COASTAL LAGOONS IN THE REPUBLIC OF IRELAND

VOLUME I

BACKGROUND, OUTLINE AND SUMMARY OF THE SURVEY

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February 1997

Prepared for the National Parks and Wildlife Service

This volume contributes to BioMar,
a project part-funded by the European Commission under the LIFE programme

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1. INTRODUCTION, BACKGROUND AND OBJECTIVES

1.1 INTRODUCTION

1.1.1 Purpose of the Survey

The Habitats Directive (92/43/EEC) identifies coastal lagoons as a high priority for conservation. All member states are therefore obliged by European law to evaluate the lagoons within their national territories and protect those deemed worthy of conservation.

At present, there is no existing comprehensive account of coastal lagoons in Ireland and they are not included in ongoing coastal surveys. Only a small proportion of those known has been described although some information is available for those important for their ornithological value. The geomorphology of barrier systems has been studied on a few limited sections of the coastline especially in Wexford.

The objectives of this survey, therefore, are:

- to identify all coastal lagoons and briefly describe them;
- to classify those identified according to geomorphological type, hydrological regime and biotic communities;
- to evaluate the sites identified and select 20 representative ones for further study.
- to provide descriptions of the selected sites and assess their conservation value.

1.1.2 Definition of Lagoons

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). The Manual allows that "salt basins and salt ponds may also be considered as lagoons, providing that they had their origin on a transformed old natural lagoon or on a salt marsh, and are characterised by a minor impact from exploitation".

The CORINE classification of biotopes on which the above definition is based was developed chiefly for terrestrial habitats, however, and that used for marine habitats is provisional and has proved to be unsatisfactory. A classification of benthic marine biotopes of the north-east Atlantic to replace the existing one is being developed by the Marine Nature Conservation Review (MNCR) in Britain in association with BioMar. The lagoon sub-group which met in November 1994 agreed on a definition of lagoons as **"marine saline systems where the normal tidal range and exchange of water are reduced by physical features, but water is continually present"**. This broad definition includes silled sea inlets, sluiced pools and bayheads as well as lagoons in the strict sense i.e. with sedimentary barriers.

The European Union for Coastal Conservation ECOCOAST project proposes a much narrower definition: **"Shallow, virtually tideless, pond- or lake-like bodies of coastal salt or brackish water that are isolated from the sea by sedimentary barriers, but which nevertheless receive an influx of water from the sea."** These are considered to be "true lagoons" or "sedimentary lagoons" in this report.

The Habitats Directive definition refers to geomorphological formations which owe their existence to sedimentary processes or sea-level changes. Although artificially created systems are not specifically excluded, natural origins are implied. However, as almost all lagoons in Europe have been modified in some way by human interference, it also seems reasonable to allow inclusion of natural systems which owe their brackish nature to artificial constructions. There are, in fact, no differences between the communities of natural lagoons and those of artificial brackish waters. In designating coastal lagoons as a high priority for conservation, the chief intent is to conserve natural systems with their characteristic physiography and ecology, but artificial ones with good fauna may well be worth consideration.

Some difficulty was experienced in deciding what actually constitutes a lagoon as defined by the Habitats Directive. According to our interpretation of the definition, a coastal lake is a lagoon if it is shallow, has a measurable salinity (i.e. 1‰ or more), and is separated from the sea by a barrier of sand, shingle or rock. Neither depth of water nor barrier width are defined. In the literature, the barrier is usually described as being narrow, allowing percolation or overwash of seawater, or having a short inlet. Where a broad barrier has evolved by accretion e.g. as a series of dune ridges which preclude percolation or overwash, and connection with the sea is by a channel only, the lake may be viewed as an old lagoon. The definition would appear to exclude deep lakes e.g. brackish sea loughs with tidal rapids, and those where the barrier is broad and the only connection with the sea is by way of a long channel through bog, heath or farmland. An intent to exclude these types is uncertain, however.

Part of the difficulty involved in deciding what is and what is not a lagoon derives from the traditional view of lagoons as marine habitats which are therefore studied by marine biologists whose interest is inversely related to salinity. On the other hand freshwater biologists show little interest in lakes with any marine influence. Insects, for example, are frequently not identified (no beetles, dragonfly larvae, or caddis larvae, and only three corixids, were identified to species during a five year survey of English lagoons (Smith and Laffoley 1992) and their salinity tolerances are largely unknown. In practice, many coastal lakes are only slightly saline and it would be more appropriate to consider them as freshwater systems receiving small influxes of water from the sea. The literature on low salinity systems is poor, however, and it is not clear whether their biota should be treated as communities distinct from those of true freshwaters.

In view of the uncertainties surrounding the present and future definitions of lagoons, and the possible value of artificial systems as reservoirs of threatened lagoonal species, this inventory includes all lagoons in the strict sense, including those which become hypersaline, and all isolated or semi-enclosed waters which are measurably brackish or where some seawater influence can be detected, regardless of origin. In this way, a wide range of geomorphological formations and species assemblages could be identified.

1.2 COASTAL LAGOONS

1.2.1 Classification Of Lagoons

Lagoons are defined and classified differently by different authors. In a survey of British lagoons (Barnes 1989, Sheader 1989, Davidson *et al.* 1991), two main types were recognised: natural saline lagoons formed behind shingle or sand barriers, and natural or artificial saline ponds. Barnes (1989) defined eight types of natural lagoon on the basis of location and physiomorphological characteristics, the main types being isolated lagoons, percolation pools and sea inlets. Sheader (1989), divided saline ponds into five categories, a large proportion of which were artificial or of mixed origin.

In this report, lakes which have natural sedimentary or rock barriers which allow percolation or overwash and are shallow are termed **lagoons.** All others, including artificial systems, are called **saline lakes** or **pools** (the term "pond" used in England did not seem appropriate for the generally much larger water bodies visited in this survey.) For convenience, both types are sometimes referred to collectively as "lagoons" in this report.

Lagoons

- *Sedimentary Lagoons*, or "true lagoons", are formed by partial or complete enclosure of a bay or inlet by longshore or onshore movements of sediment or, more rarely, by transgression of seawater into a freshwater lake. Typically, they are more or less isolated from the sea by a barrier of sand, gravel or shingle, which allows discharge of water by seepage and through which some seawater percolates landwards. A narrow inlet/outlet may persist allowing seawater to enter at high tides but the tidal flow is always small. Lagoons are all recent and transient features which owe their origins to relative changes in sea level or the action of local water currents. In geological terms they are unstable systems, subject to variations in erosion and sedimentation processes and to changes in sea level. The barrier itself may be undergoing continual changes resulting in narrowing, broadening or migration of the outlet and variation in the frequency of overwash.

- *Rock lagoons* occur chiefly in limestone areas where seawater is able to penetrate landward through subterranean fissures in the rock. Also included here are large, brackish, supralittoral rock pools into which seawater may wash at high tides.

Natural and semi-natural saline lakes

- *Silled sea inlets* have a narrow connection to the sea, often with rapids, which restricts tidal flow. They are deeper than lagoons. Only systems in which brackish conditions are widespread are considered, e.g. L. Hyne was excluded.

- *Coastal lakes* of various origins have natural outlets to the sea through which the sea may enter at high tide but the outlet has often been modified to limit tidal flow and is sometimes sluiced. They differ from lagoons in being separated from the sea by broad tracts of land which do not generally allow percolation or overwash.

- *Bayheads* are quiet regions at the head of long sea inlets subject to a small tidal influence. Accumulated freshwater draining from the surrounding land in areas of heavy rainfall is mixed with seawater to give persistent brackish conditions with only slight water flow.

Artificial saline lakes
i.e. with artificial barriers.

- *Polder drainage channels*. Land behind the sea wall is below the level of high tides and landward percolation may be extensive. A mixture of seawater and freshwater is pumped out and water levels are strictly controlled. Channels are broad and water flow is slow.

- *Lakes in former salt marshes*. Sluiced outlets allow excess water to drain away and prevent tidal flooding, but some seawater enters, either by percolation under the barrier or through the sluice, especially when the latter is jammed open by stones or algae.

- *Former bays and creeks* were cut off from the sea during road or railway construction. They may have a bridged entrance which allows restricted tidal flow, or a culverted drain or pipe.

1.2.2 Characteristics of Coastal Lagoons And Saline Lakes

Despite their many different origins and varied geomorphology, all lagoons and saline lakes included in this study share the following characteristics which distinguish them from other marine, freshwater or estuarine habitats:

1.2.2.1 Water levels

With the exception of polder channels, in which the water level is strictly controlled by varying the rate of pumping, water levels generally undergo seasonal changes corresponding to variations in precipitation and evaporation, rising in winter and falling in summer. Narrow channels, especially when sluiced, prevent flooding of the surrounding land by seawater, but they limit the rate of outflow and discharge rates may be too slow to prevent temporary flooding following heavy rainfall. Sedimentary barriers may be periodically breached by artificial or natural means, resulting in significant and rapid changes in water level. There may also be fluctuations in water level associated with tides in open systems, but these are always small.

1.2.2.2 Salinity

Salinity is highly variable, both spatially and temporally. Steep gradients between freshwater and seawater inflows are typical. Shallow water usually precludes significant vertical gradients but deep pools e.g. in rocky areas, may be highly stratified. Seasonal cycles of salinity change related to variations in precipitation and evaporation are generally correlated with changes in water volume. Percolation through barriers tends to be most noticeable during spring tides. Non-cyclical,

localised rises in salinity are also common and are usually caused by the overtopping of barriers by high waves or the temporary jamming of sluice valves.

1.2.2.3 Littoral zone

Except where water levels are rigidly controlled, the littoral zone usually shows evidence of fluctuations in the volume of water either from tidal influence or seasonal variations in rainfall. Where there is direct contact with the sea, banks may be strewn with kelp or fucoid debris, probably deposited during storms. Beds of emergent reeds or sedges are common where the edge slopes gently and where fluctuations in water levels are small. Salt marsh communities may be present on the shore and in the region of seawater seeps. Brackish waters surrounded by peat or peaty soil generally have vertical banks, especially in inlet channels.

1.2.2.4 Submerged macrophytes

A submerged community of aquatic plants is typical. They often grow profusely and their total biomass can be high. Typical vascular plants are *Ruppia* spp. and *Zostera marina* at medium to high salinities and *Potamogeton pectinatus, Ranunculus baudotii* and *Myriophyllum spicatum* at low salinities. Charophytes, some characteristic of lagoons e.g. *Chara canescens, Chara baltica* and *Lamprothamnium papulosum*, are sometimes well represented and may form dense beds. *Enteromorpha* and *Cladophora* species are nearly always present but *Chaetomorpha linum* is the most typical algal species of these habitats. Other macrophytic algae such as fucoids and rhodophytes are mostly confined to relatively high salinity, the number of species increasing with tidal influence. *Fucus ceranoides* is a characteristic species of brackish waters at higher salinity.

1.2.2.5 Characteristic species

A characteristic assemblage of aquatic plants and animals inhabits non-tidal brackish waters. In Britain, 39 species have been listed as specialist "lagoonal species" i.e. distinctly more characteristic of lagoon-like habitats than of freshwater, estuarine or sea waters (Table 1.1) (Barnes 1989, Bamber *et al.* 1992*)*. Some of these are rare and are listed as endangered species in Britain, and a number have not been recorded in Ireland. A similar list for Ireland was not available at the start of this survey.

In addition to "lagoonal species", a number of others are adapted to reduced and variable salinity and are also frequent in estuaries and saltmarshes. They are useful indicators of brackish conditions. Common examples are *Enteromorpha* spp., *Scirpus maritimus, Carcinus maenas, Crangon crangon, Pomatoschistus microps* and *Platichthys flesus.*

Table. 1.1 Specialist lagoonal species in Britain (species distinctly more characteristic of lagoon-like habitats than of freshwater, estuarine brackish waters or the sea). Species present in the larval phase only omitted. (From Davidson *et al.* 1991).

Cnidaria
Laomedea loveni
Edwardsia ivelli [r]
Nematostella vectensis
Polychaeta
Armandia cirrhosa [r]
Almaria romijni
Crustacea
Lekanesphaera hookeri
Idotea chelipes
Gammarus chevreuxi
G. insensibilis
Corophium insidiosum
Palaemonetes varians
Mollusca
Hydrobia ventrosa
H. neglecta
Onoba aculeus
Littorina tenebrosa
Cerastoderma glaucum

Insecta
Sigara selecta
S. stagnalis
S. concinna

Insecta (cont.)
Agabus conspersus [r]
Berosus spinosus [r]
Coelambus parallelogrammus [r]
Dytiscus circumflexus [r]
Enochrus bicolor
E. halophilus
E. melanocephalus [r]
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 papulosus
Tolypella n. nidifica [r]
Angiosperms
*Ruppia cirrhosa**
R. maritima

[r] rare species, or not recorded during the British national survey (Barnes 1989). They may be more widespread in Ireland however.
* This species was not listed by Davidson *et al.* but is regarded as a lagoonal species during this study.

1.2.2.6 Species occurrence

Characteristically, all brackish waters, including lagoons, are poor in species compared with marine ecosystems or freshwater lakes. The concept of the "horohalinicum", a critical salinity of about 5‰ at which a minimum number of species occurs (Fig. 1.1) applies in general to lagoons although its validity is sometimes disputed e.g. Deaton and Greenberg (1986).

The isolation and short life of enclosed brackish waters, together with their variable conditions, mean that most of the characteristic lagoonal species have a low constancy value and the species present tend to vary both temporally and spatially within and

between sites.. Only a small number of species occur regularly in a high proportion of sites. The majority tolerate wide fluctuations in salinity but most flourish within a restricted salinity range. Typical suites of species are associated with different parts of the salinity range, characterising waters in which the relative importance of marine and freshwater influence differs. Five categories of brackish water flora and fauna may be distinguished (salinity preferences for algae and plants are taken from den Hartog 1967, Moore 1986 and Verhoeven and Vierssen 1978):

1. **Marine species** living in systems where the salinity remains high or those entering the system intermittently which tolerate reduced salinity but probably do not breed. They tend to disappear when the salinity falls below about 25‰. Their presence indicates an existing or recent communication with the sea.
   Examples: Marine algae such as *Chorda filum, Fucus vesiculosus* and *Ulva lactuca.* Faunal species include *Hydrobia ulvae, Mytilus edulis, Semibalanus balanoides, Littorina littorea,* and various fish.

2. **High salinity (poly-mesohaline) species.** Species typically found above about 15‰.
   Examples: *Zostera marina, Ruppia maritima, R. cirrhosa, Lamprothamnium papulosum, Corophium volutator, Praunus flexuosus, Gammarus locusta, Hydrobia ventrosa, Littorina "tenebrosa", Cerastoderma glaucum, Mya arenaria.*

3. **Euryhaline species** with wide salinity tolerance, found throughout nearly the whole salinity range, often also in the open sea.
   Examples: *Enteromorpha* sp., *Neomysis integer, Lekanesphaera hookeri, Idotea chelipes, Gammarus zaddachi, G. duebeni, Palaemonetes varians, Sigara stagnalis, Conopeum seuratum, Gasterosteus aculeatus, Pomatoschistus microps.*

4. **Low salinity (oligo-mesohaline) species,** typically found below about 15‰.
   Examples: *Potamogeton pectinatus, Chara canescens,* Notonectidae, *Limnephilus affinis, Ischnura elegans, Notonecta viridis,* many Coleoptera, *Einfeldia* spp., *Potamopyrgus antipodarum.*

5. **Limnic (freshwater) species** with some tolerance of brackish conditions.
   Examples: *Sigara dorsalis* , many Coleoptera, Ephemeroptera, Hirudinea, *Lymnaea* spp, *Pisidium* spp.

These categories, based on a few studies in Irish lagoons, are somewhat different from those given by other authors, particularly Bamber *et al.* (1992) , but are believed to be appropriate for the present purpose because they reflect current and recent environmental conditions and especially the degree of contact with the sea, and allow interpretation of the dominant influences on the systems.

Although salinity is probably the single most important factor limiting the ecological distribution of species, faunal assemblages do not generally appear to be directly related to salinity nor to any historical, topographic, physiographic or biotic factors, probably because the element of chance in dispersal and colonisation processes is

important and the liability to extinction unpredictable (Barnes 1988, Bamber *et al.* 1992). Also, there is generally a time lag in the response of populations to changes in environmental conditions so that salinity, for example, measured at the time of sampling, may not be representative of that experienced by the fauna for most of the time.

A frequent lack of relationship between species occurrence and environmental parameters, especially salinity, highlights an important characteristic of the lagoonal environment, namely its long term variability. The community of the same lagoon which is dominated by species characteristic of low salinity one year, may be dominated by species more characteristic of high salinity a few years later if there has been a major incursion of seawater. Intolerant species, or those with a high reproductive rate such as mysids, amphipods, isopods, and corixids, tend to respond rapidly to such events while changes in the populations of more tolerant species, and those which are slow to build up populations such as hydrobiids, may not become apparent for several years. Different response rates within communities make it difficult to characterise them as persistent systems. (See also 1.4.3.)

1.2.2.7 Species richness and colonisation

Species richness, i.e. the number of species inhabiting a given brackish water, is usually low by comparison with estuaries or habitats on the open coast. The number of species present depends on many factors including the salinity regime (consistently high or low salinity waters generally have more species, see Fig. 1.1), size of the water body, habitat diversity (the presence of rocks allows colonisation by sessile species and vegetation provides shelter and food for herbivores), the degree of contact with the sea facilitating colonisation by marine species, and the proximity of other lagoon-like habitats which might supply colonists.

Species richness is not, therefore, a reliable measure of the health of the system and cannot be used to evaluate lagoons except within narrowly defined habitat categories.

1.2.2.8 Birds

Enclosed brackish waters are often frequented by large numbers of waterfowl attracted by the sheltered conditions close to coastal feeding grounds and by the rich food supply which the shallow water makes accessible. *Ruppia* and *Potamogeton* are particularly favoured by swans while the invertebrates and fish are consumed by a wide range of wildfowl as well as herons, cormorants, grebes and diving ducks. In places where there are expanses of bare mud or shingle on the shoreline, these often attract waders. Some lagoons are well known to birdwatchers as places where they are likely to see rare vagrant species. Reed beds provide shelter and nest sites for some species.

1.2.2.9 Productivity

Non-tidal brackish waters are highly productive ecosystems being fed by a continuous supply of nutrients from the surrounding land which can reach moderately high levels in the shallow waters. There are often luxuriant growths of macrophytes and some invertebrates, particularly crustaceans, can reach high densities in summer owing to the

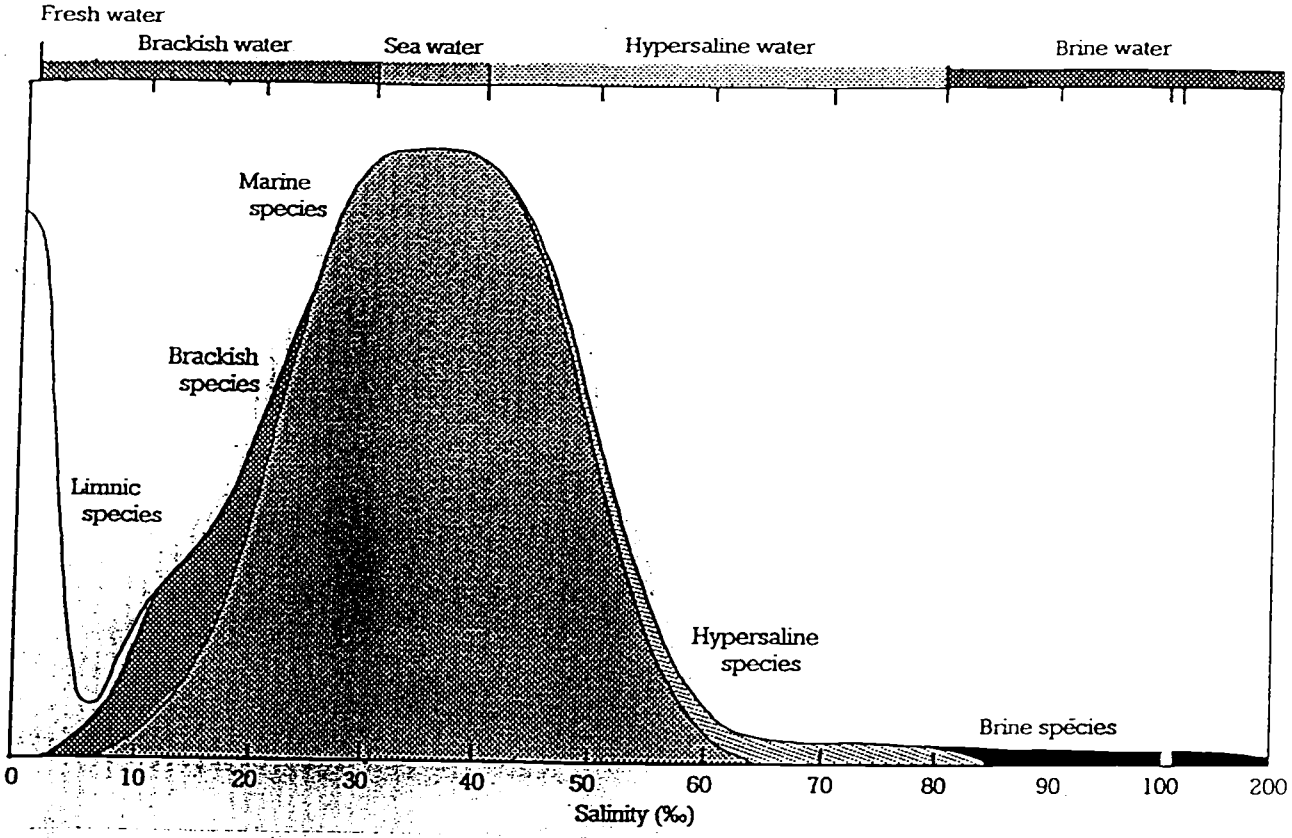

Fig. 1.1 Relative number of species of aquatic invertebrates inhabiting fresh, brackish, sea, hypersaline or brine water. (From Davidson *et al.* 1991, derived from Kinne 1971)

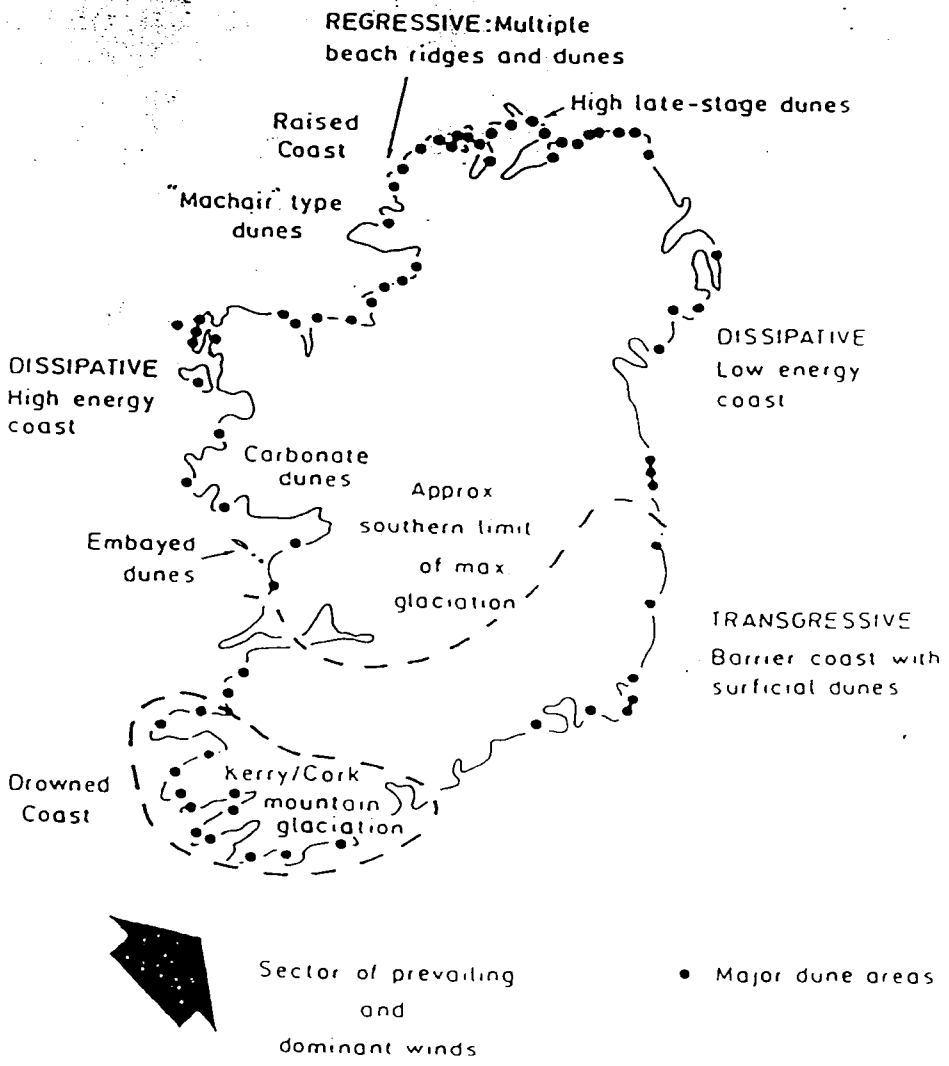

Fig. 1.2 Distribution and type of coastal formations in Ireland. (From Carter 1990)

relatively high water temperatures which allow two or more generations to be produced in a season.

1.3 ENVIRONMENTAL FACTORS

The factors determining the range of lagoon types, their distribution around the Irish coast, their salinity regime and species composition, and their survival in the future are:

- geology, geomorphology and post-glacial history of the coastline;
- oceanographic influences (tidal range, wave force, storm frequency and magnitude);
- climate, especially rainfall and wind speed;
- sea-level changes;
- coastal erosion;
- threats from exploitation, eutrophication/pollution, coastal defence projects and land reclamation.

1.3.1 The Irish Coastline

The Republic has nearly 6500 km of coastline (including islands and estuaries up to the first bridge) of which a considerable proportion is represented by sedimentary shores. The greatest proportion of beaches are found in counties Wexford, Kerry, Mayo and Donegal (Martin *et al.* 1974). The present day coastline is strongly influenced by glacial and post-glacial history. Only the north of the country and the mountains of the southwest were covered by the last glaciation, the position of the southern border of the ice sheet corresponding to a tilt-line, south of which the sea level has been rising over the past 17,000 years while to the north of the line there has been some isostatic land rise (Carter 1992). This tilting of the land mass has had its most obvious effect on the landscape of the southwest where valleys in rock with roughly E-W trending folds have been drowned to give a very dissected coast. The effects of the dominant formative influences on coastal geomorphology are summarised in Fig. 1.2.

The west and southwest coasts are predominantly rocky and the high energy Atlantic waves have segmented the coastline into a series of headlands and rock-bound embayments. Sandy beaches are confined to sheltered bays and are mostly short. A feature of the north-west, (Galway, Mayo and Donegal) is the widespread occurrence of machair, a formation associated with evenly distributed rainfall (238-248 rain days), strong winds throughout the year (annual average reaches 7 m/s) and cool temperatures, characteristics which also favour the persistence of shallow lakes in the moist areas (Bassett and Curtis 1985). In contrast, the southeast comprises a low-lying glacial plain where a series of stream catchments between Bray in N. Wicklow and Cullenstown in W. Wexford became blocked behind barriers of gravel, or sand and gravel, to form extensive areas of marshland with lagoons (Carter *et al.* 1984). All of this land was subjected to drainage schemes during the 19th century, however, and today only a few lagoons remain more or less intact, the remainder being reduced to relict systems.

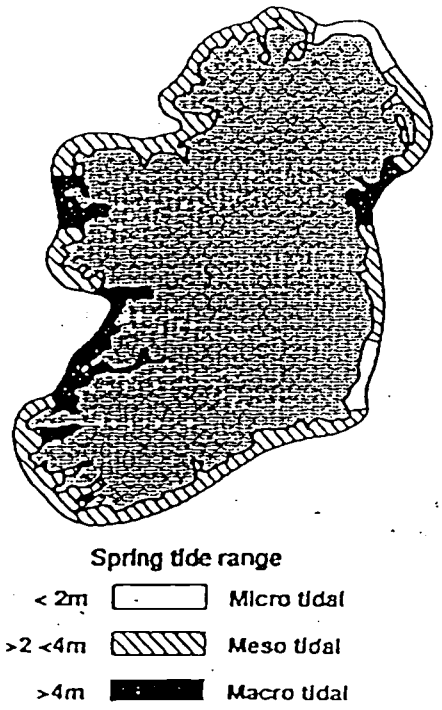

Fig. 1.3 Tidal ranges around the Irish Coast (form Carter 1992)

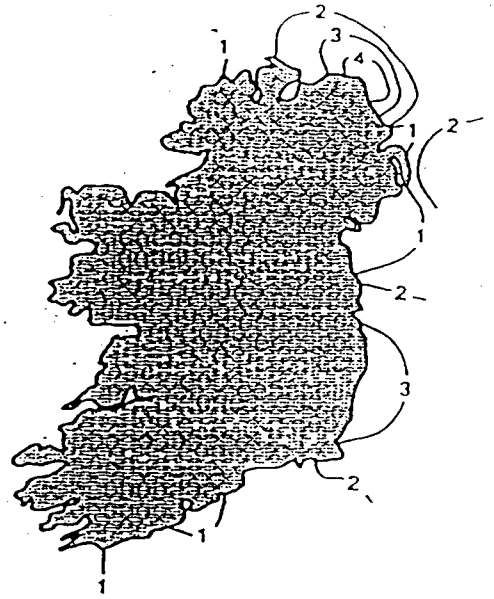

Fig. 1.4 Maximum tidal current velocities (m/s) at mean spring tides (from Carter 1992)

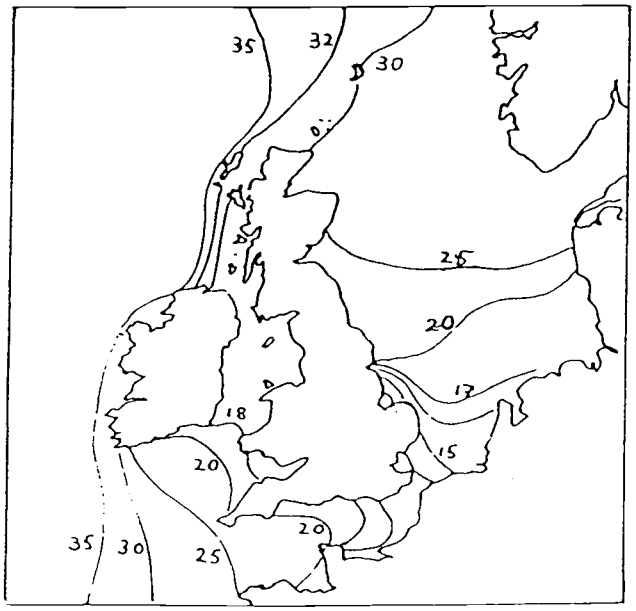

Fig. 1.5 Wave heights on Irish and British coasts (maximum occurring once in 50 years) (from Couper 1983)

Fig. 1.6 Average annual rainfall 1951-1980 (from Rohan 1986)

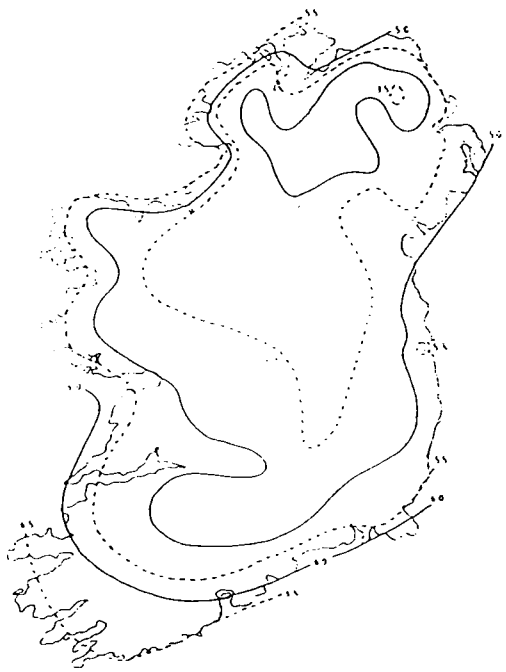

Fig. 1.7a Mean daily air temperature (°C) January 1951-1980 (reduced to mean sea level)

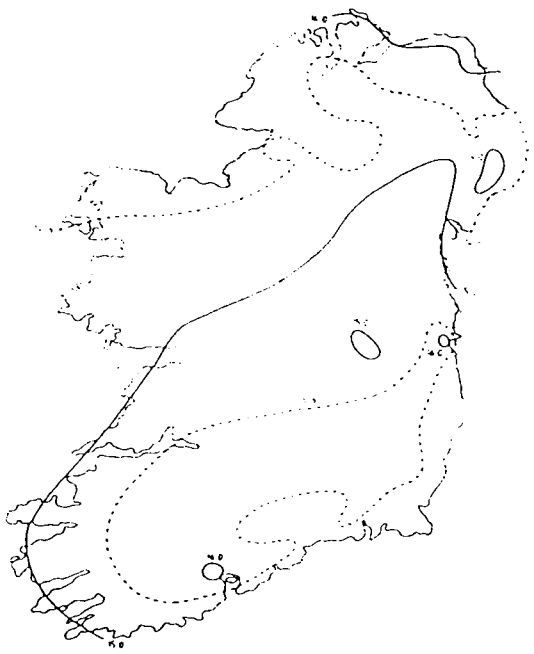

Fig. 1.7b Mean daily air temperature (°C) July 1951-198 (reduced to mean sea level)

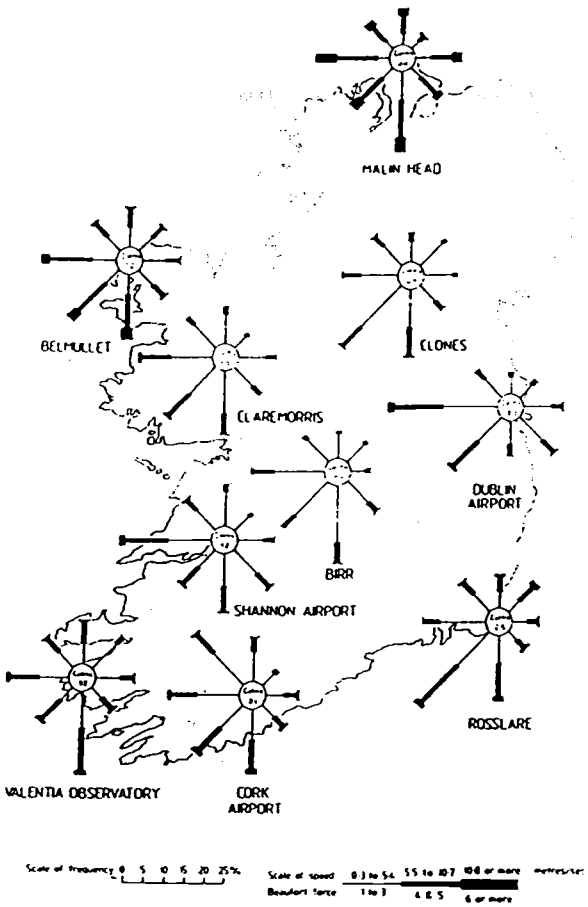

Fig. 1.8 Frequency of simultaneous occurrence of specified ranges of wind speed and direction. (from Rohan 1986)

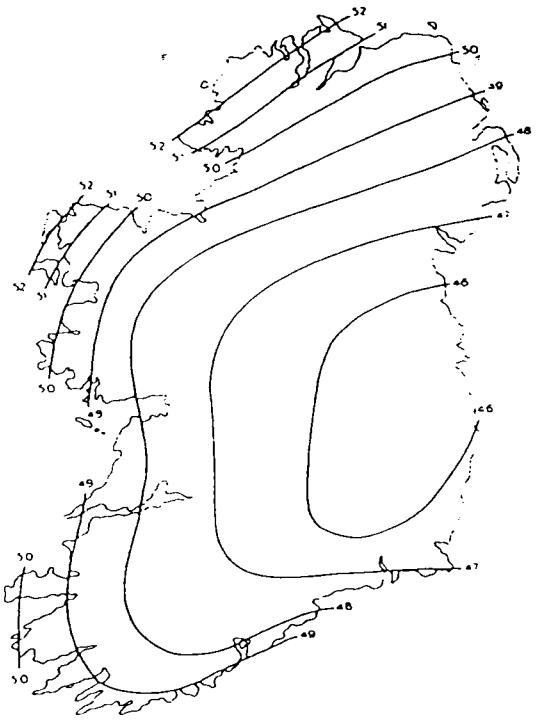

Fig. 1.9 Maximum wind speed (m/s) in a gust with a return period of 50 years (from Rohan 1986)

Barrier systems, which characteristically separate lagoons (in the strict sense i.e. those of sedimentary origin) from the sea, occur where there is an abundant supply of material. Extensive sand or gravel barriers are found on the east and southeast coasts and those in Co. Wexford are well documented (Carter and Orford 1980, Carter and Johnston 1982, Orford and Carter 1982, Carter *et al.* 1984, Ruz 1989). Much less is known about the western shores where spits and bars tend to be shorter and situated in relatively sheltered areas. Only a few western barriers have been investigated, chiefly in Clare and south Mayo (Delaney and Devoy 1995, Devoy *et al.* 1996). Barriers occurring between W. Cork and N. Donegal are generally composed of shingle (particles >6 mm in diameter), with cobbles (6-25 mm) usually dominant. Cobble barriers are often described as "boulder bars".

All Irish barriers are to some extent transgressive, especially those of the southeast, due to low sediment supply. Seaward seepage through gravel and shingle barriers is usually sufficient to prevent the formation of inlets and sediment transport is mainly onshore (Orford and Carter 1984).

1.3.2 Oceanographic Influences

The spring tidal range over most of the Irish coast is between 3 and 5 metres (meso-macrotidal) with the highest in parts of the west (Fig. 1.3). Only on the north Wexford coast (and in Co. Antrim) is the range less than 2 m i.e. microtidal, a regime which often favours lagoon formation but along this stretch of coastline previously existing lagoons have been drained.

Differences between wind force and wave height, and therefore wave energy, between east and west coasts also have important consequences for coastal formations. The west coast receives long period Atlantic swell waves approaching from the west or southwest with median wave heights of 1.5-3.0 m. Frequent cyclonic depressions also produce large waves, especially toward the north. On the south coast, there is a marked east-west gradient in median wave height which falls to < 1 m in the Irish sea. In the west of the country, both wave height and wind speed can be greater than anywhere else in western Europe. Maximum wave heights (averaging once in 50 years) (Fig. 1.4) are 30-35 m on the west coast, diminishing from west to east along the south coast and falling to 17-18 m on the east coast (Couper 1983). In the west, inshore breakers on rocky coasts commonly exceed 8 m in height (Carter 1992). Tidal current speeds, on the other hand, are greater in the east (Fig. 1.4) where longshore currents have formed a series of spits and barriers.

1.3.3 Climate

Rainfall. The average annual rainfall (1951-1980) varies between 750 mm in the east and 1500 mm in coastal areas of the west (Fig. 1.6). (Rainfall >2000 mm is confined to mountain districts.) The monthly average is generally highest in December-January and lowest in February-June (Rohan 1986).

The number of rain days (days on which 0.2 mm or more are measured) vary between 190/yr near east and southeast coasts and about 250/yr in places near the west coast (Rohan 1986).

Temperature. Mean daily air temperatures in coastal areas remain above 5°C throughout the Irish Republic (Fig. 1.7) and frosts are rare. Ice may form occasionally on saline waters but is of short duration.

Wind. South, southwest or west winds predominate throughout the country (Fig. 1.8).Maximum wind speeds reach over 50 m/s on parts of the west coast, decreasing eastward (Fig. 1.9). Mean annual wind speeds range from 8.1 m/s at Malin Head to 5.2 m/s at Dublin and the mean number of days with gales follows a similar pattern (Table 1.2). These trends are reflected in variations in wave height (see 1.3.2).

Evaporation and humidity. Class A pan values for evaporation from a water surface range from 650 to 800 mm/yr at coastal stations There are no clear regional differences. Annual mean values of relative humidity at noon are 75-80% on all parts of the Irish coast.

Table 1.2 Wind speed data (m/s) for seven coastal stations (from Rohan 1986)

	Annual mean hourly wind speed	Annual mean number of days with gales	Annual max. 10 min. wind speed
Malin Head	8.1	57.4	34.5
Belmullet	6.7	29.2	34.0
Galway	5.0	-	-
Valencia	5.6	10.7	29.9
Roches Point	6.3	32.0	31.9
Rosslare	5.9	12.1	26.8
Dublin Airport	5.2	7.0	25.2

Future climate trends. While there is still uncertainty as to whether or not the enhanced greenhouse effect will affect global climate, current models indicate a likely rise of global mean temperature of about 0.3°C per decade (Houghton *et al.* 1990). Other predictions for the north-east Atlantic include an increase in precipitation in winter (McWilliams 1992) and increases in wind speed and storm frequency. Measurements of ocean waves in Britain in the past 25 years suggest that there has been a substantial increase in wave height in the north-east Atlantic (Carter and Draper 1988) and it appears likely that the trend will continue.

1.3.4 Sea-level changes

Sea level has been rising worldwide since the last glaciation due to rising global temperature resulting in thermal expansion and ice-melt. Glaciated regions are also experiencing isostatic rebound following the decline of ice-sheets. Global warming has caused a global sea-level rise of 1-2 mm/yr since the end of the 19th century.

Recent Irish tide gauge records indicate that sea level is rising at a rate of 0.2 mm/yr at Dublin, is stationary at Belfast and is falling by as much 2.4 mm/yr at Malin Head, Donegal (Carter and Johnston 1982, Carter 1992). These regional differences are explained by isostatic "tilting" of the land mass following retreat of the ice sheet after the last glaciation. The sheet only extended over the northern half of the country, roughly to a line between Dublin and Galway, together with a smaller area in the southwest. Near the tilt line there has been little observable change in sea-level while the rate of land uplift increases northward. Evidence from Castlemaine Harbour and Cork Harbour, however, suggests a sea-level rise of only 0.8-1.1 mm/yr over the last 2000 years which is close to the eustatic global trend (Carter *et al.* 1989) and therefore may not be due to isostatic sinking of the land. The coastal scenery of the southwest is typical of a drowning landscape. In the southeast, where shores are mainly sedimentary, rising sea-level is associated with severe coastal erosion and enhanced transgression of barriers.

Rising sea level on southern coasts will have a direct effect on coastal lagoons by increasing the incidence of flooding by seawater, erosion of barriers, and damage to barriers caused by destructive storm surges. Indirect effects will include the redistribution of coastal sediments, and an increase in the urgency of coastal protection schemes. Reclaimed land will be particularly vulnerable. Barriers are likely to transgress landward more rapidly and mobile gravel beaches would be subject to major changes (Carter 1992). The flood control systems currently in use will become steadily less effective.

An increase in the rate of global warming and therefore sea-level rise, due to the greenhouse effect, is not yet proven. The Intergovernmental Panel on Climate Change considered that unequivocal detection of an enhanced greenhouse effect would not be possible until at least the year 2000 (Houghton *et al.* 1990).

1.3.5 Coastal erosion

Low sediment supply means that coastal erosion is taking place on most parts of the Irish coast and is affecting about 25% of the shoreline (Carter and Johnston 1982). The most serious problems are experienced on sedimentary coasts, particularly Dublin, Wicklow and Wexford. Port developments, sediment extraction and recreational activities are adding to the problem of coastal protection.

1.3.6 Threats to coastal lagoons

True lagoons are transient features which would eventually evolve into freshwater lakes and eventually fill in if the barrier remains stable, or 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 the supply of sediment to barriers, such as sand or gravel extraction, pier extension or upstream coastal protection schemes, may have far-reaching consequences for lagoons in the area.

Many lagoons, and natural or semi-natural saline lakes, are threatened by land reclamation projects, and some have been drained in recent years. The commonest form of pollution is nutrient enrichment mostly from fertilizer or slurry application on surrounding land, overflowing slurry tanks, silage, and sewage leaks from septic tanks. Cattle herds can also cause significant enrichment, especially in small water bodies. The impact of enrichment on lagoonal communities depends mainly on the flushing rate and systems with outlets are less vulnerable to adverse effects. Small, shallow systems are particularly susceptible.

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2. OUTLINE AND LIMITATIONS OF THE SURVEY

2.1 OBJECTIVES

The survey took place in two phases.

The objectives of **Phase 1** were:

- to identify the lagoons and lagoon like habitats in the Republic of Ireland according to the definitions given in 1.1.2, second and final paragraphs;
- to classify them as far as possible on the basis of geomorphology and hydrological regime i.e. the degree of marine influence;
- to provide a provisional evaluation of the site according to the criteria listed under 2.4, as appropriate;
- to select 20 sites for further study in Phase 2.

The objectives of **Phase 2** were:

- to describe the main topographic and physiographic features (geomorphology, hydrology, salinity regime, and, where possible, the variability of environmental conditions);
- to determine the species and communities present, their relative abundance, and their distribution within the systems;
- to evaluate the sites as areas of scientific interest and make recommendations for their conservation.

Four aspects of the lagoons were studied:

Geomorphology and hydrology
Vegetation
Aquatic fauna
Ecotonal Coleoptera.

2.2 Programme

Phase 1. Inventory of Irish lagoons.

Identification of potential sites (1 week).

Visits to as many sites as possible for a quick assessment of lagoon type, environmental conditions and biota (4 weeks).

Selection of 20 sites for Phase 2.

Phase 2 Surveys of 20 selected sites.

Field work and sample analysis (approx. 3 months).
Identification and preparation of reports (approx 6 weeks).

2.3 Deployment of the Survey Team

The survey team consisted of four members, a botanist, an entomologist, and two zoologists who studied the aquatic fauna and also made observations on geomorphology and hydrology. For Phase 1, three members of the team together recorded observations on geomorphology, hydrology, vegetation and aquatic fauna. Ecotonal Coeoptera required a diffferent approach and timetable, for example the use of pitfall traps meant that sites had to be revisited to collect the catch. An advantage of splitting the survey team in this way was that observations on salinities and tides were often made on two or more occasions. In Phase 2, investigations into vegetation, aquatic fauna and ecotonal Coleoptera were carried out independently.

2.4 Scientific evaluation

The basic criteria used in evaluating the sites are those in general use for the assessment of marine sites for conservation (Mitchell 1987, Davidson *et al.* 1991), but we have given more emphasis to the geomophological value of the site than would be usual for other marine ecosystems.

Naturalness. Preference in selecting sites was for natural lagoons as the high priority identified in the Habitats Directive. Few lagoons have not been modified in some way and the presence of simple flood control systems, many of them quite old, was thought not to detract unduly from the overall naturalness, even when management altered the salinity regime and colonisation processes.

Representativeness. Sites were rated highly if they were considered to be good examples of a geomorphological type and contained representative examples of recognised plant and animal communities.

Rarity. The presence of rare and interesting species was considered to be important but rarity was often difficult to assess because the frequency of occurrence and distribution of many groups, especially invertebrates, in Ireland is imperfectly known. Moreover, comparisons with Britain may not be valid because some lagoonal species which are frequent in Britain are rare or unrecorded in Ireland while others which are rare in Britain may be more widespread here. An assessment of their rarity in the European context is even more difficult. Many rarity ratings in this report are provisional only.

"Interesting species" are those which occur only sporadically and are generally those classified as lagoonal species which are therefore dependent for their survival on the presence of lagoon-like habitats. While it cannot be assumed that the same species characterise lagoons here as in Britain, the British list (Table 1.1) provides a useful guide.

The concept of rarity was also applied to geomorphology and special consideration was given to types believed to be unusual in the European context such as lagoons in karst and those formed in peat.

Diversity. For reasons explained above (1.2.2.7), species diversity was not not a reliable criterion for the evaluation of sites, except in so far as it reflected habitat diversity or where very similar habitats occurred in a number of lagoons and could be compared. In some cases, low diversity is characteristic of the environmental regime,

e.g. at Farranamanagh, which is geomorphologically a classic lagoon and is therefore valued on that basis.

Fragility. This has particular application to shallow lagoons with sedimentary barriers. Attempts to avoid degradation by natural events are inappropriate unless endangered species are threatened, but deliberate or unconscious damage to barriers, and pollution of small, shallow systems, is often avoidable.

Size. The principle applied here is the avoidance of "edge effects" in small systems. Where these are not seen as important (e.g. the Lettermullen rock pool), smaller water bodies may be capable of maintaining ecological integrity (viable unit concept).

Situation. Sites were considered to be particularly worthy of conservation if a high rating would lend support to existing proposals for protection status or enlarge already designated conservation areas.

Recorded history. We know of only three published accounts of aquatic faunal communities in Irish lagoons although populations of some lagoonal species have been investigated. Accounts of aquatic flora are mainly in the form of species records which are widely dispersed in the literature. There is somewhat more documentation relating to some barrier systems and where it is known it has been taken into account.

Research and educational potential. A few sites have a history of scientific research. Others not so well known could be designated as having educational potential if they were situated near a University or large town.

Restoration potential. This is interpreted as the possibility of restoring the system to "health" e.g. by limiting agricultural effluent or human wastes. We have not considered it necessary to restore a physically altered or managed lagoon to its natural state, e.g.

by removing flood control structures, unless current management procedures are detrimental to endangered species or habitats.

Intrinsic appeal. Although innately subjective, it is generally accepted that the "expert eye" approach is an important and valuable contribution to the identification of sites of potential conservation importance.

Vulnerability. Sites in populated areas are generally more susceptible to existing or potential threats while remote sites have a better chance of survival.

Urgency. This could only be assessed when short term plans for reclamation or changes likely to cause environmental damage were known. Generally, we have not sought this kind of information.

Feasibility. For most sites, we have not felt competent to express an opinion about the feasibility of protecting the site effectively, but practical aspects of conservation or management are sometimes discussed.

The above criteria have been applied, with some modification, to British lagoons (e.g. Bamber *et al.* 1992) by rating each criterion to produce a conservation "index" but this did not seem appropriate for the present purpose. Instead, we have listed what we perceive to be the main assets of each lagoon, and identified actual or potential threats where these were evident.

Usage of lagoons by birds could not be assessed as part of this survey but counts of wintering waterfowl for recent years have been considered in the evaluation. Sites rated of International Importance as holding either total numbers of wintering waterfowl in excess of 20,000, or 1% or more of the distinct European population of a given species, are likely to have been already designated as SPAs and some efforts made to safeguard them for birds. However, management procedures which enhance a lagoon for waterfowl may not be the same as those which would be required to protect certain plants or aquatic fauna and the designation of a site as an SPA or Refuge for Fauna may not, in fact, benefit lagoonal flora and fauna as a whole and may even threaten their survival.

2.5 Limitations of Sampling Methods

The wide range of habitats and conditions, both within and between lagoons, means that a number of different sampling methods need to be employed, making it difficult to compare different sites. The vegetation survey concentrated on marginal communities and those which could be reached by wading; consequently, plant communities in deeper water, which could only be reached by grapnel, were undersampled. In the case of invertebrates, the nature of the habitats often makes quantitative sampling difficult, if not impossible. Collection of swimming forms by sweep-netting, for example, is much more difficult in reed-beds than in open water, and requires a different technique. The methods used for faunal sampling and for aquatic flora can, at best, be described as semi-quantitative. Sampling efficiency and the difficulties encountered are discussed under Methods in the appropriate sections.

2.6 General Constraints

Because time was limited, not all potential sites could be visited. None of the likely ones on islands was sampled and there is information on topography for only two. As a result of experience gained during the survey, further sites which did not initially appear likely from maps are now considered probable. This is particularly true in Connemara.

Time constraints also meant that effort was concentrated on the larger lagoons. Nearly all were at least 2 ha in area, most were >5 ha, and many >20 ha. In an equivalent survey in England (Smith and Laffoley 1992), most sites were <10 ha and many <1 ha and even ponds as small as 0.1 ha were included. This makes it difficult to compare the resources in the two countries.

Some specimens have not been identified, mainly those in groups for which taxonomic expertise is not readily available. The few active specialists in identification of "difficult" groups who might be interested to identify material are mostly too busy. This has become a serious problem for environmental studies in all countries. Some groups which remain unidentified in our collections are potentially useful indicators of the environmental regime and the health of the system e.g. algae and dipteran larvae.

A major difficulty in surveying and evaluating lagoons is their extreme variability. Cyclical changes in species occurrence correlated with tides and seasons, and unpredictable fluctuations in conditions resulting from storms and rainfall extremes,

mean that "snap-shot" studies give a very incomplete picture of the ecosystem. Even for the 20 intensive surveys, it was only possible to spend 2-3 days at each site and different sites were visited at different states of tide (springs or neaps) and in different seasons. Species which were easy to observe or identify in early summer, for example, may not have been located in September. This is particularly true of insects. Wherever possible, we have tried to obtain information on variability and extreme conditions by talking to local residents.

3. INVENTORY OF LAGOONS AND SALINE LAKES

3.1 IDENTIFICATION OF POTENTIAL SITES

Possible sites were identified from maps (OS Discovery Series where available), aided by aerial photographs. Some others were suggested by NPWS staff. All isolated saline waters, and those with inlets which were expected to be brackish and where extensive areas of the substratum were not uncovered at low tide, were considered.

3.2 FIELD METHODS

Sites were visited between 11 June and 7 July 1996.

3.2.1 Identification of lagoons and saline lakes

Isolated lakes were considered to be saline if the salinity was 1‰ or more or if certain indicator species were present. Indicators of marine influence in waters which were fresh at the time of sampling were:

Algae; *Enteromorpha*

Plants: *Ruppia* spp., *Ranunculus baudotii, Myriophyllum spicatum, Scirpus maritimus,* and salt-marsh plants on the shore. The presence of salt-sensitive species such as water-lilies and water lobelia was taken to indicate permanently freshwater.

Fauna: nereid polychaetes, mysids, *Lekanesphaera, Palaemonetes varians,* juvenile flatfish.

Tidal waters were considered to be brackish if the salinity was <33‰ or if certain indicators of brackish conditions were present. Indicators of freshwater influence in waters of salinity >33‰ at the time of sampling were:

Algae: *Chaetomorpha linum, Fucus ceranoides*

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

Fauna: *Cerastoderma glaucum, Hemiptera, Coleoptera*

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.

On arrival at a potential site, a quick assessment was made and if it could be classified as a lagoon or saline lake according to the criteria above, it was then sampled.

3.2.2 Site descriptions

Description of the site and sampling of the flora and aquatic fauna were completed in 1-2 hours, depending on the the size of the lagoon. Observations in the lagoon were confined to the littoral zone and areas accessible by wading.

Notes were made on the topography of the lagoon and the surrounding land and a rough map of the site was drawn, indicating the positions of the major features and the sampling station or stations. Particular attention was paid to the barrier, when present,

and to freshwater streams and sea inlets. The latter were not always easily accessible, however, and their existence was sometimes inferred from salinity and their position judged from maps.

Sites were photographed whenever the weather and light permitted.

3.2.3 Hydrology and salinity

Freshwater and marine influences were was estimated from salinity measurements made using a pocket refractometer accurate to 1‰. Measurements were made at several points on the lagoon shore, especially near inlets and in the region of barriers where seawater seepage could sometimes be detected. Where seaward seepage of lagoon water was apparent as rills on the beach, the salinity of this was also measured. As it was not possible to make observations at both high and low tide, we were not able to observe both tidal flow and beach rills at the same site.

3.2.4 Vegetation

At each site visited, all aquatic and emergent species were identified and the dominant species in marginal halophytic communities recorded. Algae and plants which could not be identified in the field were collected and dried for identification later. The main vegetation types, and their occurrence in and around the lagoon, were briefly described. Particular importance was placed on key species and communities which were considered to be indicators of brackish conditions. *Ruppia* spp. and *Scirpus maritimus* were seen as most significant at this stage. However, Ruppia species could not be reliably distinguished at this stage because the plants had not begun to set seed. Some observations on the vegetation of the surrounding land were also made.

3.2.5 Aquatic fauna

Sampling of aquatic fauna consisted of hand net sweeps in the different habitats (open water, macrophyte beds, near reed or sedge beds, near sea inlets or freshwater inflows) and general searching. Rocks and stones were overturned and immovable structures examined for sessile fauna. Where possible, samples of the substratum were sieved. Faunal samples were preserved in 70% alcohol. The larger crabs and fish were not collected but were identified and returned to the habitat.

3.2.6 Ecotonal Coleoptera and other marginal fauna

Only lakes with shores likely to harbour Carabidae and Staphylinidae were sampled. Suitable habitats included grassland, salt marsh, rush and sedge swards, reed beds, sandy and stony shores, and peat. Observations and sampling were confined to the zone bordering the lagoon which was subject to its influence.

The following sampling methods were used:
Ground searches were made at all but two of the sites visited. Searches were made on surfaces with <50% vegetation cover during warm weather without rain.

Pitfall traps, consisting of plastic cups containing ethylene glycol preservative, were used at all but one of the sites eventually short-listed and six others. Those from Inch L. were not collected until...

Flotation was used where burrow casts were observed and the substrate was suitable. Samples were agitated with water at the site.

Stone-turning was done within 2 m of the water margin.

3.3 INVENTORY RESULTS

Brief descriptions of the 56 sites identified as lagoons or saline lakes, including summaries of findings on the 20 selected sites, are presented in Volume II of this report. A summary of the inventory is given in Section 4.1 (Volume I).

3.4 SELECTION OF 20 SITES FOR INTENSIVE SITE SURVEYS

Twenty sites were selected for intensive study in Phase 2 of the survey as being good representatives of a wide range of lagoon types, situated as far as possible in different parts of the country. They are listed in Table 3.1 and their locations are shown in Fig 3.1.

Methods and Results for this part of the survey are presented in the form of separate Site Surveys in Volume III of the Report (Parts 1-20). A summary of the Site Surveys is given in Section 4.2 (Volume I).

Table 3.1 Sites selected for intensive survey in Phase 2.

	Name	County	Nearest town or village	OS Grid Reference	Discovery Map No.
1	Lady's Island Lake	Wexford	Rosslare	T 099065	77
2	Tacumshin Lake	Wexford	Rosslare	T 050065	77
3	Kilkeran Lake	Cork	Rosscarbery	W 338344	89
4	Lissagriffin Lake	Cork	Crookhaven	V 775265	88
5	Farranamanagh Lake	Cork	Kilcrohane	V 830378	88
6	Drongawn Lough	Kerry	Sneem	V 731640	84
7	Lough Gill	Kerry	Castlegregory	Q 606142	70/71
8	Cloonconeen Pool	Clare	Carrigaholt	Q 836497	63
9	Lough Donnell	Clare	Quilty	R 002707	57
10	Lough Murree	Clare	Ballyvaughan	M 255119	51
11	Aughinish Lagoon	Clare	Kinvarra	M 286134	51
12	Bridge Lough	Galway	Kinvarra	M 342128	(52)*
13	Lettermullen Pool	Galway	Lettermullen	L 827213	44
14	Loch Tanaí	Galway	Costelloe	L 950305	45
15	Lough Aconeera	Galway	Kilkieran	L 875369	44
16	Mill Lough	Galway	Carna	L 755331	44
17	Corragaun Lough	Mayo	Killadoon	L 748698	37
18	Roonah Lough	Mayo	Killadoon	L 755765	37
19	Furnace Lough	Mayo	Newport	L 965975	31
20	Durnesh Lake	Donegal	Ballintra	G 878695	11

* Not published at time of writing

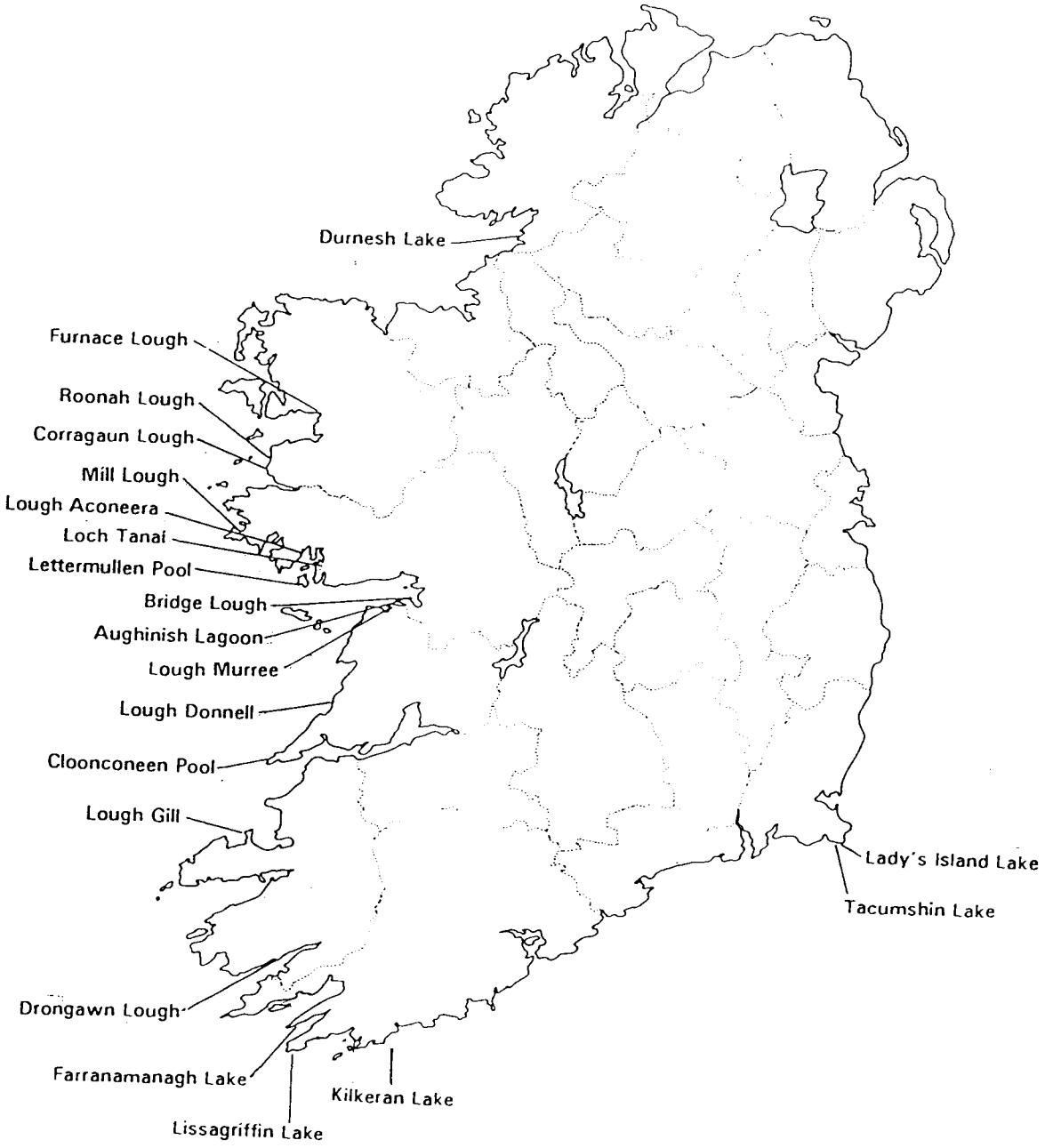

Figure 3.1 Location of the 20 sites sampled during the Survey of Coastal Lagoons, 1996

4. SUMMARY OF THE SURVEY

4.1 SUMMARY OF THE INVENTORY

4.1.1 Identification of lagoons and saline lakes

Out of a total of 147 potential sites, 99 were visited, 56 sampled and 43 not visited (Table 4.1). Information and species records for 5 other sites were available from previous surveys.

Among 56 sites identified as lagoons or saline lakes, 19 were sedimentary lagoons, 3 were rock lagoons, 14 were natural saline lakes and 20 were artificial saline lakes (Table 4.2, Fig. 4.1.). These lagoons and lakes are described and evaluated, and the species recorded in them listed (or references given), in Vol. II. Some of the geomorphological types are believed to be limited to Ireland and Scotland. These sites have therefore been rated highly for their conservation value as unique landforms.

4.1.2 Regional distribution of lagoon types

There are distinct regional differences in the number and type of lagoons (Table 4.3, Fig. 4.1) which are related to coastal topography, land use, and the level of urbanisation. No natural lagoons or saline lakes were found on the east coast. If they existed in the past, they have disappeared as a result of land reclamation or flood control schemes. The main concentrations of lagoon-like habitats today are in southeast Wexford, West Cork, and Connemara, in each case for different reasons

Table 4.3 Distribution of the four main lagoon types (sedimentary lagoon, rock lagoon, natural saline lake and artificial saline lake) in six regions of the coastline.

	Sed. lagoon	*Rock lagoon*	*Nat. sal. lake*	*Artificial sal. lake*	*Total*
Dublin-Wexford	2	0	0	4	6
Cork	5	0	0	11	16
Kerry	1	0	1	0	2
Clare	3	2	0	1	6
Galway	3	1	8	1	13
Mayo	4	0	1	1	6
Donegal	1	0	4	2	7
TOTAL	19	3	14	20	56

Southeast. The two large sedimentary lagoons in southeast Wexford, Lady's Island Lake and Tacumshin Lake, are well documented and highly valued for their geomorphology and birdlife. The other main brackishwaters are in three large areas of saltmarsh and mudflats which were reclaimed in the last century to form the sloblands, polders which lie below sea level and are continuously drained by pumping. (North and

South Slobs, Ballyteige Slob). Considerable amounts of seawater percolates into these through sea walls and dune barriers and the broad drainage channels have a relatively constant salinity and a surprisingly rich fauna.

Southwest. No lagoons or saline lakes are presently found between Hook Head and the east shore of Cork Harbour (the lagoon at Ballycotton is now open to the sea and tidal, and pools at Shanagarry and Ballymacoda are tidal salt marsh creeks). In West Cork, artificial brackishwater bodies are the predominant lagoon type. The coastline is deeply dissected by the postglacial flooding of valleys in east-west trending rock formations and extensive road-building has resulted in bays and inlets being isolated behind causeways with bridged, culverted or sluiced pipes to control water level. Natural lagoons are also present in West Cork and Kerry, with both sand-gravel and cobble barriers (Kilkeran Lake, Farranamanagh Lake, Lough Gill).

Clare-South Galway. This region encompasses a range of landforms from the highly porous Burren karst in the north to poorly drained peatlands in the south. Cloonconeen Pool on the Loop Peninsula is unusual in being a peat lake with a cobble barrier; it probably originated as an old peat cutting in an area subject to flooding. Lough Donnell on the mid Clare coast is a classic lagoon with an impressive cobble barrier but the lake outlet is artificial. One of the Burren limestone lagoons has a cobble barrier and a tidal inlet (Aughinish Lagoon), two others appear to receive seawater entirely through underground rock fissures (Muckinish Lough, Lough Murree). There may be similar formations on the Aran Islands.

Connemara. This region contains the greatest concentration of natural saline lakes. The drowned coastline with its numerous inlets, bays and islands, includes some areas which are inaccessible by road and the region has not been fully explored. Many of the numerous lakes in the rocky peatland which characterises the region lie close to the coast and have outlets to the sea which are often tidal. The saturated peat supplies freshwater all the year round so that even lakes and pools which receive regular influxes of seawater can remain brackish e.g. Lettermullen Pool, Mill Lough, Lough Athola. A number of lakes in the southern part of the region are connected to the sea by long inlets up to 1 km in length e.g. Lough Tanaí, Lough Carafinla and several others which have not been investigated. They may have had their origins in areas of peat cutting and the inlets themselves may originally have been artificial drainage channels. Further north near Clifden, where the coast is more open, there are a few sedimentary lagoons with barriers of sand (Ballyconneely Lough) or cobbles (Lough Anillaun, Lough Bofin).

Mayo-Donegal. The coastline from Killary Harbour to the Fanad Peninsula comprises long stretches of sand dunes and machair, interrupted by rocky headlands. Natural lagoons appear to have been more numerous in the region in the past. Whereas in the south of the country the identification of brackish waters from maps was relatively easy and few of those visited turned out to be freshwater lakes, from south Mayo to N. Donegal many lakes which because of their proximity to the sea were expected to show marine influence were actually fresh, with no brackish flora or fauna. For example, only two of the five lakes visited in the Murrisk region of Mayo showed any evidence of seawater incursion and the salinity in one of these was <1‰ at the time of sampling (Roonagh L.); two others were typical lagoons according to their

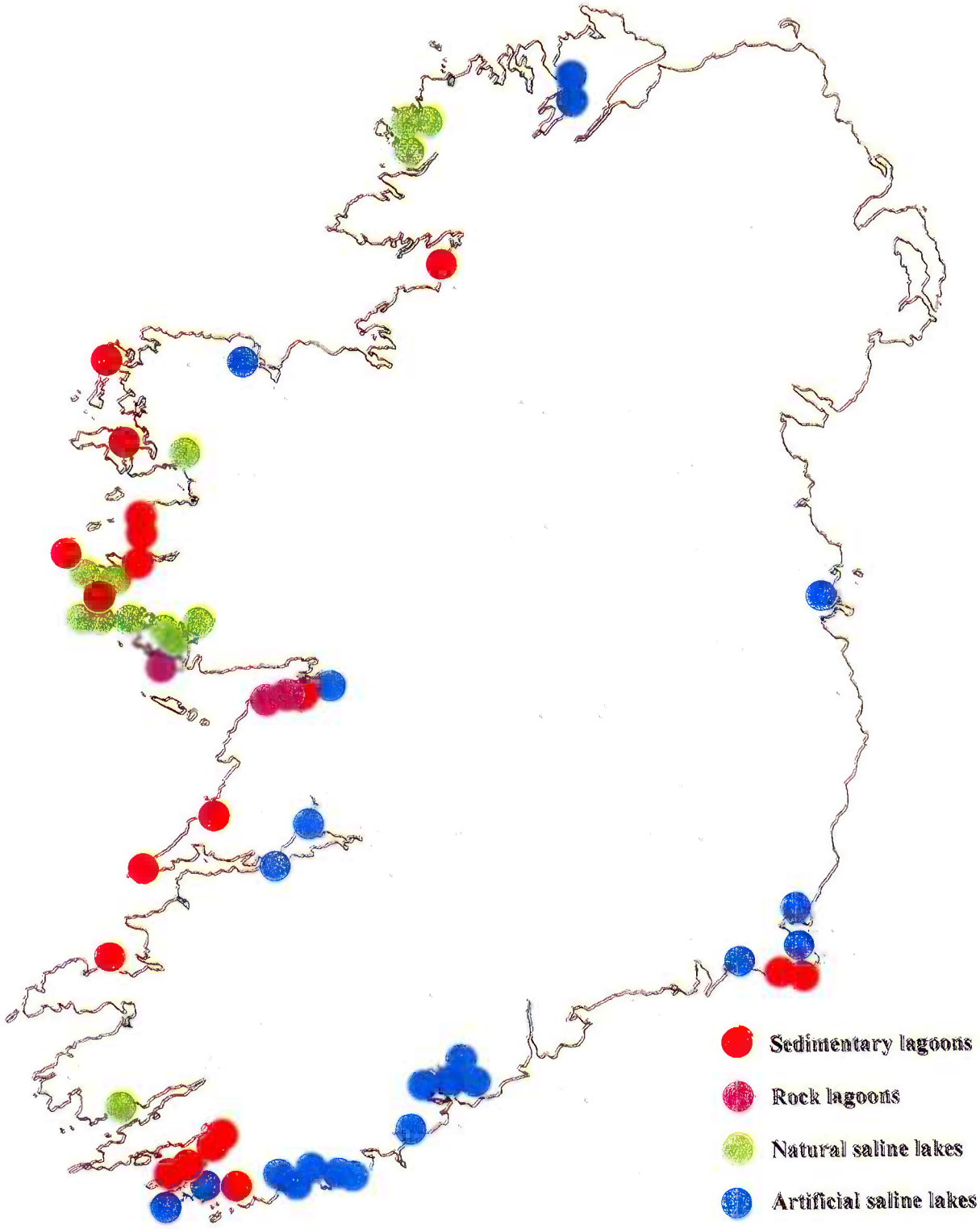

Fig. 4.1 Distribution of the Principal Lagoon Types Surveyed in 1996.

Table 4.1 Known and possible lagoons and saline lakes. PR-previous records; NV-not visited; S-sampled. Salinities in brackets are previous records.

County	Name	Grid ref.	Visit	Salinity	Description
Louth	Ballymascanlan	J 0810	NV	-	not known
Meath	(none identified)				
Dublin	Broadmeadow Water	O 215473	PR	(3-33)	artificial saline lake, tidal inlet
Wicklow	Broadlough	T 3096	V	tidal	tidal inlet, extensive areas exposed
	Ferrybank	T 2573	NV	-	reclaimed?
Wexford	North Slob Channel	T 075239	S	11-24	drainage channel
	South Slob Channel	T 072183	S	3	drainage channel
	Lady's Island Lake	T 099065	S	18-24	sedimentary lagoon, no outlet
	Tacumshin Lake	T 050065	S	0-4	sedimentary lagoon, artificial outlet
	Ballyteige Slob Channel	T 950062	PR	0-18	drainage channels
Waterford	(None identified)				
Cork	Ballymacoda	X 2472	NV	tidal?	salt marsh creek?
	Ballycotton Lagoon	W 9865	V	tidal	former lagoon, now tidal
	Shanagarry	W 9967	V	tidal	salt marsh creek
	Rostellan Lake	W 871660	S	4-35	artificial saline lake, unsluiced outlet
	Cuskinny Lake	W 839674	S	22-27	artificial saline lake, unsluiced outlet
	Fota Is. Lake	W 808723	S	11-24	artificial saline lake, unsluiced outlet?
	L. Beg, Ringaskiddy	W 775634	PR	(0-10)	artificial saline lake, sluiced outlet
	Kinsale Marsh	W 630498	S	30-35	artificial saline lake, sluiced outlet
	Inchydoney Lake	W 398394	S	37	artificial saline lake, unsluiced outlet
	Muckruss Lake, Clonakilty	W 384393	S	40	artificial saline lake, unsluiced outlet
	Kilkeran Lake	W 338344	S	10-15	sedimentary lagoon, intermittent inlet
	Rosscarbery Lake	W290367	S	14-25	artificial saline lake, with bridge
	Blind Harbour	W 206313	V	tidal	artificial saline lake, with bridge
	Toormore Lake	V 844306	S	40	artificial saline lake, with pipes at HW
	Lissagriffin Lake	V 775265	S	25-30	artificial saline lake with bridged inlet
	Farranamanagh Lake	V 830378	S	19-27	sedimentary lagoon with natural inlet
	Reen Pt pools, Durrus Pen.	V 8839	V	23	sedimentary lagoon pools on tombolo
	Kilmore Lake, Whiddy Is.	V 8548	V	-	sedimentary lagoon, temporary (?) inlet
	Reenydonagan Lake	V 000514	S	12-25	sedimentary lagoon, artifical oulet, unsluiced
	Derryvegal, Beara Pen.	V 6455	NV	-	not known
Kerry	Derreenrickard L.	V 7666	NV	-	not known
	Drongawn Lough, Sneem	V 731640	S	26-29	natural saline lake with tidal inlet
	Lough Currane, Waterville	V 5165	V	fresh	freshwater lake
	Lough Gill	Q 606142	S	2-5	sedimentary lagoon, artificial sluiced outlet
	Akeragh L.	Q 7526	V	dry	former lagoon? drained
	L. Naparka	Q 6217	NV	-	not known
	Tarbert Bay	R 0747	NV	-	not known
Limerick	Aughinish Is.	R 2853	NV	-	artificial saline lake ?
Clare	Shannon Airport Lagoon	R 351622	S	13	artificial saline lake, sluiced outlet
	Scattery Is.	Q 9752	NV	-	not known
	Cloonconeen Pool	Q 836497	S	8-35	sedimentary lagoon(or former turf cutting)
	Farrihy Lough, Kilkee	Q 9164	NV	-	probably freshwater
	Doonbeg Lough	Q 9665	V	tidal/fresh	partly blocked tidal estuary
	Lough Donnell	R 002707	S	fresh	sedimentary lagoon, artificial unsluiced outlet
	Muckinish Lough	M 276087	S	14	rock lagoon
	Lough Luirk	M 2808	V	nearly dry	nearly dry turlough
	Lough Murree	M 255119	S	18	rock lagoon with cobble barrier
	Aughinish Lagoon	M 286134	S	39	sedimentary lagoon with inlet
Galway	Bridge Lough, Knockakilleen	M 342128	S	30-33	artificial saline lake, sluiced outlet

Table 4.1 (cont.) Known and possible lagoons and saline lakes. PR-previous records; NV-not visited; S-sampled. Salinities in brackets are previous records.

	Lough Atalia, Galway City	M 3125	PR	(25-30)	tidal bay
	Loch Ceann Gainamh, Inishmaan	L 9506	NV	-	not known
	Port Chorruch, Inishmore	L 8511	NV	-	not known
	Lettermullen Pool	L 827213	S	(28) 34-35	rock lagoon, rock barrier, overwashed
	L. an Mhuilinn	L 8623	V	fresh/saline	not known
	Keeraunagark Bay	L 9722	PR	(25-30, tidal	tidal bay
	L. Carafinla	L 966280	S	10	natural saline lake, inlet through peat
	Loch Ui Chadhain	L 966283	NV	-	not known
	L. Tanai	L 95305	S	29-31	natural saline lake, inlet through peat
	Lough Aughagaddy	L 950305	V	22	natural saline lake, indirect inlet
	Loch Fhada	L 949306	NV	-	not known
	Loch an Oileainin	L 933308	NV	-	not known
	Lough Nafurnace	L 9736	S	fresh	freshwater lake
	Lough Ahalia (3 connecting lakes)	L 950385	S	0-1	natural saline lakes with tidal inlet
	Inverbeg Lough	L 9139	S	fresh	freshwater lake
	Invermore Lough	L 9039	V	fresh	freshwater lake
	Lough Aconeera	L 875369	S	11	natural saline lake with tidal inlet
	Flannery Bridge	L 8635	V	tidal	tidal inlet
	Lough Nageeron	L 7532	NV	-	not known
	Mill Lough	L 784315	S	2	natural saline lake with tidal inlet
	Toombeola Br. (Owenmore R.)	L 7544	V	fresh	blocked river mouth, freshwater
	Lough Naneeve	L 8038	NV	-	not known
	Loch na gCaor	L 7531	NV	-	not known
	Lough Ateesky	L 7831	V	tidal	tidal inlet
	Lough Keeraun	L 784315	S	3	natural saline lake without permanent outlet
	Ballyconneely Lough	L 620437	S	5	sedimentary lagoon, artificial sluiced outlet
	Doonloughan	L 5744	V	fresh	former lagoon? now freshwater
	Lough Athola	L 626484	S	6-33	natural saline lake with tidal inlet through peat
	Ballinaboy Lough	L 6647	V	fresh	freshwater lake
	Salt Lake	L 662493	S	(4) 16-35	natural saline lake, tidal inlet
	Fahy Lough, Omey Is.	L 5655	S	fresh	former sedimentary lagoon? now freshwater
	Aughrusbeg Lough	L 5658	NV	-	freshwater lake
	Lough Anillaun	L 613581	S	fresh	sedimentary lagoon, artificial outlet
	Rusheenduff Lough	L 6763	V	fresh	former sedimentary lagoon, now freshwater
	Lough Bofin, Inishbofin	L 5265	NV	-	sedimentary lagoon without outlet?
Mayo	Doovilra Lough	L 7567	S	fresh	former sedimentary lagoon?, now freshwater
	Dooaghtry Lough	L 7470	NV	-	freshwater?
	Corragaun Lough	L 748698	S	0-1	sedimentary lagoon with inlet
	Cross Lough	L 7475	V	fresh	former sedimentary lagoon, now freshwater
	Roonagh Lough	L 755765	S	fresh (4)	sedimentary lagoon with outlet
	Lough Cahasy	L7578	NV	fresh	former sedimentary lagoon, now freshwater
	Lough Baun	L 7579	V	fresh	former lagoon?, now freshwater
	Lough Polimore	L 7479	S	fresh	former sedimentary lagoon, now freshwater
	Annagh Lough Westport Bay	L 9583	NV	-	not known
	Murrisk N.	L 9283	NV	-	not known
	Murrisk S.	L 9282	NV	-	not known
	Westport House Lough	L 9884	V	fresh	freshwater lake
	Furnace Lough	L 965975	S	2	natural saline lake with tidal inlet
	Lough Feeagh	L 9698	S	fresh	freshwater lake
	Keel Lough, Achill	F 6405	S	fresh	former sedimentary lagoon? now freshwater
	Sruhill Beg, Achill	F 6504	V	fresh	former sedimentary lagoon? now freshwater
	Lough Nakeeroge, Achill	F 5708	NV	-	probably freshwater
	Lough Nakeeroge, Annagh Strand	F 5907	NV	-	probably freshwater
	Lough Nambrack, Achill	F 7009	V	fresh	former sedimentary lagoon? now freshwater
	Lough Doo, Achill	F 7109	V	fresh	former sedimentary lagoon? now freshwater
	Sruhill Lough, Achill	F 7208	V	tidal	tidal inlet
	Dooniver Lough, Achill	F 728074	S	fresh	sedimentary lagoon, artificial outlet
	Inishbiggle Is.	F 7406	NV	-	not known
	Drumsleed	F 7611	NV	-	not known
	Feorinyeo Bay, Mullet Pen.	F 6423	NV	-	not known

Table 4.1 (cont.) Known and possible lagoons and saline lakes. PR-previous records; NV-not visited; S-sampled. Salinities in brackets are previous records.

	Leam Lough Mullet Pen.	F 6427	S	tidal	tidal bay, inlet through peat
	Cross Lough, Mullet Pen.	F 645296	V	fresh	former sedimentary lagoon, some marine influence
	Doon Lough, Inishkea Is.	F 5623	NV	-	not known
	Cartoon Lough, Killala Bay	G 1932	V	36	artificial saline lake, unsluiced outlet?
Sligo	Bunduff Lough	G 7155	S	fresh	former sediment. lagoon? some marine influence
	Lough Gill	G 7235	V	fresh	freshwater lake
	Portroyal, Ballysadare Bay	G 5834	V	-	sedimentary lagoon, shingle barrier with inlet
Leitrim	(none identified)				
Donegal	Durnesh Lough	G 878695	S	5-7	sedimentary lagoon, artificial sluiced outlet
	Shanahan, Ardara	G 7091	NV	-	not known
	Sheskinmore Lough	G 7096	NV	fresh?	freshwater lake
	Clooney Lough	G 7299	V	fresh	freshwater lake
	Maghery Lough	G 723094	S	18-27	natural saline lake, sluiced outlet
	Toberkeen	G 7510	V	fresh	freshwater lake
	Loch O Thuaidh, Tory Is.	G 8447	NV	-	not known
	Loch O Dheas, Tory Is.	G 8446	NV	-	not known
	Lough Meela	B 7313	V	fresh	freshwater lake
	Sally's Lake	B 7216	S	tidal	natural saline lake, artificial outlet
	Kinkas Lough	B 792197	S	6-10	natural saline lake, artificial outlet
	Mullaghderg Lough	B 7620	V	fresh	freshwater lake
	Carnboy Lough	B 7823	V	fresh	freshwater lake
	Inishirrer Is.	B 7829	NV	-	not known
	Moorlagh Lough	B 790187	S	5	natural saline lake, sluiced outlet
	Corganniver Glebe	B 9936	NV	dry	former lagoon?
	Dunfanaghy New Lake	C 0035	V	fresh	freshwater lake
	Melmore Lough	C 1243	V	fresh	former lagoon?
	Lackagh R., Glen Lough	C 0930	V	fresh	river estuary, freshwater
	Rosapenna	C 1138	NV	fresh	freshwater lake
	Back Lough	C 1835	V	tidal	tidal bay
	Wee Sea	C 1939	V	tidal	tidal bay
	Kindrum Lough	C 1843	NV	-	freshwater lake
	Rinboy Lough, Fanad Pen.	C 1744	NV	-	not known, probably freshwater
	Eelburn Loughs, Fanad	C 1944	V	fresh	freshwater lakes
	Kinny Lough, Fanad	C 2044	V	fresh	freshwater lake
	Maghera-Dromann, Fanad	C 2045	NV	-	not known, probably freshwater
	Shannagh Lough	C 2145	NV	-	not known, probably freshwater
	Blanket Nook Lough	C 307194	S	10-20	artificial saline lake, sluiced outlet
	Inch Lough	C 34827	S	6	artificial saline lake, sluiced outlet
	Isle of Dooagh	C 3952	V	dry	former lagoon, drained

Table 4.2 Sites identified as lagoons or saline lakes

Name	Salinity	Description	Barrier	Inlet/outlet
Dublin				
Broadmeadow Water	(3-33)	artificial saline lake	causeway	bridge
Wexford				
North Slob	4-30	artificial saline lake	causeway	pump station
South Slob	2-5	artificial saline lake	causeway	pump station
Lady's Island L.	18-24	sedimentary lagoon	sand/gravel	temporary breach
Tacumshin L.	0-4	sedimentary lagoon	sand/gravel	pipes
Ballyteige Slob	4-34	artificial saline lake	dunes	pump station
Cork				
Rostellan L.	4-35	artifical saline lake	causeway	artificial outlet
Cuskinny L.	22-27	artificial saline lake	artificial? with road	artificial outlet
Fota Is.	11-24	artificial saline lake	causeway	small bridge
L. Beg	(0-10)	artificial saline lake	causeway	sluiced pipe
Kinsale Marsh	30-35	artificial saline lake	causeway	sluices with flaps
Inchydoney L.,	37	artificial saline lake	causeway	artificial outlet
Muckruss L.	40	artificial saline lake	causeway	artificial outlet
Kilkeran L.	10-15	sedimentary lagoon	sand/gravel	temporary natural inlet
Rosscarbery	14-25	artificial saline lake	causeway	bridge
ToormoreL.	40	artificial saline lake	causeway	pipes at HW
Lissagriffin L.	25-30	artificial saline lake	sand dunes and causeway	bridge
Farranamanagh L.,	19-27	sedimentary lagoon	cobble	natural inlet
Reen Pt.	23	sedimentary lagoons	cobble	none?
Kilmore L. Whiddy Is.	-	sedimentary lagoon	cobble	frequent overwash
Reenydonagan L.	12-25	sedimentary lagoon	cobble	pipes
Kerry				
Drongawn L.	26-29	natural saline lake	wide, rocks etc.	sill with rapids
L. Gill	2-5	sedimentary lagoon	sand dunes	modified inlet with sluice gates
Clare				
Cloonconeen Pool	8-35	sedimentary lagoon	cobble and peat	frequent overwash
L. Donnell	fresh	sedimentary lagoon	cobble	artificial outlet
Muckinish E.	14	rock lagoon	rock	fissures
L. Murree	18	rock lagoon	rock	fissures
Aughinish L.	39	rock lagoon	rock	natural inlet (+fissures?)
Galway				
Bridge L.	30-33	artificial saline lake	causeway	artificial channel (and fissures?)
Lettermullen Pool	(28) 34-35	rock lagoon	rock	occasional overwash
L. Carafinla	10	natural saline lake	wide, mainly peat	natural (?) inlet
L. Tanai	29-31	natural saline lake	wide, mainly peat	natural (?) inlet
L. Ahalia	0-1	natural saline lake	wide, rock etc	modified inlet
L. Aconeera	11	natural saline lake	wide, road, rock etc	bridged outlet
Mill Lough	2	natural saline lake	wide, road, rock etc	modified inlet
L. Keeraun	3	natural saline lake	wide, rock etc	dry ditch
Ballyconneely L.	5	sedimentary lagoon	cobble + sand	sluice with flap
L. Athola	6-33	natural saline lake	wide, rock, peat etc	creeks in peaty salt marsh
Salt Lake	(4) 16-15	natural saline lake	rock etc	bridged sill with rapids, modified
L. Anillaun	fresh	sedimentary lagoon	cobble topped with road	narrow bridge
L. Bofin, Inishbofin	34	sedimentary lagoon	cobble	none?
Mayo				
Corragaun L.	0-1	sedimentary lagoon	sand	natural inlet
Roonagh L.	fresh (4)	sedimentary lagoon	cobble etc, wide	natural outlet
Furnace L.	2	natural saline lake	wide, rock etc	modified inlet with weirs
Cross L., Mullet Pen.	fresh	former lagoon	sand dunes, wide	shallow ditch
Sligo				
Bunduff L.	fresh	former lagoon	sand dunes, wide	natural inlet artificially blocked
Donegal				
Durnesh L.	5-7	sedimentary lagoon	sand dunes and cobble	artificial outlet
Maghery L.	18-27	natural saline lake	rock and soil	modified sluiced outlet
Sally's Lake	tidal	artificial saline lake	wide, rock etc	artificial outlet, no obstruction
Kinkas L.	6-10	natural saline lake	wide, rock etc	artificial outlet, no obstruction
Moorlagh L.	5	natural saline lake	rock etc	modified, sluiced outlet
Blanket Nook	10-20	artificial saline lake	causeway	artificial outlet, no obstruction
Inch Lough	6	artificial saline lake	causeway	artificial outlet, sluice gates

geomorphology, being separated from the sea by shingle barriers, and occasional overwash seemed probable yet no brackish water species could be found in them (L. Polimore and Cross L.); a third, Doovilra L., lies at the top of a sandy beach behind a low sand bank but observations made during a gale revealed that wave surges did not actually reach the lake and seawater entry is probably a rare event. This part of the coastline contains extensive areas of machair which depend on windblown sand. It is possible that coastal lakes here are subject to infilling by sand and this, together with an almost continuous input of freshwater which quickly flushes out any seawater which might enter, speeds the evolution of lagoons to freshwater lakes..

Further north on Achill Island, the Mullet Peninsula and parts of Donegal, many lakes which are probably former lagoons are now too far from the sea to allow seawater entry. They are assumed to have become isolated either by accretion of marine or wind-blown sediment or, possibly, as a result of land uplift. (see Sea Level Changes). Only one of the six coastal lakes visited on Achill showed any marine influence (L. Dooniver).

The east shore of Lough Swilly includes large low-lying areas drained by a series of ditches. Two large artificial brackish lakes receive water from these and as they are very shallow, both are important bird areas.

4.1.3 Vegetation

The species identified at the sites visited during Phase 1 are listed in Table 4.4. None is listed in Annex 2 of the Habitats Directive. Four species of Charophyta are considered to be rare and their status in Ireland is given as either *vulnerable* or *indeterminate* in the Red Data Book for Britain and Ireland (Stewart and Church 1992). The record of *Chara baltica* is the first confirmed find for Ireland. The record of *Chara connivens* at Shannon Airport Lagoon needs confirmation. It was last seen in Ireland in 1959 in Co. Clare and there is a record for the South Slob. New records of *Lamprothamnium papulosum* have more than doubled the known Irish localities of the species and new sites for *Chara canescens* have been identified. The seaweed *Cystoseira foeniculata* is "rather rare".

Emergent beds and marginal halophytic communities were well developed on shores which were gently sloping with few rocks. Reed and sedge beds were often as extensive as in freshwater lakes but were poorly developed where water level fluctuations were large, and absent at salinities close to seawater e.g. at Aughinish Lagoon and Lettermullen Pool. *Juncus maritimus* stands characterised high salinity systems, *Scirpus maritimus* and *Schoenoplectus lacustris* ssp. *tabernaemontani* those with medium salinity, and *S. l. tabernaemontani* and *Phragmites australis* low salinities, especially at the mouth of river inlets.

Aquatic communities varied according to both salinity and substratum. At high salinity, marine algae were abundant and diverse if hard substrates were present, especially in or near sea inlets where there were strong tidal currents, but they were poorly represented if the substrate was sand, mud or peat. Pondweeds and charophytes, on the other hand, flourished on soft substrates in shallow water

Table 4.4 Aquatics recorded during Phase 1 of the survey

		salinity	Ruppia sp.	R. baudotii	P. pectinatus	Lamprothamnium	C. canescens (?)	C. connivens *	C. aspera var. aspe	C. vulgaris	Zostera	M. spicatum	others
Wexford	North Slob	(ll-33)	*								*	*	Zannichellia
	South Slob	3		*	*								Lemna trisulca
	Lady's Island	18	*		*	*							
	Tacumshin	4	*	*	*		*					*	P.pusillus, Zannichellia
Cork	Rostellan	4-35	*		*								P.pectinatus extensive
	Cuskinny	27											no aquatic angiosperms
	Fota	22-24											no aquatic angiosperms
	Kinsale	30-32											no aquatic angiosperms
	Inchydoney	37-38											no aquatic angiosperms
	Muckruss	40											no aquatic angiosperms
	Kilkeran	10-15			*								P. pectinatus extensive
	Rosscarbery	14-25											no aquatic angiosperms
	Blind Harbour	tidal											no aquatic angiosperms
	Toormore	38											no aquatic angiosperms
	Lissagriffin	30	*										Ruppia low-growing
	Farranamanagh	20-27	*								*		Zostera, fragments only
	Reenydonagan	12-25			*								
Kerry:	Drongawn L.	26	*										Ruppia extensive
	L. Gill	5	*		*				*		*	*	Zostera frag., Zannichellia
Clare	Shannon Airport	13			*		*	*					Zannichellia
	Cloonconeen	30	*										
	L. Donnell	0	*										Ruppia low-growing
	Muckinish	14	*										Charophyte - no sample
	L. Murree	17	*		*	*							
	Aughinish L.	39											no aquatic angiosperms
Galway:	Bridge L.	30-33	*										Ruppia landward end only
	Lettermullen	34-35	*			*					*		
	L. Carafinla	10	*		*								
	L. Tanai	29-31	*			*					*		
	L. Ahalia	0-1	*								*		Zostera fragments only
	L. Aconeera	11	*		*								
	Mill Lough	2	*										
	L. Keeraun	3			*								
	Ballyconneely L.	5		*									R. sceleratus
	L. Athola	6,33	*								*		Zostera, fragments only
	Salt Lake	16-35											No aquatic angiosperms
	L. Anillaun	0	*										
	Rusheenduff	0											Elodea canadensis
Mayo:	Doovilra L.	0											P.natans, Polygon. amph.
	Corragaun L.	0-1	*										
	Cross Lough	0		*									C.stagnalis, Myriophyll. sp.
	Roonah Lough	0(4)	*										
	L. Furnace	2			*								Litorella
	Dooniver	0	*										
	Cross Lough, Mull	0		*	*								M.alterniflorum
Sligo	(Bunduff)	0			*				*	*			Myriophyll. sp., Polyg. am
Donegal	Maghery	18-27	*										
	Kincas L.	6,10	*										
	Moorlagh	5	*										Ruppia in dense beds
	Blanket Nook	6			*								
	Inch L.	10,20			*								

* Record of *Chara connivens* not confirmed

if the substrate was sand, mud or peat. Pondweeds and charophytes, on the other hand, flourished on soft substrates in shallow water

4.1.4 Aquatic Fauna

The brief time available for sampling the aquatic fauna, and the restriction of sampling, usually, to one sampling station, meant that only a general assessment of the fauna could be made. Some of the material collected remains to be identified. Distribution of the species in relation to geographic region and ecology are discussed in relation to the 20 selected sites in Section 4.2 and in the Site Surveys (Volume III).

4.1.5 Ecotonal Coleoptera

Collections of marginal beetles were made at 20 sites during Phase 1, including sites selected for intensive survey which are discussed in Vol. III. Other sites sampled which were identified as lagoons or saline lakes but were not selected for further study were Kinsale, Reenydonagan, Carafinla, Doovilra, Portroyal and Inch L. These collections have not been analysed.

4.2. SUMMARY OF INTENSIVE SITE SURVEYS

4.2.1 Geomorphology and environment

The 20 sites studied in Phase 2 of the survey presented a wide range of geomorphological structures and environmental conditions which are capable of influenceing species distributions and the nature of floral and faunal communities.

Regional distribution of geomorphological types

All four major categories of lagoons were represented (Table 4.5). They were situated in Wexford and from West Cork to South Donegal. Sedimentary lagoons, which accounted for 13 of those studied, were similarly spread between Wexford and Donegal. Only two of those studied were artificial, i.e. created by construction of an artificial barrier.

Table 4.5 Representation and distribution of the major types of lagoons

Lagoon Type	*Number*	*Counties*
Sedimentary barrier:		
sand/gravel	7	Wexford, Cork, Kerry, Mayo, Donegal
cobble	4	Cork, Clare, Galway
Rock barrier	2	Clare, Galway
Natural saline lake	5	Kerry, Galway, Mayo
Artificial saline lake	2	Cork, Galway

Sea Inlets/Outlets

Nine of those studied had natural inlets through which tidal seawater could penetrate, at least during spring tides, and five had artificial outlets of which two were sluiced. Six had no permanent opening to the sea; of these, two were percolation lagoons which were breached artificially when water rose to unacceptable levels, three received seawater by occasional overtopping of the barrier, and one through underground rock fissures.

Lagoon size

Lagoon area varied between 1 ha (Lettermullen) and 450 ha (Lady's Island and Tacumshin), with a mean area of 73 ha (Fig.4.2). Half were between five and 20 ha.

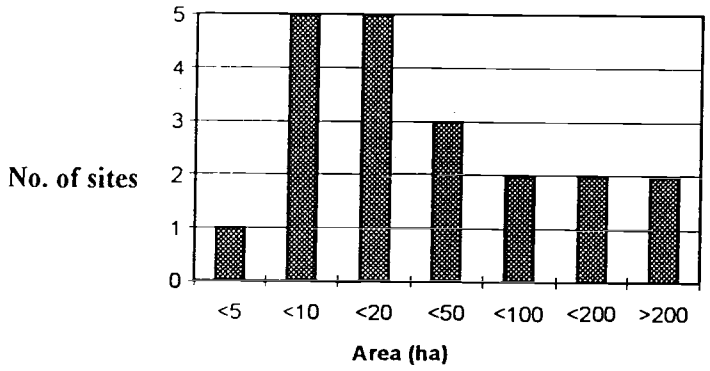

Fig. 4.2 Size distribution of the 20 sites studied.

Salinity

Salinities measured on different occasions at each site by different members of the survey team (Table 4.6) show some of the variation, both spatial and temporal, which the systems experience. Different salinity regimes were represented as follows:

Mostly < 5‰ - (Kilkeran, Gill, Donnell, Roonah, Durnesh)
Mostly >28‰ - (Drongawn, Cloonconeen, Aughinish, Bridge, Lettermullen, Tanaí)
Medium - (Murree, Aconeera, Mill)
Wide range - (Lady's Island, Tacumshin, Lissagriffin, Farranamanagh, Corragaun, Furnace)

Table 4.6 Salinities (‰) measured on four occasions at each of the 20 sites (different dates for each site)

	1st	2nd	3rd	4th
Lady's Island L.	18-24	23	4-26	5-23
Tacumshin L.	0-4	9	0-19	2-35
Kilkeran L.	10-15	1-2	1-2	0-2
Lissagriffin L.	25-30	4-28	25-30	0-20
Farranamanagh L.	19-27	1-6	4	16-25
Drongawn L.	26-29	33	10-32	34
L. Gill	2-5	0-2	2	0-3
Cloonconeen P.	35		30-34	33-36
L. Donnell	0		2-6	0-5
L. Murree	18	10-27	11-22	13-24
Aughinish L.	39	40	34-40	31-33
Bridge L.	30-33	38	31-38	32
Lettermullen P.	34-35		35-37	34-35
L. Tanai	29-31		28-34	32
L. Aconeera	11	10-13	0-14	11
Mill L.	2	12	5-21	2-34
Corragaun L.	0-1	7	25-32	0-4
Roonah L.	0	0-2	0	0-2
Furnace L.	2	6	0-22	0-20
Durnesh L.	5-7	5	0-2	0-5

Substrates

Generally, substrate varied within the lagoons according to tidal and freshwater currents and the nature of the surrounding land. Most were sandy with varying amounts of gravel or silt. Several were rocky with gravel and stones and often also peat. Two were almost entirely composed of peat.

Depths

Most were less than 2-5 m and could be described as shallow but two contained deeper areas (Aconeera and Mill) and two reached depths of 18 m or more (Furnace and Drongawn).

4.2.2 Species records and lagoonal specialists

A total of 484 taxa were recognised of which 451 were identified to species (Table 4.7). Species occurring in marginal vegetation are not included. Only 18 of the 38 lagoonal specialists listed for Britain were recorded, 12 fauna and 6 plants (including algae and charophytes, and *Ruppia cirrhosa* which was not listed by Davidson *et al.* (1991) possibly due to an oversight. Among the ecotonal Coleoptera, 16 were recognised as indicator species, i.e. with specialised habitat requirements, comprising 8% of Carabidae and 8% of Staphylinidae.

Table 4.7 Species records, lagoonal specialists and indicator species.

	Aquatic fauna	*Aquatic flora*	*Ecotonal Coleoptera*
No. of taxa	243	36	205
No of species identif.	213	33	205
Lagoonal specialists	11	6	
Indicator spp.			16

4.2.3 Aquatic vegetation

Vascular plants and charophytes were in most cases identified to species but some of the algae were not determined. *Fucus ceranoides*, a useful brackish indicator, needs to be confirmed and no attempt has been made to identify filamentous green algae. Masses resembling *Chaetomorpha* were present at some sites (especially Bridge Lough), but their identity was not confirmed. *Chaetomorpha linum* is a lagoonal specialist, thus correct identification is important..

Among the 36 taxa recognised, 19 are algae, 6 are charophytes (one represented by 2 varieties) and 11 are vascular plants (Table 4.8). Three charophytes, all lagoonal specialists, are Red Data Book species: *Chara baltica* is a new record for Ireland and its British status is "vulnerable", *Chara canescens* is "vulnerable" in Ireland and "endangered" in Britain, and *Lamprothamnium papulosum* is "vulnerable" in Ireland and Britain (Stewart and Church 1992).

Ruppia species could not be determined with certainty at sites surveyed in early summer. *Ruppia* was present at all but one site (Aughinish where the salinity is probably always near seawater and often hypersaline). Both species were widely distributed with *R. maritima* somewhat more frequent. At five sites, both species were present.

Species richness of the aquatic vegetation

The number of taxa present varied between 2 and 10 (Table 4.8). The most species were found at high salinity where marine algae were present (Aughinish, Lettermullen, Tanai), or at very low salinity where various vascular aquatics were found (Gill, Durnesh).

Ecology of Ruppia, Zostera, and charophytes

Both species of *Ruppia* occurred in the full range of salinities from 0-35‰ (Tables 4.9, 4.10) but *R. maritima* was more frequent at low salinity. *R. cirrhosa* was more frequent at sites with a peat/rock substrate and absent from those with sandy bottoms while *R. maritima* occurred widely on all substrates (Table 4.11).

Table 4.8 Occurrence of Algae, charophytes and aquatic vascular plants.

	Lady' Island L.	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen P.	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen P.	L. Tanai	L. Aconeera	Mill L	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
Algae																				
Cladophora sp.	+	+			+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
Enteromorpha sp.	+		+	+		+	+		+	+	+	+		+	+	+	+	+	+	+
Chaetomorpha sp.												+	+							
Ulva lactuca				+							+									
Codium tomentosum						+					+		+							
Phyllophora pseudoceranoides														+						
Fucus ceranoides ?												?		+	+	+				
F. serratus						+					+									
F. spiralis				+																
F. vesiculosus														+						
Fucus sp.						+								+	+	+			+	
Ascophyllum bodosum																				
Cystoseira foeniculata											+									
Plocamium cartilagineum											+									
Polysiphonia elongata											+		+							
Osmundia hybrida											+									
Corallina officinalis													+							
Chondrus crispus													+							
Lomentaria clavellosa													+							
Charophyta																				
Chara aspera var. aspera			+				+												+	+
Chara baltica															+					
Chara canescens		+								+										+
Chara globularis var. *virgata*																		+		
Chara globularis var. *annulata*																		+		
Chara hispida var. *minor*																				+
Lamprothamnium papulosum	+									+			+	+						
Vascular plants																				
Ruppia maritima	+	?	+				+	+	+	+		+					+	+		
Ruppia cirrhosa	+					?				+			+		+	+				
Ruppia sp.				+	+									+					+	+
Potamogeton pectinatus	+	+	+				+			+					+				+	+
P. cf obtusifolius																				+
Zostera marina													+	+						
Polygonum amphibium			+																	
Mynophyllum spicatum							+													+
Callitriche stagnalis																				+
C hermaphroditica							+													
Zannichellia palustris							+													
Lemna minor	+						+													+
TOTAL TAXA	7	4	5	4	2	6	9	2	2	7	9	5	10	9	7	5	3	5	6	10

Table 4.9 The occurrence of Ruppia, Potamogeton pectinatus and charophytes in relation to salinity and substrate

	Salinity	Substrate	*Ruppia*	*Ruppia*	*Ruppia* sp.	*Potamog.*	*Zostera*	*Lampro-*	*Chara*
	ppt.		*cirrhosa*	*maritima*		*pectinatus*	*marina*	*thamnium*	*canescens**
Lady's Island L.	14-23	silt/gravel	+	+				+	
Tacumshin L.	13-35	silt/gravel		cf		+			
Kilkeran L.	2	sandy		+		+			+
Lissagriffin L.	0-6 (20)	sandy			+				
Farranamanagh L.	16-25	gravel			+				
Drongawn L.	34	peat/rock	cf						
L. Gill	0-3	sandy		+		+			
Cloonconeen P.	33-36	peat		+					
L. Donnell	0-5	sandy		+					
L. Murree	13-24	gravel	+	+		+		+	+
Aughinish L.	31-33	peat/rock							
Bridge L.	32	peat		+					
Lettermullen P.	34-35	peat/rock	+				+	+	
L. Tanai	(5) 32	peat/rock	+	+			+	+	
L. Aconeera	14	peat/rock	+			+			
Mill L.	May-21	peat/rock	+						
Corragaun L.	0-4	sandy		cf					
Roonah L.	0-2	sandy		+					
Furnace L.	0-5(20)	peat/rock	cf	+		+			
Durnesh L.	0-5	gravel	+	+		+			+

**Chara canescens* at 13 ppt at Tacumshin L. and L. Muree.
cf - identity unconfirmed

Table 4.10 Salinity range of brackish water species and number of sites in high, medium and low salinity at which the species occur.

	Salinity range	Number of sites		
		0-10‰	10-30‰	30‰+
Ruppia cirrhosa	0-35	3	4	3
Ruppia maritima	0-36	7	3	4
Potamogeton pectinatus	0-24	5	2	0
Lamprotham. papulosum	13-35	0	2	2
Chara canescens	0-13	1	2	0

Table 4.11 Distribution of brackish species in relation to substrate.

	Number of sites		
	sand	gravel	peat/rock
Ruppia cirrhosa	0	3	6
Ruppia maritima	5	4	4
Potamogeton pectinatus	2	3	2
Lamprotham. papulosum	0	2	2
Chara canescens	0	3	0

Zostera marina was only found growing at Lettermullen and L. Tanai, both at high salinity (Table 4.9), but floating leaves were seen at several other sites and the species may be more widespread.

The two most frequent charophytes showed different but overlapping salinity preferences with *Lamprothamnium* occurring in medium salinity and seawater and *Chara canescens* in low-medium salinity (Table 4.10). Neither was found on sandy substrates (Table 4.11). These conclusions must remain tentative, however, in view of the small number of records.

4.2.4 Aquatic Fauna

The full list of taxa and nominal species recorded at the 20 sites is given in Table 4.12. Certain species were notably less frequent in Ireland than in England (Smith and Laffoley 1992), in particular *Hydrobia ventrosa, Idotea chelipes* and *Corophium volutator.* Species distinctly more frequent in Ireland are *Neomysis integer, Potamopyrgus antipodarum, Jaera* spp. *Anguilla anguilla, Gasterosteus aculeatus* and *Platichthys flesus.*

New records and rare species

Hydrometra gracilenta, identified from samples collected by Galvin (1992) in Kilkeran, and *Cercyon stagnalis*, from L. Gill, are new Irish records

Species believed to be rare according to the literature, some of which may, in fact, be fairly widespread, include the following:

Amphipoda (Costello *et al.* 1991)
Gammarus chevreuxi (Aughinish, Durnesh, abundant at the latter) is known from only two previous records from the north of Ireland.
Erichthonius difformis (Drongawn) - one record from L. Hyne
Lembos longipes ((Drongawn, Furnace) - three previous records
Leptocheirus pilosus (Furnace) - records from the North Slob (Devlin 1992) and Wexford Harbour only.

Isopoda
Jaera forsmani (Drongawn) - recorded from L. Hyne?

Hemiptera (Southward and Leston 1959)
Sigara concinna (lagoonal specialist, Lady's Island, Tacumshin, Kilkeran) -regarded as rare in Ireland.
Notonecta viridis (Lady's Island, Tacumshin, Kilkeran, Donnell) - previously known only from N. Kerry and Lady's Island.

Mollusca (pers. comm.)
Littorina "tenebrosa" (Lettermullen, and also the N. Slob) - these are the only known localities in Ireland.
Cnidaria (Cornelius 1995)

Laomedea angulata (Lettermullen) - considered rare but possibly overlooked.
Cordylophora caspia (Durnesh, Rostellan) - not considered rare in Britain but the only other lagoon habitat in Ireland is Lady's Island.

Lagoonal specialists

Davidson *et al.* list 32 faunal species as lagoonal specialists in Britain. Of these, 12 are regarded as rare or not recorded during the English National Survey (Barnes 1989), and at least one is presumed extinct. Of the remaining 20 species, at least one (*Sigara selecta*) is not known to occur in Ireland, and there may be several others.

Table 4.12 Faunal Species Recorded in the 20 Selected Sites.

		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. Tanaf	L. Aconcera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
Porifera	*Halichondria panicea*						+														
Cnidaria	*Actinia equina*												+								
	Acanthopleura balli						+														
	Anemonia viridis											+									
	Aurelia aurita					+								+	+					+	
	Crysaora hysoscella						+					+									
	Cordylophora caspia																				+
	Dynamena pumila											+					+				
	Laomedia angulata													+							
Turbellaria																+				+	
Nemertea											+			+	+						
Annelida	*Amphitrite edwardsi*						+														
	Arenicola marina	+					+					+	+	+	+	+	+	+			
	Capitella capitata											+									
	Clitellio arenarius							+			+										
	Hediste diversicolor	+	+		+						+	+		+	+		+				
	Janua pagenstecheri						+							+							
	Lepidonotus squamatus											+									
	Neanthes virens																				
	Platynereis dumerili						+														
	Pomatoceros triqueter						+					+									
	Tubificoides heterochaeta								+												
	Hirudinea sp.							+											+		
	Naididae							+													
	Nereidae						+														
	Polychaeta indet.											+			+						
	Spirorbidae indet.						+					+		+							
	Tubificidae indet.														+						
Crustacea																					
Ostracoda								+													+
Copepoda								+						+							+
Cirripedia	*Balanus balanus*											+									
	Balanus improvisus	+												+							
	Semibalanus balanoides						+					+									
	Verruca stroemia						+														
Mysidacea	*Heteromysis lamornae*						+														
	Leptomysis lingvura																+				
	Mysidopsis gibbosa											+									
	Neomysis integer	+	+	+	+	+	+	+		+	+					+	+	+	+	+	+
	Praunus neglectus											+									
	Praunus flexuosus	+					+					+	+	+	+		+				
	Siriella jaltensis													+							

Table 4.12 (cont.) Faunal Species Recorded in the 20 Selected Sites.

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Clonconeen 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.
Cumacea														+							
Isopoda	*Asellus sp.*	+										+									
	Eurydice pulchra																	+			
	Idotea baltica											+		+		?					+
	Idotea chelipes	+											+	+	+	?					
	Jaera albifrons																			+	
	J. ischiosetosa										+									+	
	J. forsmani						+														
	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											+									
Tanaidacea	*Tanais dulongi*													+							
Decapoda	*Carcinus maenas*	+			+	+	+		+	+		+	+	+	+	+	+	+	+	+	+
	Crangon crangon	+			+	+				+		+						+		+	+
	Macropodium rostrata											+									
	Pagurus bernhardus											+									
	Palaemon elegans				+		+					+		+			+			+	
	P. longirostris						+														
	P. serratus				+		+					+					+	+			
	Palaemonetes varians	+	+	+	+	+	+		+	+	+		+		+	+	+	+		+	+
	Hippolyte varians											+									
	Thoralus cranchii											+									
Arachnida																					
Hydrocarina							+								+						

Table 4.12 (cont.) Faunal Species Recorded in the 20 Selected Sites.

		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.
Pycnogonida							+														
Insecta																					
Thysanura	*Petrobius sp.*				+																
Ephemeroptera	*Cloeon dipterum*			+																	+
	C. simile							+											+		
	Procloeon bifidum							+													
Odonata	*Ischnura elegans*	+	+	+				+		+	+					+			+	+	+
Plecoptera				+				+											+		+
Trichoptera	(cases)							+		+	+					+			+		+
Hemiptera	*Hydrometra gracilenta**			+																	
	H. stagnorum			+																+	
	Gerris lacustris																			+	
	G. odontogaster		+																		
	G. thoracicus		+																		
	Nepa cinerea							+													
	Notonecta glaucum		+	+																+	
	Notonecta viridis	+	+	+						+											
	Plea leachi		+																		
	Cymatia bonsdorffi																		+		
	Callicorixa praeusta	+	+	( )				+											+		+
	Corixa punctata		+					+													
	C. panzeri	+	+	+				+											+		+
	Hesperocorixa linnaei		+																		+
	Arctocorisa germari							+													+
	Sigara dorsalis	+	+	+			+	+		+									+		+
	S. falleni																				+
	S. concinna	+	+	+																	
	S. semistriata																		+		
	S. stagnalis	+	+	+	+				+	+								+	+		+
Coleoptera	*Agabus montanus*																		+		
	A. nebulosus										+										
	Anacaena globulus					+															+
	A. lutescens			+																	
	Cercyon littoralis												+				+				
	C. marinus			+																	
	C. sternalis							+													
	Coccidula rufa			+																	
	Colymbetes fuscus	+	+																		
	Dryops luridus									+											
	Elmis aenea																		+		

Table 4.12 (cont.) Faunal Species Recorded in the 20 Selected Sites.

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Cloonconeen Pool	L. Dunnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanaf	L. Aconeera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
	Enochrus bicolor	+							+		+		+	+	+						
	E. halophilus		+																		
	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		+					+		+											+
	Laccobius biguttatus							+													
	L. minutus							+											+		
	Laccophilus minutus		+					+													+
	Llybius fuliginosus							+											+		
	Megasternum obscurum																			+	
	Nebrioporus depressus							+											+	+	
	Noterus clavicornis	+	+							+											+
	Rhantus frontalis		+																		
Diptera	Chironomidae	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+
	Tipulidae							+										+			
	Ephydridae	+								+											
	Culicidae									+	+										
	Syrphidae										+										
Mollusca																					
Polyplacophora	*Lepidochitona cinerea*						+	+				+		+							
Prosobranchia	*Bittium reticulatum*						+					+		+							
	Gibbula umbilicalis						+					+		+							
	Hinia incrassata													+							
	Hydrobia ulvae				+				+						+		+				

Table 4.12 (cont.) Faunal Species Recorded in the 20 Selected Sites.

		Lady's Island	Tacumshin L.	Kilkeran L.	Lissagriffin L.	Farranamanagh L.	Drongawn L.	L. Gill	Clonconeen Pool	L. Donnell	L. Murree	Aughinish L.	Bridge L.	Lettermullen Pool	L. Tanaí	L. Aconcera	Mill Lough	Corragaun L.	Roonah L.	Furnace L.	Durnesh L.
	H. ventrosa	+	+				+		+		+		+		+						
	Littorina littorea						+					+	+	+							
	L. obtusata						+										+				
	L. saxatilis						+				+	+			+						
	L. "tenebrosa"													+							
	Nucella lapillus													+							
	Onoba sp.						+														
	Patella aspera											+									
	Patella vulgata						+							+							
	Potamopyrgus antipodarum	+	+	+	+	+		+		+	+					+	+	+	+	+	+
	Rissoa membranacea						+							+	+						
	Rissoa sp.						+														
	Skeneopsis planorbis													+							
Pulmonata	*Aplexa hypnorum*																		+		
	Lymnaea palustris		+																+		
	L. peregra		+					+											+		+
	Planorbis leucostoma		+																		
	P. corneus																				+
	Sementina complanata							+											+		+
Opisthobranchia	*Aeolidia papillosa*											+									
	Akera bullata														+						
	Elysia viridis						+					+		+							
	Limaponta depressa												+								
	Scaphander lignarius						+														
Bivalvia	*Abra sp.*																			+	
	Anomia sp.						+														
(shells omitted)	*Cerastoderma edule*											+									
	C. glaucum						+		+				+	+	+	+	+				
	Chlamys varia						+														
	Modiolarca tumida											+									
	Musculus discors														+						
	Mya arenaria															+					
	Mytilus edulis						+					+		+	+					+	
	Mytilus edulis						+					+	+	+	+	+				+	
	Ostrea edulis						+					+									
	Parvicardium ovale						+														
	Pisidium sp.							+													
	Sphaerium sp.							+													
	Venerupis sp.						+					+									
Bryozoa	*Alcyonidium gelatinosum*											+									
	Alcyonidium mamillatum													+							
	Bowerbankia gracilis						?					+		+							
	Conopeum seurati	+												+	+	+	+			+	
	Cryptosula pallasiana						+					+									

Table 4.12 (cont.) Faunal Species Recorded in the 20 Selected Sites.

		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.
	Flustrellidra hispida																+				
	Fredericella ?sultana			+																	
	Plumatella repens			+	+			+											+		
	Walkeria uva													+							
Echinodermata	*Amphipholis squamata*						+					+		+							
	Asterias rubens						+														
	Luidia ciliaris													+							
	Paracentrotus lividus													+							
Tunicata	*Ascidiella aspersa*						+					+		+							
	A. scabra											+		+	+		+				
	A. virginiata													+							
	Botryllus schlosseri											+		+							
	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	+			+			+		+					+		+	+			+
	Platichthys flesus	+		+	+		+	+		+					+	+	+	+	+	+	+
	Pollachius pollachius	+										+		+							
	Pomatoschistus microps	+		+	+	+	+	+		+	+	+	+			+	+			+	
	Pungitius pungitius		+																		
	Salmo trutta							+													+
	Spinachia spinachia	+																			
	Sprattus sprattus	+																			
	Syngnathus acus	+																			
	S. typhle													+							

None of the cnidarians or annelids in the British list were recorded during this survey although the smaller species may have been overlooked. Of the crustaceans, *Gammarus insensibilis* and *Corophium insidiosum* were not recorded and *Gammarus chevreuxi* was at only two sites. Of the three hemipteran species, *Sigara selecta* does not occur. *Sigara concinna*, was only recorded at the three southern sites and may not therefore be a useful indicator for the country as a whole. *Sigara stagnalis* was recorded at most of the less saline sites but also in salinities up to 30‰. In the U.K., *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 here than in Britain.

All but two of the 11 species of Coleoptera listed as lagoonal specialists for Britain were not actually recorded during the 1989 English survey, although very few of the participants identified this group at all. Both of the "common species" on their list were identified during the Irish survey. Of the molluscs, *Hydrobia neglecta* and *Onoba aculeus* were not found. Of the two lagoonal bryozoans, *Conopeum seurati* was recorded at six sites while *Victorella pavida* was recorded for Kilkeran by Galvin (1992) but this may have been a misidentification.

In conclusion, of the 20 faunal species regarded as "common" lagoonal specialists in Britain, only 12 were recorded in Ireland and several of these are relatively rare or certainly not widespread. There may, however, be other species which could be added to the list of lagoonal specialists in Ireland, although more information on the ecology and distribution of these species is needed. Possible candidates might be *Notonecta viridis*, and *Gerris thoracicus* and possibly *Neomysis integer*, which although also occurring in estuaries and salt marshes, is distinctly less frequent on the open coast and appears to be one of the most frequently occurring lagoonal species..

Species richness

The number of taxa/site varied between 14 and 68 (Table 4.13). Four factors appear to be important determinants of species richness: lagoon area, the presence of rock, salinity range and the extent of salinity variations (Table 4.13).
Highest species richness was correlated with high salinity (generally >30‰) indicating frequent incursions of seawater and easy access for colonists from the sea, and the presence of significant amounts of rock favouring sessile species (Drongawn, Aughinish, Lettermullen). The number of species also tended to be high at very low salinity where freshwater species, especially corixids and beetles, were diverse (Gill, Durnesh). The species/area relationship held for most sites with the exception of three with both high salinity and rocks where high habitat diversity in small areas, ease of colonisation from the open sea, and salinity close to that of seawater were overriding factors (Fig. 4 x).

Salinity variations may influence the fauna in two ways. Salinity gradients within the lagoon contribute to habitat diversity, especially in large systems, and could be expected to favour a wide range of ecological types (e.g. Lady's Island, Tacumshin, Furnace). Temporal variations, on the other hand, especially sudden changes related to tidal incursions, are not tolerated by stenohaline species and in such systems the fauna consists principally of euryhaline species and the total number is low.

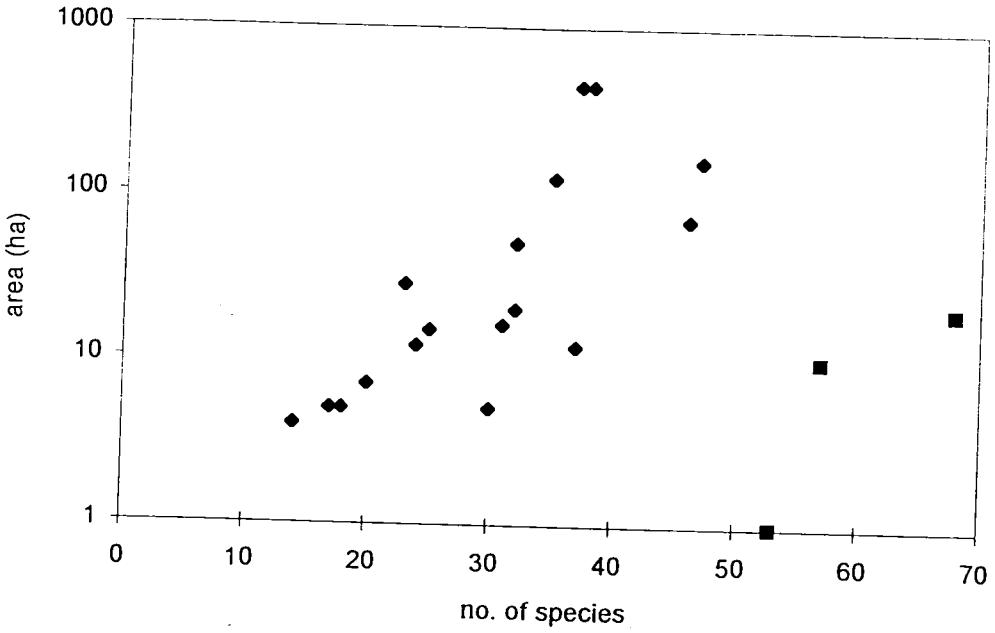

Fig. 4.3 Relationship between number of species and area of lagoon

Number of lagoonal specialists

Lagoonal specialists are species favoured by the properties of lagoons as distinct from estuaries or freshwater lakes i.e. brackish water in enclosed systems with a restricted tidal range. They can thus be used as indicators of lagoon-like systems which do not comply with geomorphological definitions.

The number of lagoonal specialists varied between eight and one (Table 4.13), with the highest number generally in true lagoons in the medium to high salinity range. Exceptions were Aughinish (one specialist) where the absence of freshwater inflows makes conditions unsuitable for brackishwater species, and Tanaí (7 specialists), a peat lake. Aconeera and Mill L., also situated in peatland, had moderate numbers of lagoonal specialists, suggesting that saline lakes in peatlands should be accepted as "lagoons" for purposes of the Habitats Directive. Low numbers of lagoonal specialists were mainly recorded at sites subject to wide and sudden fluctuations in salinity, and those with persistently very low salinity. The lists in use in Britain were compiled by marine biologists and it may be possible in the future to recognise some species considered to be freshwater forms tolerant of brackish conditions as actually preferring them and thus qualifying for inclusion as lagoonal specialists.

Table. 4.13 Number of species and lagoonal specialists in relation to lagoon area, rock and salinity regime (range, spatial and temporal variation).

	Species	Lag. spec.	% lag sp.	Area (ha)	Rock	Sal range	Spatial var.	Temp. var.
Lady's Island L.	38	8	23	450	*	4-26	large	small
Tacumshin L.	37	6	16	450		0-19	large	small
Kilkeran L.	31	3	9	16		1-15	med.	small
Lissagriffin L.	24	2	8	12		4-30	large	large
Farranamanagh L.	17	1	6	5		1-27	small	large
Drongawn L.	68	3	4	20	**	10-34	small	small
L. Gill	47	1	2	160		0-5	small	small
Cloonconeen P.	14	6	43	4		30-36	small	small
L. Donnell	32	2	6	20		0-6	small	small
L. Murree	25	3	12	15	**	10-24	small	small
Aughinish L.	57	1	2	10	**	31-40	small	small
Bridge L.	18	5	28	5	*	30-38	small	small
Lettermullen P.	53	5	9	1	**	34-37	small	small
L. Tanai	37	7	19	12	*	28-32	small	small
L. Aconeera	23	4	17	28	**	0-14	med.	med.
Mill L.	30	4	13	5	*	2-34	med.	large
Corragaun L.	20	2	10	7		0-32	small	large
Roonah L.	32	1	3	50		0-2	small	small
Furnace L.	35	3	9	125	*	0-22	large	med.
Durnesh L.	46	3	7	70		0-7	small	small

4.2.5 Ecotonal Coleoptera

The shores of the 20 lagoons were surveyed for Staphylinidae and Carabidae using suction trapping of marginal vegetation, pifall traps, water flotation of soil samples and ground searches. In total, 144 species of staphylinid and 61 species of carabid were recorded (Table 4.14). One species, *Brundinia meridionalis*, was previously unrecorded in Ireland. It is a halobiont species and was restricted to three sites with eutrophic, silty lagoon margins with extensive growth of filamentous algae.

Species were selected as indicators of conservation value if: (1) they have a restricted habitat preference to a specific type of microhabitat associated with the lagoon margins; 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. Eleven species of staphylinid and five species of carabid were selected as indicator species. Sites were rated on the basis of the number of indicator species, taking into account the nature of the associated fauna and the characteristics of the habitat.

Six sites were rated as having average conservation value, and one as average, but potentially exceptional (Table 4.15). The latter, Loch Tanaí in Connemara, contained gently sloping peat grading from blanket bog to open water with zones of marginal vegetation flooded at high spring tides. The indicator species were characteristic of marshy soil and flooded peaty soil, and the associated fauna were mainly bog species and were not halophilous. The combination of a bog/saline lake peat shore with irregular brackish water flooding may produce a habitat suitable for specialised peat soil fauna, and requires further investigation.

Overall, the fauna was more characteristic of wetland than saline soils, with many halobiont species not recorded. Winter flooding by freshwater may have more impact that seawater flooding in the western seaboard, especially at sites with large watersheds.

4.2.6 References

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Table 4.14 Species list and total numbers of ecotonal Coleoptera (Carabidae, Staphylinidae) sampled from coastal lagoons in 1996.

Carabidae

	Abax parallelipedus (Pill.Mitt.)	10	
	Acupalpus parvulus (Sturm)	1	
	Agonum fuliginosum (Panz.)	6	
	Agonum gracile (Gyll.)	7	
	Agonum marginatum (L.)	23	
	Agonum muelleri (Hbst.)	3	
*	*Agonum nigrum* Dej.	2	**Indicator species**
	Agonum pelidnum (Payk.)	47	
	Agonum viduum (Panz.)	1	
	Anisodactylus binotatus (F.)	1	
	Amara ovata (F.)	2	
*	*Bembidion aeneum* Germ.	2	**Indicator species**
	Bembidion assimile Gyll.	44	
*	*Bembidion bipunctatum* (L.)	10	**Indicator species**
	Bembidion guttula (F.)	2	
	Bembidion lampros (Hbst)	5	
	Bembidion mannerheimi Sahlb.	89	
	Bembidion minimum (F.)	55	
	Bembidion normannum Dej.	1	
	Bembidion obtusum Serv.	1	
	Bembidion pallidipenne (Ill.)	13	
	Bembidion tetracolum Say	3	
	Bembidion varium (Ol.)	58	
*	*Blethsia multipunctata* (L.)	1	**Indicator species**
	Bradycellus harpalinus (Serv.)	2	
	Broscus cephalotes (L.)	2	
	Calathus fuscipes (Goeze)	91	
	Calathus melanocephalus (L.)	8	
	Calathus micropterus (Duft.)	1	
	Calathus ochropterus (Duft.)	1	
*	*Carabus clathratus* L.	1	**Indicator species**
	Carabus granulatus L.	14	
	Demetrias atricapillus (L.)	7	
	Dicheirotrichus gustavi Crotch	47	
	Dromius linearis (Ol.)	8	
	Dromius melanocephalus Dej.	2	
	Dyschirius globosus (Hbst.)	82	
	Dyschirius luedersi Wagn.	18	
	Dyschirius politus (Dej.)	3	
	Dyschirius thoracicus (Rossi)	1	
	Elaphrus cupreus Duft.	20	
	Harpalus rufipes (Geer)	31	
	Leistus fulvibarbis Dej.	2	
	Leistus terminatus (Hellw.)	2	
	Loricera pilicornis (F.)	10	
	Nebria brevicollis (F.)	25	
	Notiophilus aquaticus (L.)	1	
	Notiophilus biguttatus (F.)	1	
	Notiophilus palustris (Duft.)	3	
	Platynus albipes (F.)	15	

Carabidae (continued)

	Pogonus chalceus (Marsh.)	6
	Pterostichus diligens (Sturm)	6
	Pterostichus madidus (F.)	1
	Pterostichus melanarius (Ill.)	10
	Pterostichus minor (Gyll.)	6
	Pterostichus niger (Schall.)	239
	Pterostichus nigrita (Payk.)	71
	Pterostichus strenuus (Panz.)	3
	Pterostichus vernalis (Panz.)	1
	Trechus obtusus Er.	7
	Trichocellus placidus (Gyll.)	1

Total number of species : 61
Total number of individuals : 1136
Percentage of indicator species : 8%

Staphylinidae

	Acrotona pusilla (Brundin)	1	
	Aleochara bipustulata (L.)	4	
	Aleochara lanuginosa Grav.	1	
	Alianta incana (Er.)	1	
	Aloconota gregaria (Er.)	32	
	Amischa analis (Grav.)	32	
	Amischa decipiens (Sharp)	4	
	Amischa nigrofusca (Steph.)	168	
	Anotylus maritimus Thoms.	1	
	Anotylus rugosus (F.)	32	
	Astenus longelytratus Palm	1	
	Atheta amplicollis (Muls. Rey)	109	
	Atheta atramentaria (Gyll.)	5	
	Atheta celata (Er.)	3	
	Atheta clientula (Er.)	8	
	Atheta elongatula (Grav.)	56	
	Atheta fungi (Grav.)	31	
	Atheta graminicola (Grav.)	106	
*	*Atheta gyllenhali* (Thoms.)	1	**Indicator species**
*	*Atheta liliputana* (Bris.)	1	**Indicator species**
	Atheta luteipes (Er.)	1	
	Atheta melanocera (Thoms.)	8	
	Atheta orbata (Er.)	3	
	Atheta vestita (Grav.)	42	
	Atheta volans (Scriba)	67	
	Bledius fergussoni Joy	39	
	Bledius gallicus (Grav.)	9	
	Bledius limicola Totth.	9	
	Bledius longulus Er.	14	
	Bledius subniger Schneid.	21	
*	*Brundinia meridionalis* (Muls. Rey)	121	**Indicator species**
	Calodera aethiops Grav.	2	
	Carpelimus bilineatus (Steph.)	1	
	Carpelimus corticinus (Grav.)	26	
	Carpelimus elongatulus (Er.)	6	
	Carpelimus rivularis (Motsch.)	5	
	Cordalia obscura (Grav.)	44	

Staphylinidae (continued)			
	Cryptobium fracticorne (Payk.)	4	
	Cypha laeviuscula (Mannh.)	5	
*	*Cypha punctum* (Motsch.)	1	**Indicator species**
	Deubelia picina (Aubé)	2	
	Diglotta mersa (Hal.)	5	
	Diglotta submarina (Fairm. Lab.)	1	
	Dinaraea angustula (Gyll.)	4	
	Drusilla canaliculata (F.)	210	
	Encephalus complicans Steph.	1	
	Erichsonius cinerascens (Grav.)	2	
	Euaesthetus bipunctatus (Ljungh)	1	
	Euaesthetus laeviusculus Mannh.	1	
	Euaesthetus ruficapillus Bois. Lac.	8	
*	*Gabrius keysianus* Sharp	6	**Indicator species**
	Gabrius nigritulus (Grav.)	1	
	Gabrius pennatus Sharp	15	
	Gabrius subnigritulus (Reitt.)	4	
	Geostiba circellaris (Grav.)	13	
	Gnypeta carbonaria (Mannh.)	16	
	Gyrohypnus angustatus (Steph.)	7	
	Halobrecta flavipes Thoms.	2	
	Ischnopoda atra (Grav.)	8	
	Lathrobium brunnipes (F.)	5	
	Lathrobium geminum Kr.	1	
	Lathrobium quadratum (Payk.)	4	
	Lathrobium terminatum Grav.	3	
	Lesteva sicula Er.	15	
	Megarthrus depressus (Payk.)	1	
	Metopsia retusa (Steph.)	1	
	Mycetoporus splendidus (Grav.)	2	
	Myllaena dubia (Grav.)	7	
	Myllaena infuscata Kr.	5	
	Olophrum fuscum (Grav.)	8	
	Ocypus aeneocephalus (Geer)	5	
	Ocypus ater (Grav.)	14	
	Ocypus olens (Müll.)	27	
	Omalium excavatum Steph.	1	
	Omalium laeviusculum Gyll.	11	
	Othius laeviusculus Steph.	1	
	Othius melanocephalus (Grav.)	2	
	Oxypoda elongatula Aubé	7	
	Paederus fuscipes Curt.	67	
	Philonthus addendus Sharp	1	
	Philonthus carbonarius (Grav.)	5	
	Philonthus cognatus (Steph.)	15	
*	*Philonthus fumarius* (Grav.)	17	**Indicator species**
*	*Philonthus furcifer* Renk.	2	**Indicator species**
	Philonthus laminatus (Creutz.)	15	
	Philonthus marginatus (Ström)	4	
	Philonthus micans (Grav.)	5	
	Philonthus nigrita (Grav.)	1	
	Philonthus politus (L.)	1	
	Philonthus quisquiliarius (Gyll.)	15	
	Philonthus varians (Payk.)	2	
	Phytosus balticus Kr.	1	
	Platystethus cornutus (Grav.)	1	
	Polystomota grisea (Kr.)	1	

Staphylinidae (continued)

	Quedius fuliginosus (Grav.)	3	
	Quedius molochinus (Grav.)	3	
	Quedius nigriceps Kr.	3	
	Quedius schatzmayri Grid.	2	
	Quedius semiaeneus (Steph.)	15	
	Quedius tristis (Grav.)	4	
	Rugilus erichsoni (Fauv.)	7	
*	*Schistoglossa gemina* (Er.)	1	**Indicator species**
	Sepedophilus nigripennis (Steph.)	24	
	Staphylinus dimidiaticornis Gemm.	3	
	Stenus bifoveolatus Gyll.	15	
	Stenus bimaculatus Gyll.	20	
	Stenus boops Ljungh	35	
	Stenus brunnipes Steph.	16	
	Stenus canaliculatus Gyll.	95	
	Stenus cicindeloides (Schall.)	13	
	Stenus clavicornis (Scop.)	29	
	Stenus formicetorum Mannh.	3	
	Stenus fulvicornis Steph.	20	
	Stenus fuscipes Grav.	14	
	Stenus impressus Germ.	3	
	Stenus incrassatus Er.	76	
	Stenus juno (Payk.)	87	
*	*Stenus lustrator* Er.	13	**Indicator species**
	Stenus melanopus (Marsh.)	8	
*	*Stenus nigritulus* Gyll.	4	**Indicator species**
	Stenus nitens Steph.	5	
	Stenus nitidiusculus Steph.	19	
*	*Stenus opticus* Grav.	4	**Indicator species**
	Stenus ossium Steph.	11	
	Stenus pallitarsus Steph.	1	
	Stenus picipennis Er.	1	
	Stenus similis (Hbst.)	5	
	Stenus tarsalis Ljungh	1	
	Tachinus laticollis Grav.	1	
	Tachinus signatus Grav.	24	
	Tachyporus chrysomelinus (L.)	40	
	Tachyporus dispar (Payk.)	47	
	Tachyporus hypnorum (F.)	7	
	Tachyporus nitidulus (F.)	28	
	Tachyporus obtusus (L.)	4	
	Tachyporus pallidus Sharp	1	
	Tachyporus pusillus Grav.	16	
	Tachyporus solutus Er.	2	
	Tachyporus tersus Er.	1	
	Tinotus morion (Grav.)	1	
	Xantholinus glabratus (Grav.)	1	
	Xantholinus linearis (Ol.)	1	
	Xantholinus longiventris Heer	14	
	Zyras limbatus (Payk.)	1	

Total number of species : 144
Total number of individuals : 2357
Percentage of indicator species : 8%

Table 4.15 Coastal lagoon sites rated for conservation importance according to interpretation of ecotonal Coleoptera (Carabidae, Staphylinidae) sampled in 1996. See methodolology section for explanation of interpretation.

Categories : None , low, average, exceptional.

Site	Conservation value	No. indicator species
Lough Tanaí	Average, potentially exceptional	2
Cloonconeen Pool	Average	2
Durnesh Lake	Average	3
Kilkeran Lake	Average	3
Lady's Island Lake	Average	3
Lough Gill	Average	2
Lough Murree	Average	2
Drongawn Lough	Low	1
Faranamanagh Lake	Low	1
Lissagriffin Lake	Low	1
Lough Aconeera	Low	2
Lough Donnell	Low	2
Tacumshin Lake	Low	1
Aughinish Lagoon	None	0
Bridge Lough	None	1
Corragaun Lough	None	0
Lettermullen Pool	None	-
Lough Furnace	None	0
Mill Lough	None	0
Roonah Lough	None	1

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