Sanitary Survey Review for Lough Foyle

Produced by AQUAFACT part of the APEM group

On behalf of The Food Standards Agency in Northern Ireland

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Glossary

AFBI	Agri-Food and Biosciences Institute
ANOVA	Analysis Of Variance
ASP	Amnesic Shellfish Poisoning
Bathymetry	The measurement of water depth at various places of a water body
BOD	Biochemical Oxygen Demand
BTO	British Trust for Ornithology
CD	Chart Datum; is the level of water that charted depths displayed on a nautical chart are measured from. Common chart datums are lowest astronomical tide and mean lower low water
CEFAS	Centre for Environmental, Fisheries & Aquaculture Science
CEH	Centre for Ecology & Hydrology
CSO	Combined Sewer Overflow
DAERA	Department of Agriculture, Environment and Rural Affairs
Depuration	The process of purification or removal of impurities
EC	European Communities
E. coli	*Escherichia coli*
EMS	Environmental Monitoring Stations
Fetch	The distance a wave can travel towards land without being blocked
FSA in NI	Food Standards Agency in Northern Ireland
Geometric Mean	The nth root of the product of n numbers (The average of the logarithmic values of a data set, converted back to a base 10 number).
GIS	Geographical Information Systems
GPS	Global Positioning System
Hydrodynamic	Forces in or motions of liquids
Hydrography	The description and analysis of the physical conditions, boundaries, flows and related characteristics of water bodies
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
NI Water	Northern Ireland Water

NRFA	National River Flow Archive
Pathogenic	Capable of causing disease
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
SAC	Special Area of Conservation
SMILE	Sustainable Mariculture in northern Irish Lough Ecosystems
SOA	Super Output Areas or ward
SPA	Special Protection Area
SPS	Sewage Pumping Station
SS	Suspended Solids
Suspension feeders	Animals that feed on small particles suspended in water
Telemetry	The measurement and transmission of data from remote sources to receiving stations for recording and analysis
UKAS	United Kingdom Accreditation Service
UKHO	United Kingdom Hydrographic Office
WeBS	Wetland Bird Survey
WWTW	Waste Water 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 and relaying areas to undertake a sanitary survey. The purpose of this is to determine the extent to which potential sources of pollution may impact on a 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 production areas. In accordance with the EURL Guide to Good Practice on the microbiological monitoring of bivalve mollusc harvesting areas, a re-evaluation of pollution sources and the sampling plan (primary sanitary survey) should be undertaken if a time trigger (6 years or > since last survey) or change in the environment has occurred. As the sanitary survey for Lough Foyle was completed in 2010 a review of this sanitary survey is required. This report will review any changes to Lough Foyle and assess whether or not the changes are likely to affect the microbiological concentration of the classified production area.

Lough Foyle is a 186km2 shallow estuarine sea Lough located along the northern coast of Ireland between Co. Donegal in the Republic of Ireland and County Derry in Northern Ireland. It exhibits extensive intertidal and subtidal areas of mud flats and sand flats, which are intersected by tidal channels. The Lough is relatively shallow, with an average depth of approximately 4m. The deeper tidal channels reach an average depth of approximately 8-12m, whereas the entrance channel, where the width is constrained by headlands, is over 20m deep. The Lough supports populations of blue mussels (*Mytilus edulis*), native oysters (*Ostrea edulis*) and Pacific oysters (*Crassostrea gigas*), all of which have designated fisheries within the Lough.

This report attempts to document and quantify all known sources of pollution to the Lough. It was concluded that the main sources of pollution in Lough Foyle come from direct sewage discharges into the Lough and into the Rivers Foyle, Faughan and Roe and from non-point sources related to agricultural land-use in the wider Foyle area. There are also seasonal variations in the contribution of microbiological sources of contamination from wildfowl (birds), boats (shipping and recreational activity) and tourism.

The south-eastern section of the Lough is more vulnerable to pollution due to the shallow depths (increased suspended sediment concentration) and weak currents than the north-western section which has deeper depths and much stronger currents. It was on the basis of hydrodynamic and spatial features (i.e. areas of similar depth, tidal currents, suspended sediment levels and freshwater influence) that resulted in the Lough been divided into 4 production areas. Each of these production areas contain one Representative Monitoring Point (RMP) for each of the species found within it i.e. blue mussel, native oyster and Pacific oyster. In total there are 9 RMPs in the Lough, to be sampled monthly.

2. Overview of the Fishery/Production Area

2.1. Location/Extent of Growing/Harvesting Area

Figure 2.1 shows the locations of the blue mussel (*Mytilus edulis*) grounds within Lough Foyle. This map was produced following an extensive baseline survey by CEFAS (Centre for Environmental, Fisheries & Aquaculture Science) (2007). During the CEFAS (2007) survey, it was not possible to distinguish between wild and re-laid mussels in all cases; however, experienced opinions were sought as to the likely locations of wild and re-laid mussels. The mussel grounds that could not be differentiated were labelled ‘undifferentiated mussel’. There is 23.34km^2 of re-laid mussel ground, 4.11km^2 of wild mussel ground, 7.62km^2 of undifferentiated mussel ground and 2km^2 of intertidal mussel beds. The intertidal mussel beds are located at Vances Point, north of Leper’s Point and south of Ture Point on the western shoreline, at Longfield Bank east to Cross Bank on the southern shoreline and at Shell Bank and approximately 1km west of Balls Point on the eastern shoreline.

Figure 2.1: Mussel grounds located within Lough Foyle (Source: CEFAS, 2007 & Loughs Agency).

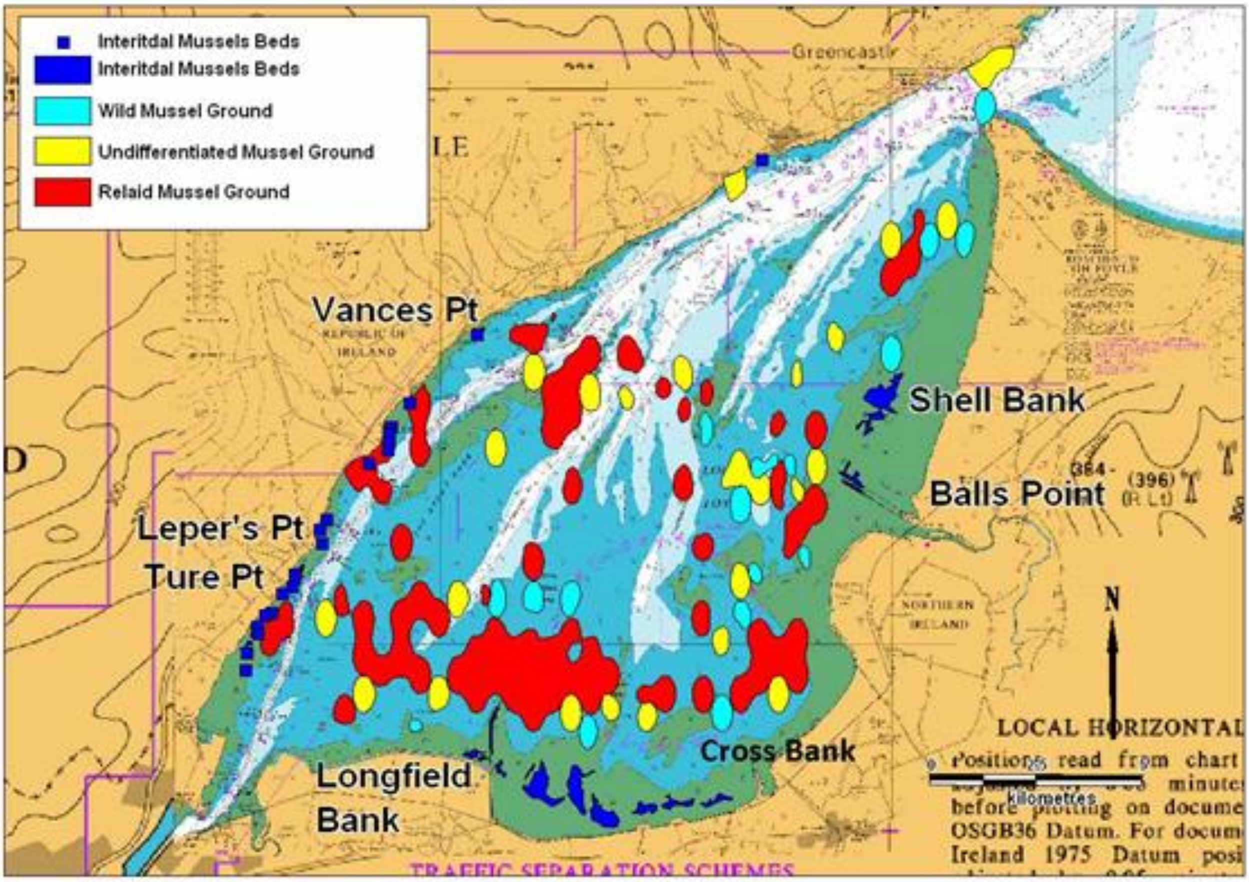


Figure 2.2 shows the native oyster (*Ostrea edulis*) grounds within Lough Foyle. This map was also produced following an extensive baseline survey by CEFAS (2007). The oyster grounds were typified not only by the presence of oysters but also of suitable shell cultch. The cultch typically contained oyster shell, but also clam, cockle and mussel shell. The oyster ground shown in Figure 2.2 includes locations that, while containing few if any oysters, contained quantities of cultch which would suggest that it had supported oysters in the past and might do so again in the future. There is 63.83km^2 of potential oyster grounds and 0.02km^2 of intertidal Pacific oyster grounds, which are farmed within Lough Foyle. The intertidal oyster grounds are located along the western shoreline and extend from Culmore Point to Black Point located some 13km northeast. Figure 2.2 also shows the wild Pacific oyster sites recorded on native oyster beds during a Loughs Agency survey in 2009 (Loughs Agency, 2009a). Wild Pacific oyster populations were observed in 25 different locations around the Lough. Figure 2.3 shows oyster density class recorded from oyster beds during a Loughs Agency survey in 2010 (Loughs Agency, 2010). The High class oysters are located at The Perch, between Quigleys

Point and Vances Point, between Ture Point and Quigley's Point and in the Crooked Channel. The majority of Medium class oysters are located between Ture Point and Castlecary, in the East Channel, South Middle Bank, Crooked Channel and northwest and northeast of the Crooked Channel. The remaining locations are all of a Low class.

Data on oyster density for 2020 was taken from the Loughs Agency's autumn 2020 pre-fishery survey (Loughs Agency, 2020). It can be see in Figure 2.4 that the abundance of native oysters was higher in 2020 than in 2010. Figure 2.5 shows the adult density of native oysters from 2008 to 2020. It can be seen that there is a high level of variability in density from year to year.

At the time of writing there was no available recent data on mussel densities in the lough.

Figure 2.2: Oyster grounds located within Lough Foyle (Source: CEFAS, 2007 & Loughs Agency).

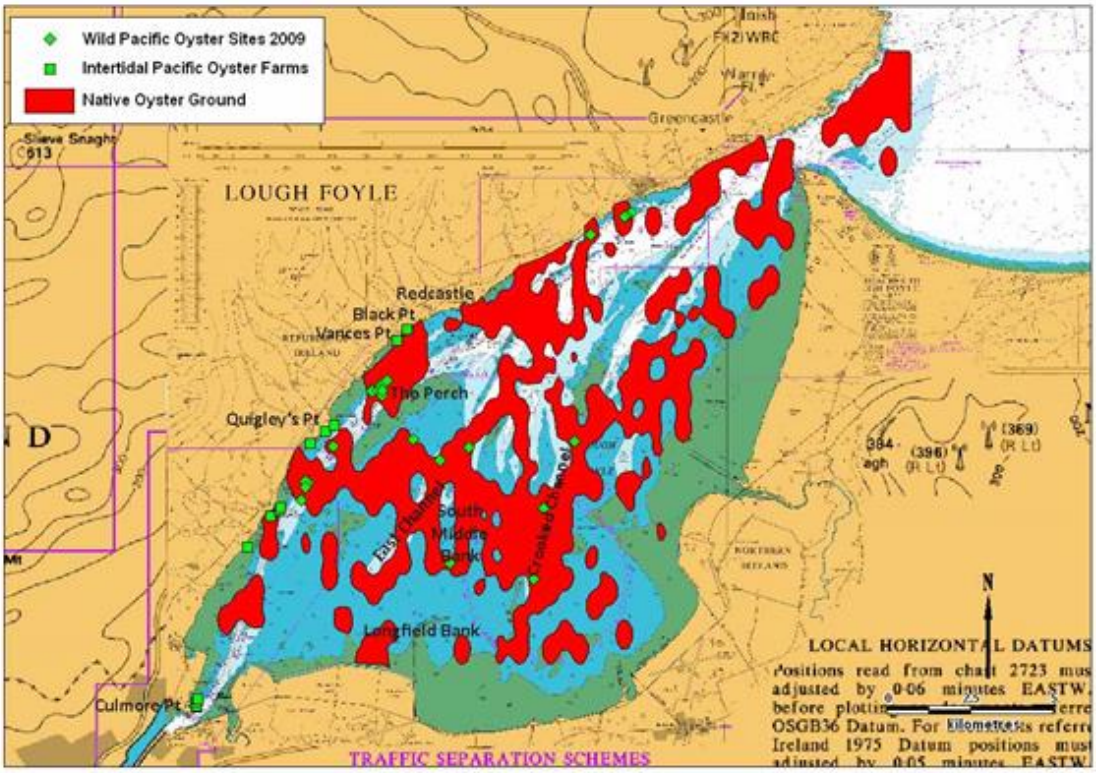


Figure 2.3: Oyster density class in Lough Foyle (Source: The Loughs Agency).

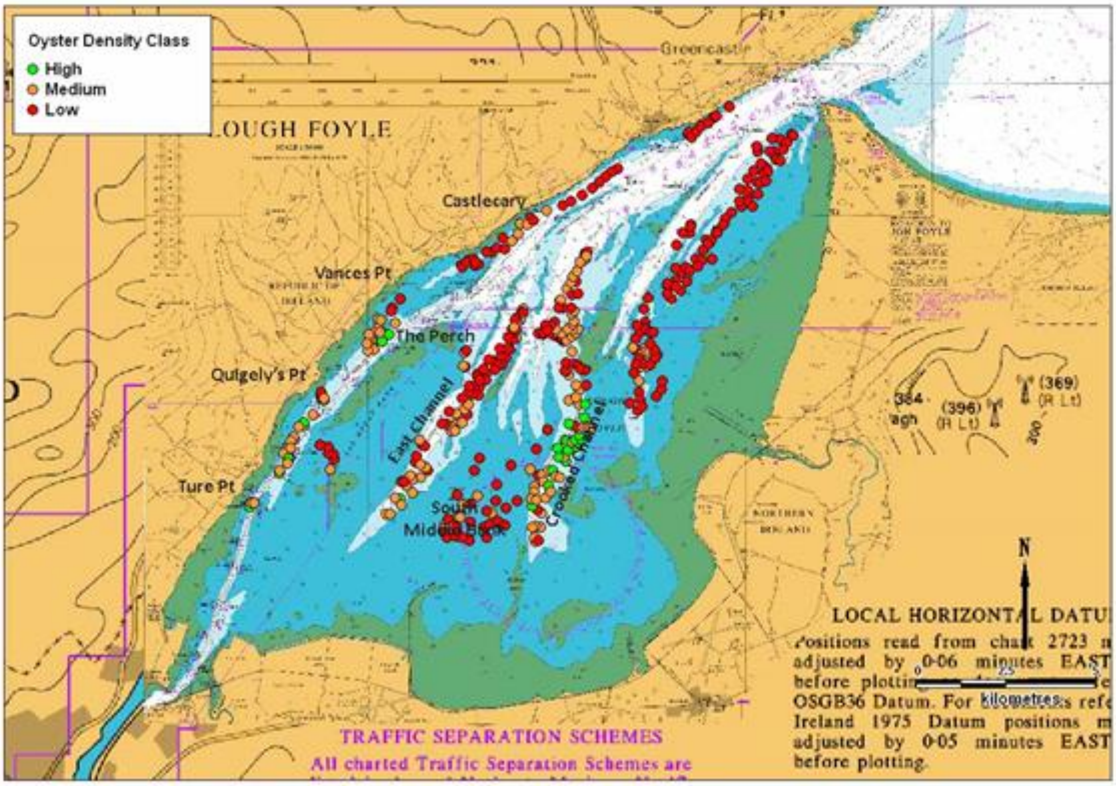


Figure 2.4: Lough Foyle native oyster abundance 2020 (Loughs Agency, 2020)

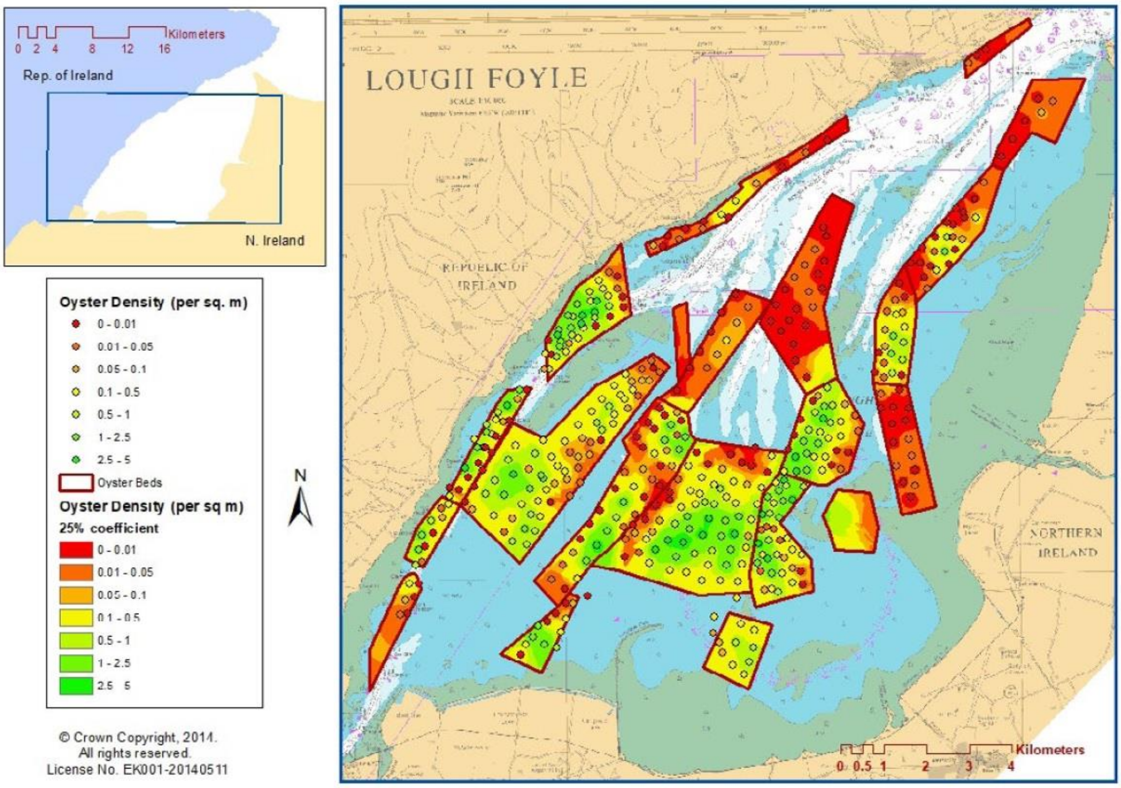
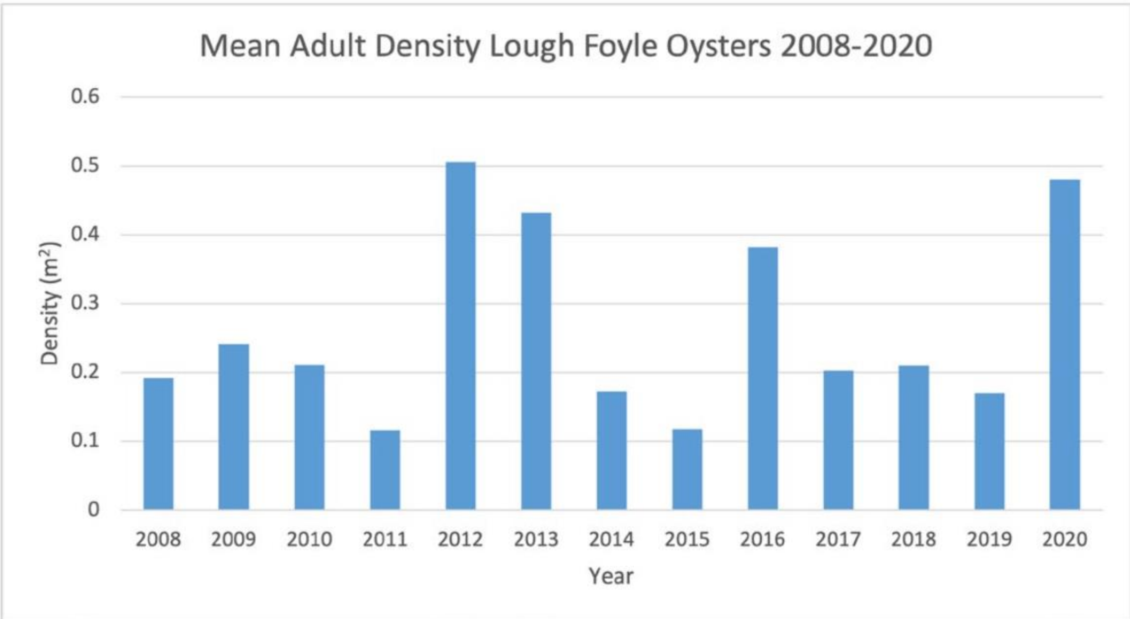


Figure 2.5: Lough Foyle native oyster abundance 2008 - 2020 (Loughs Agency, 2020)



2.2. Description of the Area

Lough Foyle is a 186km^2 shallow estuarine sea Lough located along the northern coast of Ireland between Co. Donegal in the Republic of Ireland and County Derry in Northern Ireland. The littoral communities found in Lough Foyle reflect the dominance of intertidal sands and muds (Ramsar, 2009). While rocky substrate is very limited, the extensive beds of common mussel *Mytilus edulis* provide a stable surface for acorn barnacle *Semibalanus balanoides* and edible periwinkle *Littorina littorea*. The polychaete green leaf worm *Eulalia viridis* is a common associate. The soft shores hold a range of invertebrates typical of mud and sand shores, with a number of species, such as the polychaete worm *Hediste diversicolor*, indicative of reduced salinity conditions. Balls Point has the highest diversity of sediment and community types in Lough Foyle and holds large populations of the bivalves sand gaper *Mya arenaria* and peppery furrow shell *Scrobicularia plana*.

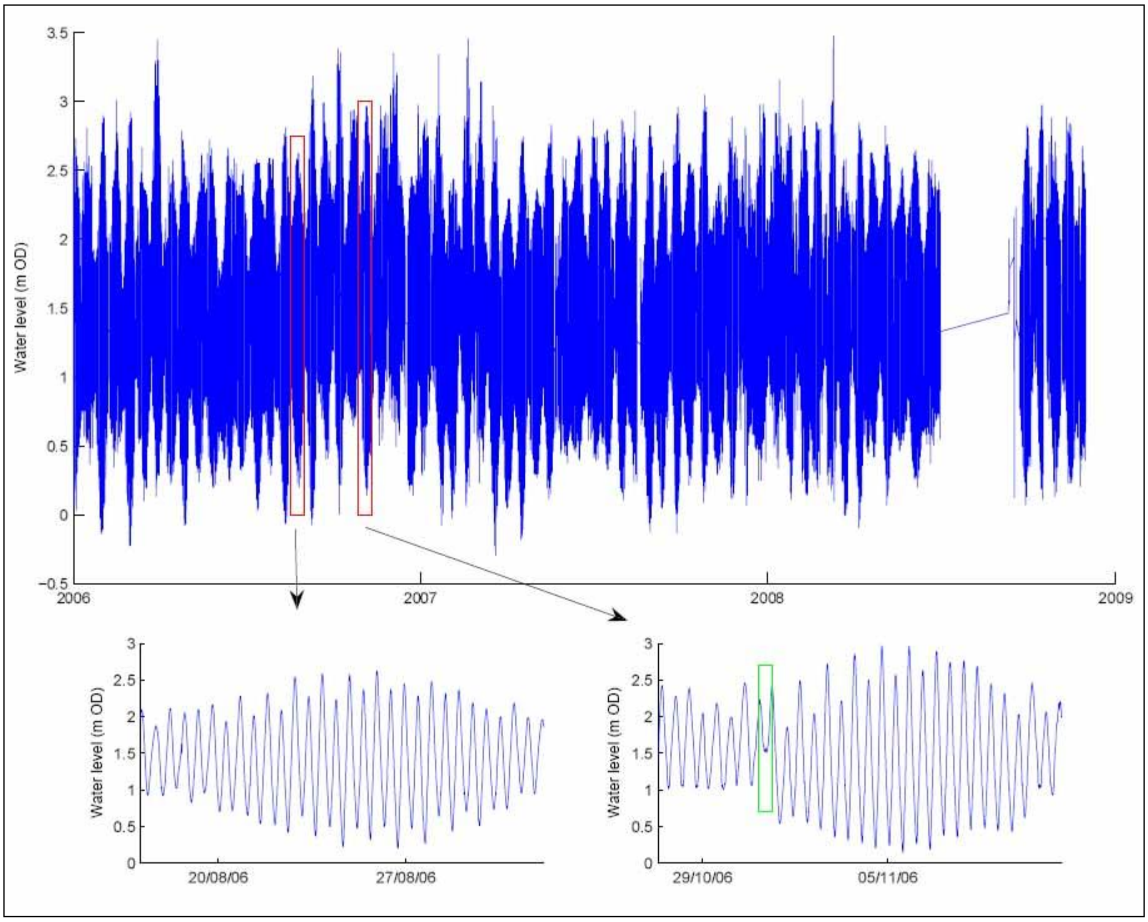
The intertidal area consists of extensive mudflats, which support large beds of both common mussel *Mytilus edulis* and eelgrass *Zostera* spp. (Ramsar, 2009). The latter are amongst the largest colonies of this vegetation type in Northern Ireland and includes two species, narrow-leaved eelgrass *Zostera angustifolia* and dwarf eelgrass *Z. noltii*. Large stands of saltmarsh vegetation occur along the foreshore, displaying a transitional sequence of community types. The lower colonising saltmarsh consists of a community dominated by common saltmarsh-grass *Puccinellia maritima*. As tidal influence declines up the shore, this is replaced by a 'middle-marsh' community, characterised by red fescue *Festuca rubra* and mud rush *Juncus gerardii*. Localised stands of sea club-rush *Bolboschoenus maritimus* and common reed *Phragmites australis* also occur. The uppermost saltmarsh features a community dominated by common couch *Elytrigia repens*. Just west of the Ballykelly Bank, on the large intertidal mudflats which form part of a larger creek network, the lower saltmarsh communities are replaced by extensive stands of common cord-grass *Spartina anglica*. Brackish dykes behind the shore support a maritime aquatic and swamp vegetation, including the rare reflexed saltmarsh-grass *Puccinellia distans* and spiral tasselweed *Ruppia cirrhosa*.

3. Hydrography/Hydrodynamics

3.1. Tides & Currents

The Londonderry Port and Harbour Commissioners (LPHC) operates a tidal gauge near Lisahally in the southwest corner of Lough Foyle. A time series of recorded water levels for the period 1-1-2006 to 30-11-2008 (at a 1 min interval); can be seen in Figure 3.1 (Deltares, 2009). The tidal motion in the Lough is characterised by a semi-diurnal tide travelling from east to west, with daily inequality, especially apparent in the heights of high waters. A 14-day spring-neap cycle can be observed, with a mean spring tidal range of 2.2m and mean neap tidal range of 1m. From the Deltares (2009) Delft3D-FLOW model, validated by data from EGS International Ltd., the tidal wave gets amplified as it travels up the Lough; the mean tidal range increases by several decimetres from the entrance channel to the south-western corner of Lough Foyle near Culmore, a distance of approximately 25km. The tidal amplification is accompanied by a phase difference between the northern and southern corner of the Lough, which is approximately 1 hour. Next to water level variations due to tidal forcing, variations in air pressure and wind setup affects the water level in the Lough. These phenomena may generate water level variations in the order of a few decimetres.

Figure 3.1: Lough Foyle water levels 2008-2009 (Source: Deltares, 2009).



The characteristic tidal levels at the River Foyle at Lisahally can be seen in Table 3.1. These are taken from the Admiralty Tide Tables (UKHO, 2006) and from tidal analysis carried out by Deltares (2009). Levels are presented in metres Chart Datum, which is approximately equal to Lowest Astronomical Tide (LAT).

Table 3.1 River Foyle (Lisahally) tidal characteristics (Source: UKHO, 2006 and tidal analysis carried out by Deltares, 2009).

Tidal Level	Admiralty Chart Levels (m CD)	Derived levels (m CD)
HAT	3.1	2.96
MNWS	2.6	2.52
MHWN	1.9	1.78
MSL	1.4	1.36
MLWN	0.9	0.97
MLWS	0.4	0.23
LAT	0.0	-0.04
Ordnance Datum Belfast (ODB)	1.37	-

The current flow within Lough Foyle is governed by the tides and river flow and to a lesser extent by wind conditions. The combination of fresh water flowing in from the rivers and salt water from the ocean leads to density differences between these two water masses, creating stratified conditions and three dimensional flow patterns. In combination with a bathymetry consisting of extensive shallow tidal flats intersected by tidal channels, complex hydrodynamic patterns and considerable spatial variation in current flow are found in the Lough.

A 1990 survey carried out by Atkins indicated a complex flow regime with significant spatial variation in the vicinity of the major channels (Atkins, 1990). Fragmented current speed data is reported in Atkins (1990) for various survey sites spread over the Lough. Maximum current velocities up to 1.2 m/s were recorded in the East Channel and flow reversal around slack tides was observed. In addition to this survey, EGS International Ltd. collected ADCP (Acoustic Doppler Current Profiler) measurements from Lough Foyle to validate a Delft3D-FLOW model which Deltares (2009) produced. The outputs from this model show the current speeds and directions during a spring and neap tide (See Figure 3.2 to Figure 3.9).

Figure 3.2: Surface current velocities and direction during a spring tide, flood flow at 16:30:00 November 13th 2008 (Source: Deltares Delft3D-FLOW).

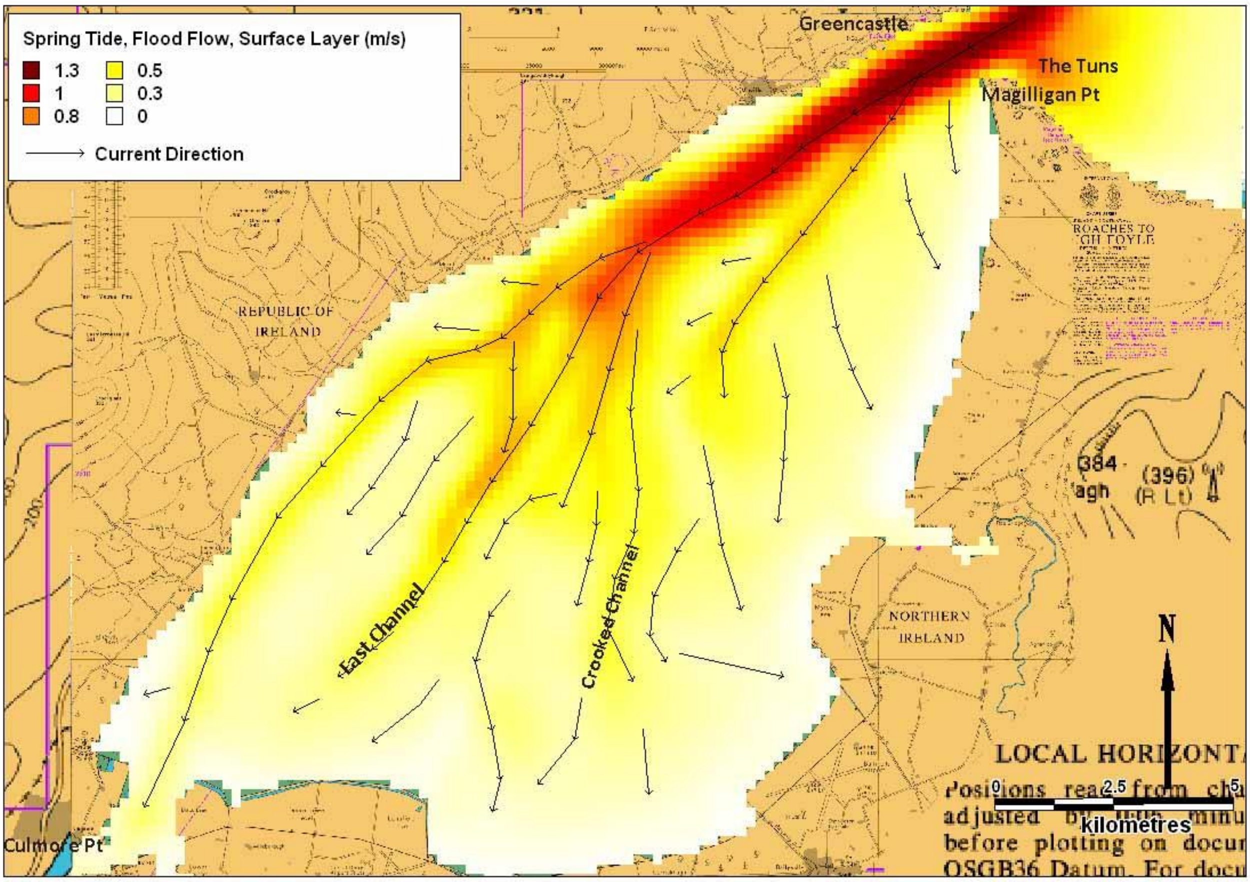


Figure 3.3: Bottom current velocities and direction during a spring tide, flood flow at 16:30:00 November 13th 2008 (Source: Deltares Delft3D-FLOW).

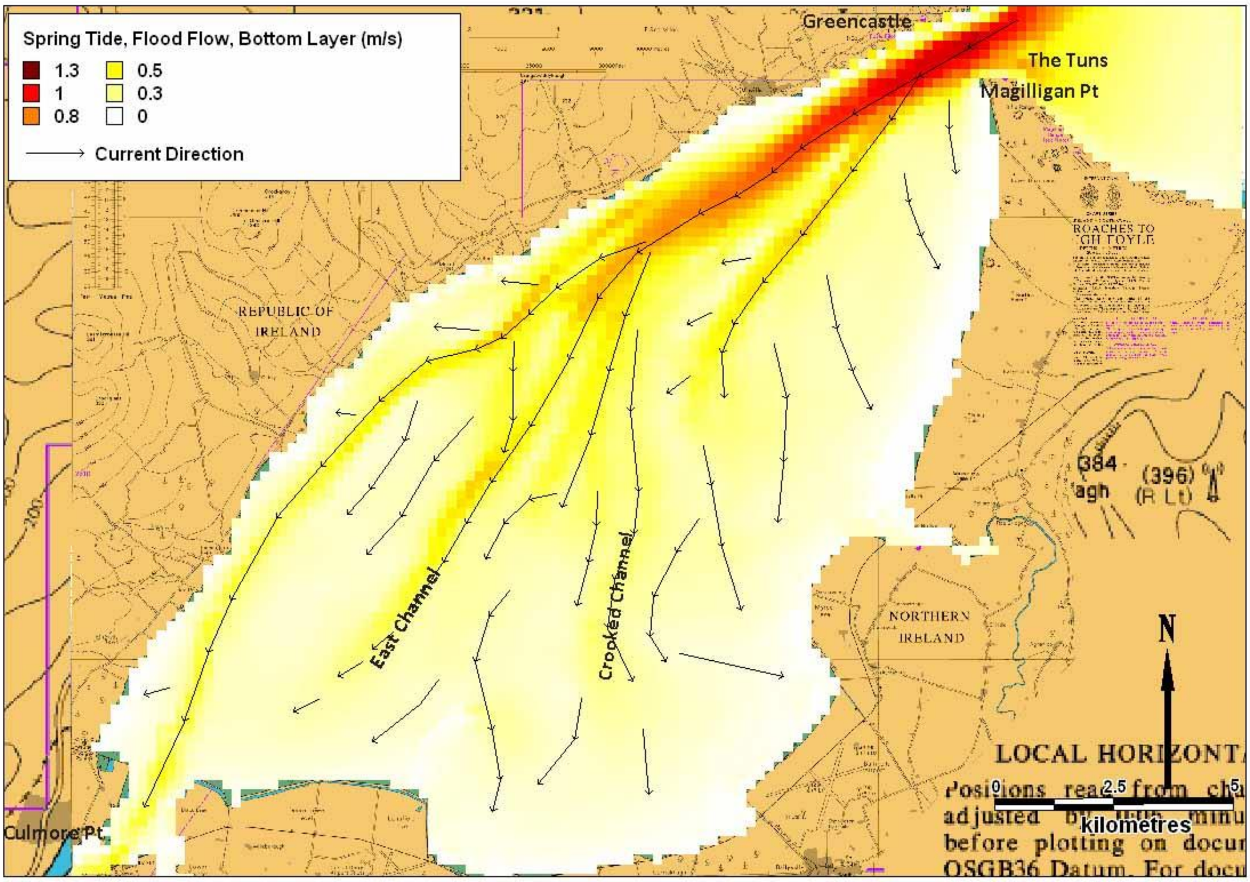


Figure 3.4: Surface current velocities and direction during a spring tide, ebb flow at 21:30:00 November 13th 2008 (Source: Deltares Delft3D-FLOW).

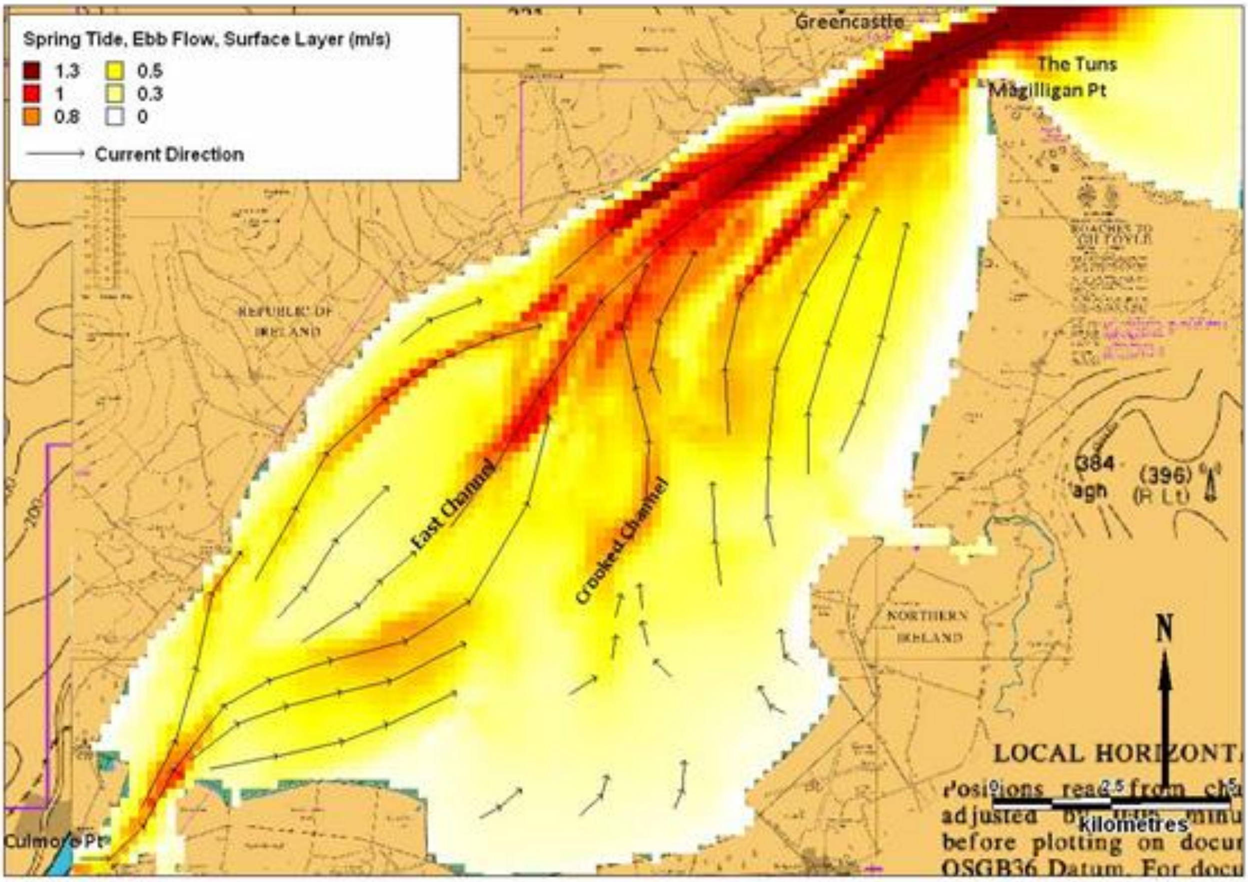


Figure 3.5: Bottom current velocities and direction during a spring tide, ebb flow at 21:30:00 November 13th 2008 (Source: Deltares Delft3D-FLOW).

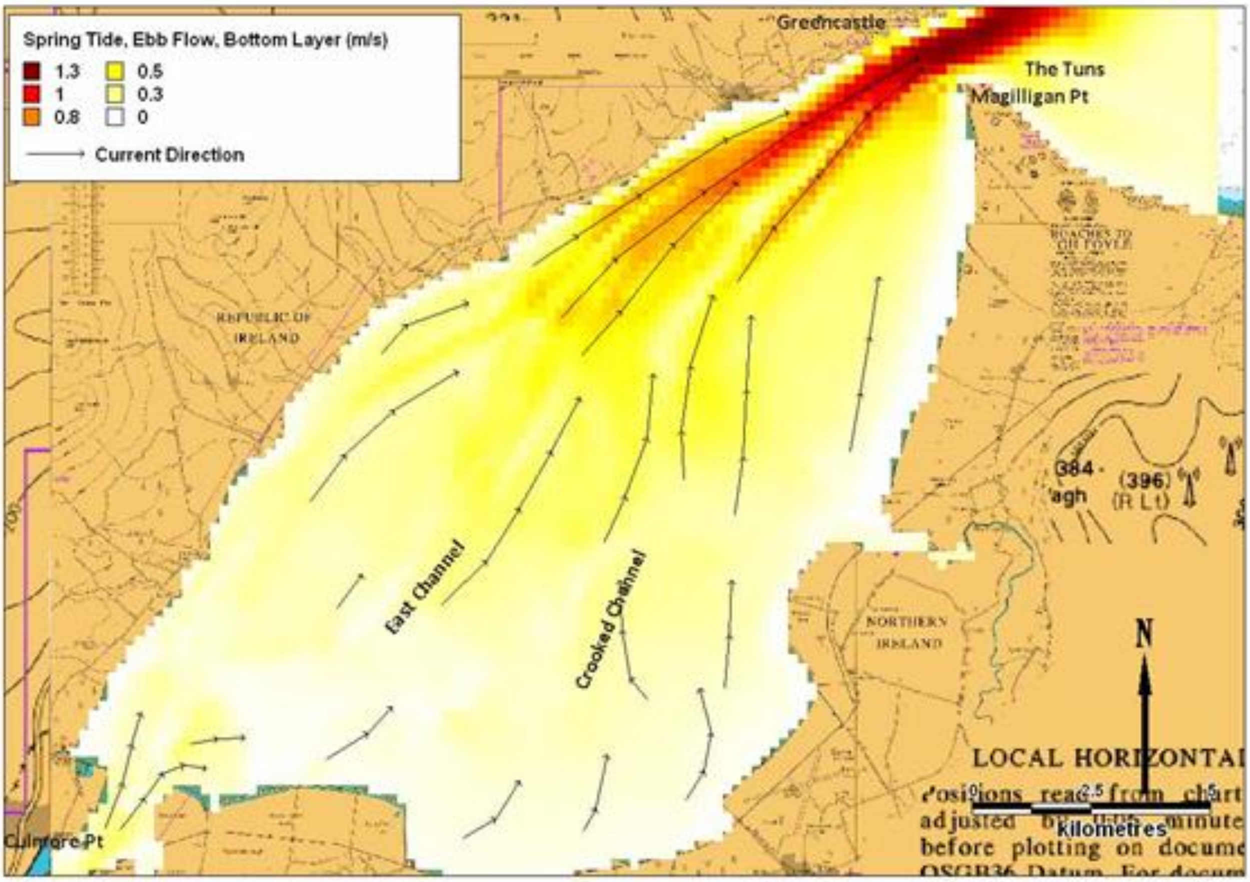


Figure 3.6: Surface current velocities and direction during a neap tide, flood flow at 10:30:00 November 5th 2008 (Source: Deltares Delft3D-FLOW).

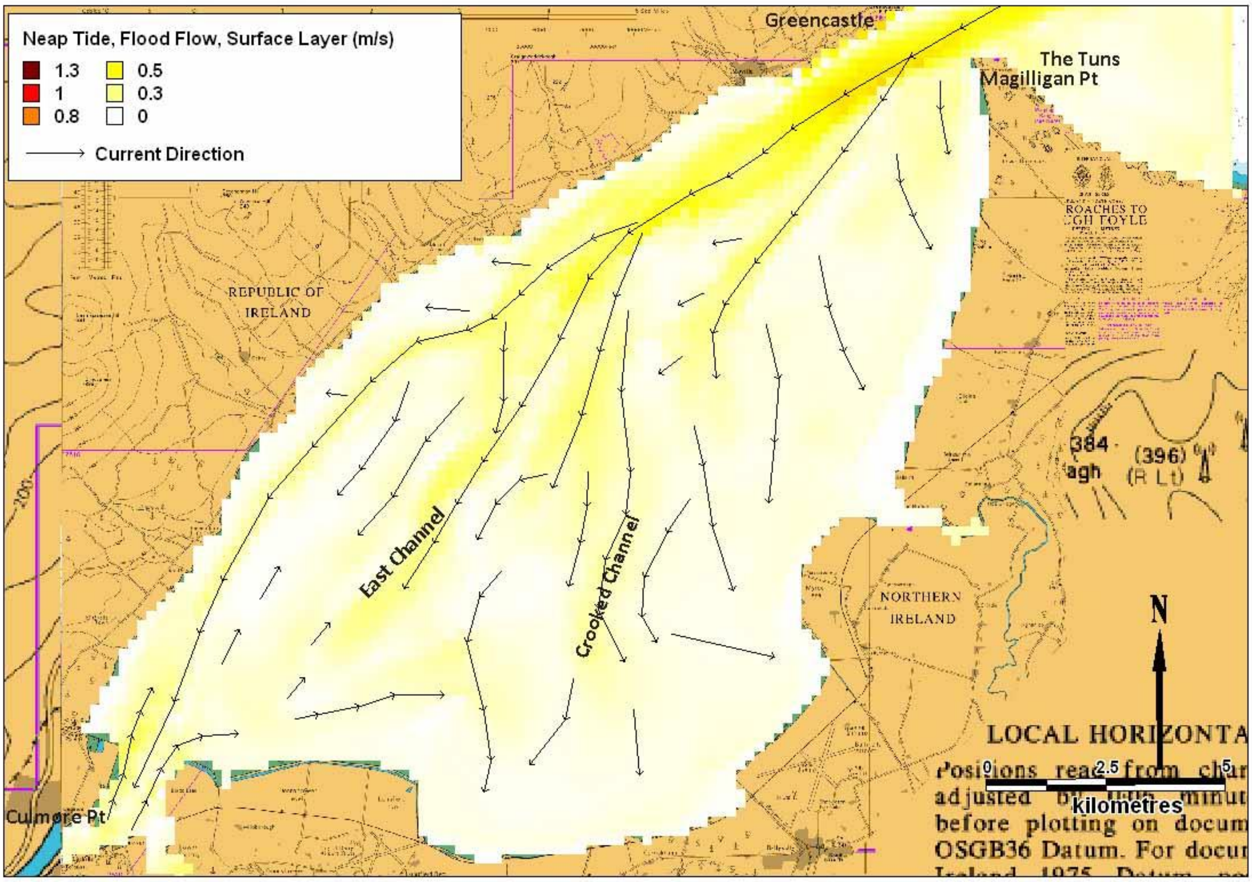


Figure 3.7: Bottom current velocities and direction during a neap tide, flood flow at 10:30:00 November 5th 2008 (Source: Deltares Delft3D-FLOW).

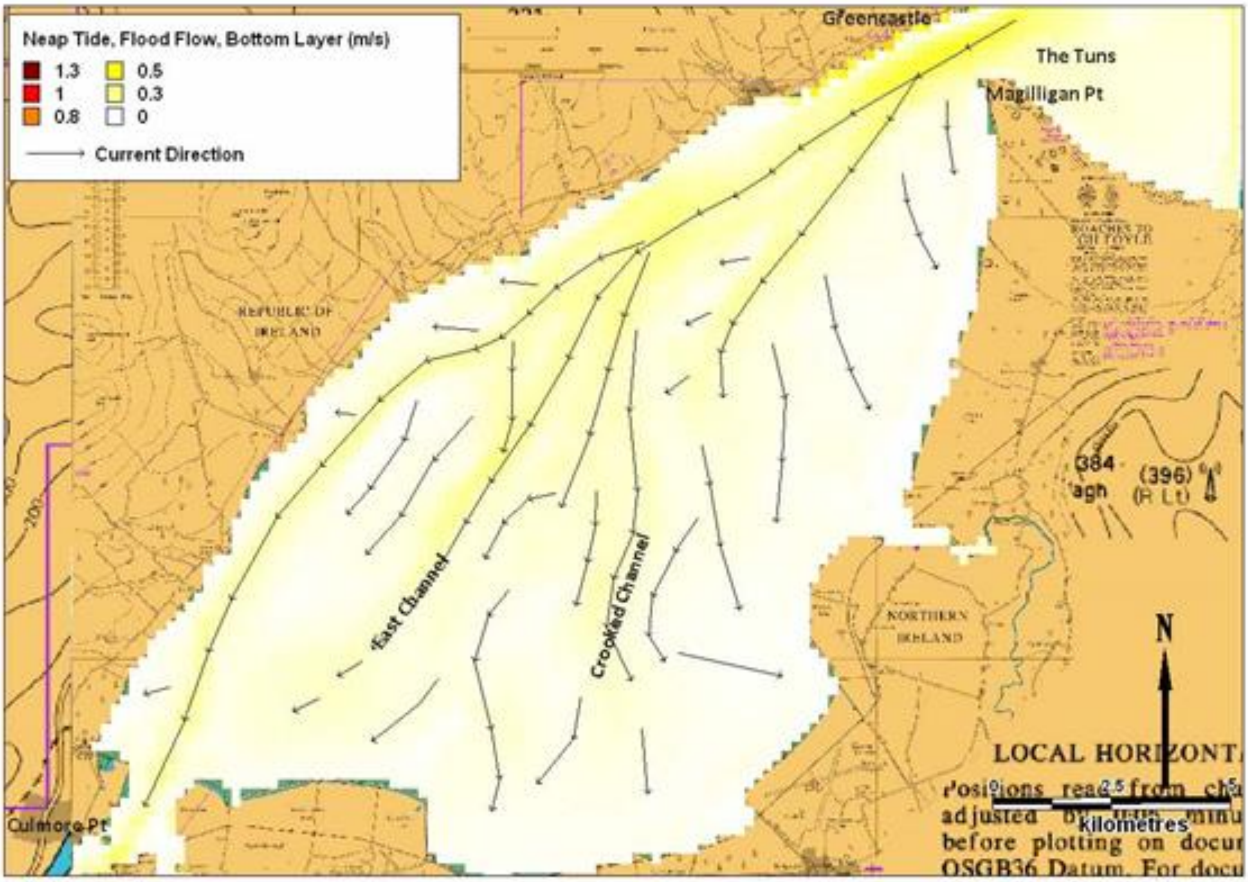


Figure 3.8: Surface current velocities and direction during a neap tide, ebb flow at 15:30:00 November 5th 2008 (Source: Deltares Delft3D-FLOW).

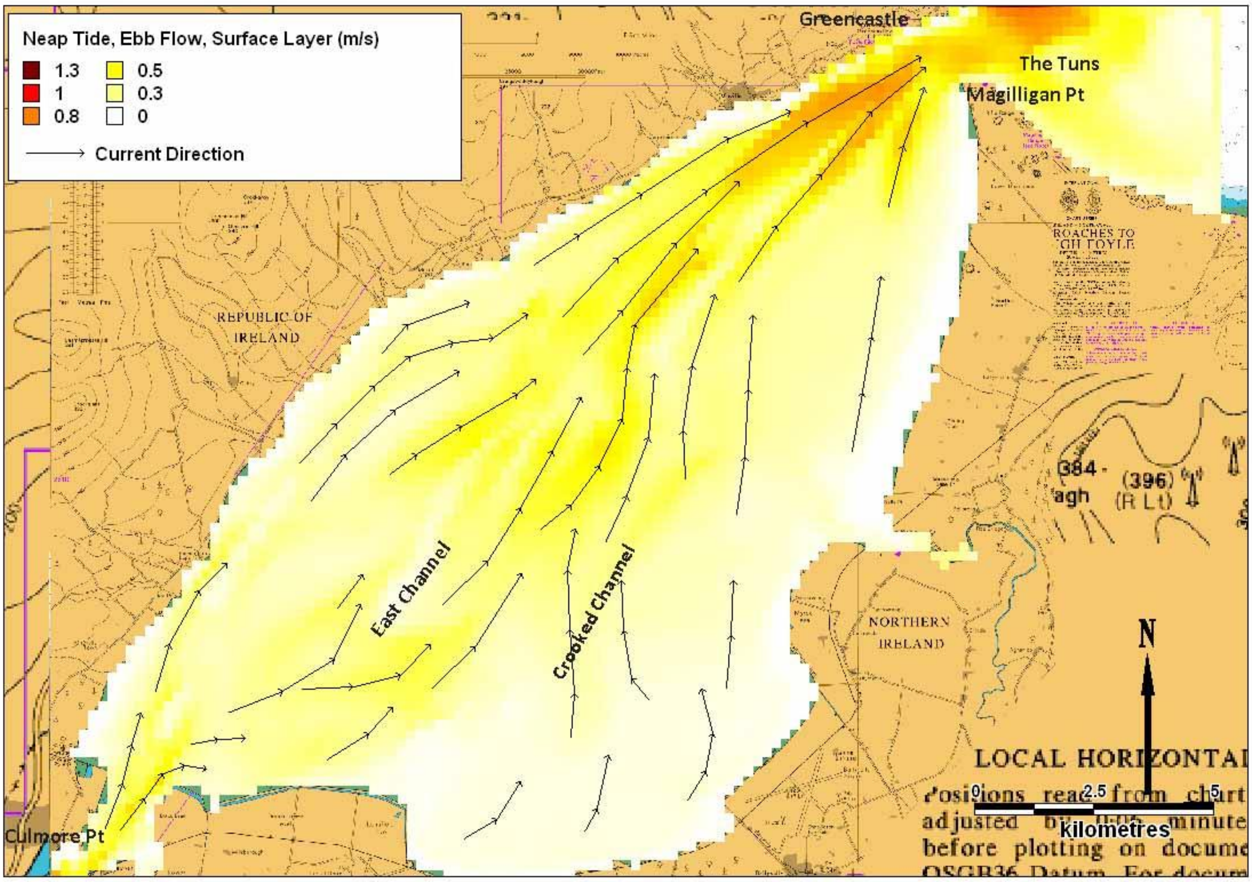
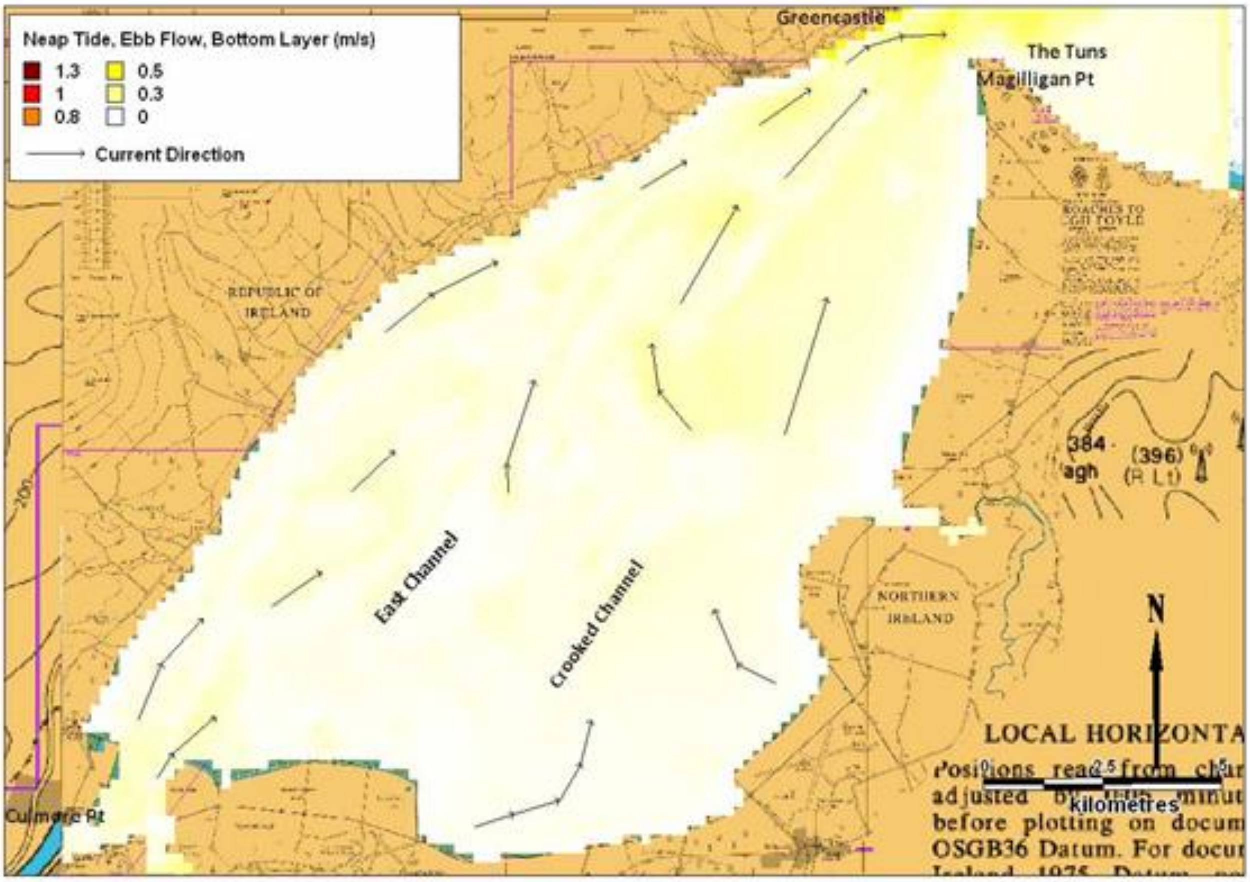


Figure 3.9: Bottom current velocities and direction during a neap tide, ebb flow at 15:30:00 November 5th 2008 (Source: Deltares Delft3D-FLOW).



From low water, the tidal currents start filling Lough Foyle from the southern side of the entrance channel: the flow first passes over The Tuns (a shallow offshore area east of the entrance to Lough Foyle), especially during spring tide, and only later arrives from the North Channel. Maximum flood velocities are found in the narrowest and deepest part of the entrance channel between Magilligan Point and Greencastle. The flow fills the Lough through the deeper channels before laterally flooding the shallower areas. Velocities over the shallow areas are low in comparison to the velocities in the tidal channels and navigation channel. Differences between the bottom and surface currents express themselves mainly in magnitude.

Water during flood flow largely moves into the East Channel, before flooding over the shallower tidal flats in the south, and also into the navigation channel. Under spring tidal conditions, the flood tidal flow pushes back the river flow and currents are directed upstream in the River Foyle mouth. Conversely, under neap tidal conditions, the tidal flow is less dominant relative to the river flow. At the bottom in the mouth of the Foyle, inward directed currents are still present, whereas at the surface, seaward directed river runoff is evident (see Figure 3.6 and Figure 3.7).

On the ebbing tide, strong currents are generated at the surface layer in the river mouth. Bottom velocities, especially in the vicinity of the river mouth, are relatively low in comparison to the surface velocities. This can be explained by the increased return flow in the surface layer due to the less dense river discharge affecting the vertical velocity profile.

The river discharge and tidal emptying of the south-western corner of Lough Foyle occurs mostly through East Channel and Crooked Channel. Water running off the shallow areas is not strictly confined to the deeper tidal channels, opposite to the flooding tide, but generally takes the shortest route towards the entrance channel. The strongest ebb currents occur in the entrance channel region.

The velocity distribution over Lough Foyle shows a clear spring-neap variation and a reduction in magnitude further into the Lough, with an exception in the river mouth. The largest velocities are found in the entrance channel with maximum of approximately 1.9 m/s on the ebb flow during spring tides and slightly lower maximums on the flood flow.

The current pattern in the river mouth is clearly affected by the density differences between the river runoff and sea water. Strong ebb flow peaks are generated at the surface and strong flood flow peaks at the bottom, pointing at stratified conditions and the influence of a salt-water wedge. In the navigation channel, large differences between the bottom and surface velocities are apparent during the ebb flow, whereas this is less evident during the flood flow. This is also related to the river discharge affecting the velocity profile over depth. The reduced flow in the top layer in flood currents is caused by the opposing river flow and the accelerated ebb flow by the reinforcement of the river flow. In addition, the bottom ebb tide velocities, especially during neap tide, are reduced due to the penetrating salt wedge, resulting in a net inland residual current (estuarine circulation).

The effect of density differences on flow patterns is evident from differences in current magnitudes over the vertical profile. However, it also affects current directions, resulting in a net estuarine circulation. The estuarine circulation affects the residual current pattern over Lough Foyle, which in turn has an effect on transport and sedimentation patterns. The net inward bottom flow due to estuarine circulation will give the bed load transport a mainly inward direction on the long term, whereas suspended sediment will be affected by both the inward directed bottom flow and outward directed surface flow. This generalised trend can be overruled by short-term events (e.g. storms), in which this sediment transport direction will depend on surges, wave and wind driven currents and local bathymetry.

3.1. Rainfall Data

3.1.1. Amount & Time of Year

Figure **3.10** and Figure 3.11 show the average monthly rainfall data for Northern Ireland (Met Office, 2010) from 1971 to 2000. Table 3.2 shows the average rainfall range and median value along the Lough Foyle coastline. During the period 1971 to 2000, the average rainfall along the Northern Ireland coastline of Lough Foyle ranged from 30-120mm, with the lowest levels occurring in May (40-60mm) and the highest levels occurring in December (60-120mm). The lowest median value was 50mm in May and the highest was 90mm in December. Table 3.3 shows the total seasonal rainfall values based on the median rainfall values. Seasonally, spring was the driest season (178mm) and winter was the wettest season (235mm). Seasons were selected by grouping the results from the following periods: spring (March - May), summer (June – July), autumn (September – November) and winter (December – February).

Figure 3.13 show the average monthly rainfall data for Northern Ireland (Met Office, 2021) from 1981 to 2010. Table 3.3 shows the average rainfall along the Lough Foyle coastline. During the period 1981 to 2010, the average rainfall along the Northern Ireland coastline of Donegal ranged from 56.9mm to 117.4mm, these values are similar to those reported from 1971 to 2000.

Figure 3.12 shows the seasonal averages for Northern Ireland from 1981 to 2010. Table 3.4 and Table 3.5 show the mean seasonal rainfall values. Similar to data from 1971 to 2000, spring was the driest season (205.9mm) and winter was the wettest season (316.4mm).

Figure 3.10: Average monthly rainfall (mm) data for January to June from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

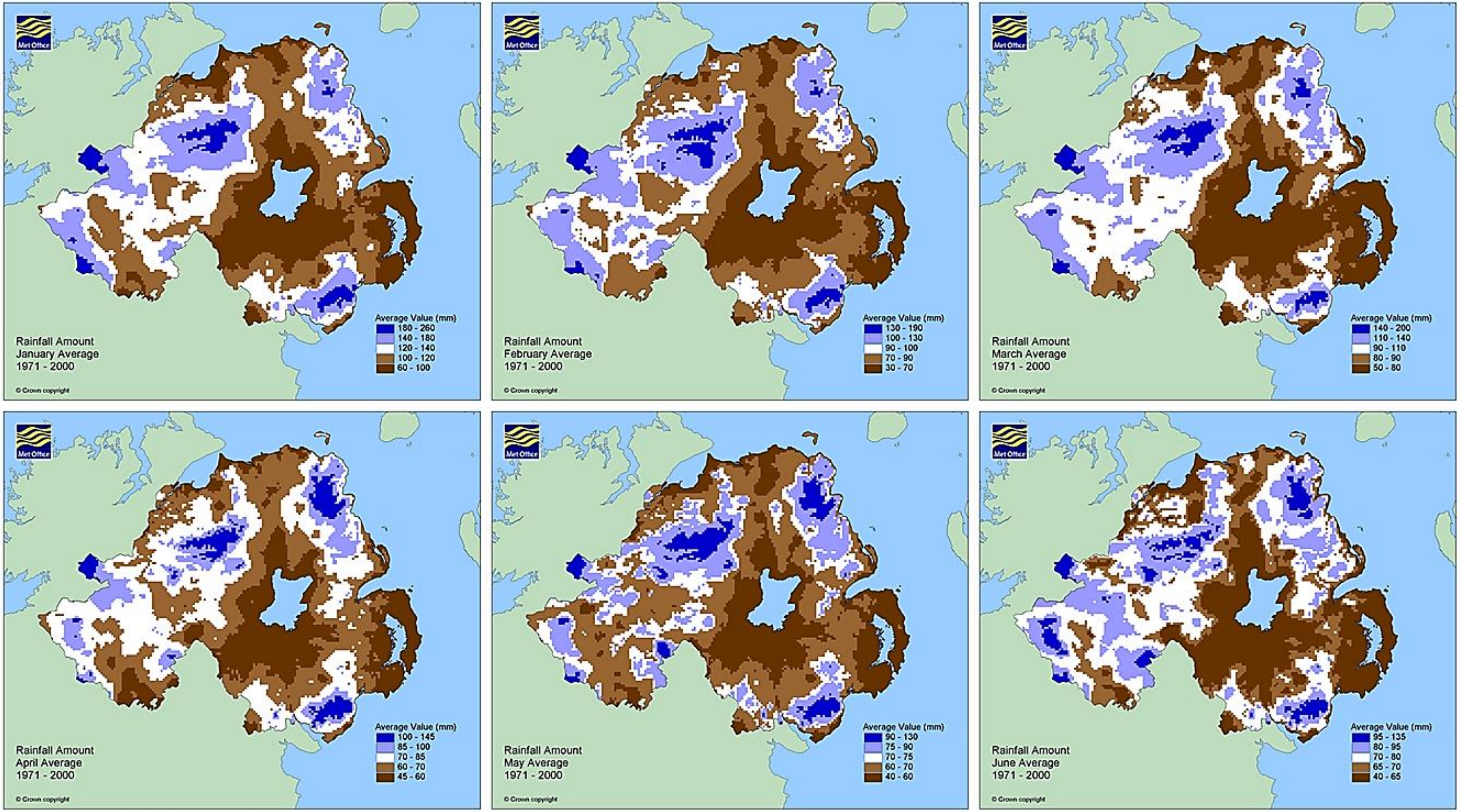


Figure 3.11: Average monthly rainfall (mm) data for July to December from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

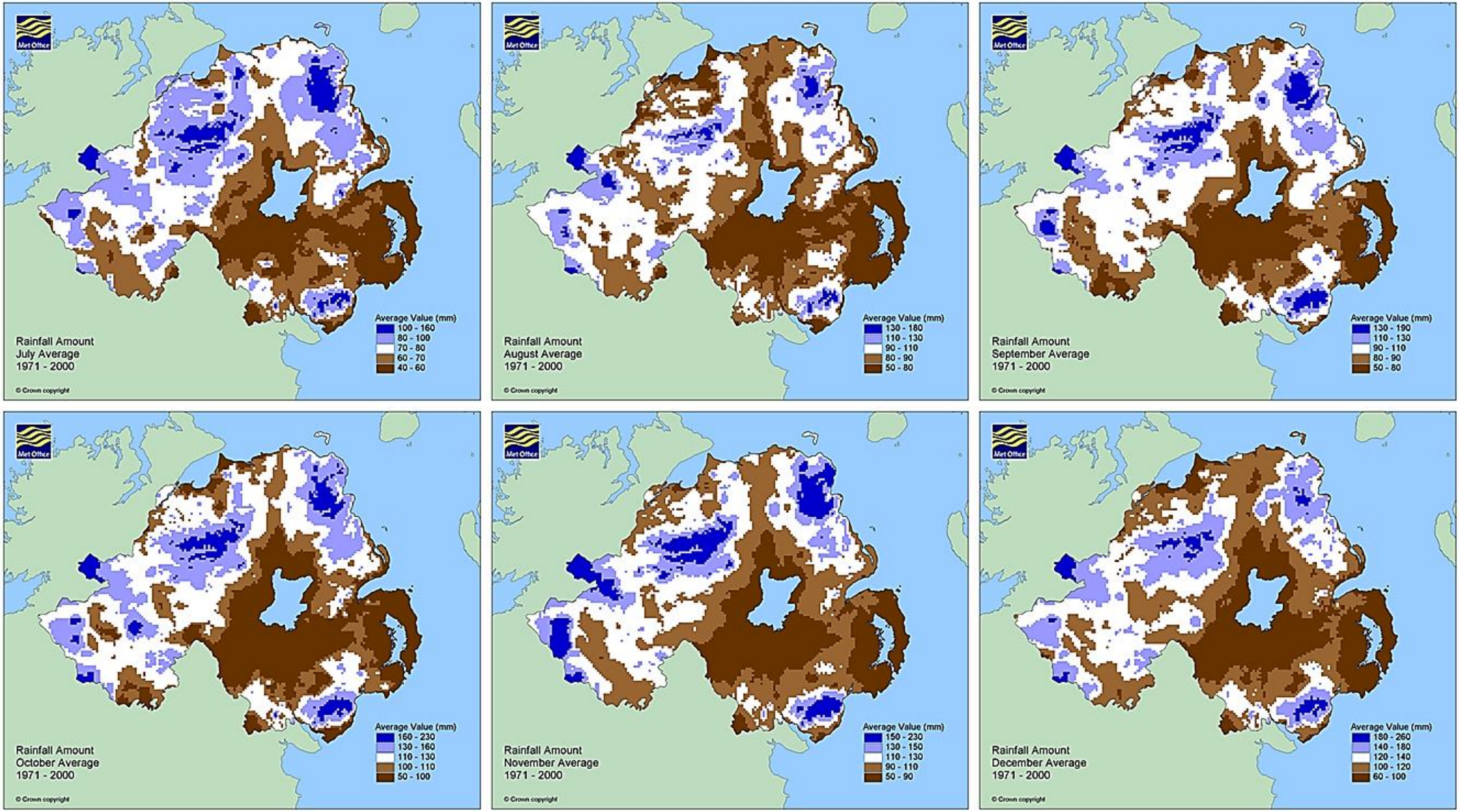


Figure 3.12: Average seasonal rainfall (mm) data from 1981 to 2010 for Northern Ireland (Source: Met Office, 2010).

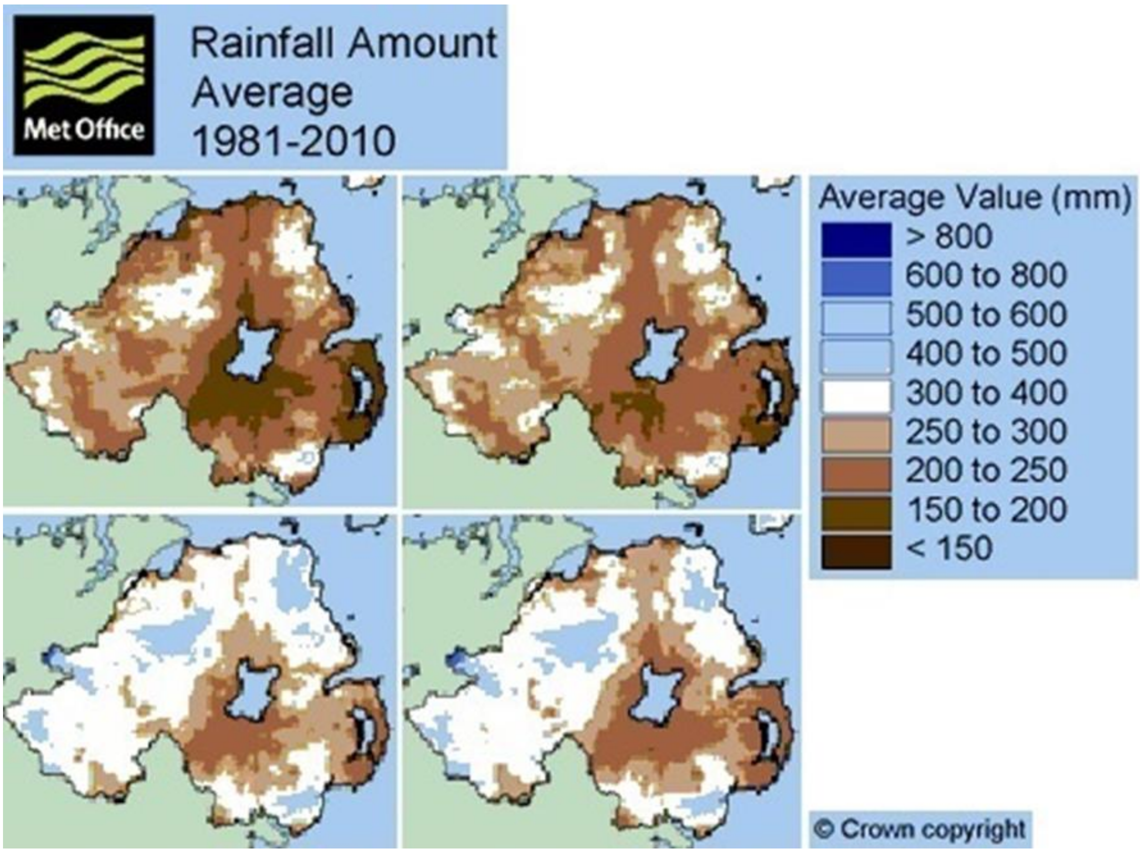


Figure 3.13: Average monthly rainfall (mm) data from 1981 to 2010 for Northern Ireland (Source: Met Office, 2010)

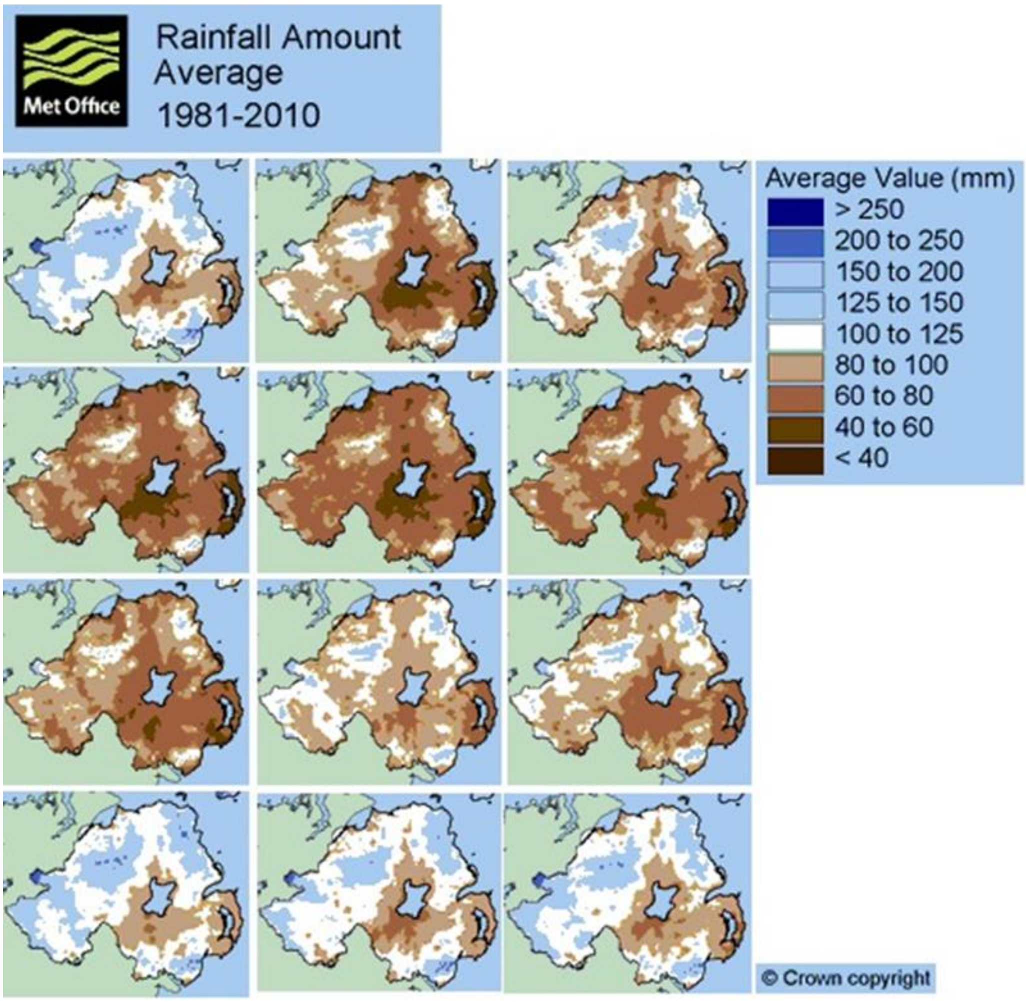


Table 3.2: Rainfall range and median monthly rainfall (mm) data along the Lough Foyle coastline from 1971 to 2000 (Source: Met Office, 2010).

Month/Season	Rainfall Range (mm)	Median Value (mm)
January	60-110	85
February	30-90	60
March	50-90	70
April	45-70	58
May	40-60	50
June	40-65	53
July	40-100	70
August	50-90	70
September	50-90	70
October	50-110	80
November	50-110	80
December	60-120	90

Table 3.3: Rainfall range and median monthly rainfall (mm) data along the Lough Foyle coastline from 1981 to 2010 (Source: Met Office, 2010).

Month/Season	Mean Value (mm)
January	117.4
February	84.8
March	85.9
April	63.1
May	56.9
June	69.1
July	76.8
August	93.2
September	91.8
October	118.4
November	104.5
December	114.2

Table 3.4: Total seasonal rainfall values (mm) from 1971-2000 based on the median rainfall value (Source: Met Office, 2010).

Season	Median
Spring	178
Summer	193
Autumn	230
Winter	235

Table 3.5: Total seasonal rainfall values (mm) from 1981-2010 based on the median rainfall value (Source: Met Office, 2010).

Season	Mean
Spring	205.9
Summer	239.1
Autumn	314.7
Winter	316.4

Table 3.6 shows average monthly rainfall data at Malin Head from 2005 to 2009 (Met Eireann, 2010a). Table 3.9 shows the total seasonal rainfall at Malin Head from 2005-2009 (Met Eireann, 2010a). The Malin Head station is located approximately 30km northwest of Lough Foyle. Rainfall ranged from 7.4mm in May 2008 to 227.6mm in November 2009. The following seasonal fluctuations were observed from 2005-2009: In 2005, the summer was the driest season and winter was the wettest, in 2006, summer was driest and autumn was the wettest, in 2007 spring was the driest and winter was the wettest, in 2008 spring was the driest and autumn and winter were the wettest and in 2009 winter was the driest season and autumn was the wettest. This data was collected from Met Eireann Monthly Weather Bulletins from 2005 to 2009.

Table 3.7 shows average monthly rainfall data at Malin Head from 2010 to 2015 (Met Eireann, 2021a). Table 3.10 shows the total seasonal rainfall at Malin Head from 2010-2015 (Met Eireann, 2021a). Rainfall ranged from 23mm in September 2014 (which was higher than data recorded from 2005 to 2009) to 272.9mm in December 2015. The following seasonal fluctuations were observed from 2010-2015: In 2010, the summer was the driest season and autumn was the wettest, in 2011, summer was driest and autumn was the wettest, in 2012 spring was the driest and autumn was the wettest, in 2013 spring was the driest and autumn and winter were the wettest in 2014 spring was the driest season and winter was the wettest season and in 2015 summer was the driest season and winter was the wettest. This data was collected from Met Eireann Monthly Weather Bulletins from 2010 to 2015.

Table 3.8 shows average monthly rainfall data at Malin Head from 2016 to 2020 (Met Eireann, 2021a). Table 3.11 shows the total seasonal rainfall at Malin Head from 2016-2020 (Met Eireann, 2021a). Similar to data from 2010 to 2015, rainfall ranged from 20.1mm in April 2020 to 210.4mm in February 2020. The following seasonal fluctuations were observed from 2016-2020: In 2016, the spring was the driest season and winter was the wettest, in 2017, spring was driest and summer was the wettest, in 2018 spring was the driest and winter was the wettest, in 2019 winter was the driest and summer and winter was the wettest and in 2020 spring was the driest season and winter was the wettest. This data was collected from Met Eireann Monthly Weather Bulletins from 2016 to 2020.

Table 3.6: Average monthly rainfall (mm) data at Malin Head, Co. Donegal from 2005 to 2009 (Source: Met Eireann, 2010a).

Month/Year	2009	2008	2007	2006	2005	Monthly Total	Monthly Average
Jan	98.8	188.9	161.5	67.6	139.1	655.9	131.18
Feb	40.4	89.6	63.9	40.6	75.2	309.7	61.94
Mar	87.6	142.7	59.7	107.2	65.2	462.4	92.48
Apr	94.7	54.2	32.6	69.9	78.8	330.2	66.04
May	95.2	7.4	101.8	73.4	94.6	372.4	74.48
Jun	47.7	74.8	83.3	63.3	65.9	335	67
Jul	72.2	125.8	105.4	74.1	24.3	401.8	80.36
Aug	170.9	123.2	86.2	73.1	128	581.4	116.28
Sep	71	89.9	79.5	112.7	94	447.1	89.42
Oct	108.6	144.8	77	123.9	109.5	563.8	112.76
Nov	227.6	115.6	102.1	170.2	107.7	723.2	144.64
Dec	57	85.7	109.4	184.7	103.8	540.6	108.12
Annual Total	1171.7	1242.6	1062.4	1160.7	1086.1	-	-
Annual Average	97.6	103.6	88.5	96.7	90.5	-	-

Table 3.7: Average monthly rainfall (mm) data at Malin Head, Co. Donegal from 2010 to 2015 (Source: Met Eireann, 2021a).

Month/Year	2015	2014	2013	2012	2011	2010	Monthly Total	Monthly Average
Jan	176	162.2	140.9	134.7	89.6	68.3	771.7	128.61
Feb	85.8	189.9	74.1	68.1	105.5	85.4	608.8	101.46
Mar	123.1	71.6	61.7	29.8	59	83.5	428.7	71.45
Apr	64.7	33.4	61.6	46.3	66.2	51.9	324.1	54.0
May	137	86.8	102.5	50.7	100.4	50.7	528.1	88.01
Jun	56.1	48.6	85.5	141.1	84.5	24.8	440.6	73.43
Jul	132.7	86	56.6	91.4	49.9	136	552.6	92.1
Aug	111	95.3	92.6	87.3	79	64.4	529.6	88.26
Sep	29.7	23	69.7	139.2	133	144.1	538.7	89.78
Oct	71.8	131.4	103.8	123.5	177.1	68.5	676.1	112.68
Nov	222.9	134.4	116	87.4	103.7	115.6	780	130
Dec	272.9	150.5	178.6	149.3	184.2	69.2	1004.7	167.45
Annual Total	1483.7	1213.1	1143.6	1148.8	1232.1	962.4	-	-
Annual Average	123.64	101.09	95.3	95.73	102.675	80.2	-	-

Table 3.8: Average monthly rainfall (mm) data at Malin Head, Co. Donegal from 2016 to 2020 (Source: Met Eireann, 2021b).

Month/Year	2016	2017	2018	2019	2020	Monthly Total	Monthly Average
Jan	166.3	56.7	203.7	81.5	79.3	587.5	117.5
Feb	130.7	85.1	74.2	59.7	210.4	560.1	112.02
Mar	72.7	96.9	67.2	138.8	79.4	455	91
Apr	52.9	41.1	63.4	49.9	20.1	227.4	45.48
May	65.6	50.9	41.5	79.9	37.3	275.2	55.04
Jun	72.4	77.7	51.1	67.3	106.3	374.8	74.96
Jul	109.9	114.6	60.3	85.9	133.8	504.5	100.9
Aug	79.9	172.5	126	162.9	123.1	664.4	132.88
Sep	94.7	88.2	108.5	124.5	115.7	531.6	106.32
Oct	37.6	109.9	105.8	83.4	148.4	485.1	97.02
Nov	113.9	137.5	100.8	91.7	130	573.9	114.78
Dec	76	117	97.7	124.2	144.3	559.2	111.84
Annual Total	1072.6	1148.1	1100.2	1149.7	1328.1	-	-
Annual Average	89.38	95.675	91.68	95.80	110.67	-	-

Table 3.9: Total seasonal rainfall (mm) at Malin Head from 2005-2009 (Source: Met Eireann, 2010a).

Season/Year	2009	2008	2007	2006	2005
Spring	277.5	204.3	194.1	250.5	236.8
Summer	290.8	323.8	274.9	210.5	218.2
Autumn	407.2	350.3	258.6	406.8	311.2
Winter	196.2	364.2	334.8	292.9	318.1

Table 3.10: Total seasonal rainfall (mm) at Malin Head from 2010-2015 (Source: Met Eireann, 2010a).

Season/Year	2010	2011	2012	2013	2014	2015
Spring	186.1	225.6	126.8	225.8	191.8	324.8
Summer	225.2	213.4	319.8	234.7	229.9	299.8
Autumn	328.2	413.8	350.1	289.5	288.8	324.4
Winter	222.9	379.3	352.1	393.6	502.6	534.7

Table 3.11: Total seasonal rainfall (mm) at Malin Head from 2016-2020 (Source: Met Eireann, 2010a).

Season/Year	2016	2017	2018	2019	2020
Spring	191.2	188.9	172.1	268.6	136.8
Summer	262.2	364.8	237.4	316.1	363.2
Autumn	246.2	335.6	315.1	299.6	394.1
Winter	373	258.8	375.6	265.4	434

3.1.2. Frequency of Significant Rainfalls

Figure 3.14 and Figure 3.15 show the average monthly rainfall for the Lough Foyle area from 1971-2000 and 2081-2010 respectively. Figure 3.17 shows the average monthly rainfall data at the Malin Head station from 2005-2009. October, November, December and January are typically the wettest months on average 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 as can be seen in Figure 3.16 and Figure 3.17 when July and August experienced very heavy rainfall in 2008 and 2009.

Figure 3.15 shows the average monthly rainfall for the Lough Foyle area from 1981-2010. Figure 3.18 shows the average monthly rainfall data at the Malin Head station from 2010-2015 and Figure 3.19 shows the average monthly rainfall data at the Malin Head station from 2016-2020. October, November, December and January are typically the wettest months on average similar to data from 2005 to 2009 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 as can be seen in Figure 3.18 and Figure 3.19 when July and August experienced very heavy rainfall in 2008, 2009, 2017, 2019 and 2020.

Figure 3.14: Average monthly rainfall (mm) data along the Lough Foyle coast from 1971-2000 (Source: Met Office, 2010).

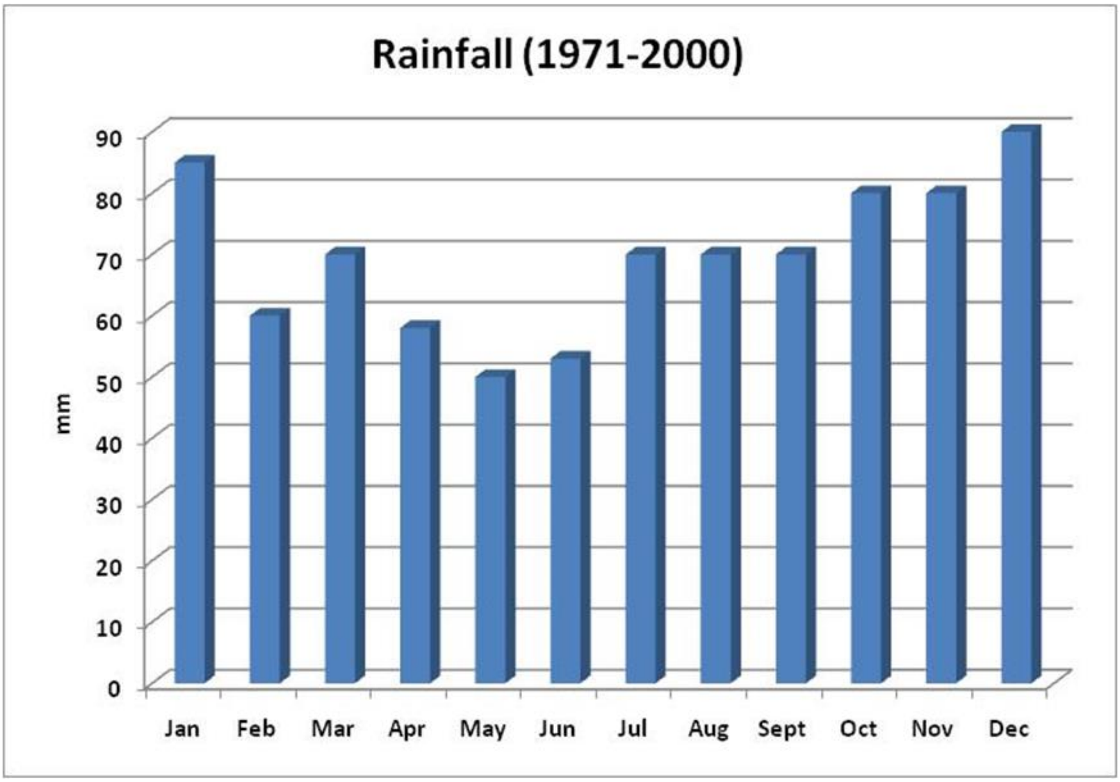


Figure 3.15: Average monthly rainfall (mm) data along the Lough Foyle coast from 1981-2010 (Source: Met Office, 2010).

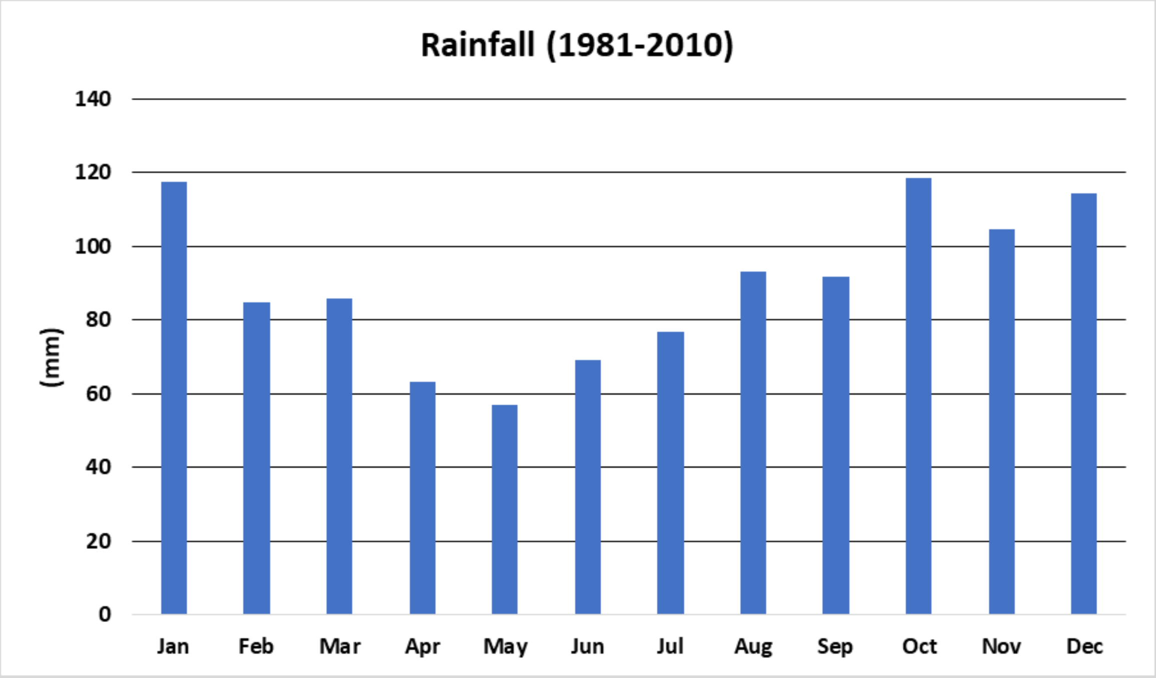


Figure 3.16: Average monthly rainfall (mm) data along the Lough Foyle coast from 2005-2009 (Source: Met Eireann, 2010a).

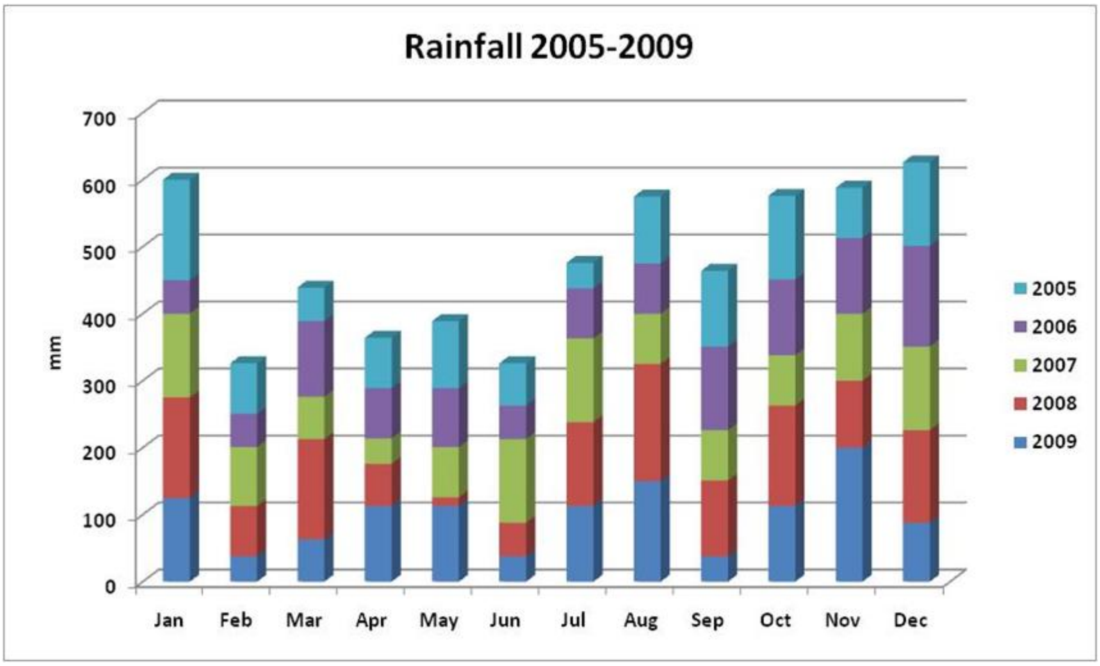


Figure 3.17: Average monthly rainfall (mm) data at Malin Head, Co. Donegal from 2005 to 2009 (Source: Met Eireann, 2010a).

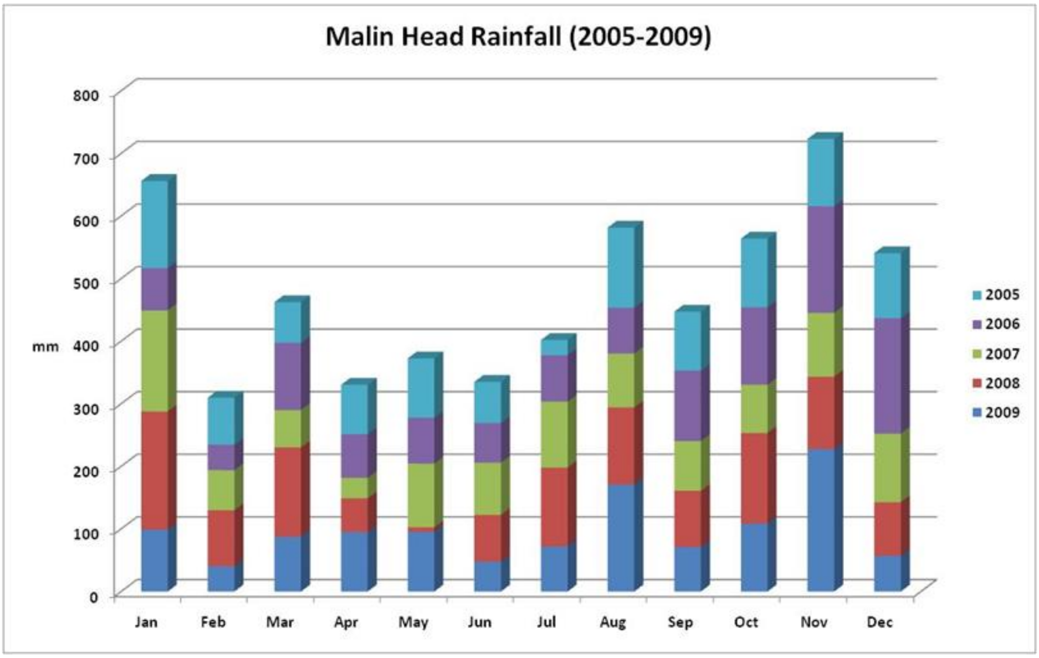


Figure 3.18: Average monthly rainfall (mm) data at Malin Head, Co. Donegal from 2010 to 2015 (Source: Met Eireann, 2021).

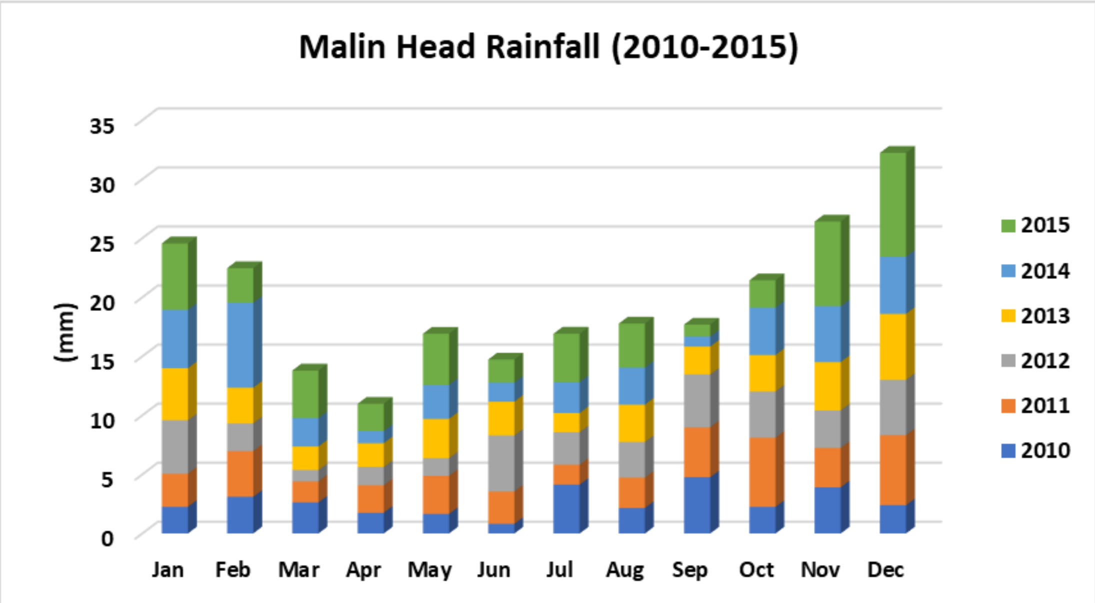
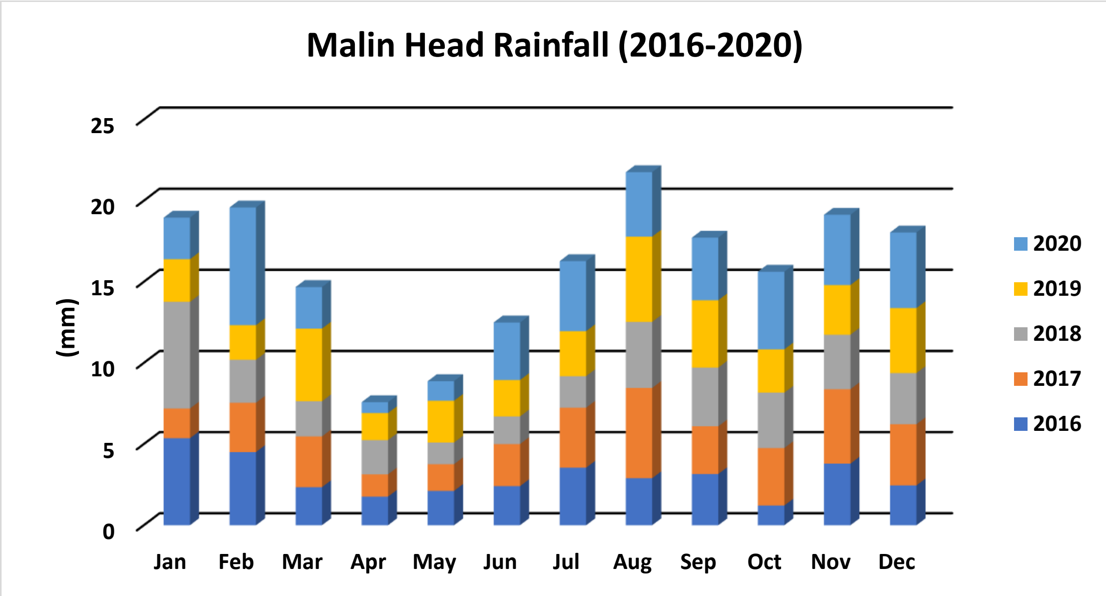


Figure 3.19: Average monthly rainfall (mm) data at Malin Head, Co. Donegal from 2016 to 2020 (Source: Met Eireann, 2021).



3.2. Wind and Waves

Wind data for Malin Head from 2005 to 2009 is displayed in Table 3.12 below and wind roses for each year can be seen Figure 3.20 in below. In 2005, 25% of the wind came from the south south west; while 16.7% each came from the north, east south east and the south. The strongest winds came from the south south west (16-21 knots). In 2006, 25% of the wind came from the south while 16.7% each came from the north, west, west south west and south south west. The strongest winds in 2006 came from the south, north and west (16-21 knots). In 2007, 25% of the wind came from the south while 16.7% each came from the north northwest and south west. The strongest winds in 2007 were from the south west (>21 knots). In 2008, 25% of the winds came from both the north and west south west. The strongest winds in 2008 came from the north, north north west, north west and west south west (16-21 knots). In 2009 20% of the wind came from each of the following directions: east north east, south west and west south west. The strongest winds in 2009 came from the south east. Table 3.14 shows the seasonal averages from 2005 to 2009. Seasonal averages over the past 5 years indicate that winds are typically stronger in the winter months, decreasing by approximately 2 knots in the spring and decreasing by approximately a further 3.5 knots in the summer and increasing by approximately 3 knots in autumn.

Wind data for Malin Head from 2016 to 2020 is displayed in Table 3.14 below and wind roses for each year can be seen in Figure 3.20. In 2016, 25% of the wind came from the south; while 25% came from the south south east, 16.67% came from the south west and 33% came from the south south west. The strongest winds came from the south south west (18.3 knots). In 2017, 33% of the wind came from the south south west, 35% came from the south south east, 25% came from the south west and 8% came from both the west and west south west. The strongest winds in 2017 came from the south south east (17.6 knots). In 2018, 33% of the wind came from the south west, 16.67 came from both the south south east and south east, and 8% came from both the south and west south west. The strongest winds in 2018 were from the south west (18.4 knots). In 2019 33.3% of the winds came from the south west, 25% from the south, 16.67% from south south west, 16.67% from the south east and 8% from the east. The strongest winds in 2019 came from the south south west (18.42 knots). In 2020 41.6% of the wind came from south west, 16.67% came from the south south west, 25% came from the south south east, 8% from the south and 8% came from the south west. The strongest winds in 2020 came from the south west (22.3knots).

Table 3.15 shows the seasonal averages from 2016 to 2020. Seasonal averages over the past 5 years indicate that winds are typically stronger in the winter months, decreasing by approximately 2 knots in the spring and decreasing by approximately a further 3 knots in the summer and increasing by approximately 5 knots in autumn. This data does not differ much from 2005-2009 data with similar seasonal averages reported for both sets of data.

Table 3.12: Wind speed and direction data for Malin Head from 2005-2009 (Source: Met Eireann, 2010a).

	2005		2006		2007		2008		2009	
Month	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**
January	20.7	200	15.7	200	21.5	230	18.4	250	16.5	140
February	15.8	340	16.6	360	15.8	190	18.7	350	14.4	60
March	14.1	360	16.1	170	17.9	350	20.4	320	16	360
April	14.4	210	14.9	10	11.4	310	17.3	10	12.1	70
May	11	110	16.3	190	13.8	220	13.1	130	14.8	230
June	8.5	230	11.6	250	11.8	90	14.5	240	10.7	250
July	8.6	210	10.5	210	10.2	180	14.2	170	10.8	100
August	9.9	170	13.3	300	12.7	340	12.8	110	12.3	230
September	13	190	13	180	13.5	340	12.3	50	12.8	170
October	13.2	110	15.2	250	13	180	19.2	10	12.1	250
November	15.8	350	19.3	260	17.2	50	17.4	330	n/a	n/a
December	13.7	150	17.5	280	16.5	150	15.6	250	n/a	n/a

Table 3.13: Wind speed and direction data for Malin Head from 2016-2020 (Source: Met Eireann, 2021a).

	2016		**2017**		**2018**		**2019**		**2020**	
Month	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**	**Mean Speed (kn)**	**Max 10-min Mean Dir (°)**
January	18.3	194.51	16.5	201.93	18.4	210.32	15.3	220.645	19.1	225.48
February	17.8	217.24	17.6	174.64	17.2	210	15.9	175.35	22.3	230.68
March	13.1	214.19	14	176.77	17.8	149.03	18.4	224.83	16.5	193.87
April	15.2	156	14.4	229.66	14.3	140.66	15.6	125.33	12.4	157.66
May	12.1	159.67	11.3	164.51	11.7	185.48	10.9	183.22	13.2	153.22
June	9.9	176	14.5	204.13	9.2	168.33	12.3	139.33	12.1	206.33
July	12.4	213.54	13	201.93	9.9	218.70	11.4	203.548	13.4	233.22
August	13.3	186.12	13.1	226	13.3	209.35	13.6	215.62	11.5	164.83
September	14.6	185	15	216	16.3	246.33	13.8	215.66	14.2	189
October	13.7	149.66	18	225.16	16.7	227.41	16.3	172.90	17.2	225.80
November	14.9	197.33	16.9	267	17.5	152.66	14.9	98.33	15.6	220
December	16.8	192.90	16.9	252.58	15.8	201.61	17.3	223.87	17.9	208.06

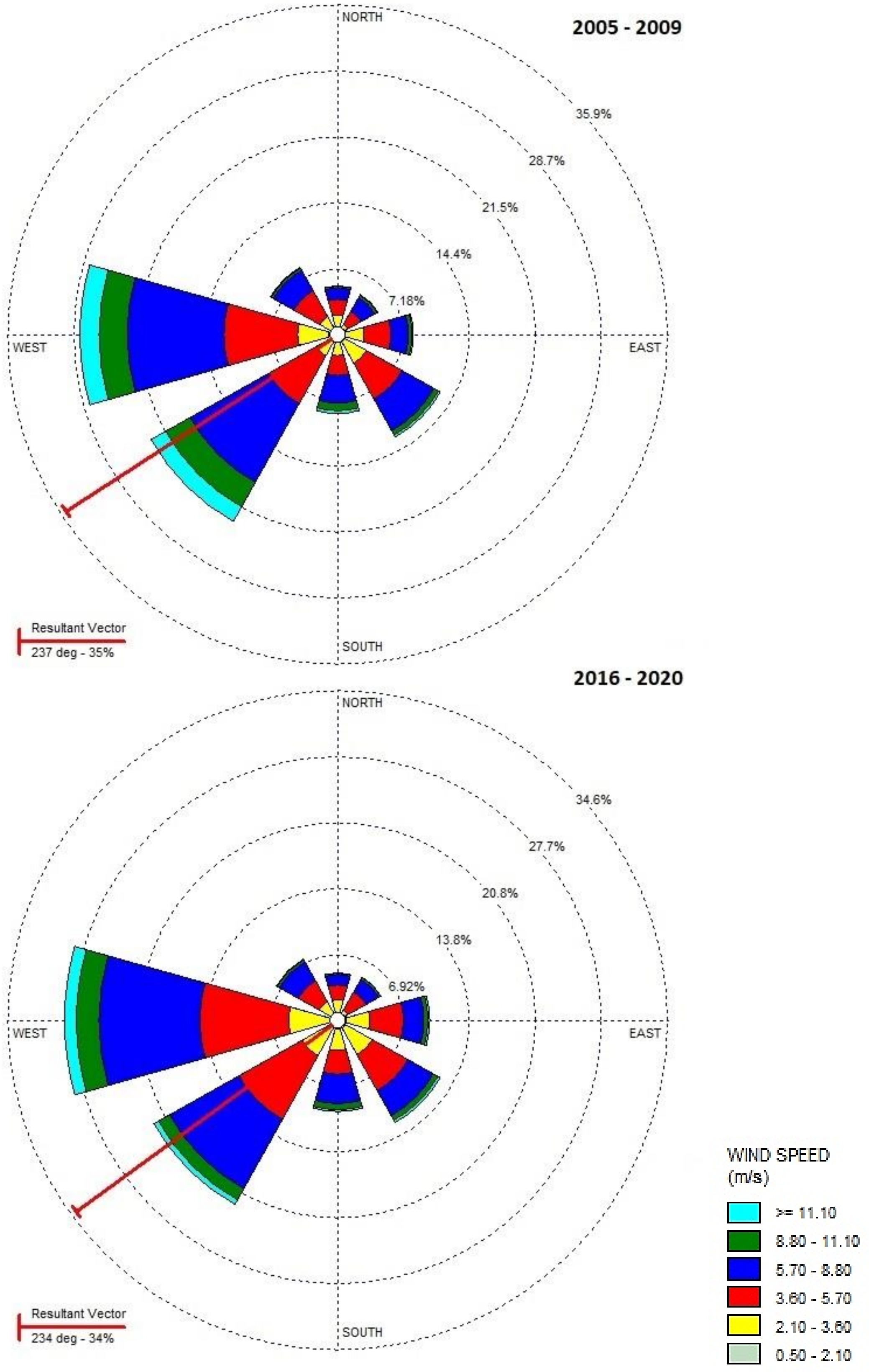
Table 3.14: Seasonal averages (knots) for Malin Head wind data 2005 - 2009 (Source: Met Eireann, 2010a).

Season	2009	2008	2007	2006	2005	5-year Average
Winter	15.5	17.6	17.9	16.6	16.7	16.9
Spring	14.3	16.9	14.4	15.8	13.2	14.9
Summer	11.3	13.8	11.6	11.8	9	11.5
Autumn	12.5	16.3	14.6	15.8	14	14.6

Table 3.15: Seasonal averages (knots) for Malin Head wind data 2016 – 2020 (Source: Met Eireann, 2021a).

Season	2020	2019	2018	2017	2016	5-year Average
Winter	19.76	16.16	17.13	17	17.63	17.54
Spring	14.03	14.96	14.6	13.23	13.46	14.06
Summer	12.33	12.43	10.8	13.53	11.86	12.19
Autumn	15.66	15	16.83	16.63	14.4	15.70

Figure 3.20: Wind roses for Malin Head from 2005 to 2009 and 2015 to 2020. (Source: Met Eireann, 2021a).



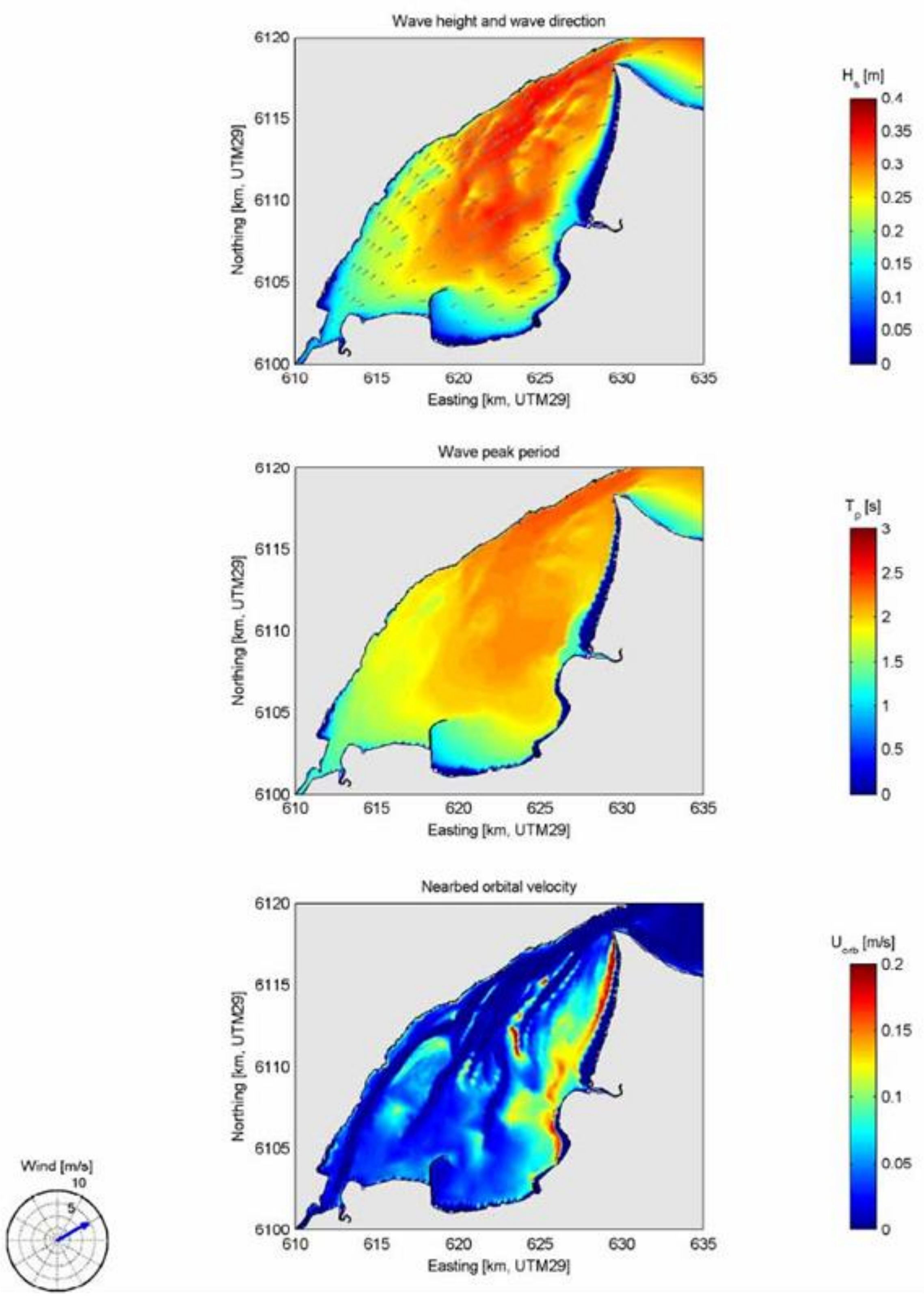
Wind conditions affect the hydrodynamic conditions in Lough Foyle by generating set up, wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Especially over the vast shallow areas of Lough Foyle, wave-induced bottom friction may lead to resuspension of material and entrainment of sediments in the water column. Atkins (1992) reports that even for the smallest wind waves (< 30cm), the critical shear stress may be exceeded for resuspension of fine material in shallow areas.

Wind data recorded at the port of Lisahally at the south-western corner of Lough Foyle, from 1/1/2006 to 25/11/2008 was used to analyse the local wind conditions for the Delft3D-FLOW model (Deltares, 2009). It should be noted that there were gaps in the dataset used i.e. December 2006, August-September 2008 and December 2008. The median wind speed over the months varied between 6 and 8 m/s, with a mean monthly average of 7 m/s. Over the year a slight seasonal effect was apparent, with lower wind speeds in summer months and somewhat higher in winter months. The mean monthly wind direction was 240°N (WSW), which corresponds to the approximate orientation of Lough Foyle. A strong divergence of the average value occurred in the month of May, when mean wind direction was 150°N (SSE). No clear seasonal effect in mean direction was apparent; however during spring and summer, the wind direction was more variable than during autumn and winter. It is expected that because of the hills alongside the Lough, the wind is somewhat tunnelled in the direction of the Lough and will have an even more uniform direction over the water. It is therefore expected that the potential for wind driven advection of potentially contaminated surface waters is predominately from the head to the mouth of the Lough.

There is no significant offshore wave penetration into Lough Foyle beyond Greencastle (Deltares, 2009). Any wave energy arriving from offshore is presumable dissipated mostly on The Tuns (a shallow area east offshore of the Lough's entrance) and does not enter the narrow entrance channel to Lough Foyle. Local wind generated waves thus predominate the wave climate in Lough Foyle. Atkins (1992) reports monthly wave height exceedances based on local wind data. Their analysis showed that during the winter months, wave heights exceeded 0.9 m only 1% of time and 0.6 m about 7% of time. In summer, there is a 2% exceedance of 0.6 m and 17% of 0.3 m. This shows that Lough Foyle experiences mild wave conditions over the year.

Figure 3.21 shows wave heights, peak period and near-bed orbital velocity for a wind speed 7m/s and a wind direction of 240°. This was produced by Deltares using the wave model SWAN (Booij et al., 1999). The predominant wind direction (240°, WSW) lies parallel to the dominant axis of the Lough, therefore resulting in the longest fetch length and highest waves on the northeasterly shore. The maximum computed wave height at the downwind shore is approximately 0.3m and maximum wave period of 2s. On the shallow tidal flats, the wave heights are reduced because of depth limitations, whereas the highest and longest waves are found in the deeper channels of the Lough. However, the largest near-bed velocities (and bed shear stresses) were found on the shallow areas (see Figure 3.21, lowest panel), indicating that most sediment resuspension through wave action takes place in these areas.

Figure 3.21: Computed wave height, peak period and near-bed orbital velocity for wind speed of 7 m/s and a wind direction of 240° (Source: Deltares, 2009).



3.3. River Discharges

Lough Foyle receives a large quantity of freshwater from the rivers Foyle, Faughan and Roe (Loughs Agency, 2009b). Figure 3.22 below shows the catchment areas of these rivers with three permanent measuring stations, operated by the Rivers Agency. It should be noted that there is no operational measurement data available for the River Foyle. Therefore, the measurement station at River Mourne (Drumnabouy House) was used as a representative for the variations in river discharge for the River Foyle. Based on the records at these locations (15 min. interval) strong yearly variation in fluvial flow can be observed for all three rivers. Peaks in discharge occur in all rivers after large rain events.

The discharge for Drumnabouy House (River Mourne) is presented in Figure 3.23 for the period 2006 - 2008. Strong seasonal patterns in river flow are evident with the largest discharges in late summer and autumn. The average monthly values range from 10 to 75 m3/s. The peak recorded discharge reached 1058 m3/s on 22-Oct-1987. Based on the time series, characteristic discharge values are derived for the three rivers, presented in Table 3.16. Average values are 7 m3/s for the River Faughan, 8 m3/s for the River Roe and 58 m3/s for the River Mourne. No permanent record for the actual river discharge at River Foyle is available. The Loughs Agency report a mean value of 90 m3/s for the River Foyle (Loughs Agency, 2009b).

The river discharge also determines the limit of tidal influence upriver, the vertical current profiles near the river mouth and the distance that the salt wedge travels upriver. During periods of high river flows, the tide will be kept back further than during lower river flows.

The discharge for Drumnabouy House (River Mourne) is presented in Figure 3.24 for the period 2009- 2015. Similar to data from 2006 to 2008, strong seasonal patterns in river flow are evident with the largest discharges in late summer and autumn. The average monthly values range from 6.3 to 205.15m3/s. The peak recorded discharge reached 205.15 m3/s in November 2009.

The discharge for Drumnabouy House (River Mourne) is presented in Figure 3.25 for the period 2016 – 2020. Strong seasonal patterns in river flow are evident with the largest discharges in late summer and autumn which is similar to data recorded from 2006-2008 and 2009-2015. The average monthly values range from 10.33 to 215.77 m3/s which is similar to values reported for the period 2009-2015. The peak recorded discharge reached 215.77 m3/s in February 2020.

Figure 3.22: Rivers and river monitoring stations (Source: NRFA, 2020).

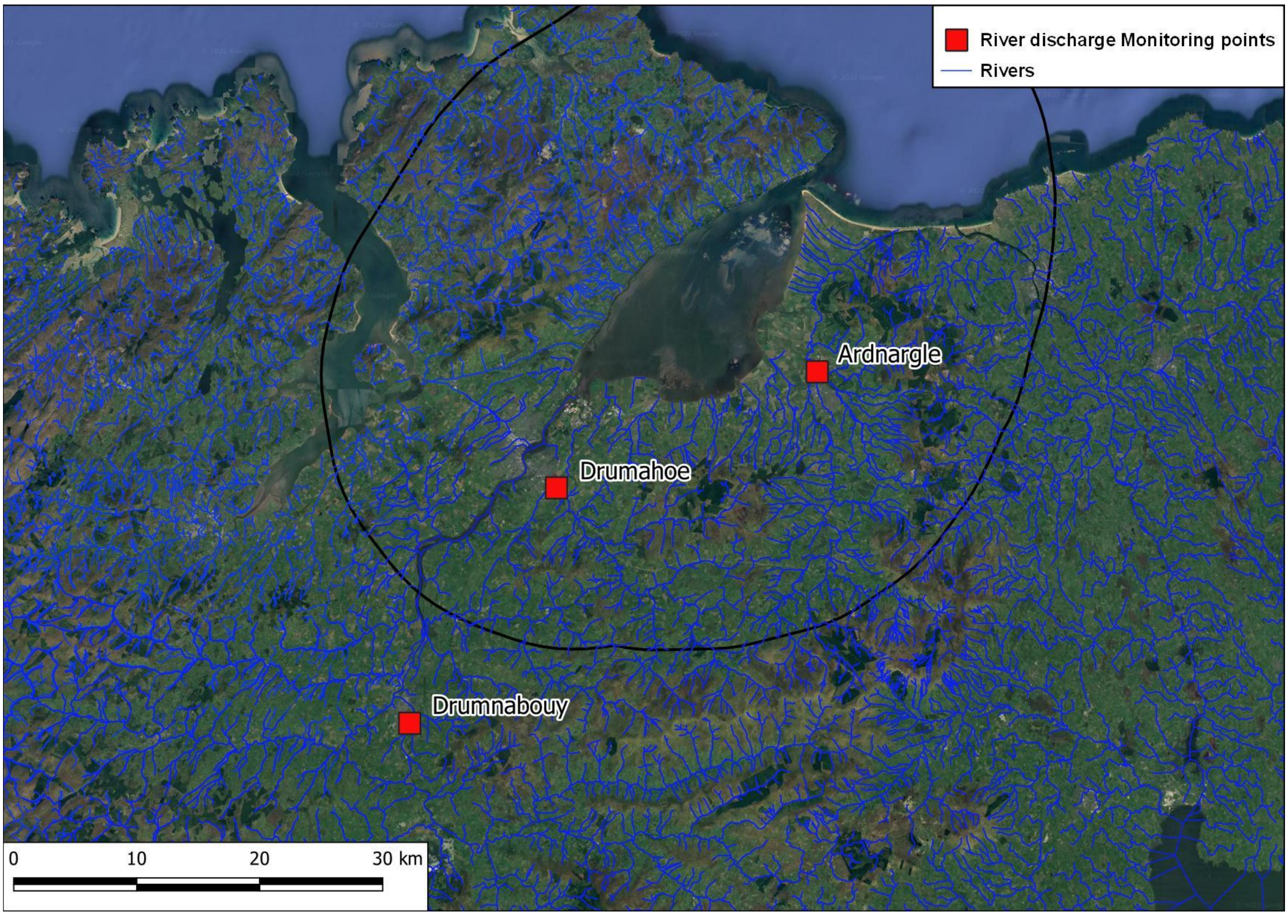


Figure 3.23: River Mourne discharge at Drumnabouy House a) boxplot distribution of discharge per month and b) recorded time series (Source: Deltares, 2009).

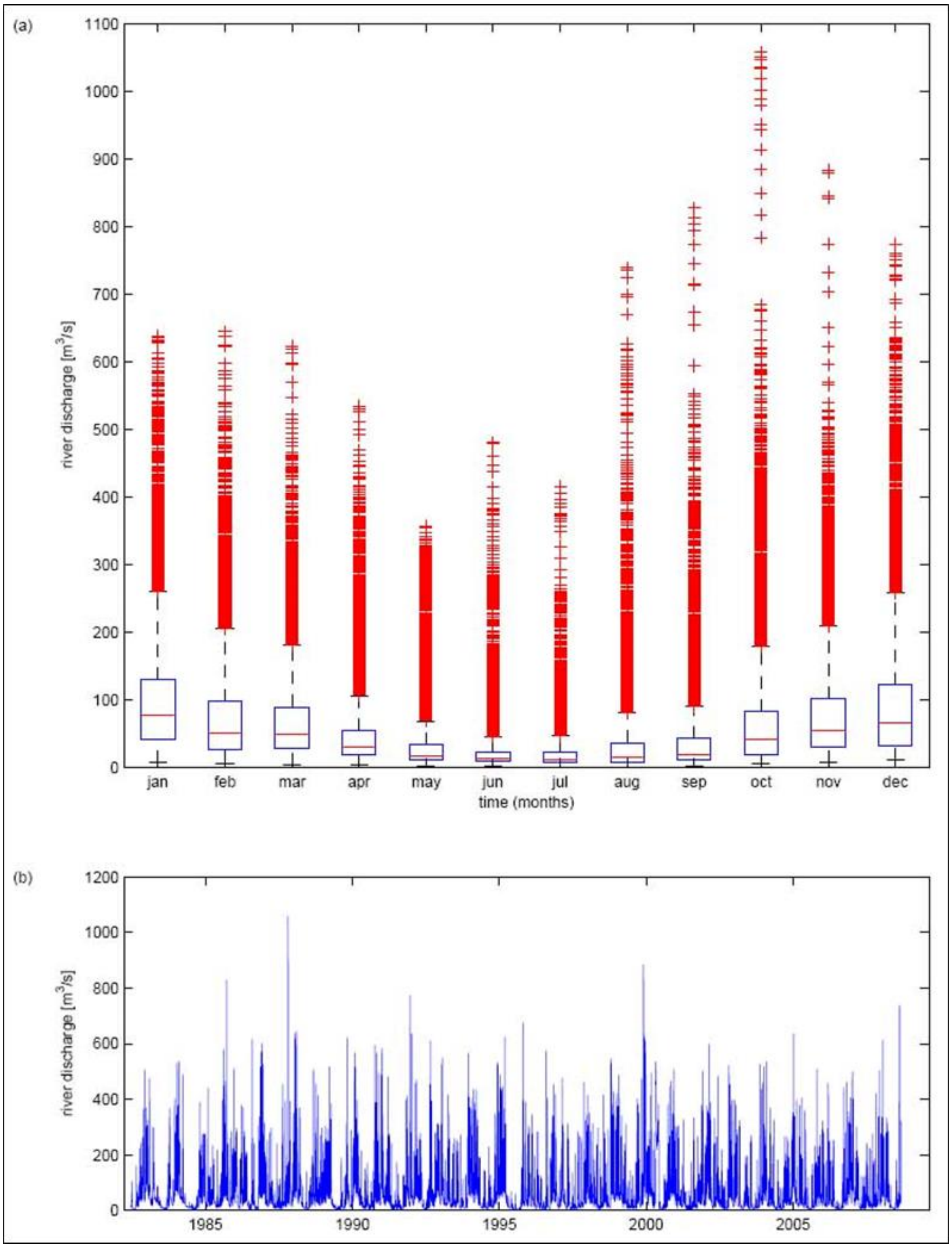


Table 3.16: River discharges m^3/s (Source: Rivers Agency in Deltares, 2009).

River	Gauge Location	Interval	1% percentile	10% percentile	Mean	90% percentile	99% percentile	Max
Mourne	Drumnabouy House	17/6/1982–5/9/2008	4	8	58	139	357	1058
Faughan	Drumahoe	27/8/1976-15/9/2008	1	2	8	17	51	253
Roe	Ardnargle	10/1/1975-15/9/2008	0	1	9	23	71	186

Figure 3.24: Average and monthly flow data from the Mourne at Drumnabuoy House 2009 -2015 (Source: NRFA, 2021)

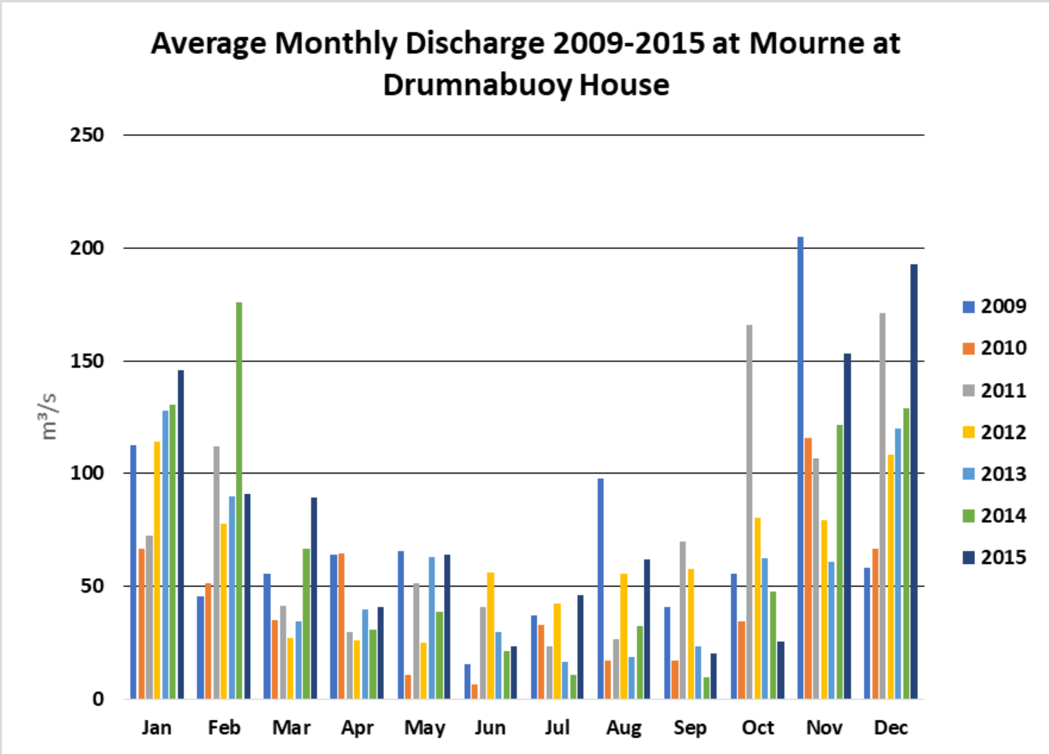
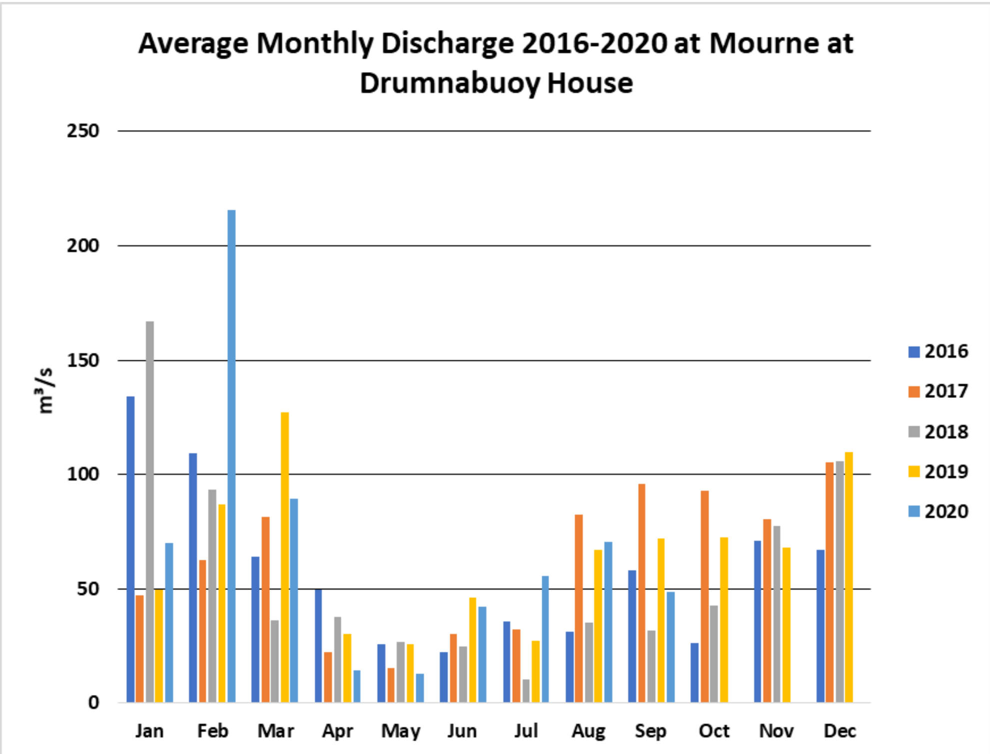


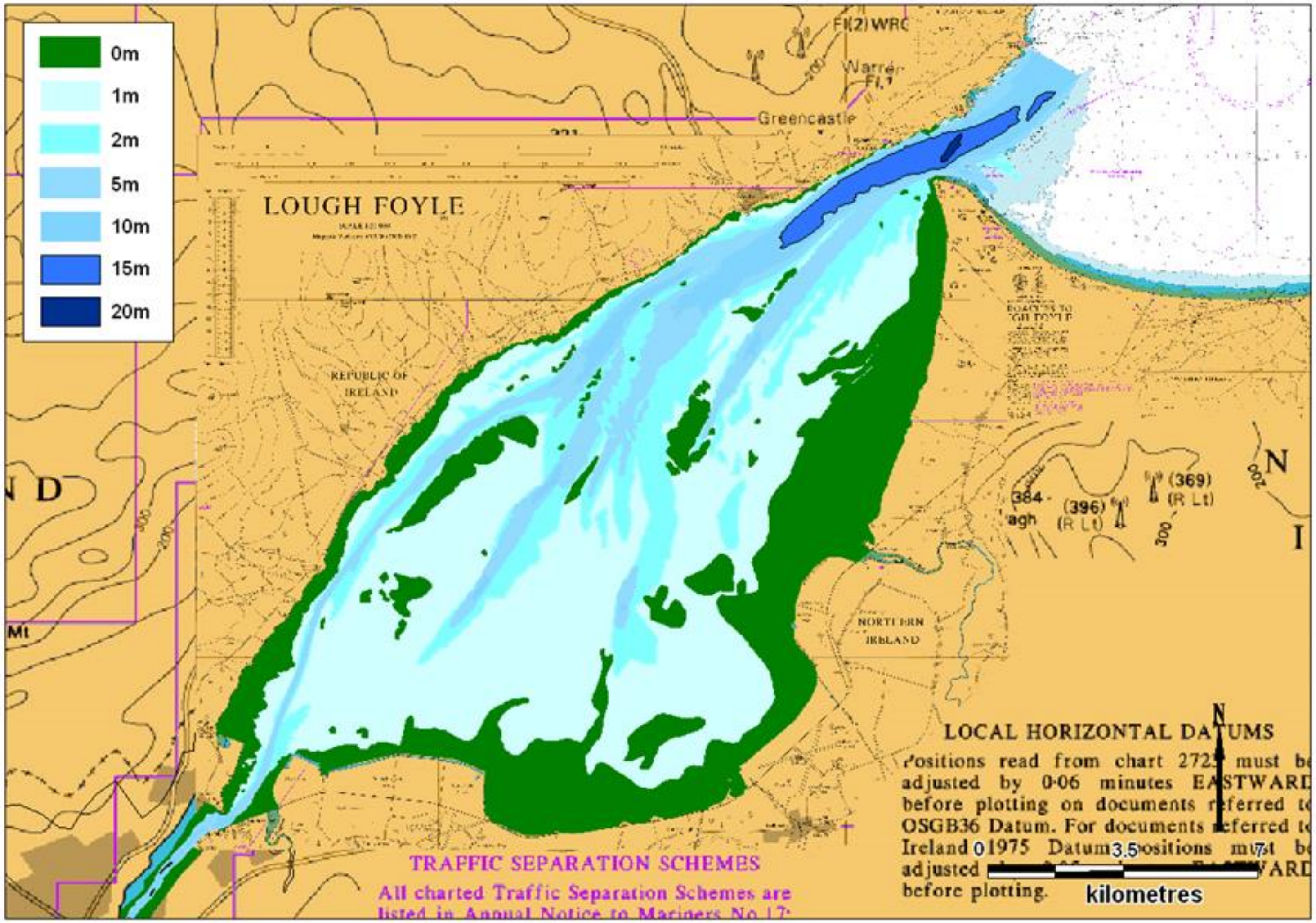
Figure 3.25: Average and monthly flow data from the Mourne at Drumnabuoy House 2016 -2020 (Source: NRFA, 2021)



3.4. Depth

Lough Foyle exhibits extensive intertidal and subtidal areas of mud flats and sand flats, which are intersected by tidal channels. The Lough is relatively shallow, with an average depth of approximately 4m. The deeper tidal channels reach an average depth of approximately 8 – 12m, whereas the entrance channel, where the width is constrained by headlands, is over 20m deep. Figure 3.26 shows a bathymetric map of Lough Foyle.

Figure 3.26: Depths in Lough Foyle (Source: The Loughs Agency).

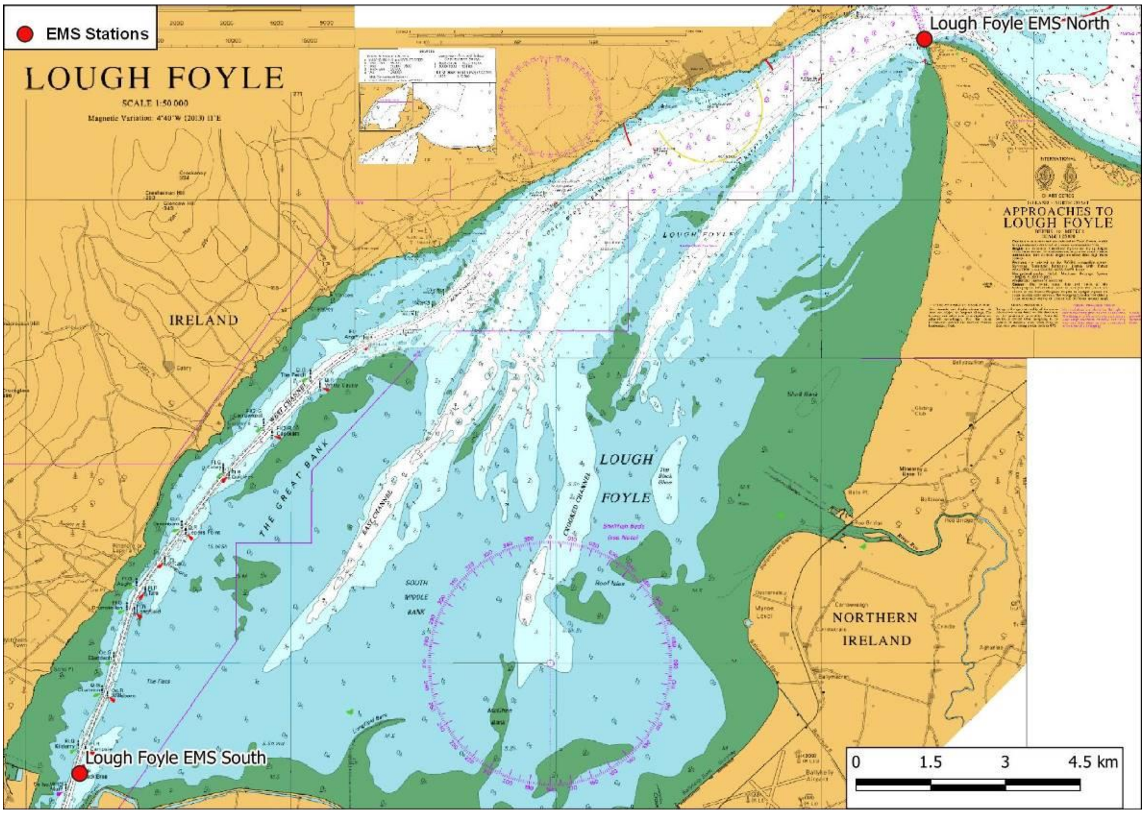


3.5. Salinity

Lough Foyle receives a large quantity of freshwater from the rivers Foyle (90m3/s), Faughan (7m3/s) and Roe (8m3/s) (Loughs Agency, 2009b). This freshwater and the saltwater that enters the Lough every tidal cycle creates density differences and variations in salinity distribution over the water column and spatially over the Lough.

The Loughs Agency collects data on coastal water quality including salinity via a network of remotely moored Environmental Monitoring Stations (EMS) in Loughs Foyle. The Agri-Food and Biosciences Institute (AFBI) manage and process this data. The EMS consists of an electronic unit which houses the data storage devices for capturing real time data and the GSM (Global System for Mobile Communication) telemetry system for communication of this data with a base station on-land. There are two EMS stations located within Lough Foyle, North and South (see Figure 3.27). The Lough Foyle North EMS is located at Magilligan Point and the Lough Foyle South EMS is located at Black Braes.

Figure 3.27: Location of the salinity and turbidity monitoring sites in Lough Foyle.



The salinity data presented in Figure 3.28 (from the Lough Foyle South EMS) shows the seasonal flow of freshwater runoff to the Foyle estuary at the Black Braes site. This less dense fresh water stays at the surface of the estuarine water thereby lowering surface salinity and creating a halocline. This trend is most closely associated with the high precipitation levels experienced during these periods. Low summer river levels and tidal ingress of seawater lead to higher salinity values during the summer months. The bottom salinities are usually higher than the surface owing to the fact that dense oceanic seawater with high salinity inhabits the bottom of the water column, the less dense freshwater floating on top of this highly saline bottom layer. The results of the salinity measurements at Black Braes reveal a variable salinity throughout the year with surface levels as low as 6.34 psu in October 2008 and as high as 30.38 psu in January 2009. Bottom salinity ranged from 11.36 psu (October 2008) to 33.91 (January 2009).

The results of the salinity measurements at Black Braes in 2020 reveal a variable salinity throughout the year with surface levels as low as 17.61 psu in October 2020 and as high 27.77 psu in October 2020, these results differ from the results from 2006 to 2008 above. Bottom salinity ranged from 19.22 psu (October 2020) to 29.93 psu (September 2020), these results are higher than those reported in 2006 and 2008. As salinity is highly variable depending on rainfall and wind patterns the difference in salinity between 2008/09 and 2020 is not significant.

Figure 3.28: Salinity profile at Lough Foyle South EMS from July 2008 to March 2009. (Source: Loughs Agency).

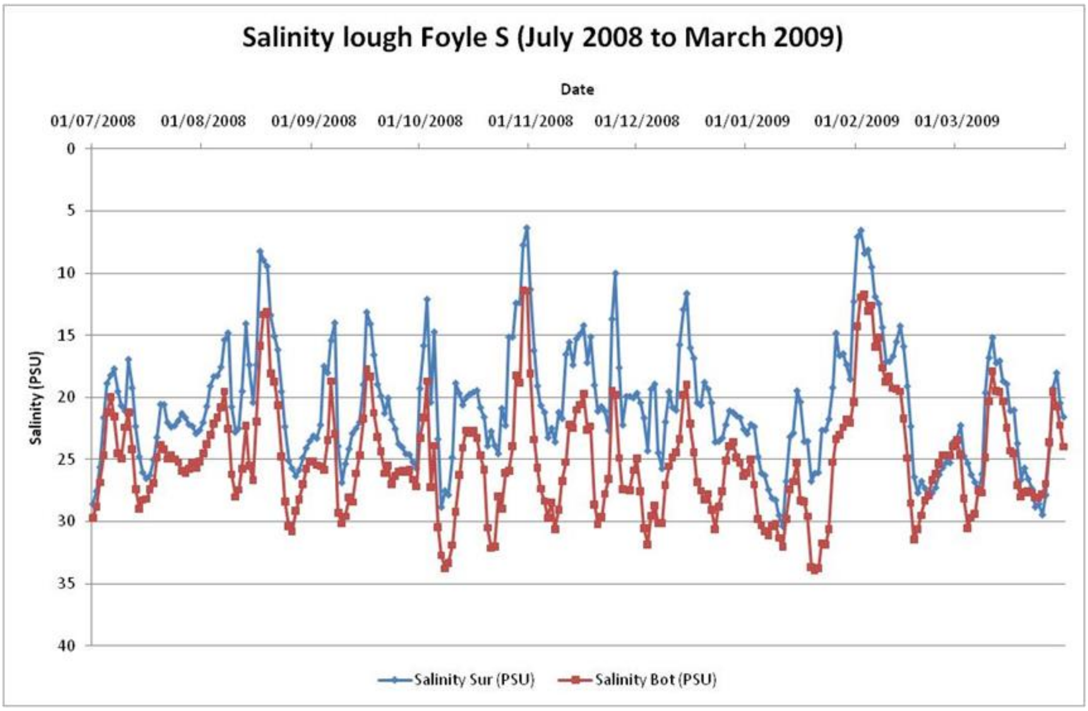
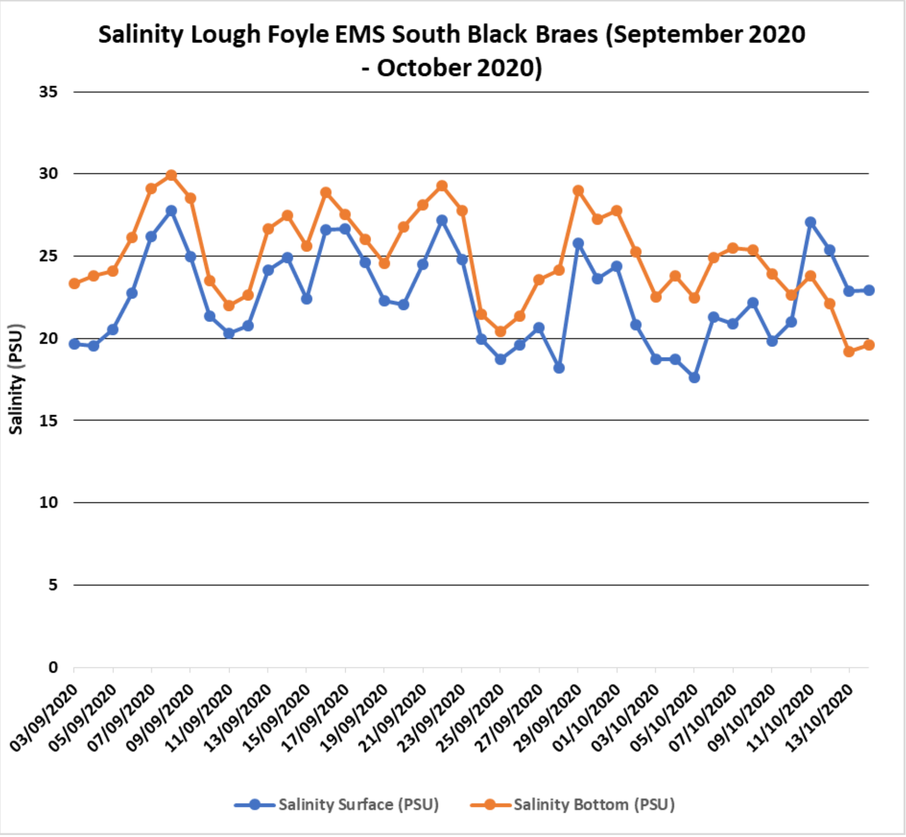
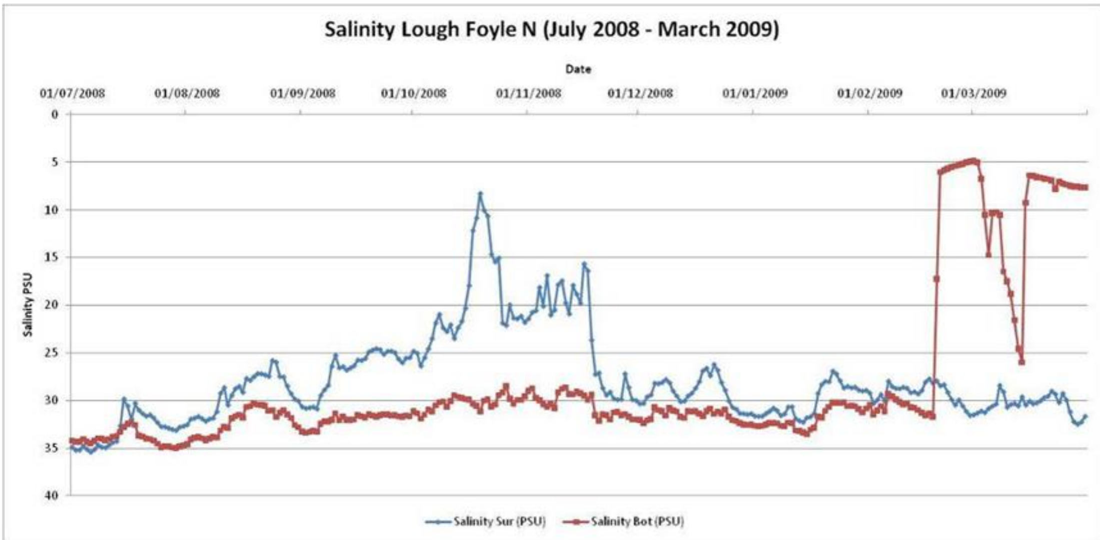


Figure 3.29: Salinity profile at Lough Foyle South EMS from September 2020 to October 2020. (Source: Loughs Agency).



Salinity levels are typically much higher at Magilligan than at the inner Lough station as seen in Figure 3.30. Surface levels typically ranged from 8.27 psu (October 2008) to 35.44 psu (July 2008) and bottom salinity levels ranged from 4.84 psu (March 2009) to 35.02 psu (July 2008). The variability seen is probably associated with the tidal cycle and river discharge levels. Salinity levels appear to become more variable as the year progresses and as precipitation levels increase in the Autumn/Winter period, with some decreases in salinity (October and November 2008) probably correlating with freshwater discharges after periods of high precipitation.

Figure 3.30: Salinity profile at Lough Foyle North EMS from July 2008 to March 2009 (Source: Loughs Agency).



3.6. Turbidity

Turbidity is a measure of the degree to which water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Table 3.17 shows the depth and turbidity NTU at Lough Foyle South EMS from September to December in 2020.

Depths at Lough Foyle South EMS ranged from a minimum of 2.46m a maximum of 5.30m. Turbidity at Lough Foyle South EMS ranged from an average level 8.95 NTU at the surface to 32.24 NTU at the bottom (see Table 18).

Table 3.17 Depth and Turbidity (NTU) in Lough Foyle in 2020.

Month	Lough Foyle South EMS			
	Mean Surface Depth (m)	Mean Surface Turbidity (NTU)	Mean Bottom Depth (m)	Mean Bottom Turbidity (NTU)
9	2.46	12.92	5.01	23.64
10	2.58	15.46	5.21	32.24
11	2.68	8.95	5.30	26.98
12	5.06	26.59	2.73	15.49

3.7. Simple/Complex Models

The Loughs Agency in conjunction with Londonderry Port & Harbour Commissioners commissioned a Delft3D-FLOW model in 2008. This work modelled the hydrodynamics of Lough Foyle and current velocity and direction outputs can be seen in Section 3.1 above and wave outputs can be seen in Section 3.3 above. These model outputs were consulted to aid in the identification of sampling points.

It should be noted that the used hydrodynamic data were derived from an existing hydrodynamic model (Delft3D-FLOW) that was set up by Deltares for a sediment dispersion study in Lough Foyle. This model was calibrated and validated for the purpose of this sediment dispersion study and provides an indication of the expected flow in other areas of Lough Foyle, but requires additional validation (by means of measurements) in the shallow east and southeast parts of Lough Foyle. The presented hydrodynamic flow data were derived from model simulations that simulated normal (tidal) flow conditions, average river discharges and used a normal wind condition, i.e. 7 m/s from a south-westerly direction (240°N).

3.8. Discussion

The bathymetric and hydrographic characteristics of Lough Foyle are such that the northwestern section with deeper depths and strong tidal currents is a well mixed and flushed area of the Lough and as a result any contaminants will be diluted and dispersed rapidly. This area is therefore less vulnerable to contamination than other areas of the Lough. The southeastern section of the Lough is much shallower in nature and therefore has higher suspended sediment concentrations coupled with weak currents. This area receives large quantities of freshwater input from the Foyle, Faughan and Roe and as a result of these factors is more vulnerable to contamination. The area at the mouth of the Foyle, while it does have strong tidal currents during the ebb flow of a spring tide, it also receives the largest freshwater input accompanied with high suspended sediment loads and is therefore also vulnerable to contamination.

Since 2010, the rainfall patterns have remained consistent with autumn and winter being the wettest seasons. On average the annual rainfall has been slightly higher (+3%) from 2010 to 2020 than from 2005 to 2009. October to January remain the wettest months with high rainfall also occurring in July and August in 2008, 2009, 2017, 2019 and 2020.

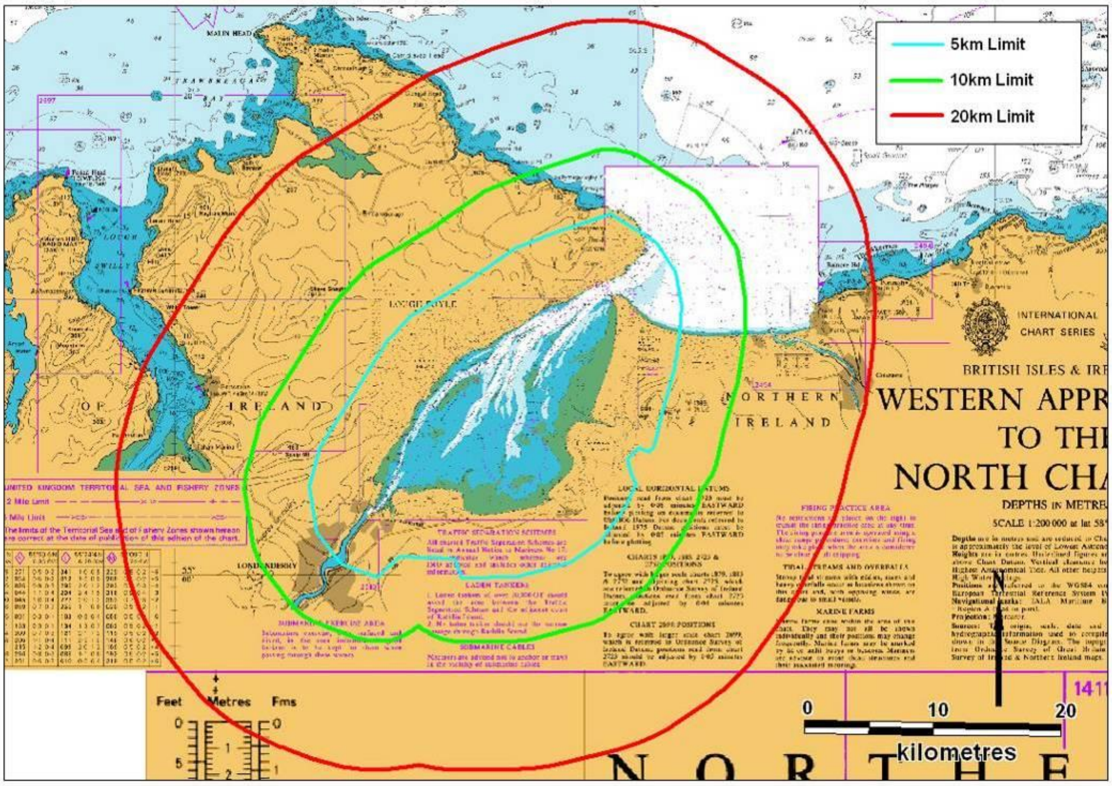
There has been no significant changes to wind patterns, river flow or salinity since the 2010 sanitary survey.

4. Identification of Pollution Sources

4.1. Desktop Survey

Pollution sources were considered up to a distance of 20km from the shores of Lough Foyle and are where appropriate divided into three zones; 0-5km, 5-10km and 10-20km. Sources greater than 20km from Lough Foyle were considered if significant. Any sources within the 20km limit that discharged into Lough Swilly and not Lough Foyle were not considered. Figure 4.1 shows the 3 distance limits used for this assessment.

Figure 4.1: Distance limits used for assessment of the pollution sources.



4.1.1. Human Population

Figure 4.2 shows all of the counties which fall within the 20km limit for Lough Foyle: Donegal, Tyrone, Derry and Antrim. Population census data for Northern Ireland is given in units of Super Output Areas (SOA) or wards and Electoral Divisions (EDs) are used by the Central Statistics Office (CSO) for Co. Donegal. Figure 4.3 shows the Northern Ireland SOAs and the

Republic of Ireland EDs with a 20km radius of Lough Foyle (Figure 4.4 shows the legend for Figure 4.3).

Figure 4.2: Counties within a 20km radius of Lough Foyle.

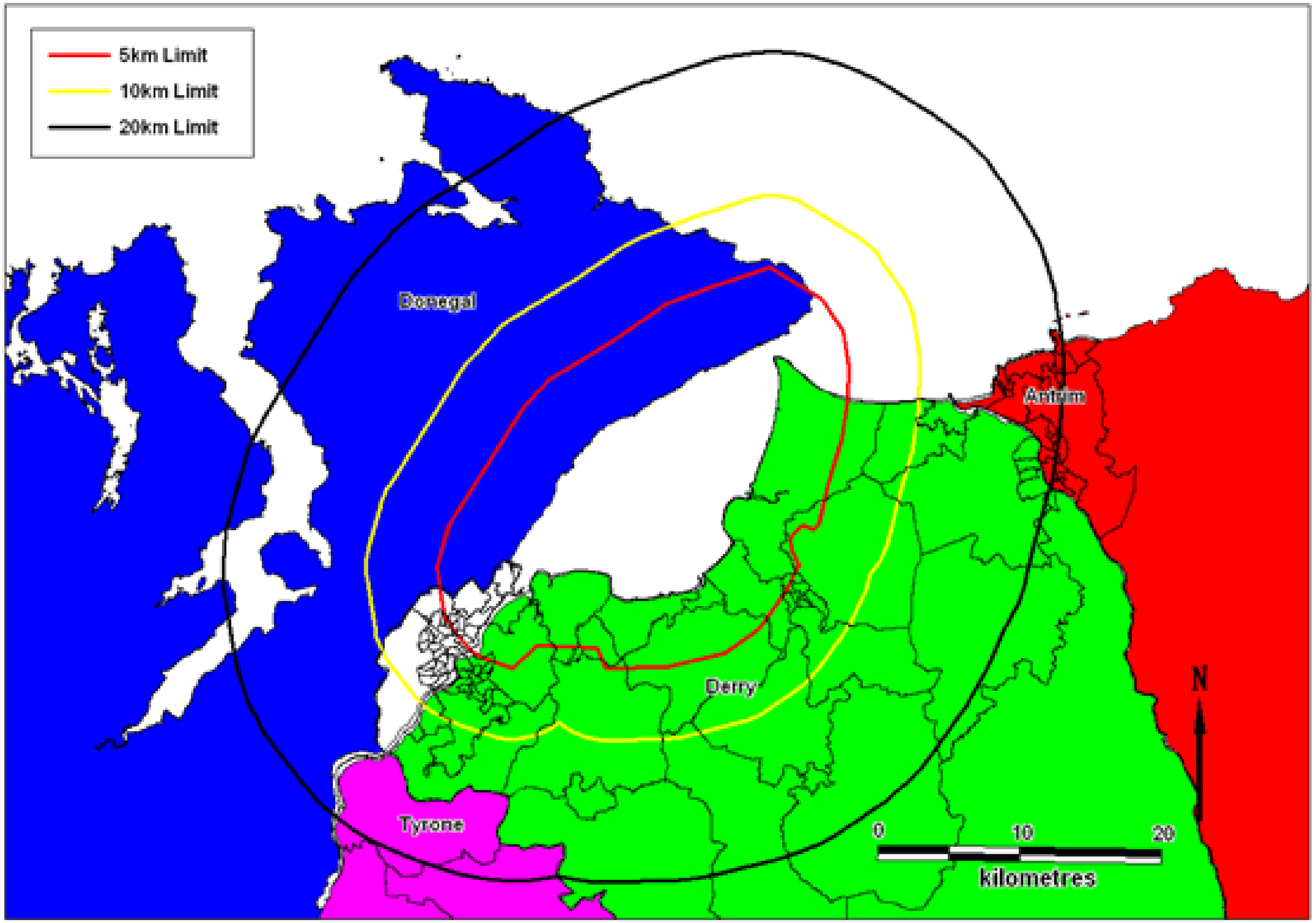


Figure 4.3: SOAs and EDs within a 20km radius of Lough Foyle.

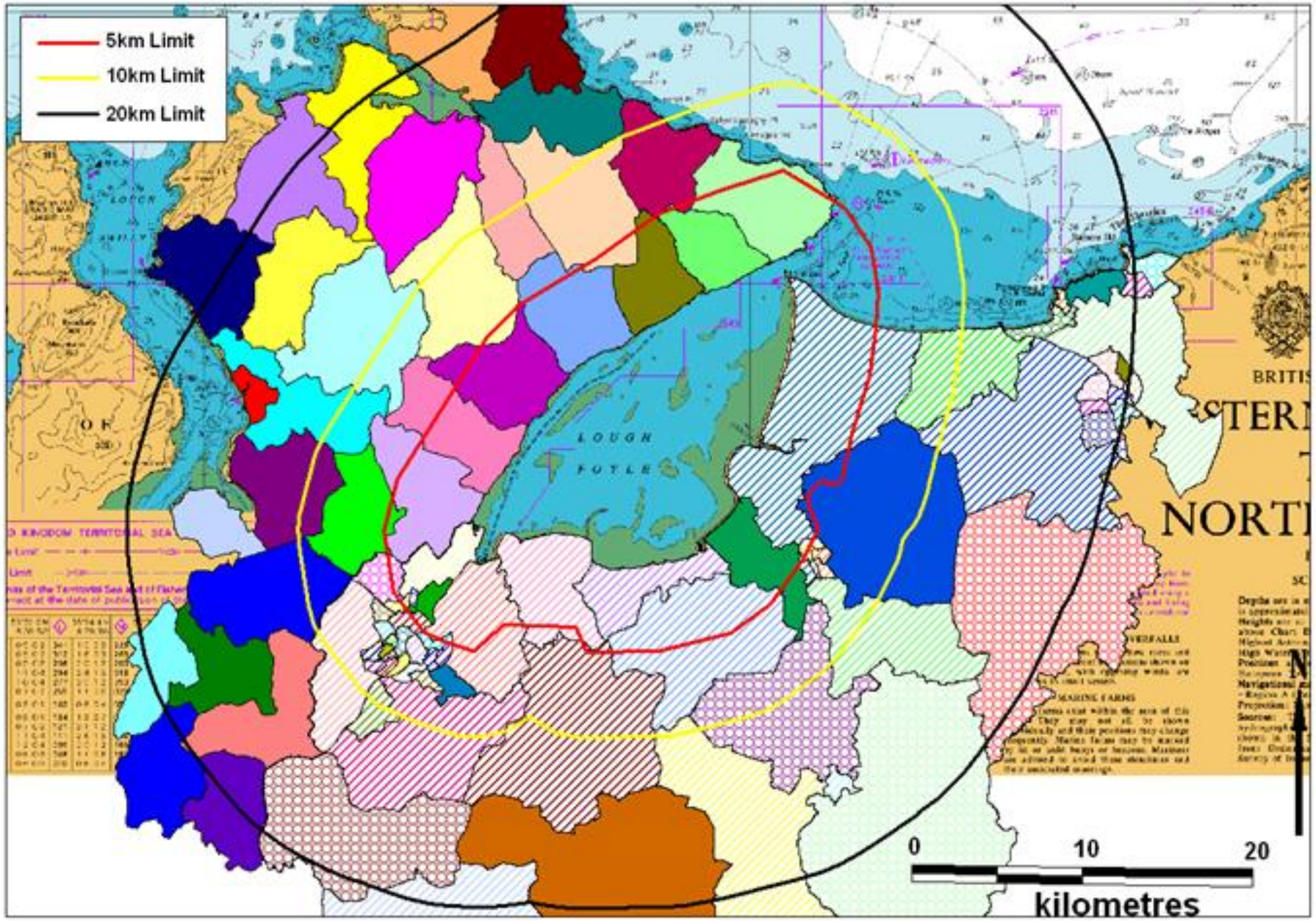
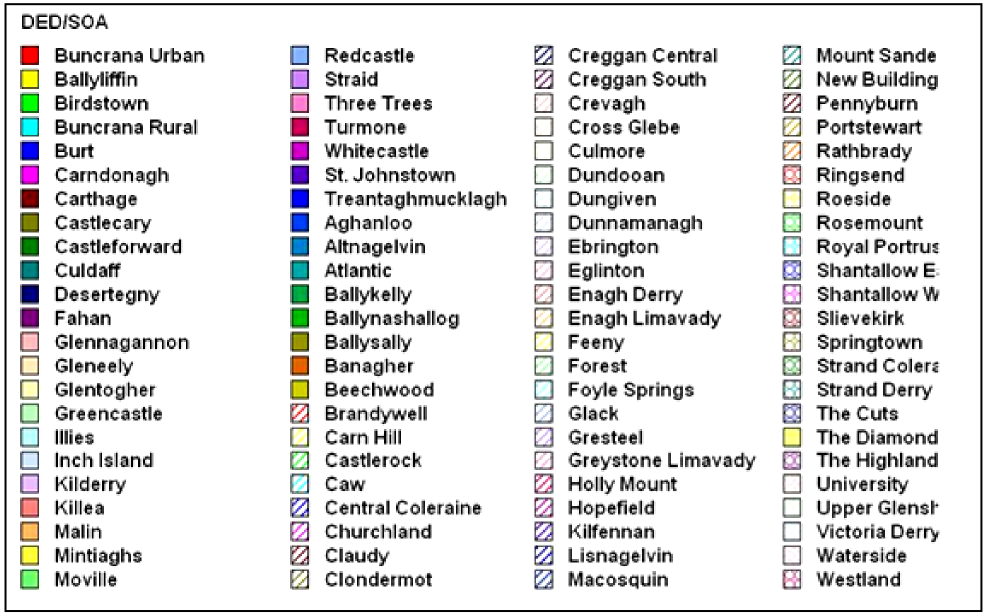


Figure 4.4: Legend to accompany Figure 4.3.



Data on human populations for Northern Ireland was obtained from The Northern Ireland Statistics and Research Agency (NISRA) website. The Republic of Ireland data was obtained through the Central Statistics Office (CSO) online census programme (CSO, 2019) for the year 2016. Figure 4.5 shows the human population within a 20km radius of Lough Foyle and Table 4.1 shows this data in graphical form.

The largest population centres in the study area remain Culmore and Shantallow West, followed by Crevagh in Londonderry City. Along the western coastline, the highest population occurs in Moville (2366, +8.8%) and Kilderry (2089, +19.8%). The highest population along the eastern shore occurs at Eglinton (4,374, +1.6%) and Gresteel (3,495, -10.8%). The population overall within 20km of Lough Foyle is 229,055 an increased by 4% (+8,785).

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 geographic boundaries used. However, it is clear that areas with a higher population will have higher levels of sewage and wastewater entering the Foyle system.

Figure 4.5: Population change within 20km of Lough Foyle from 2006 to 2016.

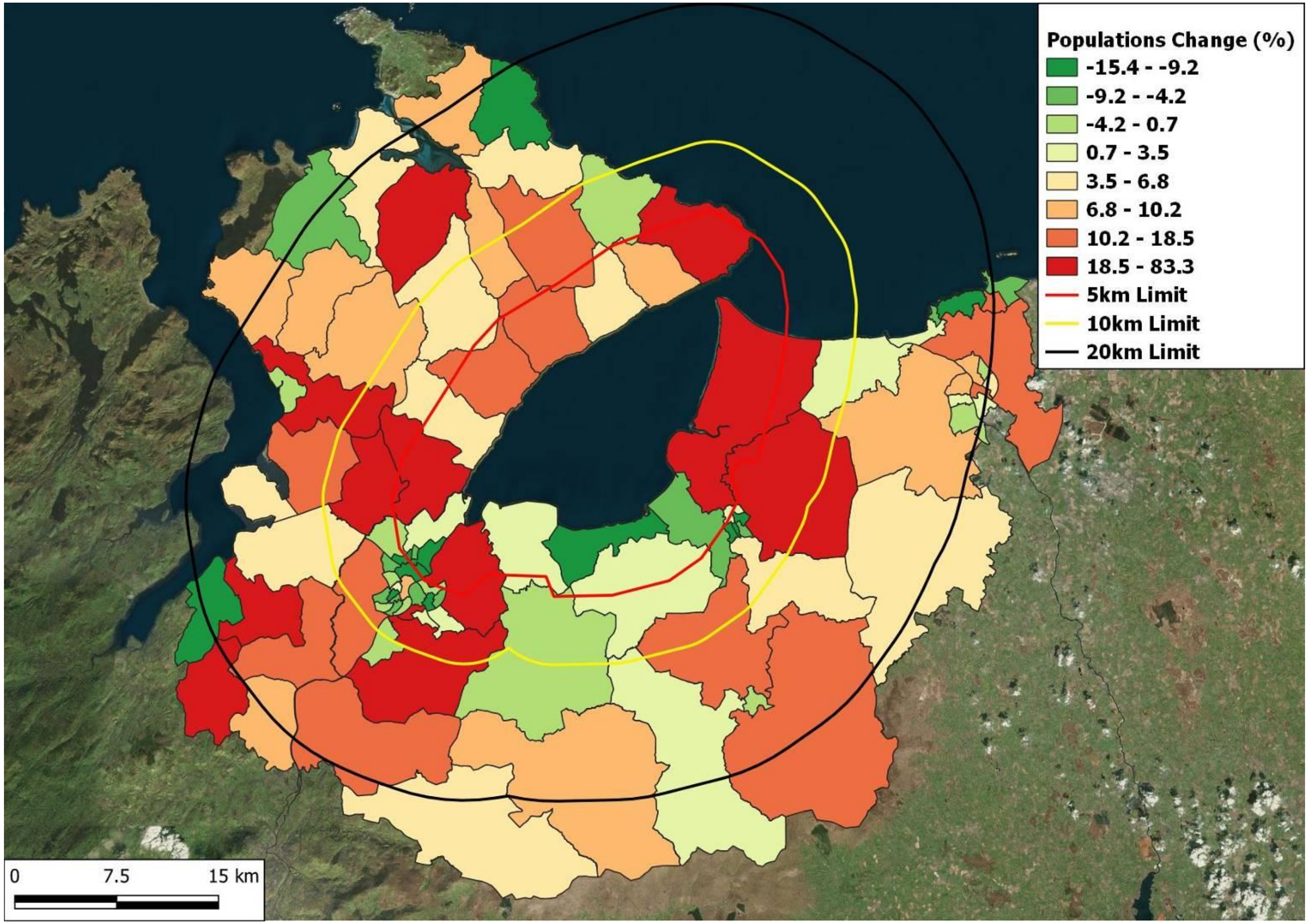


Table 4.1: Human population within the Lough Foyle Catchment Area (Source: NISRA, 2020: CSO, 2019).

SOA/ED	Pop. 2006	Pop. 2016	% Change
Buncrana Urban	3411	3396	-0.44
Ballyliffin	1299	1381	6.31
Birdstown	1026	1312	27.88
Buncrana Rural	2949	3836	30.08
Burt	1264	1310	3.64
Carndonagh	1931	2339	21.13
Carthage	995	886	-10.95
Castlecary	666	705	5.86
Castleforward	909	1356	49.17
Culdaff	899	935	4.00
Desertegny	662	713	7.70
Fahan	1476	1697	14.97
Glennagannon	671	730	8.79
Gleneely	746	827	10.86
Glentogher	1133	1184	4.50
Greencastle	807	1016	25.90
Illies	796	865	8.67
Inch Island	438	461	5.25
Kilderry	1744	2089	19.78
Killea	1547	1793	15.90
Malin	622	668	7.40
Mintiaghs	797	866	8.66
Moville	2174	2366	8.83
Newtown Cunningham	1178	996	-15.45
Redcastle	791	935	18.20
Straid	1344	1288	-4.17
Three Trees	646	675	4.49
Turmone	297	296	-0.34
Whitecastle	883	1001	13.36
St. Johnstown	1227	1343	9.45
Treantaghmucklagh	637	802	25.90
Slievekirk	2090	2361	12.97
Dunnamanagh	2085	2,189	4.99
Upper Glenshane	2150	2,409	12.05
The Highlands	1635	1,876	14.74
Roeside	1435	1,461	1.81
Rathbrady	1645	1,471	-10.58
Magilligan	1960	2,338	19.29

SOA/ED	Pop. 2006	Pop. 2016	% Change
Greystone Limavady	1595	1,362	-14.61
Glack	2050	2,121	3.46
Forest	2385	2,471	3.61
Feeny	2115	2,181	3.12
Dungiven	2110	2,032	-3.70
Coolessan	1680	1,496	-10.95
Ballykelly	1900	1,819	-4.26
Westland	2255	2,161	-4.17
Victoria_Derry	2530	3,087	22.02
The Diamond	2355	2,345	-0.42
Shantallow East	2745	2,581	-5.97
Rosemount	2490	2,564	2.97
Creggan South	2395	2,339	-2.34
Caw	2700	2,615	-3.15
Brandywell	2630	2,430	-7.60
Beechwood	2555	2,271	-11.12
Banagher	3120	3,374	8.14
Waterside	2585	2,817	8.97
University	2565	2,768	7.91
Royal Portrush	2310	2,133	-7.66
Ringsend	2210	2,354	6.52
Portstewart	1930	1,773	-8.13
Mount Sandel	1815	1,868	2.92
Macosquin	2105	2,290	8.79
Cross Glebe	2455	2,576	4.93
Churchland	2270	2,350	3.52
Central Coleraine	1620	1,838	13.46
Atlantic	2550	2,313	-9.29
Ebrington	2725	2,569	-5.72
Ballysally	2555	2,537	-0.70
Castlerock	3075	3,118	1.40
Dundooan	2915	3,246	11.36
Hopefield	3345	3,717	11.12
Strand Coleraine	2700	2,763	2.33
The Cuts	4295	4,148	-3.42
Altnagelvin	3210	3,259	1.53
Ballynashallog	3990	3,429	-14.06
Carn Hill	3245	2,746	-15.38
Claudy	3560	3,554	-0.17
Creggan Central	3015	2,838	-5.87
Crevagh	5225	5,890	12.73
Culmore	8625	8,899	3.18
Eglinton	4305	4,374	1.60
Enagh Derry	3435	5,216	51.85

SOA/ED	Pop. 2006	Pop. 2016	% Change
Foyle Springs	4095	3,926	-4.13
Holly Mount	3895	4,995	28.24
Kilfennan	3235	3,038	-6.09
Lisnagelvin	3705	3,350	-9.58
New Buildings	3655	3,524	-3.58
Pennyburn	2895	2,611	-9.81
Shantallow West	6460	6,502	0.65
Springtown	3610	3,278	-9.20
Strand Derry	3490	3,731	6.91
Aghanloo	2290	4,197	83.28
Enagh Limavady	2865	2,632	-8.13
Gresteel	3920	3,498	-10.77
Clondermot	2945	2,969	0.81

4.1.2. Tourism

In 2018, 2,809,000 tourists visited Northern Ireland compared to 1,918,000 in 2009 (NITB {Northern Ireland Tourist Board}, 2018). This is a 46.5% increase in tourism to Northern Ireland since the last sanitary survey. Of these tourists, 46% were visiting family and friends and 37% were holidaying, 30% of them arrived in between July and September and 25% of them arrived between April and June and 49% stayed with family or friends while 30% stayed in a hotel/guesthouse/B&B. The Lough Foyle Catchment partially overlaps two Northern Ireland Local Government Districts (LGD) for tourism numbers ‘Derry City and Strabane’ and ‘Causeway Coast and Glens’. The Northern Ireland LGD boundaries were changed since the 2011 sanitary survey and so tourism statistics cannot be directly compared. These two LGDs received 1,346,359 tourists in 2018. As the tourism numbers in Northern Ireland have increased by 46.5% it is likely that the tourism numbers in the Lough Foyle area have also increased. The catchment also partially overlaps County Donegal. County Donegal received 255,000 overseas tourists in 2017, an increase of 25% from 2008. There is however no way of estimating the number of tourists who visited the Lough Foyle catchment area during their stay.

There are numerous activities which tourists can partake in along the shores of Lough Foyle, i.e. walking, climbing, water activities, golf, cycling, equestrian, spa and wellness and cultural and heritage sights and centres. Figure 4.6 shows all tourism related activity sites around Lough Foyle. This data was gathered from a Loughs Agency Marine Tourism Audit.

Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Lough Foyle area. In addition, Papadakis et al. (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria. In 2007, Elmir *et al*. (2007) showed the role of human skin as an intermediate mechanism of pathogen transmission to the water column.

In order to identify any significant differences in *E. coli* levels based on seasonality, a one-way analysis of variance (ANOVA) was performed on seasonal E. coli results (for the period 2011 to 2020) from shellfish flesh taken at a number of monitoring points around the lough (Refer to Section 5.1.2 for more details on the sampling points). 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).

This analysis found that there was no significant difference between seasons for O3 native oysters, M1 mussels and PO1 pacific oysters. A significant difference was found between seasons for M2, M3 and M4 for mussels and O1, O2 and O4 for native oysters.

Figure 4.7 to Figure 4.12 show box-plots for each shellfish bed which had a significant seasonal difference in *E. coli* levels. These graphs are composed of a median line (or the middle line of the data), the bottom box, which indicates the first quartile value (25% of the data values are less than or equal to this value), the top box which indicates the third quartile (75% of the data values are less than or equal to this value), the lower whisker is the lower limit and the upper whisker is the highest data value within the upper limit.

M2 mussels had significantly lower *E.coli* results in spring when compared to winter and autumn. M3 mussels had significantly higher results in winter and autumn than in summer and spring. M4 mussels had significantly higher results in winter and autumn than in summer and spring. O1 native oysters had significantly higher results in autumn than in winter and spring. O2 native oysters had significantly higher results in summer and autumn than in winter and spring. Autumn also had significantly higher results than summer. O4 native oysters had significantly higher results in winter and autumn than in spring.

The trend at all of these site appears to be linked to rainfall levels and run-off from land. As such tourism does not appear to have a significant effect on the shellfish quality in the bay.

Figure 4.6: Tourist facilities within the Lough Foyle Catchment Area.

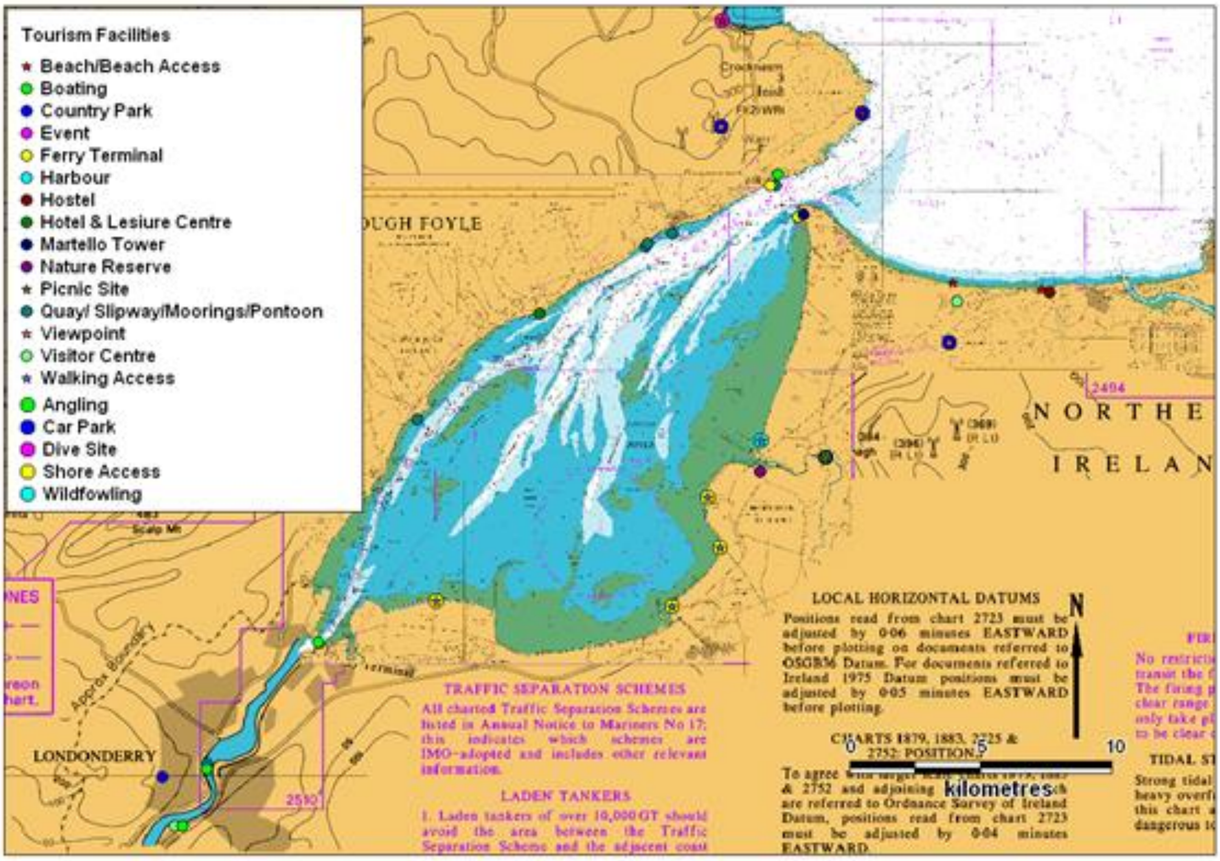


Figure 4.7: Seasonal variation of *E. coli* in mussel flesh from M2 monitoring point.

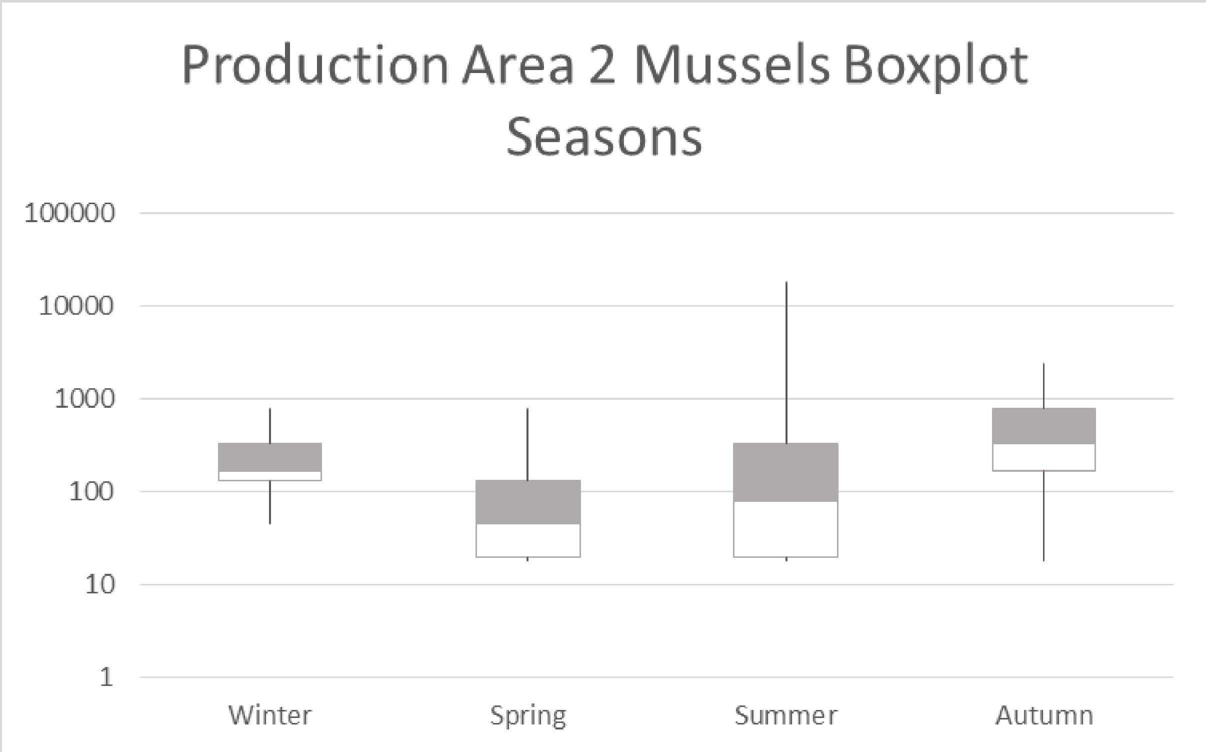


Figure 4.8: Seasonal variation of *E. coli* in mussels flesh from M3 monitoring point.

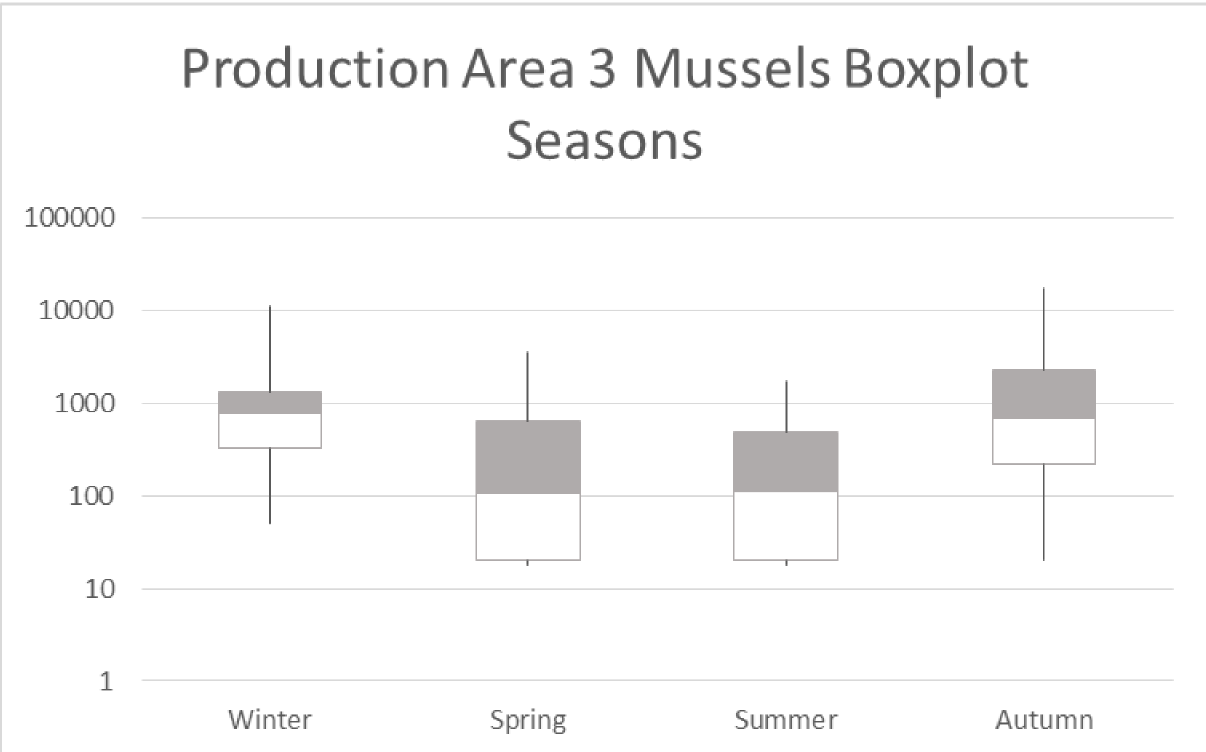


Figure 4.9: Seasonal variation of *E. coli* in mussel flesh from M4 monitoring point.

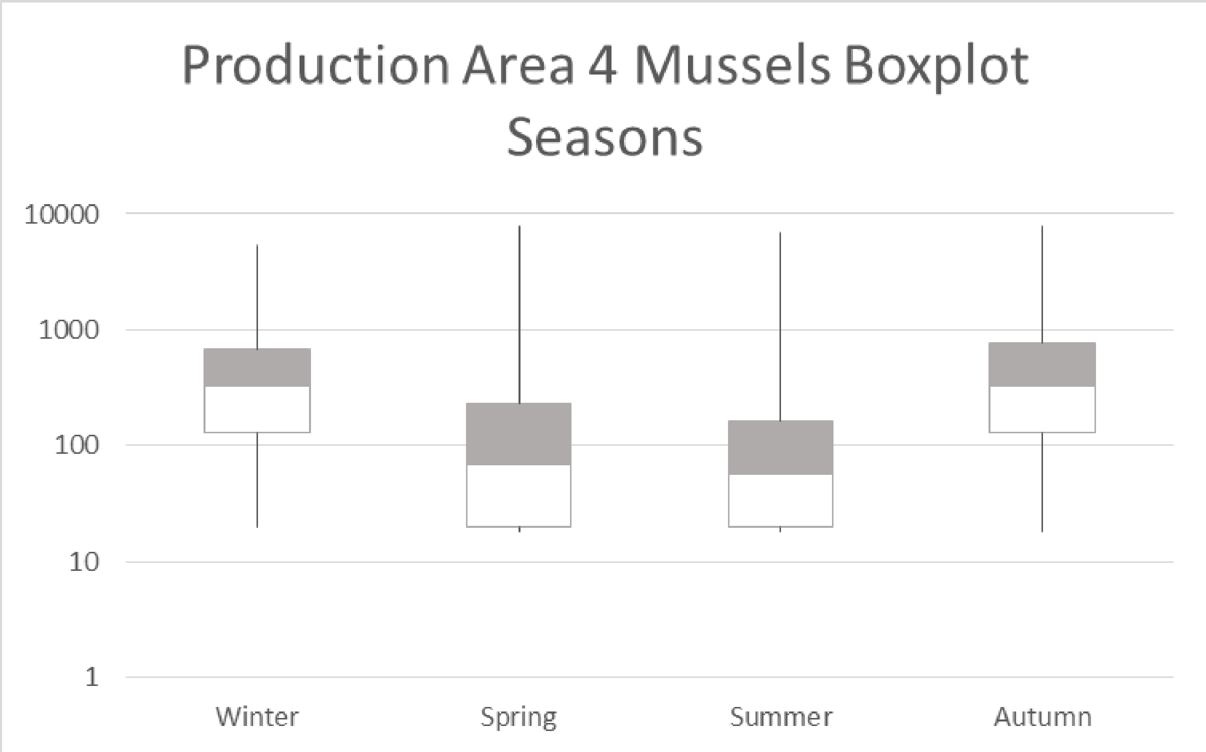


Figure 4.10: Seasonal variation of *E. coli* in native oyster flesh from O1 monitoring point.

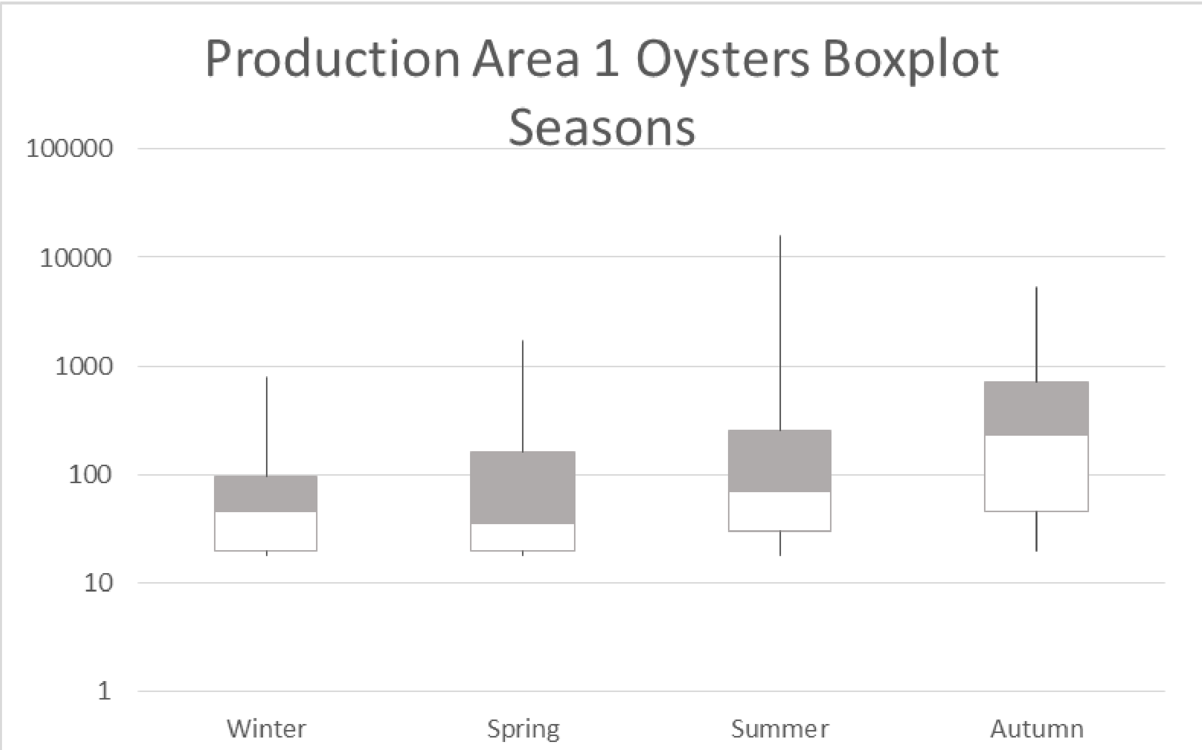


Figure 4.11: Seasonal variation of *E. coli* in native oyster flesh from O2 monitoring point.

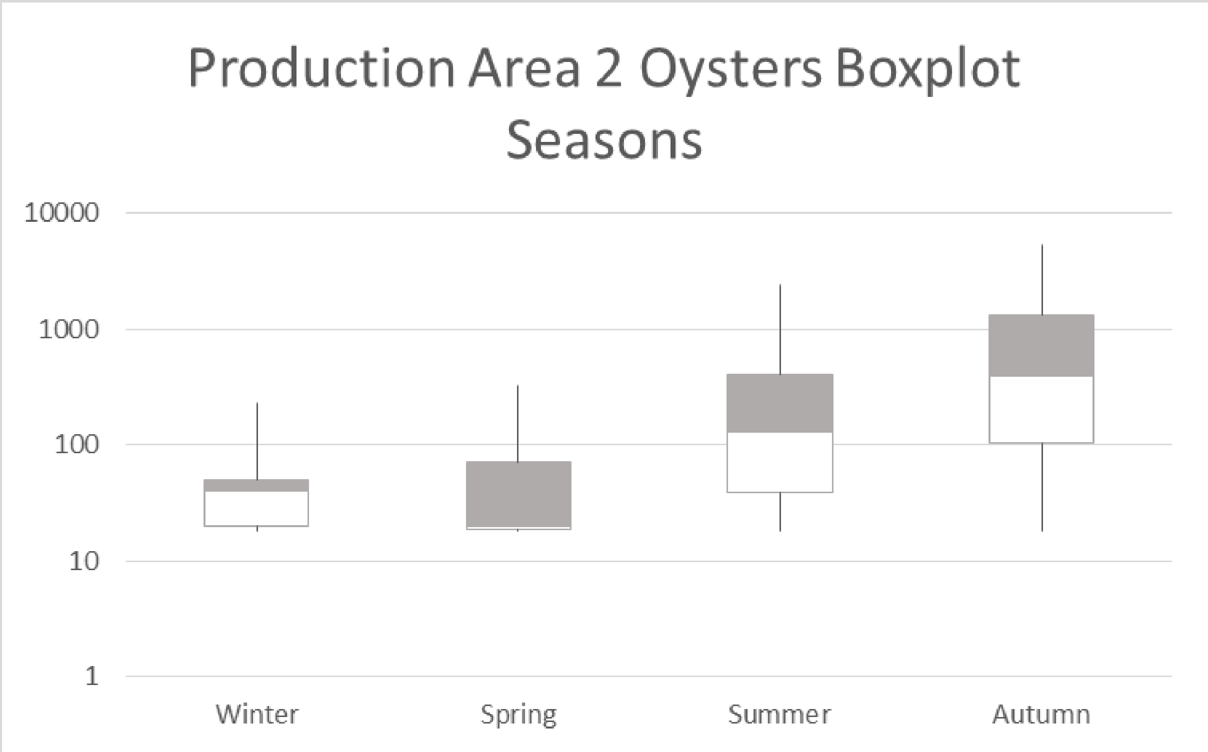
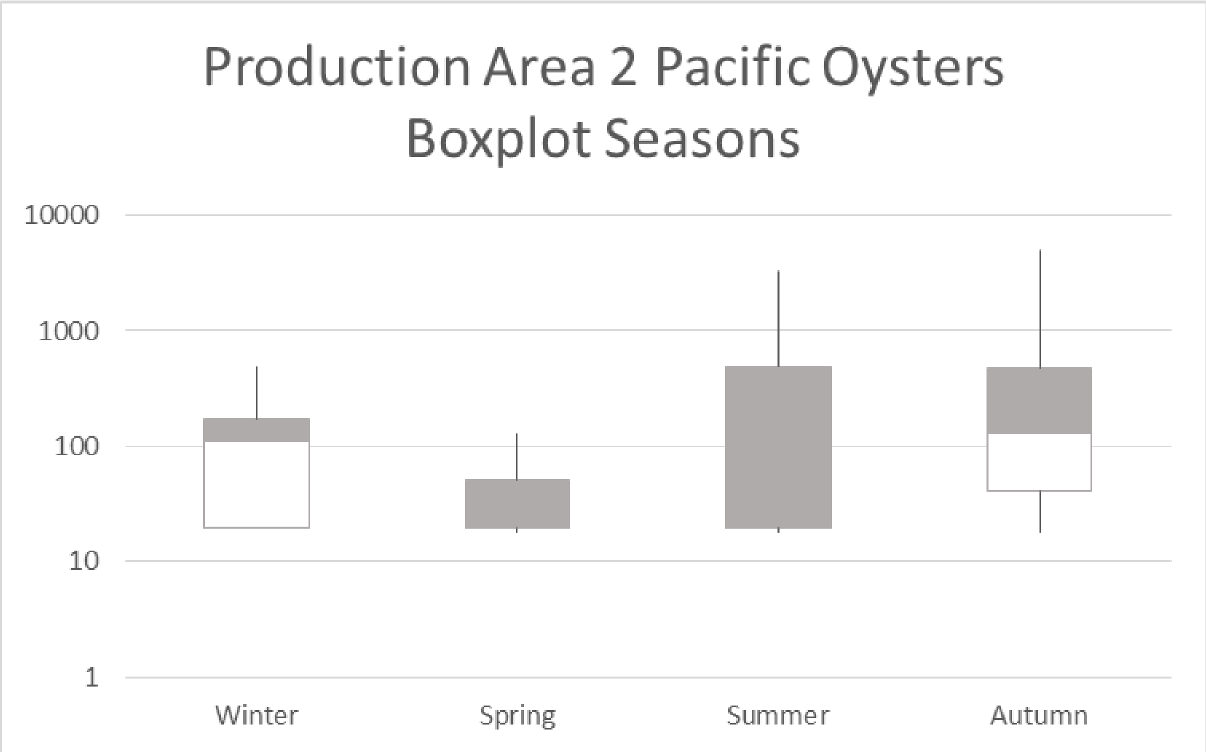


Figure 4.12: Seasonal variation of *E. coli* in native oyster flesh from PO1 monitoring point.



4.1.3. Sewage Discharges

Sewage effluent can vary in nature depending on the degree to which the sewage 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 at all (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 - N down to 5 mg/l and phosphorus to 2mg/l.
- tertiary (settling, biological treatment and an effluent polishing step which may involve a reed bed (unlikely for a coastal works) or a treatment to reduce the load of micro-organisms in the effluent), typically removes 100% of BOD, 100% of suspended solids, 33% of nitrogen and 38% of phosphorus from the untreated sewage.

Figure 4.13 shows all 64 Waste Water Treatment Works within the Lough Foyle catchment area. Table 4.2 shows the coordinates and population equivalents (p.e.) of these plants. There are 64 Waste Water Treatment Works (WWTWs) in the Lough Foyle catchment, serving a population of approximately 187,728 p.e. The major works are those at Culmore, Limavady, Magilligan Point Road, Donnybrewer, Dungiven, Ballykelly, Claudy and Greysteel, these eight works together account for 92.9% of the total population equivalent of the catchment. Of the 64 WWTWs 56 are below/at capacity and 8 are over capacity. The eight plants that are over capacity account for 2.5% of the load on the WWTW in the catchment. The 56 plants that are below/at capacity account for 97.5% of the load on the WWTW in the catchment. Importantly Culmore WWTW which accounts for 71.3% of the load on the WWTW in the catchment is operating at 16,184 p.e. below capacity.

Figure 4.13: WWTWs within the Lough Foyle Catchment Area (Source: NI Water/ EPA).

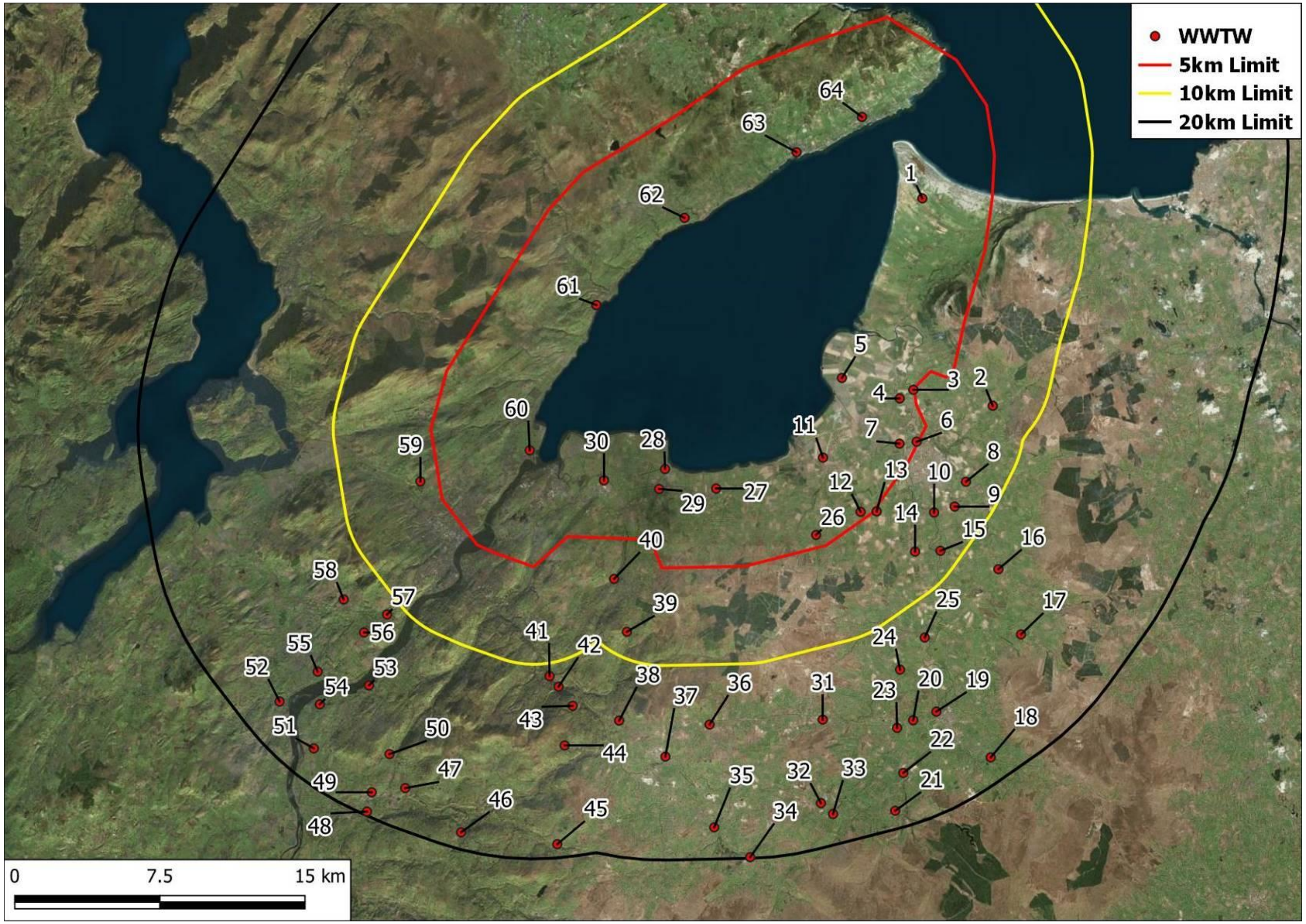


Table 4.2: WWTWs within the Lough Foyle Catchment Area (Source: NI Water/ EPA).

Map ID	NAME	Easting	Northing	Longitude	Latitude	Current p.e.	Design p.e.	Available capacity
1	Magilligan Point Road WwTW	267499.6	436177.2	-6.94156	55.16814	5674	8696	3022
2	Bolea WwTW	271278.2	425617.4	-6.88492	55.07277	113	130	17
3	Aghanloo 1 WwTW	267187.8	426375	-6.94877	55.08015	841	550	-291
4	Myroe WwTW	266492.2	425921.4	-6.95976	55.07617	178	200	22
5	Carrowclare WwTW	263509.3	426928.1	-7.00623	55.0856	286	280	-6
6	Limavady WwTW	267394.1	423715.8	-6.94616	55.05624	16258	20490	4232
7	Lisnakilly WwTW	266516	423601	-6.95993	55.05533	33	48	15
8	Drummond WwTW	269962	421701	-6.90648	55.03779	22	31	9
9	Edenmore Road WwTW	269404.7	420420	-6.91551	55.02636	12	12	0
10	Ardgarvan WwTW	268348.8	420097.2	-6.93209	55.02361	164	191	27
11	Ballykelly WwTW	262592.9	422829.1	-7.02148	55.0489	3649	7840	4191
12	Drumraighland WwTW	264568	420076.2	-6.9912	55.02393	81	180	99
13	Dromore Highlands WwTW	265390.4	420108.2	-6.97834	55.02411	116	150	34
14	Largy Limavady WwTW	267399.3	418077.5	-6.94741	55.0056	151	200	49
15	Ballyquin WwTW	268706	418137.9	-6.92698	55.00596	101	107	6
16	Drumsurn WwTW	271705.8	417241.4	-6.88033	54.99749	592	696	104
17	Ballymacallion WwTW	272921.7	413910.7	-6.86218	54.9674	18	22	4
18	Crebarkey WwTW	271462	407560	-6.88655	54.91058	24	48	24
19	Dungiven WwTW	268623.3	409873.8	-6.93025	54.93176	4744	5742	998
20	Owenbeg WwTW	267431	409414	-6.94895	54.92779	30	44	14
21	Caugh Hill East WwTW	266576.3	404741.3	-6.96336	54.88594	9	26	17
22	Carnanbane WwTW	266965.2	406690.2	-6.95685	54.90339	75	49	-26

Map ID	NAME	Easting	Northing	Longitude	Latitude	Current p.e.	Design p.e.	Available capacity
23	Dernaflaw WwTW	266608	409004.4	-6.96188	54.92422	394	224	-170
24	Gortnahey WwTW	266715.1	412001.7	-6.95952	54.95113	395	470	75
25	Bonnanaboigh WwTW	267965.5	413673.2	-6.93961	54.96597	273	400	127
26	Glack Laurel Road WwTW	262294.5	418858.5	-7.02701	55.01328	219	300	81
27	Greysteel 1 WwTW	257120.5	421170.3	-7.10741	55.03466	2181	2300	119
28	Longfield Eglinton WwTW	254480.1	422140.6	-7.14852	55.04367	232	130	-102
29	Killylane Eglinton WwTW	254189	421112.3	-7.15326	55.03447	103	190	87
30	Donnybrewer WwTW	251347.2	421520.6	-7.19763	55.03844	5246	7888	2642
31	Foreglen WwTW	262765.4	409376.9	-7.02172	54.92806	489	518	29
32	Feeny WwTW	262732.9	405078.4	-7.02316	54.88946	924	1353	429
33	Fincarn WwTW	263369.5	404526.1	-7.01337	54.88442	87	100	13
34	Park WwTW	259121.3	402247.4	-7.08002	54.86447	766	1087	321
35	Gortscreagan WwTW	257243.3	403755	-7.10896	54.87823	68	100	32
36	Mulderg WwTW	256935.1	409046.3	-7.11272	54.92579	55	99	44
37	Claudy WwTW	254678.6	407365	-7.14823	54.91094	2722	3409	687
38	Killaloo WwTW	252268.6	409189.9	-7.18547	54.92759	92	150	58
39	Ervey Road WwTW	252618	413762.2	-7.17918	54.96862	14	47	33
40	Tamnaherin WwTW	251925	416471	-7.18951	54.99302	393	470	77
41	Knockbrack WwTW	248657.9	411438.3	-7.2414	54.94815	22	36	14
42	Gosheden Two WwTW	249126.6	410900.4	-7.23418	54.94327	92	120	28
43	Legaghory WwTW	249860.2	409921.7	-7.2229	54.93441	30	50	20
44	Ardground WwTW	249473.9	407879	-7.22928	54.9161	69	100	31
45	Moneycanon WwTW	249148	402794.3	-7.23523	54.87046	37	82	45
46	Donemana WwTW	244175	403355	-7.31259	54.87596	1040	634	-406

Map ID	NAME	Easting	Northing	Longitude	Latitude	Current p.e.	Design p.e.	Available capacity
47	Mountcastle WwTW	241269.5	405602.7	-7.35753	54.8964	11	18	7
48	Milltown Burndennet WwTW	239301.3	404376.5	-7.38837	54.88554	49	54	5
49	Donagheady WwTW	239541.9	405371	-7.38449	54.89446	188	300	112
50	Cullion WwTW	240437.9	407346	-7.37025	54.91213	79	100	21
51	Bready WwTW	236533.3	407605.1	-7.43109	54.91475	301	400	99
52	St Johnston	234750	410000	-7.45861	54.93639	330	1050	720
53	Magheramason WwTW	239354.2	410870.8	-7.38666	54.94387	591	1200	609
54	Creaghcor WwTW	236824	409874	-7.42627	54.93511	30	18	-12
55	Carrigans	236698	411554	-7.42802	54.95021	280	347	67
56	Molenan WwTW	239072.2	413586.9	-7.39069	54.96829	36	44	8
57	Nixons Corner WwTW	240250.8	414520.9	-7.37216	54.97659	285	520	235
58	Killea	238010	415272	-7.40705	54.98351	520	800	280
59	Glenabbey WwTW	241902.3	421369.7	-7.34537	55.03797	45	47	2
60	Culmore 2 WwTW	247510.6	423020.9	-7.25738	55.05229	133891	150075	16184
61	Greenbank No.1 Housing Scheme	250851	430502	-7.20379	55.11915	28	28	0
62	Redcastle Housing Scheme	255319	435013	-7.13289	55.15919	40	40	0
63	Moville	261019	438445	-7.04275	55.18935	1820	0	-1820
64	Greencastle Housing Scheme	264345	440292	-6.99012	55.20551	90	90	0

N/A indicates data were Not Available.

4.1.3.1. Continuous Sewage Discharges

Figure 4.14 shows the continuous sewage discharges associated with the WWTWs within the Lough Foyle catchment area. Table 4.3 shows the coordinates for the continuous discharges from WWTW.

All of the WWTW shown in Figure 4.7 above have continuous discharge pipes associated with them, however, coordinates for some discharge pipes were not available (those marked with * in Table 4.4). Assumptions as to the location of their discharge pipes were made based on the plant's location in relation to the nearest water body.

In total, there are 6 direct discharges into Lough Foyle and the remainder discharge into rivers which ultimately discharge into the lough.

Figure 4.14: Location of Continuous Sewage Discharges within the Lough Foyle Catchment Area (Source: NI Water/ EPA).

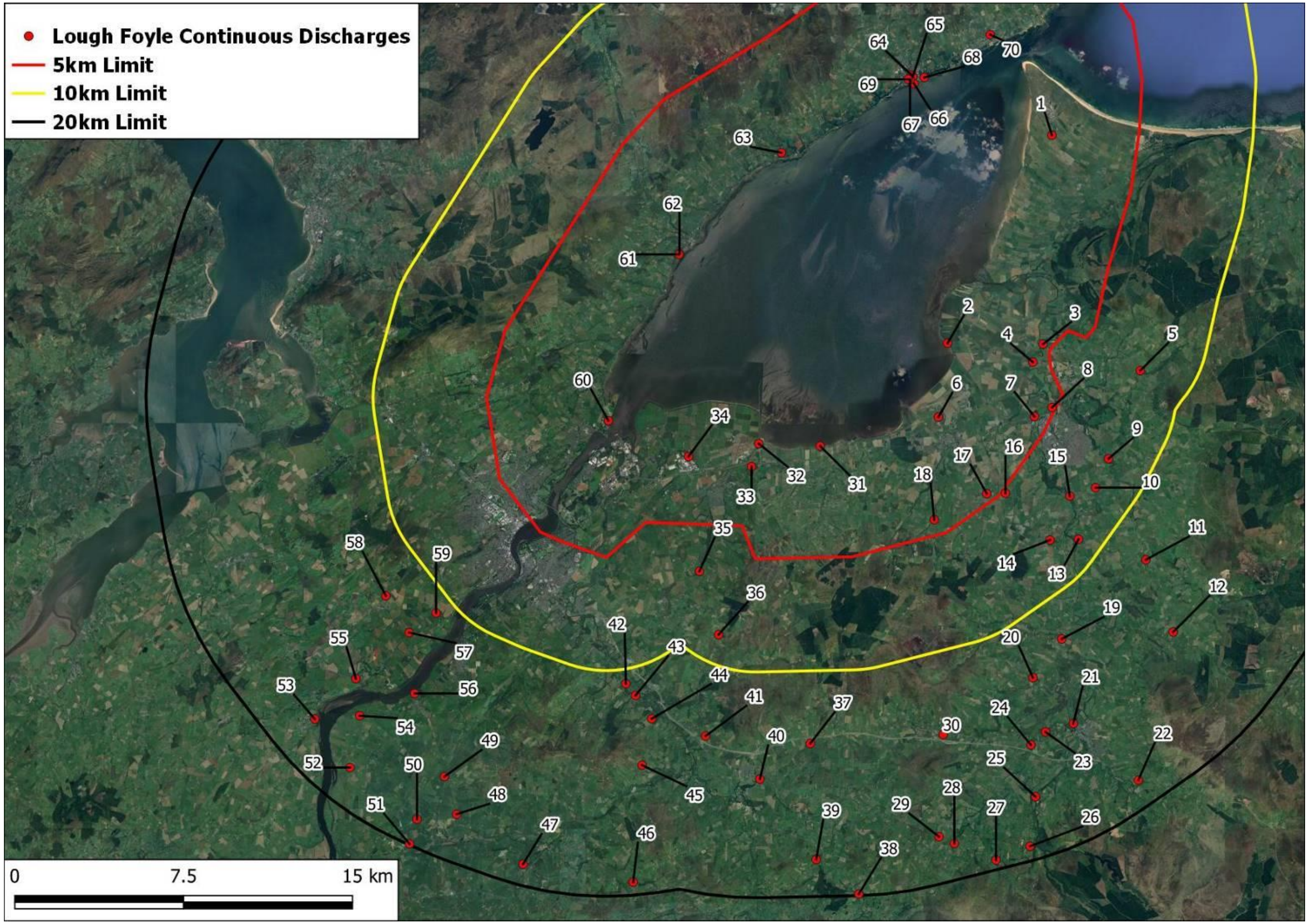


Table 4.3: WWTW Continuous Discharges within the Lough Foyle Catchment Area (Source: NI Water/ EPA).

Map ID	Plant	Longitude	Latitude	Easting	Northing
1	Magilligan Point Road WwTW*	55.16605	-6.94585	267229.6	435940.2
2	Carrowclare WwTW*	55.08365	-7.01807	262756.2	426700.9
3	Aghanloo 1 WwTW	55.08328	-6.95204	266973.5	426720.4
4	Myroe WwTW	55.07615	-6.95906	266536.9	425920.4
5	Bolea WwTW	55.07277	-6.88474	271290.0	425617.5
6	Ballykelly WwTW	55.05434	-7.02442	262396.5	423432.1
7	Lisnakilly WwTW	55.05454	-6.95796	266643.4	423515.7
8	Limavady WwTW	55.05816	-6.94576	267416.7	423929.7
9	Drummond WwTW	55.03779	-6.90671	269947.3	421700.4
10	Edenmore Road WwTW	55.02629	-6.91567	269394.4	420412.1
11	Drumsurn WwTW	54.99767	-6.88092	271667.8	417261.1
12	Ballymacallion WwTW	54.96895	-6.86200	272930.8	414083.1
13	Ballyquin WwTW	55.00582	-6.92746	268675.5	418121.3
14	Largy Limavady WwTW	55.00551	-6.94721	267412.2	418067.1
15	Ardgarvan WwTW	55.02296	-6.93354	268257.4	420024.0
16	Dromore Highlands WwTW	55.02409	-6.97804	265409.4	420106.6
17	Drumraighland WwTW	55.02394	-6.99099	264581.4	420078.1
18	Glack Laurel Road WwTW	55.01356	-7.02733	262273.5	418889.6
19	Bonnanaboigh WwTW*	54.96618	-6.93909	267998.2	413696.9
20	Gortnahey WwTW	54.95077	-6.95905	266745.6	411963.1
21	Dungiven WwTW	54.93251	-6.93108	268568.4	409957.3
22	Crebarkey WwTW	54.91000	-6.88609	271492.4	407496.4
23	Owenbeg WwTW	54.92916	-6.95028	267343.2	409565.7
24	Dernaflaw WwTW	54.92401	-6.96038	266704.6	408982.6
25	Carnanbane WwTW	54.90338	-6.95725	266939.4	406688.5
26	Caugh Hill East WwTW	54.88364	-6.96102	266730.3	404487.5
27	Unknown	54.87813	-6.98454	265229.8	403852.6
28	Fincarn WwTW	54.88475	-7.01340	263367.1	404562.8
29	Feeny WwTW	54.88742	-7.02393	262686.8	404850.8
30	Foreglen WwTW	54.92813	-7.02109	262805.7	409384.9
31	Greysteel 1 WwTW	55.04286	-7.10617	257188.0	422083.6
32	Longfield Eglinton WwTW*	55.04375	-7.14863	254472.7	422149.2
33	Killylane Eglinton WwTW	55.03468	-7.15365	254163.9	421135.4
34	Donnybrewer WwTW*	55.03866	-7.19726	251370.4	421545.2
35	Tamnaherin WwTW*	54.99309	-7.18968	251914.0	416478.3
36	Ervey Road WwTW*	54.96790	-7.17643	252794.9	413684.1
37	Mulderg WwTW	54.92455	-7.11308	256913.7	408908.0
38	Park WwTW	54.86459	-7.07949	259154.8	402261.2
39	Gortscreagan WwTW	54.87838	-7.10894	257244.2	403771.8

40	Claudy WwTW	54.91045	-7.14788	254701.7	407310.1
41	Killaloo WwTW	54.92756	-7.18541	252272.1	409186.6
42	Knockbrack WwTW*	54.94837	-7.24058	248710.0	411463.0
43	Gosheden Two WwTW	54.94369	-7.23391	249143.4	410946.4
44	Legaghory WwTW*	54.93443	-7.22269	249873.6	409924.1
45	Ardground WwTW	54.91593	-7.22941	249466.0	407859.5
46	Moneycanon WwTW	54.86934	-7.23552	249130.7	402668.9
47	Donemana WwTW	54.87648	-7.31174	244229.4	403413.2
48	Mountcastle WwTW	54.89640	-7.35761	241264.2	405602.7
49	Cullion WwTW	54.91139	-7.36609	240705.5	407266.5
50	Donagheady WwTW*	54.89443	-7.38506	239505.3	405367.6
51	Milltown Burndennet WwTW	54.88458	-7.39026	239181.2	404268.0
52	Bready WwTW*	54.91498	-7.43138	236514.3	407630.5
53	St Johnston	54.93434	-7.45578	234933.0	409773.0
54	Creaghcor WwTW*	54.93561	-7.42471	236923.6	409929.9
55	Carrigans	54.95040	-7.42736	236740.0	411575.0
56	Magheramason WwTW*	54.94450	-7.38673	239348.9	410940.6
57	Molenan WwTW	54.96871	-7.39046	239086.8	413633.1
58	Killea	54.98332	-7.40662	238038.0	415251.0
59	Nixons Corner WwTW*	54.97651	-7.37189	240268.0	414512.0
60	Culmore 2 WwTW*	55.05289	-7.25268	247810.4	423091.0
61	Greenbank No. 1 housing scheme	55.11883	-7.20381	250850.0	430466.0
62	Greenbank No. 1 housing scheme	55.11906	-7.20352	250868.0	430492.0
63	Redcastle housing scheme	55.15912	-7.13302	255311.0	435005.0
64	Moville	55.18986	-7.04302	261001.0	438502.0
65	Moville	55.18913	-7.04215	261057.0	438421.0
66	Moville	55.18641	-7.04125	261119.0	438119.0
67	Moville	55.18812	-7.04402	260940.0	438308.0
68	Moville	55.18887	-7.03417	261566.0	438400.0
69	Moville	55.18818	-7.04543	260850.0	438313.0
70	Greencastle housing sheme	55.20584	-6.98854	264445.0	440330.0

4.1.3.2. Rainfall Dependent Sewage Discharges

Figure 4.15 to Figure 4.20 show all rainfall dependent discharges *i.e.,* overflows, group septic tanks and private sewage treatment respectively, within 20km of Lough Foyle. Table 4.4 documents the Combined Sewer Overflows (CSO) and Sewage Pumping Station (SPS) overflows which discharge into Lough Foyle or a tributary of it and Table 4.5 documents the septic tanks. There are 173 rainfall dependent discharges and 41 group septic tanks within 20km of Lough Foyle. There are 458 private sewage systems within 20km of Lough Foyle in Northern Ireland. The locations of private sewage systems in the Republic of Ireland are not available, however, the number present within 20km of Lough Foyle has been estimated at 3,648 from the 2016 census data.

Figure 4.15: All storm water and combined sewer overflow discharges within 20km of Lough Foyle (Source: NI Water/ EPA).

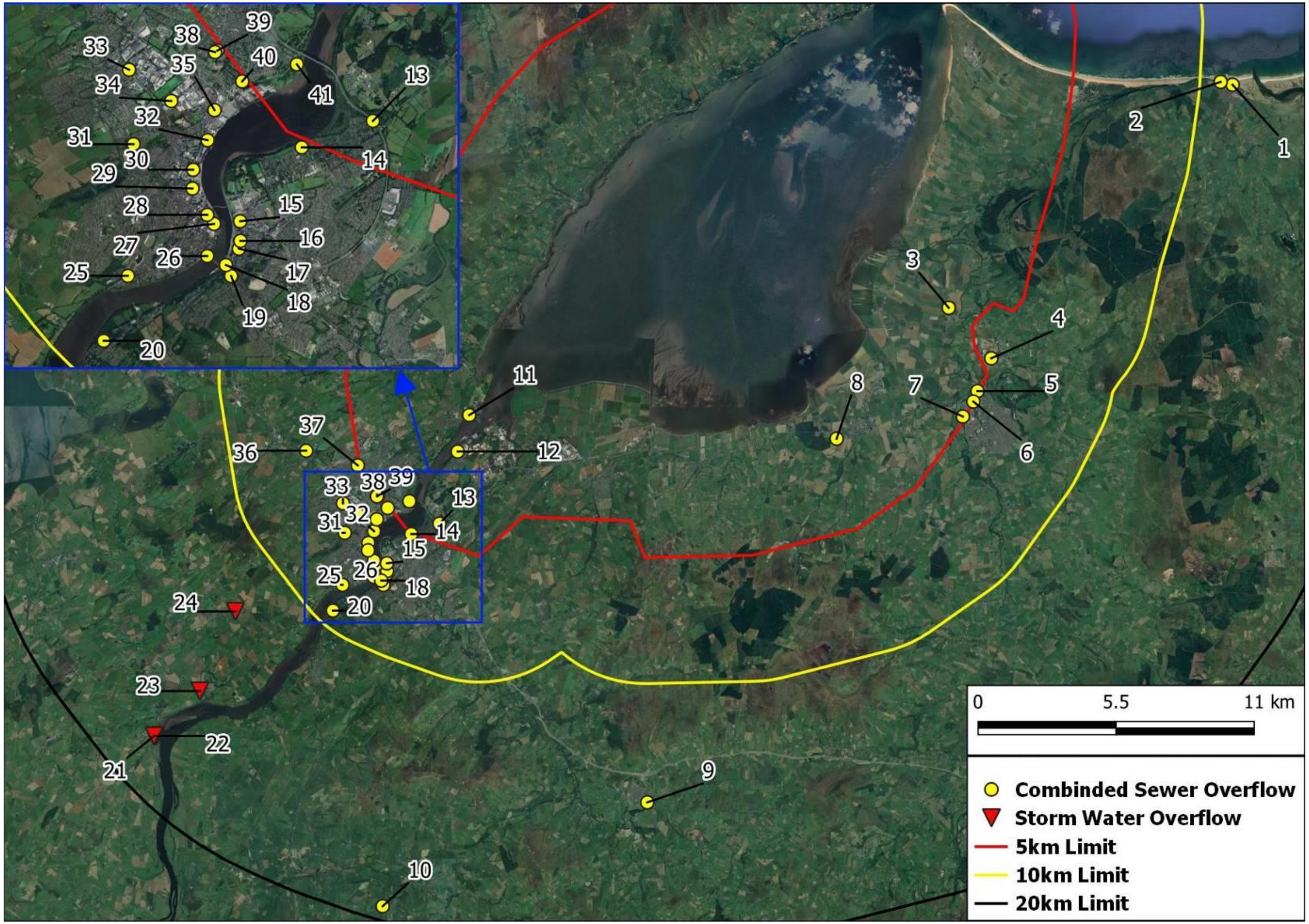


Figure 4.16: All Pumping station overflow discharges to the south of Lough Foyle within 20km (Source: NI Water/ EPA).

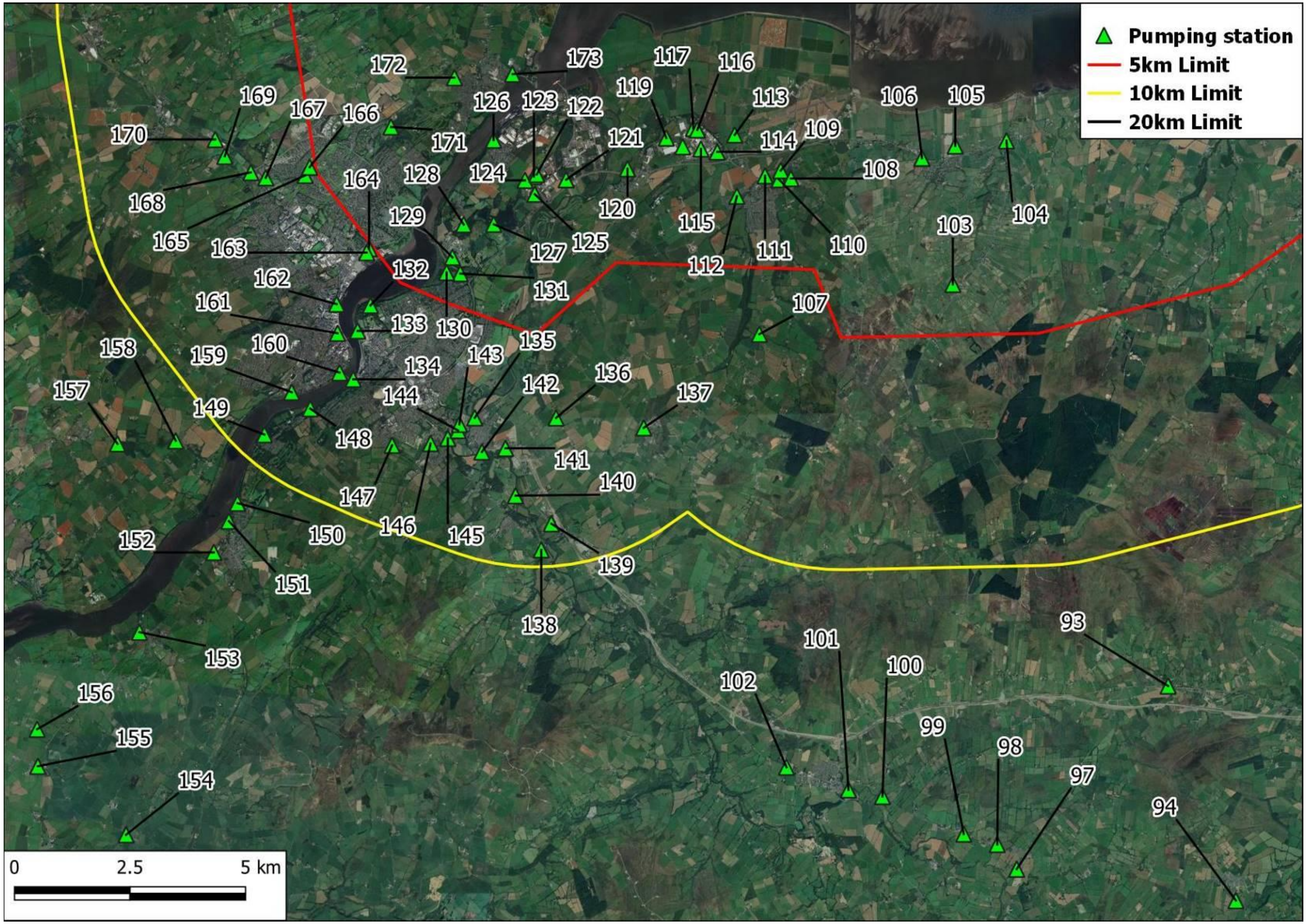


Figure 4.17: All Pumping station overflow discharges to the south east of Lough Foyle within 20km (Source: NI Water/ EPA).

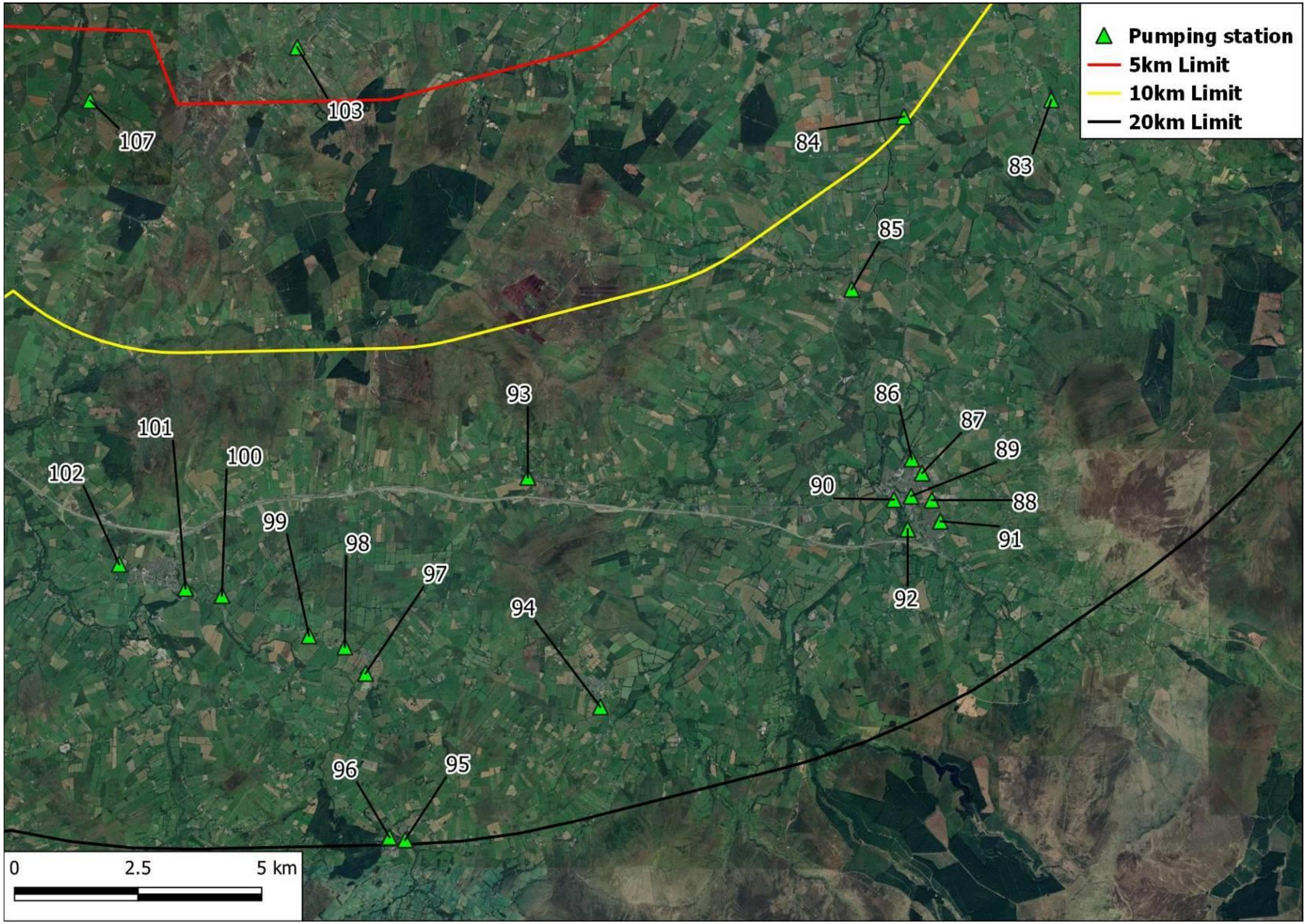


Figure 4.18: All Pumping station overflow discharges to the east of Lough Foyle within 20km (Source: NI Water/ EPA).

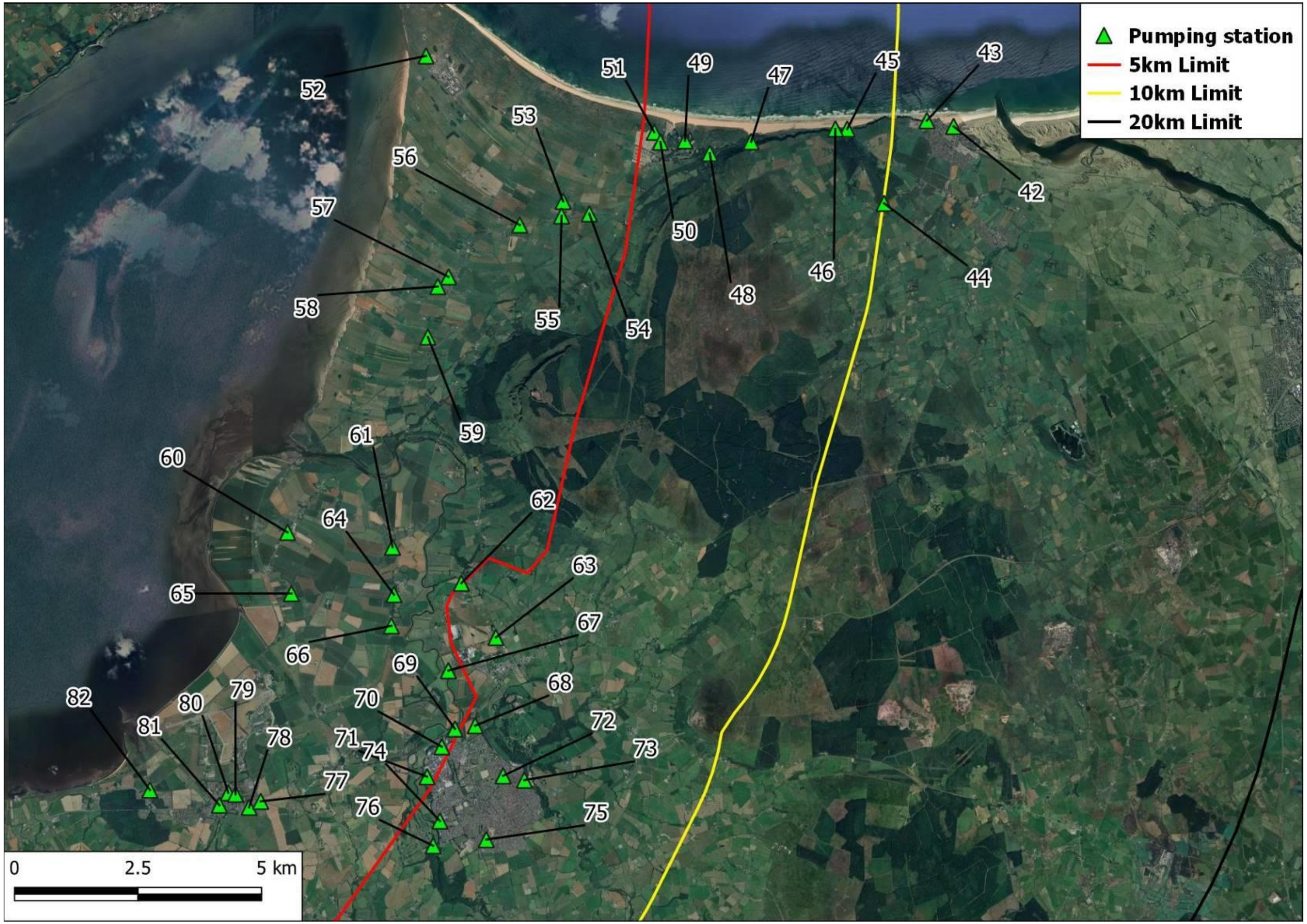


Figure 4.19: All septic tanks within the Lough Foyle Catchment Area (Source: NI Water).

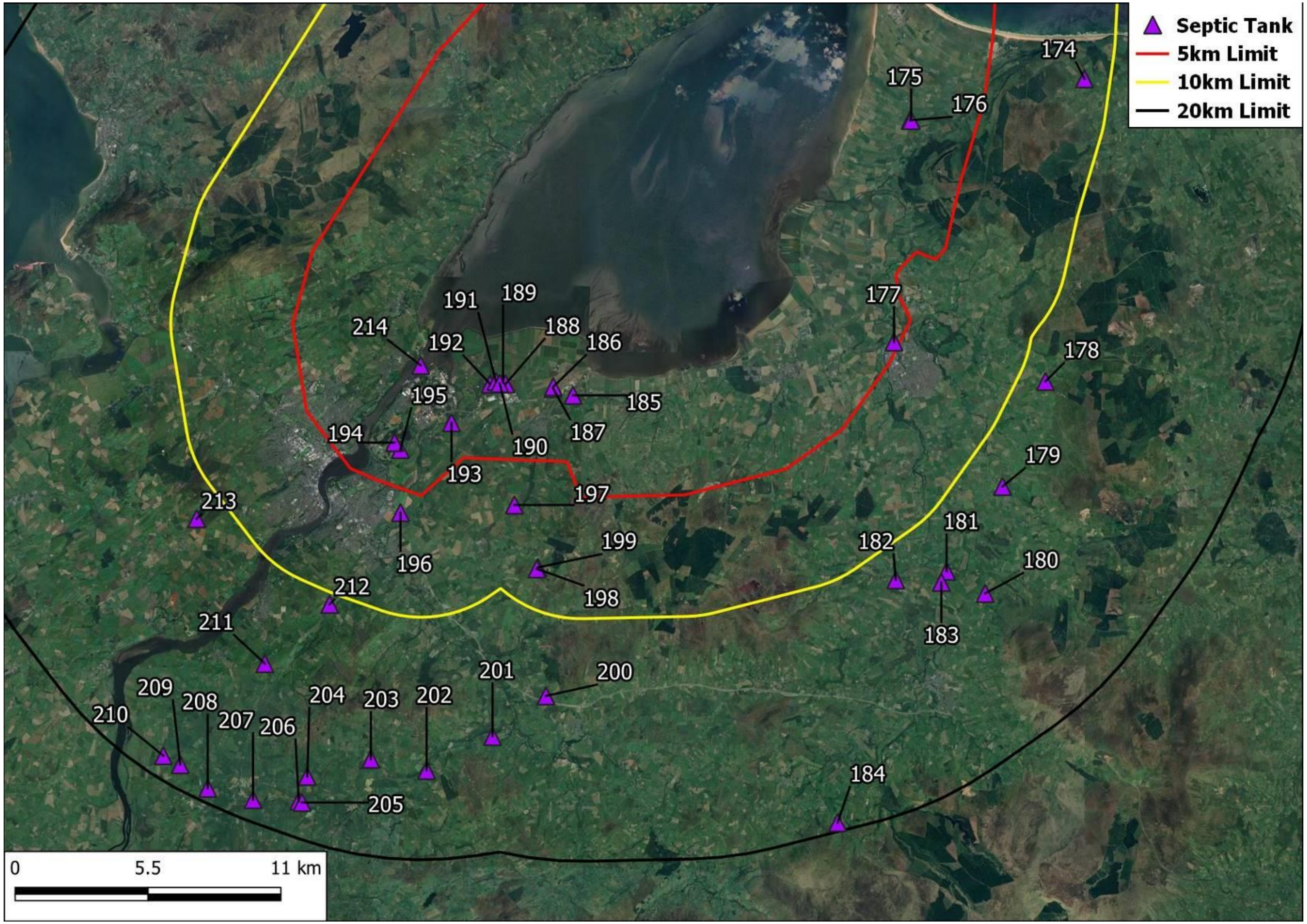


Figure 4.20: All private sewage systems within the Lough Foyle Catchment Area (Source: NI Water).

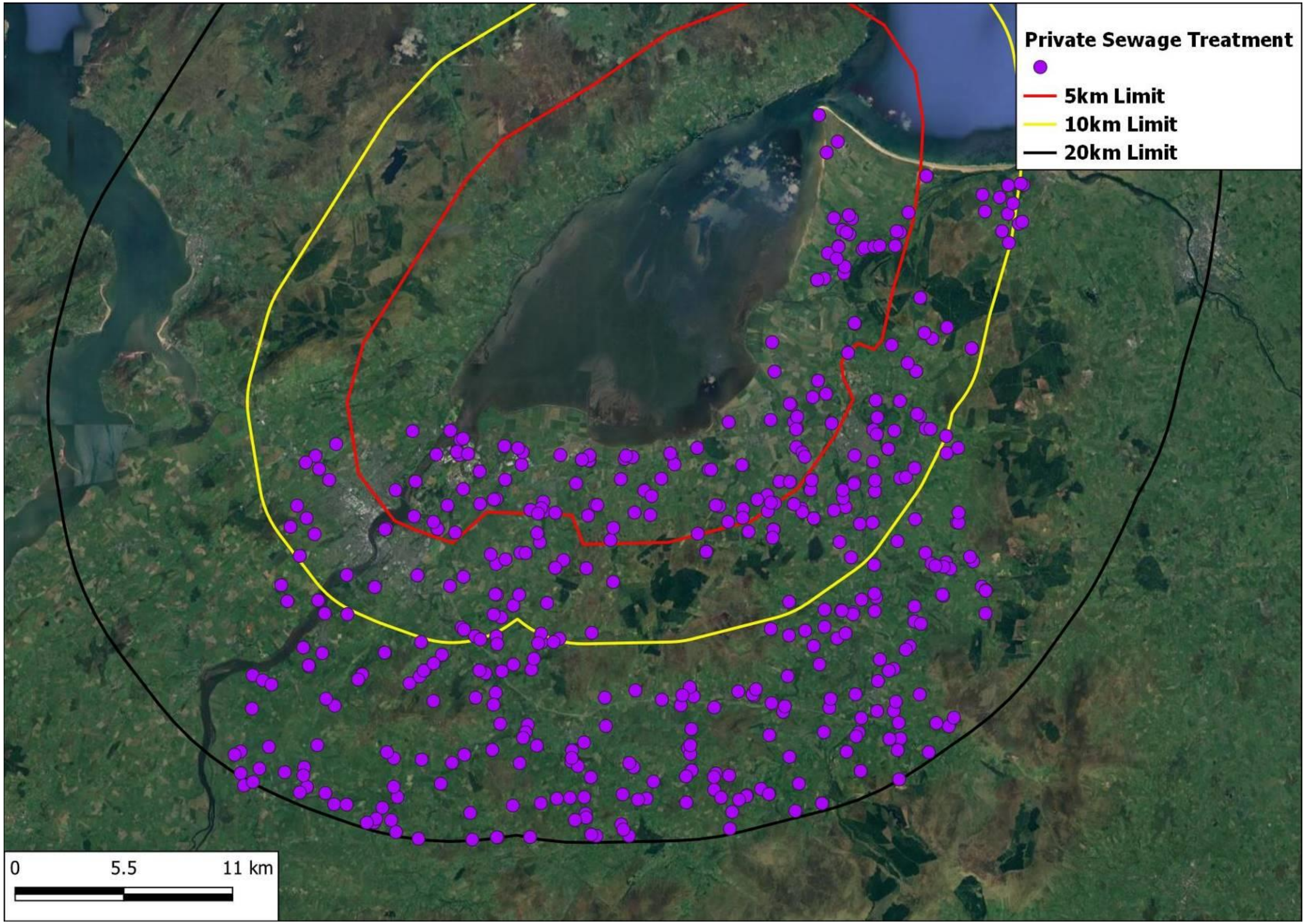


Table 4.4: CSO and WwPS overflows within the Lough Foyle catchment Area (Source: NI Water/ EPA).

Map ID	Name	Longitude	Latitude	Easting	Northing	Function
1	Promenade Castlerock CSO	-6.78628	55.16632	277350	436159	Combined
2	Main Street Swimming Pool CSO	-6.79369	55.16734	276876	436264	Combined
3	Seacoast Road CSO	-6.96249	55.08702	266252	427149	Combined
4	Road Service Yard CSO	-6.93607	55.06903	267969	425173	Combined
5	Limavady CSO	-6.94464	55.05736	267442	423865	Combined
6	Ballyclose Street CSO	-6.94720	55.05361	267284	423446	Combined
7	Roemill Road CSO	-6.95370	55.04830	266878	422849	Combined
8	Foyle Drive CSO	-7.03206	55.04041	261881	421897	Foul
9	Pinewood Crescent CSO	-7.14961	54.91061	254542	407350	Combined
10	Berryhill Road Dunamanagh CSO	-7.31389	54.87347	244047	403099	Combined
11	Culmore Point Coney CSO	-7.26013	55.04882	247291	422655	Combined
12	Strathfoyle CSO	-7.26732	55.03583	246847	421205	Combined
13	Caw CSO	-7.27863	55.01014	246153	418337	Combined
14	Caw Park CSO	-7.29612	55.00641	245038	417911	Combined
15	Alfred Street Florence CSO	-7.31125	54.99598	244082	416740	Combined
16	Bonds Hill CSO	-7.31118	54.99321	244089	416432	Combined
17	Duke Street Roundabout CSO	-7.31155	54.99212	244067	416310	Combined
18	Duke Street CSO	-7.31474	54.98980	243865	416050	Combined
19	Dunfield Terrace 2 CSO	-7.31346	54.98826	243949	415879	Combined
20	Victoria Road Prehen CSO	-7.34475	54.97911	241955	414841	Combined

21	St Johnston SW004	-7.45578	54.93434	234933	409773	Storm water overflow
22	St Johnston SW003	-7.45475	54.93432	234999	409771	Storm water overflow
23	Carrigans	-7.42736	54.95040	236740	411575	Storm water overflow
24	Killea	-7.40531	54.97878	238126	414747	Storm water overflow
25	Lone Moor Road Brandywell CSO	-7.33882	54.98828	242325	415865	Combined
26	Foyle Road Craigavon Bridge CSO	-7.31932	54.99108	243570	416189	Combined
27	Orchard Street CSO	-7.31765	54.99562	243672	416695	Combined
28	Union Hall Place CSO	-7.31932	54.99689	243564	416836	Combined
29	Clarendon Terrace CSO	-7.32294	55.00061	243328	417247	Combined
30	Lawrence Hill CSO	-7.32277	55.00325	243336	417542	Combined
31	Glen Road Derry CSO	-7.33743	55.00687	242394	417936	Combined
32	Rock Road CSO	-7.31924	55.00743	243558	418009	Combined
33	Northland Road Spring Town CSO	-7.33852	55.01737	242314	419104	Combined
34	Northland Playing Fields CSO	-7.32816	55.01296	242981	418619	Combined
35	Duncreggan Road CSO	-7.31754	55.01167	243662	418482	Combined
36	Buncrana Road CSO	-7.36138	55.03611	240832	421177	Foul
37	Fairview Knockalla Shantallow CSO	-7.32932	55.03088	242888	420613	Combined
38	Racecourse Road One CSO	-7.31740	55.01986	243662	419394	Combined
39	Racecourse Road Two CSO	-7.31682	55.02007	243699	419418	Combined
40	Culmore Road Belmont CSO	-7.31074	55.01571	244093	418937	Combined
41	Gleneagles CSO	-7.29731	55.01812	244949	419214	Combined

42	Castlerock Promenade WwPS	-6.78735	55.16676	277329	436183	Combined
43	Castlerock Coastguard WwPS	-6.79580	55.16781	276788	436291	Combined
44	Ballywoodock WwPS	-6.80935	55.15285	275954	434611	Combined
45	Downhill Hotel WwPS	-6.82101	55.16629	275185	436095	Combined
46	Downhill Roadside WwPS	-6.82476	55.16631	274946	436093	Combined
47	Umbra Waterfall WwPS	-6.85144	55.16399	273250	435806	Foul
48	Umbra Level Crossing WwPS	-6.86452	55.16189	272420	435559	Foul
49	Benone Tourist Complex WwPS	-6.87237	55.16417	271916	435804	Foul
50	Benone Avenue North WwPS	-6.88015	55.16392	271421	435769	Foul
51	Benone One WwPS	-6.88210	55.16572	271293	435967	Foul
52	Lower Doaghs Magilligan TPS	-6.95435	55.17950	266666	437430	Foul
53	Aughil St Aidans TPS	-6.91095	55.15320	269476	434545	Combined
54	Aughil Seacoast East WwPS	-6.90266	55.15095	270008	434302	Foul
55	Aughil Tircreven TPS	-6.91146	55.15057	269448	434251	Foul
56	Clooney 504-524 TPS	-6.92470	55.14893	268607	434056	Combined
57	Carriage Court WwPS	-6.94725	55.13954	267185	432988	Foul
58	Drumavally WwPS	-6.95064	55.13778	266972	432789	Combined
59	Oughtymoyle 2 WwPS	-6.95378	55.12866	266787	431770	Combined
60	Carrowclare Road WwPS	-6.99819	55.09326	264011	427788	Foul
61	Crindle WwPS	-6.96497	55.09057	266136	427520	Combined
62	Dowland WwPS	-6.94318	55.08405	267538	426815	Foul
63	Aghanloo Industrial Estate WwPS	-6.93223	55.07422	268254	425731	Foul
64	Myroe Sids WwPS	-6.96451	55.08198	266179	426564	Combined

65	Ballymacran WwPS	-6.99698	55.08218	264105	426556	Foul
66	Lomond WwPS	-6.96535	55.07631	266135	425932	Combined
67	Aghanloo Dowland Park WwPS	-6.94729	55.06820	267302	425046	Combined
68	The Brickfields WwPS	-6.93880	55.05822	267861	423943	Foul
69	Limavady IPS	-6.94520	55.05763	267453	423871	Final Effluent
70	Roeville Terrace WwPS	-6.94937	55.05440	267192	423508	Foul
71	Catherine Street WwPS	-6.95402	55.04896	266904	422898	Combined
72	Castle Park Limavady WwPS	-6.92996	55.04912	268442	422940	Foul
73	Bovally WwPS	-6.92324	55.04833	268873	422858	Foul
74	Coolessan WwPS	-6.94997	55.04093	267177	422008	Foul
75	Whitehill WwPS	-6.93530	55.03755	268120	421646	Foul
76	Radison Roe Park WwPS	-6.95210	55.03644	267048	421506	Foul
77	Kings Lane 62 WwPS	-7.00671	55.04448	263544	422351	Foul
78	Drummond Park WwPS	-7.01038	55.04340	263311	422227	Foul
79	Church Hill House WwPS	-7.01469	55.04578	263032	422487	Foul
80	Dukes Lane WwPS	-7.01696	55.04604	262886	422515	Foul
81	Plantation Road WwPS	-7.01979	55.04380	262709	422263	Foul
82	Walworth WwPS	-7.04178	55.04654	261299	422548	Foul
83	Drumsurn Rushie WwPS	-6.87582	54.99877	271992	417389	Foul
84	Ballyquin Road WwPS	-6.92219	54.99576	269030	417007	Foul
85	Burnfoot WwPS	-6.93870	54.96455	268026	413516	Foul
86	Browns Bridge WwPS	-6.91976	54.93381	269292	410113	Foul
87	Rannyglas WwPS	-6.91652	54.93125	269504	409831	Foul
88	OCahan Place WwPS	-6.91346	54.92637	269709	409291	Foul
89	Hass Road WwPS	-6.91999	54.92709	269289	409364	Foul
90	Kevin Lynch Park WwPS	-6.92541	54.92646	268943	409289	Foul
91	Greenhaven WwPS	-6.91077	54.92254	269888	408867	Foul
92	Bleech Green Lane WwPS	-6.92107	54.92112	269230	408699	Foul

93	Muldonagh WwPS	-7.04074	54.93051	261543	409632	Combined
94	Glenedra Road WwPS	-7.01788	54.88890	263073	405020	Foul
95	Altinure Road WwPS	-7.07937	54.86481	259163	402285	Combined
96	Millside Crescent WwPS	-7.08434	54.86529	258842	402334	Combined
97	Clagan Claudy WwPS	-7.09183	54.89499	258319	405635	Foul
98	Killycor WwPS	-7.09838	54.89978	257891	406163	Combined
99	Glenshane Road WwPS	-7.10967	54.90179	257165	406377	Combined
100	Kinculbrack WwPS	-7.13710	54.90909	255395	407167	Combined
101	Claudy IPS	-7.14859	54.91037	254656	407301	Foul
102	Cregg WwPS	-7.16947	54.91476	253311	407774	Foul
103	Killywool WwPS	-7.11337	55.00828	256777	418229	Foul
104	Faughanvale WwPS	-7.09528	55.03606	257894	421336	Foul
105	Foyle Avenue WwPS	-7.11255	55.03506	256792	421210	Foul
106	Clooney Road Greysteel WwPS	-7.12377	55.03270	256077	420939	Foul
107	Gortinreid Bridge WwPS	-7.17863	54.99865	252614	417106	Combined
108	Killylane Muff WwPS	-7.16796	55.02877	253257	420466	Combined
109	St Canices Park One WwPS	-7.17142	55.03030	253034	420634	Combined
110	St Canices Park Two WwPS	-7.17194	55.02855	253002	420440	Foul
111	Eglinton Cottage Way WwPS	-7.17669	55.02928	252698	420517	Combined
112	Dunboyne Park WwPS	-7.18621	55.02535	252094	420073	Foul
113	Station Road Eglinton WwPS	-7.18695	55.03720	252031	421391	Foul
114	Decks WwPS	-7.19283	55.03392	251660	421021	Foul
115	Courtauld Way One WwPS	-7.19834	55.03447	251307	421079	Foul
116	Donnybrewer IPS	-7.19954	55.03816	251225	421489	Final Effluent
117	Courtauld Way Three WwPS	-7.20088	55.03844	251140	421519	Foul
118	Courtauld Way Two WwPS	-7.20447	55.03490	250914	421122	Combined
119	Transtec WwPS	-7.21000	55.03658	250559	421305	Combined

120	Campsie Eglinton WwPS	-7.22310	55.03065	249728	420635	Combined
121	Carrakeel Drive WwPS	-7.24380	55.02853	248408	420385	Combined
122	Maydown Carrakeel 2 WwPS	-7.25370	55.02955	247773	420492	Combined
123	PSNI Maydown Two WwPS	-7.25468	55.02914	247711	420445	Foul
124	PSNI Maydown One WwPS	-7.25766	55.02841	247521	420362	Foul
125	Templetown Park WwPS	-7.25437	55.02573	247735	420066	Foul
126	Strathfoyle 2 WwPS	-7.26827	55.03620	246834	421222	Combined
127	Judges Road WwPS	-7.26823	55.01991	246855	419409	Foul
128	Gransha Park 2 WwPS	-7.27834	55.01986	246209	419396	Combined
129	Gransha Hospital WwPS	-7.28216	55.01352	245972	418688	Foul
130	Waterfoot Caw WwPS	-7.28411	55.01060	245850	418361	Foul
131	Caw WwPS	-7.27950	55.01037	246145	418339	Foul
132	St Columbs Park Clooney WwPS	-7.30981	55.00421	244213	417634	Foul
133	Browning Drive WwPS	-7.31412	54.99929	243942	417083	Foul
134	Duke Street 2 WwPS	-7.31561	54.98992	243857	416039	Combined
135	Faughan Crescent WwPS	-7.27463	54.98247	246489	415236	Combined
136	Gortree Road WwPS	-7.24719	54.98244	248246	415252	Combined
137	Lettershendony 2 WwPS	-7.21763	54.98052	250141	415059	Combined
138	Berryburn Ardkill WwPS	-7.25219	54.95690	247956	412405	Foul
139	Cross Drumahoe WwPS	-7.24879	54.96195	248168	412969	Combined
140	Bleach Green WwPS	-7.26088	54.96738	247387	413566	Combined
141	Beeches Drumahoe WwPS	-7.26425	54.97656	247160	414586	Foul
142	Old Mill Mews Drumahoe WwPS	-7.27221	54.97586	246652	414502	Foul
143	Three Mile WwPS	-7.27981	54.98120	246159	415091	Combined
144	Drumahoe WwPS	-7.28026	54.98001	246131	414959	Combined
145	Riverside Park WwPS	-7.28371	54.97849	245912	414787	Foul
146	Tullyally West WwPS	-7.28952	54.97749	245541	414672	Foul

147	Trench Road 18 WwPS	-7.30251	54.97716	244710	414627	Combined
148	Boat House Prehen WwPS	-7.33010	54.98423	242936	415397	Foul
149	Prehen WwPS	-7.34556	54.97920	241951	414828	Combined
150	Dunhugh Manor WwPS	-7.35465	54.96593	241383	413345	Foul
151	New Buildings WwPS	-7.35755	54.96245	241201	412956	Combined
152	New Buildings Desmonds WwPS	-7.36263	54.95640	240881	412279	Foul
153	Dunnalong Road WwPS	-7.38773	54.94094	239289	410543	Foul
154	Tamnabryan WwPS	-7.39223	54.90166	239038	406168	Combined
155	Bready Church WwPS	-7.42199	54.91495	237117	407631	Foul
156	Bready Primary School WwPS	-7.42223	54.92213	237095	408431	Foul
157	Ballougry Hill Road Killea WwPS	-7.39513	54.97743	238779	414601	Foul
158	Ballinacross Meadows WwPS	-7.37548	54.97800	240037	414677	Foul
159	Coshowen Foyle Road WwPS	-7.33638	54.98740	242531	415746	Combined
160	Foyle Road Craigavon Bridge WwPS	-7.32020	54.99120	243562	416179	Combined
161	Victoria Market Car Park WwPS	-7.32089	54.99883	243509	417028	Combined
162	Queens Quay WwPS	-7.32120	55.00447	243484	417655	Combined
163	Bay Road Shell WwPS	-7.31107	55.01443	244121	418771	Surface
164	Pennyburn WwPS	-7.31028	55.01522	244171	418859	Combined
165	Galliagh Park WwPS	-7.33183	55.02936	242777	420420	Foul
166	Fairview Knockalla 2 WwPS	-7.33032	55.03096	242872	420599	Foul
167	Upper Galliagh Road WwPS	-7.34512	55.02890	241928	420361	Foul
168	Skeoge Link Roundabout WwPS	-7.35013	55.02994	241606	420473	Foul
169	Coshquin West WwPS	-7.35894	55.03306	241039	420816	Foul

170	Buncrana Road WwPS	-7.36215	55.03631	240831	421176	Foul
171	Ballyarnet Springfield WwPS	-7.30288	55.03872	244618	421480	Foul
172	Spruce Meadows WwPS	-7.28146	55.04826	245977	422556	Foul
173	Culmore Point Front Strand WwPS	-7.26189	55.04894	247227	422645	Combined

Table 4.5: Septic tanks within the Lough Foyle catchment Area (Source: NI Water).

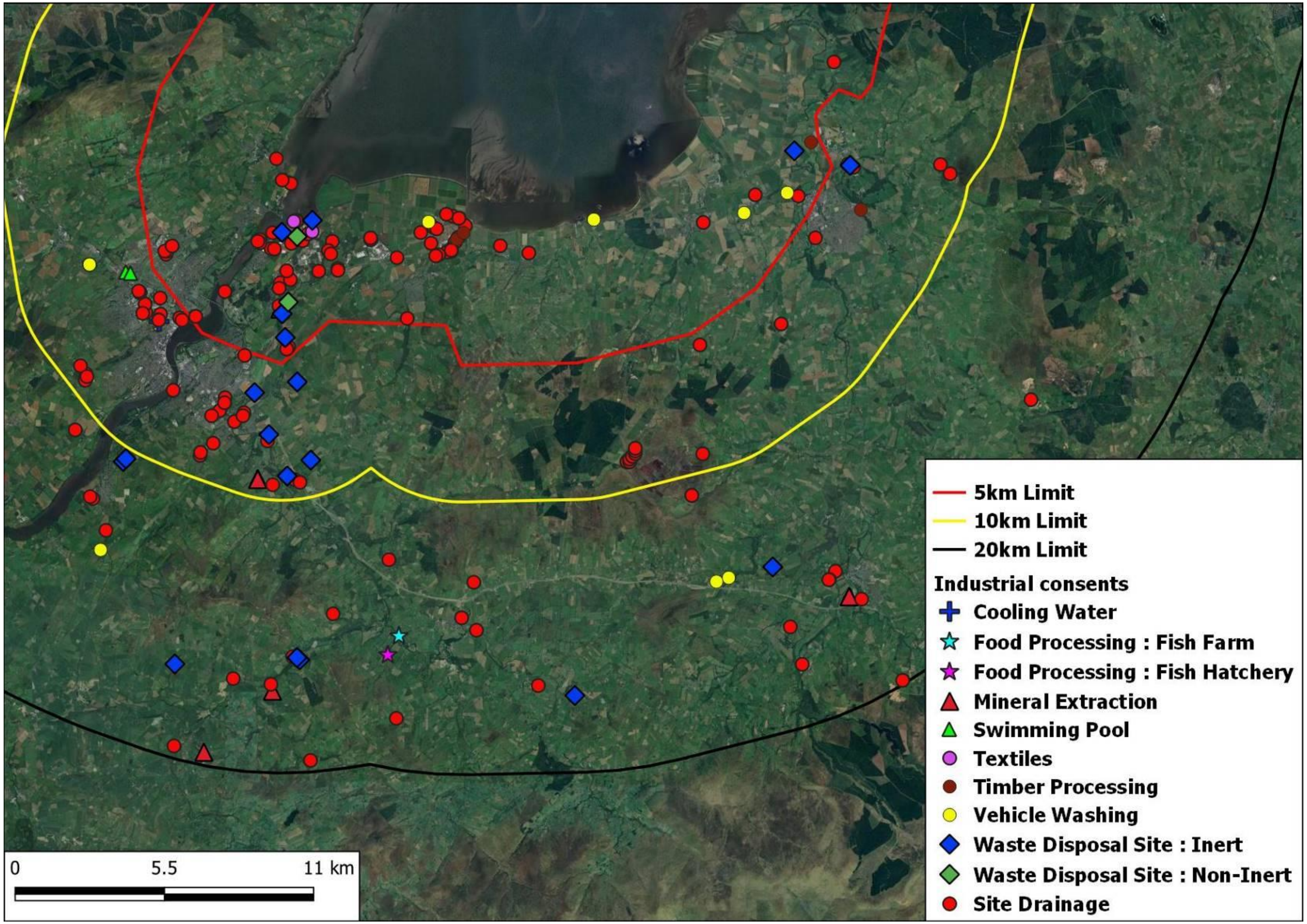
Map Id	Name	Longitude	Latitude	Easting	Northing
174	Ballyhacket Road 2-8 ST	-6.82644	55.15246	274865	434550
175	Limestone Road Two ST	-6.93819	55.13710	267767	432726
176	Limestone Road One ST	-6.93887	55.13716	267724	432732
177	Roeside ST	-6.94923	55.05536	267200	423615
178	Ballyavelin Road ST	-6.85162	55.04078	273464	422090
179	Drumsurn Road 234-238 ST	-6.87929	55.00196	271765	417740
180	Gortnagross Road 38-40 ST	-6.89044	54.96238	271121	413323
181	Drumneechy ST	-6.91532	54.97060	269513	414213
182	Bovevagh Road 37-41 ST	-6.94810	54.96741	267419	413826
183	Derryork Road 33-35 ST	-6.91871	54.96649	269303	413752
184	Glenedra Road 109-111 ST	-6.98560	54.87743	265163	403774
185	Brisland Road 3-5 ST	-7.15617	55.03566	254001	421243
186	Airfield Road ST	-7.16889	55.03884	253184	421587
187	Airfield Road Meat Plant ST	-7.16904	55.03821	253176	421517
188	McLean Road One ST	-7.19959	55.03988	251220	421680
189	McLean Road Two ST	-7.20123	55.04052	251114	421750
190	Donnybrewer Road 97-99 ST	-7.20343	55.04003	250974	421694
191	Donnybrewer Road 98-100 ST	-7.20587	55.04078	250817	421776
192	Donnybrewer Road 88 ST	-7.20962	55.03983	250579	421667
193	Faughan ST	-7.23452	55.02553	249005	420057
194	Gransha Stradreagh More ST	-7.27120	55.01820	246667	419216
195	Stradreagh Grandha Park ST	-7.26745	55.01566	246910	418936
196	Ardlough Road ST	-7.26742	54.99231	246939	416336
197	Edenreagh Road 39-41 ST	-7.19392	54.99512	251640	416701

Map Id	Name	Longitude	Latitude	Easting	Northing
198	Ervey Road 62 ST	-7.17950	54.97146	252594	414078
199	Ervey Road 66 ST	-7.17880	54.97202	252638	414140
200	Foreglen Road 51-53 ST	-7.17362	54.92443	253032	408847
201	Bonds Glen Road 149-151 ST	-7.20806	54.90938	250843	407146
202	Bonds Glen Road 65-67 ST	-7.25054	54.89679	248134	405715
203	Glenagoorland ST	-7.28651	54.90097	245821	406156
204	Castlemellan Upper ST	-7.32751	54.89459	243198	405420
205	Tullyard Donemana ST	-7.33088	54.88493	242991	404341
206	Castlemellan Lower ST	-7.33300	54.88551	242855	404405
207	Ballyheather Road121-123 ST	-7.36247	54.88596	240963	404437
208	Whin Road 21-23 ST	-7.39170	54.89019	239083	404892
209	Willow Road ST	-7.40938	54.89893	237941	405855
210	Victoria Road 277-279 ST	-7.42030	54.90228	237237	406222
211	Duncastle Road 52-60 ST	-7.35483	54.93641	241402	410058
212	Trench Road 66-70 ST	-7.31309	54.95836	244053	412527
213	Killea ST	-7.39880	54.99003	238532	416003
214	Culmore Point ST	-7.25437	55.04673	247710	422403

4.1.4. Industrial Discharges

Figure 4.21 shows the industrial discharges within the Lough Foyle catchment area accounted for during the desk-based assessment. In total, there are 193 industrial discharges within 20km of Lough Foyle. Site drainage account for 144 of these charges with inert and non-inert waste disposal accounting for a further 21.

Figure 4.21: All industrial discharges within 20km of Lough Foyle (Source: NIEA water information request viewer).

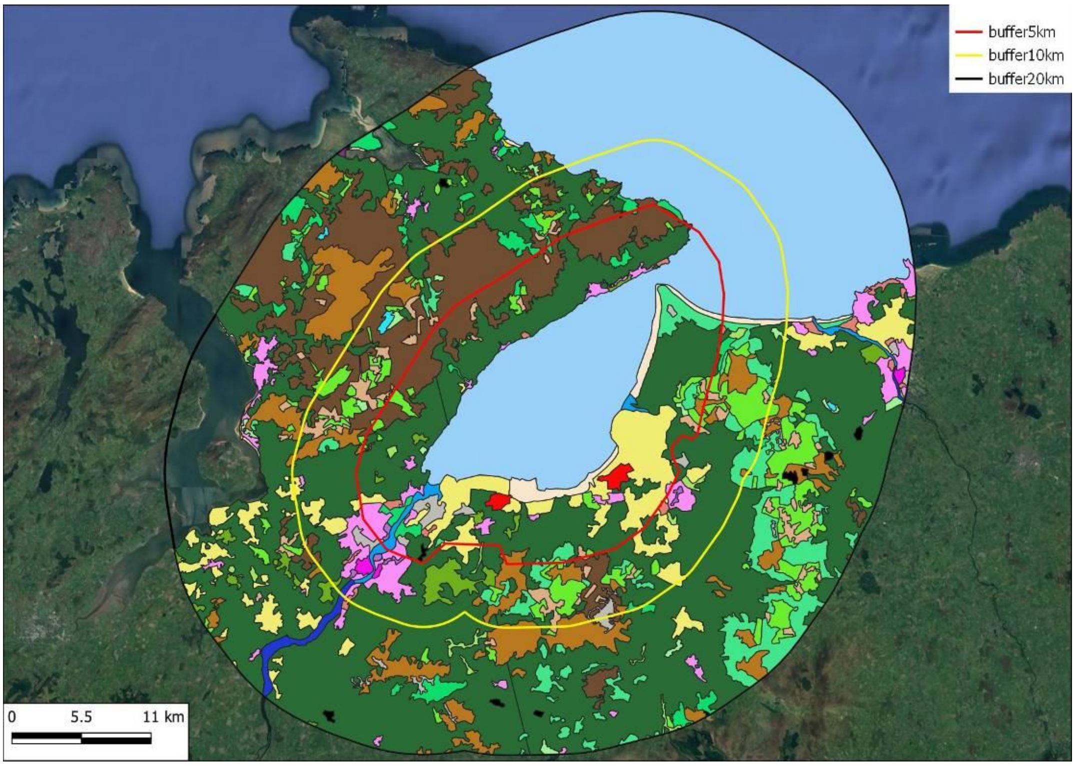


4.1.5. Land use Discharges

Figure 4.22 shows the Corine land use within 20km of the Lough Foyle for 2009 and 2018. Legend for land use can be seen in Figure 4.20

Within 20km of Lough Foyle, land use proportions have changed little. The dominated land use type remains pastures (increased from 47% to 50%), followed by peat bogs (down from 13.9% to 13.2%) and moors and heathland (up from 6.2% to 7.5%) (see Figure 4.24). Forestry (coniferous, broad-leafed and mixed) has increased from 4% to 6.2% of the land use. Land associated with agricultural activities (non-irrigated arable land, pastures, complex cultivation patterns and agriculture/natural vegetation) has increased moderately from 59.1 to 59.8% of the land use in the area.

Figure 4.22: Corine land use within 20km of Lough Foyle 2009 (Bottom) and 2018 (Top) (Source: CLC, 2018).



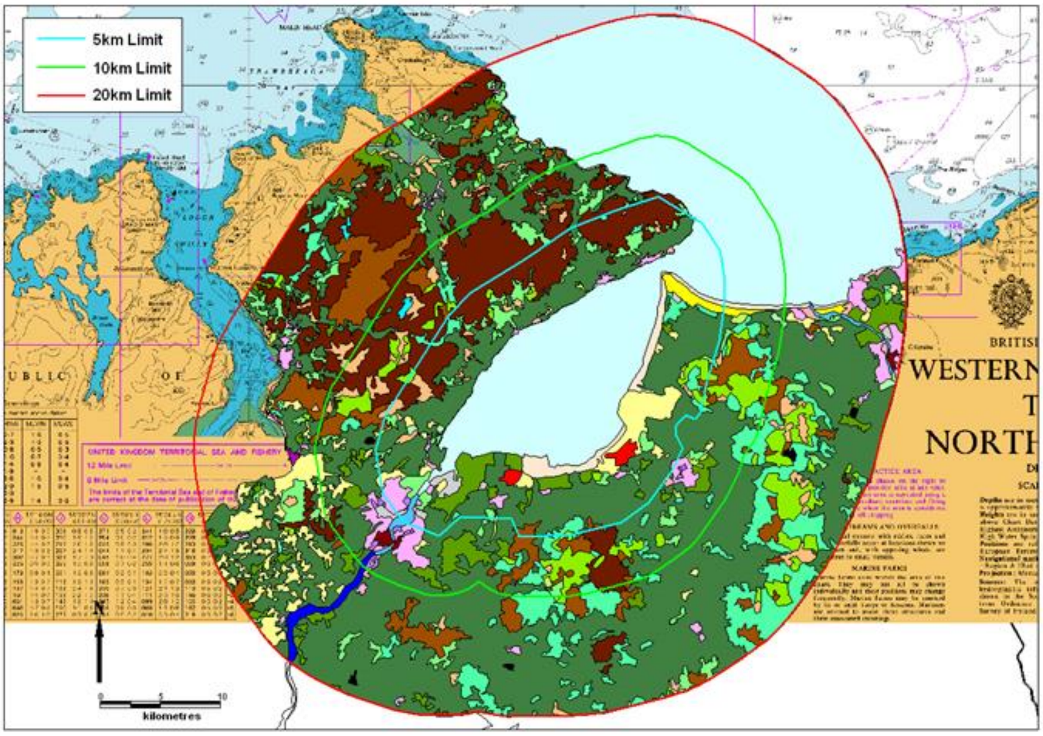


Figure 4.23: Corine land use legend for figure 4.19.

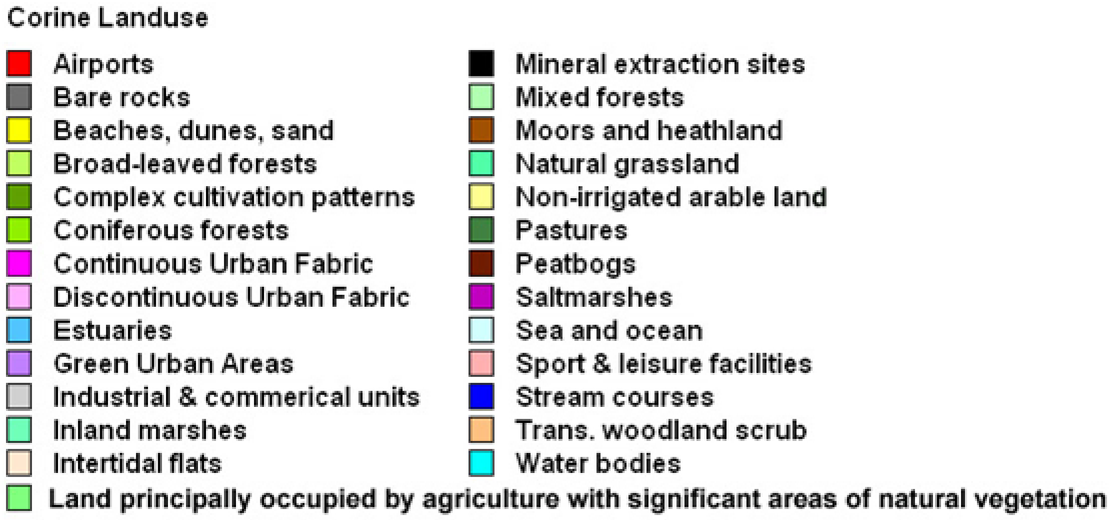
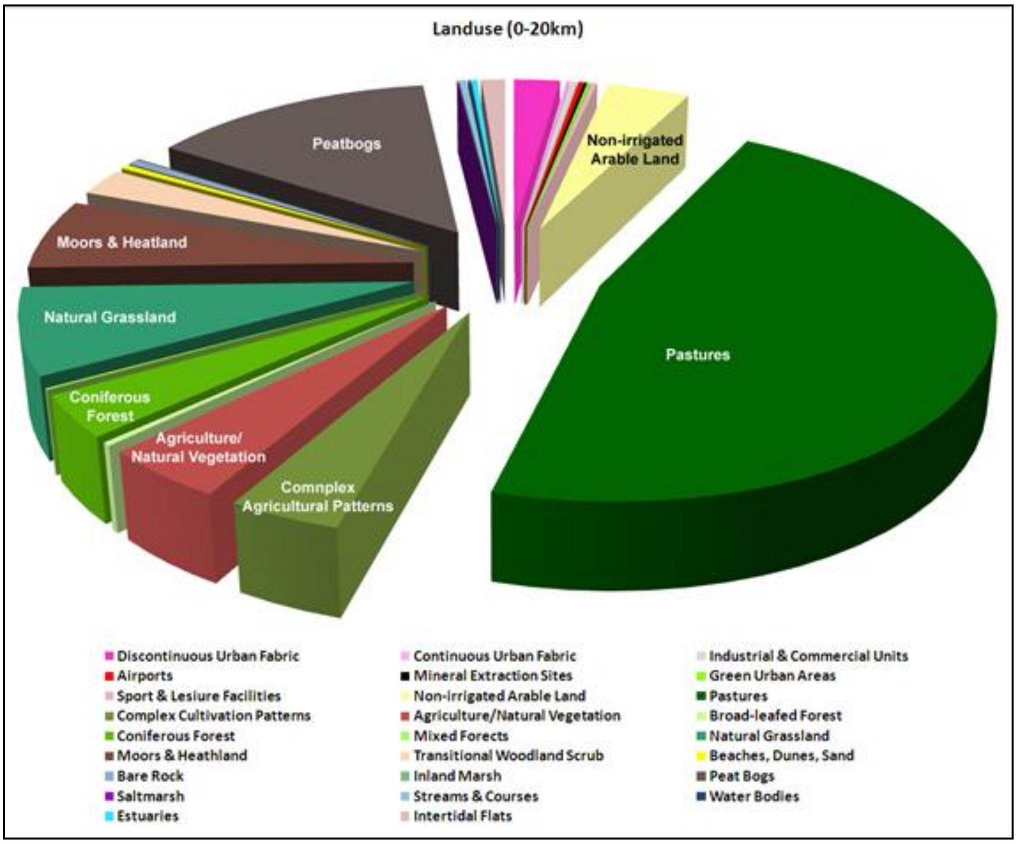
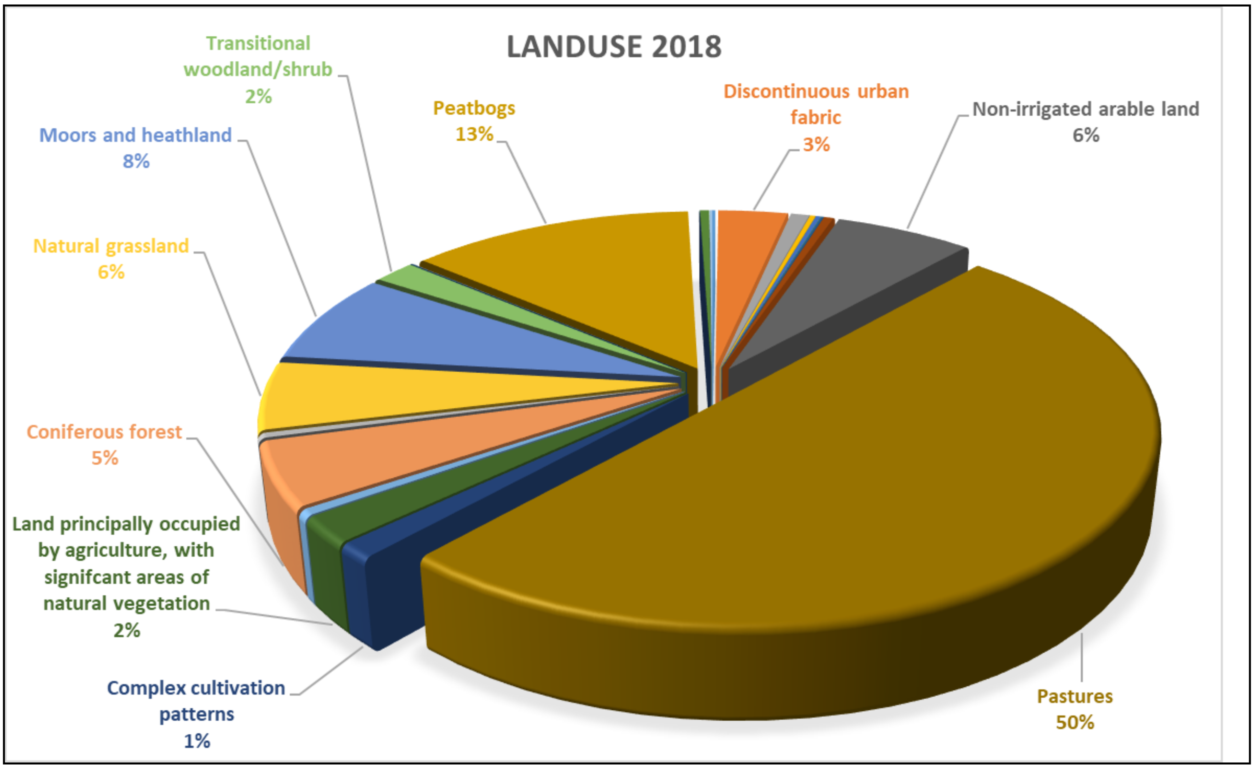


Figure 4.24: Breakdown of land use within 20km of Lough Foyle 2009 (Top) and 2018 (Bottom).





Agricultural data used in the 2009 sanitary survey were organised by SOA (Super Output Area) for Northern Ireland; however, the 2018 agricultural data are not available in this format. The 2018 data have been organised by wards which are similar to SOA boundaries but vary somewhat. Changes in agricultural data can therefore not be directly compared. However, visual representation of these data can be used to compare the distribution of farming practices in the catchment (Figure 4.25 to Figure 4.32). The highest number of farms and area farmed remain in the south and east of the catchment. The majority of land used for crops is still located along the eastern shore of the lough and the lands bordering the River Foyle. A large proportion of the farmland in all divisions is used for grasses. The highest numbers of cattle are present in the south and east which is the same as 2009. The highest number of sheep are located in the south east of the catchment for both 2009 and 2018. The highest numbers of pigs are still farmed in the east. The highest density of poultry framing is in the east. In 2009, there was also a high density of poultry in the south but this has reduced.

Although individual divisions cannot be compared due to the change in division type some comparison can be made on a catchment scale. As some of the wards (2018) or SOAs (2009) only partially overlap the 20km boundary an attempt was made to account for this. The percentage of each division within the catchment was estimated in GIS. This percentage was then applied to the agri data to estimate the proportion within the catchment. Based on this area used for crops has increased by 11.1% (1349ha) and sheep numbers have decreased by 8.6% (32,914). Cattle numbers have increased by 5.2% (6,624), pigs by 61.5% (1,853) and poultry by 111.5% (200,963). There has also been a 4.1% (4736ha) increase in the area of farmland within 20km. Jones and White (1984) estimated the potential daily load for different livestock. Based on this the change in stocking densities of the different species will lead to an estimated reduction in daily *E. coli* load by $543{,}439 \times 10^{9}$. This reduction is due to the significant decrease of sheep in the area which have a much higher daily *E. coli* load than other livestock (See Table 4.6).

Table 4.6: Potential daily loading of *E. coli* (Jones & White, 1984).

Source	**Faecal Production (g/day)**	**Average Number (*E. coli*/g)**	**Daily Load (*E. coli*)**	**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

Figure 4.25: Number of farms within 20km of Lough Foyle for 2009 (top) and 2018 (bottom) (Source: DAERA, 2009 & 2018: CSO, 2019a).

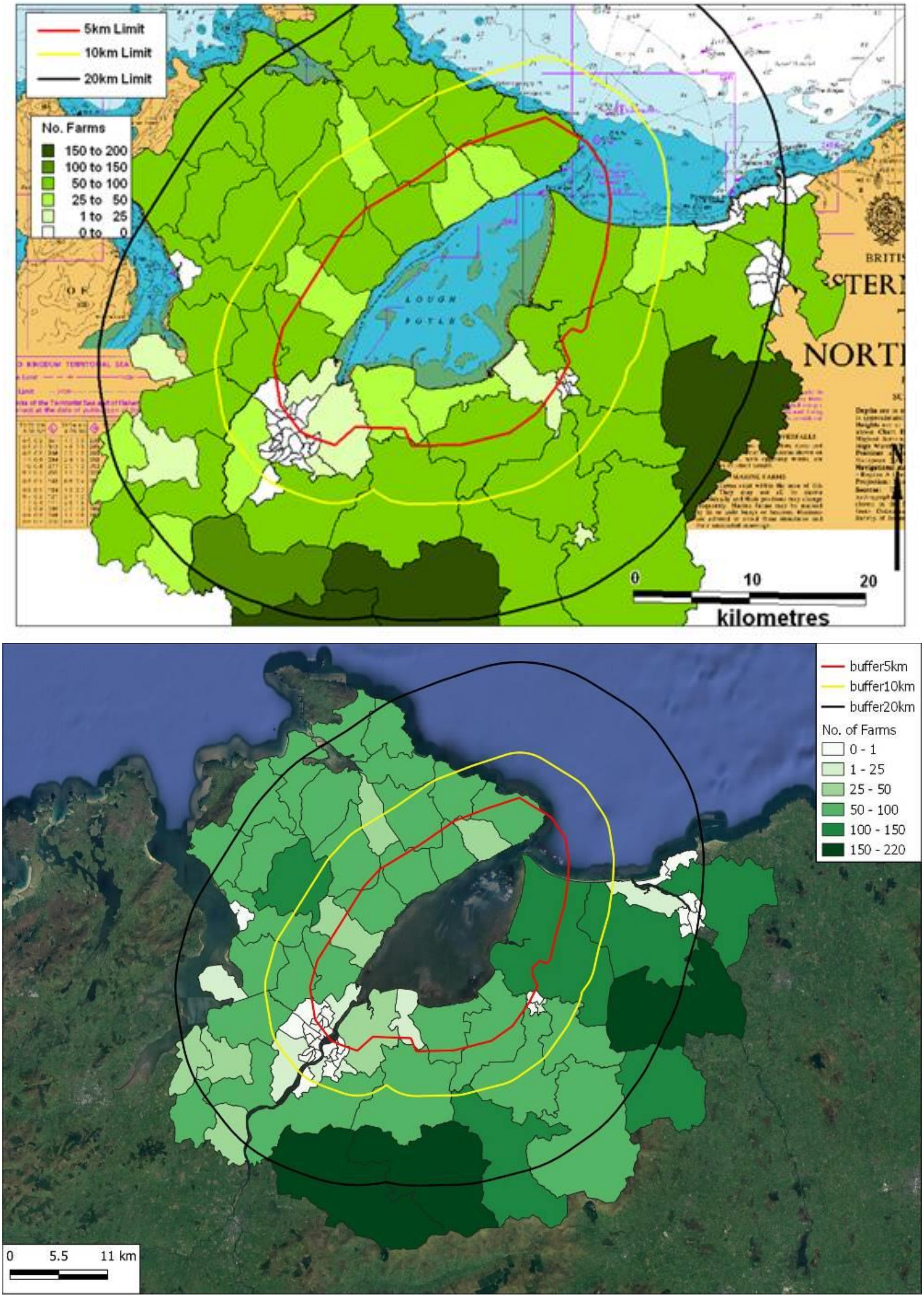


Figure 4.26: Area farmed (ha) within 20km of Lough Foyle for 2009 (top) and 2018 (bottom) (Source: DAERA, 2009 & 2018; CSO, 2019a).

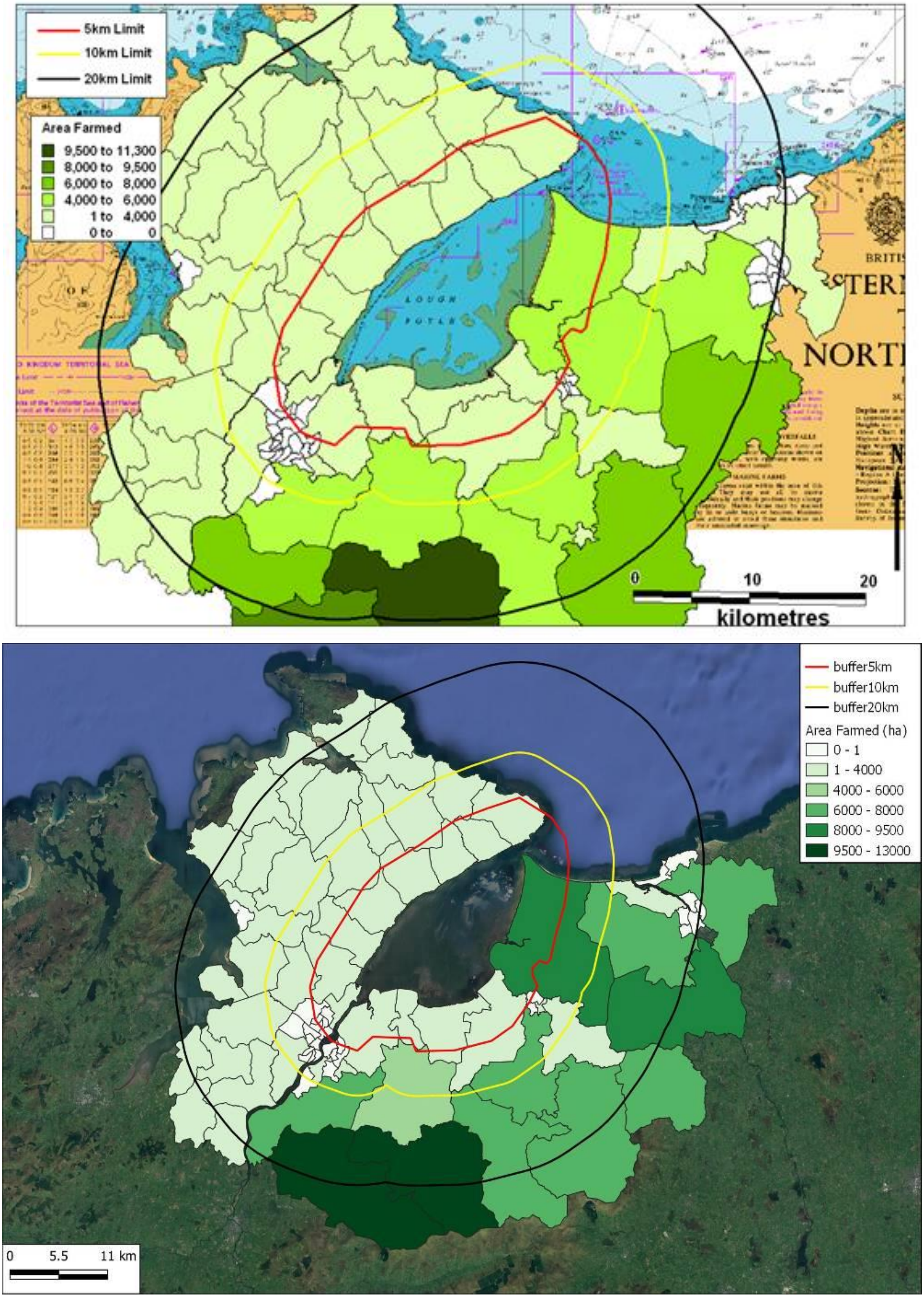


Figure 4.27: Total crops within 20km of Lough Foyle for 2009 (top) and 2018 (bottom) (Source: DAERA, 2009 & 2018; CSO, 2019a).

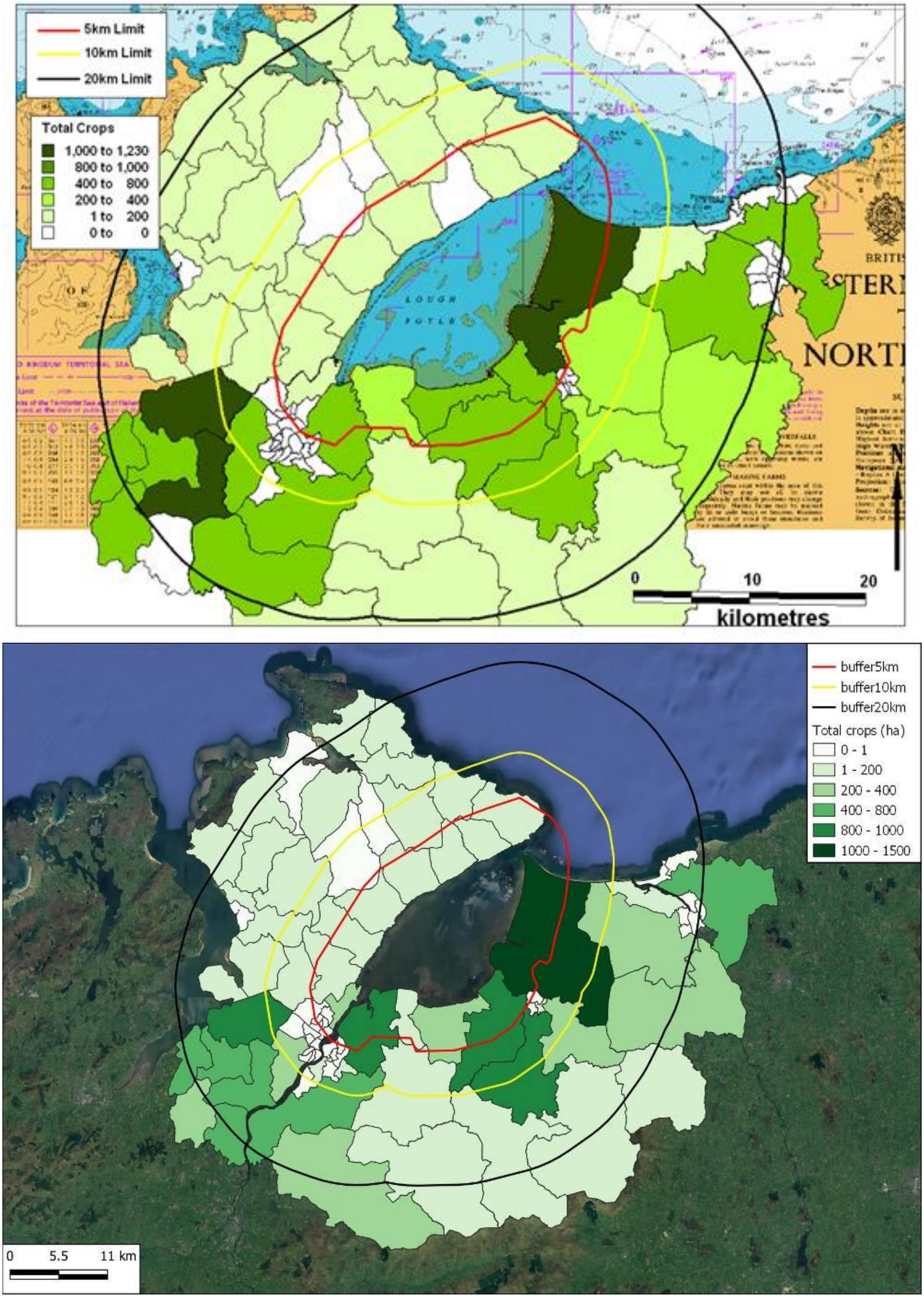


Figure 4.28: Total grasses within 20km of Lough Foyle for 2009 (top) and 2018 (bottom) (Source: DAERA, 2009 & 2018; CSO, 2019a).

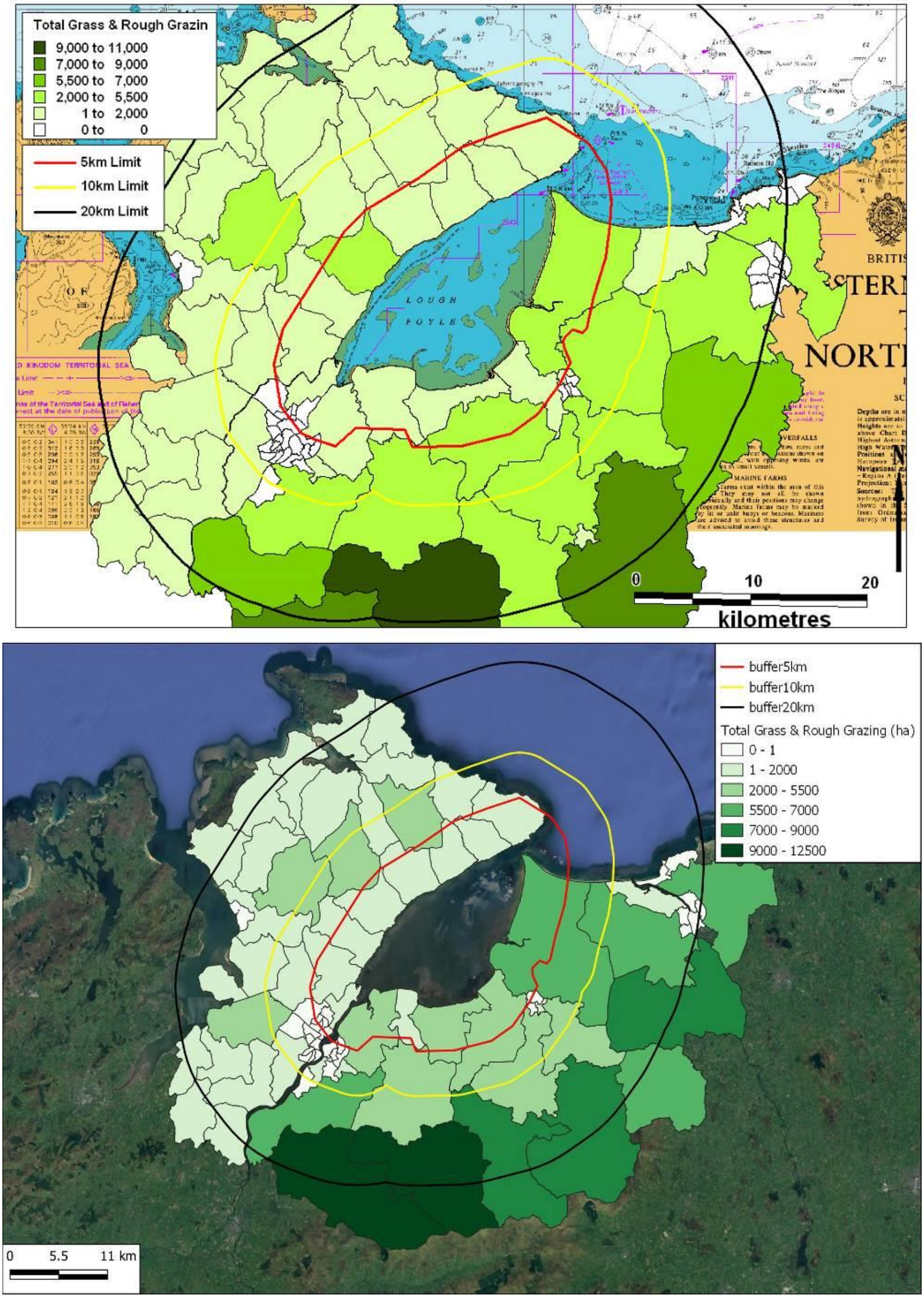


Figure 4.29: Cattle within 20km of Lough Foyle for 2009 (top) and 2018 (bottom) (Source: DAERA, 2009 & 2018; CSO, 2019a).

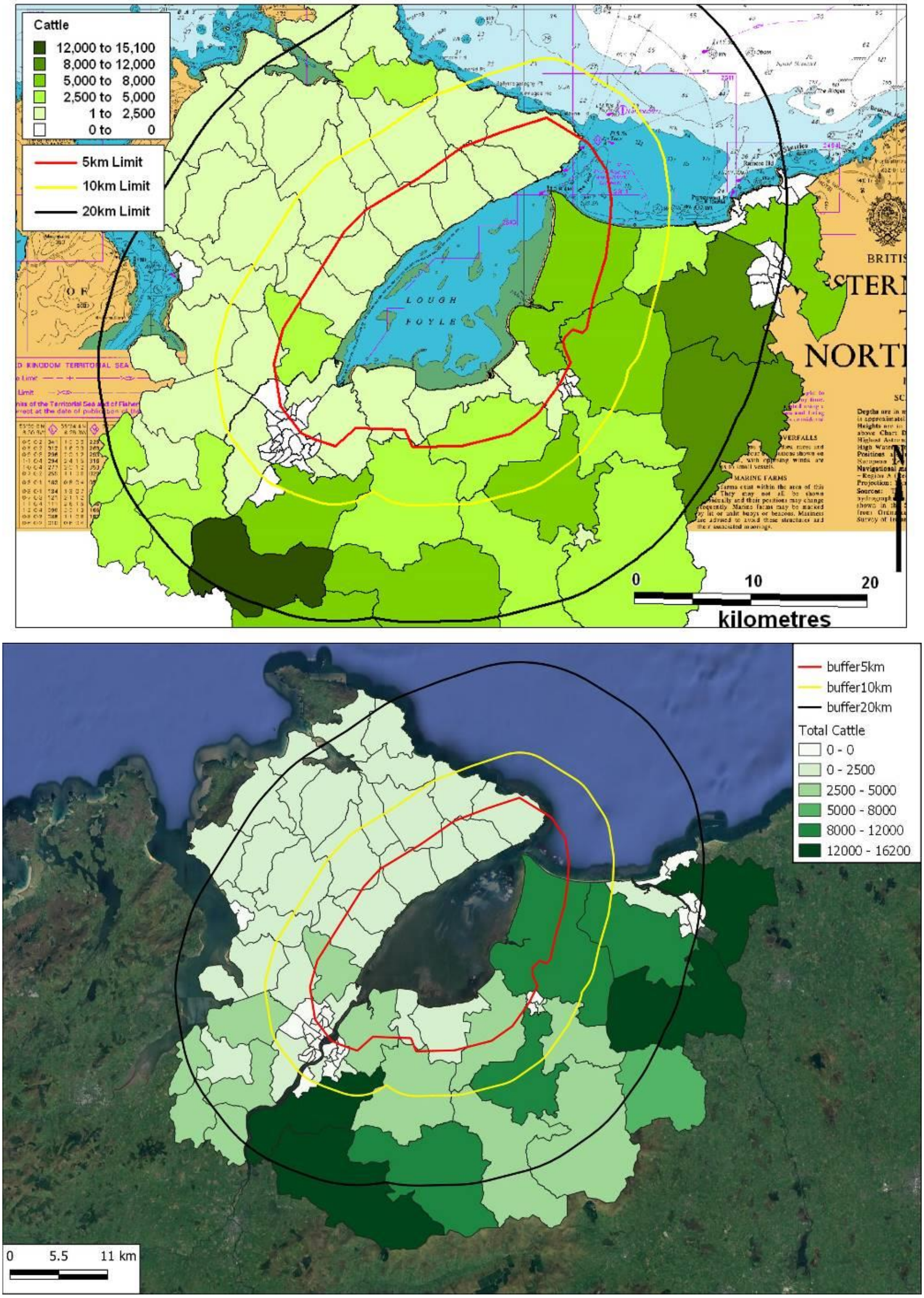
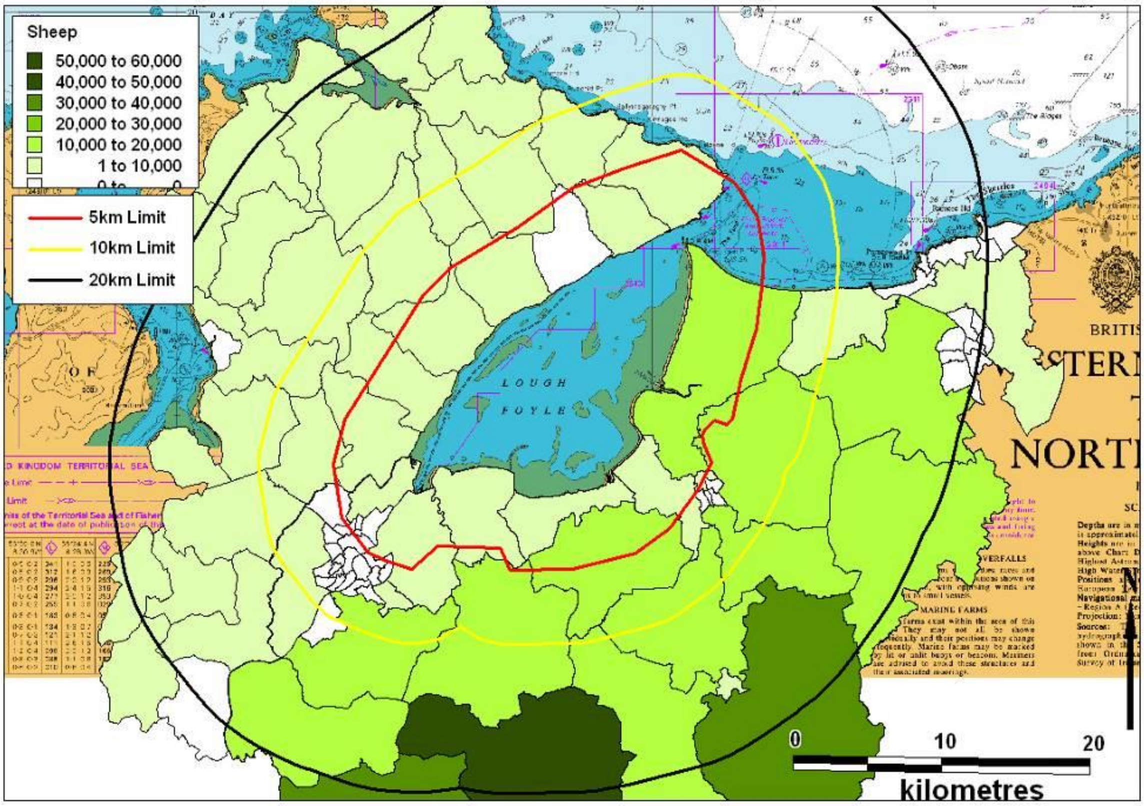


Figure 4.30: Sheep within 20km of Lough Foyle for 2009 (top) and 2018 (bottom) (Source: DAERA, 2009 & 2018; CSO, 2019a).



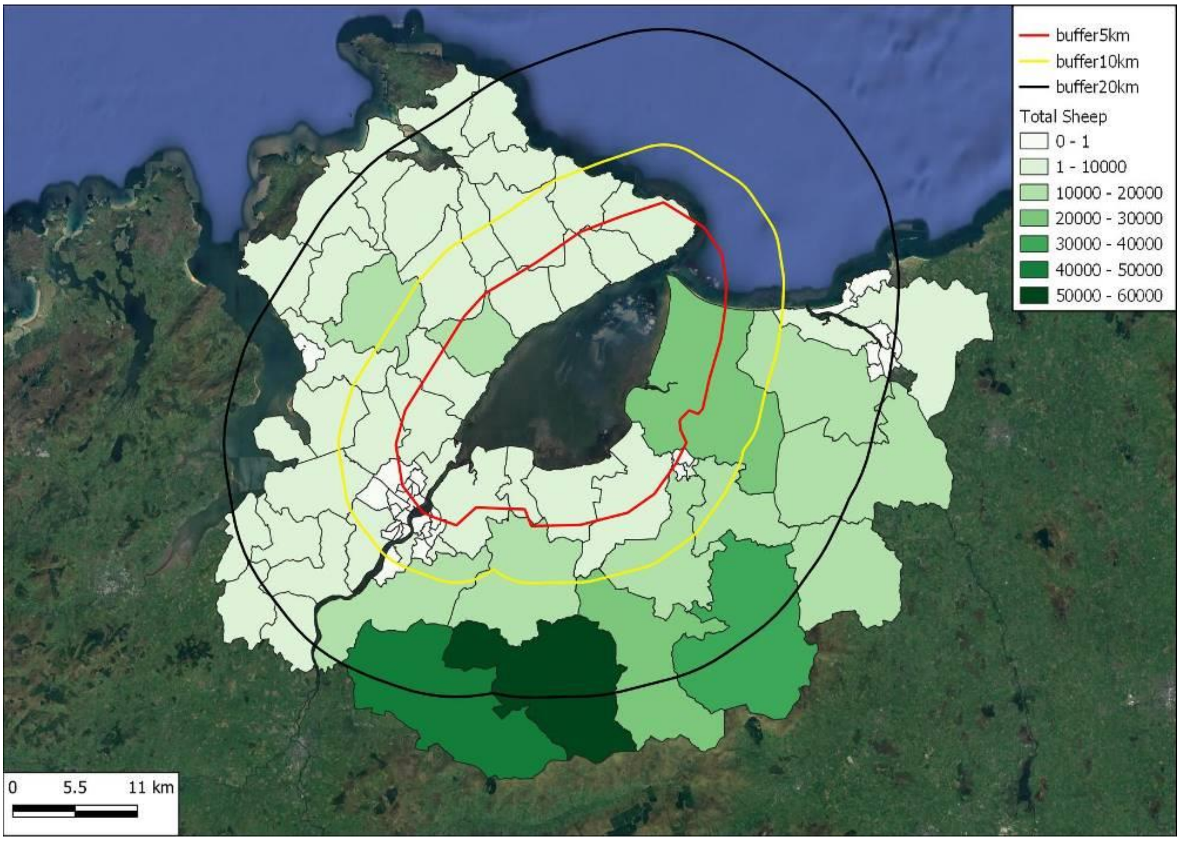
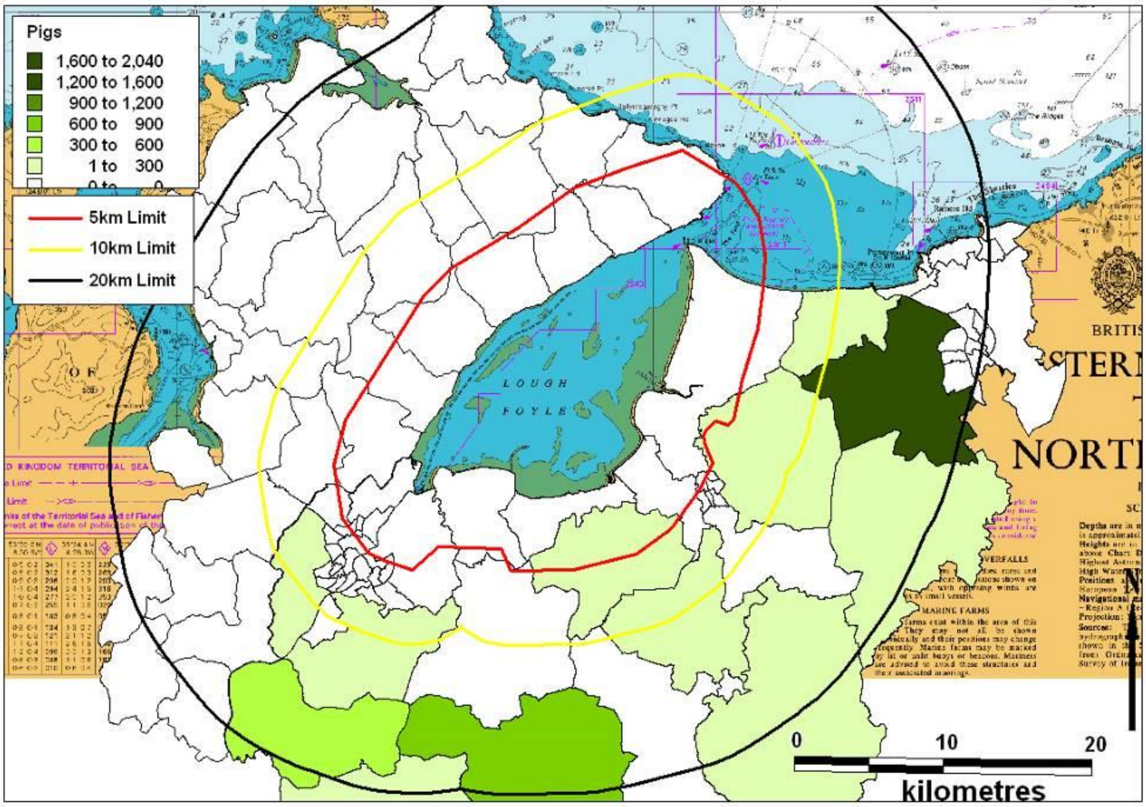


Figure 4.31: Pigs within 20km of Lough Foyle for 2009 (top) and 2018 (bottom) (Source: DAERA, 2009 & 2018; CSO, 2019a).



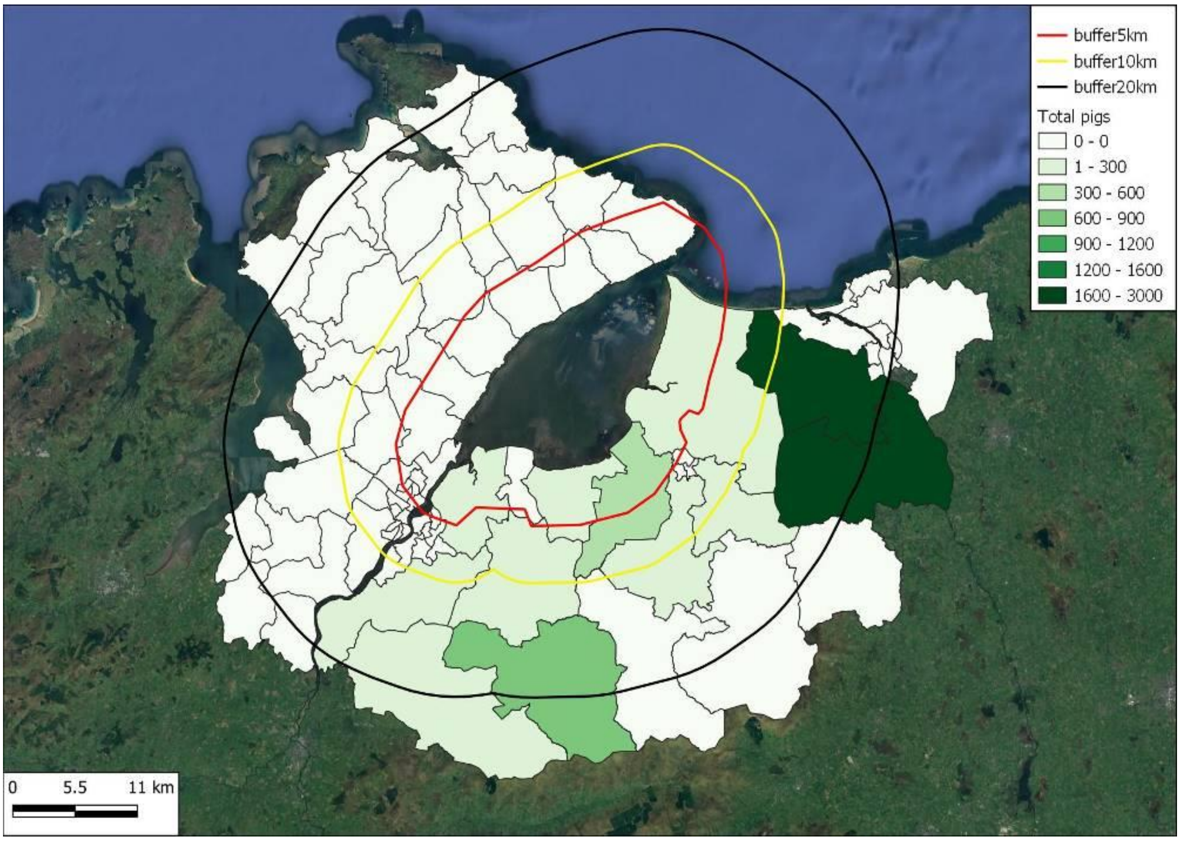
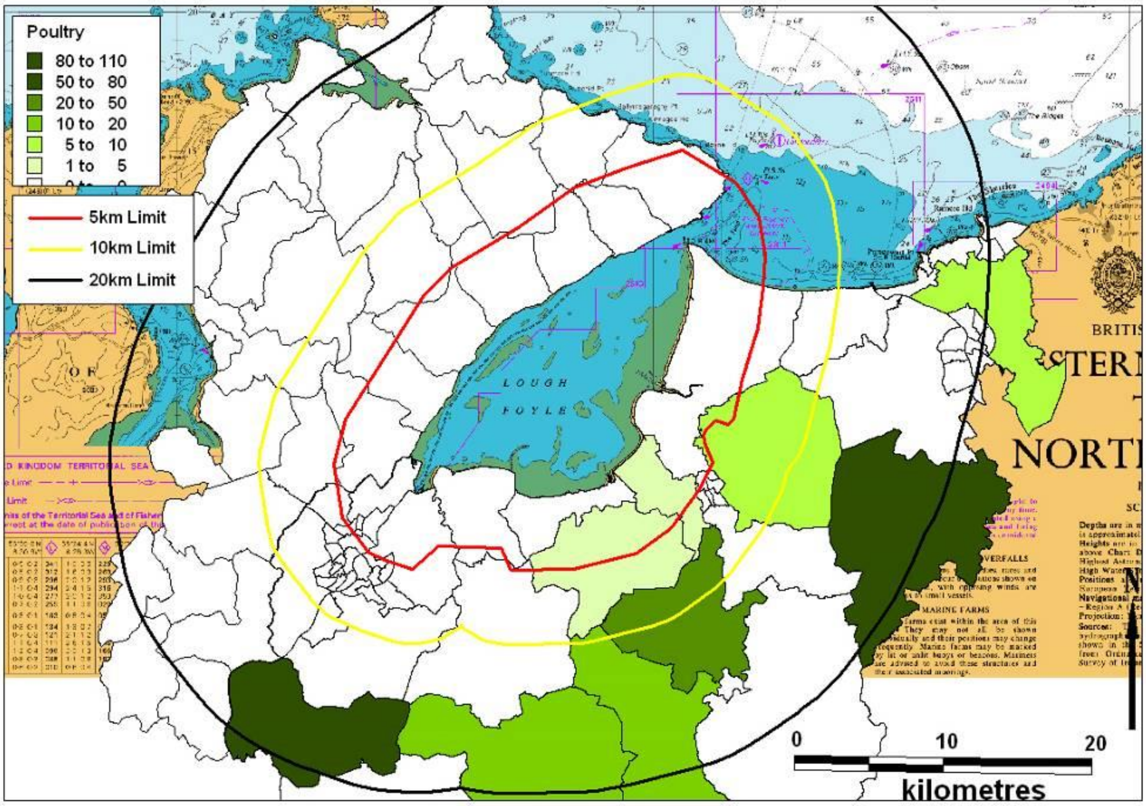
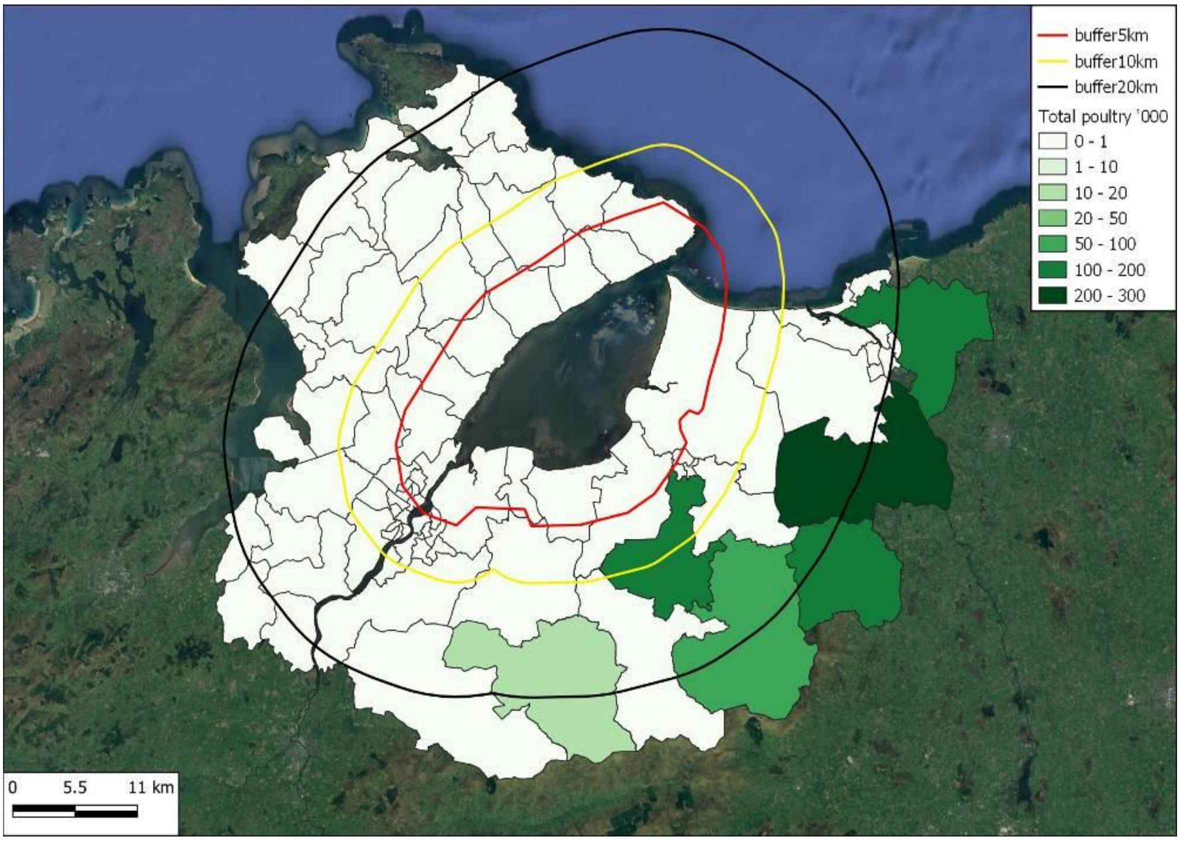


Figure 4.32: Poultry within 20km of Lough Foyle for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018; CSO, 2019a).





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

4.1.6. Other Pollution Sources

4.1.6.1. Shipping

Operational waste from vessels, if not properly managed, can 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 "drainage from medical premises, toilets, urinals, spaces containing live animals and other waste waters 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 comminuting and disinfecting system or a sewage holding tank. Within 3 miles of shore, Annex IV requires that sewage discharges be treated by a certified Marine Sanitation Device (MSD) prior to discharge into the ocean. Sewage discharges made between 3 and 12 miles of shore must be treated by no less than maceration and chlorination and sewage discharged greater than 12 miles from shore are unrestricted. Annex IV also established certain sewage reception facility standards and responsibilities for ports and contracting parties.

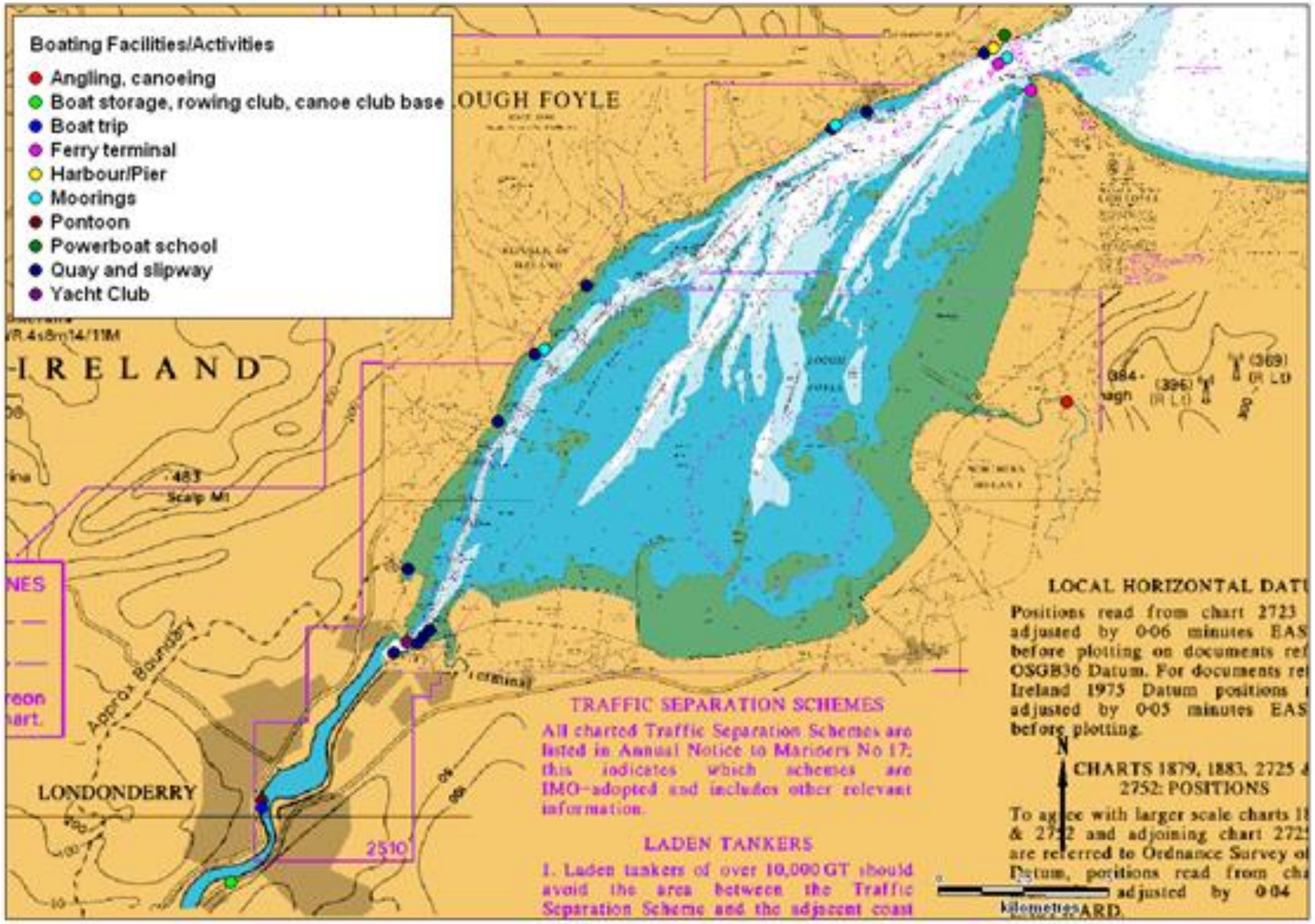
Ship sewage originates from water-borne human waste, wastewaters generated in preparing food, washing dishes, laundries, showers, toilets and medical facilities. However, as waste enters the lough environment from many sources, it makes the identification of specific impacts from ship/boat waste very difficult. It is widely recognised that the majority of 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 4.33 shows all boat facilities and activities in Lough Foyle. The only commercial port in the Lough is Foyle port. The tonnage of goods has increased moderately from 1,619,000 tonnes in 2009 to 1,760,000 tonnes in 2020 (NISRA, 2019). Cargo passing through Foyle Port include Agricultural products (e.g. grain, soya), Coal, Crude oil, Forestry products, metal and other typical freight. No live animals on the hoof have passed through the port in 2009 or since (NISRA, 2019).

While data on sewage discharge levels from shipping activities in Lough Foyle are not available, it is highly likely that discharging does 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 4.33: Location of all boating facilities and activities in Lough Foyle (Source: DAERA-NI, 2021).



4.1.6.2. Birds

It is important to document the bird populations in the Lough Foyle 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).

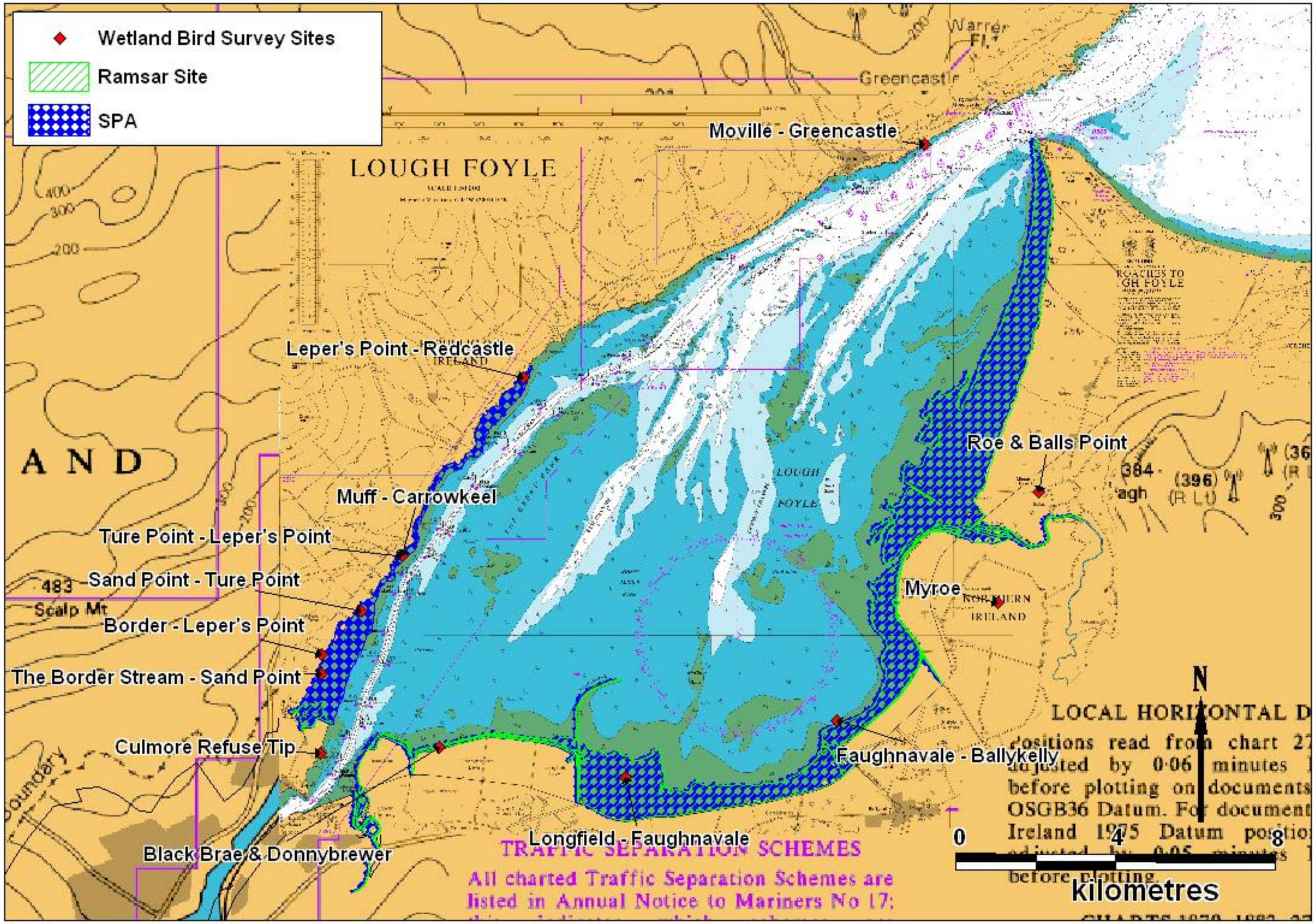
Figure 4.34 shows the locations of the Lough Foyle Special Protection Areas (SPA) and Ramsar Sites. The Lough Foyle SPA (Site Code: IE004087) is located on the County Donegal coastline from Muff northwards to approximately 1km south of Vances Point. The Lough Foyle SPA (Site Code: UK9020031) is located all along the southern and eastern coastline of Lough Foyle from the River Faughan to Magilligan Point. This SPA also includes an isolated site at Muff, Co. Donegal. The Lough Foyle Ramsar Site (Site Code: UK12014) covers the same area as the UK SPA.

Lough Foyle is routinely surveyed by the British Trust for Ornithology (BTO) (Through the WeBS [Wetland Bird Survey] Project) and Birdwatch Ireland (Through the I-WeBS[Irish Wetland Birds Survey] project). Table 4.7 shows 5-year data used for the 2011 survey and the most recent 5-year set of data. The 5-year average has decreased slightly from 35,539 to 33,165 for the most recent 5 year period.

Table 4.7: Total number of water birds in Lough Foyle from 2002/03 to 2006/07 and 2015/16 to 2019/20 (Source: Frost et al., 2020; Birdwatch Ireland).

Site Name	**2002/03**	**2003/04**	**2004/05**	**2005/06**	**2006/07**	**5 year Mean**
Lough Foyle	34,154	37,292	33,076	38,324	34,850	35,539
Site Name	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**5 year Mean**
Lough Foyle	32036	35317	32005	36477	29991	33,165

Figure 4.34: Lough Foyle SPA and Ramsar Sites.



Bird populations in the Lough Foyle area are typically higher in early winter and late spring due to migratory events and they are typically 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 pollution levels in Lough Foyle 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 Water Framework Directive. However, Lough Foyle is no longer monitored.

5.1.2. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and its subsequent Implementing Regulation (EU) 2019/627, the Food Standards Agency of Northern Ireland (FSA in NI), as competent authority, is required to establish the location and fix the boundaries of shellfish harvesting areas.

The Regulations stipulate that the competent authority must monitor the levels of *E. coli* within the harvesting area and that according to the sample results, must classify the area as being one of three categories A, B or C.

An A classification allows for the product to be placed directly on the market, whereas a B or C classification requires the product to go through a process of depuration, heat treatment or relaying before it can be placed on the market.

The FSA in NI and SFPA both monitor shellfish flesh in Lough Foyle for microbiological contamination on a monthly basis and these results are reviewed annually to determine the classification awarded. The FSA in NI currently sample shellfish flesh in Production Area 3 and 4 for classification purposes. The SFPA currently sample shellfish flesh in Production Area 1 and 2 for classification purposes. The species currently monitored in the Lough include native oysters, mussels and pacific oysters from within the classified area shown in Figure 5.1.

Lough Foyle has historically always been classified as a B harvesting areas. Table 5.1 summaries this system. Table 5.2 shows the current and historical (back to 2011) classifications within Lough Foyle.

Table 5.1: Classification system for shellfish harvesting areas.

Classification	Permitted Levels	Outcome
A	80% of sample results ≤230 *E.coli* 100g, no results exceeding 700 *E.coli*/100g –	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*/100g with none exceeding 46,000 *E. coli*/100g	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*/100g flesh	Molluscs must be subject to relaying for a period of at least 2 months or cooked by an approved method.

Figure 5.1: **Locations of FSA in NI and SFPA shellfish monitoring points for classification purposes.**

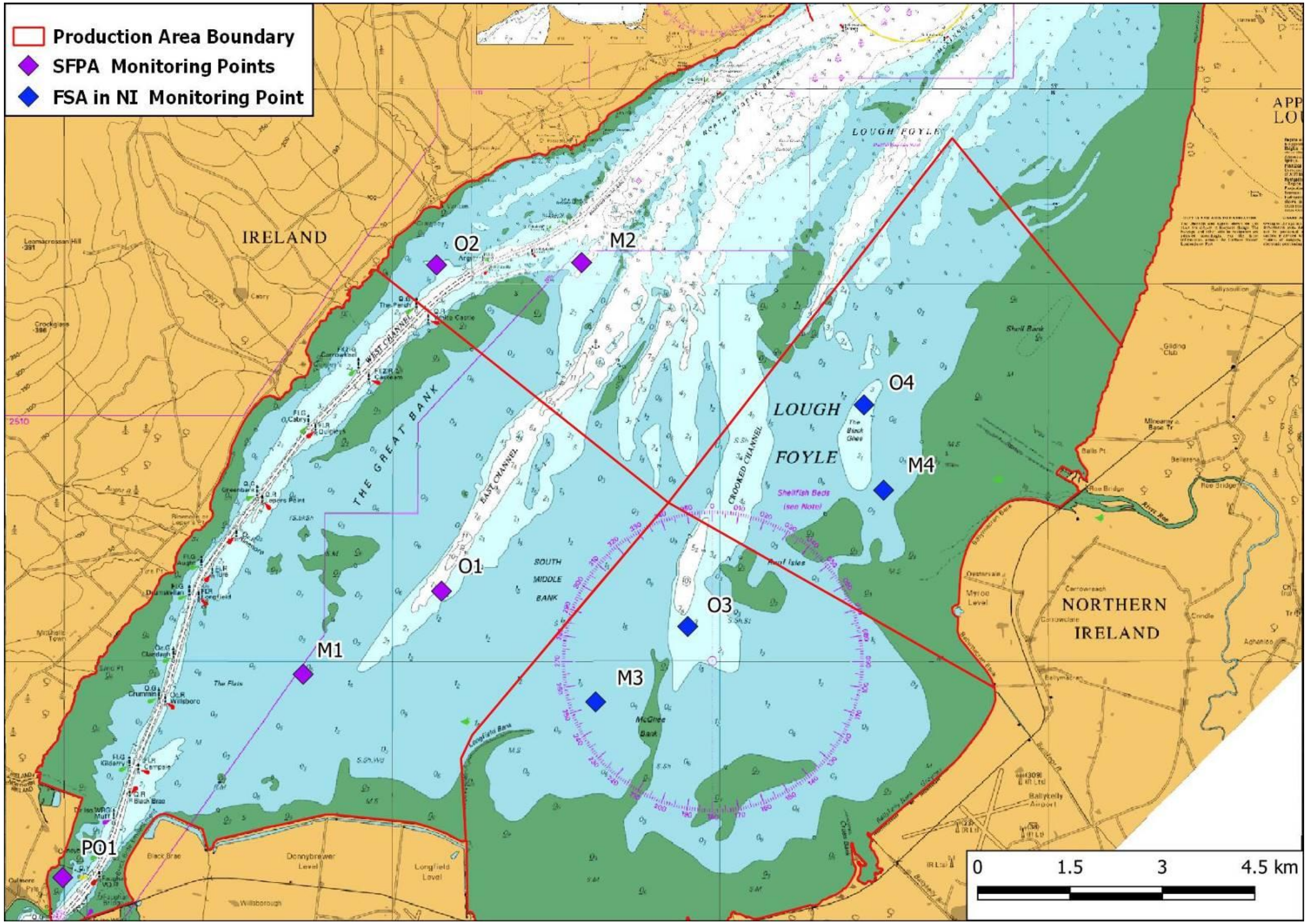


Table 5.2: Current and historical classification of shellfish beds in Lough Foyle (2011 – 2020).

Bed Name	Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
M1	mussels	B	B	B	B	B	B	B	B	B	B**
M2	mussels	B	B	B	B	B	B	B	B	B	B**
M3	mussels	B*	B	B	B	B	B	B	B	B	B
M4	mussels	B*	B	B	B	B	B	B	B	B	B
O1	Native oysters	B	B	B	B	B	B	B	B	B	B
O2	Native oysters	B	B	B	B	B	B	B	B	B	B
O3	Native oysters	B*	B	B	B	B	B	B	B	B	B
O4	Native oysters	B*	B	B	B	B	B	B	B	B	B
PO1	Pacific oysters	B	B	B	B	B	B	B	B	B	B

* Provisional Classification - Classifications are described as provisional when an area is being classified for the first time or after a period in suspension. The term may also be used where an incomplete dataset of results was to hand.

**Dormant Fishery. Contact SFPA if Re-activating

Figure 5.2 to Figure 5.10 show the *E. coli* results for mussels, native oysters and pacific oysters for all monitoring points from 2011 to 2020. The monthly *E. coli* data for each site can be access online (Classification monitoring results from previous years on the National Archives website)

Table 5.2 above shows the annual classification of all site monitored in Lough Foyle from 2011 to 2020. All monitored sites have been classified as **B** from 2011 to 2020**.** In 2011 sites M3, M4, O3 and O4 had a provisional **B.** In 2020 M1 and M2 sites were both listed as a “Dormant Fishery”.

Figure 5.2: ***E. coli* results from mussels at M1 from 2011-June 2020 (Source: SFPA).**

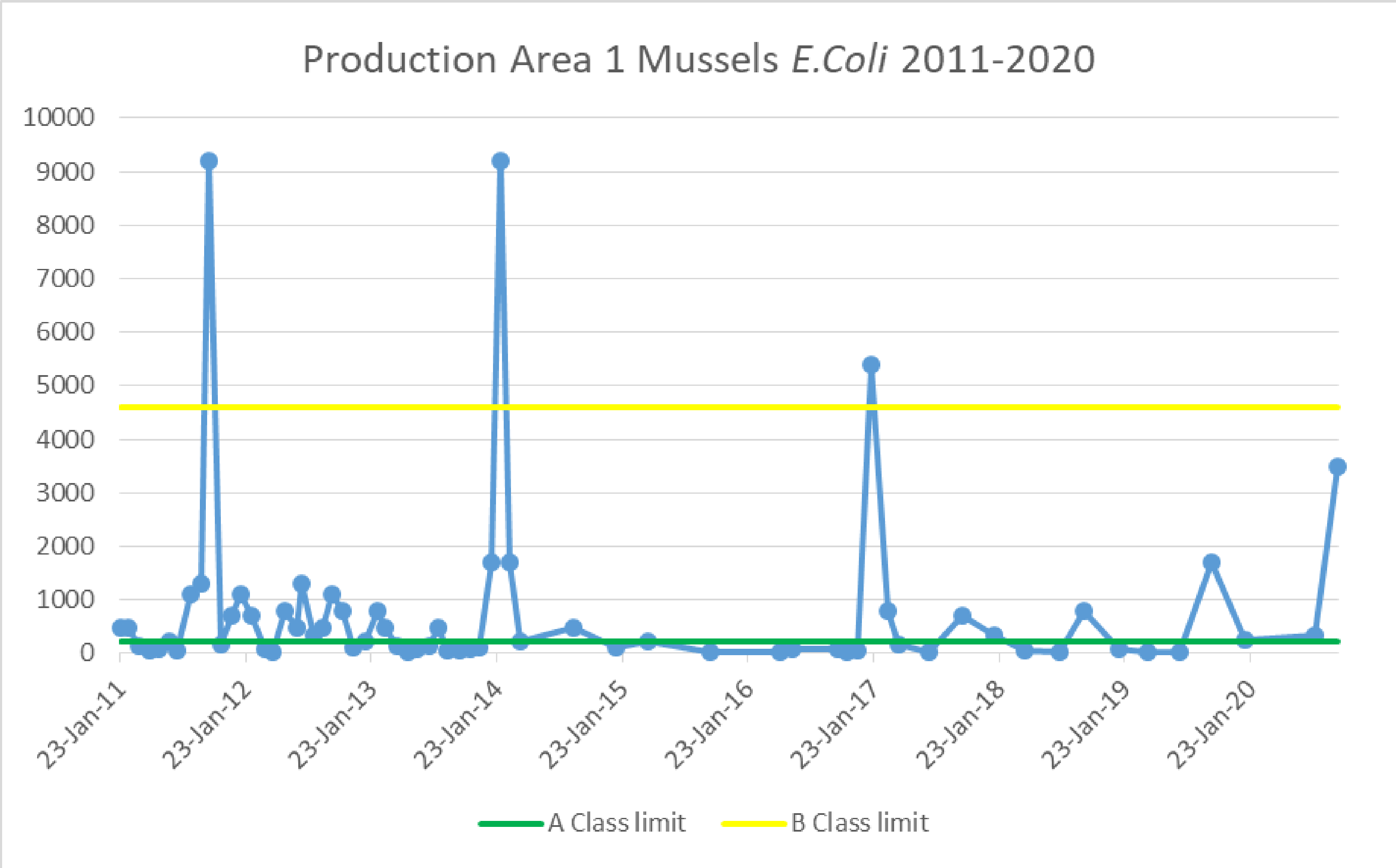


Figure 5.3: *E. coli* levels from mussels at M2 from 2011 to June 2020 (Source: SFPA).

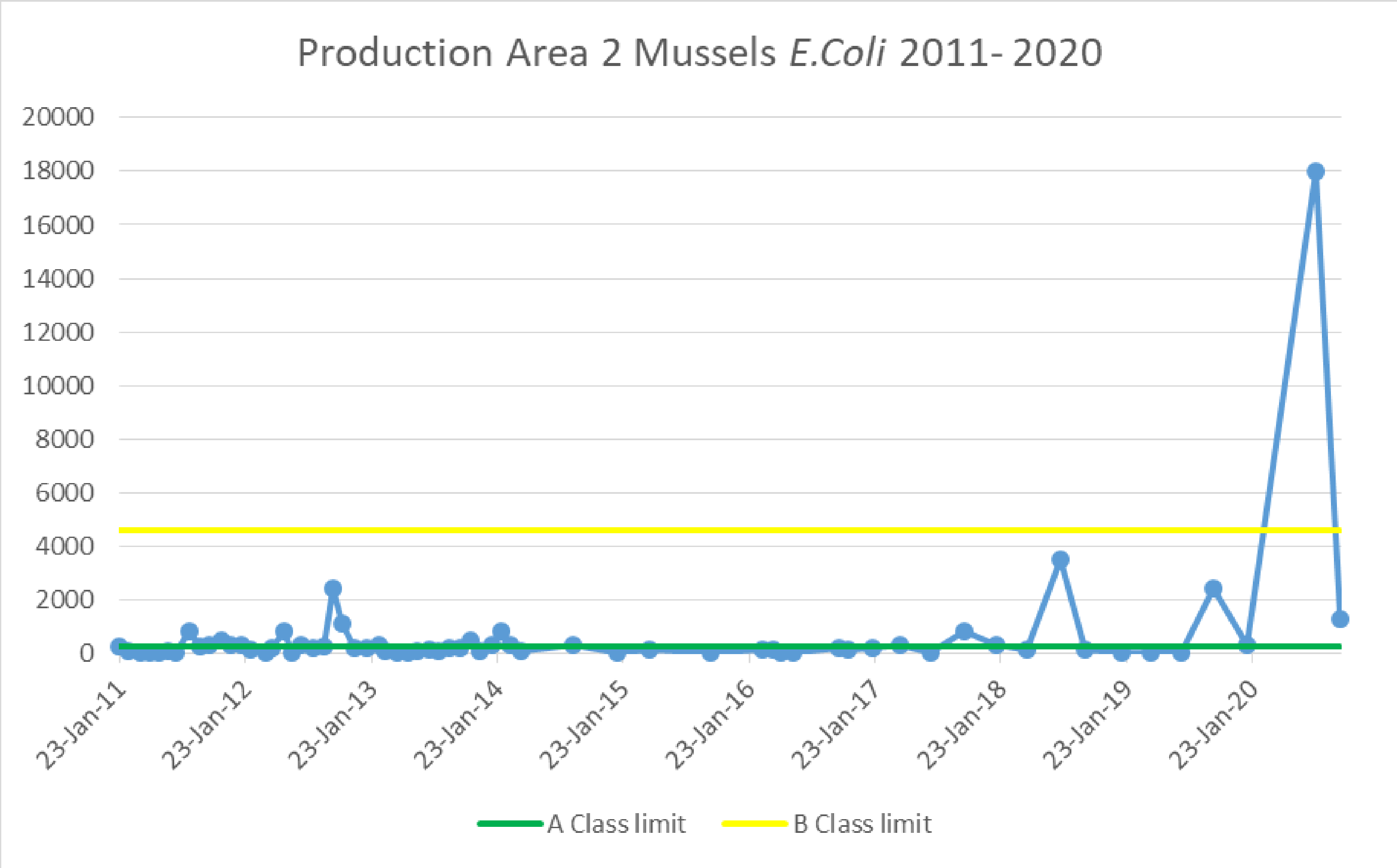


Figure 5.4: *E. coli* levels from mussels at M3 from 2011 to 2020 (Source: FSA in NI).

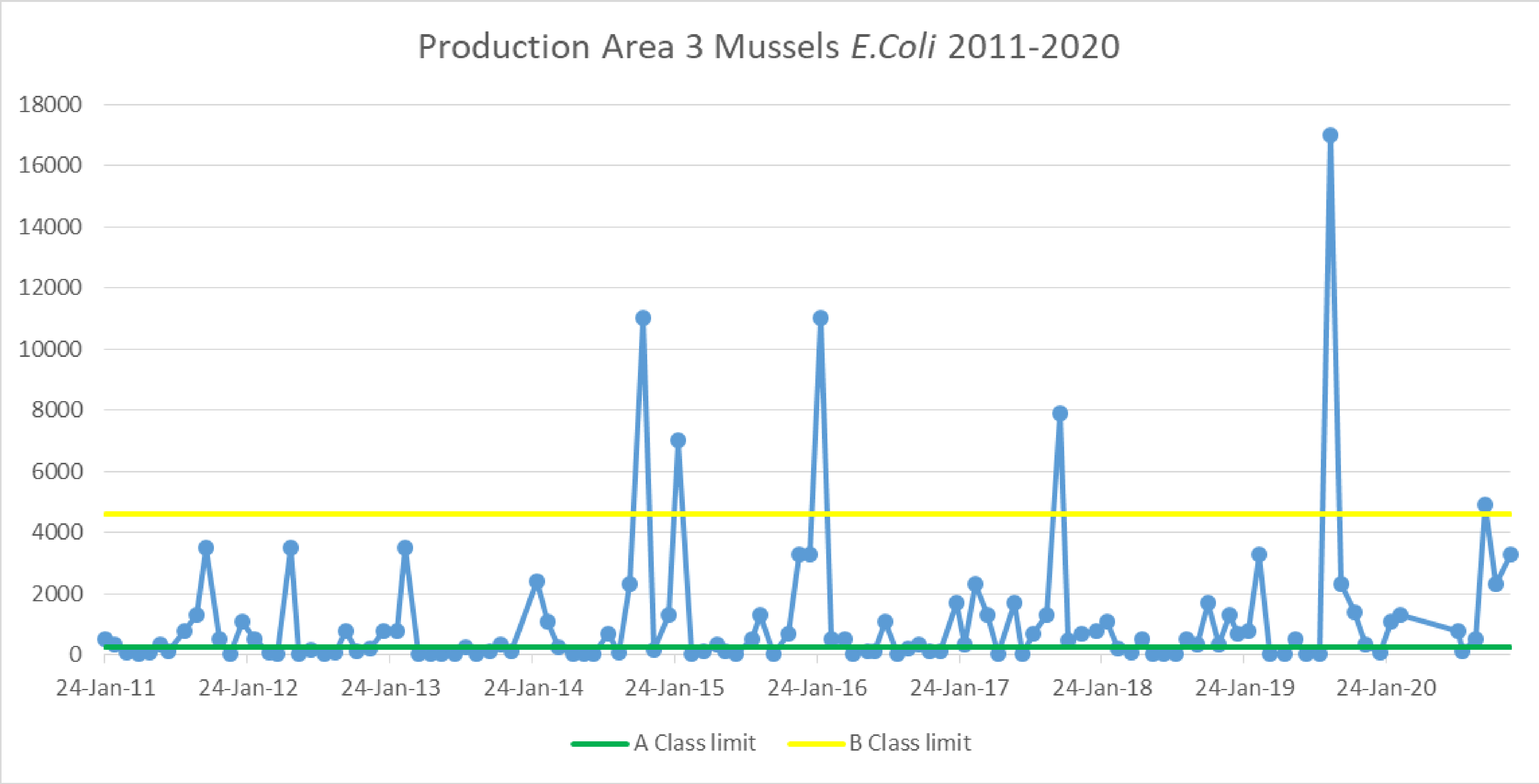


Figure 5.5: *E. coli* levels from mussels at M4 from 2011 - 2020 (Source: FSA in NI).

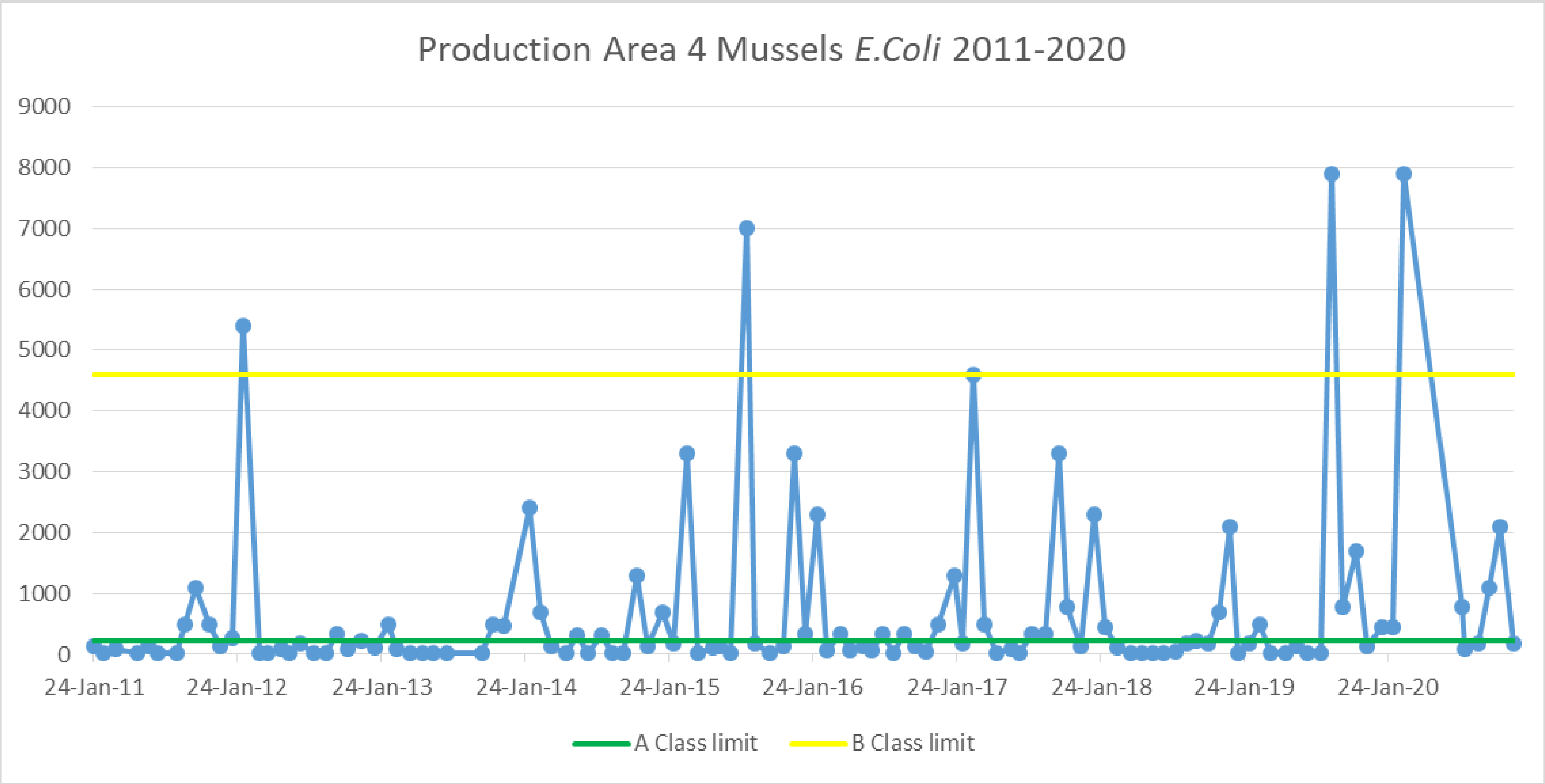


Figure 5.6: *E. coli* levels from native oysters at O1 from 2011 - 2016 (Source: SFPA).

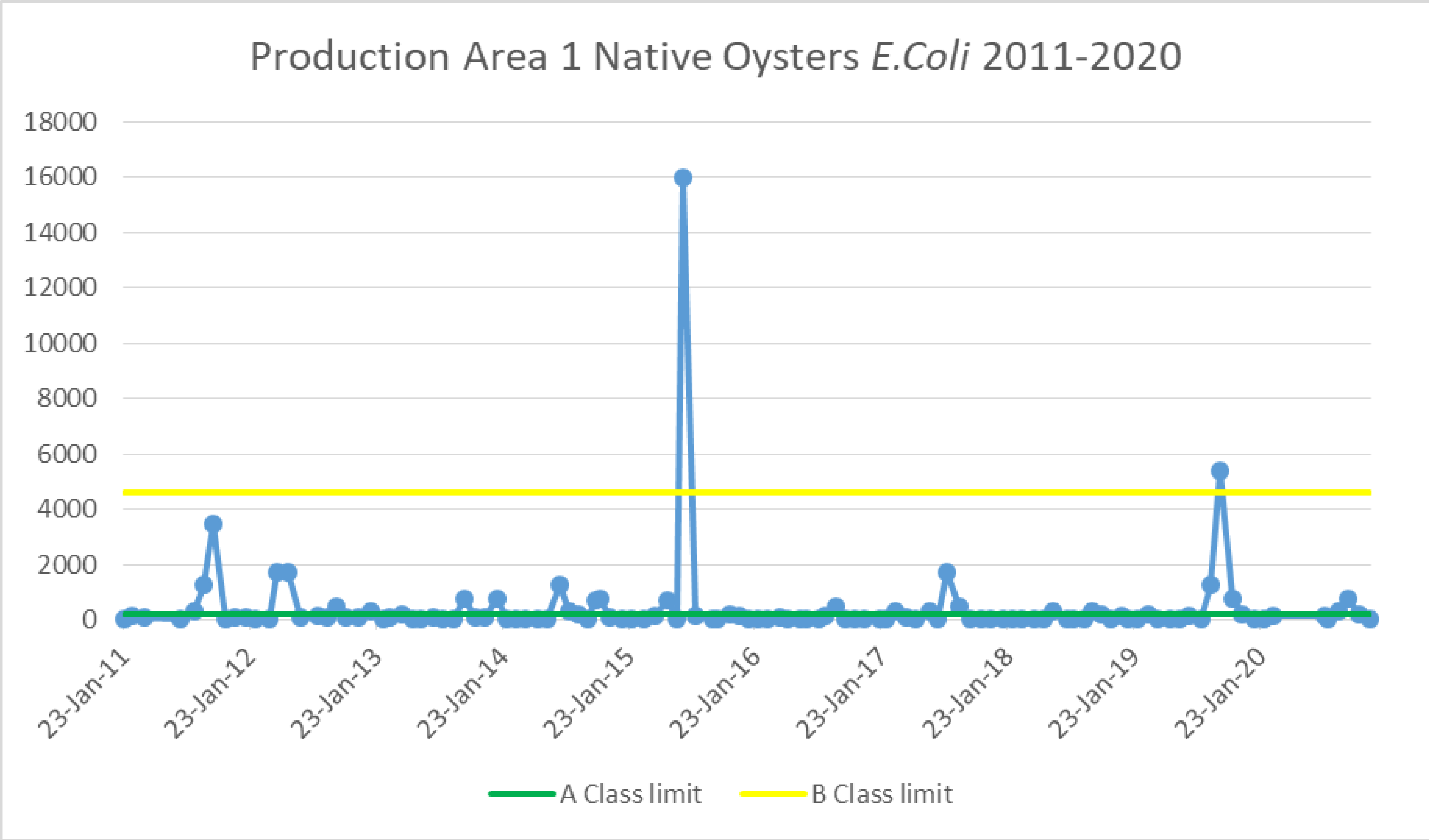


Figure 5.7: *E. coli* levels from native oysters at O2 from 2011 - 2016 (Source: SFPA).

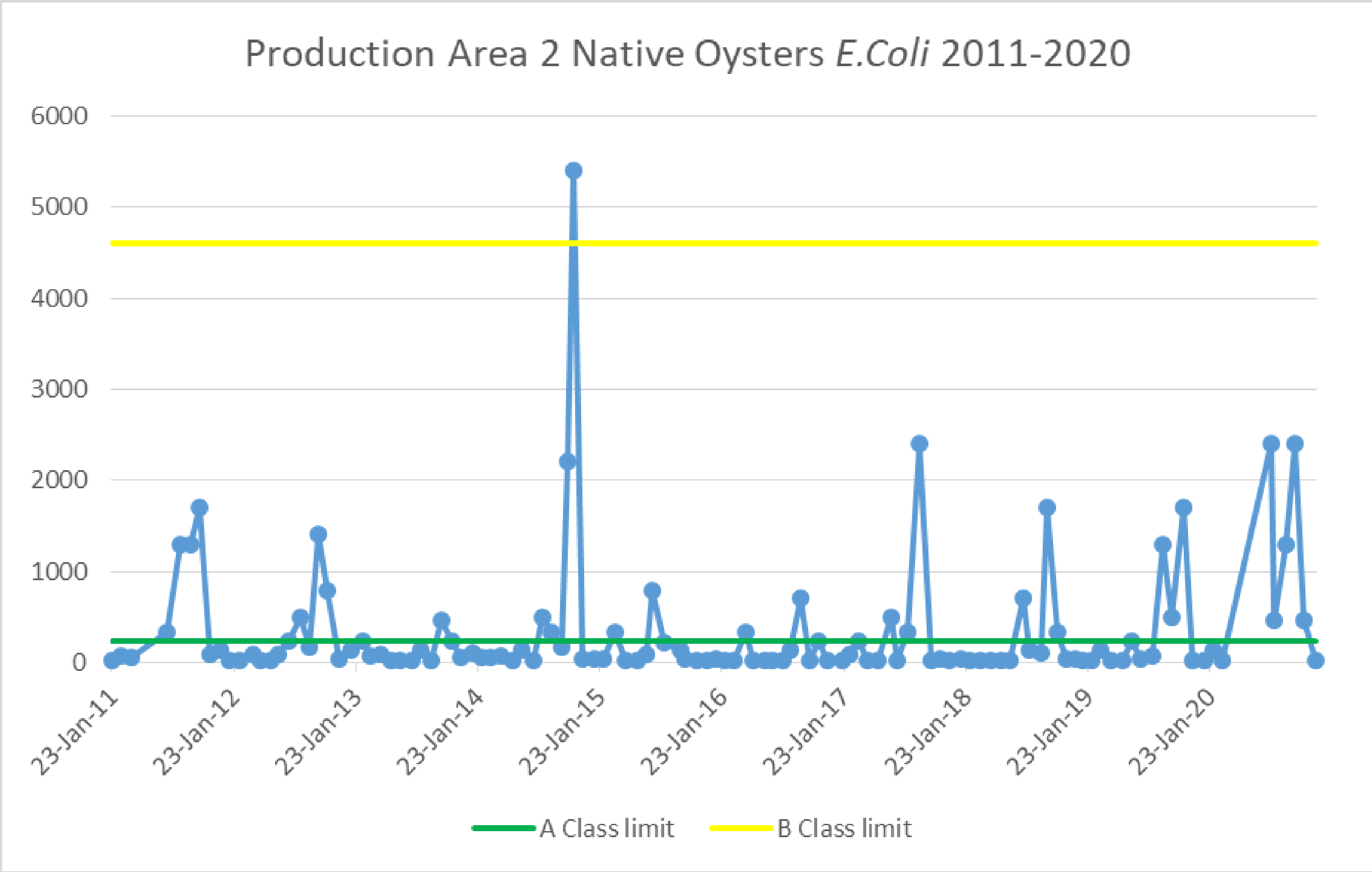


Figure 5.8: *E. coli* levels from native oysters at O3 from 2011 - 2016 (Source: FSA in NI).

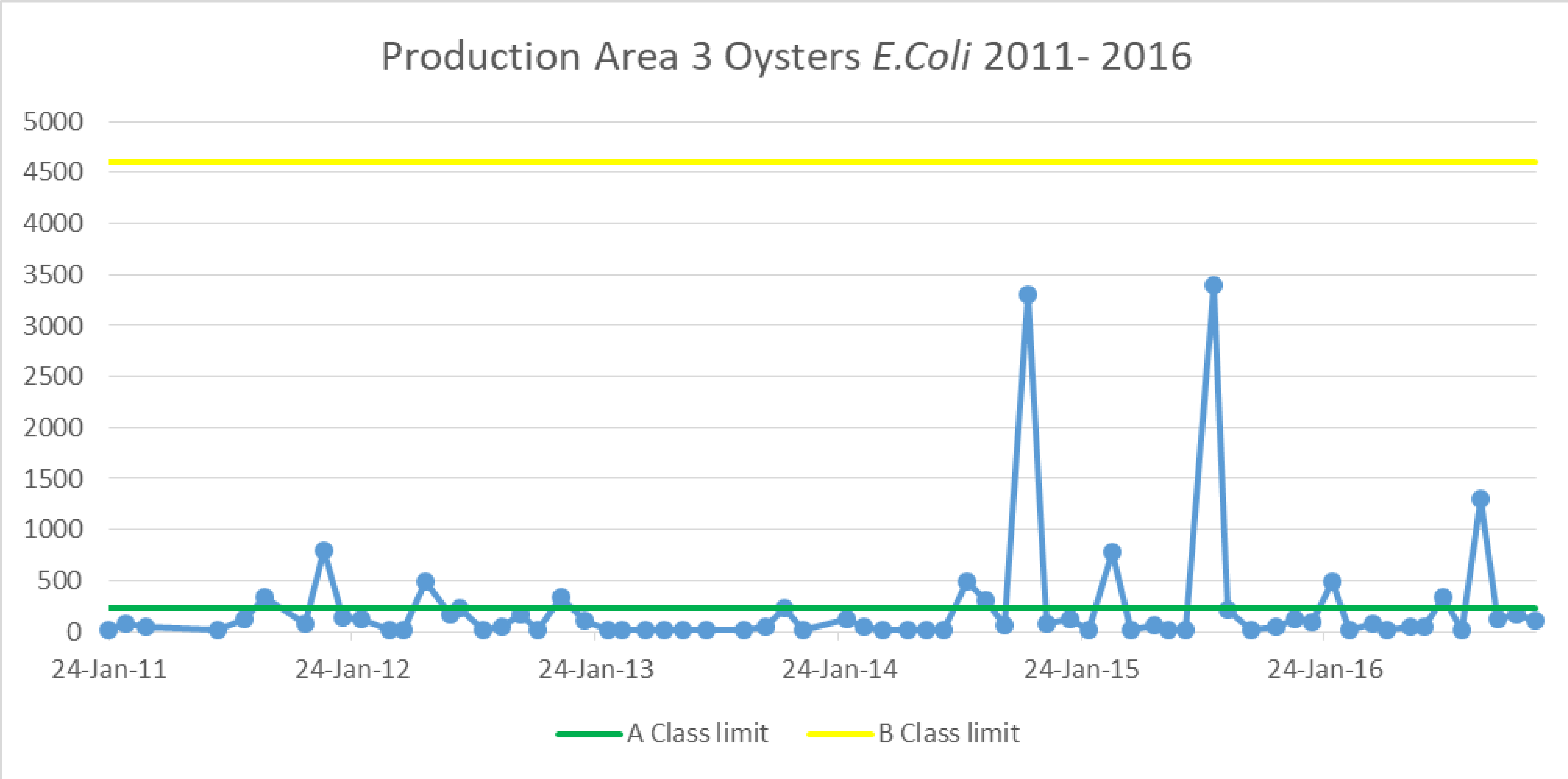


Figure 5.9: *E. coli* levels from native oysters at O4 from 2011 - 2016 (Source: FSA in NI).

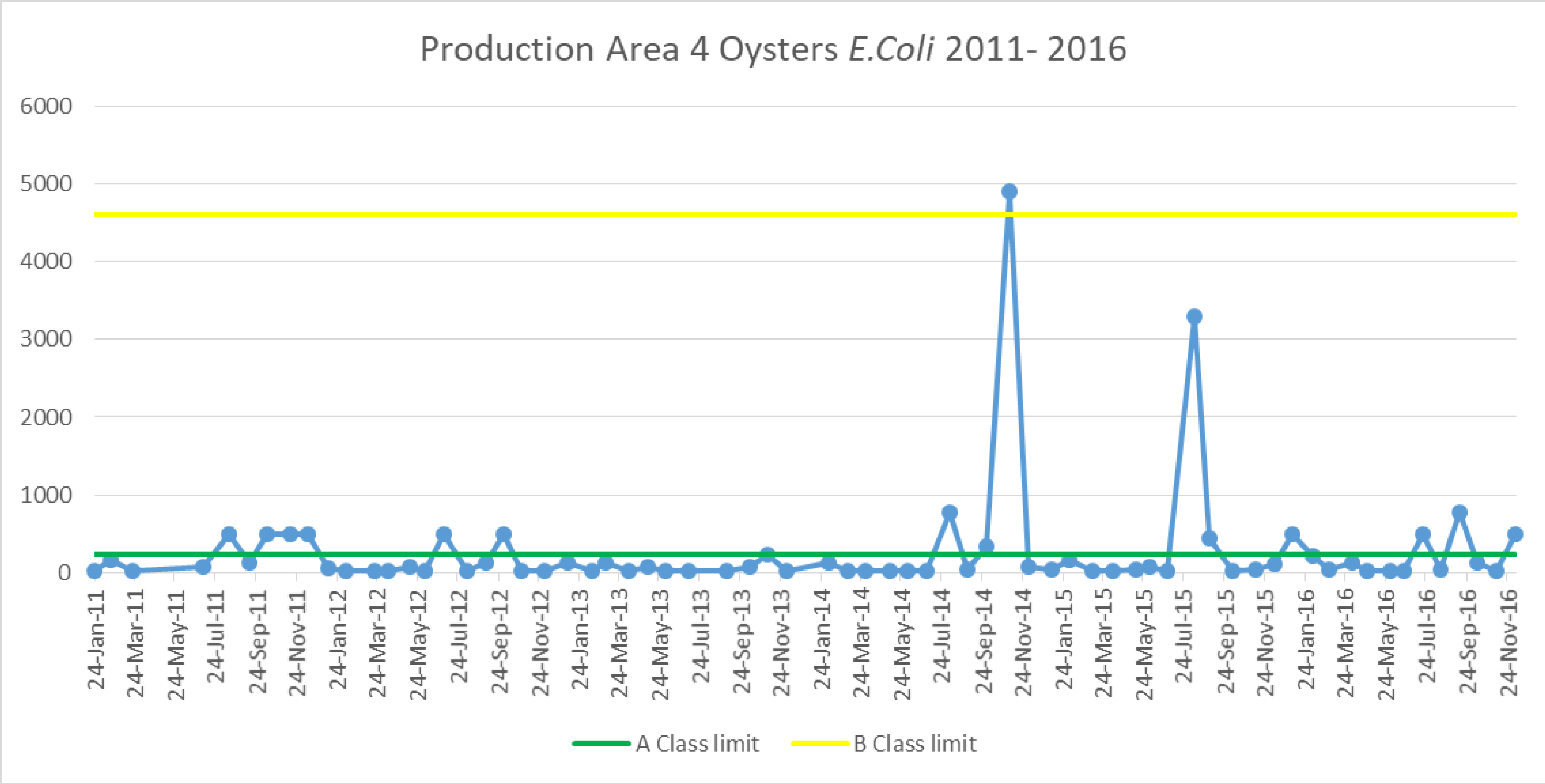


Figure 5.10: *E. coli* levels from pacific oysters at PO1 from 2011 - 2020 (Source: SFPA).

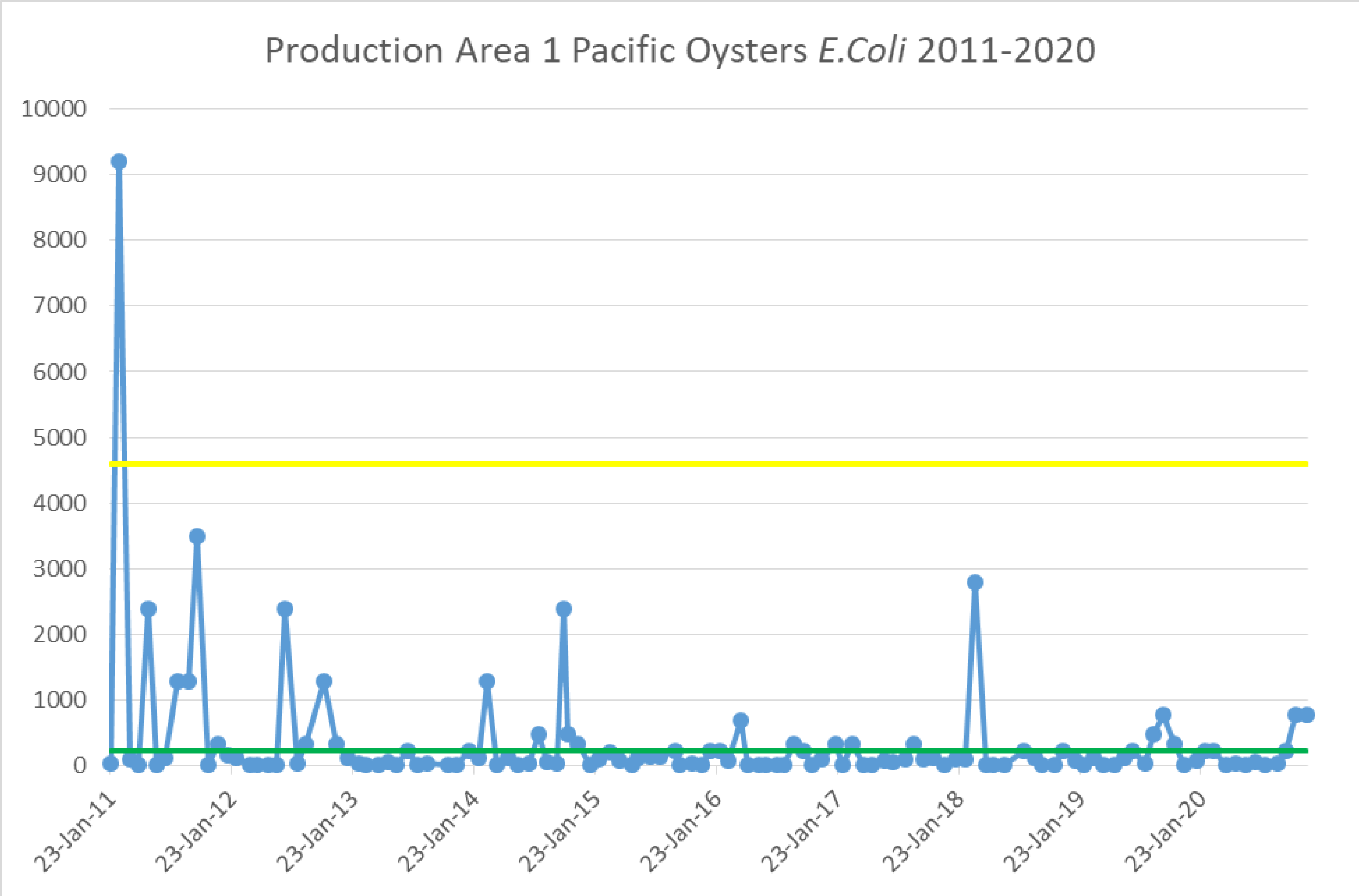


Table 5.8 shows the summary statistics for the *E. coli* historical data (2011 to 2020) from the 9 shellfish monitoring points over the period.

The geometric mean of *E. coli* levels was highest for mussels at M3 (285 MPN/100g), followed by mussels at M1 (220 MPN/100g). The lowest geometric mean was for native oysters at O3 (73 MPN/100g).

Table 5.3: Summary statistics of historical *E. coli* data monitored from shellfish beds in Lough Foyle.

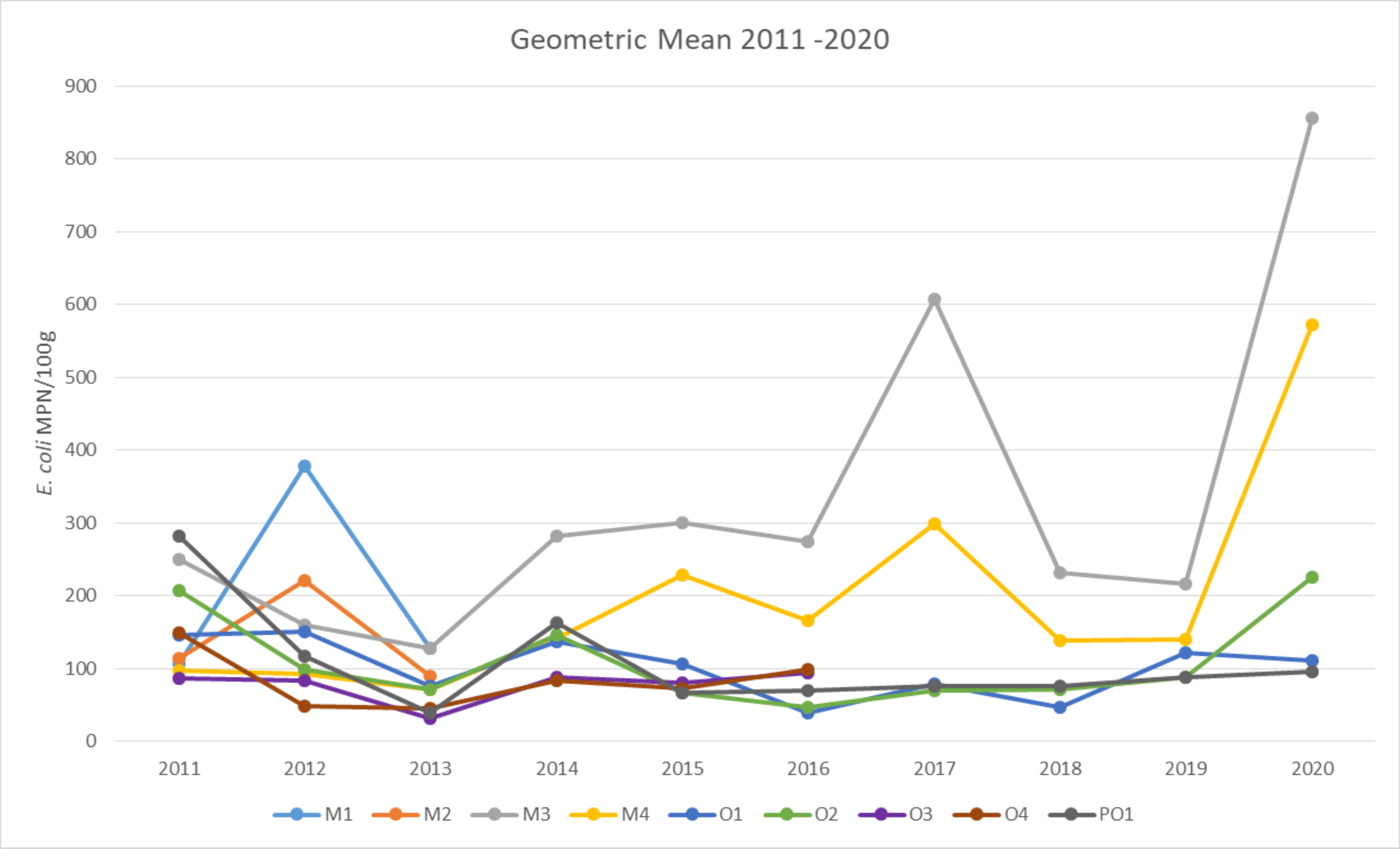
Site	Species	Date 1st Sample	Date last Sample	Min *E. coli* (MPN/100g)	Max *E. coli* (MPN/100g)	Median *E. coli* (MPN/100g)	Geometric Mean *E. coli* (MPN/100g)
M1	Mussels	23-Jan-11	05-Oct-20	18	9200	230	220
M2	Mussels	23-Jan-11	05-Oct-20	18	18000	170	150
M3	Mussels	24-Jan-11	07-Dec-20	18	17000	330	285
M4	Mussels	24-Jan-11	07-Dec-20	18	7900	140	157
O1	Native oysters	23-Jan-11	07-Dec-20	18	16000	59	90
O2	Native oysters	23-Jan-11	07-Dec-20	18	5400	70	91
O3	Native oysters	24-Jan-11	06-Dec-16	18	3400	61	73
O4	Native oysters	24-Jan-11	06-Dec-16	18	4900	47.5	75
PO1	Pacific oysters	23-Jan-11	07-Dec-20	18	9200	78	94

Table 5.4 shows the variations of the annual geometric means of *E. coli* for the shellfish monitoring points in Lough Foyle. Figure 5.11 shows the trend in geometric mean from 2011 to 2020 for all 9 shellfish monitoring points. The geometric mean for mussels at M1 ranged from 106 – 377.5 MPN/100g and at M2 ranged from 220.7- 89.7 MPN/100g.The geometric mean for M1 and M2 could only be calculate for 2011 to 2013 as less than six results were available for the other years and would have given a skewed result. The geometric mean for mussels at M3 ranged from 127.8 – 855.6 MPN/100g. The geometric mean for mussels at M4 ranged from 71.5 – 571.4 MPN/100g. The geometric mean for native oysters at O1 ranged from 38.6 – 151.0 MPN/100g. The geometric mean for native oysters at O2 ranged from 46.5 – 225.1 MPN/100g. The geometric mean for native oysters at O3 ranged from 31.7 – 93.8 MPN/100g and at O4 ranged from 44.6 – 148.8 MPN/100g. Monitoring at O3 and O4 stopped in 2016, with M3 and M4 respectively being used to set the classification for these sites. The geometric mean for pacific oysters at PO1 ranged from 39.0 – 281.4 MPN/100g.

Table 5.4: Variation of annual geometric means of *E. coli* from shellfish monitoring points in Lough Foyle.

Site	Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
M1	Mussels	106.0	377.5	128.2							
M2	Mussels	114.7	220.7	89.7							
M3	Mussels	249.4	159.7	127.8	282.4	299.9	273.6	607.2	231.0	216.2	855.6
M4	Mussels	97.3	92.0	71.5	141.6	228.6	166.3	299.0	137.7	139.5	571.4
O1	Native oysters	146.0	151.0	76.1	137.1	106.6	38.6	79.3	46.2	121.2	110.8
O2	Native oysters	206.7	98.8	71.7	146.8	66.0	46.5	69.0	70.5	88.5	225.1
O3	Native oysters	87.1	84.1	31.7	87.3	80.1	93.8				
O4	Native oysters	148.8	48.3	44.6	84.1	72.2	99.2				
PO1	Pacific oysters	281.4	117.7	39.0	163.3	66.0	69.1	75.6	76.4	88.3	95.3

Figure 5.11: Trend in geometric mean of *E. coli* levels from 2011 to 2020 for all 9 monitoring points.



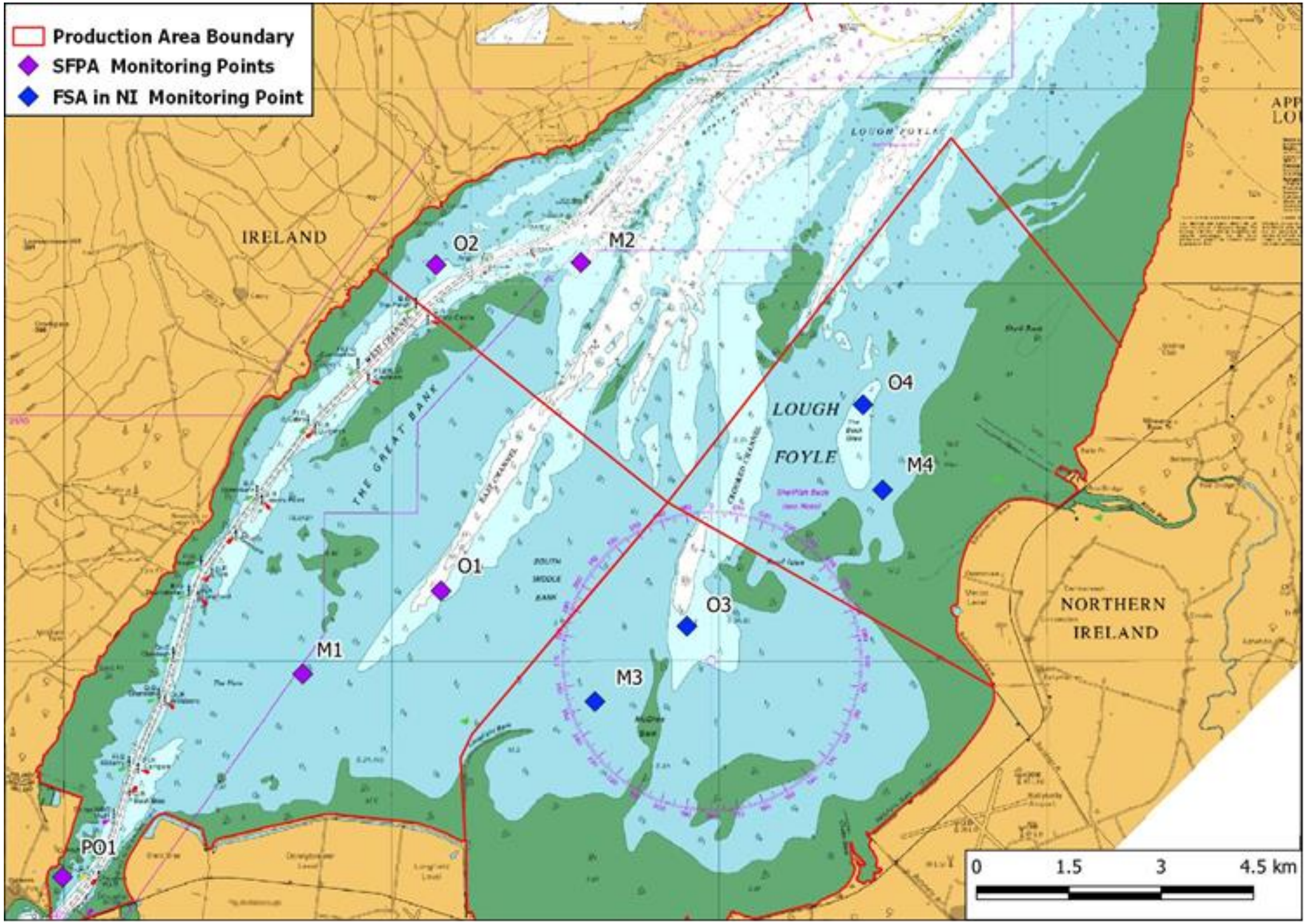
A one-way ANOVA was carried out to look for differences between years for each monitoring point and species. For this analysis, all shellfish flesh results that returned a less than value (i.e., <X) were given that value (*e.g.*, <20 becomes 20). No statistically significant difference was found between years at any of the current monitoring points.

A one-way ANOVA was also carried out on the seasonal *E. coli* counts for each monitoring point and species. This analysis found that there was no significant difference between seasons for O3 native oysters, M1 mussels and PO1 pacific oysters. A significant difference was found between seasons for M2, M3 and M4 for mussels and O1, O2 and O4 for native oysters. Refer to Section 4.1.2 ‘Tourism’ for further details on the seasonal data.

6. Production Areas for Monitoring

The 2011 sanitary survey proposed production areas based on hydrographical and spatial features *i.e.*, areas of similar depth, tidal currents, residence times, suspended sediment levels and freshwater influence as well as the results from the shellfish and water sampling. These four production areas and nine RMPs can be seen in Figure 6.1.

Figure 6.1: Production Areas and RMPs from 2010 sanitary survey.



7. Discussion/Conclusion

The monthly and seasonal wind patterns for the Lough Foyle area have remained constant over time. Winter experienced the strongest wind speeds, while summer experienced the weakest winds. The rainfall patterns have also remained the same with October to January being the wettest. However, high rainfall events can happen at other times of the year with July and August received high rainfall in a number of years.

The total population of the SOAs/EDs within 20km of Lough Foyle is 229,055 people up 4% from the 2010 sanitary survey. Along the western coastline, the highest population occurs in Moville (2366, +8.8%) and Kilderry (2089, +19.8%). The highest population along the eastern shore occurs at Eglinton (4,374, +1.6%) and Gresteel (3,495, -10.8%).

Tourism in Northern Ireland since the 2011 sanitary survey has increased significantly by 46.5%. The Lough Foyle Catchment partially overlaps two Northern Ireland Local Government Districts (LGD) for tourism numbers 'Derry City and Strabane' and 'Causeway Coast and Glens'. The Northern Ireland LGD boundaries were changed since the 2011 sanitary survey and so tourism statistics cannot be directly compared. These two LGDs received 1,346,359 tourists in 2018. As the tourism numbers in Northern Ireland have increased by 46.5% it is likely that the tourism numbers in the Lough Foyle area have also increased. The catchment also partially overlaps County Donegal. County Donegal received 255,000 overseas tourists in 2017, an increase of 25% from 2008. There is however no way of estimating the number of tourists who visited the Lough Foyle catchment area during their stay.

Statistical analysis was carried out on *E. coli* data for the active shellfish beds to ascertain if there are any seasonal patterns. This analysis found that there was no significant difference between seasons for O3 native oysters, M1 mussels and PO1 pacific oysters. A significant difference was found between seasons for M2, M3 and M4 for mussels and O1, O2 and O4 for native oysters.

M2 mussels had significantly lower E.coli results in spring when compared to winter and autumn. M3 mussels had significantly higher results in winter and autumn than in summer and spring. M4 mussels had significantly higher results in winter and autumn than in summer and spring. O1 native oysters had significantly higher results in autumn than in winter and spring. O2 native oysters had significantly higher results in summer and autumn than in winter and spring. Autumn also had significantly higher results than summer. O4 native oysters had significantly higher results in winter and autumn than in spring.

The trend at all of these site appears to be linked to rainfall levels and run-off from land. As such tourism does not appear to have a significant effect on the shellfish quality in the bay

There are 64 Waste Water Treatment Works (WWTWs) in the Lough Foyle catchment, serving a population of approximately 187,728 p.e. The major works are those at Culmore, Limavady, Magilligan Point Road, Donnybrewer, Dungiven, Ballykelly, Claudy and Greysteel, these eight works together account for 92.9% of the total population equivalent of the catchment. Of the 64 WWTWs 56 are below/at capacity and 8 are over capacity. The 56 plants that are below/at capacity account for 97.5% of the load on the WWTW in the catchment. Importantly Culmore WWTW which accounts for 71.3% of the load on the WWTW in the catchment is operating at 16,184 p.e. below capacity.

The 2010 survey only listed industrial discharges along the shoreline. All industrial discharges within the catchment have now been identified. In total, there are 193 industrial discharges within 20km of Lough Foyle. Site drainage account for 144 of these charges with inert and non-inert waste disposal accounting for a further 21.

The dominated land use type remains pastures (increased from 47% to 50%), followed by peat bogs (down from 13.9% to 13.2%) and moors and heathland (up from 6.2% to 7.5%). Land associated with agricultural activities (non-irrigated arable land, pastures, complex cultivation patterns and agriculture/natural vegetation) has increased moderately from 59.1 to 59.8% of the land use in the area. Due to a change in the reporting boundaries for the agri-census between 2009 and 2018 farming densities could not be compared directly. As some of the wards (2018) or SOAs (2009) only partially overlap the catchment an attempt was made to account for this. The percentage of each division within the catchment was estimated in GIS. This percentage was then applied to the agri data to estimate the proportion within the catchment. Based on this, the area used for crops has increased by 11.1% (+1,349ha) and sheep numbers have decreased by 8.6% (32,914). Cattle numbers have increased by 5.2% (6,624), pigs by 61.5% (1,853) and poultry by 111.5% (200,963). There has also been a 4.1% (4736ha) increase in the area of farmland within 20km. Jones and White (1984) estimated the potential daily load for different livestock. Based on this the change in stocking densities of the different species will lead to an estimated reduction in daily E. coli load by $543,439 \times 10^9$. This reduction is due to the significant decrease of sheep in the area which have a much higher daily E. coli load than other livestock

The only commercial port in the Lough is Foyle port. The tonnage of goods has increased moderately from 1,619,000 tonnes in 2009 to 1,760,000 tonnes in 2020 (NISRA, 2019). Cargo passing through Foyle Port include Agricultural products (e.g. grain, soya), Coal, Crude oil, Forestry products, metal and other typical freight. No live animals on the hoof have passed through the port in 2009 or since (NISRA, 2019).

The available data for wetland birds show no significant change since the 2011 survey. The 5-year mean has decreased from 35,539 in 2008 to 33,165 in 2020.

The FSA in NI currently sample shellfish flesh in Production Area 3 and 4 for classification purposes. The SFPA currently sample shellfish flesh in Production Area 1 and 2 for classification purposes. The species currently monitored in the Lough include native oysters, mussels and pacific oysters from within the Lough. Based on the geometric means for all available data the highest *E. coli* concentrations were recorded in the mussel samples. The results for mussels in production area 3 (PA3) were the highest followed by PA1, with PA2 and PA4 having similar levels. This follows with the findings of the original survey, with the inner bay having higher *E. coli* levels and in particular PA3 which has the least water movement.

A one-way ANOVA was carried out to look for differences between years for each monitoring point 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). No statistically significant difference was found between years at any of the current monitoring points.

The changes since the 2011 survey that are of most importance for the faecal load of the lough are the increases to population, tourism and changes to livestock numbers. The population has increased by 4% which is a large increase for a 10 year period. Importantly 97.5% of the WWTW remain either at or below capacity. The most significant of these is Culmore WWTW which treats the waste for 71.3% of the mains sewage. The facility is operating 16,184 p.e below at capacity.

Agriculture is the dominant land use in the catchment accounting for 59.8% of the land. The numbers of cattle, pigs and poultry have all increased, however, the numbers of sheep have decreased. Based on the daily faecal load for each type of livestock the daily *E. coli* load due to livestock has decreased.

Although there has been a significant increase in tourism, statistical analysis of the seasonal *E. coli* results from shellfish appears to show a trend linked to rainfall levels and run-off from land rather than tourism.

The statistical analysis of monthly *E. coli* result from 2011 to 2020 showed no significant difference between years. This along with the annual classification at all sites remaining as B shows that the *E. coli* level in shellfish in the lough has not changed since the last sanitary survey.

It has been identified that there is an accessibility issue regarding the mussel RMP for production area 4. Due to the presence of a sand bar it is unsafe to access the current RMP location. As such it has been decided to relocate the RMP. The loughs Agency carried out sampling to identify an area with suitable stock availability and accessibility. Sampling was carried out in areas identified in the sanitary survey as having similar current speeds and residence times. Based on this a new RMP was chosen (coordinates can be seen in Table 7.1).

For these reasons, a new shoreline survey is not required. With the exception of M4 mussels RMP locations (Table 7.1) or monthly sampling frequency does not need to be adjusted and no alterations to the production area boundary are required.

Table 7.1: Lough Foyle RMPS coordinates.

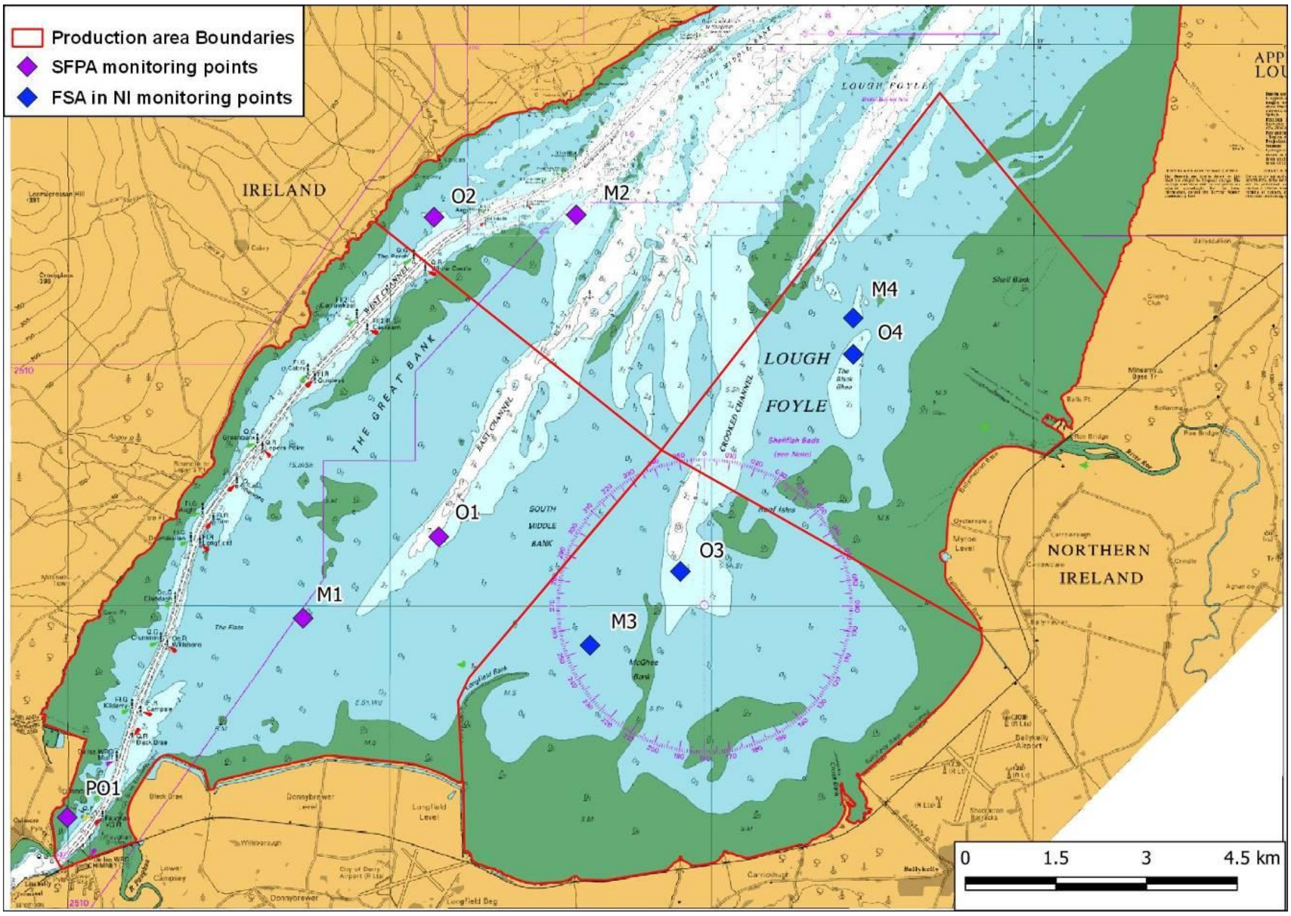
RMP	Species	Longitude	Latitude	Easting	Northing
M1	Mussels	-7.189331	55.08143	251825.0	426315.0
M2	Mussels	-7.118546	55.141342	256261.5	433039.5
M3	Mussels	-7.114984	55.077408	256578.8	425924.9
M4	Mussels	-7.045560	55.126349	260929	431407
O1	Native oysters	-7.154162	55.093528	254054.7	427688.5
O2	Native oysters	-7.155405	55.140993	253911.5	432971.6
O3	Native oysters	-7.091576	55.088388	258058.0	427166.4
O4	Native oysters	-7.046771	55.12064	260870.0	430794.9
PO1	Pacific oysters	-7.250433	55.051817	247958.0	422974.7

8. Sampling Plan

8.1. Production Areas and Monitoring Points

There has been no change to the production area boundaries that were set out in the 2011 sanitary survey. The Representative Monitoring Points have also remained unchanged, with the exception of the mussel monitoring point in production area 4 (RMP M4). M4 has been relocated approximately 2km to the north of its original location. The new location can be accessed safely when sampling and has similar hydrological and spatial features to the original location. The production areas and RMP locations can be see in Figure 8.1.

Figure 8.1: Lough Foyle shellfish productin areas and RMPs 2022.



8.2. Sampling Plan

8.2.1. Methodology

All sampling should follow the UK NRL (National Reference Laboratory) Microbiological Sampling Protocol[1], which outlines the following:

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[1] The UK NRL Microbiological Sampling 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.

8.2.2. 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 so as to avoid introducing any bias to the results.

8.2.3. Frequency of Sampling

All sampling should be carried out on a monthly basis.

8.2.4. 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.

8.2.5. 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.

8.2.6. Sample composition

The following sample sizes (in terms of number of individuals by species) are recommended for submission to the laboratory:

Oysters (Crassostrea gigas and Ostrea edulis)	12-18
Mussels (Mytilus spp.)	18-35

8.2.7. 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 fresh water 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.

8.2.8. 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.

8.2.9. 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.

8.2.10. 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.

9. References

Alderisio, K.A., & N. DeLuca. 1999. Seasonal Enumeration of Fecal Coliform Bacteria from the Feces of Ring-Billed Gulls (*Larus delawarensis*) and Canada Geese (*Branta canadensis*). *Appl. Environ. Microbiol*. **65:**655628–5630.

Crowther, J., Kay, D. & M.D. Wyer. 2002. Faecal indicator concentrations in waters draining lowland pastoral catchments in the UK: relationships with land use and farming practices. *Water Research* **36:** 1725-1734.

CSO. 2019. Census 2016 Small Area Population Statistics. http://census.cso.ie/sapmap/ Accessed April 2021

CSO. 2019b. Census of Agriculture 2010. http://census.cso.ie/censusagriculture Accessed March 2021.

CSO. 2021. Statistics of port traffic 2020. https://www.cso.ie/en/releasesandpublications/er/spt/statisticsofporttrafficquarter4year2020/ . Accessed May 2021

DAERA-NI. 2021. https://appsd.daera-ni.gov.uk/marinemapviewer/. Accessed January 2021

DAERA. 2009. Farm Census 2009. http://www.ninis.nisra.gov.uk/mapxtreme/DataCatalogue.asp?button=Agriculture. Accessed 21/03/2011.

DAERA. 2018. Farm census 2018. https://www.daera-ni.gov.uk/publications/agricultural-census-northern-ireland-2019 . Accessed September 2020.

Elmir, S.M., Wright, M.E., Abdelzaher, A., Solo-Gabriele, H.M., Fleming, L.E., Miller, G., Rybolowik, M, Shih, M.-T.P., Pillai, S.P., Cooper, J.A & E.A. Quaye. 2007. Quantitative evaluation of bacteria released by bathers in a marine water. *Water Research*, **41(1):** 3-10.

Ferreira, J.G., Hawkins, A.J.S., Monteiro, P., Service, M., Moore, H., Edwards, A., Gowen, R., Lourenco, P., Mellor, A., Nunes, J.P., Pascoe, P.L., Ramos, L., Sequeira, A., Simas, T. & J. Strong. 2007. SMILE – Sustainable Mariculture in northern Irish Lough Ecosystems – Assessment of Carrying Capacity for Environmentally Sustainable Shellfish Culture in Carlingford Lough, Carlingford Lough, Belfast Lough, Larne Lough and Lough Foyle. Ed. IMAR – Institute of Marine Science. 100pp.

Ferreira, J.G., Hawkins, A.J.S., Monteiro, P., Moore, H., Service, M., Pascoe, P.L., Ramos, L. & A. Sequeira. 2008. Integrated assessment of ecosystem-scale carrying capacity in shellfish growing areas. *Aquaculture* **275:** 138-151.

Frost, T.M., Calbrade, N.A., Birtles, G.A., Mellan, H.J., Hall, C., Robinson, A.E., Wotton, S.R., Balmer, D.E. and Austin, G.E. 2020. Waterbirds in the UK 2018/19: The Wetland Bird Survey. BTO/RSPB/JNCC. Thetford.

GESAMP. 1990. *The state of the Marine Environment*. UNEP Regional Seas Report and Studies No. 15. UNEP 1990.

Ishii, S., Hansen, D.L., Hicks, R.E., & M.J. Sadowsky. 2007. Beach sand and sediments are temporal sinks and sources of *Escherichia coli* in Lake Superior. *Environ. Sci. Technol*. **41:**2203–2209.

Jones, F., Smith, P., & D.C. Watson. 1978. Pollution of a water supply catchment by breeding gulls and the potential of environmental health implications. *J. Institution of Water Engineers and Scientists* **32:**469–482.

Levesque, B., Brousseau, P., Simard, P., Dewailly, Meisels, M., Ramsay, D. & J. Joly. 1993. Impact of the Ring-Billed Gull (*Larus delawarensis*) on the Microbiological Quality of Recreational Water. *Applied and Environmental* Microbiology 1228-1230.

Levesque, B., Brousseau, P., Bernier, F., Dewailly, E & J. Joly. 2000. Study of the content of ring-billed gull droppings in relation to recreational water quality. *Water Res*. **34:**1089–1096.

Loguhs Agency. 2020. Pre-fishery stock assessment Lough Foyle native oyster fishery. Autumn 2020.

Met Office. 2011. UK mapped climate averages. http://www.metoffice.gov.uk/climate/uk/averages/ukmapavge.html. Accessed January 2011.

Met Office. 2021. Historic station data. https://www.metoffice.gov.uk/research/climate/maps-and-data/historic-station-data Accessed May 2021.

NISRA. 2020. http://www.nisra.gov.uk . Super Output Area 2008 - 2016. Accessed September 2020.

NISRA, 2015. https://www.nisra.gov.uk/publications/settlement-2015-documentation . Headcount and household estimates for settlements. Accessed September 2020.

NITB. 2018. Tourism Facts 2018 Northern Ireland. https://tourismni.com/globalassets/facts-and-figures/research-reports/tourism-performance-statistics/annual-and-quarterly-performance/at-a-glance-jan-dec-2018.pdf

NRFA (National River Flow Archive). 2020. Gauging stations and river flow data. http://www.ceh.ac.uk/data/nrfa/. Accessed August 2020.

Oshira, R. & R. Fujioka. 1995. Sand, soil, and pigeon droppings: Sources of indicator bacteria in the waters of Hanauma Bay, Oahu, Hawaii. *Water Sci. Technol*. **31:** 251–254.

Papadakis, J.A., Mavridou, A., Richardson, S.C., Lampiri, M. & U. Marcelou. 1997. Bather-related microbial and yeast populations in sand and seawater. *Water Research*, **314:** 799-804.

Standridge, J.H., Delfino, J.J., Kleppe, L.B., & R. Butler. 1979. Effect of waterfowl (*Anas platyrhynchos*) on indicator bacteria populations in a recreational lake in Madison, Wisconsin. *Appl. Environ. Microbiol*. **38:** 547–550.

UKHO. 2004. Admiralty Chart 2800-0. UK Hydrographic Office

Appendix 1

Statistical Analysis

M1 mussel's v year

Anova: single factor

Summary

Groups	*Count*	*Sum*	*Average*	*Variance*
2011	12	30.3518	2.5293	0.4431
2012	12	30.9235	2.5770	0.3161
2013	13	27.4006	2.1077	0.2054

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.6864	2	0.8432	2.6506	0.0852	3.2759
Within Groups	10.8162	34	0.3181			
Total	12.50265	36				

M2 mussel's v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	12	24.7129	2.0594	0.3385
2012	12	28.1253	2.3438	0.3814
2013	12	23.4311	1.9526	0.2063

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.9812	2	0.4906	1.5891	0.2193	3.2849
Within Groups	10.1879	33	0.3087			
Total	11.1691	35				

M3 mussel's v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	12	28.7626	2.3969	0.4223
2012	12	26.4388	2.2032	0.5387
2013	12	25.2780	2.1065	0.5744
2014	11	26.9594	2.4509	0.9272
2015	12	29.7243	2.4770	0.7698
2016	13	31.6828	2.4371	0.6173
2017	12	33.3996	2.7833	0.6075
2018	13	30.7276	2.3637	0.5070
2019	12	30.2633	2.5219	1.0524
2020	9	26.3905	2.9323	0.3508

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.7745	9	0.6416	1.0015	0.4434	1.9677
Within Groups	69.1867	108	0.6406			
Total	74.9612	117				

M4 mussel’s v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	11	21.8708	1.9883	0.4038
2012	12	23.5665	1.9639	0.5520
2013	10	18.5439	1.8544	0.4030
2014	11	23.6625	2.1511	0.6204
2015	12	28.3085	2.3590	0.8035
2016	13	28.8700	2.2208	0.2923
2017	12	29.7073	2.4756	0.5934
2018	13	27.8058	2.1389	0.5773
2019	12	25.5230	2.1269	0.8171
2020	9	24.8128	2.7570	0.3805

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	6.5073	9	0.7230	1.3140	0.2384	1.9702
Within Groups	57.7754	105	0.5502			
Total	64.2827	114				

O1 native oyster's v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	9	19.4780	2.1642	0.5947
2012	11	23.9699	2.1791	0.3776
2013	12	22.5753	1.8813	0.2500
2014	13	27.7831	2.1372	0.4388
2015	12	24.3341	2.0278	0.7303
2016	13	20.6309	1.5870	0.2107
2017	12	22.7892	1.8991	0.4464
2018	13	21.6410	1.6647	0.2684
2019	12	25.0004	2.0834	0.6878
2020	9	18.4025	2.0447	0.2809

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.6702	9	0.5189	1.2208	0.2901	1.9694
Within Groups	45.0560	106	0.4251			
Total	49.7262	115				

O2 native oyster's v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	9	20.8390	2.3154	0.4993
2012	12	23.9385	1.9949	0.4464
2013	12	22.2654	1.8554	0.2322
2014	13	28.1676	2.1667	0.5465
2015	12	21.8368	1.8197	0.2976
2016	13	21.6719	1.6671	0.3371
2017	12	22.0680	1.8390	0.5305
2018	13	24.0258	1.8481	0.4376
2019	12	23.3639	1.9470	0.5573
2020	9	21.1712	2.3524	0.7946

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.9159	9	0.5462	1.1949	0.3058	1.9685
Within Groups	48.9106	107	0.4571			
Total	53.8265	116				

O3 native oyster's v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	8	15.5213	1.9402	0.3107
2012	12	23.0976	1.9248	0.2783
2013	11	16.5103	1.5009	0.1392
2014	11	21.3488	1.9408	0.5167
2015	12	22.8421	1.9035	0.5395
2016	13	25.6359	1.9720	0.3277

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.7759	5	0.3552	1.0002	0.4254	2.3657
Within Groups	21.6616	61	0.3551			
Total	23.4374	66				

O4 native oyster's v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	9	19.5523	2.1725	0.3381
2012	12	20.2036	1.6836	0.2986
2013	11	18.1440	1.6495	0.1770
2014	11	21.1737	1.9249	0.6579
2015	12	22.3056	1.8588	0.4621
2016	13	25.9520	1.9963	0.3912

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.0169	5	0.4034	1.0370	0.4040	2.3631
Within Groups	24.1165	62	0.3890			
Total	26.1334	67				

PO1 pacific oyster's v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2011	12	29.3919	2.4493	0.9131
2012	11	22.7787	2.0708	0.5739
2013	11	17.5056	1.5914	0.1430
2014	13	28.7694	2.2130	0.4292
2015	12	21.8352	1.8196	0.1867
2016	13	23.9139	1.8395	0.3652
2017	12	22.5437	1.8786	0.2580
2018	11	20.7159	1.8833	0.4850
2019	12	23.3539	1.9462	0.3537
2020	12	23.7495	1.9791	0.3452

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.8965	9	0.6552	1.6165	0.1193	1.9669
Within Groups	44.1770	109	0.4053			
Total	50.0734	118				

M1 mussel's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	17	44.8414	2.6377	0.4034
Spring	18	36.9835	2.0546	0.3657
Summer	13	28.4485	2.1883	0.4392
Autumn	18	44.7889	2.4883	0.6108

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.6615	3	1.2205	2.6714	0.0551	2.7530
Within Groups	28.3269	62	0.4569			
Total	31.9884	65				

M2 mussel's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	17	38.2514	2.2501	0.1284
Spring	18	32.0521	1.7807	0.2711
Summer	13	27.9467	2.1497	0.8766
Autumn	17	43.2205	2.5424	0.2802

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.1974	3	1.7325	4.8781	0.0042	2.7555
Within Groups	21.6640	61	0.3551			
Total	26.8614	64				

M3 mussel's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	29	82.9935	2.8618	0.3125
Spring	28	61.4911	2.1961	0.6667
Summer	31	61.2850	1.9769	0.4917
Autumn	29	81.3388	2.8048	0.5766

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	17.3097	3	5.7699	11.3101	0.0000	2.6849
Within Groups	57.6474	113	0.5102			
Total	74.9571	116				

M4 mussel's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	29	74.0596	2.5538	0.3650
Spring	27	52.9659	1.9617	0.6406
Summer	30	54.9020	1.8301	0.4139
Autumn	29	70.7435	2.4394	0.5169

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10.9300	3	3.6433	7.5799	0.0001	2.6864
Within Groups	53.3527	111	0.4807			
Total	64.2827	114				

O1 native oyster's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	31	52.9332	1.7075	0.1857
Spring	26	46.8858	1.8033	0.4047
Summer	27	54.1902	2.0070	0.5055
Autumn	32	72.5953	2.2686	0.4897

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.7170	3	1.9057	4.8497	0.0033	2.6856
Within Groups	44.0092	112	0.3929			
Total	49.7262	115				

O2 native oyster's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	31	48.6423	1.5691	0.1079
Spring	26	40.9032	1.5732	0.1789
Summer	28	59.8255	2.1366	0.3964
Autumn	32	79.9770	2.4993	0.5358

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	18.8065	3	6.2688	20.2279	0.0000	2.6849
Within Groups	35.0200	113	0.3099			
Total	53.8265	116				

O3 native oyster's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	17	33.7008	1.9824	0.2258
Spring	16	25.5779	1.5986	0.2666
Summer	17	30.3193	1.7835	0.4562
Autumn	17	35.3579	2.0799	0.3912

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.2676	3	0.7559	2.2494	0.0912	2.7505
Within Groups	21.1699	63	0.3360			
Total	23.4374	66				

O4 native oyster's v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	17	32.8415	1.9319	0.2690
Spring	16	24.2470	1.5154	0.0997
Summer	17	31.3978	1.8469	0.5594
Autumn	18	38.8449	2.1580	0.4592

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.5786	3	1.1929	3.3847	0.0234	2.7482
Within Groups	22.5549	64	0.3524			
Total	26.1334	67				

PO1 pacific oyster’s v Season

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
Winter	31	63.5719	2.0507	0.3393
Spring	30	53.4915	1.7831	0.4804
Summer	29	53.5972	1.8482	0.3384
Autumn	29	63.8970	2.2033	0.4724

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.2597	3	1.0866	2.6692	0.0509	2.6835
Within Groups	46.8137	115	0.4071			
Total	50.0734	118				