus

FIGURE 1: the sampled Irish coastal lagoons.



INSTRUCTIONS TO CONTRIBUTORS

1. Manuscripts should follow the format of articles in this *Bulletin*.

2. Manuscripts should be submitted as typed copy on A4 paper, using double-spacing and 2.5cm (1 inch) margins. Whenever possible, also submit the text on diskette. Wordperfect 5.1 is preferred.

3. Figures should be submitted in a size suitable for reduction to A5 without any loss of detail.

4. Records: please ensure that, when possible, the following information is incorporated in each record included in a manuscript:-
(a) latin name of organism.
(b) statement of reference work used as the source of nomenclature employed in the text. The describer's name should be also given when a zoological species is first mentioned in the text.
(c) locality details including at least a four figure Irish grid reference (e.g. N3946), county, vice-county number and some ecological data about the collection site, plus date of capture.
(d) collector's name and determiner's name (where different from collector's name), and
(e) altitude data should be included where relevant.

(5). Manuscripts should be submitted to the Editor, Dr J. P. O'Connor, at the following address:- National Museum of Ireland, Kildare Street, Dublin 2, IRELAND.

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