Lough Carra LIFE Project

Baseline Marl Crust Surveys 2023

Lough Carra LIFE LIFE20 NAT/IE/000172

Report prepared by Woodrow, APEM Group

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STATEMENT OF AUTHORITY

This report was written by Philip Doddy.

Philip is a Principal Ecologist at Woodrow. He has completed a PhD in Aquatic Sciences, a BSc (Hons) in Freshwater & Marine Biology, and a Diploma in Amenity Horticulture. He is an Associate member of the Chartered Institute of Ecology and Environmental Management (CIEEM). Philip carries out botanical monitoring, site surveys and habitat mapping, and compiles Ecological Impact Assessments (EcIAs), Appropriate Assessment (AA) screening reports, subsequent Natura Impact Statements (NISs), and vegetation monitoring reports. He also supports local community groups in their biodiversity conservation and enhancement projects. He has also carried out research on calcareous lakes and pools, microbial communities, and ecological succession.

Philip Doddy – Qualifications:

PhD – Aquatic Sciences, Galway-Mayo Institute of Technology, 2019.

BSc (Hons) – Freshwater & Marine Biology, Galway-Mayo Institute of Technology, 2013.

Diploma - Amenity Horticulture, Teagasc, National Botanic Gardens, Dublin, 2001.

CONTENTS

INTRODUCTION

Background and Scope

Woodrow (APEM Group) was commissioned by Mayo County Council to carry out sampling and analysis of marl (microbialite) crusts in Lough Carra as part of the Lough Carra LIFE Project. Woodrow worked in collaboration with the Lough Carra Catchment Association (LCCA) and the LIFE Project Team to conduct this work.

Marl crust characteristics are known to be indicative of nutrient status and ecological quality in marl lakes (Doddy *et al*. 2019a; Doddy *et al.* 2019b). This is the first time that a comprehensive marl crust survey of Lough Carra has been carried out. While previous studies (Doddy *et al*. 2019a; Woodrow, 2023a) involved sampling from specific areas within Lough Carra, the aim of the present study was to establish a baseline for chlorophyll-a concentration in the marl crust across the whole lake, as required by the Lough Carra LIFE Project. The twenty-one sampling stations used in this study ensure a broad geographical representation of marl crusts in Lough Carra. They will be revisited in the final year of the LIFE Project to repeat the sampling and analysis, and can also be used henceforth to assess longer term trends in marl characteristics.

METHODOLOGY

Site Selection

Twenty-one sampling stations were selected for marl crust sampling, based on the following criteria:

- A broad geographical representation was required.
- Sampling points near the mouths of streams and rivers were included, as these inflowing watercourses are likely to carry nutrients into the lake.
- Sampling points were included in the vicinity of the areas where the LIFE Project's agri-environmental scheme is in operation, as it is hoped that measurable improvements in nutrient conditions will occur in these areas.

The resulting sampling stations are shown in **Figure 1** on the following page. The co-ordinates of each of the stations are given in Appendix 1.

Site Visits

Sampling of the marl crusts was carried out in summer 2023, starting on July 31 and finishing on August 10. For the majority of sampling stations, a boat was used for access. Polypropylene sample containers with screw-on lids were labelled in advance. Five of these were labelled for each sampling station, for five replicate samples.

At each station, a GPS device was used to confirm the location. Five replicate samples were then taken within a 5-metre length of lakeshore. Samples were taken where the water was approximately 30 cm deep. Crust samples were removed from the substrate with a knife, keeping the crust intact as much as possible, and placed in the labelled sample containers. Sample containers were placed in a bag and taken to the LIFE Project Office at Belcarra, where they were stored in a domestic freezer in advance of analysis.

Figure 1: Twenty-one sampling stations for marl crust in Lough Carra

Pigment Extraction

The pigment extraction procedure following the method developed by Doddy *et al*. (2019a). Acetone of 90% strength was prepared by combining acetone and distilled water. Samples were removed from the freezer and allowed to thaw out at room temperature, out of direct light. Each sample was placed on tissue paper so that any excess water in the sample was absorbed. The thickness of each sample was measured and recorded. Where samples were more than 1 cm in thickness, the upper 1 cm was used for analysis, any crust below this being removed with a knife and discarded.

Each sample was ground with a mortar and pestle for one minute to form a paste. This allowed for precise measurements of volume. For each pigment extraction, 1 cm^3 of the paste was measured out, using a polycarbonate measurement cube. This material was then transferred to a graduated glass test tube. Acetone (90%) was added to bring the total volume to 10 ml. The sample and acetone were mixed thoroughly with a glass rod for three minutes. The top of the test tube was then sealed with a piece of Parafilm. All samples were refrigerated overnight. The following morning, the extract from each sample was pipetted off and transferred to a polypropylene tube with screw-on lid. Samples were then taken to Complete Laboratory Solutions (CLS), Galway for chlorophyll-a analysis.

RESULTS & DISCUSSION

Chlorophyll-a mean concentrations in marl crust samples from Lough Carra are given in **Table 1**. These are also shown in **Figure 2**. The full data from which these values are calculated are given in **Appendix 2**[1].

As in the pilot study conducted in 2022 in Lough Carra's southern basin (Woodrow, 2023a), the samples from the mouth of the Cloondaver stream give a record high result, suggesting that this is a significant conduit for nutrients entering Lough Carra. Similarly, the results from the entry point of the nearby Annie's River are among the highest recorded from Lough Carra, or indeed from any lake. The underwater spring at Moorehall has been noted locally as a site of nutrient enrichment and algal proliferation, and this is again reflected in the results of the present study. A similarly high result was found at the nearby Castle Island.

Figure 3 gives some context to the chlorophyll-a results by showing mean figures from a range of other Irish marl lakes, ranging from very good quality lakes like Cooloorta to badly nutrient-polluted lakes such as Cullaunyheeda and Lough Derg. Cooloorta lake has had the lowest marl crust chlorophyll-a concentration recorded to date in Ireland, while Lough Derg has had the highest (Doddy *et al*. 2019a; Woodrow, 2023a).

Table 1: Chlorophyll-a concentration in marl crust samples from twenty-one sampling stations in Lough Carra (summer 2023). N = 5 for all stations except Annie's, where n = 4 (see footnote).

Sampling Station	Mean chlorophyll a concentration (µg/cm³)	Standard deviation
Nagoyne A	18.5	5.2
Kilkieran	20.1	2.1
Nagoyne B	21.4	4.0
Otter Point	22.3	4.0
Ballycally	24.7	5.0
Church Island	25.0	2.9
Knockglass	25.3	5.5
Portroyal	29.0	3.9
Doon	31.6	4.6
Leamnahye	36.9	3.6
Heneghan's	38.0	9.9
Twin Islands	43.1	2.7
Flanelly's	43.6	6.5
Knocknaraha	45.1	16.8
Ballintubber	46.0	8.4
Brownstown	48.2	7.2
Bull's Well	48.4	12.6
Castle Island	89.8	8.0
Moorehall Spring	99.3	8.0
Annie's	122.2	30.7
Cloondaver	124.8	7.5

1: One result returned from the laboratory appeared to be erroneous, being an order of magnitude different from the other four results for that location (Annie's) and an implausible figure for a crust sample from any Irish marl lake. As the laboratory did not have enough extract to re-run the test, this result was removed from the calculations.

Figure 2: Mean chlorophyll-a concentrations (µg/cm³) in marl crust samples from twenty-one sampling stations in Lough Carra (summer 2023).

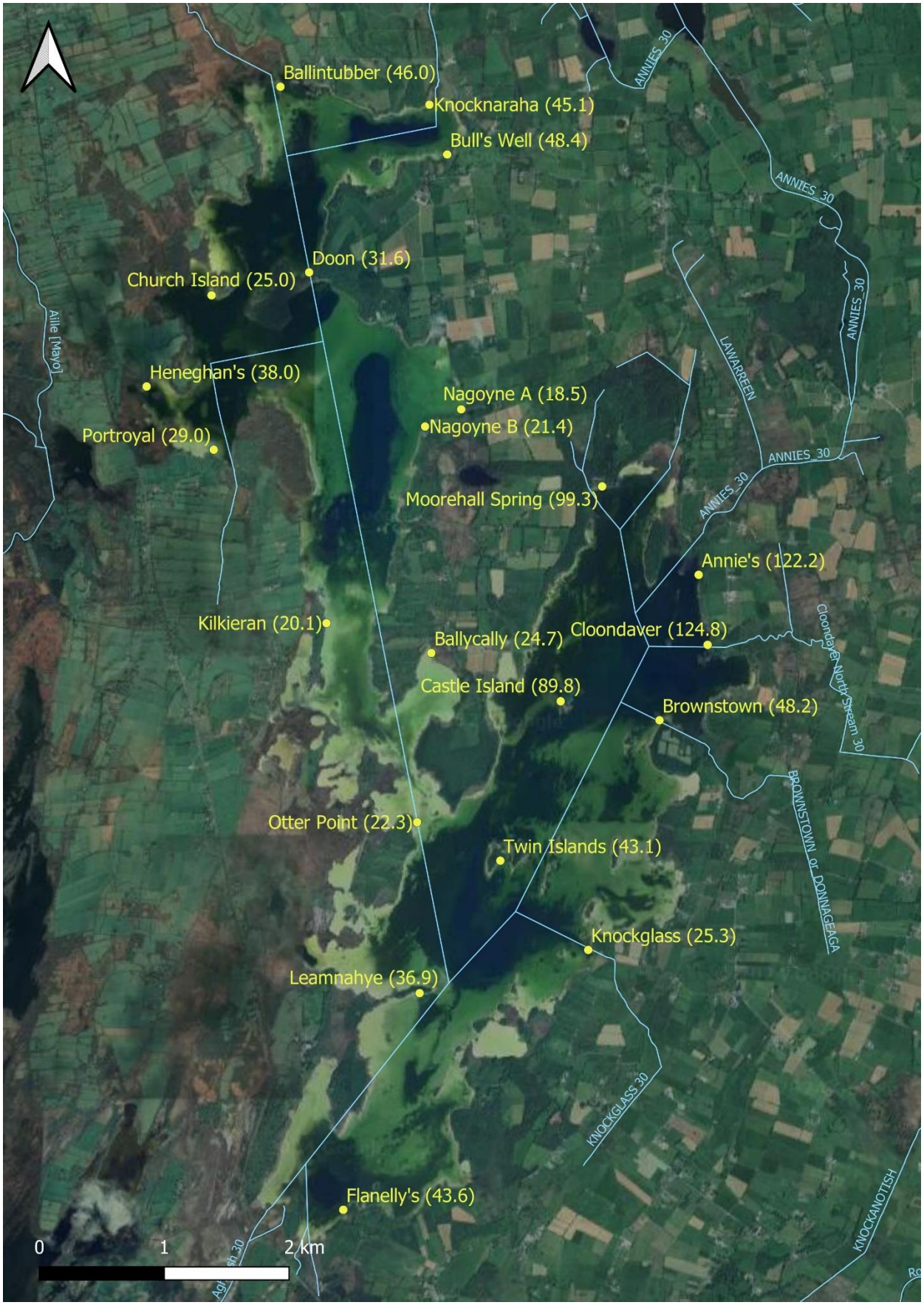
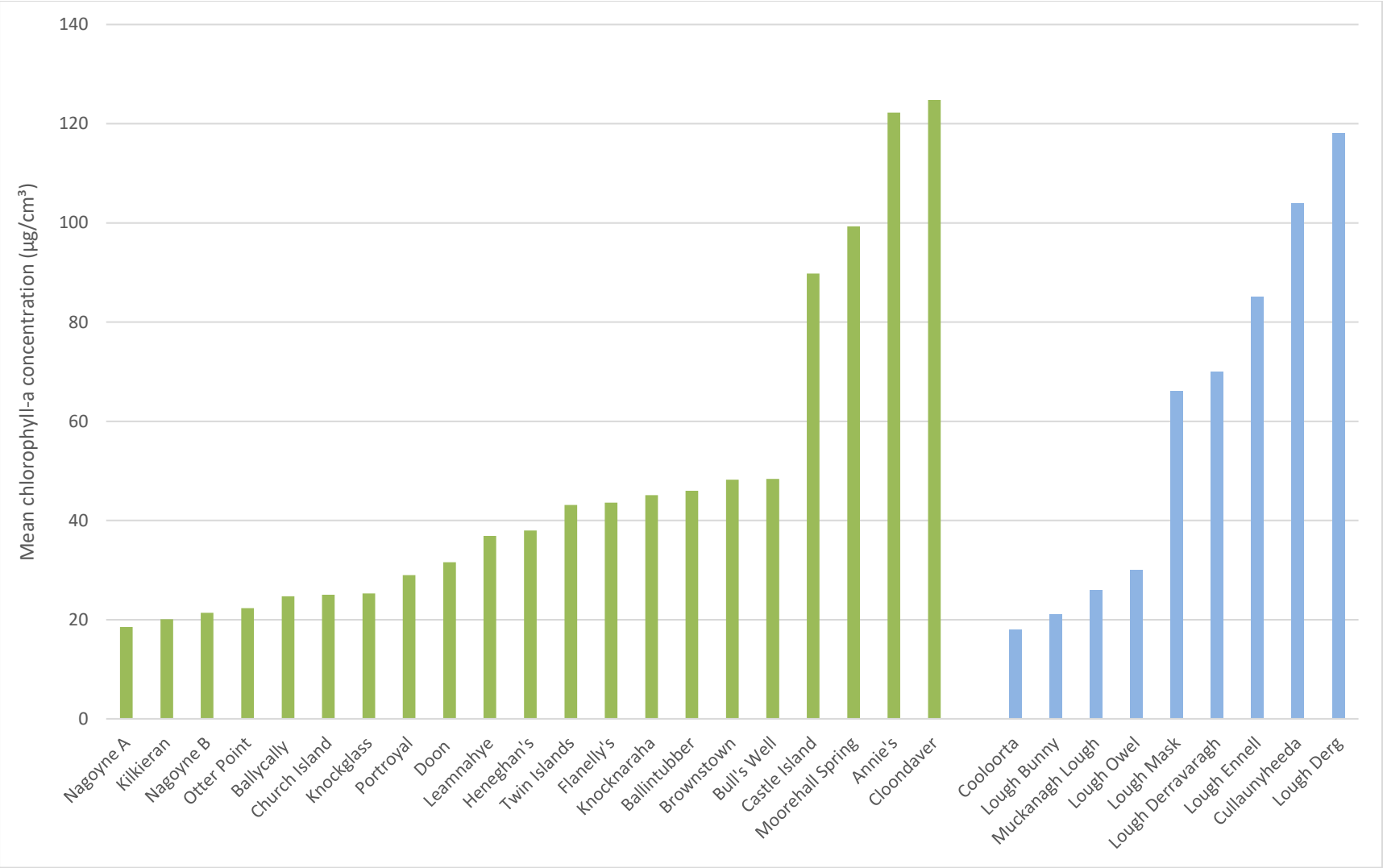


Figure 3: Chlorophyll-a concentration at sampling stations in Lough Carra (green) and in a selection of other Irish marl lakes (blue). Sources of data for other lakes: Doddy *et al.* (2019a); Woodrow (2023b).



It is startling to observe that results from parts of Lough Carra are higher than those from some of Ireland's badly-polluted lakes such as Lough Derg and Cullaunyheeda. These latter lakes are regarded as cases in which the ecological conditions have been substantially, and probably permanently, altered due to persistent nutrient pollution (Roden *et al.* 2020a; Roden *et al.* 2020b). There is much literature (e.g. Moss, 1979; Scheffer, 2001; Wiik *et al*. 2015) on the change that is caused by nutrient pollution in marl lakes from clear, oligotrophic systems with a diverse submerged macrophyte population to turbid, plankton-dominated systems, as well as how this change is almost impossible to reverse once it gets established. Parts of Lough Carra are now undergoing this transition and it is clear that nutrient input in the areas of Cloondaver, Annie's and Moorehall are causing severe degradation in this area in particular.

It is clear, nonetheless, that not all of Lough Carra is yet in this impoverished state, and that the degradation is not happening at the same rate throughout the lake, presumably as a result of different amounts of nutrient input occurring in different parts of the lake. Further information on the patterns of water movement and mixing in Lough Carra as a whole would also be interesting in this regard.

While the present study is intended as a baseline for comparisons in the future, there are some limited data from previous studies than can be considered at present. Some caution is needed in interpreting these, as sample sizes vary and locations are not always exactly the same. Nonetheless, the following box plots show five cases where data from previous work are compared with the 2023 results. The locations where samples were taken in these previous studies are shown in **Figure 9**, along with mean chlorophyll-a values in each case.

Figure 4: Brownstown chlorophyll-a results from 2018 and 2023. N = 3 (2018), n = 5 (2023).

Figure 5: Doon chlorophyll-a results from 2017 and 2023. N = 15 (2017), n = 5 (2023).

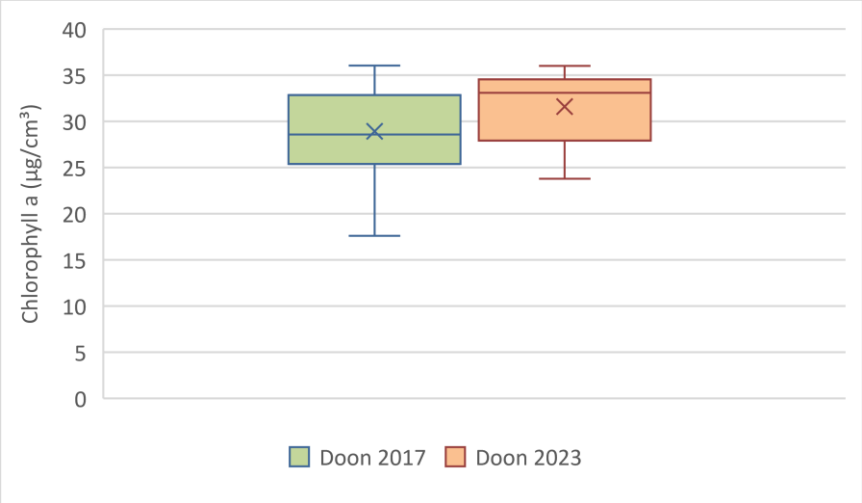


Figure 6: Ballycally chlorophyll-a results from 2016 and 2023. N = 3 (2016), n = 5 (2023).

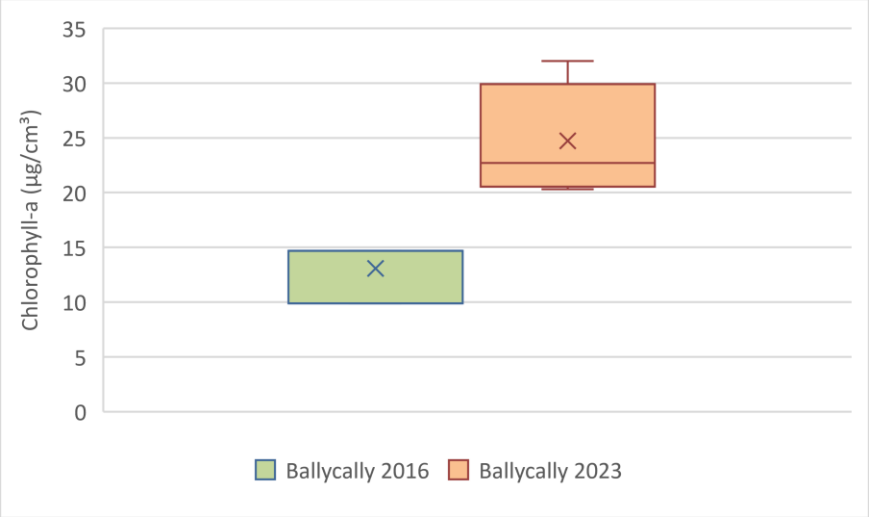


Figure 7: Burriscarra/Knocknaraha chlorophyll-a results from 2018 and 2023. N = 3 (2018), n = 5 (2023).

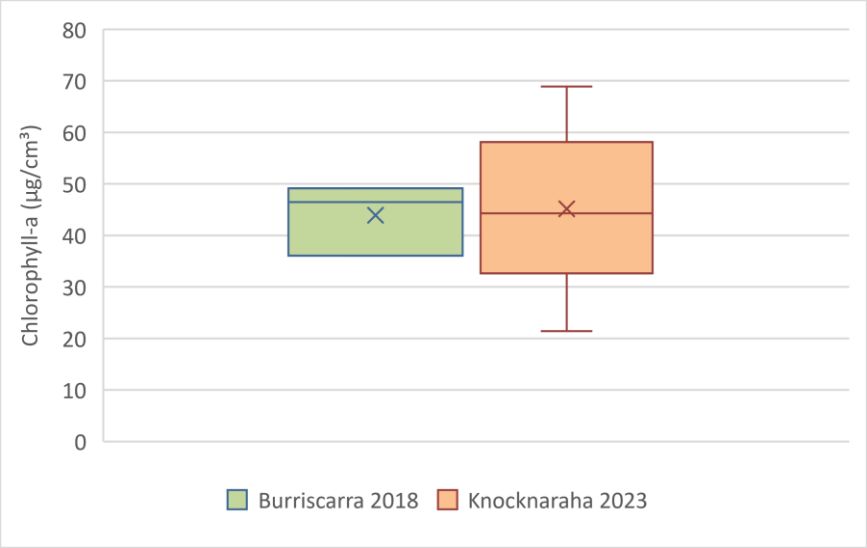
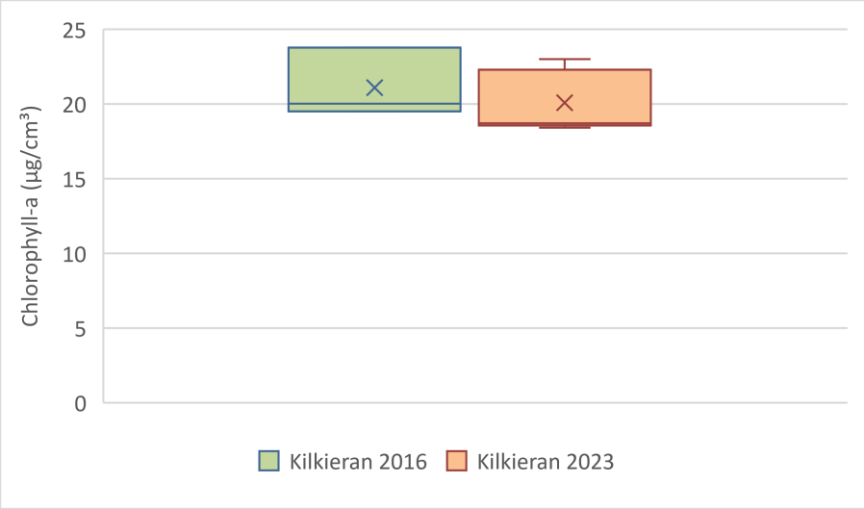


Figure 8: Kilkieran chlorophyll-a results from 2016 and 2023. N = 3 (2016), n = 5 (2023).



The results shown in **Figure 4** suggest a deterioration in nutrient conditions at Brownstown during the period of 2018-2023. Ballycally appears to show a similar trend, although in this case the sampling sites are not quite the same (see **Figure 2** and **Figure 9**). No particular trend is evident in the figures from Doon, Kilkieran and Burriscarra/Knocknaraha. While these comparisons are tentative, the present study establishes fixed sampling stations to be used again in the final year of the LIFE Project, at which time meaningful statistical analysis will be possible.

The thickness of each marl crust sample is given in **Appendix 3**. While the thickness is not needed at present for the purpose of assessing the effects of nutrient pollution on the crust, it may be useful for comparisons in the future, such as in considering the breakdown or growth of crusts over time.

Figure 9: Past records of chlorophyll-a in marl crust from Lough Carra (Source: Philip Doddy). Mean values of chlorophyll-a (µg/cm³) are shown for each location.

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APPENDIX 1: Sampling Station Locations

Table 2: Location of each sampling station from which marl samples were taken

Sampling Station	Latitude	Longitude
Nagoyne A	53.71501	-9.24429
Kilkieran	53.69947	-9.26017
Nagoyne B	53.71373	-9.24863
Otter Point	53.68527	-9.24875
Ballycally	53.69746	-9.2474
Church Island	53.72289	-9.27481
Knockglass	53.67631	-9.22775
Portroyal	53.71179	-9.27421
Doon	53.72466	-9.26302
Leamnahye	53.67299	-9.24809
Heneghan's	53.71625	-9.28248
Twin Islands	53.68261	-9.23859
Flanelly's	53.65732	-9.25687
Knocknaraha	53.73687	-9.24879
Ballintubber	53.73797	-9.26691
Brownstown	53.69291	-9.2196
Bull's Well	53.73331	-9.24653
Castle Island	53.69415	-9.23161
Moorehall Spring	53.70965	-9.22703
Cloondaver	53.69838	-9.21392
Annie's	53.70341	-9.21515

APPENDIX 2: Chlorophyll-a Concentration in Marl Crust Samples

Table 3: Chlorophyll-a concentration in marl crust samples from Lough Carra. Five replicates were used in each case and the results from these are shown individually. Chlorophyll-a analysis was done by Complete Laboratory Solutions, Galway. Due to a suspected error with one of the samples from Annie's, only four values are available from this sampling station.

Sampling Station	Nagoyne A	Kilkieran	Nagoyne B	Otter Point	Ballycally	Church Island	Knockglass	Portroyal	Doon	Leamnahye	Heneghan's
Chlorophyll-a (µg/cm³)	13.4	18.7	28.3	20.8	20.3	24.3	27.8	28.0	32.0	38.4	28.3
	17.9	21.6	19.5	23.5	32.0	27.2	23.2	34.4	23.8	35.5	36.6
	13.9	18.4	18.2	28.6	22.7	25.6	19.0	28.3	36.0	32.3	29.6
	25.6	18.7	19.8	20.6	20.8	27.5	23.2	30.4	33.1	41.9	43.3
	21.9	23.0	21.1	18.2	27.8	20.3	33.4	23.8	33.1	36.6	52.1

Sampling Station	Twin Islands	Flanelly's	Knocknaraha	Ballintubber	Brownstown	Bull's Well	Castle Island	Moorehall Spring	Cloondaver	Annie's
Chlorophyll-a (µg/cm³)	47.3	54.5	47.3	38.2	57.7	68.4	83.8	94.3	124	102
	41.4	41.9	44.3	43.0	48.6	45.4	83.0	113	129	134
	40.6	44.3	21.4	53.1	47.3	34.2	89.4	93.5	116	160
	44.3	39.0	43.8	39.0	49.9	44.1	89.7	95.9	120	92.9
	41.9	38.4	68.9	56.6	37.6	49.7	103	100	135	

APPENDIX 3: Marl Crust Thickness

Table 4: Thickness of marl crust samples from Lough Carra. Five replicates were taken from each station and the results for these are shown individually.

Sampling Station	Nagoyne A	Kilkieran	Nagoyne B	Otter Point	Ballycally	Church Island	Knockglass	Portroyal	Doon	Leamnahye	Heneghan's
Sample thickness (mm)	12	13	9	9	13	8	8	10	10	6	3
	15	7	10	7	10	10	8	7	7	6	2
	12	11	14	5	10	12	10	9	9	10	5
	16	12	12	13	7	7	14	10	10	5	7
	14	12	10	11	10	10	8	5	5	7	6

Sampling Station	Twin Islands	Flanelly's	Knocknaraha	Ballintubber	Brownstown	Bull's Well	Castle Island	Moorehall Spring	Cloondaver	Annie's
Sample thickness (mm)	8	10	8	9	8	9	6	4	7	7
	10	8	9	10	7	22	7	4	8	8
	9	7	7	12	10	15	6	4	6	7
	9	8	10	9	9	10	7	3	8	11
	8	10	9	8	10	9	6	5	7	10

APPENDIX 4: Site Photographs

A selection of photographs from some of the Lough Carra sampling stations is shown in this section.

Plate 1: Doon sampling station, Lough Carra

Plate 2: Doon sampling station, Lough Carra

Plate 3: Portroyal sampling station, Lough Carra

Plate 4: Portroyal sampling station, Lough Carra

Plate 5: Church Island sampling station, Lough Carra

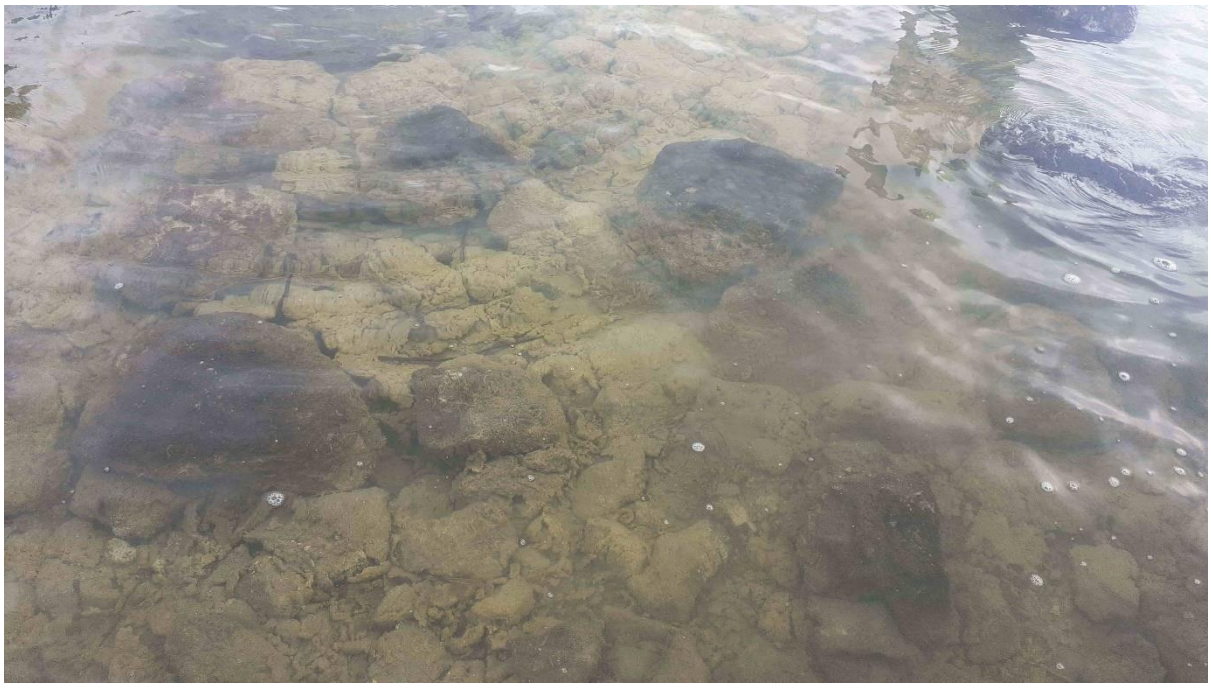

Plate 6: Church Island sampling station, Lough Carra

Plate 7: Heneghan's sampling station, Lough Carra

Plate 8: Heneghan's sampling station, Lough Carra