Food Standards Agency in Northern Ireland

Sanitary Survey Review for Larne Lough

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Glossary and acronyms

AFBI	Agri-Food and Biosciences Institute
ANOVA	Analysis of Variance
ASSI	Area of Special Scientific Interest
Bathymetry	The measurement of water depth at various places of a water body
BOD	Biochemical Oxygen Demand
BTO	British Trust for Ornithology
c.	Circa, approximately
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CSO	Combined Sewer Overflow
DAERA	Department of Agriculture, Environment and Rural Affairs
ERO	Emergency Relief Overflows
EU	European Union
E. coli	*Escherichia coli*
FA CSO	Formula A combined sewer overflow
FEPS	Final effluent pumping station
FFT CSO	Flow to full combined sewer overflow
FSA in NI	Food Standards Agency in Northern Ireland
Gal/ac	Gallons per acre
ha	Hectares (10,000 m^2)
Hydrodynamic	Forces in or motions of liquids
Hydrography	The description and analysis of the physical conditions, boundaries, flows and related characteristics of water bodies.
ISPS	Interstage pumping station
kn	Knot is a unit of speed equal to one nautical mile per hour, 1.852 km/h (approximately 1.151 mph)
LGD	Local Government District
LMA	Local Management Area
Marpol 73/78	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. Marpol is short for Marine Pollution, 73 for 1973 and 78 for 1978.
MPN	Most Probable Number
MSD	Marine Sanitation Device
NIEA	Northern Ireland Environment Agency

NISRA	Northern Ireland Statistics and Research Agency
NIW	Northern Ireland Water
P.E.	Population Equivalent
PSU	Practical Salinity Units
RAMSAR	A term adopted following an international conference, held in 1971 in Ramsar in Iran, to identify wetland sites of international importance, especially as waterfowl habitat.
Regulation (EU) 2017/625	of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products.
RMP	Representative Monitoring Point
SMILE	Sustainable Mariculture in northern Irish Sea Lough Ecosystems
SOA	Super Output Areas or ward
SPA	Special Protection Area
SPS	Sewage Pumping Station
WeBS	Wetland Bird Survey
WwTW	Wastewater Treatment Works

1. Executive Summary

Under Regulation (EU) 2017/625 and its subsequent Implementing Regulation (EU) 2019/627, there is a requirement for competent authorities intending to classify bivalve production or relaying areas to undertake a sanitary survey. The purpose of this review is to determine the extent to which potential sources of pollution may impact on a licensed bivalve mollusc production area and ultimately inform the sampling plan for the Official Control Microbiological Monitoring Programme, the results of which determine the annual classification for bivalve mollusc licensed areas.

A Sanitary Survey involves an inventory of pollution sources, both human and animal, that may cause contamination in the shellfish production area. It includes an examination of the quantities of organic pollutants released during the different periods of the year, considering seasonal variations of human and animal populations within the catchment area, along with rainfall data and wastewater treatment information. Additionally, it involves determining the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry, and the tidal cycle in the production area. This report will appraise any changes to Larne Lough since the last review and assess whether the changes are likely to affect the microbiological concentration of the classified licensed areas in accordance with the Community Guide to the Principles of Good Practice for the Microbiological Classification and Monitoring of Bivalve Mollusc Production and Relaying Areas with regard to Implementing Regulation 2019/627 (updated 2021).

For completeness, the Food Standards Agency in Northern Ireland (FSA NI) undertakes a re-evaluation of pollution sources. Following CEFAS 2018 guidance, a sampling plan (primary sanitary survey) is undertaken if a time trigger (six years or more since the last survey) or change in the environment has occurred. The original sanitary survey for Larne Lough was completed in 2009. The 2009 survey was conducted to identify the location, extent, and nature of the shellfishery, the potential sources of faecal contamination to the shellfishery, and to recommend sampling plans for the classified licensed sites within Larne Lough. A review of the 2009 sanitary survey was carried out in 2015 by CEFAS (CEFAS, 2015). The 2015 review consisted of an analysis of publicly available information to assess changes that had occurred since the 2009 report. The 2015 report did not intend to present information on pollution sources identified in the 2009 report. As more than six years have elapsed since the last sanitary survey review of Larne Lough, the FSA commissioned a further review by Aquafact for 2023/24. This entailed a review of the previous 2009 and 2015 reports and findings, and incorporation of updates to all data where applicable, including revision to the RMP locations. In light of this, it was determined that a shoreline survey was not required at this time.

Larne Lough is a sea lough located on the west coast of Northern Ireland in Co. Antrim. Larne town is located on the western side of the mouth of the lough, while the eastern side is bordered by the Islandmagee peninsula. The lough is *c.* 9 km long and 2 km wide, narrowing at Barney's Point and Magheramorne Quarry. The surrounding habitat of the lough is comprised of an artificial brackish lagoon, mudflats, rocky shores, and salt marshes. Spiral tasselweed and a community of bryozoans are among the species supported by the brackish environment. The priapulid worm (*Priapulus caudatus*) can be found in the mudflat habitat at Old Church Bay, while thick mats of the sponge *Hymeniacidon* sp. inhabit the lower shore of Barney's Point. The saltmarshes span the intertidal zone at Ballycarry, giving rise to a diversity of rare plant species such as lax-flowered sea-lavender, saltmarsh flat-sedge, spring squill, frosted orache, and sea-purslane.

This report documents a review of publicly available information in order to assess any changes that have occurred since the 2015 Sanitary Survey for Larne Lough. This is carried out through a desktop analysis of all information previously reported in the 2015 Sanitary Survey report, to identify any changes or updates which may be applicable. A shoreline survey was not carried out for the purpose of this report. This report attempts to document and quantify all known sources of pollution to the lough. It was concluded within the 2014/15 Sanitary Survey that the primary sources of pollution into Larne Lough come from the livestock present on the agricultural land dominating the land cover around the inner lough, the density of birds and livestock noted from the 2014 shoreline survey on the shoreline bordering the licensed shellfish production areas, and direct discharges into the lough from Wastewater Treatment Works (WwTW) outfalls in the inner lough. This information was reassessed as part of this review.

Statistical analysis of *E. coli* data from 2017 to 2022 indicated there are no seasonal variations in the contribution of microbiological sources of contamination from various sources such as wildfowl (birds), boats (shipping and recreational activity), and tourism.

However, there were a number of data points missing in this analysis due to a lack of data collection during the Coronavirus pandemic and a longer-term, complete data set may better inform this conclusion, so seasonal variation should not be completely discounted. The inner section of the lough is vulnerable to pollution due to the shallow depths (increased suspended sediment concentration) and a longer residence time of 18 to 19 days.

Based on historical data and reviewing the varying nature of inputs into Larne Lough at different geographic locations, a decision was made to recommend three representative monitoring points (RMPs). These RMPs are strategically placed to address the potential bacterial contamination identified in the inner lough and the various species of shellfish produced. The proposed locations are in the L1, L3, and L5 production areas, to effectively monitor and manage the diverse potential sources of contamination across the lough.

2. Overview of the Fishery/Production Area

2.1. Location/Extent of Growing/Harvesting Area

Larne Lough is an inlet on the west coast of Northern Ireland (**Figure 2-1**), in County Antrim. The town of Larne is located on the west side of the mouth of the lough, while the east side is bordered by a peninsula of land called Islandmagee, which is joined to the mainland south of the lough head.

The 2009 Sanitary Survey Report identified seven classified fisheries operating within five shellfish beds. Cultivated species included native and Pacific oysters, manila and native clams, and common mussels. Common mussels and clams were grown using bottom culture techniques, with oysters grown on trestles on the lower intertidal area. As stated in the 2015 Sanitary Survey Report, the licensed shellfish sites included Mill Bay (L5) mussels and oysters and Island Shellfish (L1) clams, however following publication of the 2015 Sanitary Survey Report the clam was declassified by the Food Standards Agency in Northern Ireland (FSA NI). According to the 2022 NI Shellfish Classification List (V18_0), the licensed areas within Larne Lough that were classified at that time (effective from 2020) were L3 oysters and L5 mussels and oysters. **Figure 2-1** shows the locations of licensed shellfish areas within Larne Lough. The only licensed area in Larne Lough currently classified is L3 (4.6 ha) for Pacific oysters (*Crassostrea gigas*). Shellfish production area L5 (20 ha) had been classified for both mussels and oysters. However, it was declassified for both shellfish species in 2022. Shellfish production area L1 (24.6 ha) had previously been classified for clams but has been declassified since just after the last review in 2015. Pre-classification monitoring is currently being carried out to classify L5 and L1 for Pacific oysters.

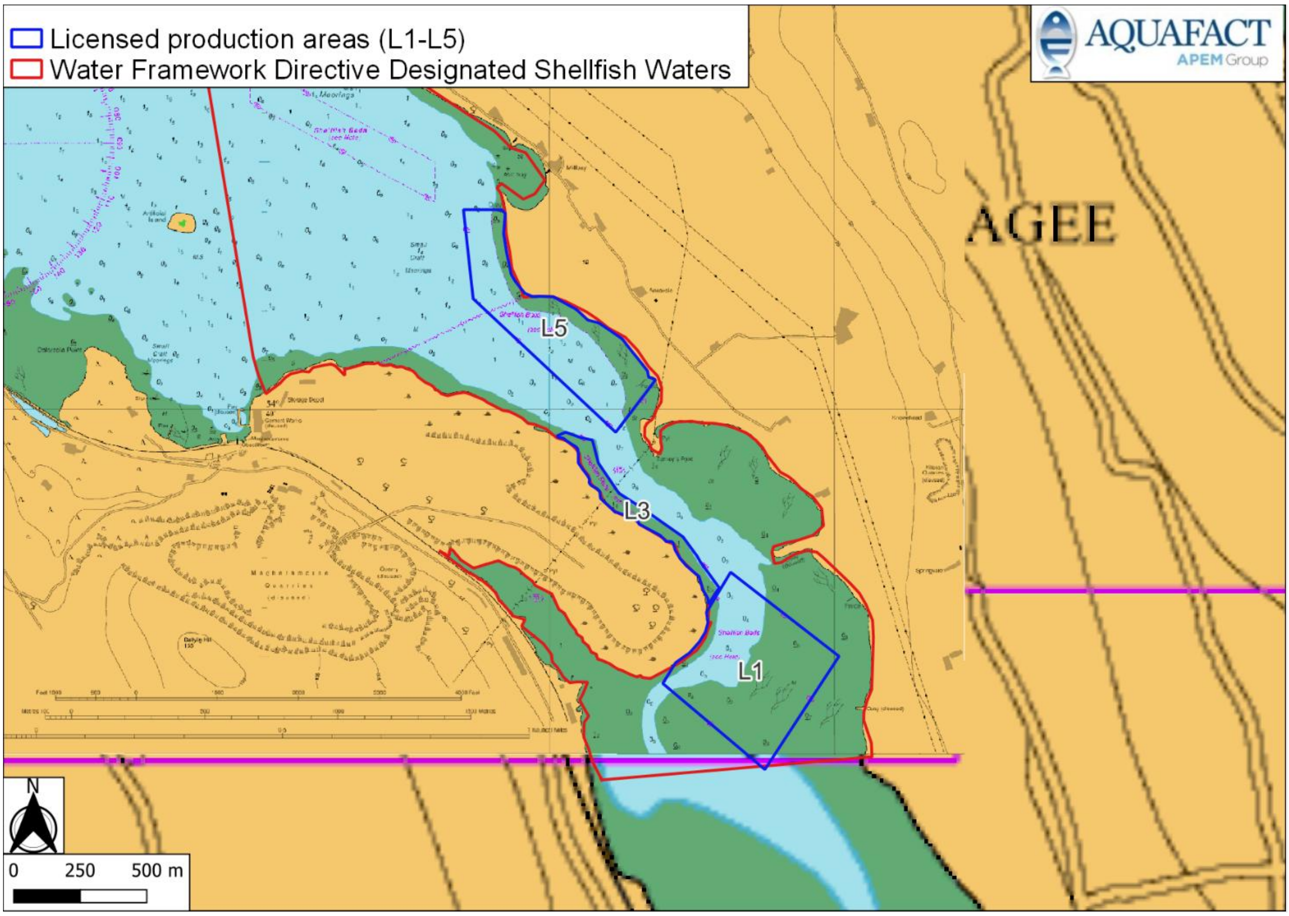

Figure 2-1: Licensed shellfish production areas (L1, L3, and L5) and Water Framework Directive designated shellfish waters within Larne Lough (source: DAERA, 2023).

2.2. Description of the Area

Larne Lough is *c.* 9 km long and 2 km wide, narrowing at Barney's Point and Magheramorne Quarry. The surrounding habitat comprises an artificial brackish lagoon, mudflats, rocky shores, and saltmarshes. Spiral tasselweed and a community of bryozoans are among the species supported by the brackish lagoon. The priapulid worm (*Priapulus caudatus*) can be found in the mudflat habitat at Old Church Bay, while thick mats of the sponge *Hymeniacidon* sp. inhabit the lower shore of Barney's Point. The saltmarshes span the intertidal zone at Ballycarry, giving rise to a diversity of rare plant species such as lax-flowered sea-lavender, saltmarsh flat-sedge, spring squill, frosted orache, and sea-purslane.

Several bird species can be found throughout the ecosystem of Larne Lough, from a breeding tern population at Swan Island to overwintering birds such as goldeneye, great crested grebe, red-breasted merganser, and shelduck.

It should be noted that Larne Lough is a Special Protected Area (SPA) for light-bellied brent geese in winter and a RAMSAR site for Irish Red Book bird species. Larne Lough SPA covers an area of 398 ha and is partially comprised of Swan Island SPA which has become part of the boundary since 2015 (Larne Lough SPA Conservation Objectives).

3. Hydrography/Hydrodynamics

3.1. Tides & Currents

Larne Lough has a relatively short tidal range of 2.4 m on spring tides (Admiralty chart 1237). Both the 2009 sanitary survey and 2015 review used data from the Sustainable Mariculture in northern Irish Lough Ecosystems (SMILE project) (Ferreira *et al*., 2007). The SMILE project found that the inner section of the lough has a water residence time of 18-19 days, while the outer lough has a residence time of approximately two days. The shellfish farms are mainly located in the inner part of the lough. The freshwater runoff was estimated at 101 million m^3/year. Modelling carried out under the SMILE project indicated that currents in the inner lough can reach up to 1.0 m/s; (note: 1 m/s = 1.94 kn, approximately).

The 2015 review sourced further information on water movements through internet searches. It was found that currents tended to be unidirectional and were faster along the eastern side than the west. This is due to the presence of a deeper channel along the eastern side of the lough (VisitMyHarbour, 2022). It was also noted that halfway through the flooding tide, a weak counter current flows past the Ballylumford Power Station jetty. The maximum speed of this current on spring tides is 0.5 m/s. The 2015 survey also sourced data from a Northern Ireland Water modelling report around Barney's Point. Barney's Point is in the narrow channel between the inner and outer parts of the lough. The currents at Barney's Point are approximately 1.0 m/s on a flooding spring tide. Currents are lower on ebbing tides and neap tides. The particle transport over a single tidal cycle (one high tide plus a successive low tide) was estimated to be greater than 5 km (not considering the effects of dilution and dispersion).

A review of available online data sources, including visitmyharbour.com and eoceanic.com, indicated, at the time of writing this report, that the currents within Larne Lough are the same as reported in the 2015 report. Information taken from admiralty chart tidal diamonds (Admiralty chart 1237) shows the maximum average tidal stream at Ballylumford Pier for spring tides ranges from 1.2 kn on an ebbing tide to 1 kn on a flooding tide. On neap tides the maximum average tidal stream at the pier ranges from 0.9 kn on an ebbing tide to 0.8 kn on a flooding tide.

3.2. Rainfall Data

3.2.1. Amount and Time of Year

The meteorological data from Ballypatrick Forest Weather Station in Northern Ireland was assessed as part of this review. Ballypatrick Forest Weather Station was chosen due to the large dataset available for this station which encompasses data ranging across the coasts of Northern Ireland in comparison to other weather stations which contain fewer data points. Additionally, this weather station is located north of Larne Lough so provides relevant precipitation data for the area. **Figure 3-1** shows the average monthly rainfall data for Northern Ireland from 1981 to 2010 (Met Office, 2011). **Table 3.1** shows the average rainfall range from Ballypatrick Forest Weather Station from 1981 to 2010. From 1981 to 2010, the average monthly rainfall along the Northern Ireland coastline of Larne Lough ranged from 78.98-155.07 mm, with the lowest levels occurring in June and the highest levels occurring in October. **Figure 3-2** shows the average seasonal rainfall data over this same period. **Table 3.2** shows the mean seasonal rainfall values based on the mean monthly rainfall values. Seasonally, summer was the driest season (266.18 mm), and autumn was the wettest season (406.43 mm). Seasons were selected by grouping the results from the following periods: spring (March–May), summer (June–August), autumn (September–November), and winter (December–February).

Table 3.3 shows the average rainfall range from Ballypatrick Forest Weather Station from 1991 to 2020. During this period, the average rainfall ranged from 79.98-149.52 mm, these values are similar to those reported from 1981 to 2010. **Figure 3-3** shows the monthly rainfall averages for Northern Ireland from 1991 to 2020 and **Figure 3-4** shows the average seasonal rainfall (mm) data for this time period. **Table 3.4** shows the mean seasonal rainfall values. Spring was the driest season (257.45 mm), and autumn was the wettest season (391.89 mm). Although spring was the driest for the period 1991-2020 compared to the summers from 1981 to 2010, autumn was the wettest season for both periods.

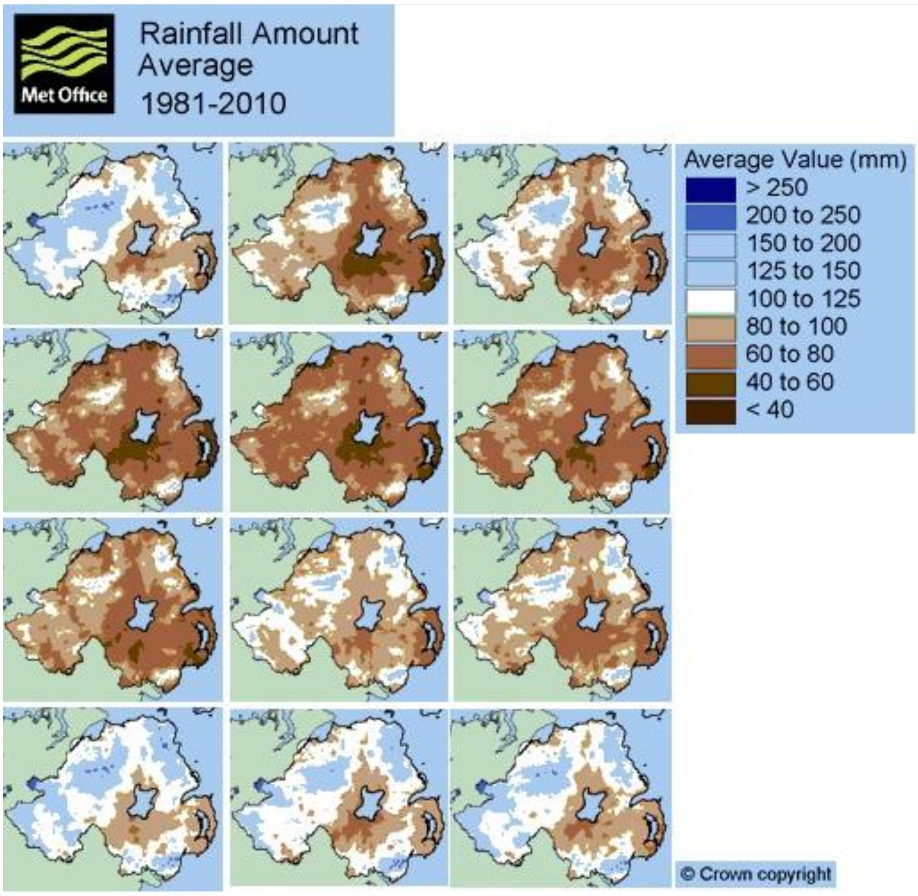

Figure 3-1: Average monthly rainfall (mm) data for January to December from 1981 to 2010 for Northern Ireland; read from left to right (source: Met Office, 2011).

Table 3.1: Mean rainfall (mm) data from Ballypatrick Forest Weather Station from 1981 to 2010 and 1991 to 2020 (source: Met Office, 2021).

Month	Mean monthly rainfall (mm) from 1981-2010	Mean monthly rainfall (mm) from 1991-2020
January	132.34	131.60
February	94.5	106.38
March	114.06	97.15
April	84.98	80.32
May	80.6	79.98
June	78.98	85.83
July	85.24	97.63
August	101.96	109.06
September	108.37	99.47
October	155.07	142.90
November	142.99	149.52
December	133.9	145.87

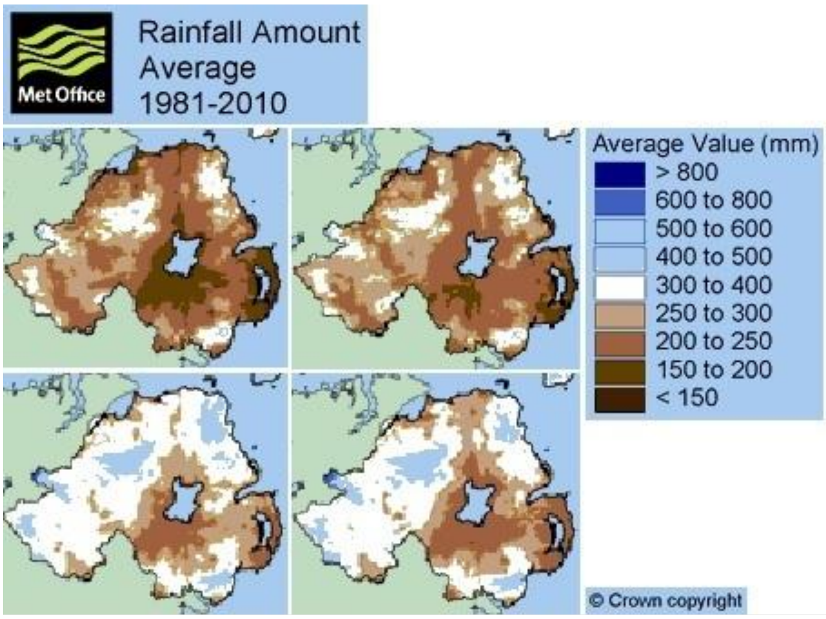

Figure 3-2: Spring to winter (left to right) average seasonal rainfall (mm) data from 1981 to 2010 for Northern Ireland (source: Met Office, 2011).

Table 3.2: The mean seasonal rainfall values based on the mean monthly rainfall values from 1981 to 2010 (source: Met Office, 2021).

Season	Mean (mm)
Spring	279.64
Summer	266.18
Autumn	406.43
Winter	360.74

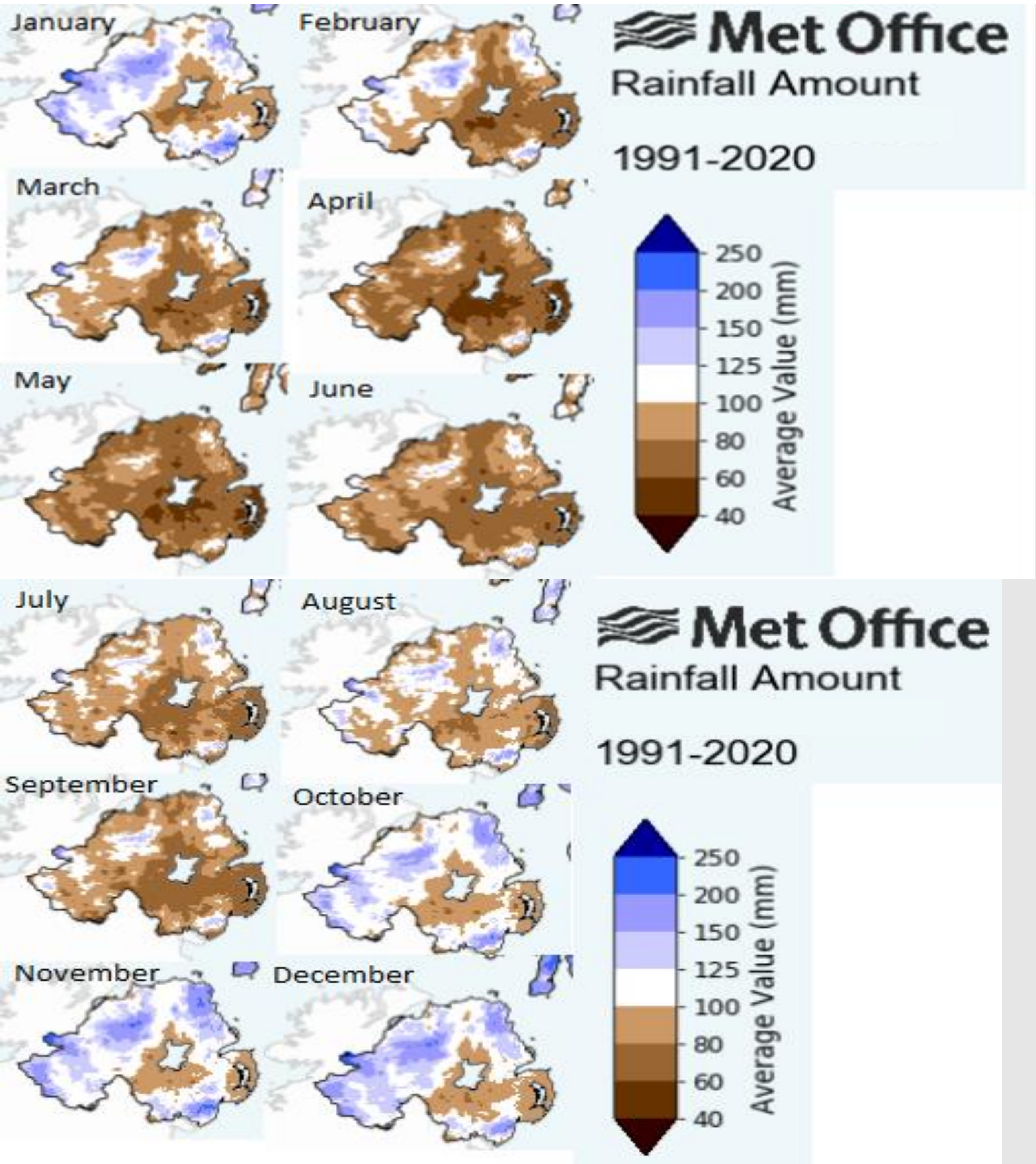

Figure 3-3: Average monthly rainfall (mm) data from 1991 to 2020 for Northern Ireland (source: Met Office, 2021).

Table 3.3: The average monthly rainfall data for Northern Ireland (source: Met Office, 2021) from 1991 to 2020.

Month	Mean (mm)
January	131.6
February	106.38
March	97.15
April	80.32
May	79.98
June	85.83
July	97.63
August	109.06
September	99.47
October	142.9
November	149.52
December	145.87

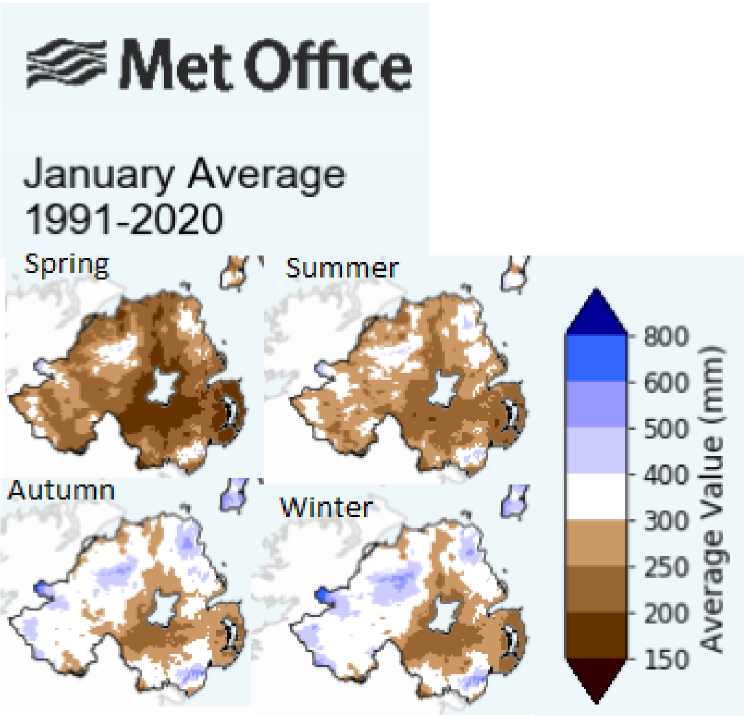

Figure 3-4: Average seasonal rainfall (mm) data from 1991 to 2020 for Northern Ireland (source: Met Office, 2021).

Table 3.4: Total seasonal rainfall values (mm) from 1991 to 2020 based on the mean rainfall value (source: Met Office, 2021).

Season	Mean (mm)
Spring	257.45
Summer	292.52
Autumn	391.89
Winter	383.85

Table 3.5 shows the average monthly rainfall data from Ballypatrick Forest Weather Station from 2011 to 2015 and **Table 3.6** the period from 2016 to 2020 (Met Office, 2021). Rainfall ranged from 12.2 mm in September 2014 to 246.4 mm in December 2011, and from 29.6 mm in April 2020 to a high of 246.4 in February of the same year.

Table 3.7 shows the total seasonal rainfall at Ballypatrick Forest from 2011-2015 (Met Office, 2021). The following seasonal fluctuations were observed from 2011-2015: in 2011, spring was the driest and winter was the wettest, in 2012 spring was the driest and summer was the wettest, in 2013 summer was the driest and autumn was the wettest, in 2014 spring was the driest season and winter was the wettest season, and in 2015 spring was the driest season and winter was the wettest.

Table 3.8 shows the total seasonal rainfall at Ballypatrick Forest Weather Station from 2016-2020 (Met Office, 2021). The following seasonal fluctuations were observed from 2016-2020: in 2016 spring was the driest season and winter was the wettest, in 2017 spring was the driest season and autumn was the wettest, in 2018 spring was the driest and winter was the wettest, in 2019 winter was the driest and summer was the wettest, and in 2020 spring was the driest and winter was the wettest.

Similar seasonal trends are seen between 2011 to 2015 and 2016 to 2020 data with spring generally the driest and winter the wettest. However, in some years winter was the driest and the summer the wettest.

Table 3.5: Average monthly rainfall (mm) data at Ballypatrick Forest Weather Station, Co. Antrim from 2011 to 2015 (source: Met Office, 2021).

Month/Year	2011	2012	2013	2014	2015	Monthly Total (mm)	Monthly Average across years (mm)
January	73.6	159.8	144.4	218	145.2	**741**	**148.2**
February	190	64.4	97.6	239.2	97.4	**688.6**	**137.7**
March	63	35	106	84.6	100.6	**389.2**	**77.8**
April	40.2	81.8	90.8	44.4	57.8	**315**	**63.0**
May	106.4	81.6	133.6	79.6	145	**546.2**	**109.2**
June	104.2	226	120.2	71.6	51.8	**573.8**	**114.8**
July	93.2	143.2	61.4	78.6	171.8	**548.2**	**109.6**
August	85.2	106.6	71	173.8	119.4	**556**	**111.2**
September	105.8	139.8	140.6	12.2	61.2	**459.6**	**91.9**
October	229.8	179.6	218.6	148.6	89.8	**866.4**	**173.3**
November	133.6	78.4	84.9	213.3	207.9	**718.1**	**143.6**
December	246.4	196	143.6	199.8	188.4	**974.2**	**194.8**
Annual Total mm	**1471.4**	**1492.2**	**1412.7**	**1563.7**	**1436.3**	**-**	**-**
Monthly Average per year mm	**122.6**	**124.4**	**117.7**	**130.3**	**119.7**	-	-

Table 3.6: Average monthly rainfall (mm) data at Ballypatrick Forest Weather Station, Co. Antrim from 2016 to 2020 (source: Met Office, 2021).

Month/Year	2016	2017	2018	2019	2020	Monthly Total (mm)	Monthly Average across years (mm)
January	229.0	86.8	198.2	67.6	71.8	**653.4**	**217.8**
February	115.6	90.4	80.6	58.8	246.4	**591.8**	**197.3**
March	67.8	122	110.6	157.4	58.4	**516.2**	**172.1**
April	91.4	38.6	73.6	84.6	29.6	**317.8**	**105.9**
May	48.4	63.4	53.8	58	37.2	**260.8**	**86.9**
June	71.0	96.2	49	100.6	95.2	**412.0**	**137.3**
July	105.8	175.2	78.6	122	128.4	**610.0**	**203.3**
August	71.9	101.8	125.6	184.4	210.8	**694.5**	**231.5**
September	72.8	178.6	80	83.8	71.6	**486.8**	**162.3**
October	60.2	115	95.4	116.4	211.2	**598.2**	**199.4**
November	108.8	148	149.8	156.5	108.8	**671.9**	**224.0**
December	80.0	140.8	150.8	132	155.8	**659.4**	**219.8**
Annual Total mm	**1122.7**	**1356.8**	**1246**	**1322.1**	**1425.2**	-	-

Monthly Average per year mm	93.6	113.1	103.8	110.2	118.8	-	-

Table 3.7: Total seasonal rainfall (mm) at Ballypatrick Forest from 2011-2015 (source: Met Office, 2021).

Season/Year	2011	2012	2013	2014	2015
Spring	209.6	198.4	330.4	208.6	303.4
Summer	282.6	475.8	252.6	324	343
Autumn	469.2	397.8	444.1	374.1	358.9
Winter	510	420.2	385.6	657	431

Table 3.8: Total seasonal rainfall (mm) at Ballypatrick Forest from 2016-2020 (source: Met Office, 2021).

Season/Year	2016	2017	2018	2019	2020
Spring	207.6	224	238	300	125.2
Summer	248.7	373.2	253.2	407	434.4
Autumn	241.8	441.6	325.2	356.7	391.6
Winter	424.6	318	429.6	258.4	474

3.2.2. Frequency of Significant Rainfalls

The average monthly rainfall reported for Ballypatrick Forest from 1981-2010 and 1991-2020, illustrate that in both 30-year periods spring/early summer was generally the driest period and autumn/early winter was the wettest. There was no difference between the average annual rainfall over the two periods. The reported monthly rainfall data at the Ballypatrick Forest Weather Station from 2011-2015 and 2016-2020 depict the wettest months on average are typically October to February and, therefore, during these months there may be an increased risk of contamination from land run-off and rainfall associated sewer overflows. It is important to highlight that it is not just the winter months that are at risk of increased contamination. There is a high level of variability between years with May, June, and July being the wettest months in some years.

3.3. Wind and Waves

Wind conditions affect the hydrodynamic conditions in Larne Lough by generating wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Especially over the shallow areas of Larne Lough, wave-induced bottom friction may lead to resuspension of material and entrainment of sediments in the water column.

Wind data for Ballypatrick Forest Weather Station are displayed as wind roses for 2011-2015 and 2016-2020 (**Figure 3-5**). From 2011-2015, 20.3% of the wind emanated from the southwest, while 20.2% came from the south and 19.7% was from the west. The strongest winds in this period came most frequently from the west, followed by the southeast (>17 knots). From 2016-2020, 25.5% of the wind was from the west, while 18.5% came from the southwest, and 17.2% from the south. The strongest winds in this period came most frequently from the west and southwest (>17 knots).

In winter 2011-2015, 27.7% of the wind came from the west, 26.7% from the southwest, and 20.3% from the south. In autumn 23.3% of the wind came from the southwest, 22.7% from the south, and 19.9% from the west. In spring 17.6% of the wind came from the south, 16.7% from the southwest, and 16% from the west. In summer 21.3% of the wind came from the north, 20.2% from the south, and 15.6% from the west.

In winter 2016-2020, 34% of the wind was from the west, 24.3% from the southwest, and 18.1% from the south. In autumn 26% of the wind came from the west, 20% from the southwest, and 17% from the south. In spring 19.4% of the wind came from the west, 18.2% from the south, and 15.5% from the southeast. In summer 22% of the wind came from the west, 17.5% from the northwest, and 15.7%% from the southwest. The winds are strongest and most consistent during winter and autumn blowing from the west to south for more than two thirds of the time. The winds in spring and summer are weaker and less predictable.

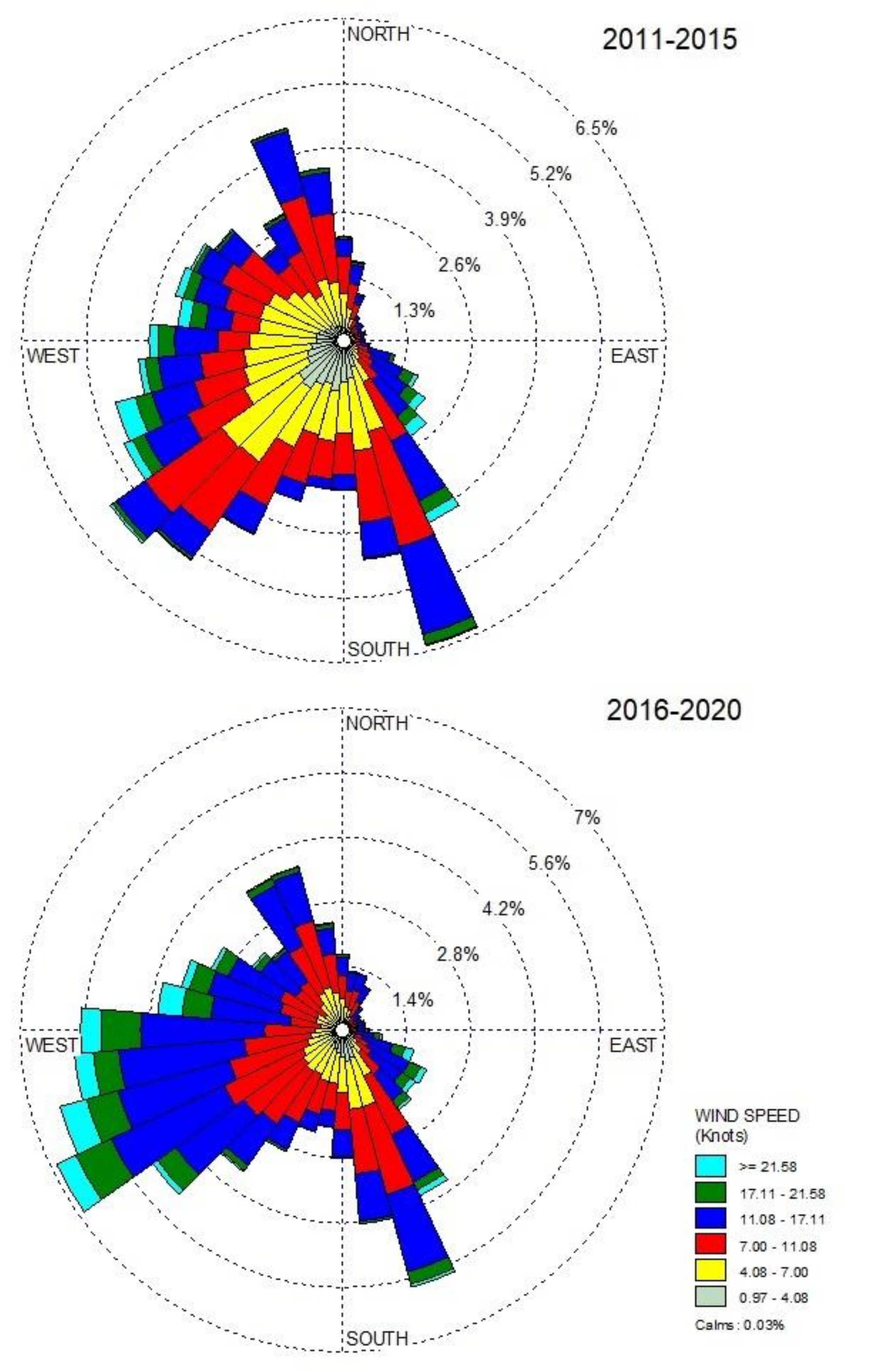

Figure 3-5: Wind roses representing wind data from Ballypatrick Forest Weather Station from 2011 to 2015 and 2016 to 2020 (source: Met Office, 2021).

3.4. River Discharges

The 2009 report noted that the Larne (Inver) River and the Glynn River were the dominant freshwater inputs into Larne Lough catchment. Total freshwater runoff was calculated at 101 million m^3/year (Ferreira *et al*., 2007). All freshwater inputs (watercourses and runoff) were concluded to potentially impact the shellfisheries in Larne Lough according to the 2009 report.

An internet search was conducted as part of the 2015 Sanitary Survey Review to find any updated/further data on river discharges into Larne Lough (CEFAS, 2015). It was found that Larne Lough is encompassed by the North Eastern River Basin District under the Water Framework Directive (WFD) and is managed under the Larne Lough local management area (LMA) (NIEA, 2014). Rivers Larne and Glynn fall within this LMA which covers a total area of *c*. 141 km^2. Five watercourses were sampled for *E. coli* during the 2014 Shoreline Survey; the highest estimated *E. coli* levels were detected in the two primary rivers draining into the lough: Rivers Larne and Glynn.

An online search was carried out for the purpose of this review for river discharge volumes in Larne Lough. At the time of writing, more recent data on river discharges was unavailable, and there were no hydrometric stations on any of the rivers in the lough for collection of water quantity (water level and flow) data. The river network for Larne Lough catchment can be seen in **Figure 3-6**.

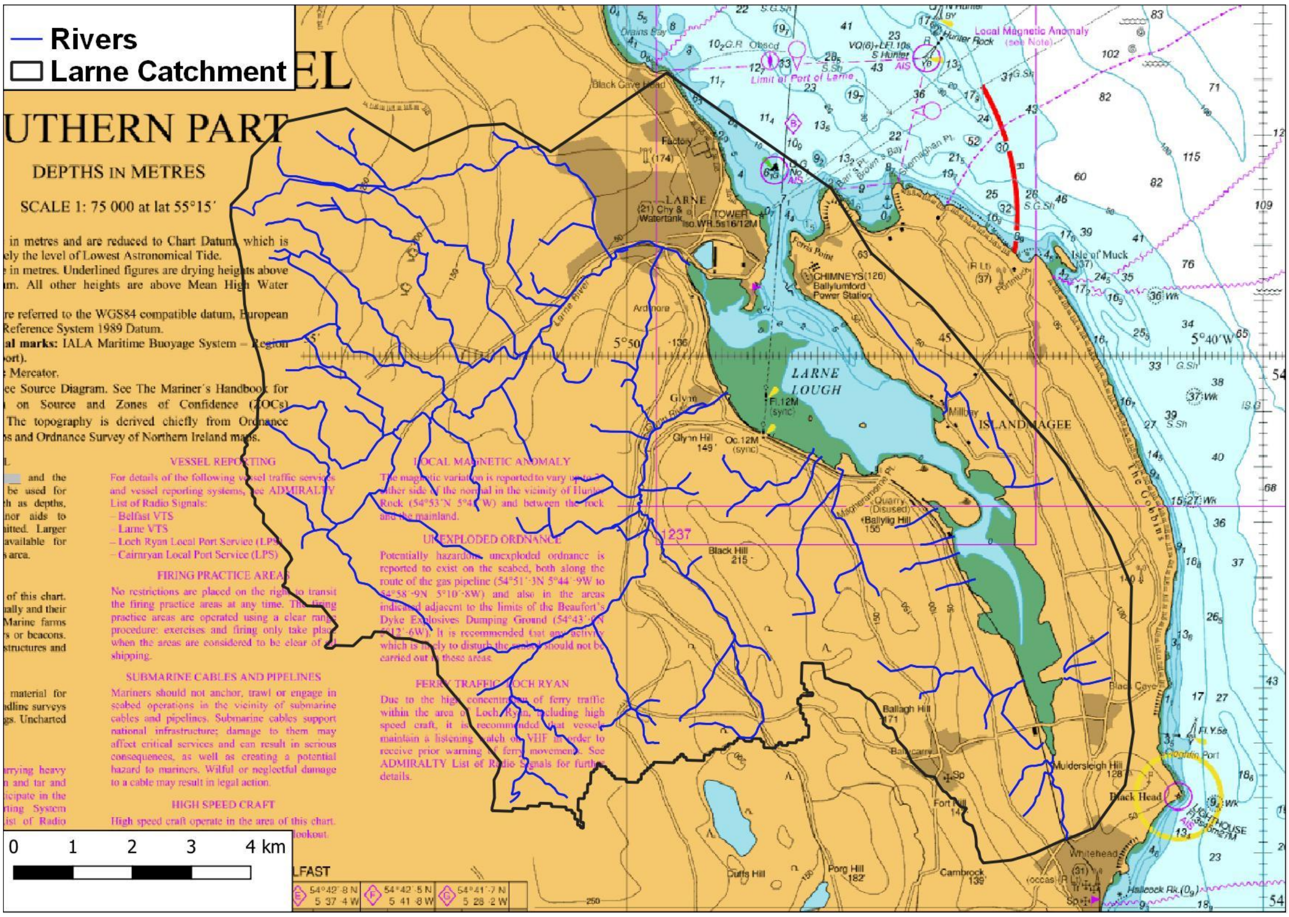

Figure 3-6: Rivers and streams within the Larne Lough catchment (information regarding catchment and river data was sourced from DAERA in 2023).

3.5. Depth

Larne Lough has a maximum depth of 10 m, comprising an area of 8 km^2, with its catchment area extending to 115 km^2 (AFBI NI, 2015). Larne Lough is comprised of a multitude of habitat types including brackish lagoons, mudflats, salt marshes, and rocky shores. **Figure 3-7** shows a bathymetric map of Larne Lough; **Figure 3-8** provides a magnified view of the lough's contours. It can be seen in these maps that the eastern side of the lough is deeper with much of the western side being intertidal in nature. A channel approximately 5 m deep extends from Ballylumford Power Station to halfway into the outer bay. At this point the channel turns southerly and continues to a disused pier at Magheramorne with depth of *c*. 3 m.

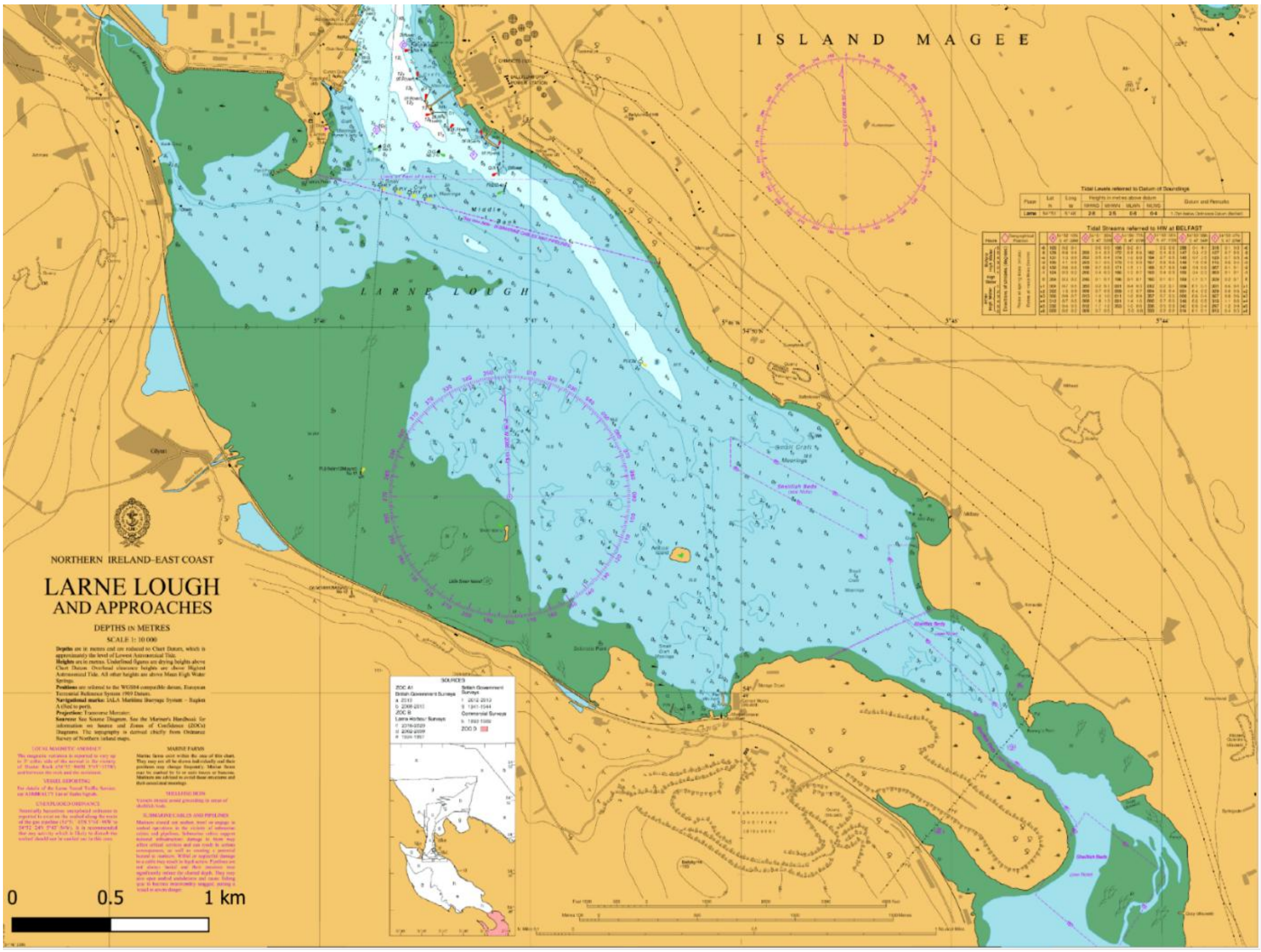

Figure 3-7: Bathymetry of Larne Lough (source: Admiralty Chart – Larne Lough and Approaches 2022).

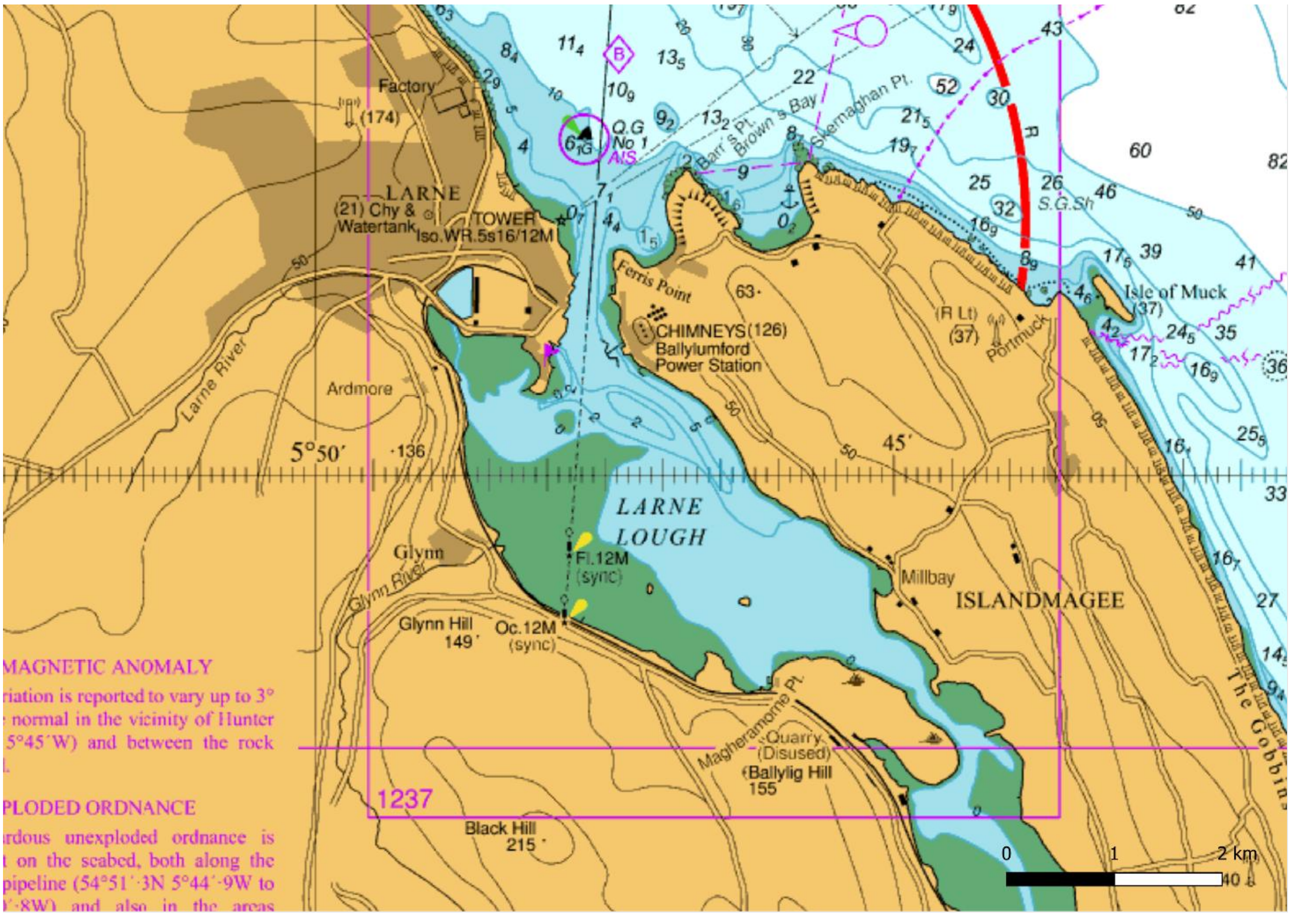

Figure 3-8: Bathymetry of Larne Lough (small scale admiralty chart, 2022).

3.6. Salinity

Larne Lough has a mean salinity of 33 psu (Agri-Food Biosciences Institute, Larne Lough Information-SMILE Project, NI, 2015). Salinity data for Larne Lough was recorded in the 2015 Sanitary Survey Review, no salinity profiles were taken however salinity samples were recorded during the shoreline survey, with the average salinity at the time calculated at 33 psu. Larne Lough has a relatively small freshwater catchment and so has a smaller freshwater input compared to the tidal exchange of seawater into the lough. As such the lough will generally have a high salinity. The salinity can be expected to be relatively lower in the area near the mouth of the Glynn River, Inver River, and in the inner lough particularly during wet periods.

3.7. Turbidity

Turbidity in seawater is not necessarily a direct sign of pollution but can be influenced by both natural processes and human activities. Natural factors include sediment transport, which increases turbidity after heavy rainfall or storms, and algal blooms, which can be driven by nutrient runoff. Human activities such as urbanisation, construction, deforestation, industrial discharges, and dredging can also elevate turbidity levels. While high turbidity alone does not indicate pollution, it indicates changes in water clarity. Therefore, scientists monitor turbidity alongside other parameters like nutrient levels, chemical contaminants, and biological indicators to assess water quality accurately. An online search was carried out for this report to obtain data on turbidity within Larne Lough however no turbidity data was available at the time of writing for Larne Lough.

Due to the muddy substrate and shallow depths, resuspension of sediment can occur during windy conditions. For that reason, the turbidity of the lough can be elevated during windy conditions, particularly when those conditions persist for extended periods.

3.8. Simple/Complex Models

Average flow rates through the narrows are <2 kn but have been recorded at up to a velocity of 3.5 kn, turning at high and low water. Approximately halfway through the flood tide a weaker counter current has been observed flowing northwards past the Ballylumford jetty, reaching a maximum speed of *c.* one knot on spring tides (VisitMyHarbour, 2022).

3.9. Discussion (Influences on Water Quality and Shellfish Production)

The bathymetric and hydrographic characteristics of Larne Lough are such that the outer section of the lough has a residence time for water of *c*. two days, while the inner section has an extended residence time of 18-19 days (Ferreira *et al*., 2007). The licensed shellfish production areas in the lough are in the inner section and in the channel between the inner and outer sections. For this reason, contamination that enters the shellfish areas may persist for an extended period depending on the tidal and weather conditions.

Since 2010, the rainfall patterns have remained consistent with autumn and winter being the wettest seasons. There was no change in the annual average rainfall between 1981–2010 and 1991–2020. The annual average rainfall from 2011–2015 was 173 mm higher than for 2016-2020. This is a decrease of 11.7% in the more recent rainfall data. A decrease in rainfall may reduce the input of contamination from land run-off and the frequency of discharges from emergency or overflow discharges from Wastewater Treatment Works (WwTW). However, in the event of a deluge, bacterial levels may spike.

There have been no significant changes to wind direction in the Larne area since the 2015 review, with the prevailing winds coming from the southwest. Also, there is no apparent increase in the frequency of stronger wind conditions.

The Nutrients Action programme (NAP) promotes efficient management of livestock manures, chemical fertilisers and other nutrient applications to land, and it applies to all farms in Northern Ireland. The closed period for spreading of organic manures including farmyard manure (excluding dirty water) runs from midnight 15th of October to midnight 31st of January. The aim of the closed period is to reduce the risk of nutrient loss to waterways as during this period plant growth is significantly reduced and nutrients are more susceptible to leaching and run-off. As of 2024, to further reduce the risk of nutrient losses at either end of the closed period for slurry application, the maximum application rate for slurry from 1st October until the beginning of the closed period, and during the month of February, has been reduced from 50 m^3/ha (4,500 gallons/acre) to 30 m^3/ha (2,700 gal/ac). Buffer zones (areas where you should not spread) around waterways and lakes increase during these periods, from 10 m to 15 m for any waterway and from 20 m to 30 m for lakes. The closed period for spreading organic matters coincides with the highest seasonal rainfall (winter), as such, if farmers were to spread slurry during these periods in the surrounding areas to Larne Lough there is a high risk of water quality degradation and subsequent reduction in the quality of shellfish in the site.

4. Identification of Pollution Sources

4.1. Desktop Survey

This study was completed through publicly available online sources only. All sources of bacterial contamination within Larne Lough catchment for which data was publicly available are considered in this section.

4.1.1. Human Population

Data on human populations for Northern Ireland were obtained from The Northern Ireland Statistics and Research Agency (NISRA) website.

Population census data for Northern Ireland is given in units of Super Output Areas (SOAs); **Figure 4-1** shows all the SOAs which fall within Larne Lough catchment.

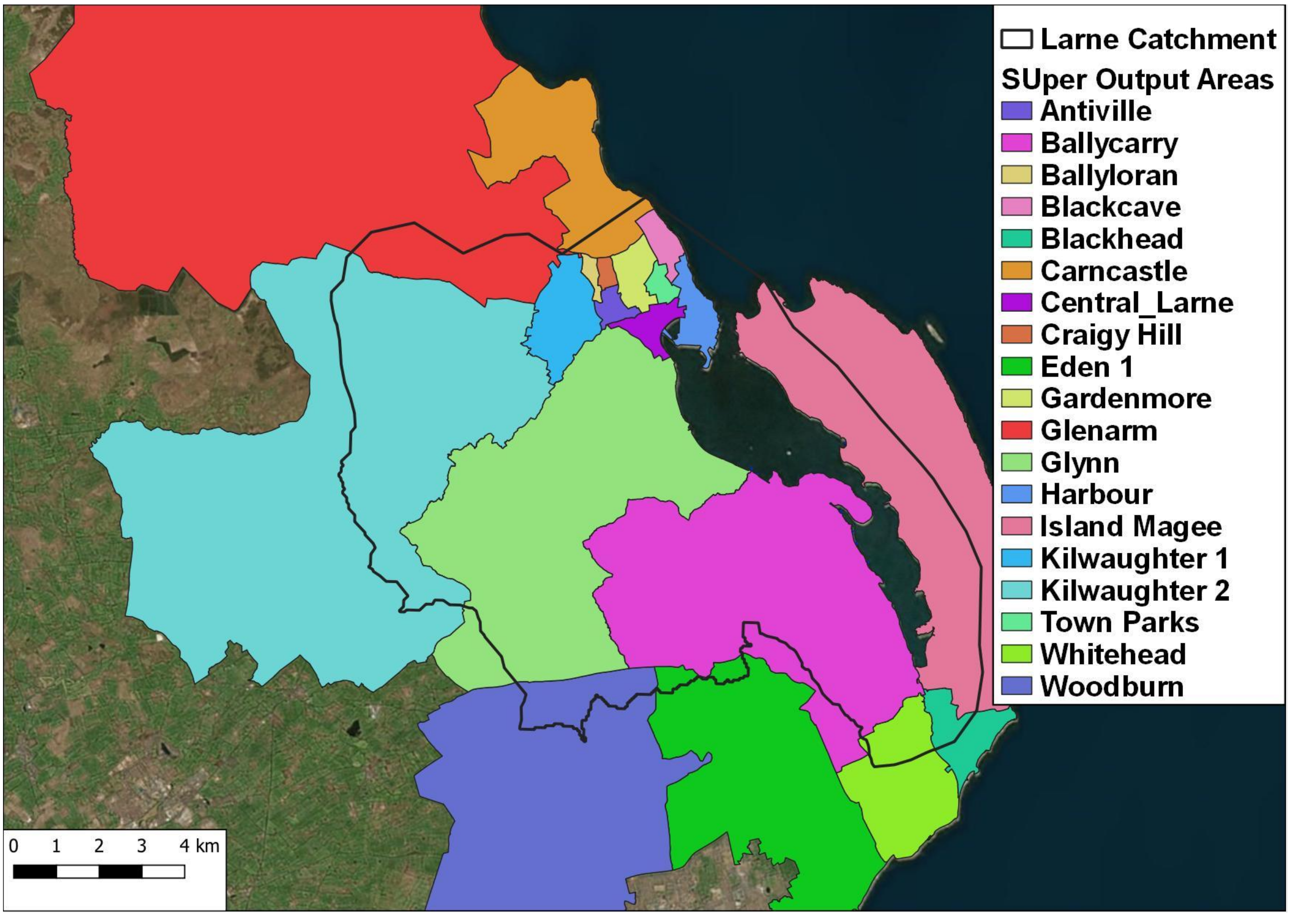

Figure 4-1: Super Output Areas (SOAs) within Larne Lough catchment (Source: NISRA, 2024).

Figure 4-2 shows the human population change within Larne Lough catchment from 2015 to 2020 and **Table 4.1** provides the population data change from 2015 and 2020. The highest populations in the study area occur in Kilwaughter 1 (4,440, +12%), Ballycarry (2,853, +3.9%), Carncastle (2,829, -0.9%), and Island Magee (2,535, -0.6%); percentage refers to the percent change in population since the 2015 review. The population in the SOAs that overlap with the Larne Lough catchment is 39,320, an increase of 0.3% since 2015 (+114).

Human population in given areas is obtainable from census data, however relating this information to the level of microbial contamination in coastal waters is difficult and is constrained by the geographical boundaries used. However, areas with a higher population typically have higher levels of sewage and wastewater entering the Larne system.

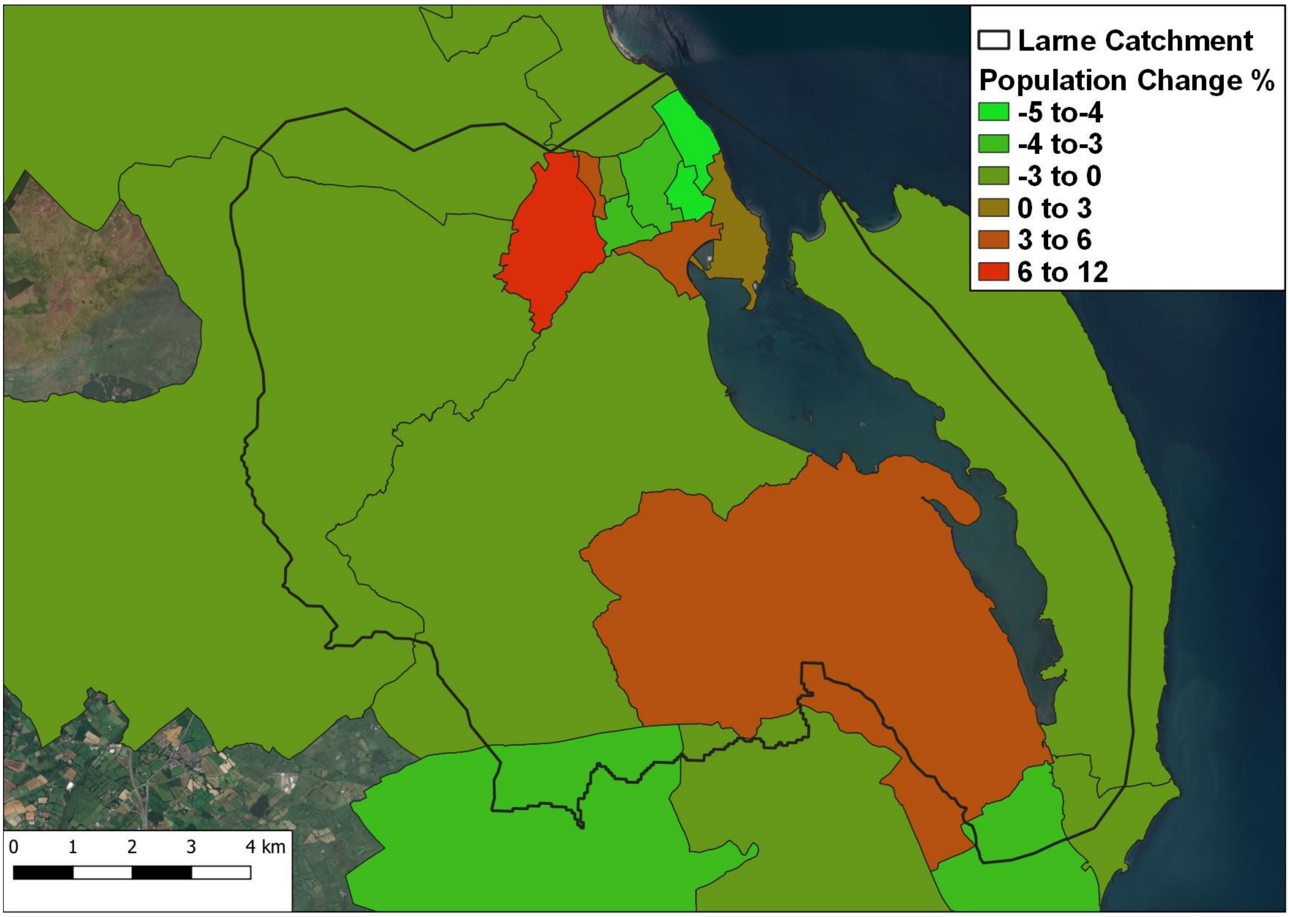

Figure 4-2: Population change within Larne Lough catchment from 2015 to 2020 (NISRA, 2024).

Table 4.1: Human population (pop.) percentage change from 2015 to 2020 within the Larne Lough catchment (source: NISRA, 2021).

SOA	Pop. 2015	Pop. 2020	% Change
Blackhead	2027	2014	-0.6
Eden 1	2321	2307	-0.6
Whitehead	2117	2046	-3.4
Woodburn	2426	2349	-3.2
Antiville	1488	1440	-3.2
Ballycarry	2747	2853	3.9
Ballyloran	1014	1050	3.6
Blackcave	1604	1539	-4.1
Carncastle	2855	2829	-0.9
Central Larne	1813	1876	3.5
Craigy Hill	1422	1383	-2.7
Gardenmore	1923	1857	-3.4
Glenarm	1839	1790	-2.7
Glynn	2019	2003	-0.8
Harbour	1818	1859	2.3
Island Magee	2550	2535	-0.6
Kilwaughter 1	3963	4440	12.0
Kilwaughter 2	1743	1708	-2.0
Town Parks	1517	1442	-4.9

4.1.2. Tourism

In this section, data from 2018/2019 was used because, due to the Coronavirus pandemic, data collection and publication by NISRA was not possible in the intervening time period between 2019 and when this report was compiled (2024). In 2019, 5.3 m tourists visited Northern Ireland, 7% more compared to 2018 (Northern Ireland Annual Tourism Statistics, NISRA, 2019). Of those tourists who spent the night in Northern Ireland, more than 43% were visiting family and friends, and 39% were holidaying. Between July and September, 29% of those tourists arrived, while 28% of them arrived between April and June. The Larne Lough catchment occurs within a Northern Ireland Local Government District (LGD) for tourism numbers 'Mid & East Antrim'. This LGD received 286,337 tourists in 2019. As the tourism numbers in Northern Ireland have increased by 7% it is likely that the tourism numbers in the Larne Lough area have also increased. There is however no way of estimating the number of tourists who specifically visited the Larne Lough catchment during their stay.

There are several recreational/tourist facilities within the lough catchment. These include two sailing/boating clubs, a number of mooring locations, and Larne docklands/Harbour. There are no beaches or swimming areas within the lough. **Figure 4-3** shows all tourism related facilities around Larne Lough. Increases in population in the local area due to tourism has the potential to increase the quantity of sewage discharged within the Larne Lough catchment.

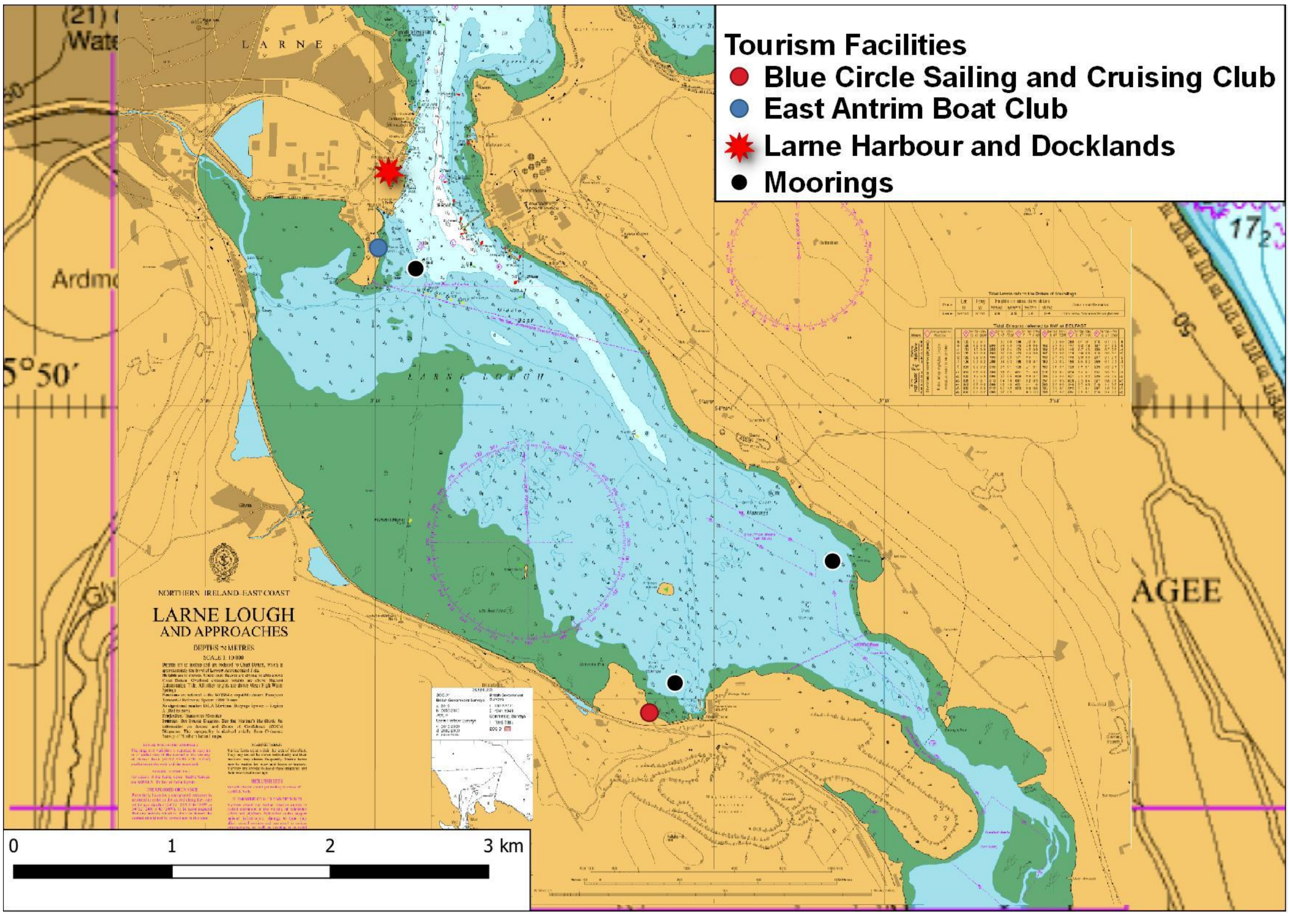

Figure 4-3: Tourist facilities within the Larne Lough area (NISRA, 2023).

4.1.3. Sewage Discharges

Sewage effluent discharges can vary in nature depending on the degree to which it has been treated. Discharges of sewage effluent can arise from a number of different sources and be continuous or intermittent in nature:

- treated effluent from urban sewage treatment plants (continuous).
- storm discharges from urban sewage treatment plants (intermittent).

- effluent from 'package' sewage treatment plants serving small populations (continuous).
- combined sewer and emergency overflows from sewerage systems (intermittent).
- septic tanks (intermittent).
- crude sewage discharges at some estuarine and coastal locations (continuous).

Treatment of sewage ranges from:

- none (crude sewage).
- preliminary (screening and/or maceration to remove/disguise solid matter).
- primary (settling to remove suspended solids as sewage sludge). Typically removes 40% of BOD (Biochemical Oxygen Demand), 60% of suspended solids; 17% of nitrogen and 20% of phosphorus from the untreated sewage.
- secondary (settling and biological treatment to reduce the organic matter content). Typically removes 95% of BOD, 95% of suspended solids, 29% of nitrogen and 35% of phosphorus from the untreated sewage. Nutrient removal steps can be incorporated into secondary treatment which can reduce ammonia – nitrogen down to 5 mg/l and phosphorus to 2 mg/l.
- tertiary (settling, biological treatment and an effluent polishing step which may involve a reed bed (unlikely for coastal works) or a treatment to reduce the load of microorganisms in the effluent). Typically removes 100% of BOD, 100% of suspended solids, 33% of nitrogen and 38% of phosphorus from the untreated sewage.

There are five WwTW within the Larne Lough catchment (**Figure 4-4**); **Table 4.2** shows the population equivalent of these treatment works. These five WwTW have a total design capacity of 43,624.74 and currently serve a population equivalent of approximately 37,119.21. The major works are those at Larne which account for approximately 74% of the total current p.e. of the catchment. The three largest WwTW in the catchment, Larne, Ballycarry and Ballystrudder, are all reported to be operating below capacity. However, Mounthill and Magheramorne WwTW are operating above capacity by approximately 154% and 141%, respectively.

While the Larne WwTW accounts for the highest p.e., the outfall location for this WwTW is at the seaward entrance to the lough and is a greater distance from the licensed shellfish areas compared to the other WwTW within the catchment. Though the Mounthill WwTW is operating above its design capacity at 215.36 p.e., this WwTW and associated outfall point are located inland of Larne Lough. The river flowing near the Mounthill outfall point discharges into the outer lough area and is not likely to contribute to *E. coli* contamination surrounding the licensed shellfish production areas.

Information was obtained from Northern Ireland Water regarding the locations, where available, of storm water overflows, emergency overflows and continuous sewage discharges associated with WwTW within the vicinity of Larne Lough. These were incorporated and assessed as part of this review. Essentially, the Magheramorne, Ballycarry, and Ballystrudder WwTW are the most likely WwTW to contribute to *E. coli* contamination in the Larne Lough catchment. Though the Magheramorne WwTW is operating above its design capacity, it only accounts for approximately 0.2% of the current p.e. for the five WwTW and approximately 0.85% of the current p.e. of the three WwTW contributing to *E. coli* in the inner lough. The 2015 Sanitary Survey Review did not report any flow data for the Magheramorne WwTW and noted that the outfall location was unusual as it was positioned across the intertidal zone, on the opposite shoreline from the WwTW. Nevertheless, that the Magheramorne WwTW appears to discharge directly into the L1 shellfish production area deems it necessary to include in the Representative Monitoring Point (RMP) assessment.

The Ballycarry and Ballystrudder WwTW outfall locations are located on the inner lough shoreline, therefore any discharges from these facilities would flow past the licensed areas. These two WwTW combined account for approximately 25% of the total current p.e., and approximately 99% of the current p.e. of the three WwTW which contribute *E. coli* directly in the inner lough. The 2015 Sanitary Survey Review noted that majority of the discharges from Ballycarry and Ballystrudder WwTW would be diverted from Larne Lough via the long sea outfall to Cloughfin Bay, which is outside of the catchment. This information is based on the 2012 Rationalisation Scheme for Whitehead, Ballycarry, and Ballystrudder; note that Whitehead is outside of the catchment (Rowe, 2012). Principally, this scheme planned to amalgamate the wastewater from these three treatment works by pumping the wastewater from one treatment works to the next, and subjecting the wastewater to different treatment levels at each location; see **Table 4.2** for treatment levels and introduction to sewage discharges. Ultimately the combined discharge would be from Ballystrudder WwTW to the

Irish Sea (Rowe, 2012), however no updated information on this scheme was found at the time of this review. Therefore, the contribution to *E. coli* levels in inner Larne Lough by the Ballycarry and Ballystrudder WwTW may be limited.

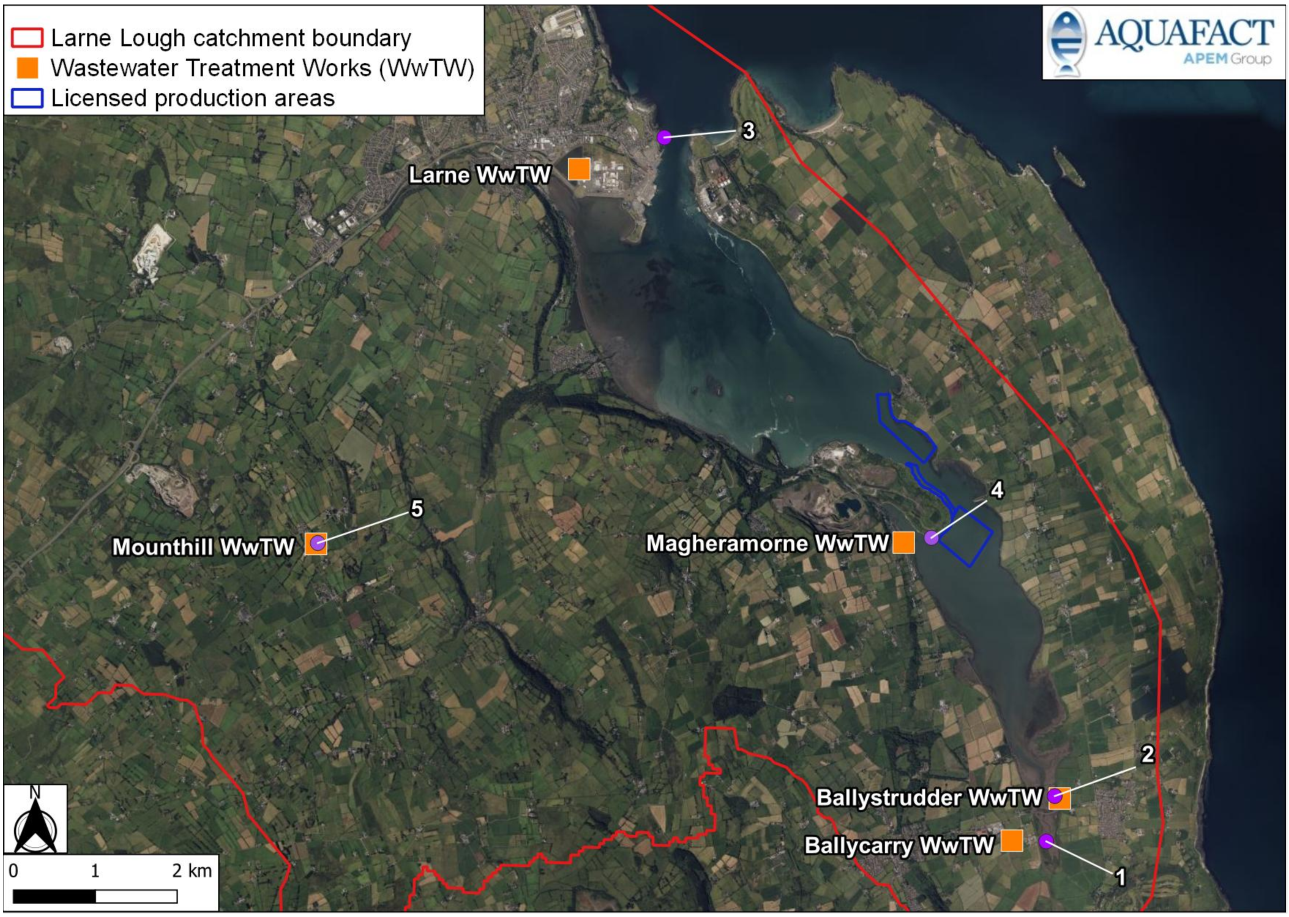

Figure 4-4: Wastewater Treatment Works (WwTW) within the Larne Lough catchment (source: NI Water, 2023).

Table 4.2: Population equivalent (p.e.) of Wastewater Treatment Works (WwTW) within the Larne Lough catchment (source: NI Water, 2023); coordinates relate to asset location rather than outfall location.

Name	Treatment category	Current p.e.	Design p.e.	Available capacity	Latitude	Longitude	Easting	Northing
Ballycarry WwTW	Tertiary B1	1753.69	2048	294.31	54.7746	-5.7294	346160	394220
Ballystrudder WwTW	Sea outfall – preliminary	7607.96	8459	851.04	54.7792	-5.7203	346727	394751
Larne WwTW	Tertiary A2	27462.3	33000	5537.7	54.8480	-5.8116	340618	402223
Magheramorne WwTW	Secondary - biological	79.9	33.1	- 46.8	54.8072	-5.7499	344721	397807
Mounthill WwTW	Secondary - biological	215.36	84.64	-130.72	54.8071	-5.8615	337549	397565

4.1.3.1. Continuous Sewage Discharges

There are no continuous sewage discharges associated with the WwTW within the Larne Lough catchment.

4.1.3.2. Rainfall Dependent Sewage Discharges

Figure 4-5 shows all combined sewer overflows within the Larne Lough catchment. **Figure 4-6** shows all rainfall dependent discharges *i.e.,* storm water overflows, within the Larne Lough catchment. **Table 4.3** documents the Combined Sewer Overflows (CSO) and Emergency Relief Overflows (ERO) which discharge into Larne Lough or a tributary of it; two storm overflows (OF002963320 and OF002859766) are listed twice, this is likely due to an error in the dataset from NIW. **Figure 4-7** shows the Sewage Pumping Station (SPS) overflows and **Figure 4-8** displays the one documented septic tank located in the Larne Lough catchment. **Figure 4-9** documents all private sewerage systems within the catchment area. There are 33 rainfall dependent discharges and one septic tank in total in the Larne Lough catchment.

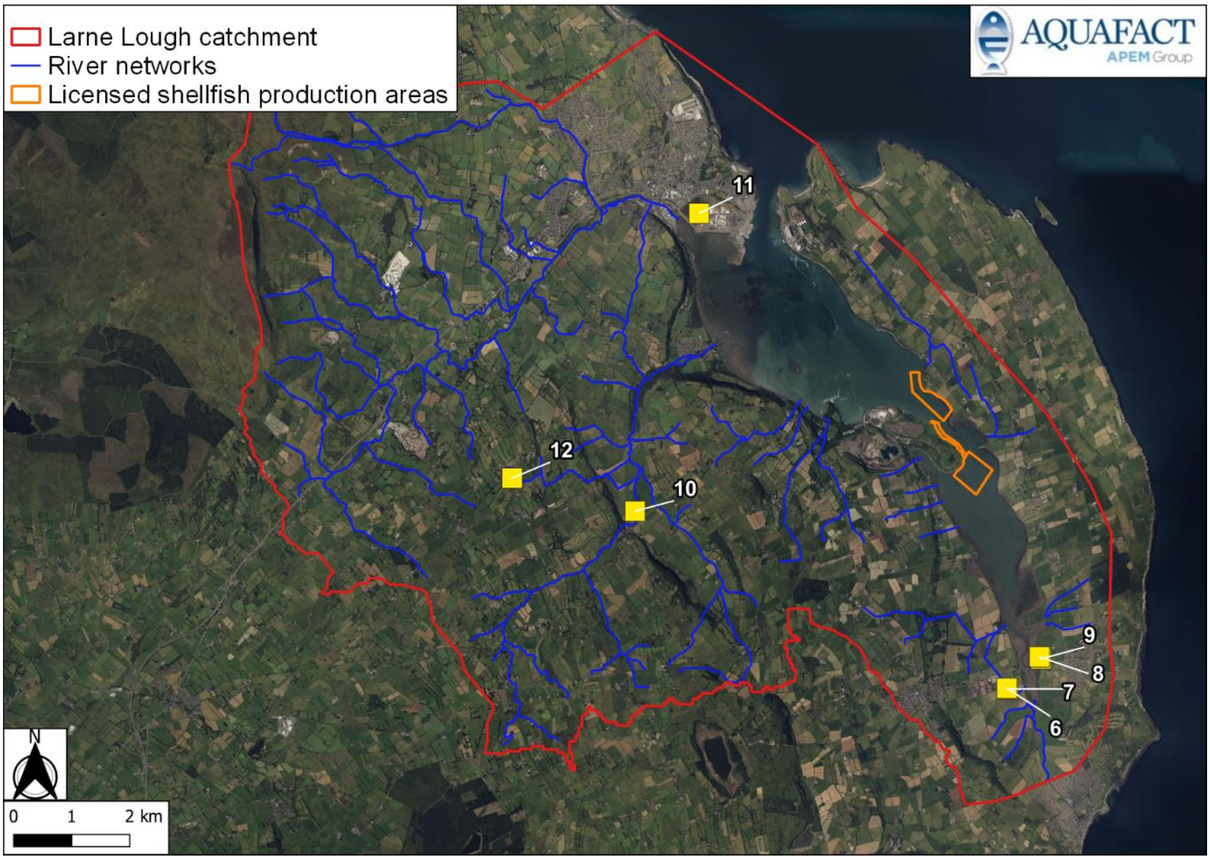

Figure 4-5: Combined sewer overflows (yellow boxes) within the Larne Lough catchment; numbers correspond to map IDs in Table 4.3 (source: NI Water, 2023).

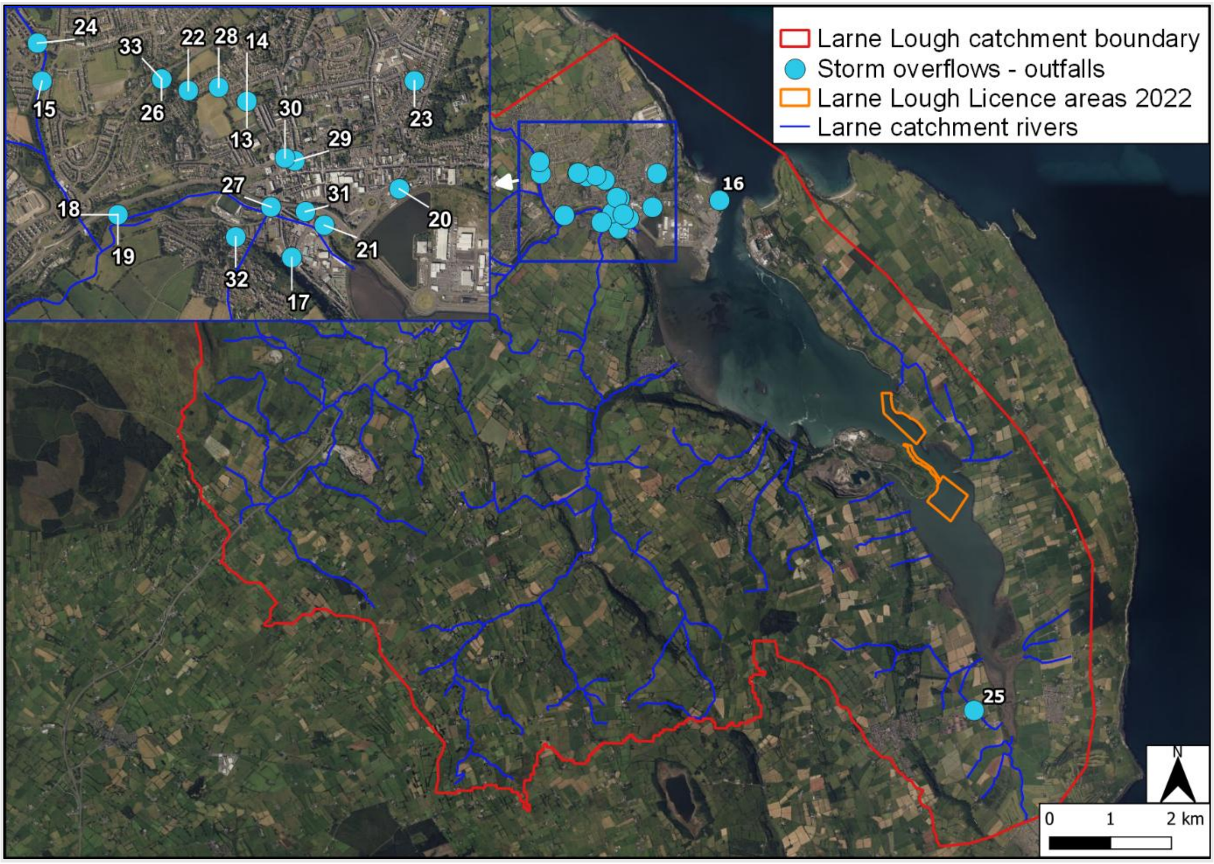

Figure 4-6: All storm water overflow discharges within Larne Lough catchment (source: NI Water, 2023); map IDs correspond to Table 4.3 which details the coordinates of each overflow point.

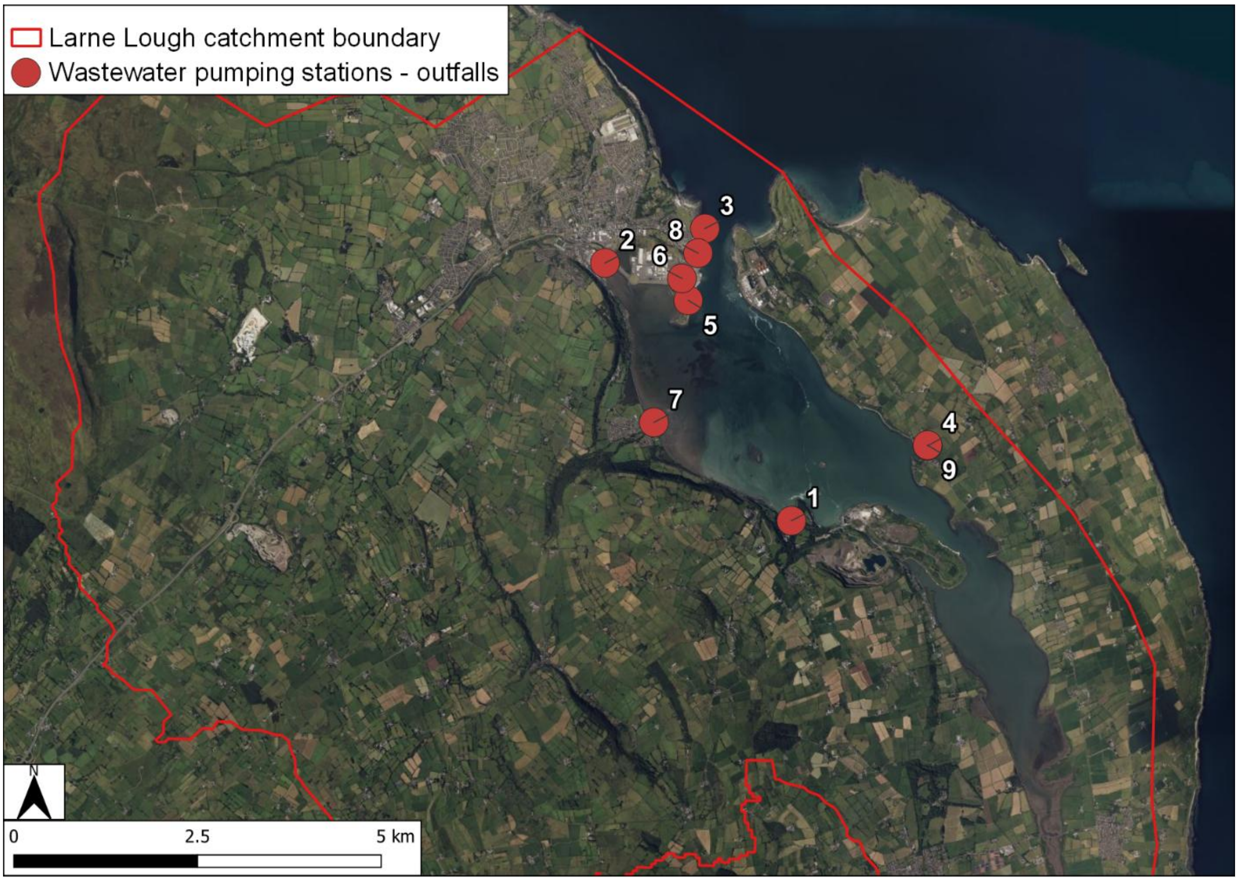

Figure 4-7: All sewage pumping station overflow discharges within Larne Lough catchment (source: NI Water 2023); map IDs correspond to Table 4.4.

Figure 4-8: Septic tank outfall location within the Larne Lough catchment (source: NI Water, 2023), coordinates of which can be found in Table 4.4.

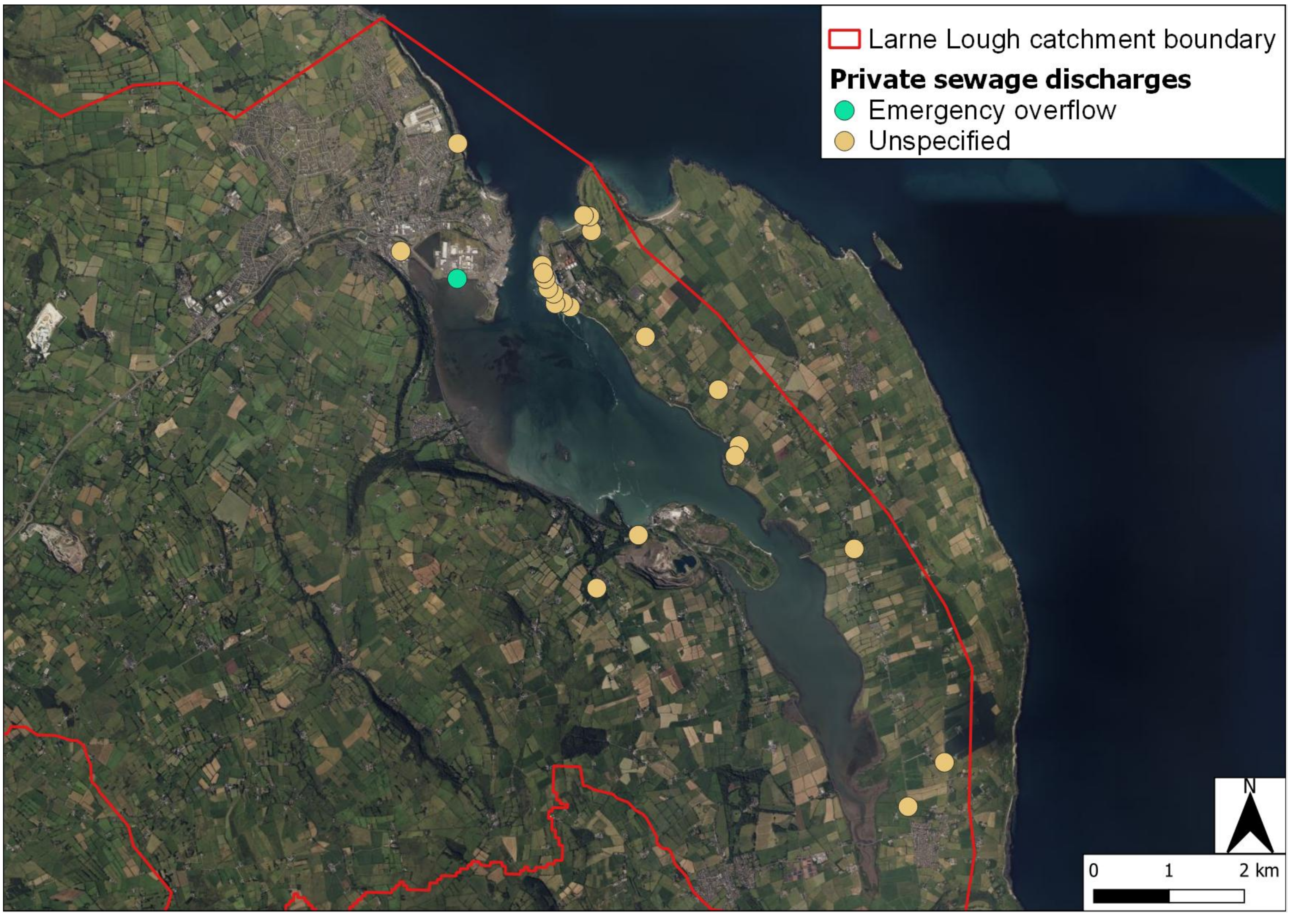

Figure 4-9: All private sewerage systems within the Larne Lough catchment (source: DAERA, 2024).

Table 4.3: Combined sewer overflows and emergency relief overflows within the Larne Lough catchment (source: NI Water, 2023). Map IDs 1-5 correspond to Figure 4-4, map IDs 6-12 correspond with Figure 4-5, and map IDs 13-33 correspond to Figure 4-6.

Map ID	Name	Longitude	Latitude	Easting	Northing	Function
1	Ballycarry/OF002797108	54.7745	-5.7229	346579	394224	WwTW outfall
2	Ballystrudder/OF002055040	54.7795	-5.7213	346665	394779	WwTW outfall
3	Larne/OF002602636	54.8515	-5.7954	341644	402641	WwTW outfall
4	Magheramorne	54.8077	-5.7447	345058	397875	WwTW outfall
5	Mounthill	54.8071	-5.8612	337570	397576	WwTW outfall
6	Ballycarry	54.7746	-5.7292	346174	394225	FA CSO
7	Ballycarry	54.7745	-5.7289	346193	394214	ISPS
8	Ballystrudder	54.7795	-5.7204	346719	394783	FA CSO
9	Ballystrudder*	54.7792	-5.7201	348946	394428	FEPS
10	Glenoe	54.8020	-5.8287	339678	397066	FFT CSO
11	Larne	54.8479	-5.8115	340620	402213	FFT CSO
12	Mounthill	54.8071	-5.8615	337547	397568	FFT CSO
13	OF002963320	54.8547	-5.8256	339690	402941	Storm water overflow
14	OF002963320	54.8547	5.8256	339690	402941	Storm water overflow
15	OF002058723	54.8557	-5.8420	338637	403012	Storm water overflow
16	OF002058230	54.8517	-5.7964	341580	402665	Storm water overflow
17	OF002963312	54.8475	-5.8221	339945	402150	Storm water overflow
18	OF002859766	54.8495	-5.8359	339047	402341	Storm water overflow
19	OF002859766	54.8495	-5.8359	339047	402341	Storm water overflow
20	OF002963498	54.8507	-5.8135	340485	402518	Storm water overflow
21	OF002060068	54.8490	-5.8195	340107	402320	Storm water overflow

Map ID	Name	Longitude	Latitude	Easting	Northing	Function
22	OF002963580	54.8552	-5.8303	339388	402987	Storm water overflow
23	OF002059744	54.8557	-5.8122	340545	403073	Storm water overflow
24	OF002059944	54.8574	-5.8424	338608	403206	Storm water overflow
25	OF002055042	54.7767	-5.7314	346021	394449	Storm water overflow
26	OF002058695	54.8557	-5.8325	339249	403042	Storm water overflow
27	OF002060082	54.8499	-5.8237	339830	402405	Storm water overflow
28	OF003240119	54.8554	-5.8279	339543	403009	Storm water overflow
29	OF003239953	54.8520	-5.8218	339945	402645	Storm water overflow
30	OF002963316	54.8521	-5.8226	339894	402658	Storm water overflow
31	OF003465661	54.8497	-5.8210	340008	402387	Storm water overflow
32	OF002058517	54.8485	-5.8266	339654	402246	Storm water overflow
33	OF004478178	54.8557	-5.8324	339250	403042	Storm water overflow

* Coordinates for this CSO relate to the outfall location rather than that of the asset itself.

Table 4.4: Pumping station and septic tank overflow coordinates within the Larne Lough catchment (source: NIW); map IDs 1-9 correspond to Figure 4-7.

Name/Map ID	Longitude	Latitude	Easting	Northing
1	54.8161	-5.7781	342881	398740
2	54.8475	-5.8175	340237	402156
3	54.8517	-5.7964	341580	402665
4	54.8252	-5.7493	344700	399815
5	54.8430	-5.7999	341384	401684
6	54.8456	-5.8013	341288	401979
7	54.8281	-5.8072	340969	400016
8	54.8487	-5.7978	341497	402328
9	54.8253	-5.7493	344699	399825
Unnamed septic tank overflow	54.8463	-5.7888	342087	402078

4.1.4. Industrial Discharges

Figure 4-10 shows the industrial discharges within the Larne Lough catchment accounted for during the desk-based assessment. In total, there are 20 industrial discharges within the catchment area. Site drainage accounts for 13 of these discharges with inert waste disposal accounting for a further three. There are also two fish farm food processing discharges and one vehicle washing site. The Ballylumford Power Station, located on the eastern side of the mouth of Larne Lough, was the only industrial discharge of note included in the 2015 review. NIEA issued a variation notice (no. P0125/06A/V4) in 2021 regarding a permit for the Ballylumford Power Station to comply with the Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2013. Based on data from this variation document, there will be no emissions to sewers from the power station. Any emissions to water, excluding that to sewers, are discharged from specific emission release points as detailed in the variation, none of which relate to *E. coli* contamination. Additionally, emissions to groundwater are governed by the Groundwater (Amendment) Regulations (Northern Ireland) 2016, therefore preventing the discharge of pollutants to groundwater. Recent data from DAERA (Department of Agriculture, Environment and Rural Affairs) provided information on three septic tanks and a sewage treatment plant associated with the power station, all of which have not been sampled.

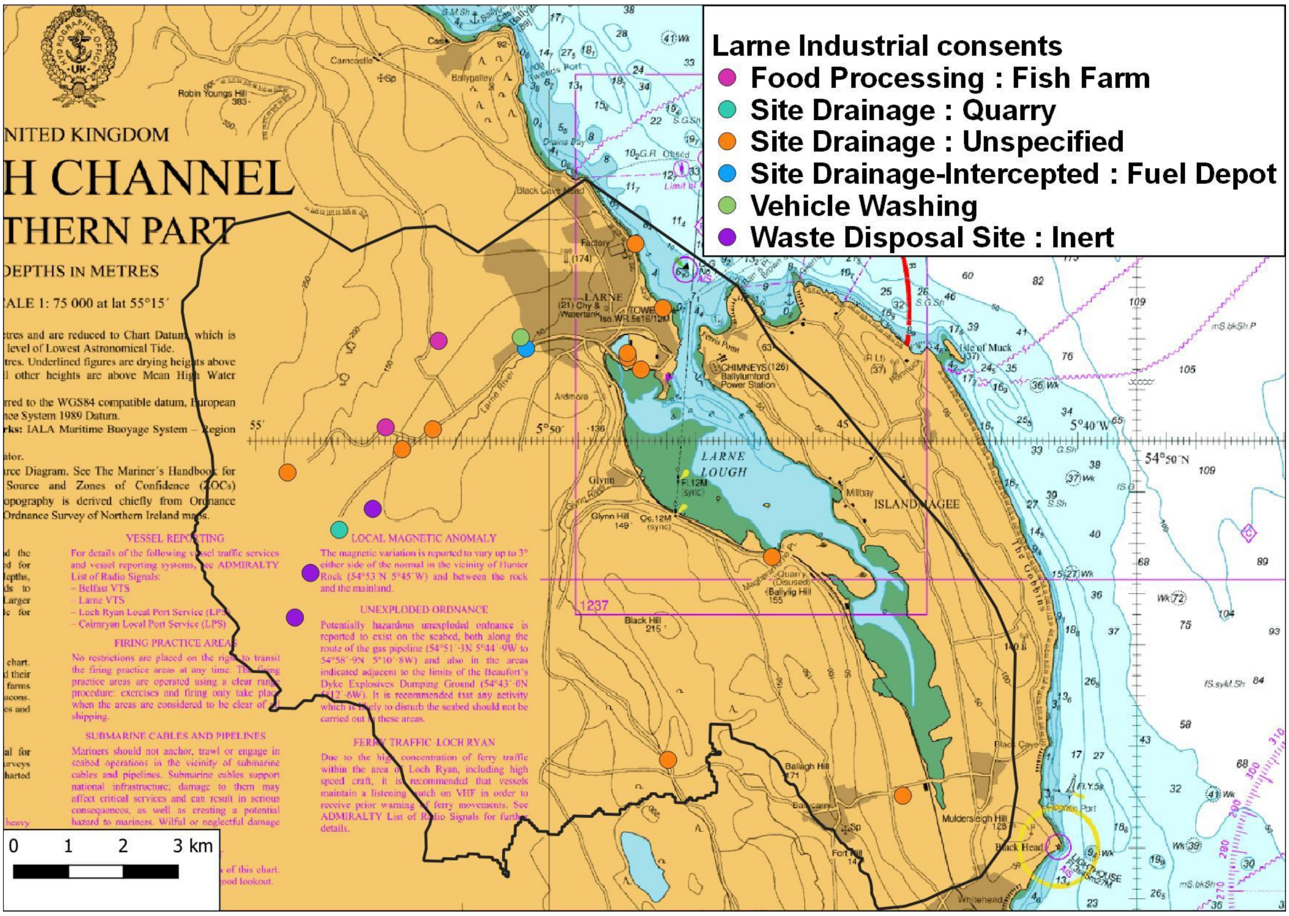

Figure 4-10: All industrial discharges within Larne Lough catchment (source: NIEA water information request viewer - Accessed 2024).

4.1.5. Land use Discharges

In the early 1980s, the need for a harmonized land cover and use dataset for Europe was identified. National maps were inconsistent, complicating environmental monitoring. To address this, the Commission launched the 'Coordination of Information on the Environment' (CORINE) programme to create standardized land cover, biotope, and air quality maps. The first CORINE Land Cover dataset was produced in 1990 and has since been a key part of the European Environment Agency's Copernicus Land Monitoring Service, providing crucial land cover/use information for over three decades.

Figure 4-11 shows the CORINE land use within Larne Lough catchment for 2018. Corine land use was not included in the 2015 review. The dominant land use type in the catchment is pastures (78.24%, 9,203 ha), followed by discontinuous urban fabric (5.28%, 621 ha), and natural grassland (5.02%, 591 ha). Forestry (coniferous and broad-leafed) accounts for 3.28% (386 ha) of the land use. Land associated with agricultural activities (non-irrigated arable land, pastures, natural grasslands, and agriculture/natural vegetation) accounts for 85.32% (10,035 ha) of the land use in the area; all data is sourced from CORINE 2018.

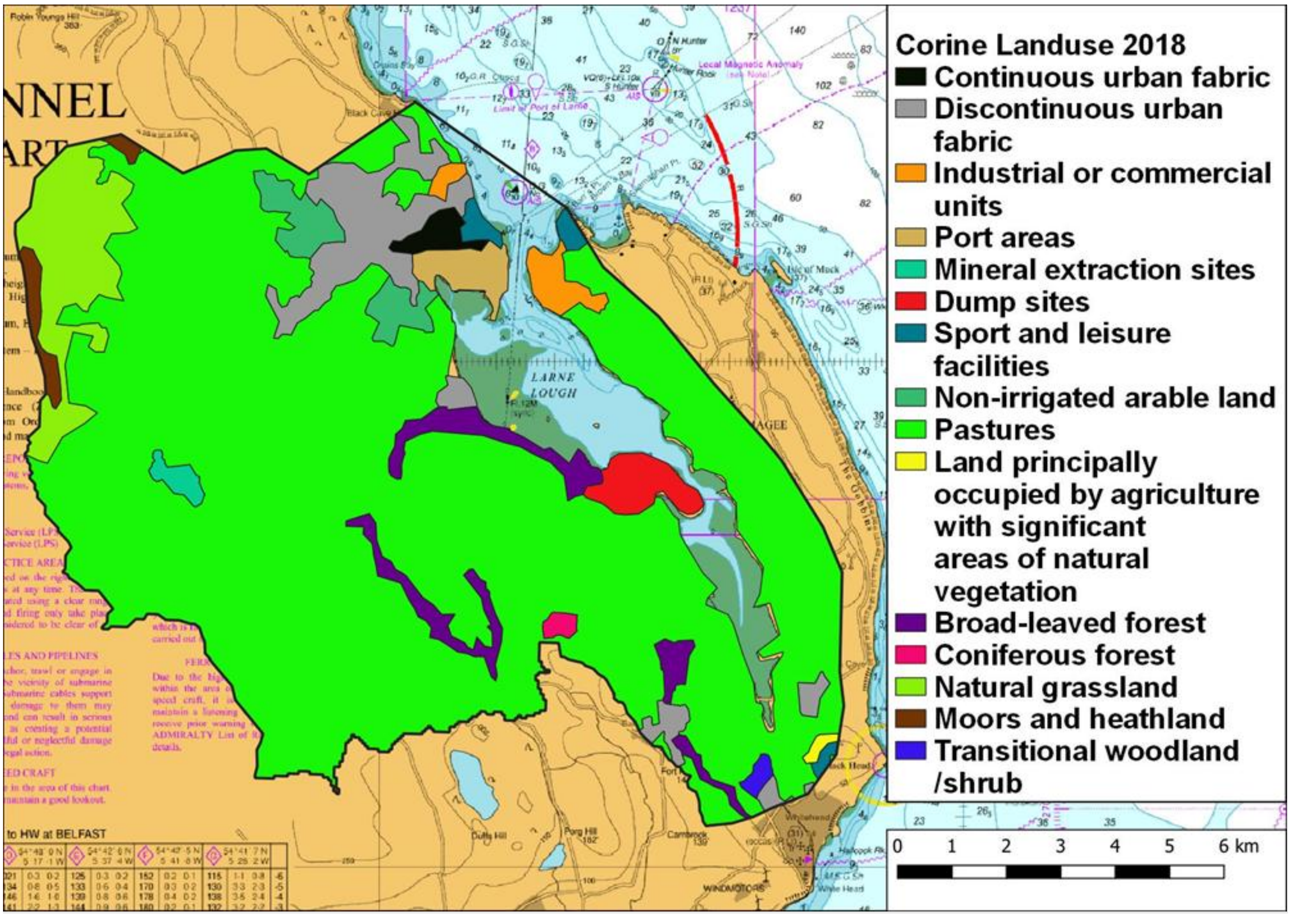

Figure 4-11: CORINE land use within the Larne Lough catchment (source: CORINE, 2018).

Agricultural data is organised by wards for Northern Ireland for 2015 and 2018. The change in agricultural intensity can be seen in **Figure 4-12** to **Figure 4-19**. There has been a slight decrease in the number of farms along the eastern shore and a slight increase along the western shore. The area farmed has increased along the eastern shore and in the northwest of the catchment. While the remainder of the catchment has remained the same or decreased overall; there has been a minor decrease of 0.2%.

Tillage production has increased in the northwest of the catchment but decreased elsewhere. The general change has been a decrease in crops of 3.7%. The farmed area used for grass has increased slightly in most of the land bordering the lough. Overall, there has been an increase in area used for grass within the west and southeast of the catchment area (**Figure 4-15**).

The number of cattle has increased along the eastern shore and in the northwest of the catchment and decreased elsewhere. There has been an increase in cattle numbers of 1.6% since 2015 (**Figure 4-16**). There has been a decrease in the number of sheep in the areas bordering the lough and an increase elsewhere. Overall, the number of sheep has changed little with a 0.2% increase (**Figure 4-17**). There has been a large increase in the number of pigs in the northwest of the catchment and a smaller increase along the western shore. Overall, the number of pigs in the catchment has doubled with an increase of 117.2% (**Figure 4-18**). Poultry numbers have increased along the western shore and decreased elsewhere. The total number of poultry has decreased by 5.4% (**Figure 4-19**). There will be an increase in faecal load from the increased numbers of cattle, sheep, and, in particular, pigs. Considering the decrease in poultry numbers the overall change in daily *E. coli* load will be an increase of approximately 2.7%; see **Table 4.5** for the estimated daily load from each type of livestock.

Table 4.5: Potential daily loading of *E. coli* (Jones & White, 1984).

Source	Faecal Production (g/day)	Average Number (*E. coli*/g)	Daily Load (*E. coli/g*)	Rank
Man	150	13×10^6	1.9×10^9	5
Cow	23600	0.23×10^6	5.4×10^9	3
Sheep	1130	16×10^6	18.1×10^9	1
Chicken	182	1.3×10^6	0.24×10^9	6
Pig	2700	3.3×10^6	8.9×10^9	2
Gull	15.3	131.2×10^6	2×10^9	4

Several studies have reported a strong association between intensive livestock farming areas and faecal indicator concentrations of microorganisms in streams and coastal waters. This has been due to run-off from manure, especially during high flow conditions, both from point and non-point sources of contamination (Crowther *et al.,* 2002).

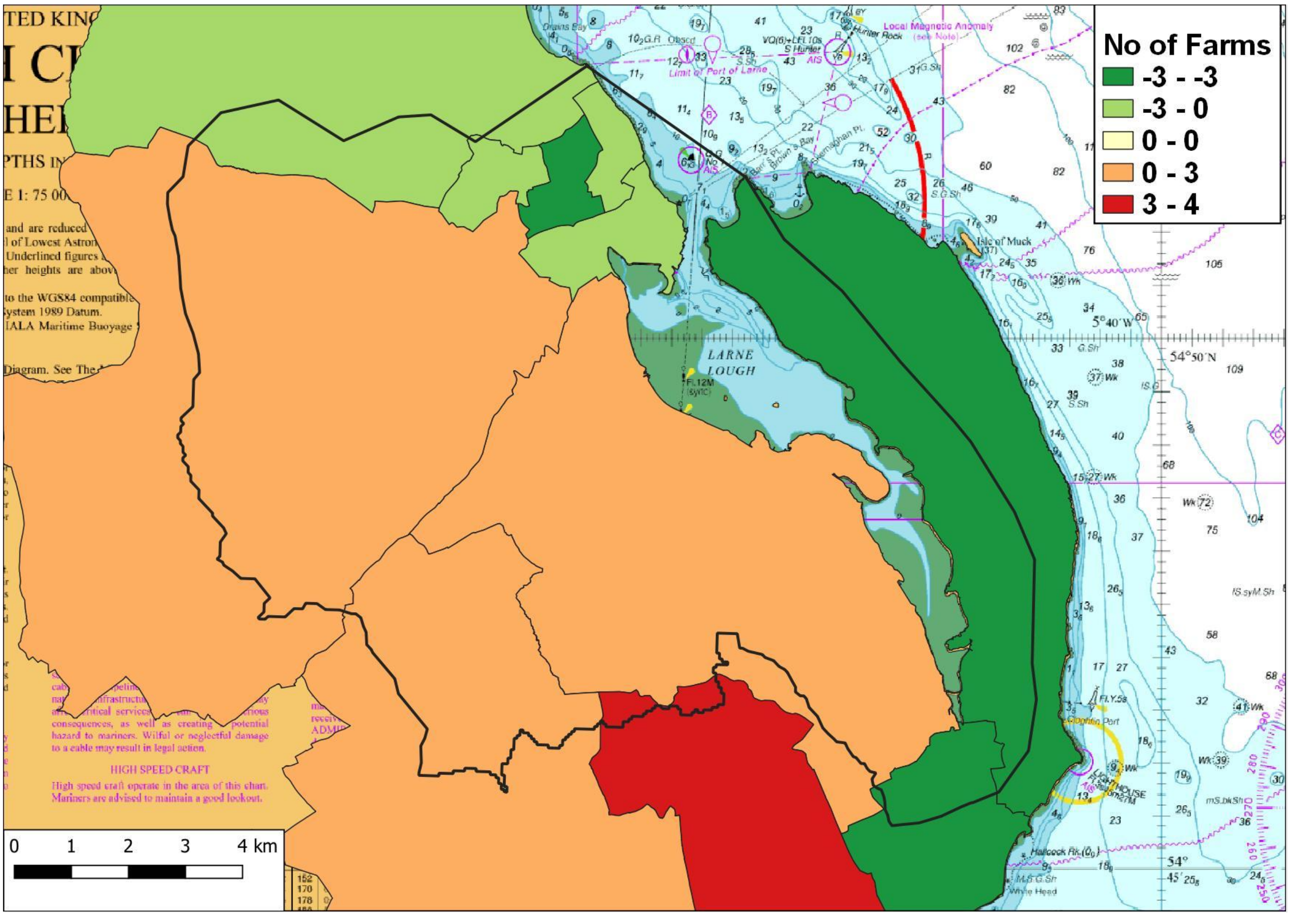

Figure 4-12: Change in number of farms within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

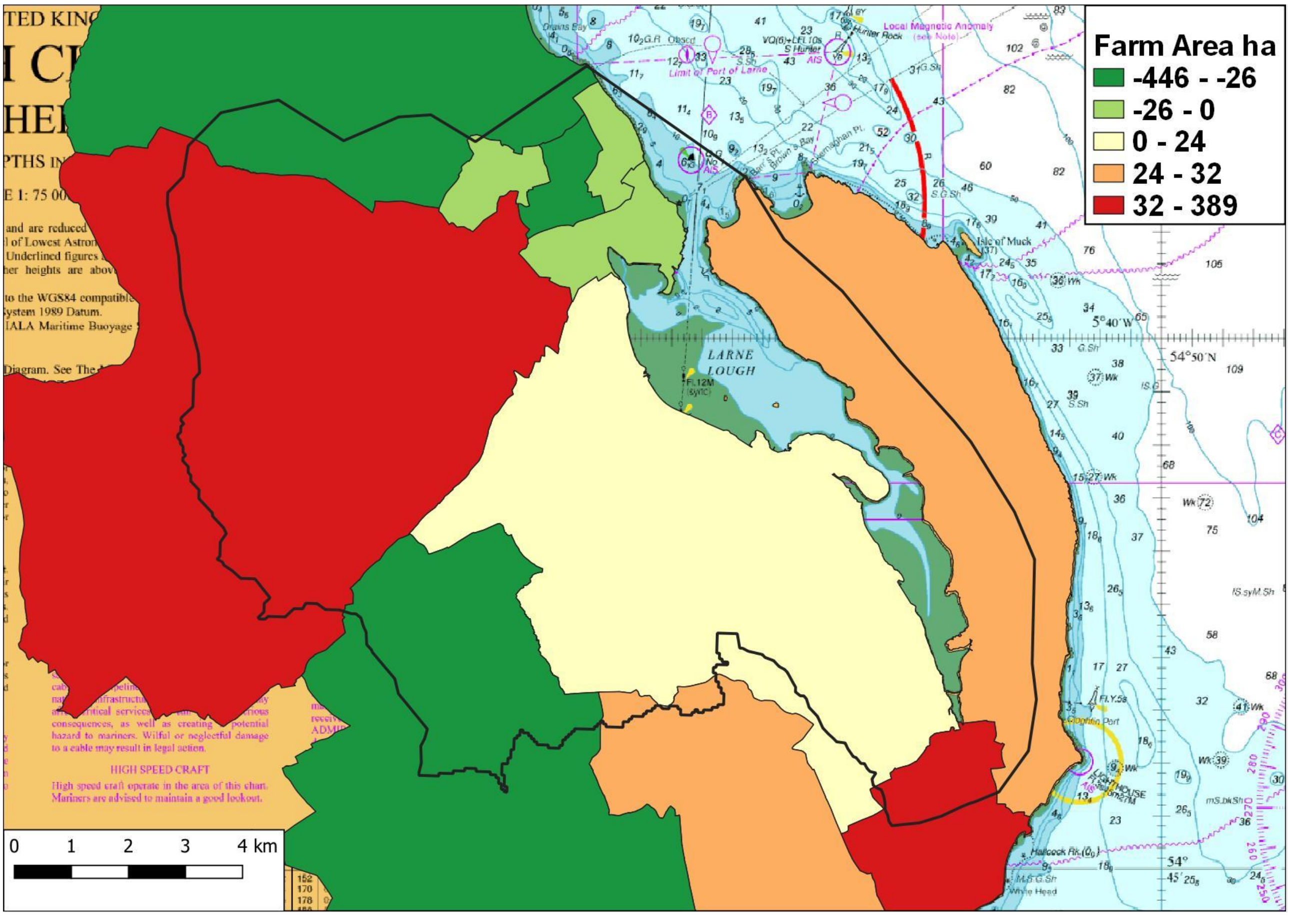

Figure 4-13: Change in area farmed (ha) within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

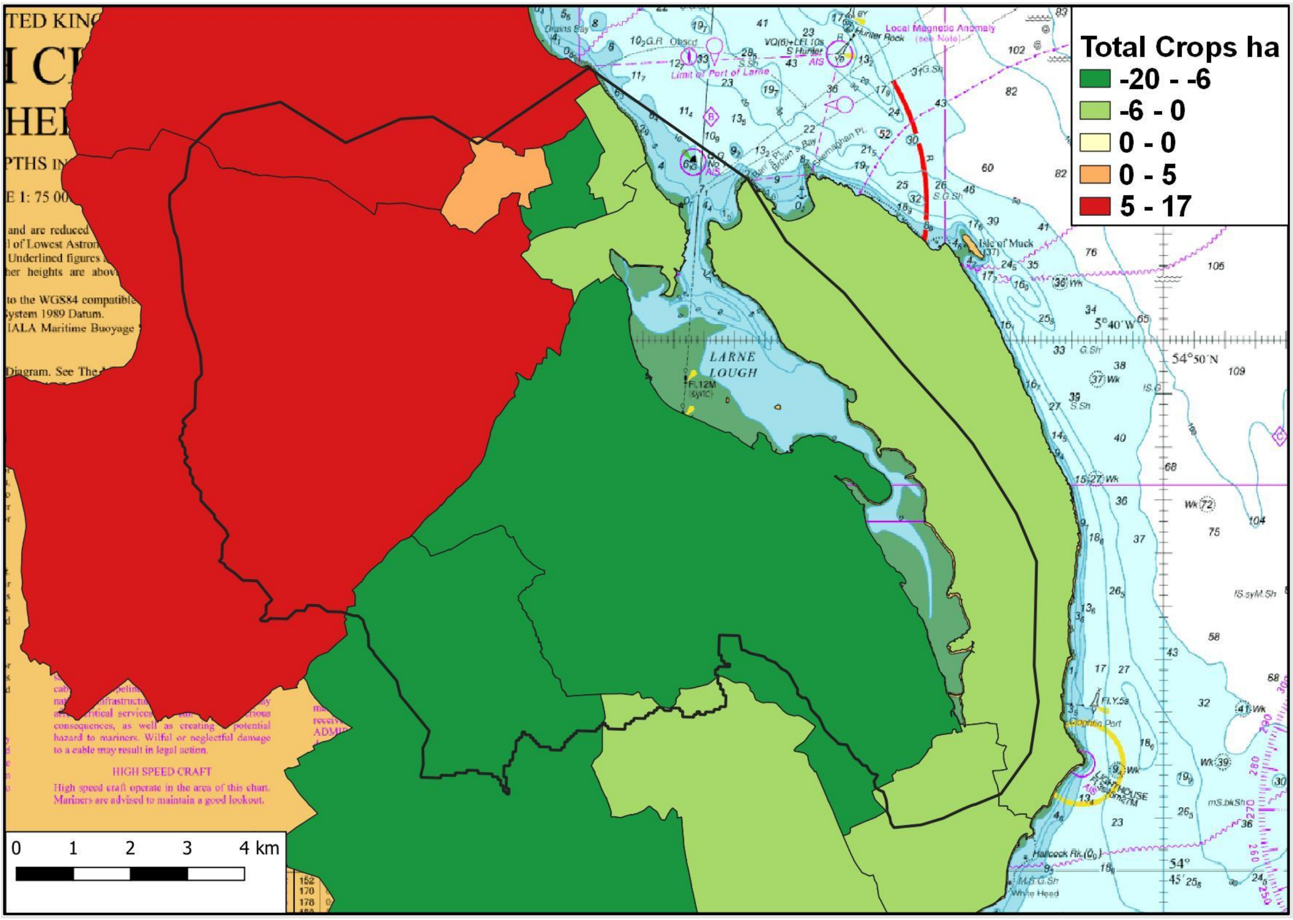

Figure 4-14: Change in total crops within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

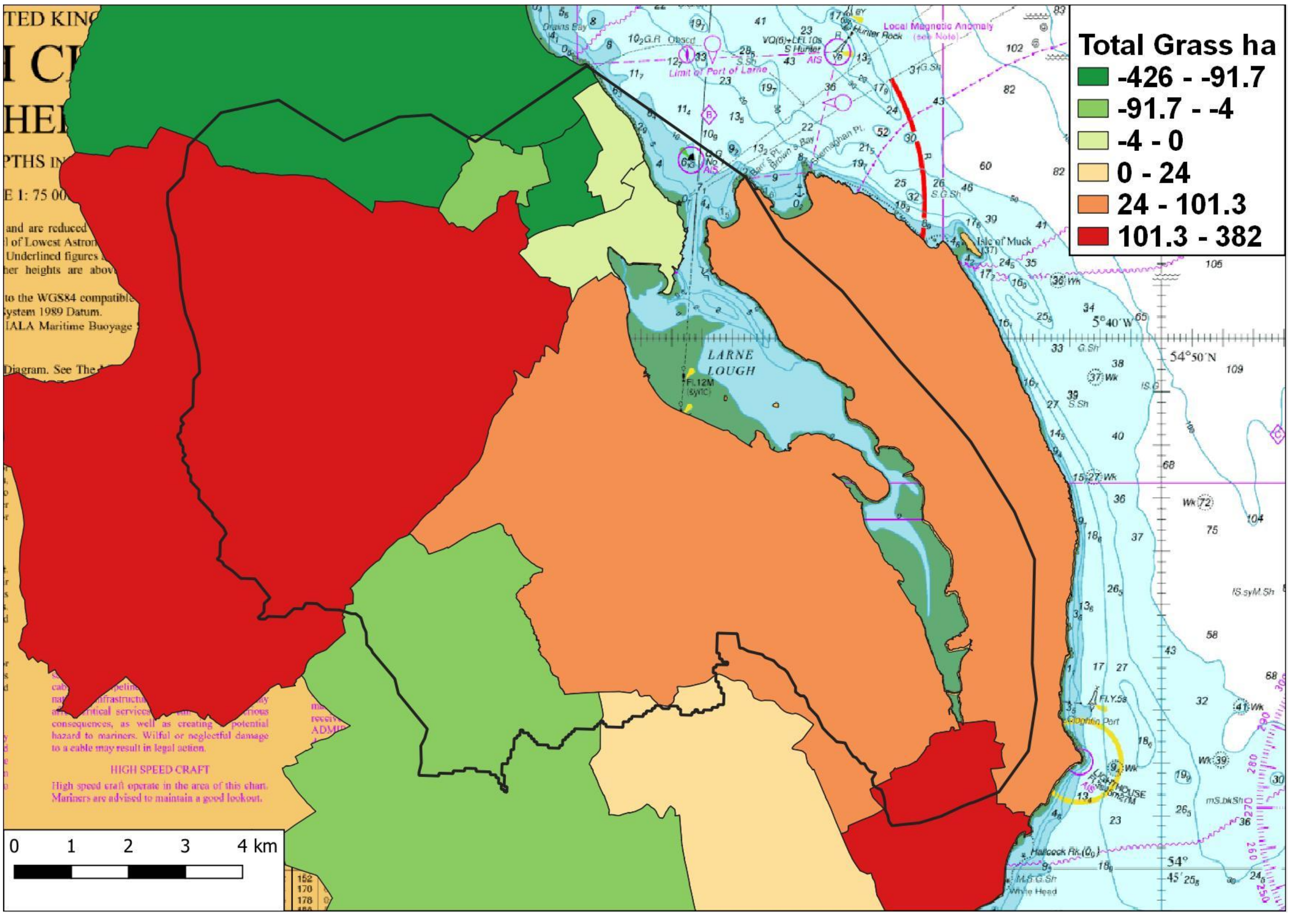

Figure 4-15: Change in total grass lands within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

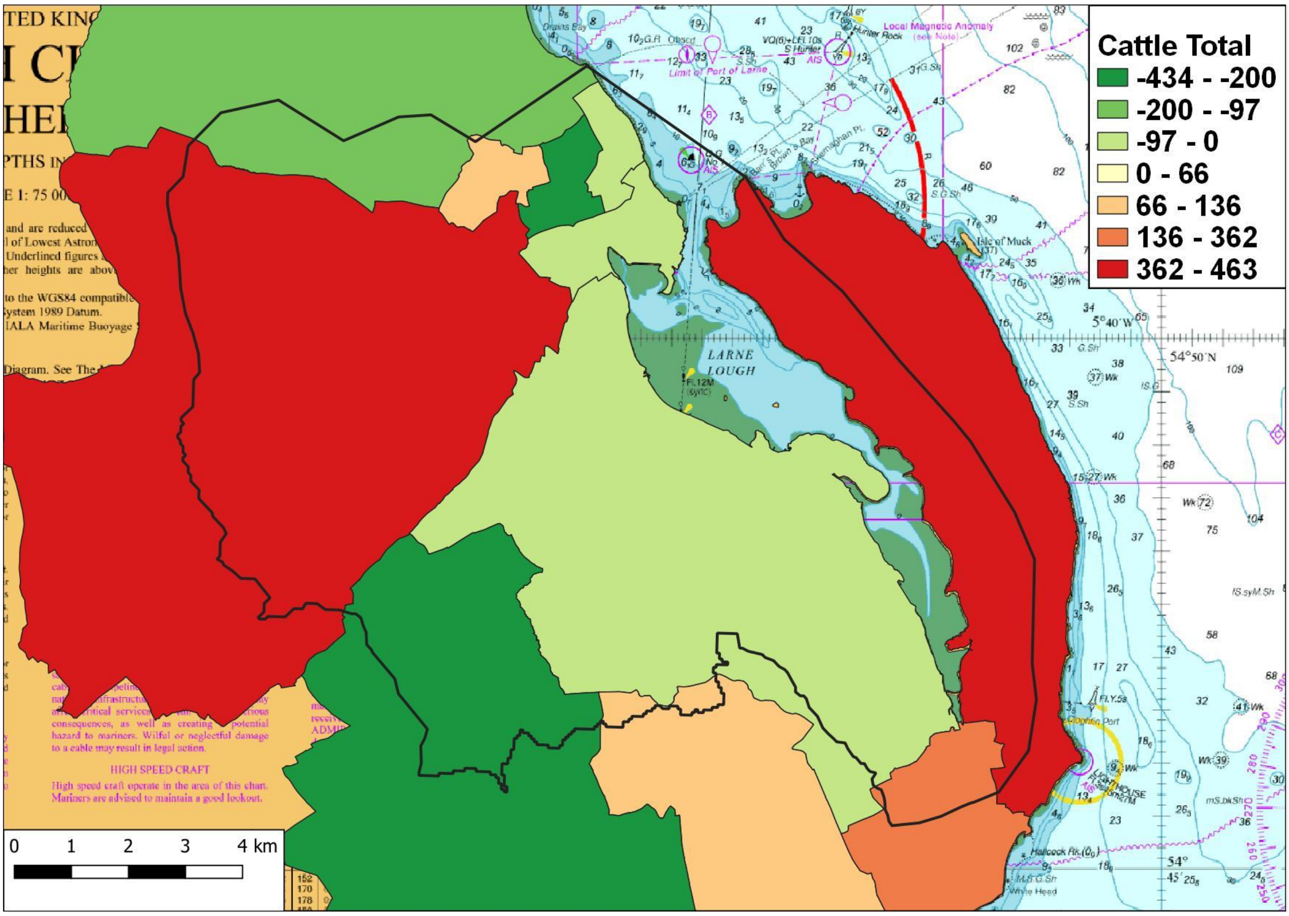

Figure 4-16: Change in cattle numbers within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

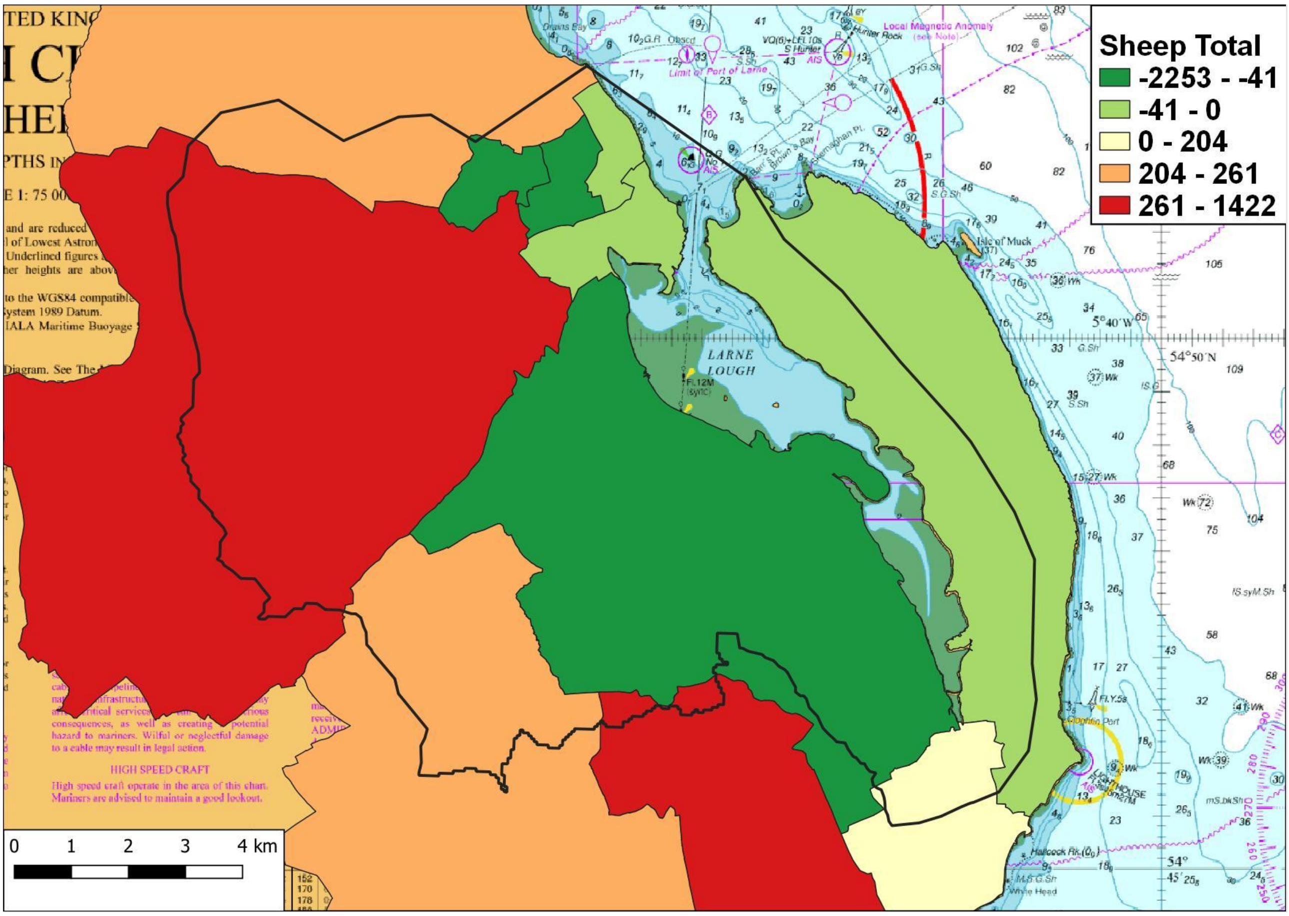

Figure 4-17: Change in sheep numbers within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

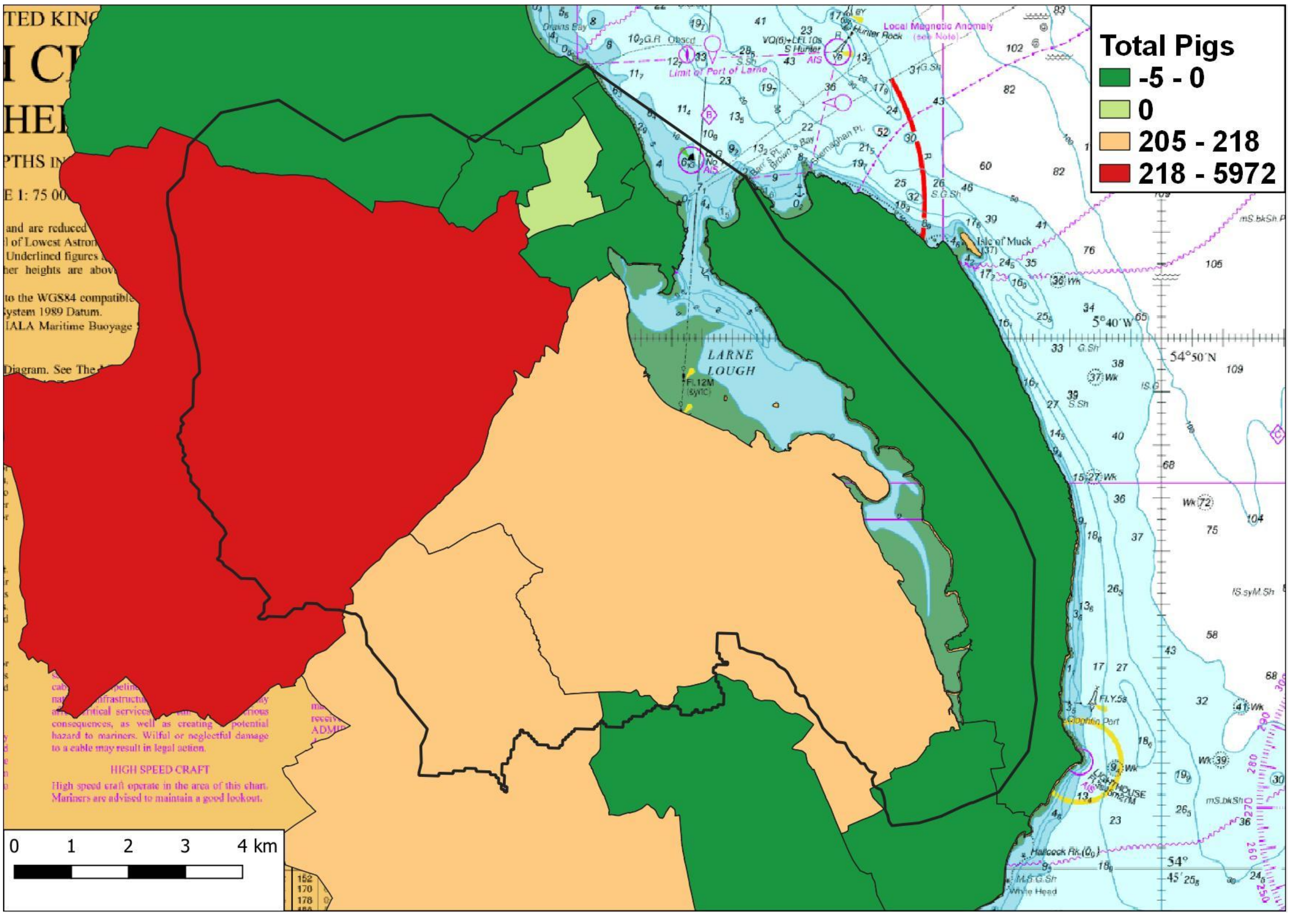

Figure 4-18: Change in pig numbers within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

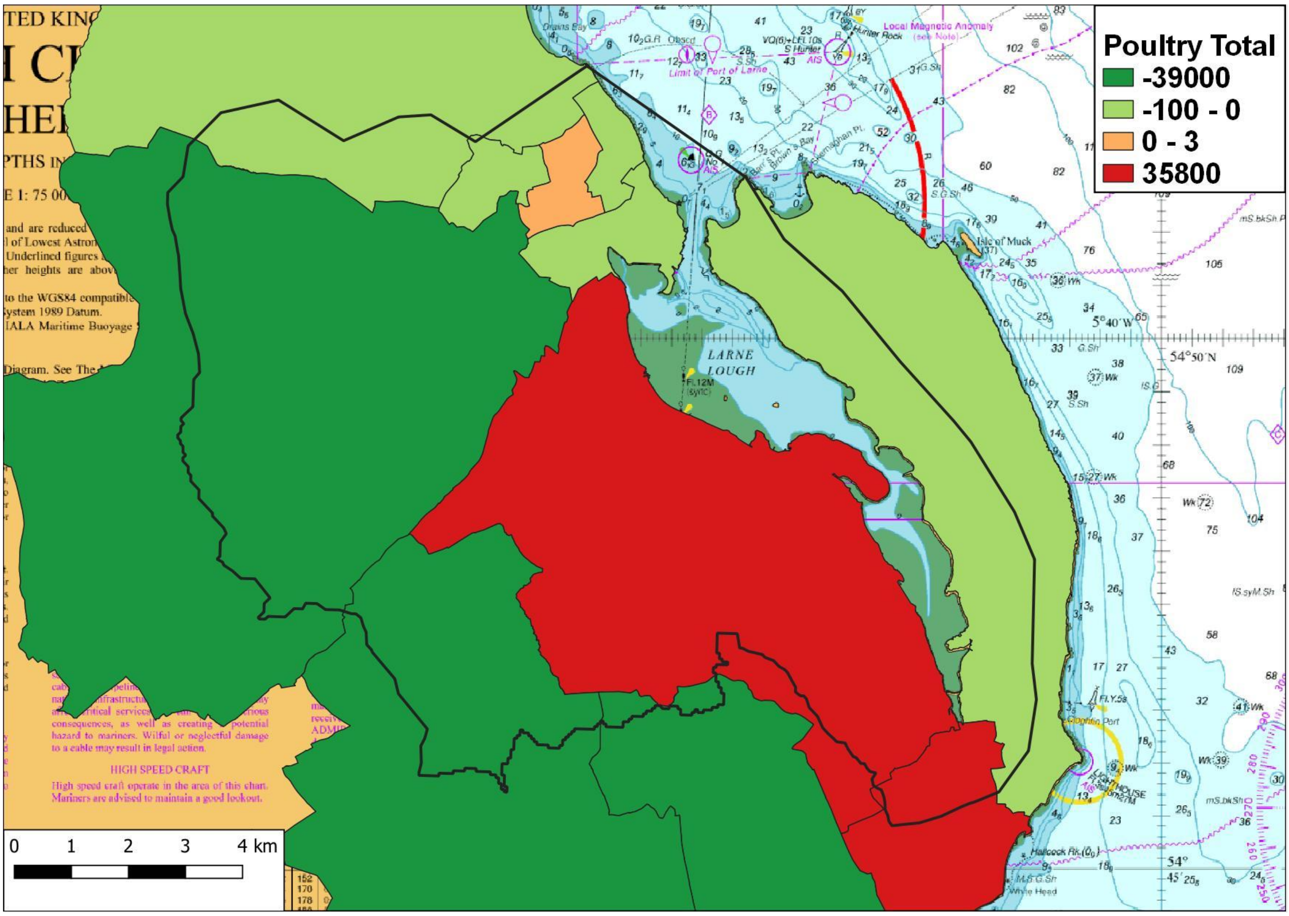

Figure 4-19: Change in poultry numbers within Larne Lough catchment between 2015 and 2018 (source: DAERA, 2015 & 2018).

4.1.6. Other Pollution Sources

4.1.6.1. Shipping

Operational waste from vessels, if not properly managed, may end up in the sea where the potential for contamination or pollution occurs. Wastes generated or landed in ports and harbours can be broadly divided into a) operational and domestic waste from ships and boats, b) waste from commercial cargo activities, and c) wastes generated from maintenance activities and associated maritime industry activities.

Marpol Annex IV defines sewage as waste “drainage from medical premises, toilets, urinals, spaces containing live animals and other wastewaters when mixed with sewage waste streams”. Although adopted in 1973, the Annex did not come into effect until September 2003, with subsequent amendments entered into force in August 2005. Annex IV requires ships to be equipped with either a sewage treatment plant, a sewage disinfecting system or a sewage holding tank. Within three miles of the shore, Annex IV requires that sewage discharges be treated by a certified Marine Sanitation Device (MSD) prior to discharging into the ocean. Sewage discharges made between three and 12 miles from the shore must be treated by no less than maceration and chlorination, and sewage discharged greater than 12 miles from shore is unrestricted. Annex IV also established certain sewerage reception facility standards and responsibilities for ports and contracting parties.

Ship sewage originates from water-borne human waste, wastewaters generated in preparing food, washing dishes, laundries, showers, toilets and medical facilities. However, as waste enters the lough environment from many sources, it makes the identification of specific impacts from ship/boat waste very difficult. It is widely recognised that most of the pollution entering the marine environment comes from land-based sources and atmospheric inputs from land-based industrial activities, with only an estimated 12% originating from shipping activities (GESAMP [Joint Group of Experts on the Scientific Aspects of Marine environmental Pollution], 1990).

Figure 4-20 shows all boat facilities and activities in Larne Lough. The only commercial port in the lough is Larne port which has five cargo berths. The port has been dredged, and depths can vary from 5.7 to 7.1 m. Larne Port handles over 200,000 freight units per year and >521,000 passengers traverse the port annually. Over the 12 months leading up to March 2022, an estimated total tonnage of 29 million tonnes passed through the major ports of Northern Ireland, an increase of 9.1% compared to the same period during the previous year (NISRA, 2022). The Port of Larne accounted for 11.8% of the total tonnage in 2022. The tonnage of goods has increased moderately from 2,559,000 tonnes in 2015 to 2,727,000 tonnes in 2020 (NISRA, 2022). Jet skis were observed ashore in the 2015 Sanitary Survey Review; the 2021 Recreational Craft Guidelines for Larne Port state that jet skis are not permitted in the inner port or main navigational channel.

Waste is collected from ships upon request, however, no reference to sewage discharges or how this type of waste is managed was reported upon in the Environmental Guidance for Ports and Harbours (DAERA, 2017). While data on sewage discharge levels from shipping activities in Larne Lough are not available, it is highly likely that discharging could occur within the lough. The effect is likely to be the greatest in enclosed areas and shallow water with little or no tidal flow in the summer and autumn when temperatures are at their highest, coinciding with the peak of the boating season. However, it is also likely that these levels are very low compared with land-based discharges.

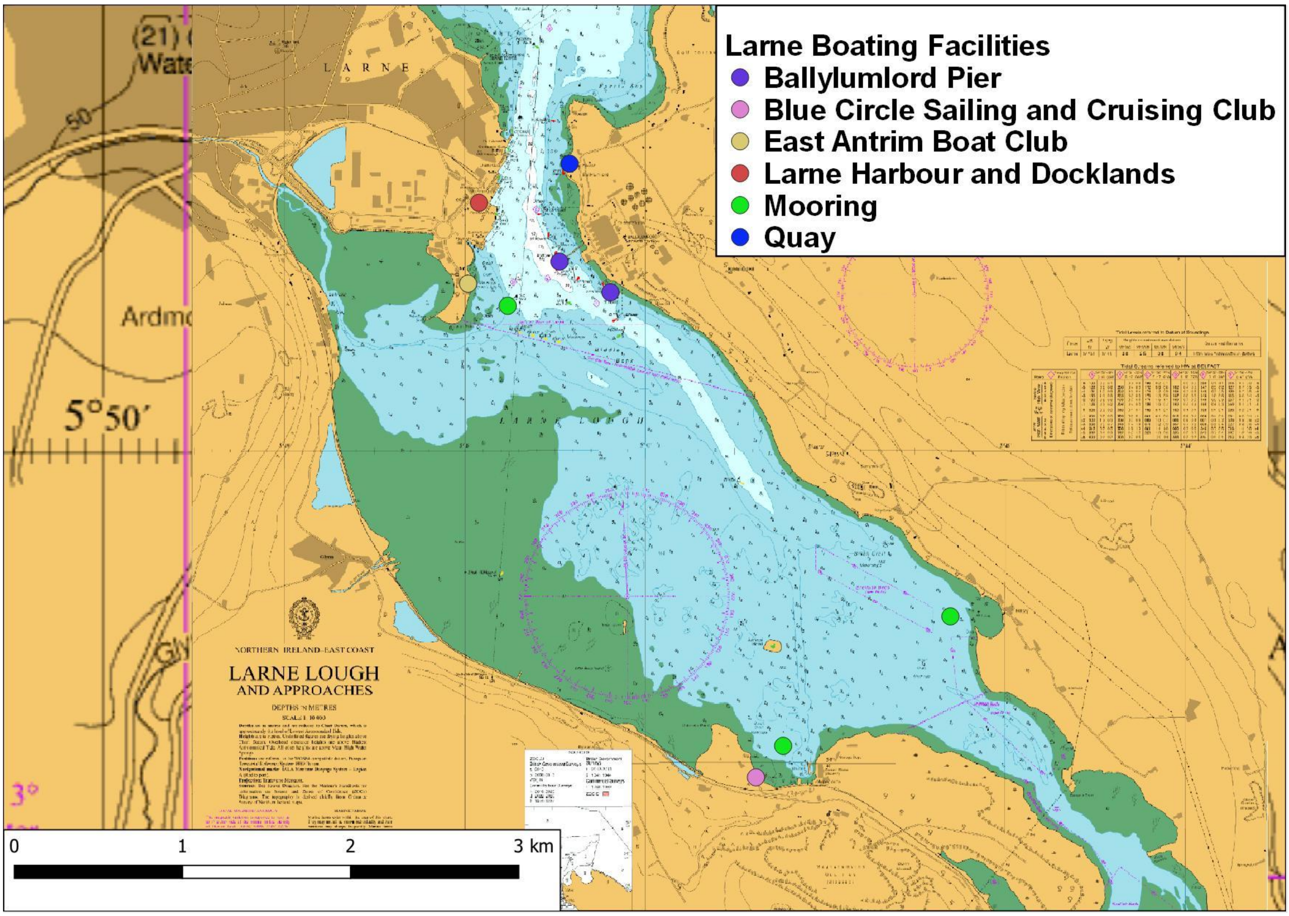

Figure 4-20: Location of all boating facilities and activities in Larne Lough (NISRA, 2022).

4.1.6.2. Birds

It is important to document the bird populations in the Larne Lough area as bird faeces are rich in faecal bacteria (Oshira & Fujioka, 1995) and have been shown to be a source of faecal contamination in the marine environment (Jones *et al.,* 1978; Standridge *et al.,* 1979; Levesque *et al.,* 1993; Alderisio & DeLuca 1999; Levesque *et al.,* 2000; Ishii *et al.,* 2007).

Larne Lough SPA, Area of Special Scientific Interest (ASSI) and Ramsar site all share the same boundary extent of 398 ha. In comparison, the total extent of Larne Lough is estimated to be 8 km^2 (*c*. 800 ha) (Ferreira *et al*. 2007). Larne Lough SPA is also partially comprised of Swan Island SPA which has become part of the boundary since 2015 (Larne Lough SPA Conservation Objectives). Larne Lough SPA is designated for breeding colonies of roseate, sandwich terns, common terns, and the wintering population of Light-bellied Brent Goose (Larne Lough SPA Conservation Objectives). However, numerous other species of waterbird occur in the vicinity of Larne Lough, such as shelduck, little grebe, redshank, and grey heron, to name but a few (**Table 4.6**). **Figure 4-21** shows the locations of the Larne Lough marine protected areas. Larne Lough is routinely surveyed by the British Trust for Ornithology (BTO) through the WeBS (Wetland Bird Survey) Project (Frost *et al.,* 2020). **Table 4.6** shows 5-year data used from 2002/3-2006/7 and the most recent 5-year set of data (2015/16-2019/20). The 5-year average has decreased slightly from 4,999 to 3,928 for the most recent 5-year period.

Table 4.6: Total number of water birds in Larne Lough from 2002/03 to 2006/07 and 2015/16 to 2019/20 (source: Woodward *et al.*, 2024).

Site Name	2002/03	2003/04	2004/05	2005/06	2006/07	5-year Mean
Larne Lough	5,046	5,302	4,992	5,548	4,109	4,999
Site Name	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**5-year Mean**
Larne Lough	3,496	4,615	3,840	3,605	4,086	3,928

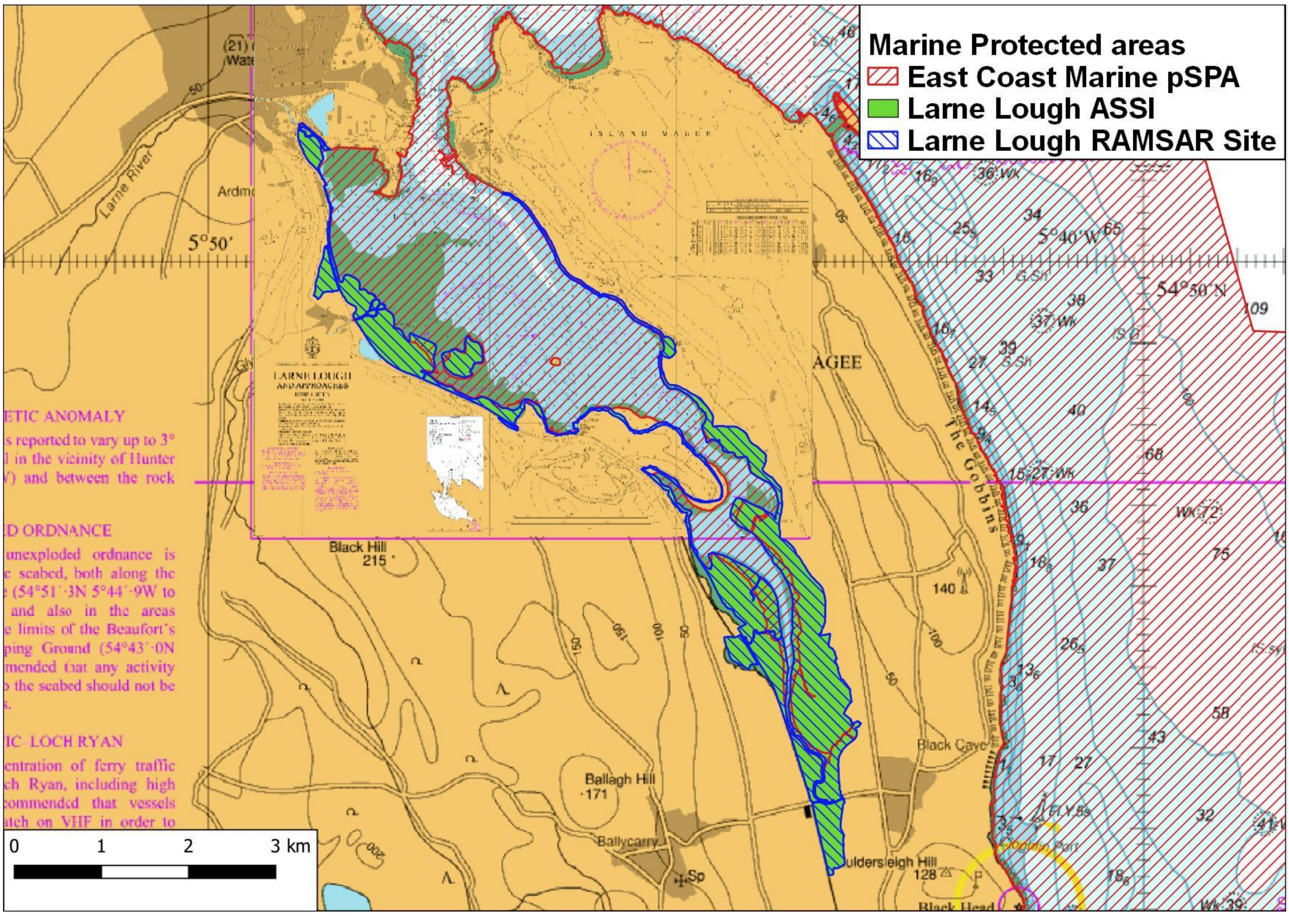

Figure 4-21: Larne Lough marine protected areas (source: DAERA, 2023).

Bird populations in the Larne Lough area are typically higher in early winter and late spring due to migratory events. Bird numbers are generally higher in mid-winter than spring and summer as the local birds tend to move off-site in the summer months to breed. Therefore, it is probable that the contribution made by wildfowl to microbial pollution levels in Larne Lough is higher in the winter months. However, it is likely that these levels are low when compared with land-based discharges.

5. Shellfish and Water Sampling

5.1. Historical Data

5.1.1. Shellfish Water Quality

DAERA Water Management Unit monitors a number of shellfish growing waters around the Northern Irish coastline as part of the WFD. The 2018 WFD classification for Larne Lough was ‘moderate’.

5.1.2. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and its subsequent Implementing Regulation (EU) 2019/627, the FSA, as the competent authority, shall fix the location and boundaries of the production and relaying areas that they classify. Currently the FSA classify all of the DAERA licensed sites. The FSA shall classify production and relaying areas from which they authorise the harvesting of live bivalve molluscs as Class A, Class B, and Class C areas according to the level of faecal contamination *i.e., E. coli*; **Table 5.1** summaries the classification system. An A classification allows for the shellfish product to be placed directly on the market, whereas a Class B shellfish can be supplied for human consumption after one of three processes:

- Purification in an approved establishment.
- Relaying for at least one month in a Class A relaying area.
- An approved heat treatment process.

Class C shellfish can only be sold for human consumption after completing one of the following three possible processes:

- Relaying for at least two months in an approved Class B relaying area followed by treatment in an approved purification centre.
- Relaying for at least two months in an approved Class A relaying area.
- After an approved heat treatment process.

The FSA NI monitor shellfish flesh in Larne Lough for microbiological contamination monthly and these results are reviewed annually to determine the classification awarded. New annual classifications may be awarded to an area after a full 12 months of routine monthly monitoring and where results allow for annual A, B or C classifications to be awarded for a 12-month period. The FSA reviews all existing classifications annually, using the one- and three-year dataset, as per EU guidance, to determine the annual classification to be awarded. It also analyses monitoring data throughout the year, which can result in changes to classification being notified via interim updates as necessary. The 2009 sanitary survey report identified seven classified fisheries operating within five shellfish beds. Cultivated species included native and Pacific oysters, manila and native clams, and common mussels. Common mussels and clams were grown using bottom culture techniques, with oysters grown on trestles on the lower intertidal area. As stated in the 2015 Sanitary Survey Report, the licensed shellfish sites included Mill Bay (L5) mussels and oysters and Island Shellfish (L1) clams, however following publication of the 2015 Sanitary Survey Report the clam site was declassified by the FSA. L3 was classified in 2015 under a B classification. According to the 2022 NI Shellfish Classification List (V18_0), the licensed areas within Larne Lough that were classified at that time (effective from 2020) were L3 oysters and L5 mussels and oysters. Larne Lough has maintained a **B** classification; **Table 5.3** shows the current and historical (back to 2012) classifications within Larne Lough. Within the 10-year period, beds L1, L2, L3 and L5 were tested. L1 and L5 are currently awaiting reclassification, L3 is currently licensed and classified, and L2 is no longer authorised with the lease having expired.

Table 5.1: Classification system for shellfish harvesting areas.

Classification	Permitted Levels	Outcome
A	80% of sample results ≤ 230 *E. coli*/100 g, no results exceeding 700 *E. coli*/100 g.	Molluscs can be harvested for direct human consumption provided the end product standard is met.
B	90% of sample results must be less than or equal to 4,600 *E. coli*/100 g with none exceeding 46,000 *E. coli*/100 g.	Molluscs can go for human consumption after: • purification in an approved establishment, or • relaying in a classified Class A relaying area, or an *E. coli* approved heat treatment process.
C	Less than 46,000 *E. coli*/100 g flesh.	Molluscs must be subject to relaying for a period of at least two months or cooked by an approved method.

Figure 5-1 shows a graph of the *E. coli* results for mussels in production area L5 from 2017 to 2019 and **Figure 5-2** shows the *E. coli* results for Pacific oysters in production area L3 from 2020 to 2022. **Figure 5-3** shows the *E. coli* results from L1 clams from 2007-2014 as reported in the 2015 Sanitary Survey Report by CEFAS.

Table 5.2 shows the summary statistics for the historical data on *E. coli* (2017 to 2022) from the two shellfish monitoring points, L3 and L5, which were previously identified as RMPs in the 2015 Sanitary Survey Report. The geometric mean of *E. coli* levels was much higher for mussels and Pacific oysters at L5 (171.5 MPN/100 g) than for Pacific oysters at L3 (78.5 MPN/100 g).

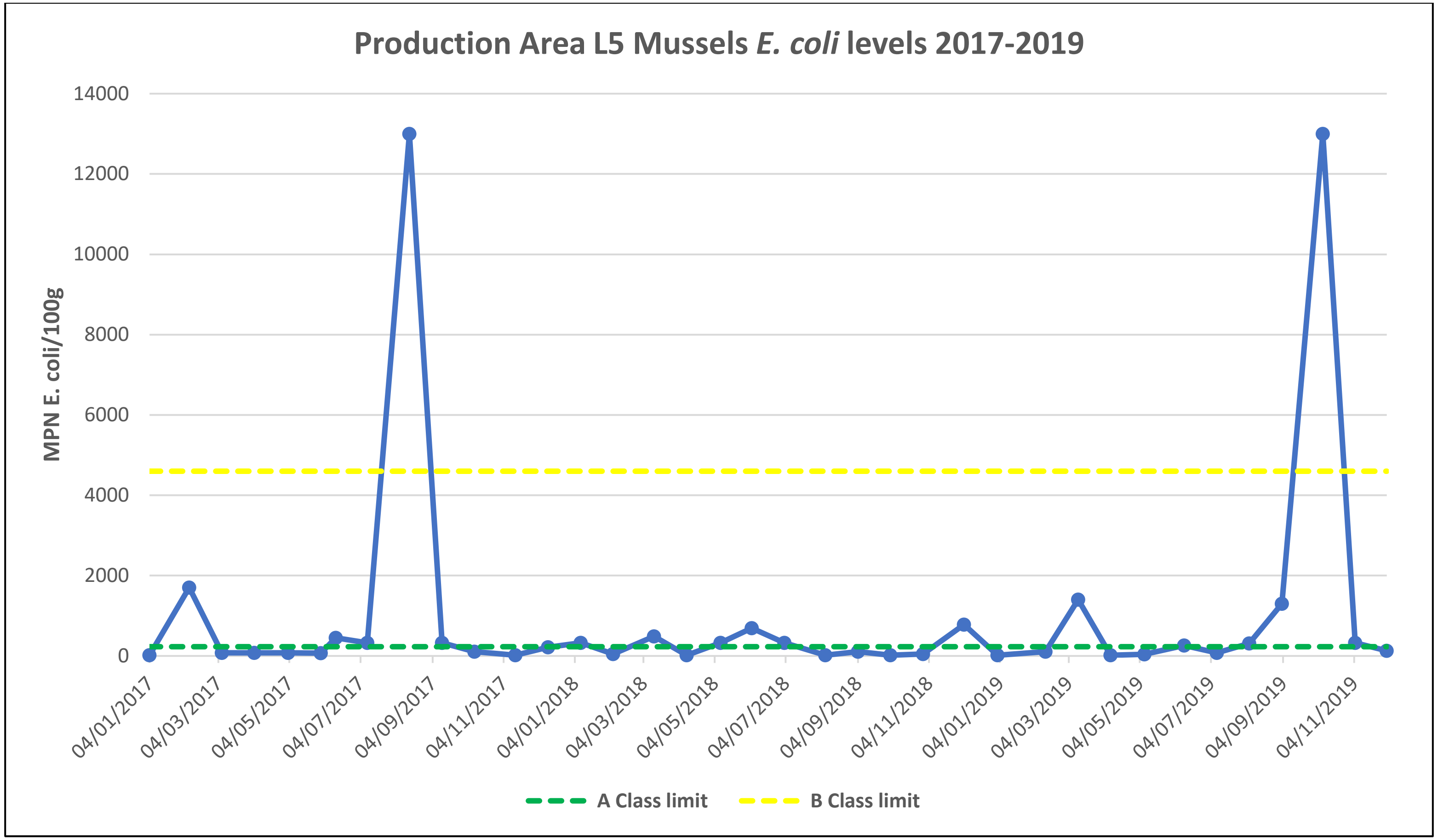

Figure 5-1: *E. coli* results from production area L5 mussels* from 2017-2019 (source: FSA).

* Mussels were used as a proxy species to represent Pacific oysters (*Crassostrea gigas*) also for this period at the shellfish bed.

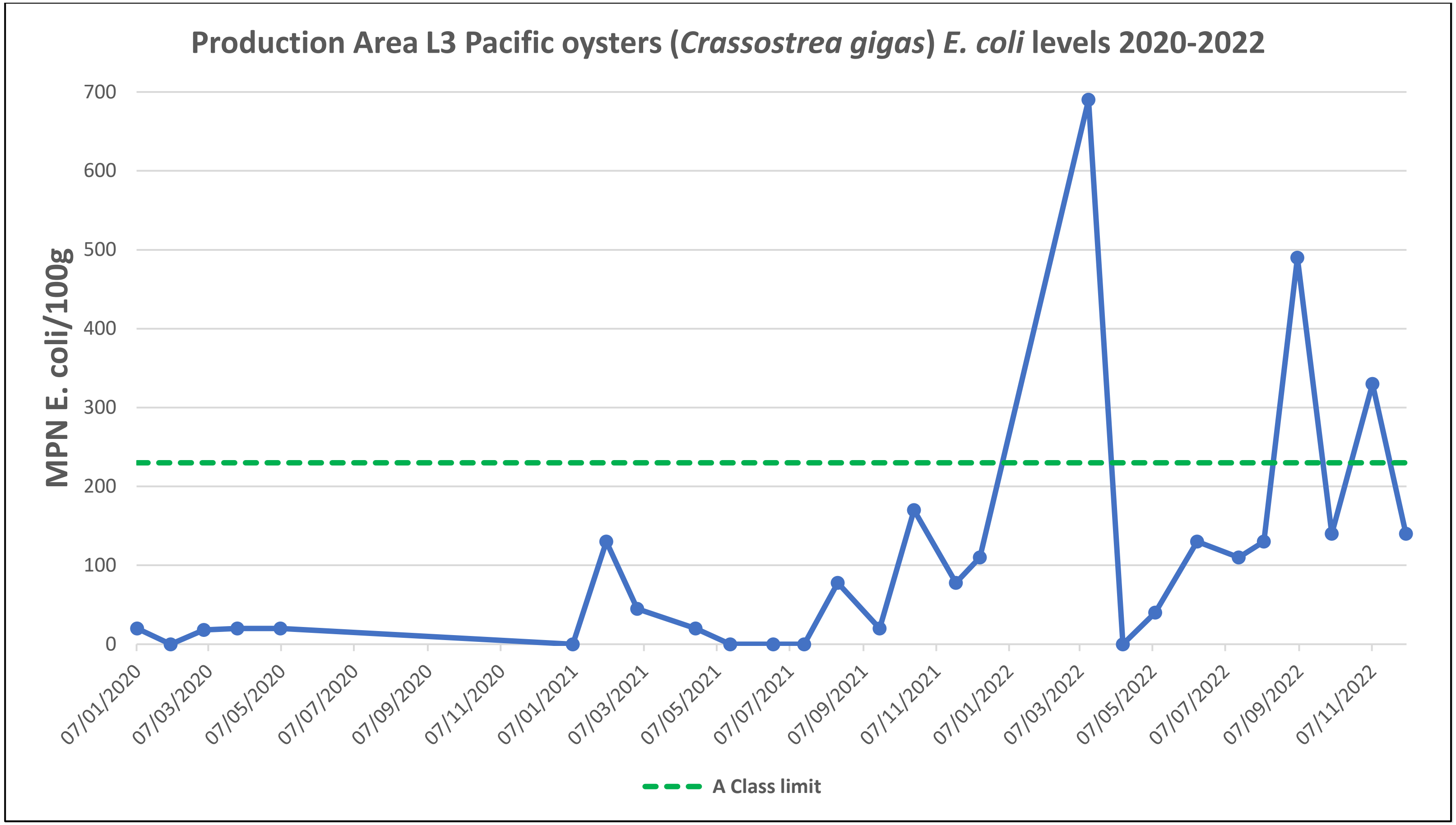

Figure 5-2: *E. coli* levels from production area L3 Pacific oysters (*Crassostrea gigas*) from 2020-2022 (source: FSA).

Table 5.2: Summary statistics of historical *E. coli* data monitored from shellfish beds in Larne Lough.

Site	Species	Date 1st Sample	Date last Sample	Min *E. coli* (MPN/100 g)	Max *E. coli* (MPN/100 g)	Median *E. coli* (MPN/100 g)	Geometric Mean *E. coli* (MPN/100 g)
L5	Mussels (*Mytilus edulis*)	04-Jan-17	02-Dec-19	18	13000	130	171.5
L3	Pacific oysters (*Crassostrea gigas*)	07-Jan-20	05-Dec-22	18	690	110	78.5

Table 5.3: Current and historical classification of shellfish beds in Larne Lough (2012–2022).

Bed Name	Species	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
L5	Mussels (*Mytilus edulis*) & Pacific oysters (*Crassostrea gigas*)	B	B	B	B	B	B	B	B	B	B	B
L3	Pacific oysters (*Crassostrea gigas*)	B	A-Prov*	A-Prov*	B	B	B	B	B	B	B	B
L1	Clams	B	B	B								
L2	Mussels (*Mytilus edulis*) & Pacific oysters (*Crassostrea gigas*)	B	B A-Prov*									

NB - Prov* relates to a ‘Provisional’ classification given to a shellfish harvesting area as stated in the classification list

Figure 5-3 is a scatterplot of Island Shellfish (L1) clam *E. coli* results by date (2007-2014) (CEFAS, 2015). Clams are grown in the sediment and the graph displays the concentration of *E. coli* (measured in MPN/100g) in samples collected over time from 2008 to 2014. The data shows significant variability, with occasional spikes in *E. coli* levels, some exceeding the threshold values of 230 and 4,600 MPN/100g. Despite these fluctuations, the overall trend remains relatively stable, with no clear, consistent increase or decrease over the period. The blue trend line indicates periodic rises and falls in *E. coli* concentration, suggesting that contamination levels are influenced by variable factors, possibly environmental or seasonal.

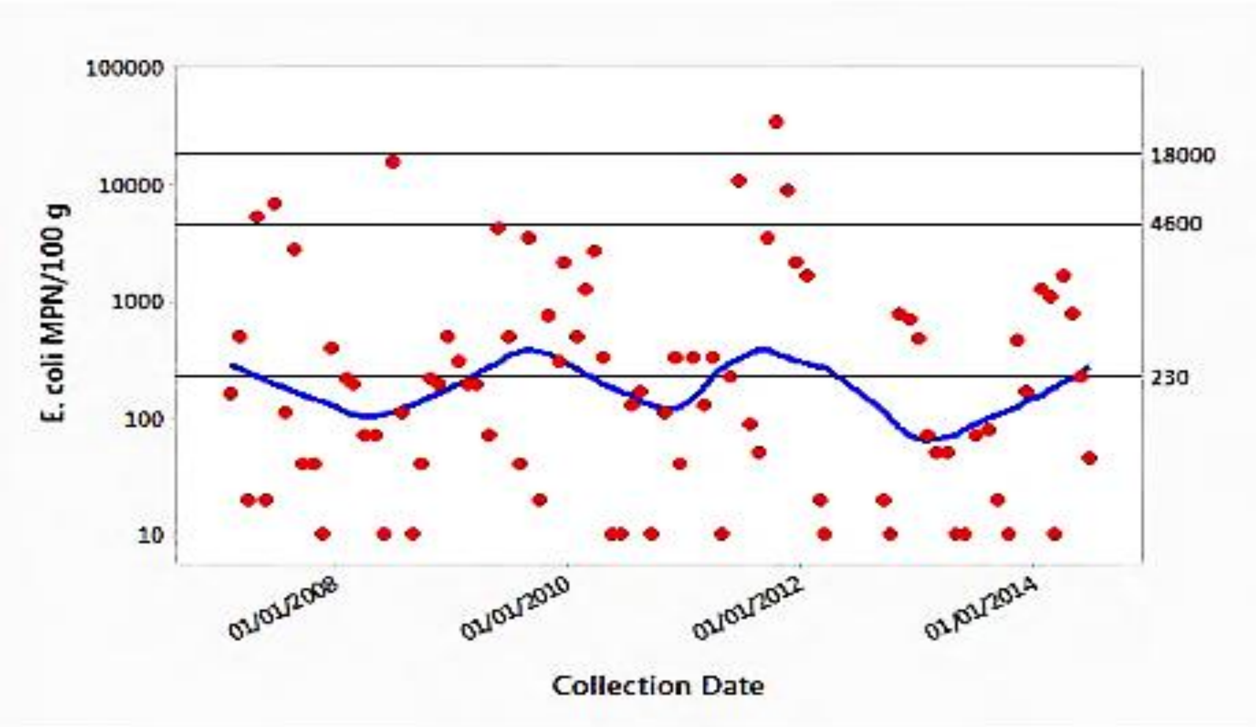

Figure 5-3: Scatterplot of Island Shellfish (L1) clam *E. coli* results by date (2007-2014) (source: CEFAS, 2015).

Table 5.3 shows the historical classification of shellfish beds in Larne Lough (2012–2022) detailing the classification of four shellfish beds and the species that were cultivated (L1, L2, L3 and L5). L5 held a "B" classification from 2012 to 2019 and in 2021. L3 alternated between "B" and "A-Prov*" classifications, with "A-Prov*" in 2013 and 2014, and "B" in other years; note A-Prov* indicates a provisional classification was awarded. L1 was classified as "B" in 2012 and 2013. L2 was "B" in 2012-2013, "A-Prov*" in 2014, and had no further classifications thereafter. "B" was the most common classification across the years. According to the 2022 NI Shellfish Classification List (V18_0), the licensed areas within

Larne Lough that were classified at that time (effective from 2020) were L3 oysters and L5 mussels and oysters. At the time of writing this report, the only classified production area was L3. Production areas L1 and L5 were both awaiting reclassification and for pre-classification sampling to commence.

A one-way ANOVA was carried out to look for differences between years for monitoring points L3 and L5, and species. For this analysis, all shellfish flesh results that returned a less than value (*i.e*., <X) were given that value (*e.g*., <20 is denoted as 20). No statistically significant difference was found between years for L5 mussels, however only three years of data were available at the time of writing this report which may have influenced these results. For L3 Pacific oysters, considering data from L5 for 2017-2019, a statistically significant difference was found in *E. coli* levels between years. Looking at data from 2020-2022 alone for L3 also returned a statistically significant difference between years. However, it is important to note that due to the Coronavirus pandemic restrictions in 2020, only four months were sampled, and two months data was missing from 2022 also; these missing data are likely to have skewed the results.

A one-way ANOVA was also carried out on the seasonal *E. coli* counts for each monitoring point and species. These analyses found that there was no significant difference between seasons for L3 Pacific oysters or L5 mussels. Not enough data was available to calculate if there was a statistically significant difference in *E. coli* counts between Pacific oysters and mussels. Additionally, as mussels usually have higher *E. coli* levels than Pacific oysters, such a comparison may not be valid.

6. Licensed Areas for Monitoring

There are three licensed areas for shellfish production in Larne Lough catchment, L1 Island Shellfish (clams), L3 Shingle Bay (Pacific oysters), and L5 Millbay (mussels and oysters), however at the time of writing this report only L3 is currently classified for Pacific oysters. Two RMPs are currently designated for these three production areas and can be seen in **Figure 6-1**.These were determined based on the 2015 Sanitary Survey Review.

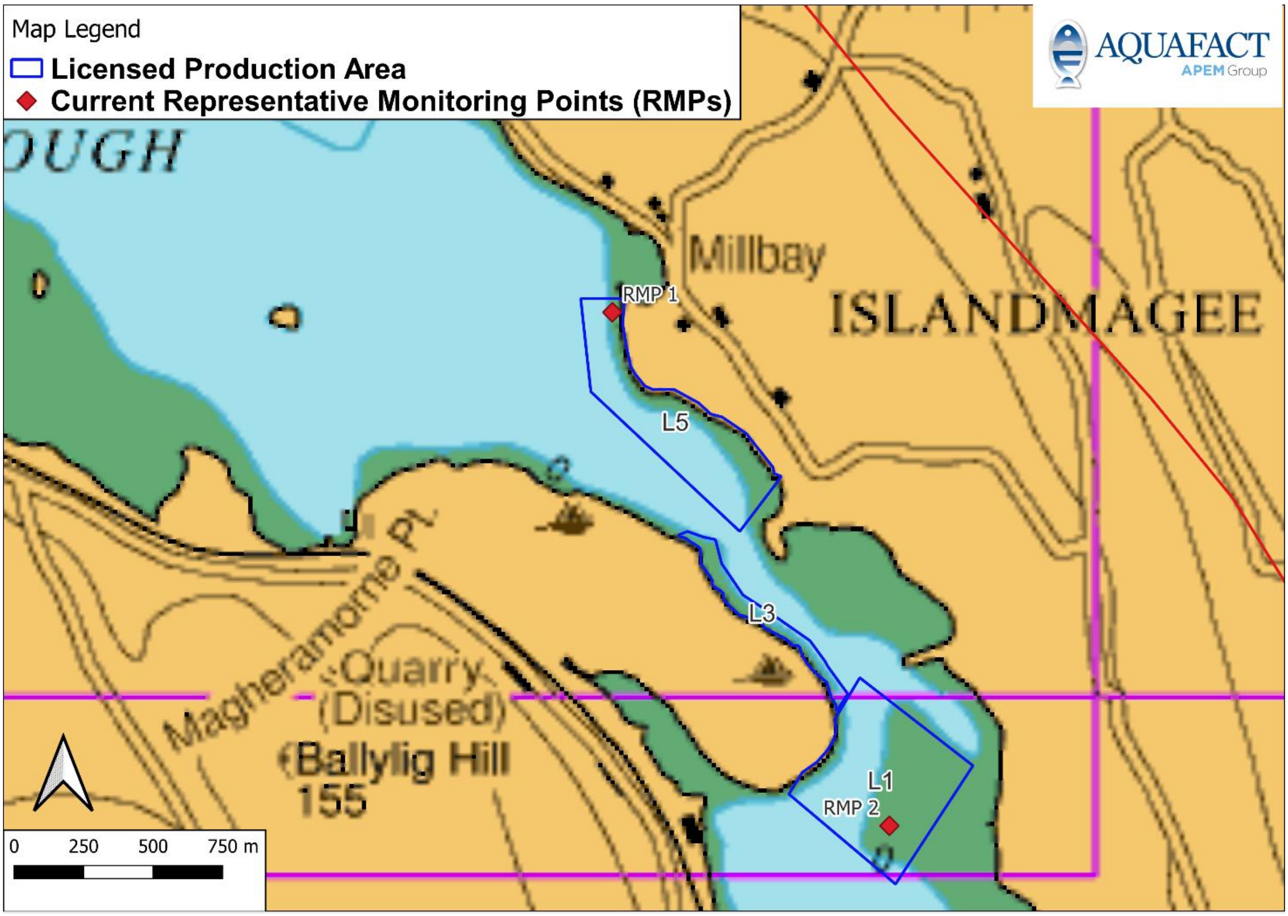

Figure 6-1: Licensed production areas in Larne Lough and current Representative Monitoring Points (RMPs).

7. Discussion/Conclusion

Wind patterns for Larne Lough are most consistent during autumn and winter, mainly blowing from the west and southwest, with strongest winds in excess of 17 knots. Wind patterns in the spring and summer are more variable and weaker, but still predominantly blow from the west, south and south-westerly directions.

Over two consecutive 30-year periods, autumn was the wettest season. From 1981 to 2010, summer was the driest, while from 1991 to 2020, spring was the driest. In shorter periods (2011-2015 and 2016-2020), spring was generally the driest and winter the wettest. However, high rainfall can occur at other times, as in 2012 and 2019 when summer was the wettest. Despite autumn/winter being typically the wettest, summer can also see significant rainfall.

The total population of the SOAs within the Larne Lough catchment is 39,320 people, up 0.3% from the 2015 review. The highest populations occur in Kilwaughter 1 (4,440, +12%) Ballycarry (2,853, +3.9%), Carncastle (2,829, -0.9%), and Island Magee (2,535, -0.6%).

Tourism in Northern Ireland in 2019 has increased by 7% since the 2015 sanitary survey (Northern Ireland Tourist Board, 2019). The Larne Lough catchment occurs within one Northern Ireland LGD for tourism numbers 'Mid & East Antrim'. This LGD received 286,337 tourists in 2019. As the tourism numbers have increased by 7% it is likely that the tourism numbers in the Larne Lough area have also increased slightly. There is however no way of estimating the number of tourists who visited the Larne Lough catchment area during their stay. As statistical analysis of the seasonal *E. coli* results from shellfish shows no statistically significant difference in *E. coli* levels across seasons, therefore tourism is not likely to be a driving factor in *E. coli* levels in Larne Lough.

There are five WwTW in the Larne Lough catchment, serving a current p.e. of approximately 37,119.21. The three largest WwTW are reportedly operating below capacity, however, Magheramorne and Mounthill WwTW are operating well above their design capacity. The major works are those at Larne which account for approximately 74% of the total population equivalent of the catchment. Nevertheless, the WwTW at Magheramorne, Ballycarry, and Ballystrudder are deemed the most influential regarding *E. coli* load in the shellfish production areas as the outfall locations for these WwTW are all located in the inner lough. It is difficult to ascertain the change in volume of wastewater, and subsequently *E. coli* load, between the current and 2015 Sanitary Survey Reviews. More data is available on the current and design capacities of WwTW in Larne Lough catchment compared to the 2015 review. There was a minimal increase in population in the catchment and it is possible that there have been upgrades to the WwTW noted within the catchment.

There are 20 industrial discharges within the Larne Lough catchment. Site drainage accounts for 13 of these discharges with inert waste disposal accounting for a further three. There are also two fish farm food processing discharges, the Ballylumford Power Station, and one vehicle washing site.

As land use type was not detailed in the 2015 review a comparison cannot be made between the data reported here and that of 2015. However, the 2015 report references the western side of the lough comprising of mostly agricultural lands and forestry areas, and the east shore consisted of agricultural land with a large number of farms. The 2009 Sanitary Survey Report for Larne Lough reported a general predominance for pasture and grasslands on Islandmagee on the eastern side of the Lough, while the western shoreline was predominantly urban with areas of intertidal flats at the head of the Lough (AFBI, 2009). The dominant land use type was pastures (78.24%, 9,203 ha), followed by discontinuous urban fabric (5.28%, 621 ha), and natural grassland (5.02%, 591 ha). Land associated with agricultural activities (non-irrigated arable land, pastures, natural grasslands, and agriculture/natural vegetation) accounted for 85.32% of the land use in the area. Between 2015 to 2018, there has been a minor decrease in the number of farms within the Larne Lough catchment (-0.2%). There has been a general decrease in crops of 3.7%. Overall, there has been virtually no change in the area used for grass in the catchment. There has been a slight increase in the numbers of sheep and cattle, however the number of pigs has doubled since the 2015 review. The numbers of poultry have decreased overall, and all other livestock numbers have decreased. Based on Jones and White (1984) the change in stocking densities of the different species will lead to an estimated increase in daily *E. coli* load by 2.7%. This increase is due to the significant increase of pigs in the area and increased numbers of cattle and sheep. Of note from the 2015 review (2014 Shoreline Survey) is the observations of livestock and birds in Larne Lough. Livestock and birds were found to be concentrated between Millbay and south of Barney's Point on Islandmagee and the corresponding stretch of shoreline on the western side of the lough, essentially the shoreline bordering the licensed shellfish production areas. Larne Lough is an SPA, ASSI, and Ramsar site, all of which cover a total area of 398 ha (approximately 50% of the Larne Lough catchment area).

Statistical analysis was carried out on *E. coli* data from shellfish flesh (mussels and Pacific oysters) for the active shellfish beds to ascertain if there were any seasonal variations. This analysis found that there was no significant difference between seasons for L3 Pacific oysters and L5 mussels. This, along with the annual classification at all sites remaining as B, shows that the *E. coli* levels in shellfish in the lough have not changed since the last sanitary survey (CEFAS, 2015). The 2015 Sanitary Survey reported that the *E. coli* levels in the clams at L1 had not varied markedly over time between 2007-2014 though there were peaks in the trend line in 2009 and 2011 (CEFAS, 2015). It further stated that consideration of results from different species was undertaken at the request of the FSA NI to determine whether an indicator species approach would be appropriate for Larne Lough, however with respect to that no comparisons could be undertaken for clams at L1 against other species as the reported sampling locations for mussels and oysters were some distance from the reported clam sampling location (CEFAS, 2015).

Under EU regulations, the FSA NI sets the boundaries for shellfish harvesting areas. It monitors *E. coli* levels to classify them as Class A, B, or C. Larne Lough's shellfish beds are not currently monitored due to inactivity. Historically, licensed species included native and Pacific oysters, Manila and native clams, and mussels.

The three licensed shellfish production areas in Larne Lough (L1, L3, and L5) are not currently being monitored by FSA as part of their official shellfish microbiological monitoring programme as they are not being actively farmed or harvested (FSA, 2024) However, all three areas have been classified at some stage by FSA. Following this sanitary survey review, pre-classification sampling is to commence for L1 and L5 for Pacific oysters.

The 2015 Sanitary Survey illustrated significantly higher *E. coli* levels in oysters at L3 than at L5 but no significant difference in *E. coli* levels in the mussels; the two highest results for mussels were seen at L5 (CEFAS, 2015). In this review, a one-way ANOVA was carried out to look for differences between years for each RMP and species. For this analysis, all shellfish flesh results that returned a less than value (*i.e.*, <X) were given that value (*e.g.*, <20 becomes 20). For L5 mussels, there was no statistically significant difference across the years 2017-2019, however this is a reasonably small dataset which may influence the results. Based on a review of the historical data, site L5 had consistently higher *E. coli* levels than site L3, with mussels at L5 showing these bacterial levels nearly 19 times greater. When looking across the years 2017-2022, *E. coli* levels in Pacific oysters at L3 appear to be significantly different. However, it should be noted that a number of samples were missing from the 2020 dataset due to sampling restrictions imposed by the Coronavirus pandemic, and two samples were missing from the 2022 dataset, which did not allow for a full set of results to be analysed.

According to the 2022 NI Shellfish Classification List, L3 (oysters) and L5 (mussels) were classified areas from 2020. Sites L5 and L3 had consistently returned B classification status from 2016 to 2022. This means that 90% of sample results were less than or equal to 4,600 *E. coli*/100 g, with none exceeding 46,000 *E. coli*/100 g.

The most significant changes for the faecal load of Larne Lough between this desktop review and the 2015 Sanitary Survey Review are the change in WwTW under consideration and the increase in livestock numbers. Glenoe WwTW was considered in the 2015 review but data on this WwTW was not provided by NIW for the current report; however, data on Glenoe flow to full treatment combined sewer overflow (FFT CSO) is mapped in **Figure 4-5**, map ID 10. As detailed in **section 4.1.3**, only three WwTW sites are likely to contribute to *E. coli* levels in the licensed shellfish production areas in Larne Lough. Sandy Bay WwTW was noted in the 2015 review as having potential to contribute to *E. coli* contamination in the lough. However, as mentioned in **section 3.8**, due to a counter current on the flooding tide around the Ballylumford Power Station, any *E. coli* contamination discharging from Sandy Bay WwTW will be prevented from dispersal to the licensed shellfish production areas. Therefore, this WwTW is not included in the current report. Excluding the Ballylumford Power Station, no other industrial discharges were reported in the 2015 review. Twenty industrial discharges are included in the current report. Majority of these discharges are located inland in the northwest of the catchment, with some on the shoreline around Larne Town, and so are unlikely to greatly contribute to the *E. coli* load surrounding the production areas.

Presently, only site L3 is classified; the current RMPs are within L5 and L1 (**Figure 6-1**) though these sites await reclassification and sampling. Larne Lough’s variable wind, rainfall, and *E. coli* inputs from wastewater and livestock necessitate ongoing monitoring of shellfish beds. It is recommended to keep the RMPs at L1 and L5 (RMP 1 and RMP 2) and establish a third RMP at L3 (RMP 3) (**Figure 8-1**, **Table 8.1**) to account for geographical, temporal and shellfish species differences, ensuring shellfish safety and maintaining the productions areas classification.

Based on the limited changes between the 2015 review (2014 Shoreline Survey) and the current 2024 review, a new shoreline survey was deemed unnecessary. Sufficient data were available to inform the RMP assessment. However, it is recommended that the WwTW outfall locations in the inner lough (**Figure 4-4**; map ID 1, 2, and 4) are verified with a shoreline visit and potential water sampling event to measure the current *E. coli* inputs from these outfalls. A low concentration of *E. coli* is anticipated from the Ballycarry and Ballystrudder WwTW due to the implementation of the long sea outfall pipe for these treatment works. Magheramorne WwTW is currently operating above design capacity (by 141%). A shoreline visit to Magheramorne WwTW outfall location would also aid to clarify the location of this outfall, and a water sample would give an indication into the *E. coli* levels being discharged.

8. Sampling Plan

8.1. Production Areas and Monitoring Points

There has been no change to the licensed production area boundaries that were set out in the 2009 Sanitary Survey, however, there have been changes to the classification status of the licensed beds over this time. Currently, RMP 1 is located in the north of L5, while RMP 2 is located within L1. It is proposed that RMP 1 and RMP 2 remain at the same locations as described in the CEFAS 2015 Sanitary Survey Review for continuity of sampling and analysis of results (**Figure 8-1**). RMP 2 should capture potential *E. coli* contamination discharging from the Ballycarry and Ballystrudder WwTW outfalls on the southeastern shoreline of the inner lough, and the Magheramorne WwTW outfall to the north of the L1 production area. The Ballycarry SOA accounts for majority of the land bordering the inner western part of the lough. In comparison to the 2015 Sanitary Survey Report, the population in Ballycarry SOA has increased by 3.9%. Based on the 2018 CORINE land cover classification, the land surrounding the inner lough is dominated by pastures. Of note in relation to the land type is that seven river networks discharge into the inner lough area from the western and eastern shorelines, providing potential routes for contamination to enter Larne Lough. Comparison of agricultural data between 2015 and 2018 is presented in **section 4.1.5**. These data show that there has been a slight increase in the number of farms on the western shore. There has been an overall increase of 1.6% in cattle, particularly on the eastern shore. Though the number of sheep in areas bordering the lough has decreased, an increase elsewhere indicates that sheep remain a potential source of *E. coli* contamination if a watercourse runs nearby their locality. The western shore has seen an increase in poultry numbers. Overall, the change in agriculture between the 2015 and 2018 census indicates an approximate increase of 2.7% in daily *E. coli* load. The proposed RMP 3 should account for any discharges from the designated dump site area on the headland bordering the L1 and L3 production areas. The proposed RMP 3 has been placed to account for *E. coli* contamination from the above-mentioned potential sources. Based on a review of the historical data, site L5 has consistently recorded notably higher *E. coli* levels than site L3, with mussels at L5 showing these bacterial levels nearly 19 times greater. Although mussels were used as a proxy for Pacific oysters, the persistently elevated bacterial levels make maintaining an RMP at L5 a prudent step to ensure systematic and reliable microbiological sampling, safeguarding the sale of shellfish harvested from this production site.

The proposed RMP 3 has been placed to account for *E. coli* contamination emanating from the dump site region and potential inputs from pastures on Islandmagee, south of Barney's Point. In the 2014 Shoreline Survey, a number of observations were made of livestock and animal faeces along the eastern shore. *E. coli* contamination from these agricultural sources could directly enter the lough or via the river discharging south of Barney's Point. While there has been a slight decrease in the number of farms along the eastern shore of Larne Lough between 2015 and 2018, the area farmed has increased here and in the northwest of the catchment. Retaining RMP 1, located on the northern boundary of the L5 site, is designed to ensure that reliable microbiological sampling occurs due to the high levels of *E. coli* recorded at the site historically.

Additionally, the Larne Lough production areas overlap with marine protected areas for birds, as detailed in **section 4.1.6.2**, and the 2014 Shoreline Survey observed a diversity of bird species concentrated in the inner lough area as far north as Millbay. The mudflat area in the inner lough area up to Barney's Point (**Figure 4-11**) provides suitable habitat for birds to forage. Therefore, birds are a potential *E. coli* source; the placement of the RMPs should pick up on this contamination.

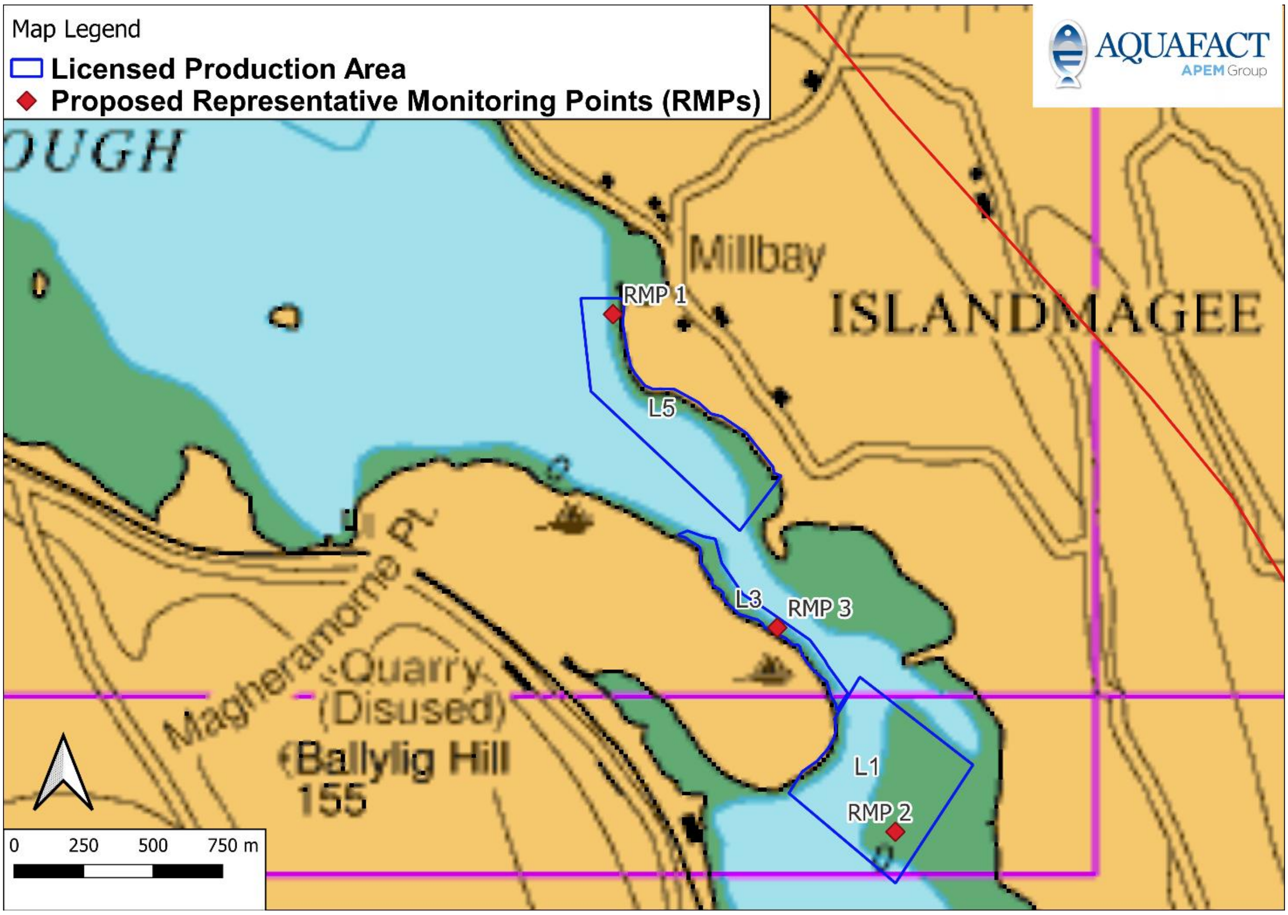

Figure 8-1: Licensed shellfish production areas in Larne Lough and proposed Representative Monitoring Points (RMPs) for Pacific oysters (*Crassostrea gigas*) based on the current 2024 Sanitary Survey Review.

Table 8.1: Proposed representative monitoring point (RMP) coordinates, resulting from the 2024 review, corresponding to Figure 8-1.

RMP	Production area	Species	Longitude	Latitude	Easting (ING)	Northing (ING)
1	L5	Pacific oysters (*Crassostrea gigas*)	54.82289	-5.75319	344456	399545
2	L1	Pacific oysters (*Crassostrea gigas*)	54.80619	-5.73739	345531.5	397719
3	L3	Pacific oysters (*Crassostrea gigas*)	54.81278	-5.744	345082.9	398438

8.2. Methodology

All sampling should follow the UK NRL (National Reference Laboratory) Microbiological Sampling Protocol. This protocol remains compliant with Commission Regulation (EC) No 2073/2005 at the time of publication and should continue to be used. The Competent Authority will utilise the NI NRL for microbiology for future amendments. The following sections (**8.2.1-8.2.9**) outline the UK NRL protocol to be followed for microbiological sampling.

8.2.1. Time of Sampling

Sampling shall be undertaken, where practical, on as random a basis as possible with respect to likely influencing environmental factors, *e.g.*, tidal state, rainfall, wind, *etc.*, to avoid introducing any bias to the results.

8.2.2. Frequency of Sampling

All sampling should be carried out monthly.

8.2.3. Sampling Method

Wherever possible, species shall be sampled by the method normally used for commercial harvesting. The temperature of the surrounding seawater at the time of sampling should be recorded on the sample submission form.

8.2.4. Size of Individual Animals

Samples should only consist of animals that are within the normal commercial size range. In circumstances where less mature stock is being commercially harvested for human consumption then samples of these smaller bivalves may be gathered for analysis.

8.2.5. Sample Composition

It is recommended that a sample size of 12-18 Pacific oysters (*Crassostrea gigas*) are collected for submission to the laboratory.

8.2.6. Preparation of Samples

Any mud and sediment adhering to the shellfish should be removed. This is best achieved by rinsing/scrubbing with clean seawater or freshwater of potable quality. If these are unavailable the seawater from the immediate area of sampling may be used instead. Do not totally re-immerse the shellfish in water. Allow to drain before placing in a food grade plastic bag.

8.2.7. Sample Transport

A cool box containing freezer packs should be delivered to the laboratory as soon as practicable but the maximum time between collection and commencement of the test should not exceed 24 hours. Samples should not be frozen and freezer packs should not come into direct contact with the samples.

The cool boxes used for such transport should be validated using appropriate temperature probes, to ensure that the recommended temperature is achieved and maintained for the appropriate period. The number and arrangement of freezer packs, and the sample packaging procedure, shown to be effective in the validation procedure should be followed during routine use. Where validation data already exists for a specific type of cool box, there is no need to take a local revalidation.

8.2.8. Sample Submission Form

Sample point identification name, map co-ordinates, time and date of collection, species sampled, method of collection, and seawater temperature should be recorded on the submission form. Any other information deemed relevant should also be recorded.

8.2.9. Delivery of Samples

Samples should be properly labelled and accompanied by a completed sample submission form. Samples should be brought within 24 hours to the chosen accredited laboratory for analysis.

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