

CHAPTER THREE

WATER QUALITY OF LAKES

INTRODUCTION

The results of the water quality monitoring and assessments carried out on Irish lakes for the three-year period 2004-2006 are presented in this chapter and tabulated for each lake in Appendix III.1. In this period 449 lakes were examined representing over 1014 km² of lake surface water or approximately 65 percent of the surface area covered by lakes in the country, including 24 of the 27 large lakes wholly or partly in the state. The majority of these lakes were located in the counties along the western seaboard and in counties Monaghan, Cavan and Leitrim in the north midlands.

The lakes are classified according to their trophic status, by the number and total surface area in each trophic category, by lake size and River Basin District. An analysis of trends in lake trophic status over the past 15 years is also presented.

The results of the long term monitoring on selected representative acid-sensitive lake systems are given. In this programme, biannual physico-chemical and biological examinations are carried out on three lake systems representative of the principal acid-sensitive areas of the country: Loughs Veagh (Donegal), Maumwee (Galway) and Glendalough Lake Upper (Wicklow) and their inflowing streams.

The information on these lakes was derived from investigations carried out by the EPA, Local authorities and the Central and Regional Fisheries Boards.

Information on the compliance in the period 2004-2006 of the bacteriological quality at each of the nine designated freshwater bathing areas, with standards set out in the EU bathing water Regulations, is also presented in this chapter.

Background

The main pressure impacting on lake water quality in Ireland is elevated inputs of phosphorus and nitrogen, which gives rise to over enrichment or eutrophication. These nutrients occur naturally in the environment and their presence at background levels in rivers and lakes is necessary to sustain plant and animal communities. However, increased inputs of phosphorus

and nitrogen, arising from human activity, at concentrations well in excess of natural levels, either directly to the lake or most commonly through its inflowing streams, can give rise to increased inlake concentrations and to eutrophication. The principal sources of these nutrients are from municipal and industrial waste discharges and losses from agricultural activities.

This form of pollution is characterised in lakes by excessive phytoplankton and cyanobacteria (formerly known as blue-green algae) growth and more intensive algal blooms and increased rooted plant growth, declining transparency, deoxygenation of the deeper layers and overall a reduced amenity value. The algal blooms are particularly noticeable on the lake surface following periods of calm weather or along shorelines where they can accumulate as a result of onshore breezes. Cyanobacteria are often the dominant planktonic organisms in eutrophic lakes during the summer months and they may, in certain circumstances, emit toxins, which are particularly harmful.

ASSESSMENT OF EUTROPHICATION AND LAKE CLASSIFICATION

The assessment of lake water quality is commonly carried out by reference to a scheme proposed by the O.E.C.D. (O.E.C.D., 1982). This scheme (Table 3.1) defines the five traditional trophic categories by setting boundaries for the annual average values for total phosphorus, chlorophyll and water transparency and for the maximum and minimum values for the latter two parameters. These are the three key parameters in assessing the level of eutrophication and its effects. Inputs of phosphorus to freshwaters commonly result in planktonic algal and cyanobacterial growth, which are most easily quantified by measurement of the algal pigment chlorophyll. Water transparency is an important aesthetic characteristic in lakes and frequently determines the suitability of a waterbody for recreational pursuits such as game fishing and swimming. It is reduced by the presence of suspended material, such as planktonic organisms, in the water column.

Table 3.1
Trophic classification scheme for lake waters proposed by the O.E.C.D. (O.E.C.D, 1982).

Lake Category	Total Phos.	Chlorophyll		Transparency	
	mg/m ³ Mean	mg/m ³ Mean Max.		m Mean Min.	
Ultra- Oligotrophic	<4	<1.0	<2.5	>12	>6
Oligotrophic	<10	<2.5	<8.0	>6	>3
Mesotrophic	10-35	2.5-8	8-25	6-3	3-1.5
Eutrophic	35-100	8-25	25-75	3-1.5	1.5-0.7
Hypertrophic	>100	>25	>75	<1.5	<0.7

In many instances the frequency of lake sampling does not provide sufficient data available to allow the calculation of the annual average values as specified in the O.E.C.D. classification scheme. To facilitate the classification of these lakes a modified version of the O.E.C.D. scheme (Table 3.2) is used in which the assessments are based on the annual maximum chlorophyll *a* concentration. In addition, because of the wide limits set for the eutrophic category in the original O.E.C.D. scheme, a sub-division of this category has been made. The lakes are classified, therefore, into six water quality categories by reference to the maximum levels of planktonic algae (including cyanobacteria) measured during the period. This arbitrary modification of the scheme is set out in Table 3.2 together with other indicators related to water quality and the probability of pollution.

Where a limited number of samples (less than ten) are taken in a year these measurements are carried out during the summer and autumn months when the greatest planktonic algal growth is likely to occur. The highest chlorophyll *a* concentrations recorded during these months are taken as estimates of the annual maximum values. These maximum values were used to assign a trophic status to the individual lakes in Appendix III.1 for each year in which it was surveyed during the review period. For the overall assessment of trophic status of each lake during the assessment period given in (Table 3.3 and Appendix III.1), the average of the annual maxima for the period has been used.

TABLE 3. 2

Modified version of the O.E.C.D. scheme based on values of annual maximum chlorophyll concentration. Indicators related to water quality and the probability of pollution are also shown.

Lake trophic Status	Classification Scheme		Category Description		Level of Pollution	Impairment of use of lake
	Annual Max. Chlorophyll		Algal Growth	Deoxygenation in Hypolimnion		
Oligotrophic (O)	<8		Low	Low	Very Low	Probably none
Mesotrophic (M)	8 – 25		Moderate	Moderate	Low	Very Little
Eutrophic	Moderately (m-E)	25 – 35	Substantial	May be high	Significant	Appreciable
	Strongly (s-E)	35 - 55	High	High	Strong	Appreciable
	Highly (h-E)	55 – 75	Very high	Probably total	High	High
Hypertrophic (H)	<75		Very high	Probably total	Very high	Very high

RECENT ASSESSMENT OF LAKE WATER QUALITY

Water quality data were available for 449 lakes in the period 2004-2006. The location and quality of each lake are set out in Appendix III.1 and are shown on the Lake Quality Map

accompanying this report. Table 3.3 and Figure 3.1 give a breakdown of water quality classification of the lakes by number and surface area. The majority (383 or 85.3%) of the lakes examined in the period 2004-2006 were of satisfactory water quality, i.e. oligotrophic or mesotrophic in status (Figure 3.1). The water quality of the remaining 66 lakes was less than satisfactory. Fifty one lakes were classified as eutrophic in varying degrees. Of these 21 were classified as moderately eutrophic and 30 as strongly or highly eutrophic compatible with a strong to high level of pollution and a marked degree of impairment of beneficial use. The remaining 15 lakes were classified as hypertrophic, i.e. the most enriched status and characterized by very high levels of algal growth consistent with a very high level of pollution and impairment of use.

Table 3.3

The breakdown of trophic status of the 449 lakes examined in the period 2004-2006 by number of lakes and surface area with percentage of total in parentheses.

Trophic Category	Number of Lakes in Category	Surface Area in Category km ²
Oligotrophic (O)	275 (61.2%)	346.3 (34.2%)
Mesotrophic (M)	108 (24.1%)	585.5 (57.7%)
Eutrophic	Moderately Eutrophic (m-E)	21 (4.7%)
	Strongly Eutrophic (s-E)	19 (4.2%)
	Highly Eutrophic (h-E)	11 (2.4%)
Hypertrophic	15 (3.3%)	35.4 (3.5%)

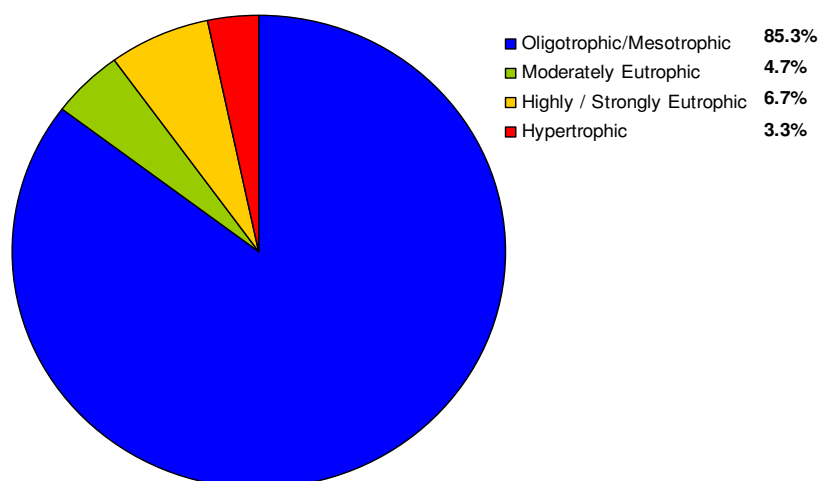


Figure 3.1. The percentage of the number of lakes in each trophic category.

Assessment by Size

The surface area of the 449 lakes examined amounted to 1014 km² (Table 3.3). Lakes accounting for 931.8 km² (91.9%) were in the unenriched oligotrophic or mesotrophic categories, marginally higher than that for the period 2001-2003 (91%). A further 46.8 km² (4.6%) were classified as eutrophic and 35.4 km² (3.5%) were assigned to the hypertrophic category.

Trophic status of lakes classified by lake size is presented in Figure 3.2. The majority of lakes examined (364) were less than 1 km² in surface area. Of these 364, 85% were in the satisfactory categories of oligotrophic or mesotrophic, 12% were classified as eutrophic and the remaining 3% were hypertrophic. In the medium size category, 1-7.5 km², 87% were classified as satisfactory with the remaining lakes distributed between the eutrophic (7%) and hypertrophic (6%) categories. Twenty four lakes were in the large lakes category (>7.5km²). Of these, 87% were in the satisfactory categories of oligotrophic or mesotrophic with the remaining classified as eutrophic or worse.

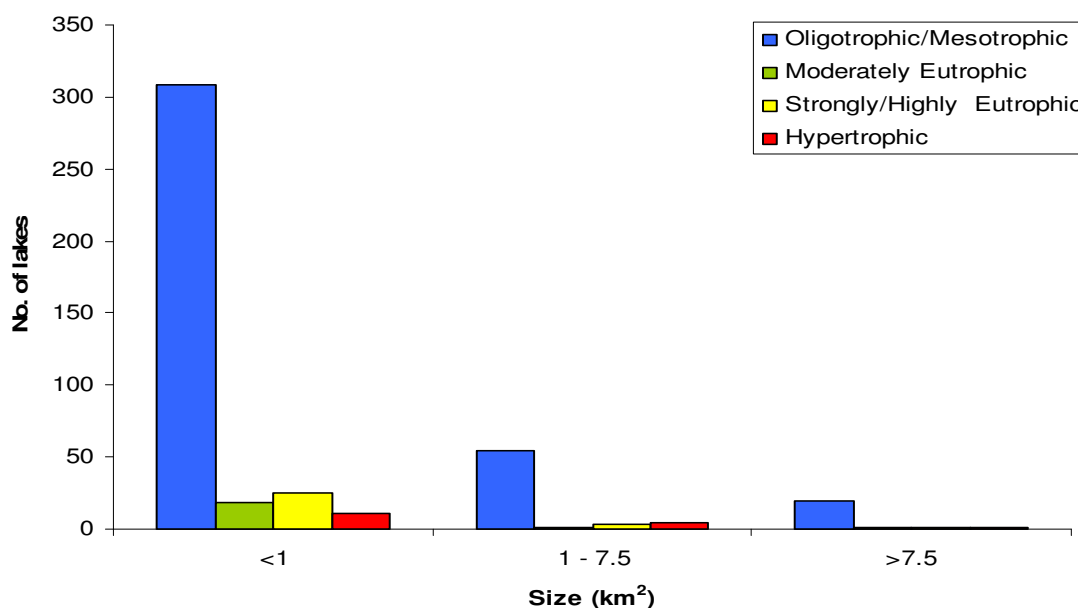


Figure 3.2. Trophic Status of lakes: Classification by Size

Assessment by River Basin District (RBD)

The number of lakes examined in each RBD is presented in Figure 3.3. Over half of the lakes examined (282) were located in the Western River Basin District (WRBD) and the North West River Basin District (NWRBD) reflecting the large number of lakes in the west of Ireland. The Shannon RBD (ShRBD) had the next highest portion of lakes at 74.

All lakes examined in the WRBD were classified as being in a satisfactory condition (Fig. 3.4). While the majority of lakes (108) in the NWRBD were classified in the satisfactory categories of oligotrophic or mesotrophic, the highest concentration of enriched lakes (27) was also in this region. These lakes were located predominantly in the north midland counties of Monaghan, Cavan and Leitrim.

Fifteen lakes were examined in the ERBD, three of which (Mullagh, Nadregeel and Ramor all in Cavan) were classified as of eutrophic or higher status. Thirteen lakes were examined in the SERBD where four were found to be enriched: Ballyshunnock, Belle, Coumduala and Knockaderry. Nine of the 42 lakes examined in the SWRBD were eutrophic; eight were in Cork and one in Kerry.

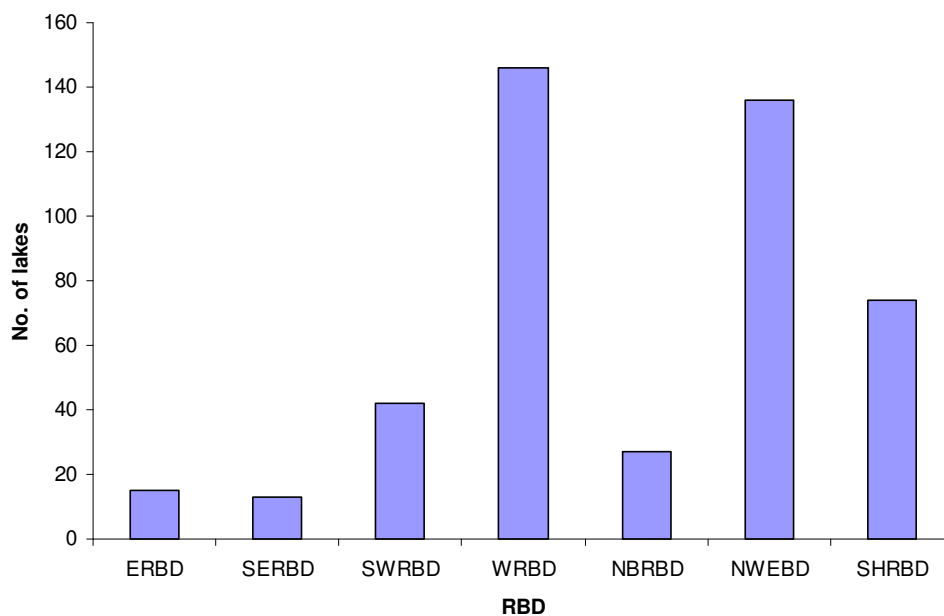


Figure 3.3 The number of lake area surveyed in each River Basin District.

Fifteen lakes in the NBRBD were in an unenriched status and twelve were in an unsatisfactory condition. The latter were all located in Monaghan. Eleven of the 74 lakes examined in the ShRBD were classified as being in an unsatisfactory condition.

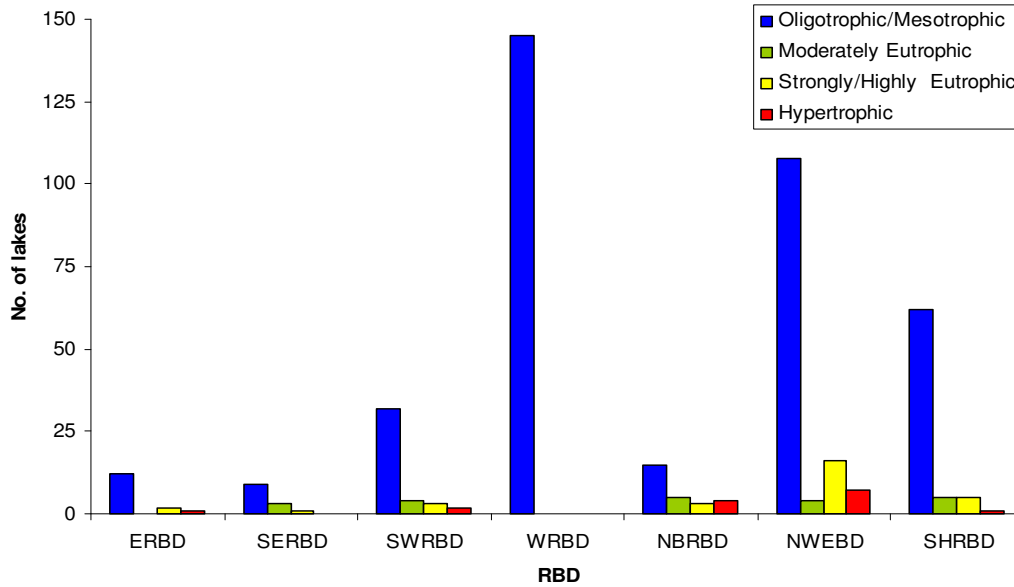


Figure 3.4 Trophic status of lakes: Classification by River basin District.

Assessment by Surface Area

The percentage of lake surface area by trophic category in each RBD is presented in Figure 3.5. Nationally, eutrophic and hypertrophic lakes accounted for a small proportion of the total lake surface area examined (8.1%). However, examination of these lakes at the RBD level revealed quite different scenarios.

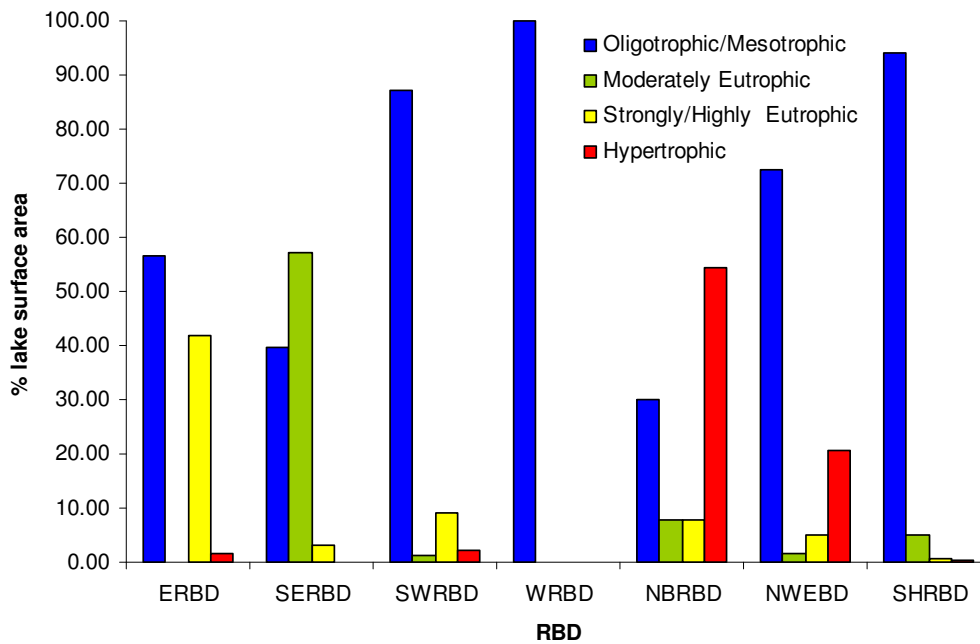


Figure 3.5 The percentage of lake area in each status category by River Basin District

Overall, eutrophic and hypertrophic lakes accounted for a high percentage of the total lake surface area in many RBDs. The three lakes classified as eutrophic or worse in the ERBD constituted 43% of the lake surface area examined. The four lakes found to be in unsatisfactory condition in the SERBD amounted to 60% of the lake area examined. The nine lakes in the SWRBD with a status of eutrophic or worse only accounted for 13% of the lake area. The 12 lakes assessed as unsatisfactory in the NBRBD accounted for 70%. The 27 eutrophic lakes in the NWRBD accounted for 27% of the lake area. The eleven unsatisfactory lakes in the ShIRBD accounted for 6%.

Assessment of the Water Quality of Large Lakes

Water quality data is available for 24 of the 27 large lakes, with surface areas exceeding 7.5 km², wholly or partly in the State. (Data was not available for three large lakes: Loughs Poulaphouca, Gara and Carrowmore). The trophic status of these large lakes is presented in Table 3.4. Two lakes, Loughs McNeen Upper and Melvin are cross border lakes.

TABLE 3.4

The trophic status of the 24 large Irish lakes (>7.5 km²) indicating changes in their water quality compared to the previous review period. The lakes are listed alphabetically according to their trophic status category determined as the mean of the annual maxima during the current period. Their surface area (km²) is shown in parentheses.

* Signifies the presence of Zebra mussels (*Dreissena polymorpha*)

Lake (km ²)	Trophic Status	Recent Change
Allen (35)	Oligotrophic	None
Arrow (12.5)*	Oligotrophic	Improvement possibly due to presence of Zebra mussels
Carra (15)	Oligotrophic	None
Cullin (10.2)	Oligotrophic	Improvement
Derg Donegal (8.6)	Oligotrophic	None
Derravaragh (12.2)*	Oligotrophic	Improvement possibly due to presence of Zebra mussels
Gill (14.3)*	Oligotrophic	Improvement possibly due to presence of Zebra mussels
Melvin (23.3)	Oligotrophic	None
Carrigadrohid (9)	Mesotrophic	None
Conn (50)	Mesotrophic	None
Corrib (170)*	Mesotrophic	None
Currane (10.4)	Mesotrophic	None
Derg (117)*	Mesotrophic	None
Ennell (14)	Mesotrophic	None
Key (9)*	Mesotrophic	deterioration
Leane (19.7)	Mesotrophic	None
McNeen Upper (10.2)	Mesotrophic	None
Mask (80)	Mesotrophic	None
Owel (9.5)	Mesotrophic	None
Ree (105)*	Mesotrophic	None
Sheelin (18.8)*	Mod.Eutrophic	Improvement possibly due to presence of Zebra mussels
Ramor (7.5)	Highly Eutrophic	None
Oughter (13)*	Hypertrophic	None
Gowna (12.9)*	Hypertrophic	Deterioration

Twenty of these lakes were in the satisfactory oligotrophic (8) or mesotrophic (12) categories representing an overall improvement from the previous assessment period. The remaining four lakes, Sheelin, Ramor, Oughter and Gowna, exhibited a high degree of enrichment. A reduced level of chlorophyll was noted at five lakes; Arrow, Derravaragh, Gill, Sheelin and Cullin compared with previous assessments. These lakes were mesotrophic in the preceding monitoring period but are now oligotrophic. This reduction could be attributed to the impact of a recent infestation of Zebra mussel in the first four of the latter lakes. In two lakes, Loughs Key and Gowna, notwithstanding the presence of Zebra mussels, marked increases in planktonic algal growth were recorded resulting in deterioration in status. No changes were observed in the mesotrophic status of Loughs Corrib, Derg, Ree and the hypertrophic Lough Oughter since the previous assessment. Zebra mussels were found in Lough Corrib in 2007.

Considerable fluctuations in the annual chlorophyll concentrations between years was observed in many of these large lakes. Of those lakes with an overall oligotrophic status, some e.g. Loughs Allen, Gill (Sligo) and Arrow, had chlorophyll values consistent with a mesotrophic status for one year of the period. Similarly, in some of those lakes with an overall mesotrophic classification annual chlorophyll values indicative of oligotrophic conditions were recorded. Of the eutrophic lakes there has been a marked reduction in the maximum chlorophyll values recorded in Lough Sheelin in 2006 and 2007, leading to an improved overall status from strongly eutrophic in the previous assessment period to moderately eutrophic in the current period. A striking reduction in annual chlorophyll concentrations was also noted in Loughs Oughter and Gowna but not sufficient to prevent an overall hypertrophic status assessment for both lakes.

Zebra Mussels in Irish Lakes

The Zebra Mussel (*Dreissena polymorpha*), first observed in Ireland in the Lower River Shannon and Lough Derg in 1998, was recorded in 33 of the lakes sampled in the 2004-2006 period (Table 3.5) including 10 of the large lakes (Table 3.4). The bivalve feeds by filtering particulate matter, including planktonic algal species, thus reducing the concentration of these organisms in the water and improving water clarity.

While fishery research data indicate that reduced algal growth causes may causes changes in fish populations such as a decline in roach stocks and increase in the trout population (CFB,

anon), the extinction of the native mussel *Anodonta* spp. in Lough Key has been attributed to the presence of the Zebra mussel (Lucy *et al.*, 2005).

Of the 33 lakes where Zebra mussels were recorded, information was available from the previous assessment period on 32 of these lakes. Eleven lakes exhibited reduced algal populations compared with those measured in 2001-2003, five lakes: Acres, Boderg, Gowna, Key and Kilglass indicated increased chlorophyll levels while the values measured in the remaining 16 lakes indicated an unchanged trophic status.

TRENDS IN LAKE WATER QUALITY

The trends, since 1991, in the trophic status of Irish lakes in terms of surface area are shown in Figure 3.6. The percentage of lake surface area classified in each trophic status has remained relatively stable since 1998-2000. However, there has been a small rise in the percentage area assessed as hypertrophic in the current sampling period. This increase coincided with a reduction in the number of in the highly/strongly eutrophic category (Lough Allua, Gowna, Inner, Muckno and Mullagh deteriorated from the highly/strongly eutrophic categories to the hypertrophic category) in the current review period.

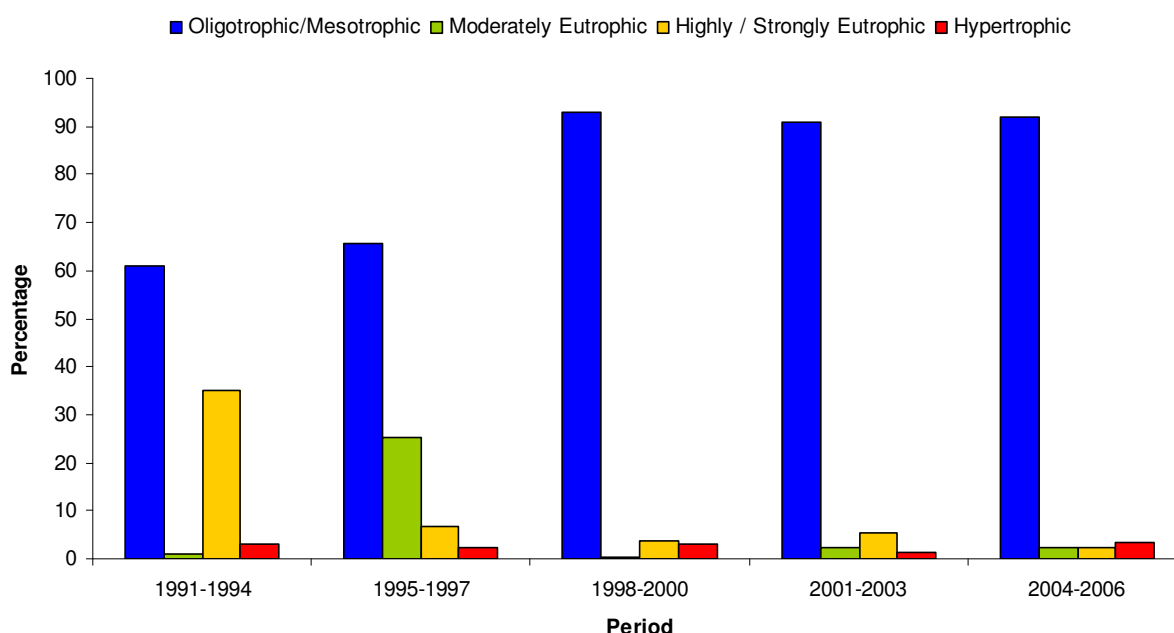


Figure 3.6 Recent changes in trophic status expressed as percentage of total lakes area surveyed.

Table 3.5

The trophic status of lakes known to have Zebra mussel in 2004-2006 and their overall trophic status. The trophic status in 2001-2003 is shown for comparative purposes and recent changes, if any, are documented. (Inclusion in the WFD monitoring programme is indicated by ^{WFD})

Lake	Location	Surf. km ²	Recent Changes	Overall Trophic Status	
				2004-06	2001-03
Acres ^{WFD}	Co. Leitrim	0.10	Detrioration	h-E	s-E
Arrow ^{WFD}	Co. Roscommon	12.50	Improvement	O	M
Ballycullinan	Co. Clare	0.36	None	m-E	m-E
Ballykeeran ^{WFD}	Co. Westmeath	0.30	Declining Chlorophyll levels	O	O
Boderg ^{WFD}	Co. Roscommon, Longford	4.30	Deterioration	M	O
Bofin (Shannon) ^{WFD}	Co. Roscommon, Longford	5.10	None	O	O
Bran	Co. Leitrim	0.16	Dramatic improvement	O	s-E
Bunerky ^{WFD}	Co. Cavan	0.77	Improvement	s-E	h-E
Conn ^{WFD}	Co. Mayo	50.00	Recent improvement	M	M
Coosan ^{WFD}	Co. Westmeath	0.81	Improvement	O	M
Corrib (Upper) ^{WFD}	Co. Galway	85.00	None	M	M
Derg ^{WFD}	Co's Clare	117.5	None	M	M
Derravaragh ^{WFD}	Co. Westmeath	12.20	Improvement	O	M
Derrycassan ^{WFD}	Co's Cavan/Leitrim	0.96	None	M	M
Drumlona ^{WFD}	Co. Monaghan	0.53	None	s-E	s-E
Forbes ^{WFD}	Co. Roscommon, Longford	3.40	None	O	O
Garadice ^{WFD}	Co. Leitrim	3.97	Improvement	O	M
Gill ^{WFD}	Co. Sligo	14.29	Improvement	O	M
Gowna North ^{WFD}	Co's Cavan and	6.25	Deterioration	H	h-E
Key ^{WFD}	Co. Roscommon, Longford	9.00	Deterioration	M	O
Kilglass	Co. Roscommon, Longford	2.33	Deterioration	M	O
Killinure ^{WFD}	Co. Westmeath	3.17	None	O	O
Kinale ^{WFD}	Co's Longford	1.95	Improvement	M	m-E
Meelagh ^{WFD}	Co. Roscommon	1.2	None	O	O
Mill (Portaliffe) ^{WFD}	Co. Cavan	0.12		M	-
Nablahy	Co. Roscommon	0.76	Improvement	O	M
Oakport	Co. Roscommon	0.50	None	O	O
Oughter ^{WFD}	Co. Cavan	13.00	None	H	H
Ree ^{WFD}	Co. Roscommon, Longford	105.00	None	M	M
Rinn ^{WFD}	Co. Leitrim	2.13	None	M	M
Sheelin ^{WFD}	Co. Cavan	17.71	Improvement	m-E	s-E
Sillan ^{WFD}	Co. Cavan	1.72	Improvement	s-E	h-E
Skean	Co. Roscommon	1.16	None	O	M

The most striking change was in the earlier part of this 15-year period. Much of the surface area classified as strongly or highly eutrophic in 1991–1994 improved to moderately eutrophic in 1995–1997 and thence to oligotrophic/mesotrophic in 1998–2000. This change, due in large measure to the reduction in planktonic algal growth in Loughs Derg and Ree, may be attributable to the impact of the Zebra mussel infestation on these lakes.

Of the 39 lakes examined in the period 1976–1981, (WPAC, 1983), 21 were examined in each subsequent review period (Table 3.6); continuous reviews of a further six lakes are available since 1982–1986. Of these lakes only four: Gleandalough Upper, Maumwee, Nafurnace and Nahasleam, were continually classified as being of oligotrophic status. Lough Lene was previously classified as oligotrophic but it is now mesotrophic. Loughs Conn, Corrib and Owel have retained a mesotrophic status since 1976, while the improved overall status of Lough Arrow, now oligotrophic notwithstanding shoreline evidence of enrichment, is probably due to Zebra mussel infestation. As previously noted (Toner *et al.*, 2005) the other lakes showed varying degrees of fluctuation in chlorophyll levels.

An improvement in water quality was noted in Derravaragh, Gortglass, Ennell, Leane and Inniscarra reservoir in the previous period and, with the exception of the Inniscarra Reservoir, further reductions in chlorophyll levels were recorded in 2004–2006. A decline in chlorophyll has occurred in Lough Sheelin since the 1998–2000 assessment, possibly due to the infestation of Zebra Mussel in the lake. Loughs Oughter and Ramor have been consistently classified as hypertrophic since 1976.

Figure 3.7 illustrates the trends, since 1991, in the number of lakes in each trophic category. The number of lakes monitored has increased substantially in this period due to increased sampling effort. Oligotrophic lakes were numerically dominant in each review period reflecting the greater number of lakes in the parts of the country with the lowest levels of pressures. Hypertrophic lakes were the least numerous, although marginally so in some years.

Table 3.6

The maximum chlorophyll concentrations, average of the annual maxima, in the 21 lakes for which data are available since 1976-1981 period and for six lakes for which data are available since 1982-86 period.

Lake	Period of Examination							
	1976-81	1982-86	1987-1990	1991-94	1995-97	1998-2000	2001-03	2004-06
Arrow	14	20	12	13	18	15	18	6
Carra	9	9	9	9	10 (28) ¹	15	7	6
Conn	17	10	11	13	10	11	14	12
Coosan	5	19	-	12	13	14	16	7
Corrib (Upper)	11	5	9	8	11	9	13	8
Corrib (Lower)	28	18	10	8	11	9	8	8
Derg (Shannon)	14	34	41	54 ² (72) ¹	27	12	10	10
Derravaragh	35	29	25	12	13	16	11	6
Ennell	47	28	19	23	16	17	21	15
Gowna	63	35	18	66	56	78	67	90
Innsicarra	34	-	61	137	43	16	29	35
Key	13	12	15	15	16	14	8	9
Killenure	16	9	-	13	11	9	6	7
Kinale	40	24	24	7	6	60	33	15
Leane (open)	15	25	14	10	71	24	15	13
Leane (Ross Bay)	63	57	23	17	41	30	32	25
Mask	12	5	7	6	11	13	12	11
Muckno	537	54	-	29	24	17	48	93
Oughter	11	99	68	158	132	104	86	97
Owel	290	7	8	12	11	12	11	9
Ramor	25	92	59	119	156	51	55	66
Ree	60	21	21	33	31	19	9	10
Sheelin	-	60	37	33 (66) ³	48	65	44	31
Glendalough (Upper)	-	3	3	1	1	2	2	1
Gortglass	-	4	21	8	34	28	15	10
Lene	-	5	6	7	8	8	8	14
Maumwee	-	3	5	1	3	3	3	2
Nafurnace	-	3	2	1	3	2	7	2
Nahasleam (west)	-	3	3	1	2	2	3	3

¹Maximum individual value

²Maximum mean value recorded in Lough Derg during 1991-92 investigation (Bowman *et al.*, 1993)

³Maximum value recorded in 1994

⁴Maximum value recorded in 1997

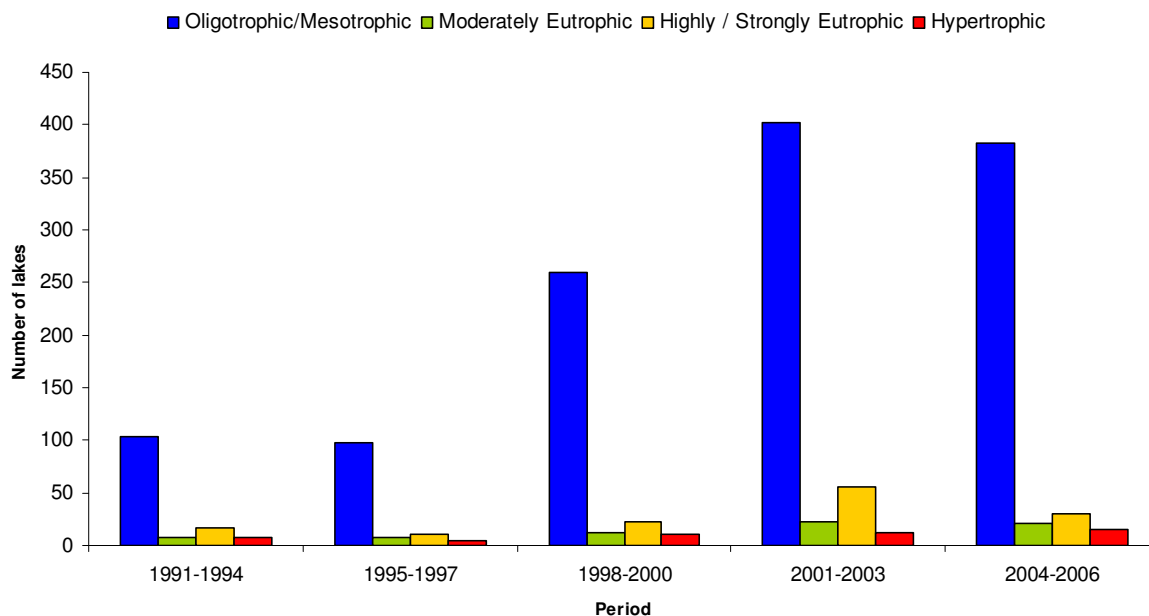


Figure 3.7 Trends in the number of lakes in each status category since 1991 9 (reflecting increased monitoring effort in recent periods).

ACID SENSITIVE WATERS

The principal areas in Ireland with acid sensitive water bodies are located along the western seaboard and in County Wicklow on the east coast. The geology in these areas is characterised by base poor rocks such as granites and schists. Waters in these areas have a poor buffering capacity typified by their low alkalinities and are in consequence sensitive to acid inputs. Sources of acid input include emissions of sulphur dioxide, principally as a result of the burning of fossil fuels, which when released into the atmosphere cause an increase in the acidity of precipitation or ‘acid rain’. However, as a result of international agreements these emissions have reduced considerably in recent years and this has resulted in a decline in the acidity of precipitation.

Investigations in the mid 1980s showed Irish waters were generally free of the impacts of anthropogenic or artificial acidification (Bowman, 1991) except in afforested catchments in acid-sensitive areas. Regular long-term biannual monitoring (in December and April) of the chemical and biological characteristics of three lakes and their inflowing streams: Loughs Veagh (Donegal), Maumwee (Galway) and Glendalough Lake Upper (Wicklow),

representative of the larger acid-sensitive areas have been performed continuously since then. These lakes were also the subject of a detailed investigation, to examine the impact of acid precipitation, in the period 1987-89 (Bowman, 1991).

The levels of acidity in the three lakes and their feeder streams were described by reference to the “Raddum Index” (N.I.V.A., 1987). This index is based on the sensitivity of the macroinvertebrate fauna to reduced pH and is used widely to describe the acid status of surface waters. Species are assigned an “acidification score” or index in accordance with the following scheme of sensitivity or tolerance to acidity:

Table 3.7

The invertebrate categories, associated acidification scores minimum pH tolerance and inferred impact are shown.

Category	Min. pH tolerated	Score	Inferred Acidification Impact by Presence
A	5.5-6.0	1.0	None
B	5.0-5.5	0.5	Moderate
C	4.7-5.0	0.25	Serious
D	<4.7	0	Severe

The Raddum Index scores for the three lakes systems examined in the period 2004–2006 are set out in Table 3.8

Table 3.8

The acidification 'score' calculated for Loughs Maumwee, Glendalough Lake Upper and Lough Veagh and their inflowing streams during the period 2004-2006. ns - not sampled

	2004		2005		2006	
	May	Nov	May	Dec	May	Nov
Lough Maumwee						
Lake shore	1	1	1	1	1	1
Inflow No.1	1	1	ns	ns	1	1
Inflow No.2	1	1	1	ns	1	1
Glendalough lake Upper	May	Dec	May	Nov	May	Nov
Lake shore	1	1	ns	0.5	0	0.5
Glenealo River	1	1	ns	1	1	1
Lugduff River	0	1	ns	0.5	0.5	0
Lough Veagh	May	Nov	May	Dec	May	Nov
Lake shore	1	*	ns	*	0.5	*
Sruthnacoille	1	1	1	1	ns	1
Derrybeg River	ns	1	1	1	ns	ns
Owenveagh River	1	1	1	1	1	ns
Glenlackburn	1	1	ns	1	1	ns

*high water levels prevented a complete sampling event

The faunal composition of the Lough Maumwee and Lough Veagh systems continue to be characterised by the presence of acid-sensitive forms. However, at Lough Veagh in each of the three years, high water levels in the lake prevented sampling at the normal littoral during the winter. The intermittent presence of acid sensitive organisms at the sampling station on

the Lugduff River tributary of Glendalough Lake Upper and in the littoral fauna of the lake suggest a reduction in the level of impact by artificial acidity in these waters which were regarded as severely degraded by acidity in the past decades.

Water samples for physico-chemical analysis were taken in conjunction with the biological examinations on all occasions. The results of these analyses are summarised in Table 3.9. Alkalinity values were very low at all sampling points indicating very poor buffering capacity and thus a high degree of sensitivity to acid inputs. However, little change in the acid status of these waters has been noted since investigations began in 1984.

With the exception of those for the Derrybeg River at Lough Veagh, the pH values recorded at Lough Maumwee and Lough Veagh showed no evidence of inputs of artificial acidity to these systems. This assessment is supported by the relatively low concentrations of non-marine sulphate and oxidised nitrogen recorded in these systems. The reason for the greater acidity in the Derrybeg stream, noted also in previous monitoring investigations, and the low minimum pH value in Inflow No.5 to Lough Veagh, are unclear. The increased acidity in the former stream does not have a detrimental impact on the macroinvertebrate population.

Table 3.9

The minimum and median pH values and the median concentration of alkalinity, total aluminium, non-marine sulphate and oxidised nitrogen in Loughs Maumwee, Glendalough Upper and Veagh and their inflowing streams during the period 2004-2006.

Location	pH		Alkal MgCaCO ₃	Tot. Al µg/l	N-M SO ₄ mg/l	Ox-Nitr µg/l N
	Min	Med.				
Lough Maumwee						
Lake Surface	5.90	6.38	4.5	50	0.42	10
Inflow No. 1	6.00	6.25	7	51	0.61	10
Inflow No. 2	6.00	6.25	5.5	50	0.67	10
Glendalough Lake Upper						
Lake Surface	5.80	5.95	4	127	2.47	120
Glenealo River	5.80	5.80	4.5	96	2.93	120
Inflow No. 2	6.00	6.30	12	30	4.74	870
Lugduff River	5.20	5.50	3	139	2.14	160
Lough Veagh						
Lake Surface	5.90	6.43	6	80	0.19	48
Sruthnacoille River	5.30	6.15	6.5	86	0.35	30
Derrybeg River	4.80	5.80	4	64	0.33	10
Owenveagh River	5.80	6.60	6	99	0.33	40
Glenlackburn River	6.00	6.70	9	61	0.53	105
Inflow No. 5	5.20	6.50	5	91	0.24	50

At all three lake systems the decline in the concentrations of non-marine sulphate, a measure of sulphate of anthropogenic origin, noted during the two previous reporting periods continued in 2004 –2006. This reduction is consistent with similar reductions at locations in mainland Europe and is attributed to reduced sulphate content in industrial emissions. Concentrations of oxidised nitrogen and total aluminium were, with some exceptions, also marginally lower than previously recorded.

At Glendalough Lake Upper on the east coast a decline in the level of acidity and concentrations of total aluminium were again measured in the waters draining the afforested catchment of one of its principal influents, the Lugduff stream. Nevertheless, the chemical composition of the water was still having an adverse impact on the fauna. In contrast the water quality of the Glenealo River, which drains an unafforested catchment remains unaffected by increased acidity or high metal concentrations.

There is a good agreement between the inferred acidity status of these waters from an examination of the macroinvertebrate communities and that indicated by the physico-chemical measurements. These data do not suggest any marked change in the acidity status of these waters since first examined in detail over a decade ago.

QUALITY OF DESIGNATED BATHING WATERS IN LAKES

The EU Directive concerning the quality of bathing waters specifies mandatory and guide standards for the protection of public health and the environment (CEC, 1976). The number of designated inland bathing areas has remained at 9 since 1994. Freshwater bathing areas achieved 100 per cent compliance with the EU mandatory standards for each year during the review period 2004 to 2007 (EPA, 2007). Compliance of the freshwater bathing areas with the more stringent EU guide values has declined from 89 per cent in 2004 to a low of 78 per cent in 2006 indicating a deterioration in water quality.

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