Sanitary Survey
Review
for Killough Harbour

Produced by

AQUAFACT International Services Ltd

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
Benthic	Of, pertaining to, or occurring at the bottom of a body of water
Biogenic	Produced by living organisms or biological processes
Bioturbation	The stirring or mixing of sediment or soil by organisms
BOD	Biochemical Oxygen Demand
BTO	British Trust for Ornithology
CAAN	Countryside Access and Activities Network
CD	Chart Datum; the level of water that charted depths displayed on a nautical chart are measured from
CEFAS	Centre for Environmental, Fisheries & Aquaculture Science
CSO	Combined Sewer Overflow
DARD	Department of Agriculture and Rural Development
Depuration	The process of purification or removal of impurities
Detrital/Detritus	Non-living, particulate, organic fragments which have been separated from the body to which they belonged
DSP	Diarrhetic Shellfish Poisoning
DWF	Dry Weather Flow
EC	European Communities
E. coli	Escherichia coli
EMS	Environmental Monitoring Stations
Epifauna	Animals living on the surface of marine or freshwater sediments
Epiflora	Plants living on the surface of marine or freshwater sediments
Fetch	The distance a wave can travel towards land without being blocked
FFT	Flow to Full Treatment
FSA	Food Standards Agency

FSA in NI	Food Standards Agency of 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).
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
LAT	Lowest Astronomical Tide
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.
MHWS	Mean High Water Spring
MHWN	Mean High Water Neap
MLWS	Mean Low Water Spring
MLWN	Mean Low Water Neap
MPN	Most Probable Number
MSD	Marine Sanitation Device
NAP	Nitrates Action Programme
NH_4	Ammonium
NIEA	Northern Ireland Environment Agency
NISRA	Northern Ireland Statistics and Research Agency
NITB	Northern Ireland Tourist Board
Nitrification	The conversion of ammonia to nitrate
NI Water	Northern Ireland Water
NO_2	Nitrite
NO_3	Nitrate
NRL	National Reference Laboratory
OD	Ordnance Datum; a vertical datum used by an ordnance survey as the basis for deriving altitudes on maps.
P	Phosphorus
PAH	Polycyclic Aromatic Hydrocarbons
Pathogenic	Capable of causing disease

PCB	Polychlorionated Biphenyls
PCP	Pentachlorophenol
p.e.	Population Equivalent
Plankton/Planktonic	Pertaining to small, free-floating organisms of aquatic systems
PSP	Paralytic Shellfish Poisoning
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
SOA	Super Output Areas or ward
SPA	Special Protection Area
SPS	Sewage Pumping Station
Suspension feeders	Animals that feed on small particles suspended in water
TBTO	Tributyl Tin Oxide
TPP	Total Physical Product
UKAS	United Kingdom Accreditation Service
UKHO	United Kingdom Hydrographic Office
WeBS	Wetland Bird Survey
WTP	Water Treatment Plant
WWPS	Waste Water Pumping Station
WWTW	Waste Water Treatment Works

1. Introduction

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 Killough Harbour was completed in 2012 a review of this sanitary survey is required. This report will review any changes to Killough Harbour and assess whether or not the changes are likely to affect the microbiological concentration of the classified production area.

Killough Harbour is located on the southeast coast of county Down between St. John’s Point and Ardglass. The harbor area is approximately 1.1km in width and in length and the entire lough is intertidal. Strand Lough is the only freshwater body that drains into the Harbour. Land cover along the coastal regions of the catchment area is a mixture of discontinuous urban fabric, pastures and agricultural/natural vegetation. Pacific oysters (Crassostrea gigas) are cultivated within Killough Harbour and mussels (Mytilus edulis) occur naturally within the harbour.

2. Overview of the Fishery/Production Area

2.1. Location/Extent of Growing/Harvesting Area

The shellfish waters in Killough Harbour are protected to maintain water quality for growth and production by designation (see Figure 2.1). This is done by DAERA under environmental legislation and covers an area of approximately 0.2km^2 and covers the outer part of the harbour area bounded to the south by two piers (Source: DAERA-NI). Oysters are cultivated in Killough Harbour.

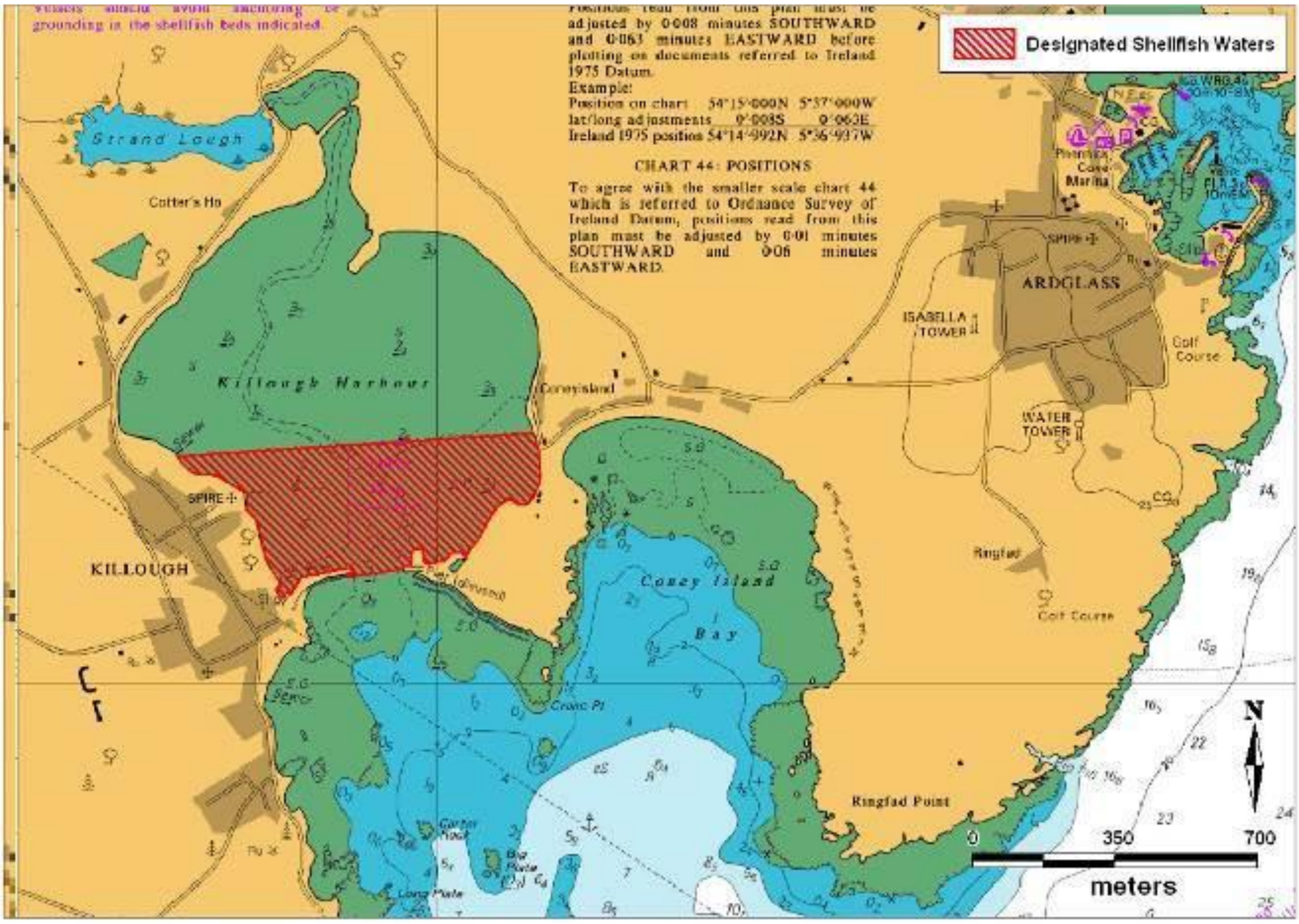


Figure 2.1: Shellfish designated waters within Killough Harbour (Source: DOENI, 2009a).

Figure 2.2 shows the current location of the licensed and classified harvesting area within Killough Harbour. This harvesting area is currently licensed to cultivate Pacific oysters, with native oysters also being harvested. The licensed site covers an area of 0.05km^2. Mussels do naturally occur in the area but at present the area is not licensed to seed or cultivate mussels. The area is currently classified by FSA for both oysters and mussels. There have been no changes to the species harvested or to the boundary of the production area since the 2012 sanitary survey.

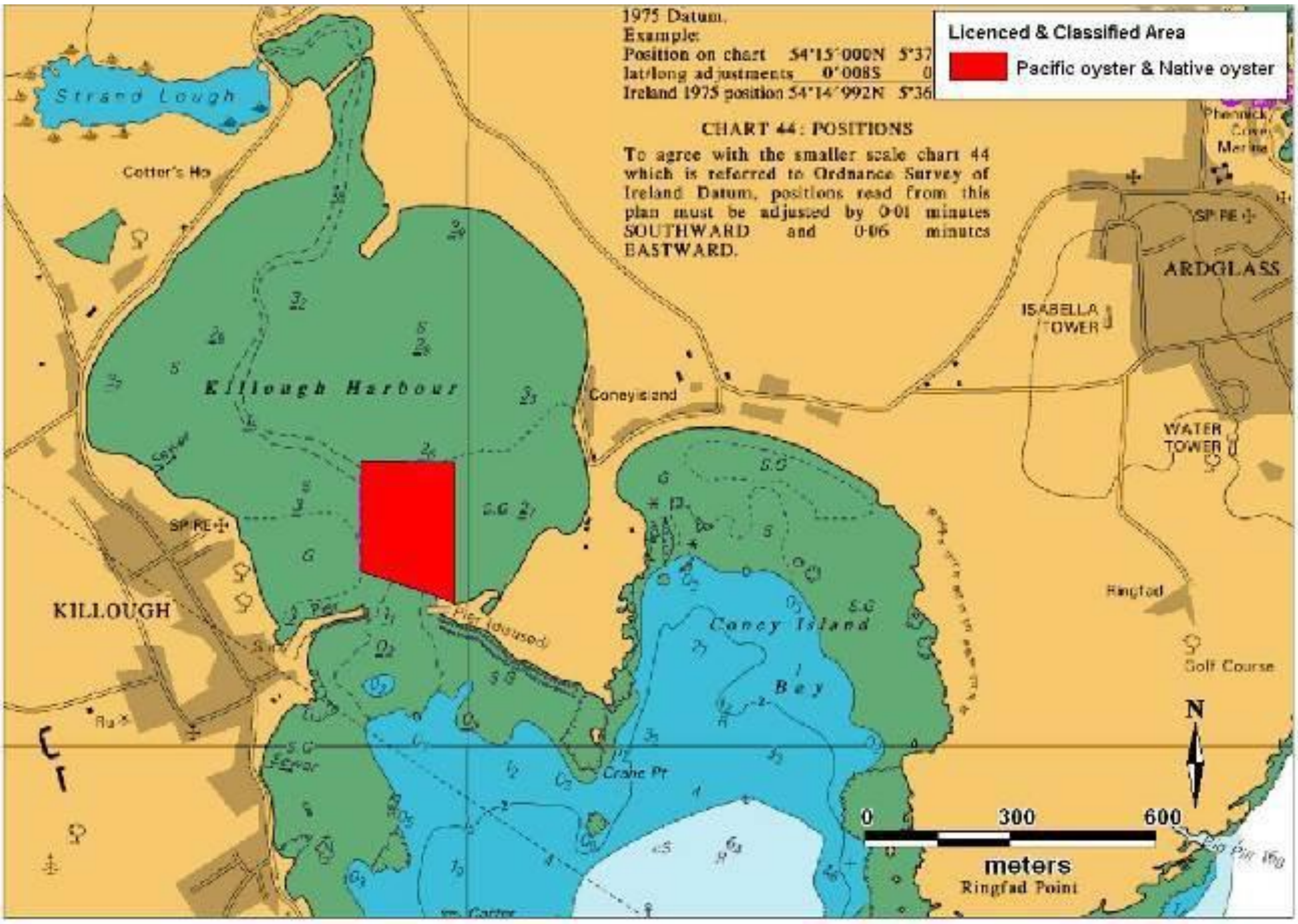


Figure 2.2: Licensed and classified harvesting area located within Killough Harbour (Source: DAERA).

3. Hydrography/Hydrodynamics

3.1. Simple/Complex Models

No hydrographic models existed for Killough Harbour at the time of the sanitary survey and none have been developed yet. However, the information that follows will allow for an understanding of the hydrographic conditions in the harbour.

3.2. Depth

Killough Harbour is all intertidal with a central channel connecting the outer Killough Bay area to

Strand Lough which is located approximately 1km north of Killough village. Depths in Killough Bay range from 0 to 20m. Figure 3.1 shows a bathymetric map of Killough Harbour and Bay.

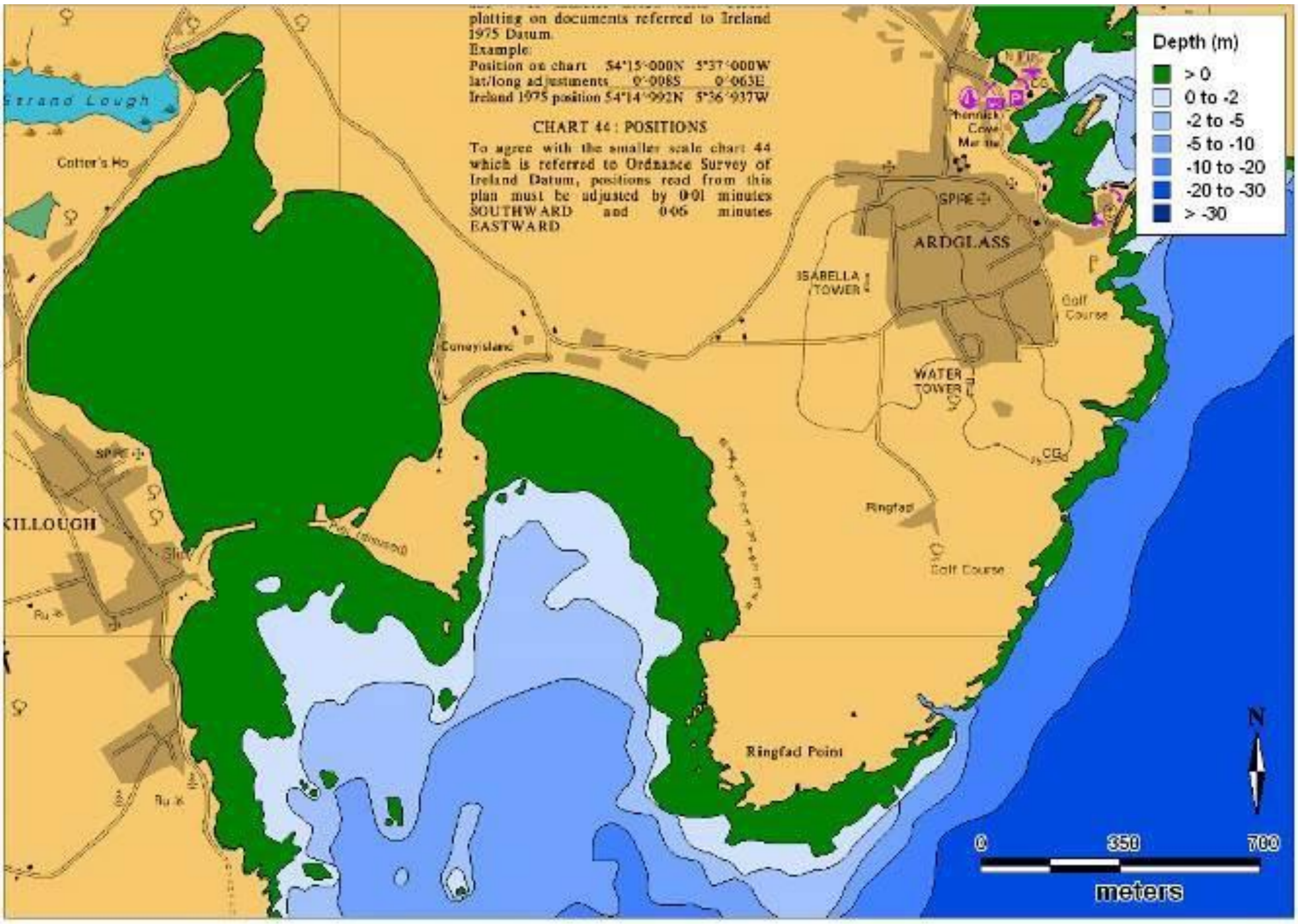


Figure 3.1: Depths in Killough Harbour and Bay (modified from The Loughs Agency data).

3.3. Tides & Currents

The characteristic tidal levels in Ardglass (a village located approximately 2.3km east of Killough Harbour) can be seen in Table 3.1. These are taken from the Admiralty Chart 44-0 (UKHO, 2001). Levels are presented in metres Chart Datum, which is approximately equal to Lowest Astronomical Tide (LAT).

Table 3.1: Ardglass tidal characteristics (Source: UKHO, 2001).

Admiralty Chart 44-0-Levels (m CD)	MHWS	MHWN	MLWN	MLWS	Datum & Remarks
Ardglass	5.2	4.2	1.7	0.7	3.14m below Ordnance Datum (OD) (Belfast)

Tidal streams along this section of coastline are weak, following the coast in both directions, but may reach a rate of 1 knot (during spring tides) off salient points (CAAN, 2011). Tidal rapids are known to occur at the mouth of Killough Harbour (DOENI, 2003). Details on current speeds in to and out of the harbour are unknown but given the configuration of the harbour are expected to be low.

Killough Harbour is intertidal and there is a complete exchange of water twice a day. As expected, water floods in from the south through the channel leading into the harbour area.

3.4. Wind and Waves

The 30 year average wind patterns appear not to have changed significantly from the averages used in the original survey (Figure 3.2) (Met Office, 2020b). The eastern coast of Northern Ireland remains the windiest area. November to February experienced the strongest wind speeds (10-20kn) while July and August experienced the weakest winds (6-15kn). Figure 3.3 shows the seasonal averages in wind speed for Northern Ireland from 1971-2000 and 1981 - 2010, in both sets of averages summer experienced the weakest speeds (6-15kn) while winter experienced the strongest (10-20kn).

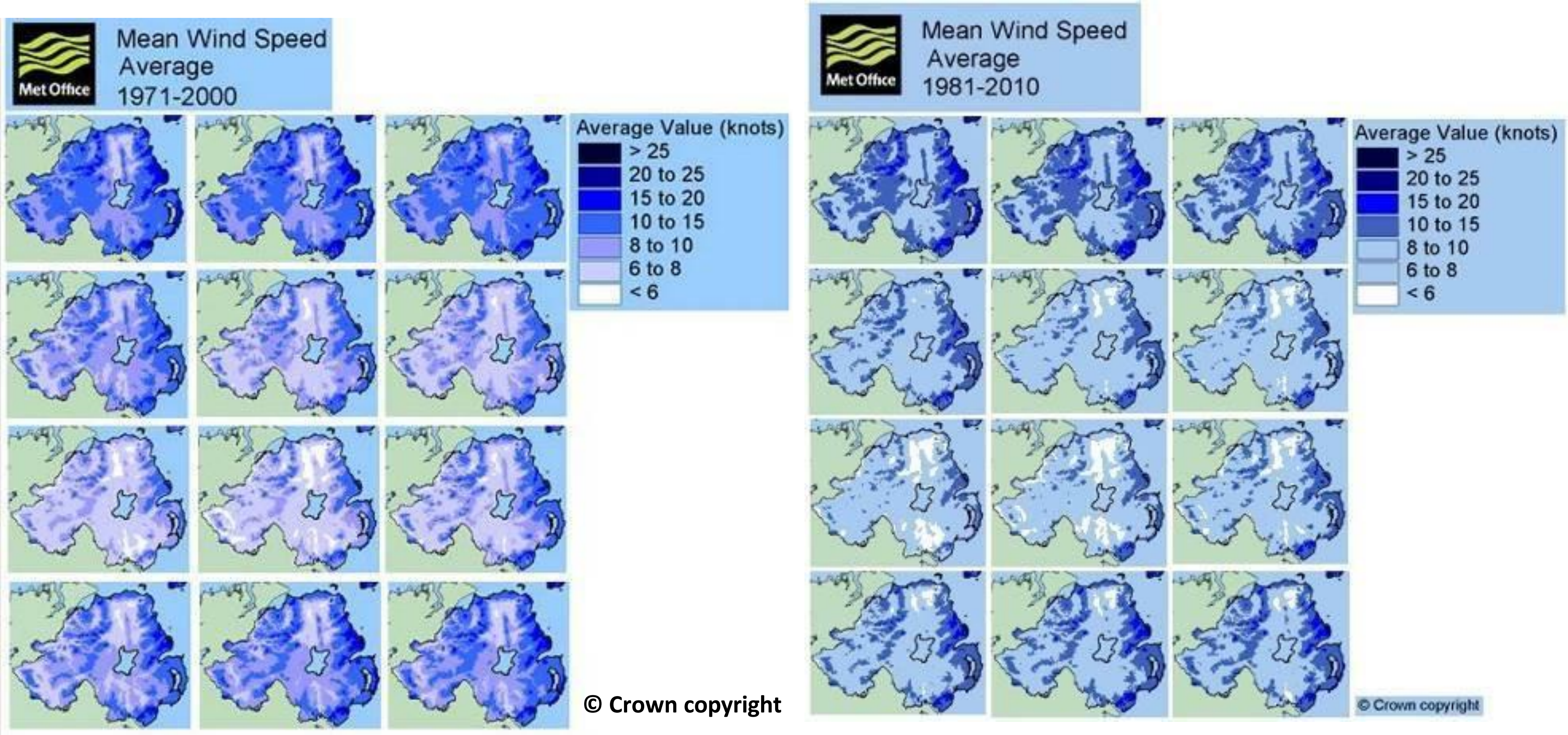


Figure 3.2: Average wind speed data for Northern Ireland from 1971 to 2000 and 1981 to 2010 (Source: Met Office, 2020b).

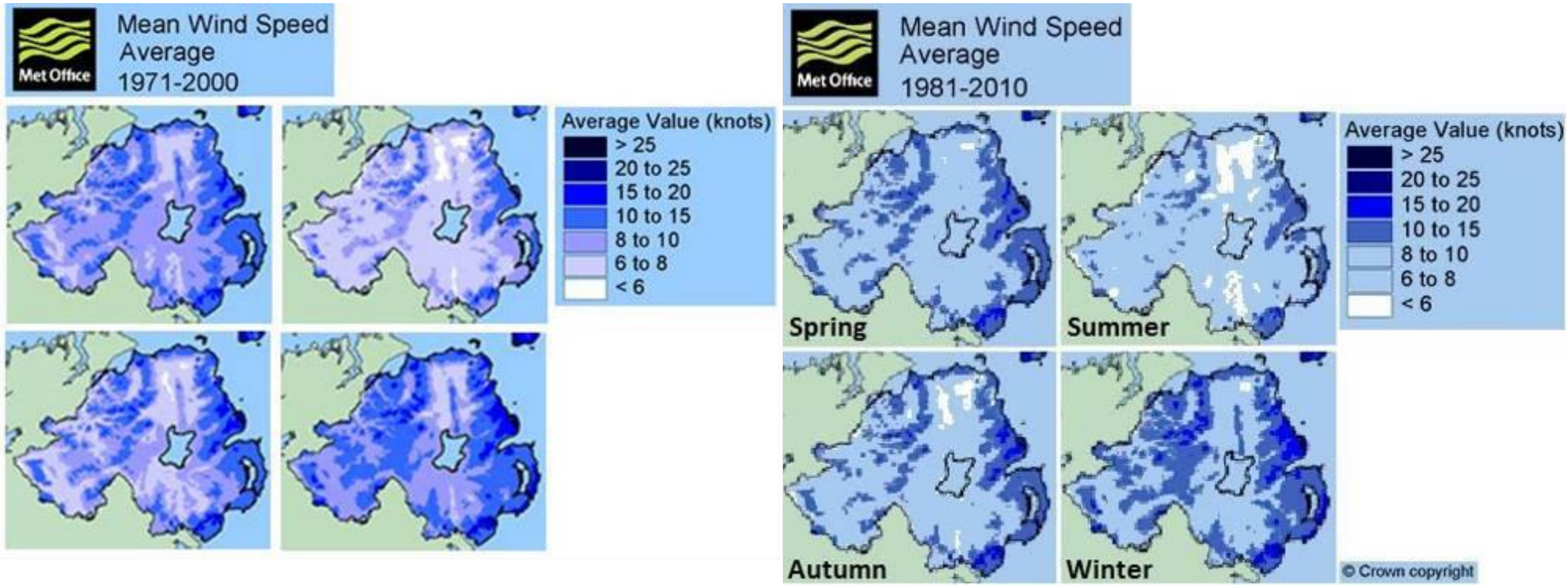


Figure 3.3: Average seasonal wind speed data for Northern Ireland from 1971 to 2000 and 1981 to2010(Source: Met Office, 2020b).

Given the fact that Killough Harbour is intertidal and sheltered, the influence of wind on water movement patterns (and subsequently on the distribution of contaminants) is negligible.

3.5. River Discharges

The only source of freshwater enters Killough Harbour through Strand Lough located approximately 1km north of Killough village at the head of the harbour. Strand Lough is a small lake, with a perimeter of approximately 1.26km and an area of 0.039km^2. It is fed by several small streams which ultimately flow into Killough Harbour. No flow data are available for the rivers within the Killough catchment area. Figure 3.4 shows all rivers discharging into Killough Harbour or a tributary of the harbour and the two hydrometric monitoring stations within the catchment.

Figure 3.4: Killough Harbour rivers and catchment area (Source: NIEA, 2011).

3.6. Rainfall Data

3.6.1. Amount & Time of Year

Figures 3.6 to 3.7 show the average monthly rainfall data for Northern Ireland (Met Office, 2010) from 1971 to 2000 (previous sanitary survey) and 1981 to 2010 (Met Office, 2020b). It can be seen form these maps that the Killough Harbour area is one of the driest in Northern Ireland. Figure 3.5

shows the average rainfall along the Killough Harbour coastline. During the period 1971 to 2000, the average rainfall ranged from 68.1mm in May to 119.1mm in January. During the 1981 to 2010 period the average rainfall ranged from 60mm in May to 92.2 in October. In fact, the average rainfall for all months during the 1981 to 2010 period where lower than the 1971 to 2000 period. Figure 3.8 and 3.9 shows the seasonal averages from 1971 to 2000 and 1981 to 2010 for Northern Ireland. Table 3.2 shows the seasonal rainfall average values. Seasonally, spring and summer were the driest seasons and autumn was the wettest season for both 30 year periods.

Figure 3.5: 30 year average monthly rainfall (mm) along the Killough Harbour coastline (Source: Met Office, 2020b).

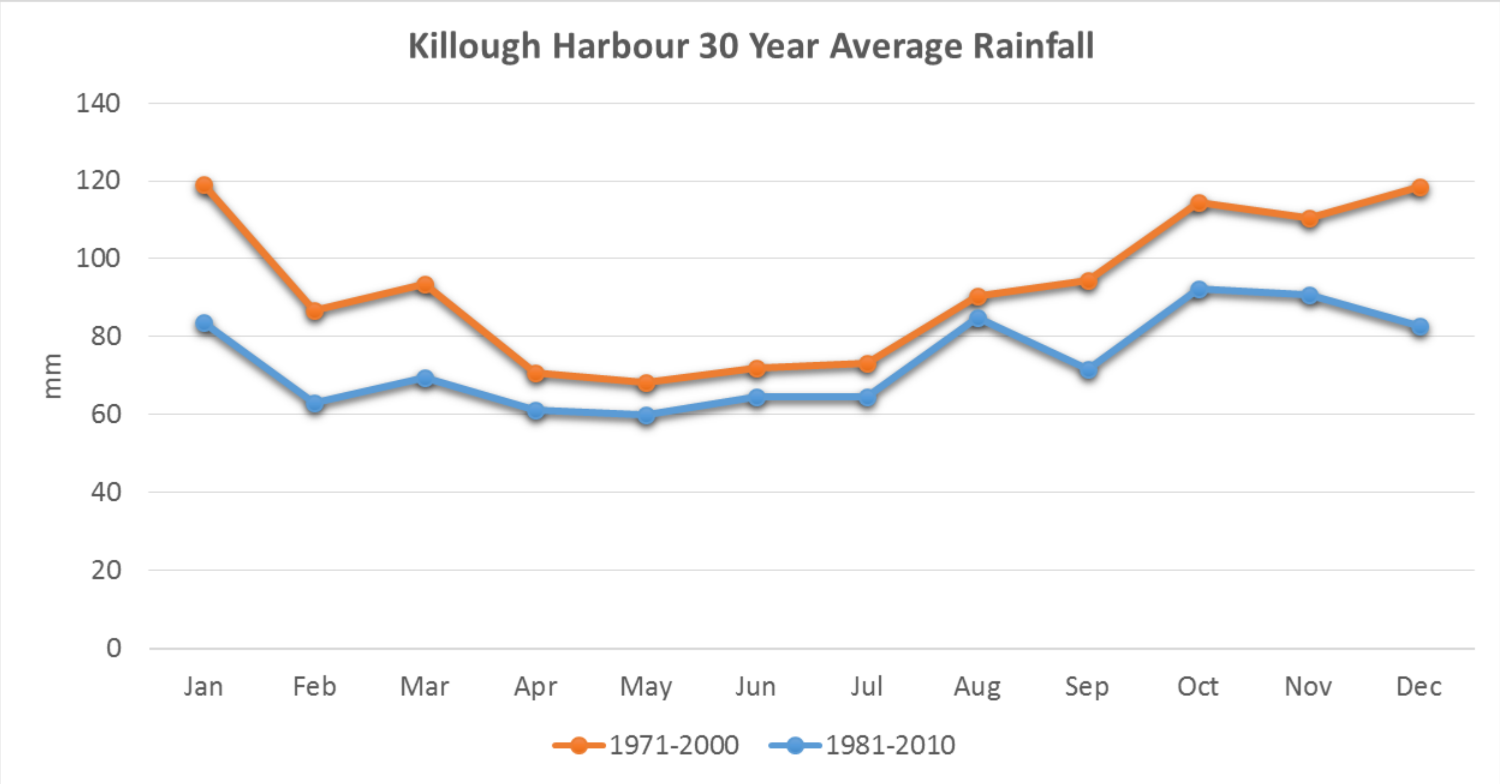


Table 3.2: Seasonal rainfall average values (mm) from 1971-2000 and 1981-2010 (Source: Met Office, 2020b).

Season	**Average Rainfall (mm) 1971-2000**	**Average Rainfall (mm) 1981-2010**
Spring	232.2	190.7
Summer	235.9	213.9
Autumn	319.7	254.5
Winter	324.2	229.1

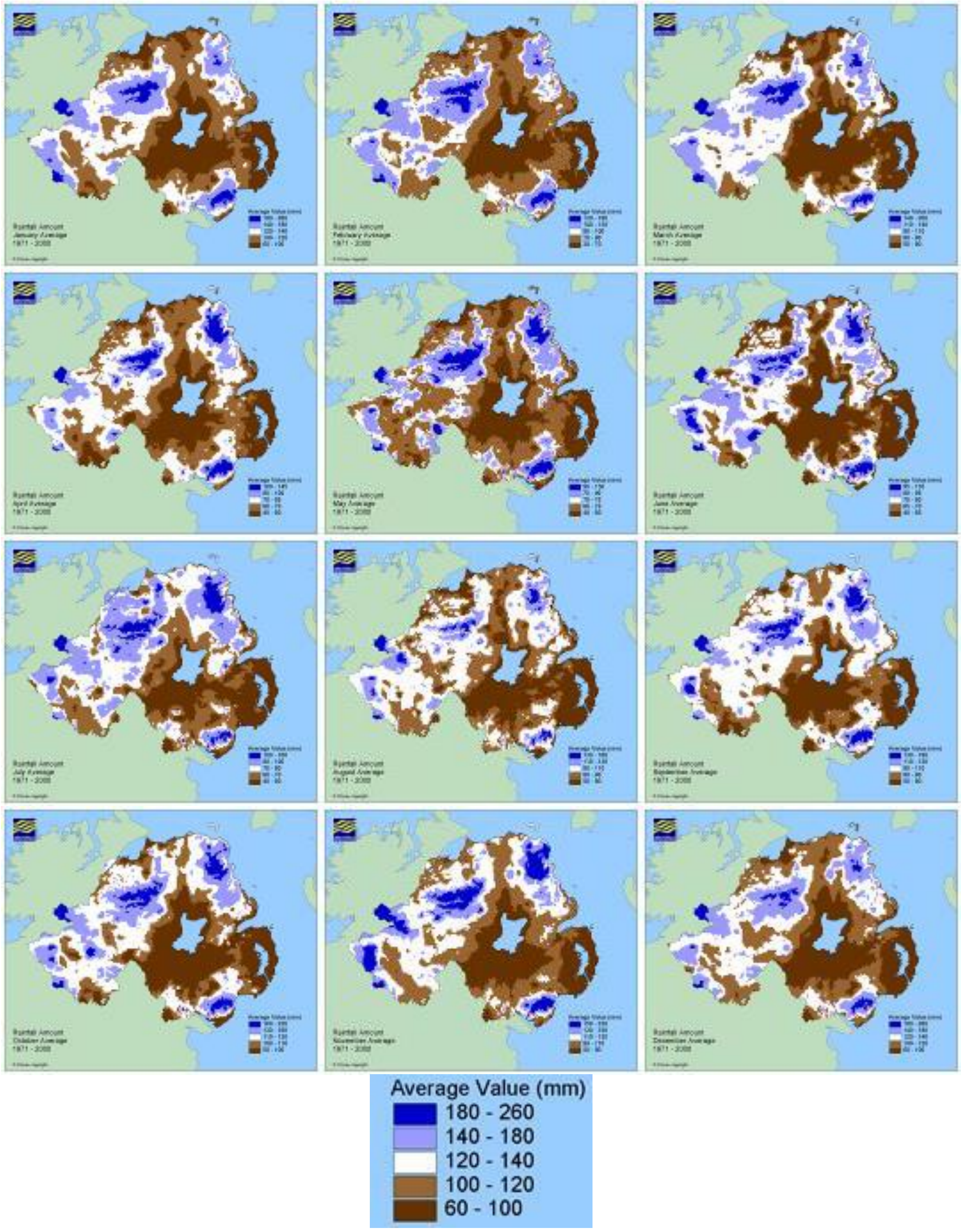


Figure 3.6: Average monthly rainfall (mm) data for January to December from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

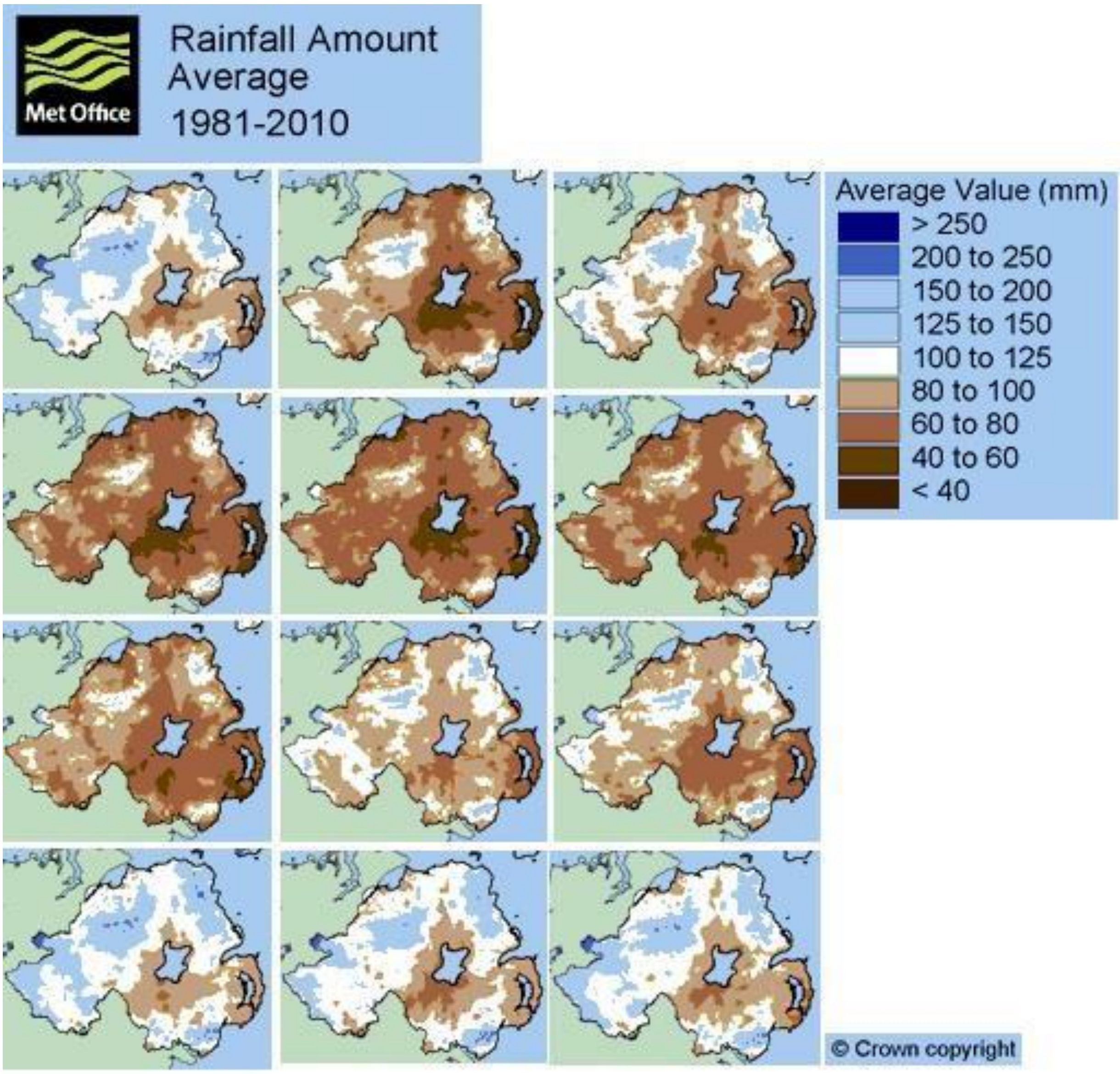


Figure 3.7: Average monthly rainfall (mm) data for January to December from 1981 to 2010 for Northern Ireland (Source: Met Office, 2020b).

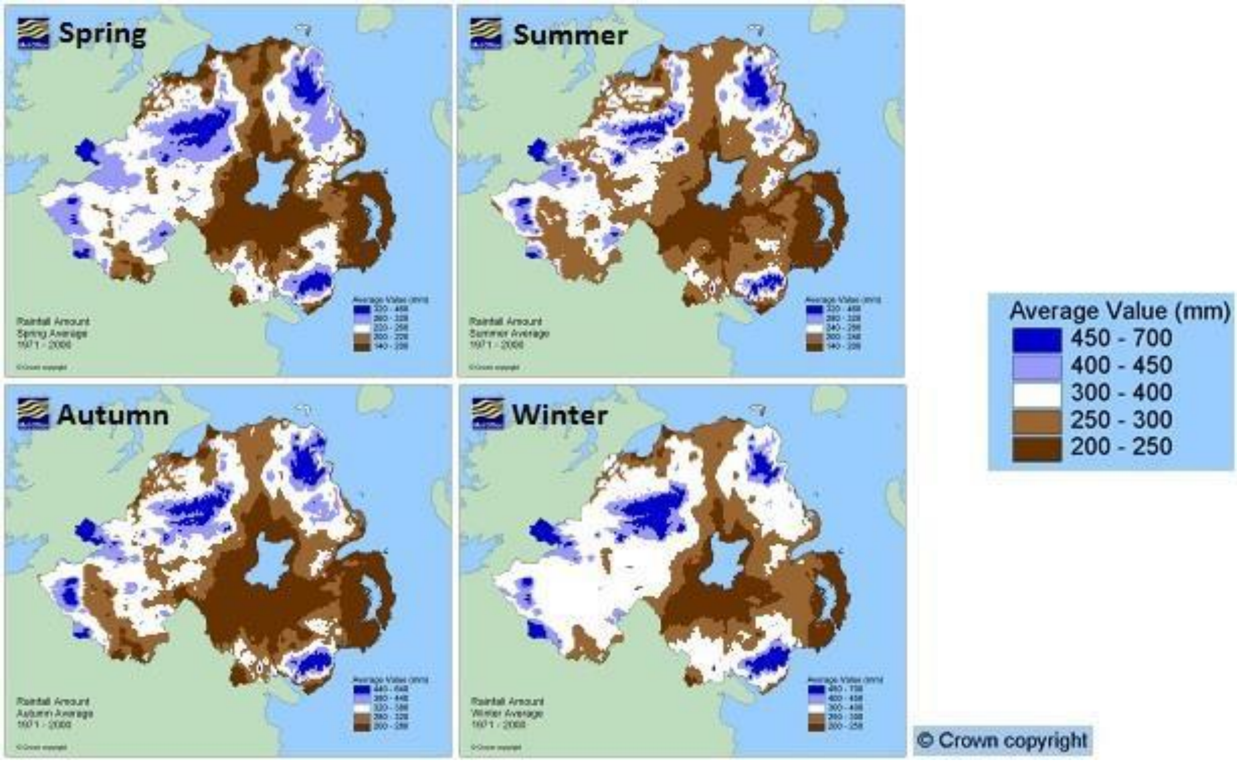


Figure 3.8: Seasonal rainfall averages (mm) from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

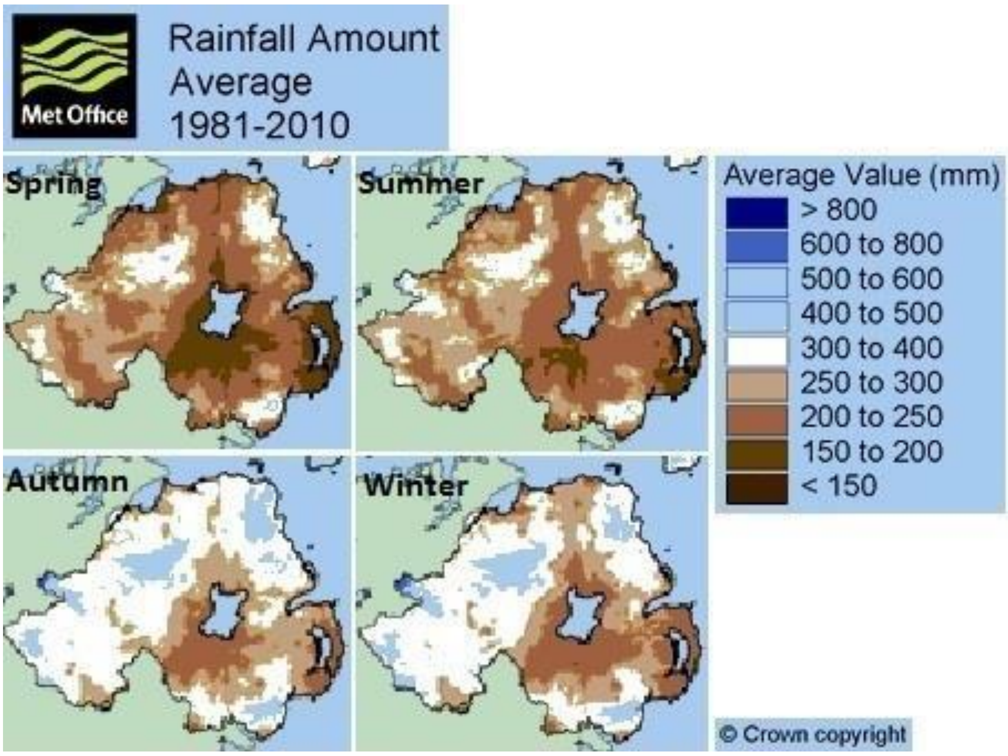


Figure 3.9: Seasonal rainfall averages (mm) from 1981 to 2010 for Northern Ireland (Source: Met Office, 2020b).

Figure 3.10 shows the 5 year average rainfall values from 2007-2011 (previous sanitary survey) and 2015-2019 for Killough Harbour (Met Office, 2020a). It can be seen that for both 5 year averages February to May is the driest period. In both cases conditions become wetter towards the end of summer. They then drop off somewhat in early autumn before increasing again in late autumn and winter. Figure 3.11 shows 5 year average seasonal rainfall for the Killough Harbour area (Met Office, 2020a). In both 5 year periods summer was the wettest season and spring the driest.

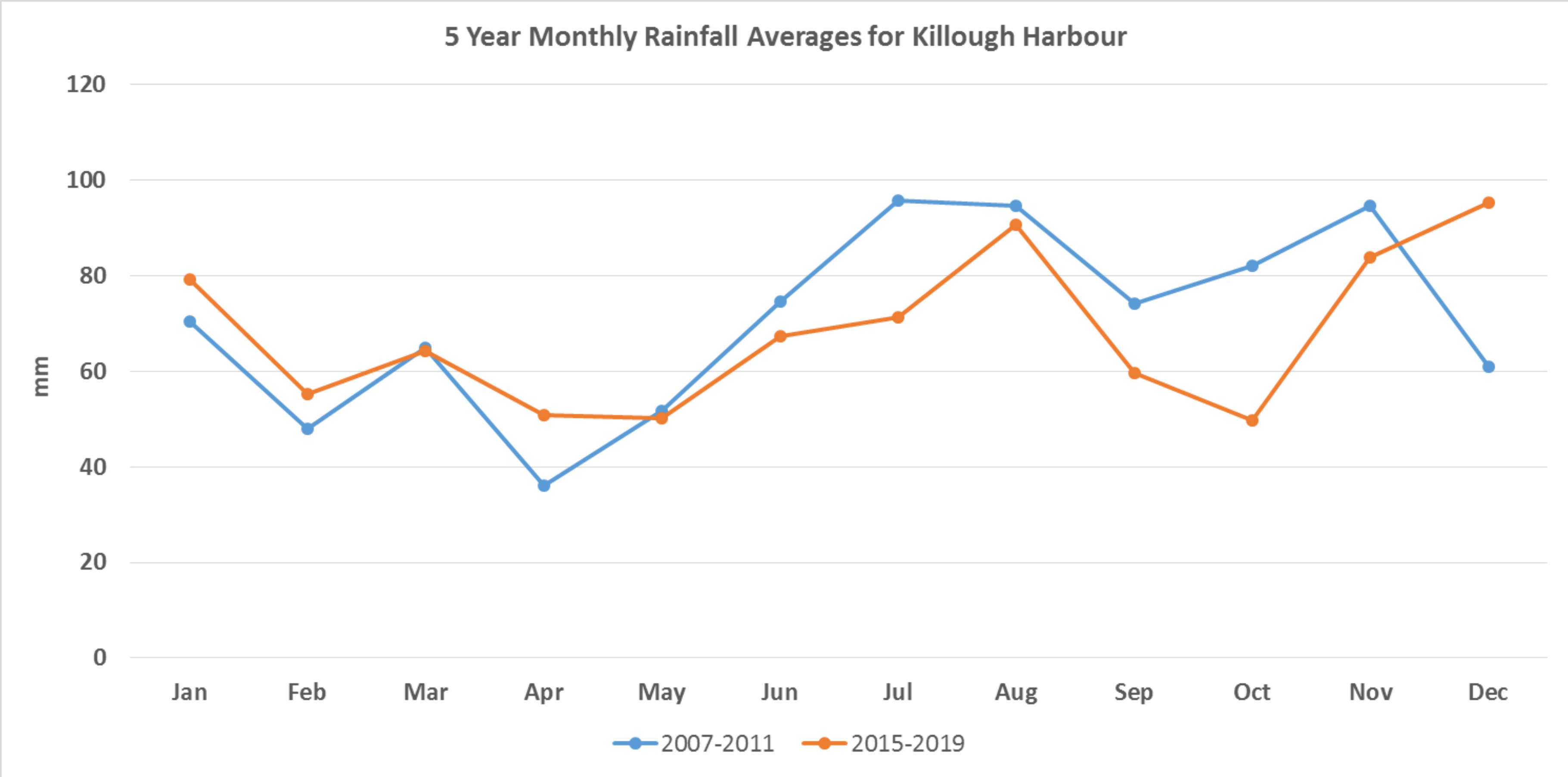


Figure 3.10: 5 Year monthly rainfall averages for Killough Harbour area (Met Office, 2020a).

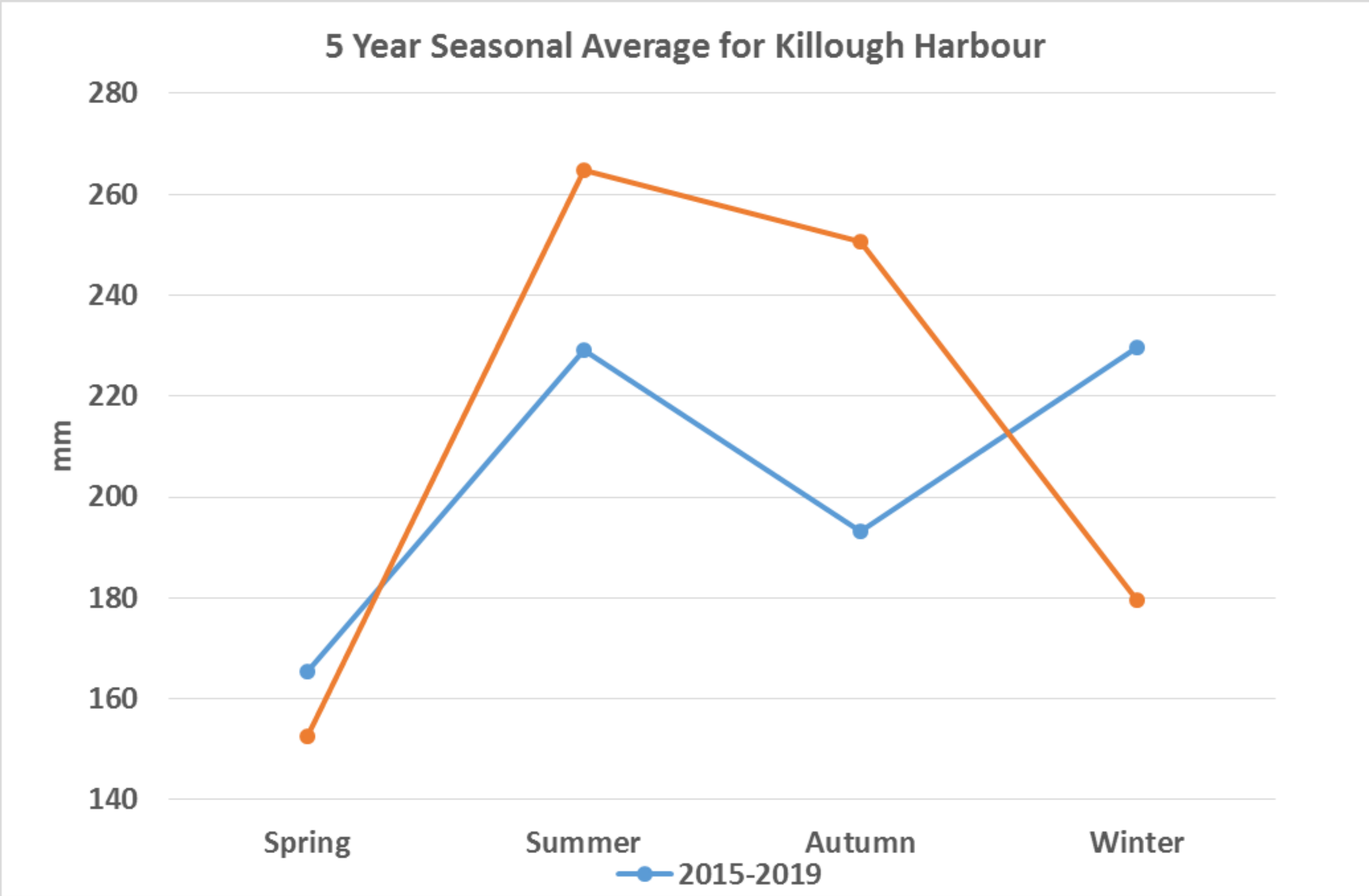


Figure 3.11: 5 Year seasonal rainfall averages for Killough Harbour area (Met Office, 2020a)

3.7. Salinity

Killough Harbour and its environs are not monitored by either the Agri-Food & Biosciences Institute (AFBI) network of remotely moored Environmental Monitoring Stations (EMS) or the Department of Agriculture, Environment and Rural Affairs (DAERA) Water Management Unit. As a result, no actual values can be reported on. In order to provide some data on salinity for Killough Harbour, AQUAFACT staff took some salinity measurements in January 2012 from the end of the pier in the harbour. Salinity values ranged from 34.03 to 34.28 ppt. These levels were expected as there is very little freshwater influence in the harbour. These values are not expected to have changed since the last sanitary survey.

4. Identification of Pollution Sources

4.1. Human Population

Killough Harbour and its catchment area are located entirely in Co. Down. Population census data for Northern Ireland are given in units of Super Output Areas (SOA). Figure 4.2 shows the SOAs within the Killough Harbour catchment area which drain into Killough Harbour.

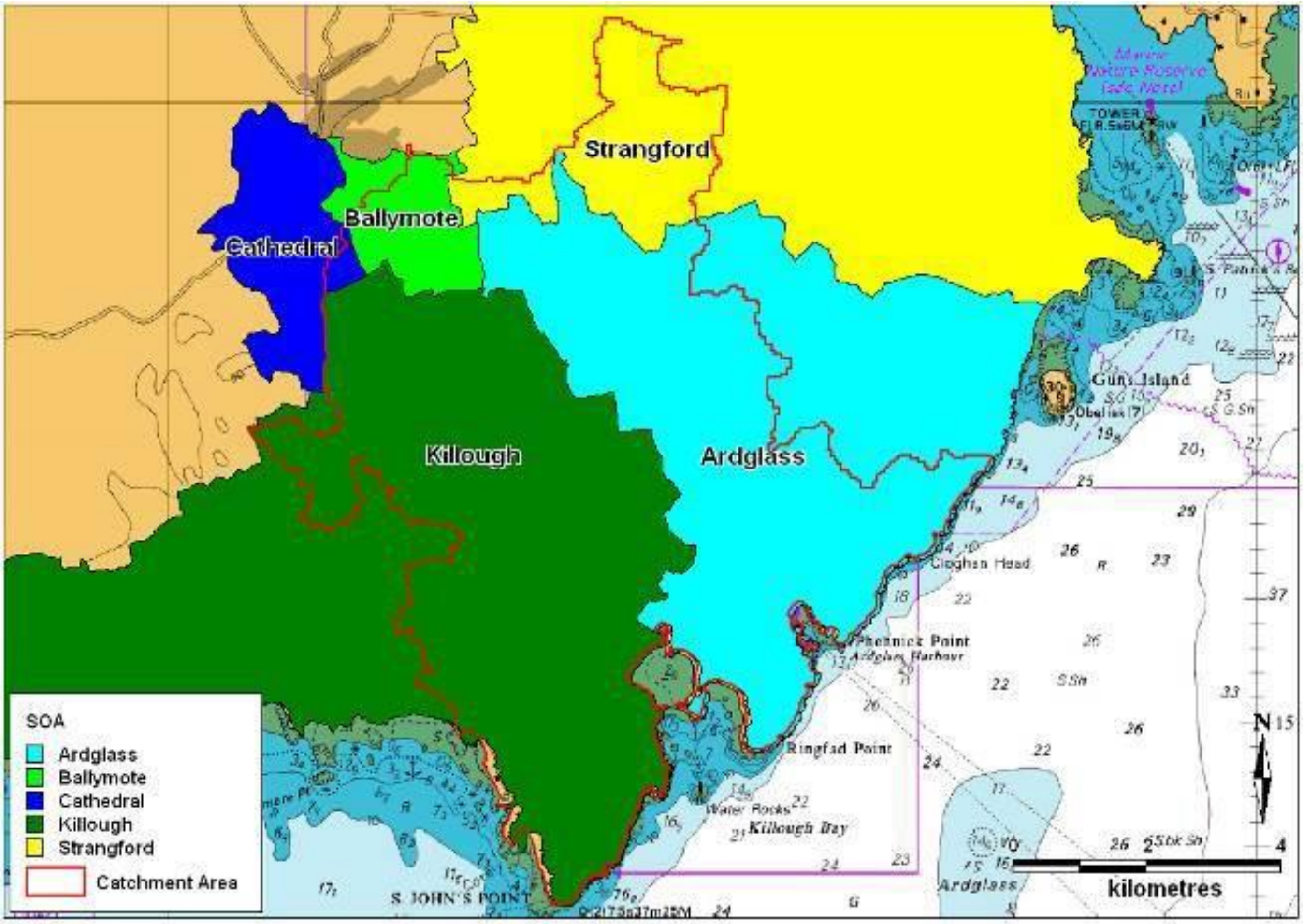


Figure 4.1: SOAs within the Killough Harbour Catchment Area.

Data on human populations for Northern Ireland were obtained from The Northern Ireland Statistics and Research Agency (NISRA) website (NISRA, 2020). This review compares the 2009 population with the most up to date population statistics (2016). Figure 4.3 shows the human population change from 2009 to 2016 within the Killough Harbour catchment area and Table 4.1

shows these data in tabular form.

Population size around the coast of Killough Harbour ranges from 3,194 (+1.2% since 2009) people in Ardglass SOA (located along the eastern shore of the Harbour) to 3,035 (-16.4% since 2009) people in Killough SOA (located along the western coast of the Harbour). Both of these SOAs account for approximately 80% of the catchment area, with the final 20% made up of parts of three other SOAs, namely Ballymote, Strangford and Cathedral. The largest population centre in the catchment area is the village of Ardglass, with a population of 1,643 (+2.4% since 2009) people (NISRA, 2020). The total population within the Killough Harbour catchment is approximated at 6, 499 people[1] (a drop of 1.5% from 2009).

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. Nonetheless, it is clear that areas with a higher population will have higher levels of sewage and wastewater entering the Killough Harbour system.

[1] Given the fact that not all SOAs in their entirety are located within the catchment area, an estimate of the total population within the catchment area was calculated based on percentages located within the catchment area and the urban centre of Ardglass was also taken into account.

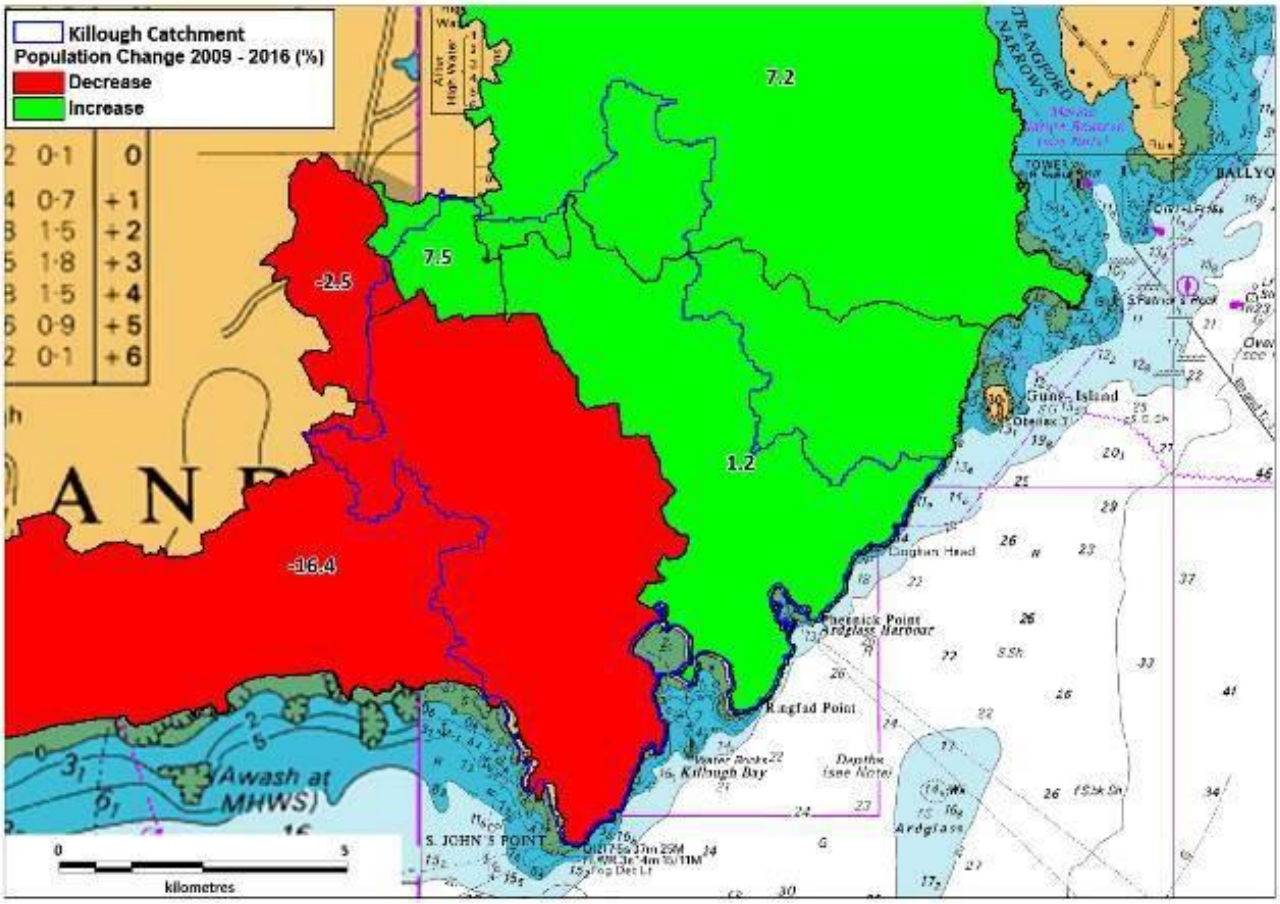


Figure 4.2: Change in human population within the Killough Harbour Catchment Area from 2009 to 2016 (Source: NISRA, 2020).

Table 4.1: Change in Human population within the Killough Harbour Catchment Area from 2009 to 2016 (Source: NISRA, 2020).

SOA	Population 2009	Population 2016	% change
Strangford	2,680	2,872	+7.2
Ballymote	2,864	3,080	+7.5
Killough	3,630	3,035	-16.4
Cathedral	3,294	3,211	-2.5
Ardglass	3,156	3,194	+1.2
Total	15,624	15,392	-1.5

4.2. 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. Due to a reform of the Local government districts in 2011, tourism statistics from the previous sanitary survey cannot be compared to the current statistics. The Killough catchment is now in the Newry, Mourne & Down district which in 2018 received 175,207 tourists from outside Northern Ireland and 274,746 from Northern Ireland. This represents approximately 9% of the visitors who visited Northern Ireland in 2018. The three main tourist attractions in the district are Quoile Countryside Centre, The Saint Patrick Centre and National Trust Castle Ward. None of these attractions are located within the Killough catchment.

Killough caters for passing tourists attracted by its natural setting within the Lecale Coast Area of Outstanding Natural Beauty, its impressive views, coastal walk and harbour (DOENI, 2009b). The village is located on a flat plain though the surrounding topography rises to the west and south where the windmill stump and coastguard station are significant features in the wider landscape and from the sea.

There have been no changes to the tourist activities/facilities in the Killough Harbour catchment area since the 2012 sanitary survey (see Figure 4.4). There is one caravan park in Killough, a golf course between Killough and Ardglass and a scenic walkway between Killough and St. John’s Point. There is also a pier and several slipways in the Harbour area.

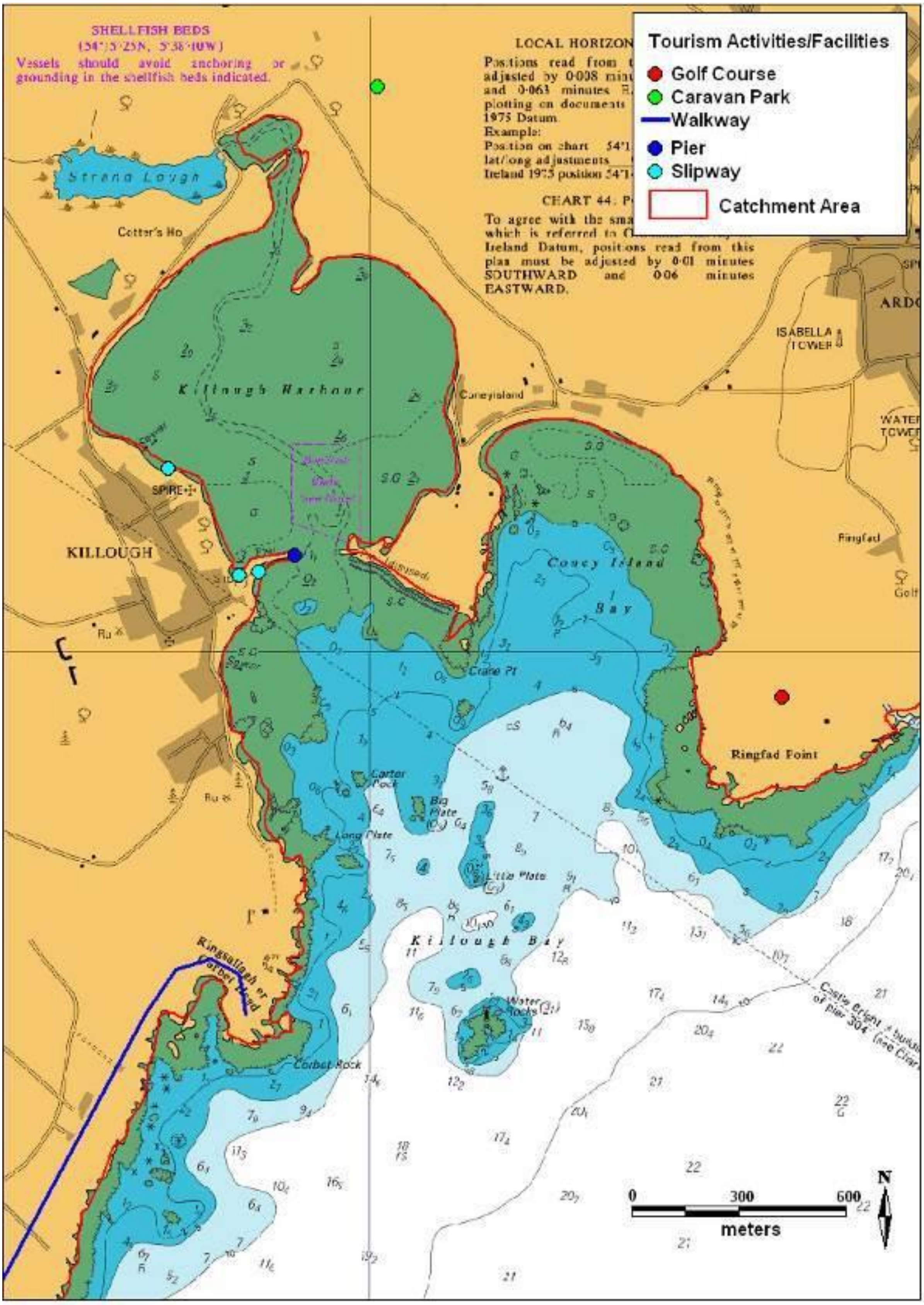


Figure 4.3: Tourist activities/facilities within the Killough Harbour Catchment Area.

Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Killough Harbour 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 from the oyster and mussel flesh from Killough Harbour and box-plots were created. For the ANOVA analysis, all shellfish flesh results that returned a less than value (i.e. <X) were given a value of X-1 (e.g. <20 becomes 19). Box-plots are frequently used to assess and compare sample distributions of microbiological data. The analysis was carried out on available data from 2005 to 2019 (Existing sanitary survey analysed data from 2005 to 2011).

Figure 4.5 shows box-plots produced for both species after grouping the data by season. 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 or lower limit and the upper whisker or the highest data value within the upper limit.

This analysis with a larger data set than the previous survey revealed that there were significant seasonal differences between E. coli levels in both oyster and mussel flesh. The summer E. coli levels for oysters were found to be significantly higher than levels for all other seasons (spring: summer P=0.000186, summer: autumn P=0.019210, summer: winter P=0.009920). The summer E. coli levels for mussels were found to be significantly higher than spring and autumn levels but not winter (spring: summer P=0.008372, summer: autumn P=0.029683). The increased population during the summer from tourism could be a factor in this. However, other factors such as increased rainfall in mid to late summer may cause contaminates which have built up on the land during the dryer period of February to May to be flushed into the system.

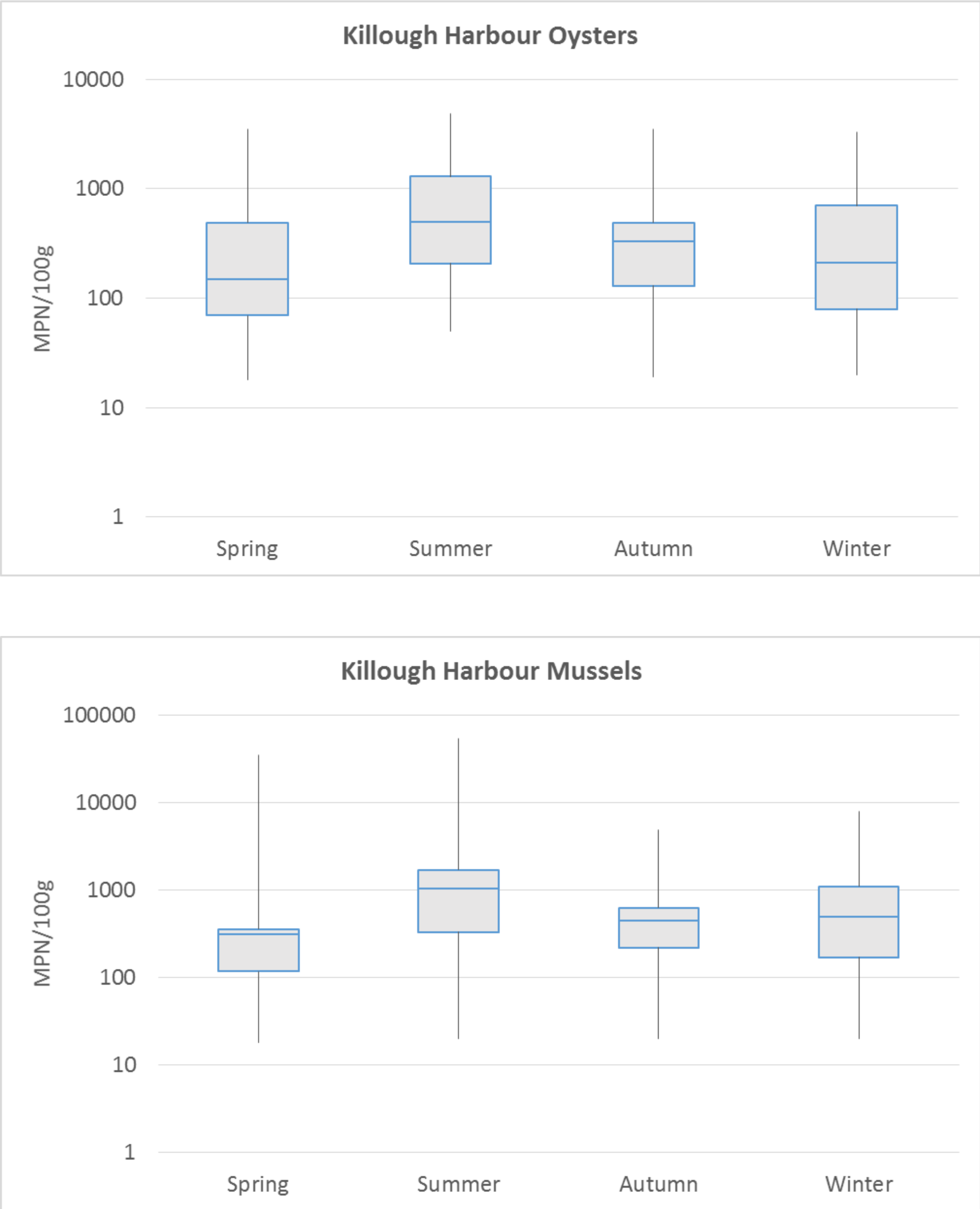


Figure 4.4: Seasonal variation of E. coli in oyster and mussel flesh from Killough Harbour (2005-2019).

4.3. 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 (P) 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.

4.3.1. Continuous Sewage Discharges

There are three Waste Water Treatment Works (WWTWs) within the Killough Harbour catchment area which discharge into Killough Harbour/Bay or into a tributary of the Harbour/Bay. The previous sanitary survey listed four treatment plants, however, the most recent info from NIW shows one of these (Ballynagross) is a Waste Water Pumping Stations (WWPS). Figure 4.5 shows the locations of these WWTWs and the locations of their continuous sewage discharge pipes and Table 4.2 gives the coordinates. Killough WWTW discharges into the outer part of Killough Bay, Coney Island WWTW discharges into Coney Island Bay and Donard View (Ballee) discharges into an unnamed stream which flows ultimately into Strand Lough and then Killough Harbour. The P.E. (population equivalent) of Killough WWTW is 1511, up from 1445. The design P.E. (Population Equivalent) for Killough is not available. Both Coney Island and Donard View plants are under their respective design P.E. see Table 4.2.

In addition, there are seven WWPSs and three outfalls associated with Sewage Pumping Stations (SPS) two of which are combined and one final effluent outfalls. The locations of these can also be seen in Figure 4.5 and Table 4.2 gives their coordinates.

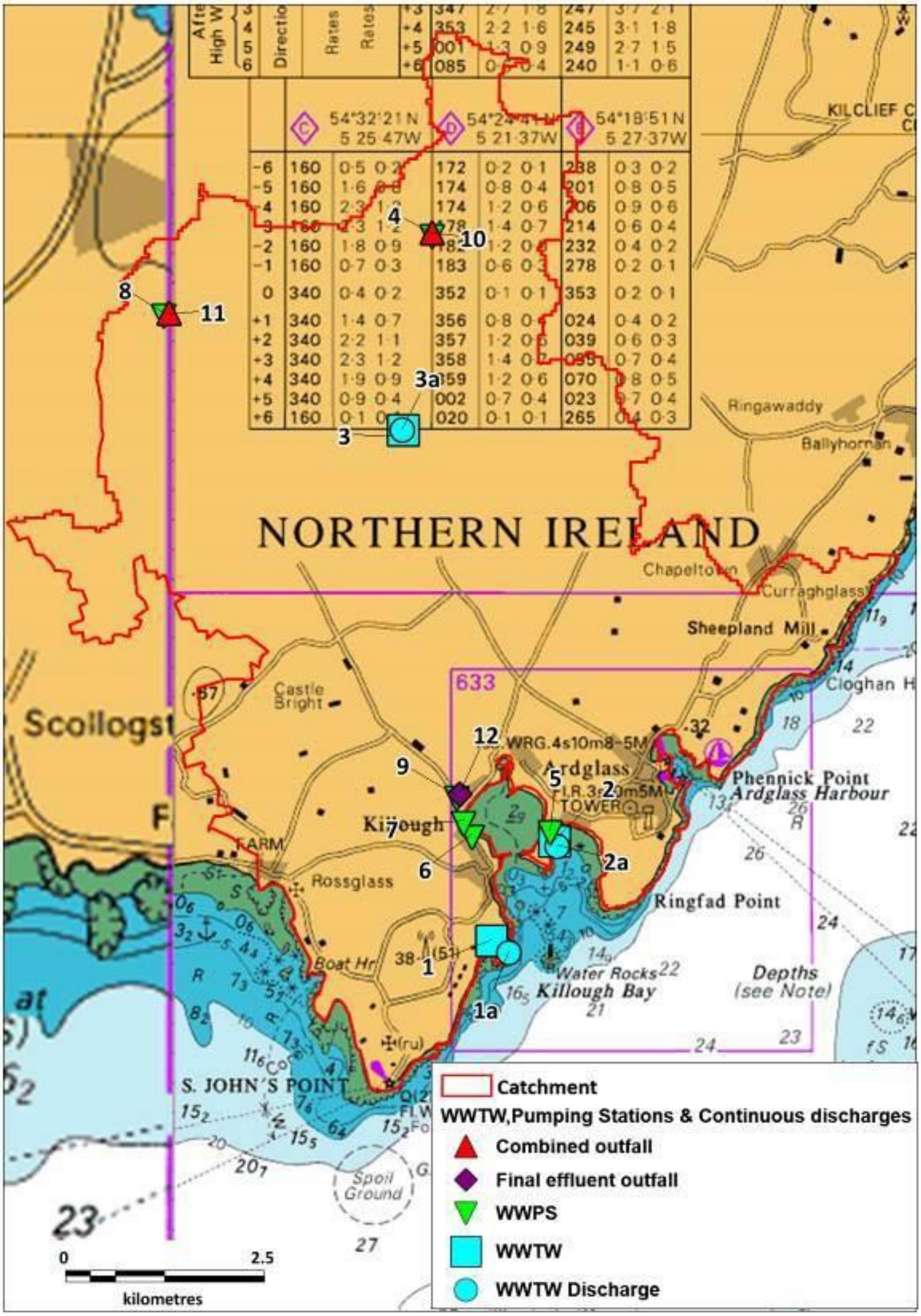


Figure 4.5: Location of WWTWs, WWPS, PS outfalls and continuous discharges within the Killough Harbour Catchment Area (Source: NI Water).

Table 4.2: WWTWs, WWPS, PS outfalls and continuous discharges within the Killough Harbour Catchment Area (Source: NI Water).

Map ID	Name	Feature	Easting	Northing	Longitude	Latitude	P.E.	Design P.E.	Treatment	FFT/m³ /day	DWF/m³ /day	Discharge Data
1	Killough WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1511	N/A	N/A	N/A	N/A	N/A
2	Coney Island WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	96	200	N/A	N/A	N/A	N/A
3	Donard View WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	37	45	N/A	N/A	N/A	N/A
1a	Killough WWTW	WWTW Discharge	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
2a	Coney Island WWTW	WWTW Discharge	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
3a	Donard View WWTW	WWTW Discharge	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
4	Ballynagross WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
5	Coney Island WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
6	Killough Village WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
7	Killough Shore WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
8	Flying Horse Road WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
9	Downpatrick Road WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
10	Ballynagross WWPS	Combined outfall	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A

Map ID	Name	Feature	Easting	Northing	Longitude	Latitude	P.E.	Design P.E.	Treatment	FFT/m³ /day	DWF/m³ /day	Discharge Data
11	Flying Horse WWPS	Combined outfall	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A
12	Downpatrick Road WWPS	Final effluent outfall	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A		N/A	N/A	N/A	N/A

N/A indicates data was Not Available. FFT = Flow to Full Treatment. DWF = Dry Weather Flow

4.3.2. Rainfall Dependent Sewage Discharges

Figure 4.6 shows the Combined Sewer Overflows (CSO) which discharge into Killough Harbour or a tributary of it and Table 4.3 gives their coordinates. Figure 4.6 also shows the locations of septic tanks in the catchment area (details are only known for one septic tank, it can be assumed that more are present throughout the catchment).

Table 4.3: Details on intermittent discharges.

Map ID	Name	Feature	Easting	Northing	Longitude	Latitude
13	Main Street Killough CSO	Combined Overflow	353636	336596	-5.64335	54.2552
14	Quay Lane	Combined Overflow	354019	336114	-5.63772	54.2507
15	Charlie Shiels	Septic Tank	353456.5	336023.6	-5.64639	54.25007

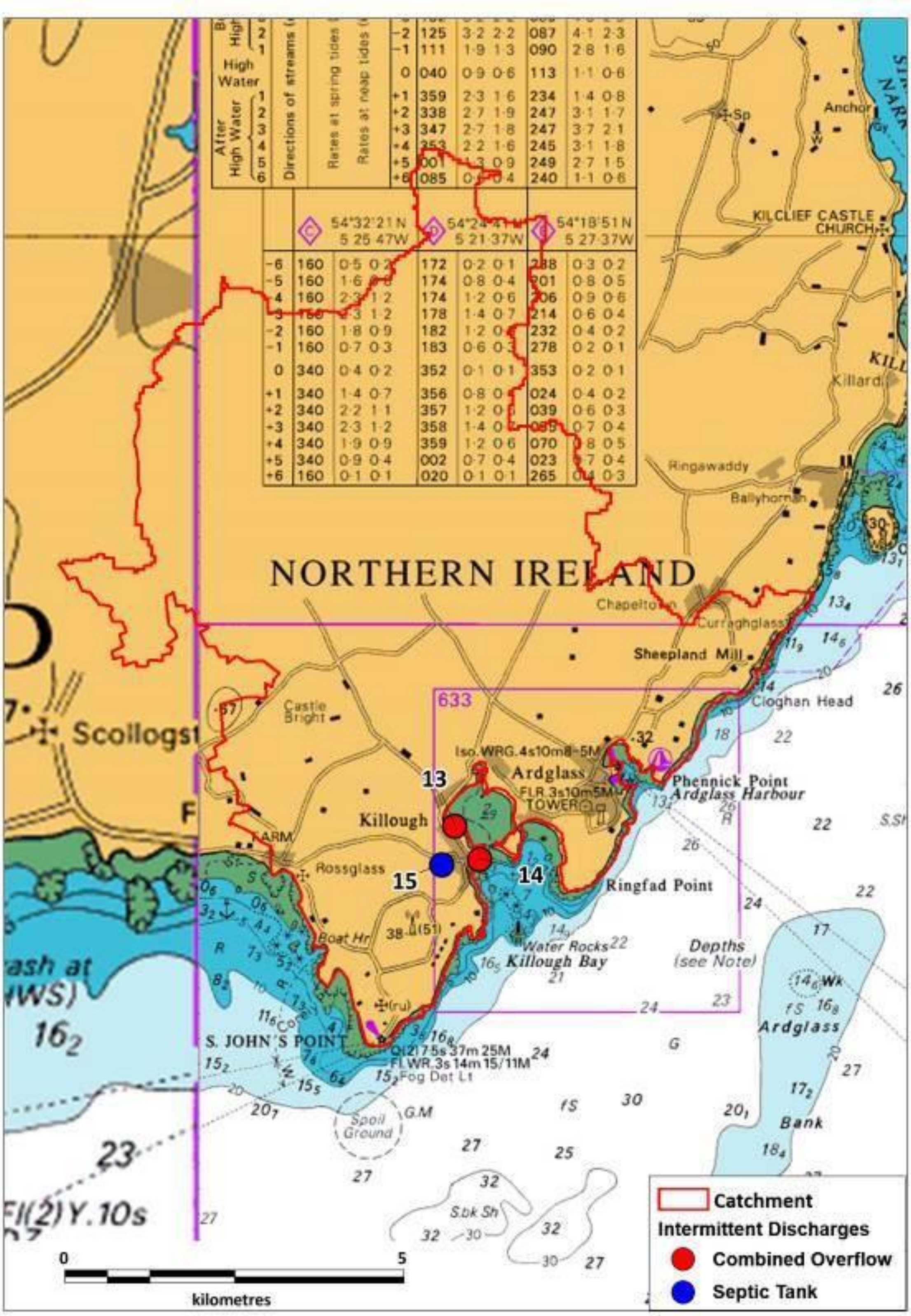


Figure 4.6: All intermittent discharges within the Killough Harbour Catchment Area (Source: NI Water).

4.3.3. Emergency Discharges

No details on emergency discharges (if any) within the catchment area were available; however it can be assumed that some if not all of the pumping stations and overflows shown in Figures 4.5 and 4.6 above have emergency flows associated with them.

4.4. Industrial Discharges

The only industrial discharges in the catchment are from a quarry and scrap yard. Neither of these are likely to have an impact on the E. coli levels in the Bay.

4.5. Landuse Discharges

Figure 4.7 shows the Corine land use within the Killough Harbour catchment area for 2012 and 2018. Figure 3.4 shows all rivers/streams within the catchment area.

Within the catchment area, landuse has not changed much since the previous survey. The corine data available for the previous survey classified 8.4% of the catchment as agriculture/natural vegetation. This area has now been reclassified as a mixture of pasture and non-irrigated arable land. Pasture remains the dominant landuse (38.02km^2; 61.2%), followed by complex cultivation patterns (12.95km^2; 20.8%), and non-irrigated arable land (7.55km^2, 12.1%) (See Figure 4.7). In total, agricultural activities (non-irrigated arable land, pastures and complex cultivation patterns) comprised 94.2% of the land use in the area, up slightly from the 2012 survey (93.5%).

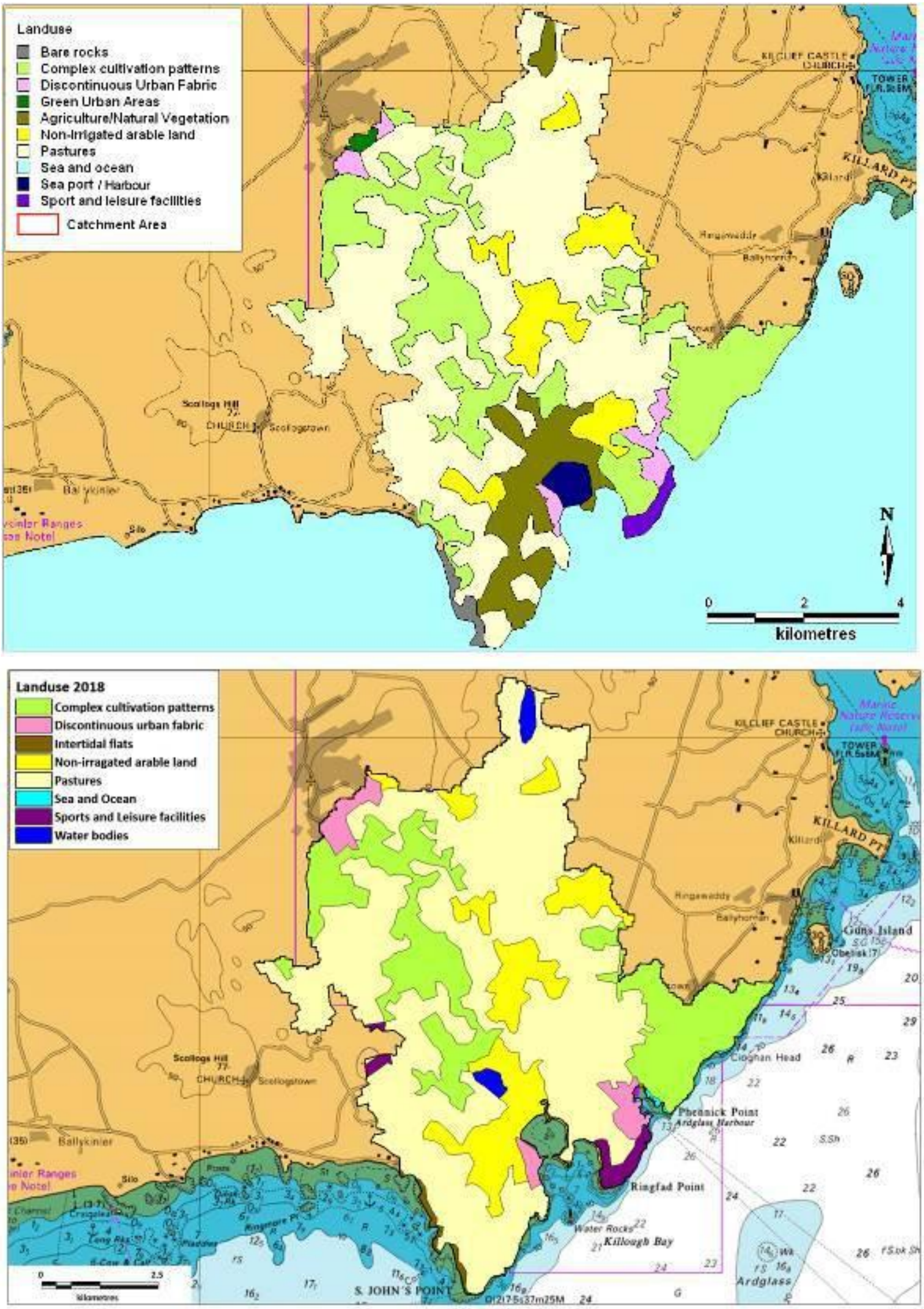
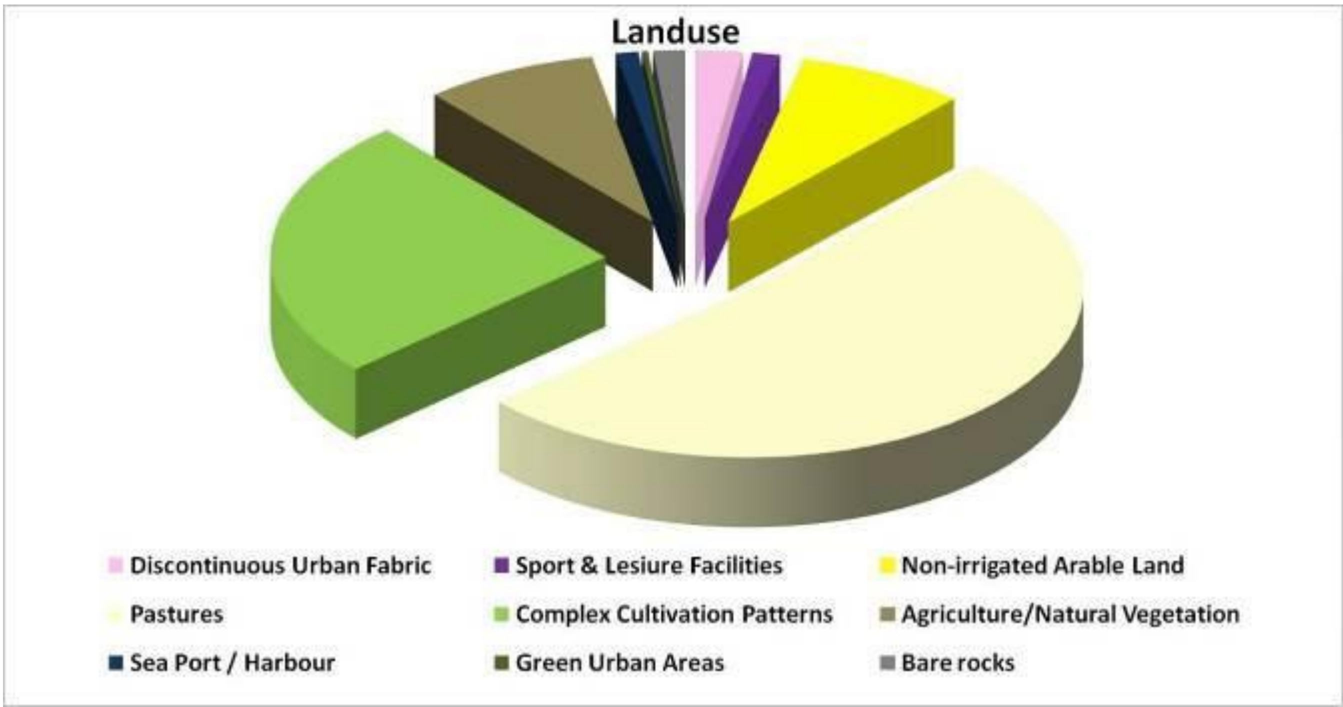


Figure 4.7: Changes in Corine land use within the Killough Harbour Catchment Area from previous survey (Source: CLC 2018)



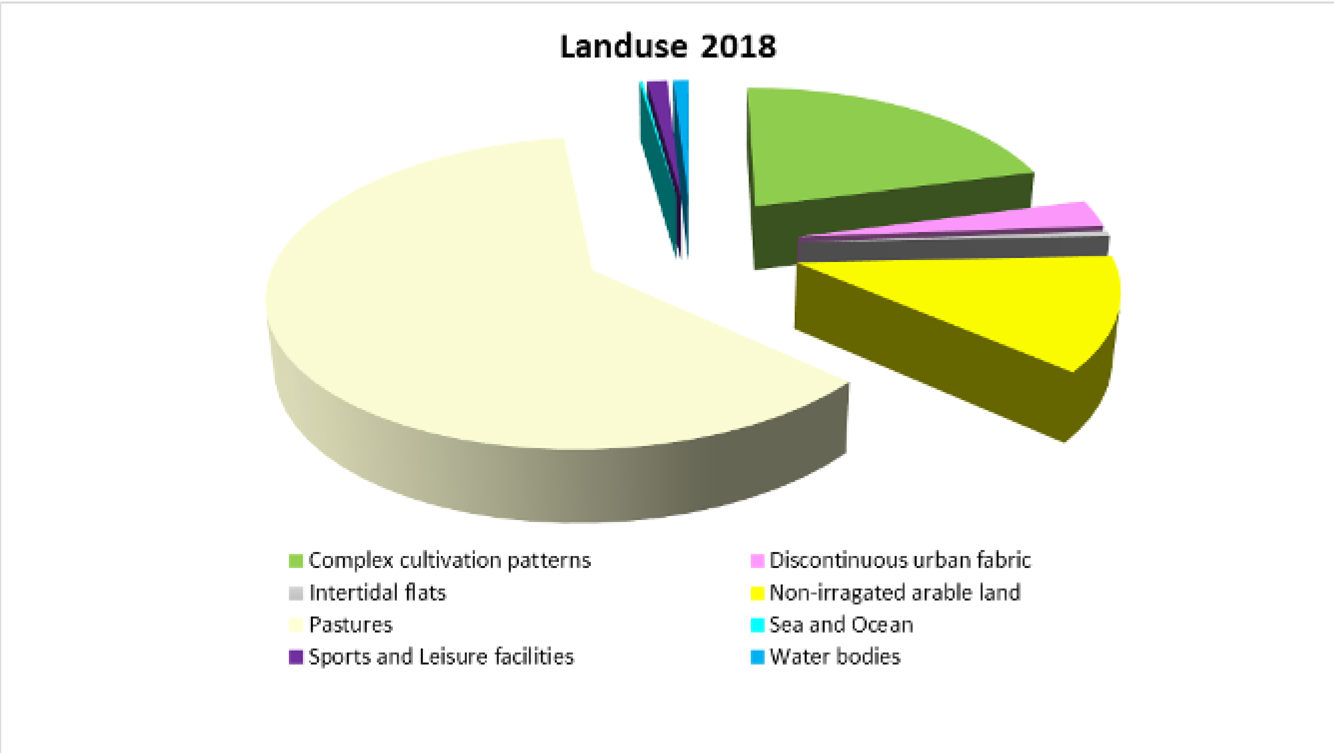


Figure 4.8: Breakdown of land use within the Killough Harbour Catchment Area previous survey and current 2018 Land cover data.

The changes from the Department of Agriculture and Rural Development Farm Census 2010 to 2019 (DAERA-NI, 2019) can be seen in Table 4.5 below. Figures 4.9 to 4.16 show thematic maps for each category in Table 4.5. It should be noted that the values given are for the entire SOA, not just the area within the catchment area.

There were no farms or agricultural activities recorded in Ballymote in 2010. Three farms were recorded in the 2019 census. However, this may be an error as 3 was entered into all columns.

There were 10 extra farms recorded in the 2019 census. The overall area farmed in the catchment decreased by 141 ha. The total crops farmed within the catchment decreased by 224 ha. Total grass and rough grazing areas within the catchment increased by 57 ha. The total number of cattle within the catchment reduced by 1,442. The total number of sheep within the catchment increased by 2,324.

Numbers of pigs within the catchment area increased by 422. The numbers of poultry within the catchment increased by 34,007, almost all of this increase was in Killough SOA.

Table 4.4 shows the potential daily loading of E. coli from livestock (compared to humans and birds). It can be seen that sheep rank the worst, followed by pigs, cows, birds, humans and poultry. Therefore, there will be an increase loading of E. coli from livestock in the catchment.

Table 4.4: 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

Table 4.5: Change in Farm data for all SOAs within the Killough Harbour Catchment Area from 2010 to 2019 (Source: DAERA-NI, 2019).

SOA	No. Farms	Area Farmed (ha)	Total Crops (ha)	Total Grass & Rough Grazing (ha)	Cattle	Sheep	Pigs	Poultry
Strangford	2	-185	-68	-45	-1317	513	-12	20
Ballymote	3	3	3	3	3	3	3	3
Killough	3	47	-58	65	-273	1217	436	33,984
Cathedral	0	52	-7	68	71	10	0	0
Ardglass	2	-58	-94	-34	74	581	-5	0
Total	10	-141	-224	57	-1442	2324	422	34,007

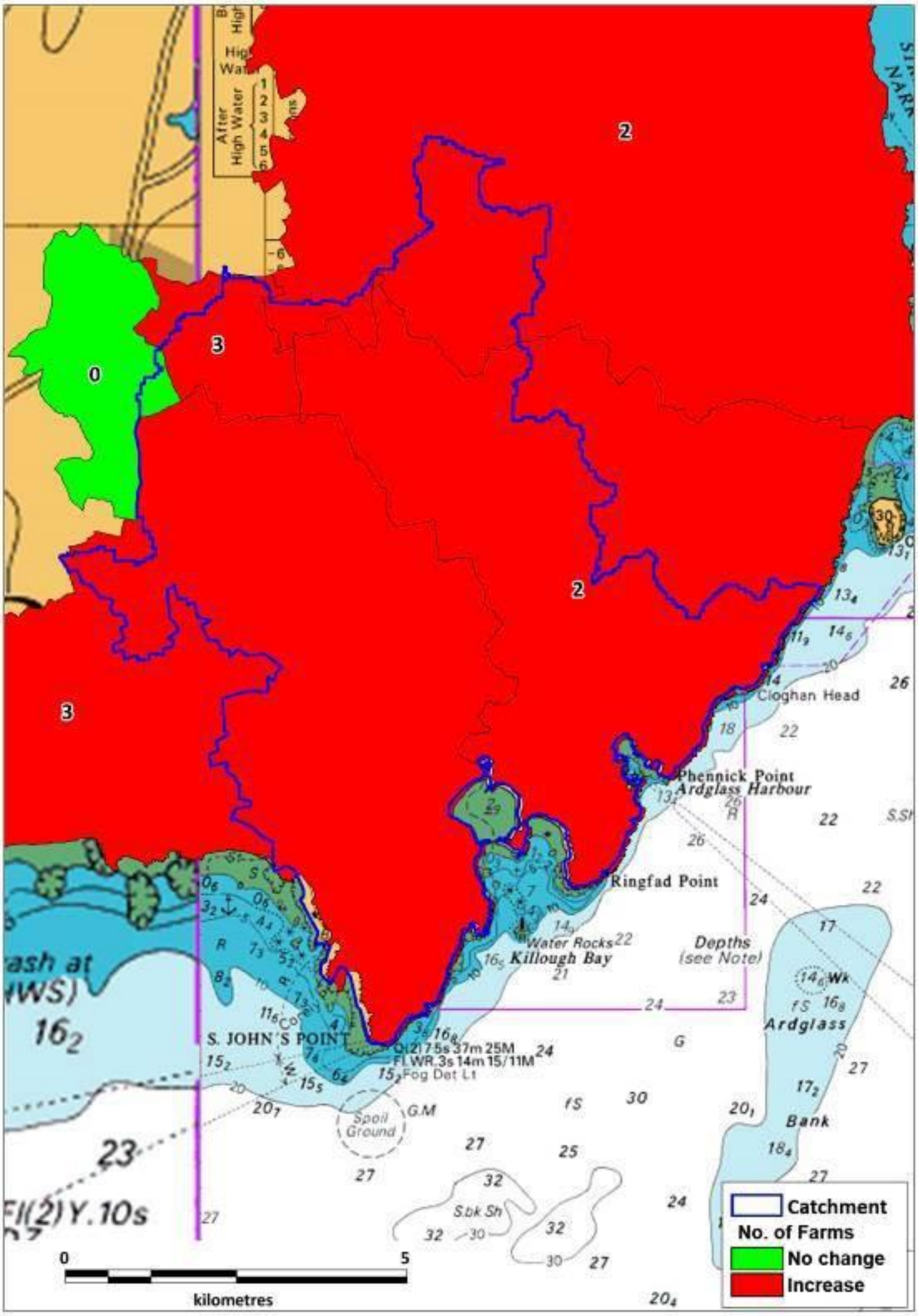


Figure 4.9: Change in number of farms within the Killough Harbour Catchment Area since last sanitary survey (Source: DAERA-NI, 2019).

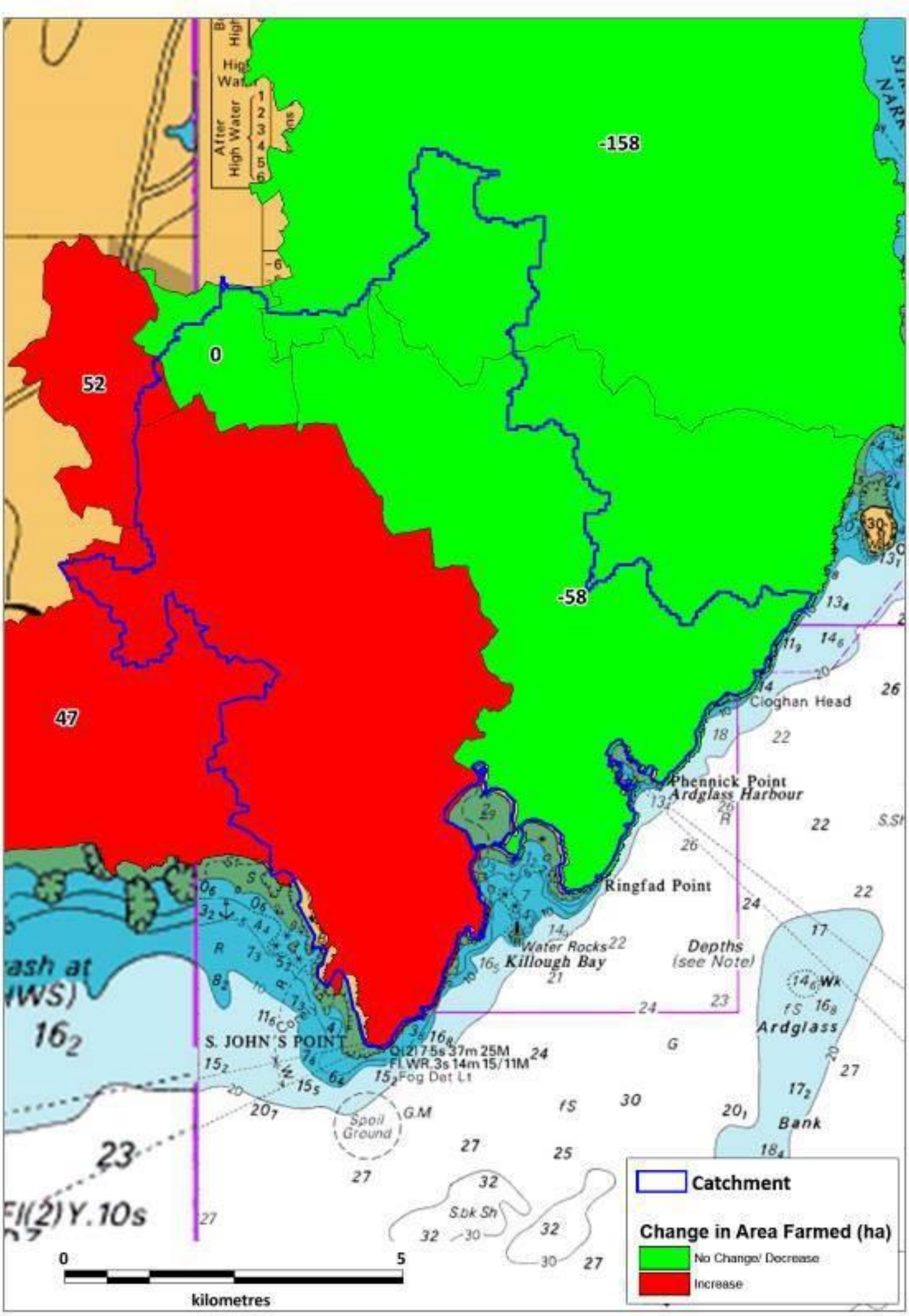


Figure 4.10: Change in Area farmed (ha) within the Killough Harbour Catchment Area since last sanitary survey (Source: DAERA-NI, 2019).

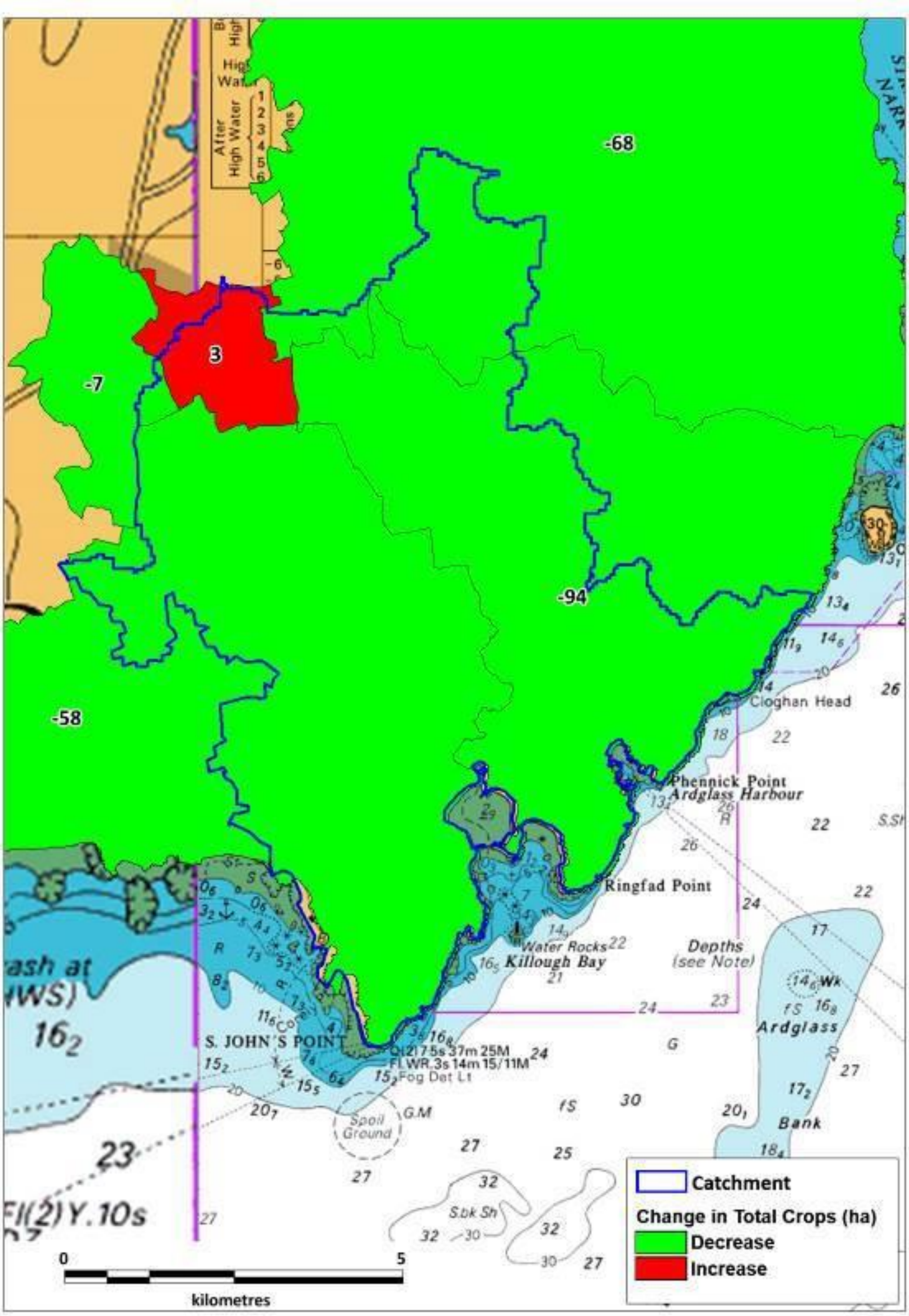


Figure 4.11: Change in total crops within the Killough Harbour Catchment Area since the last sanitary survey (Source: DAERA-NI, 2019).

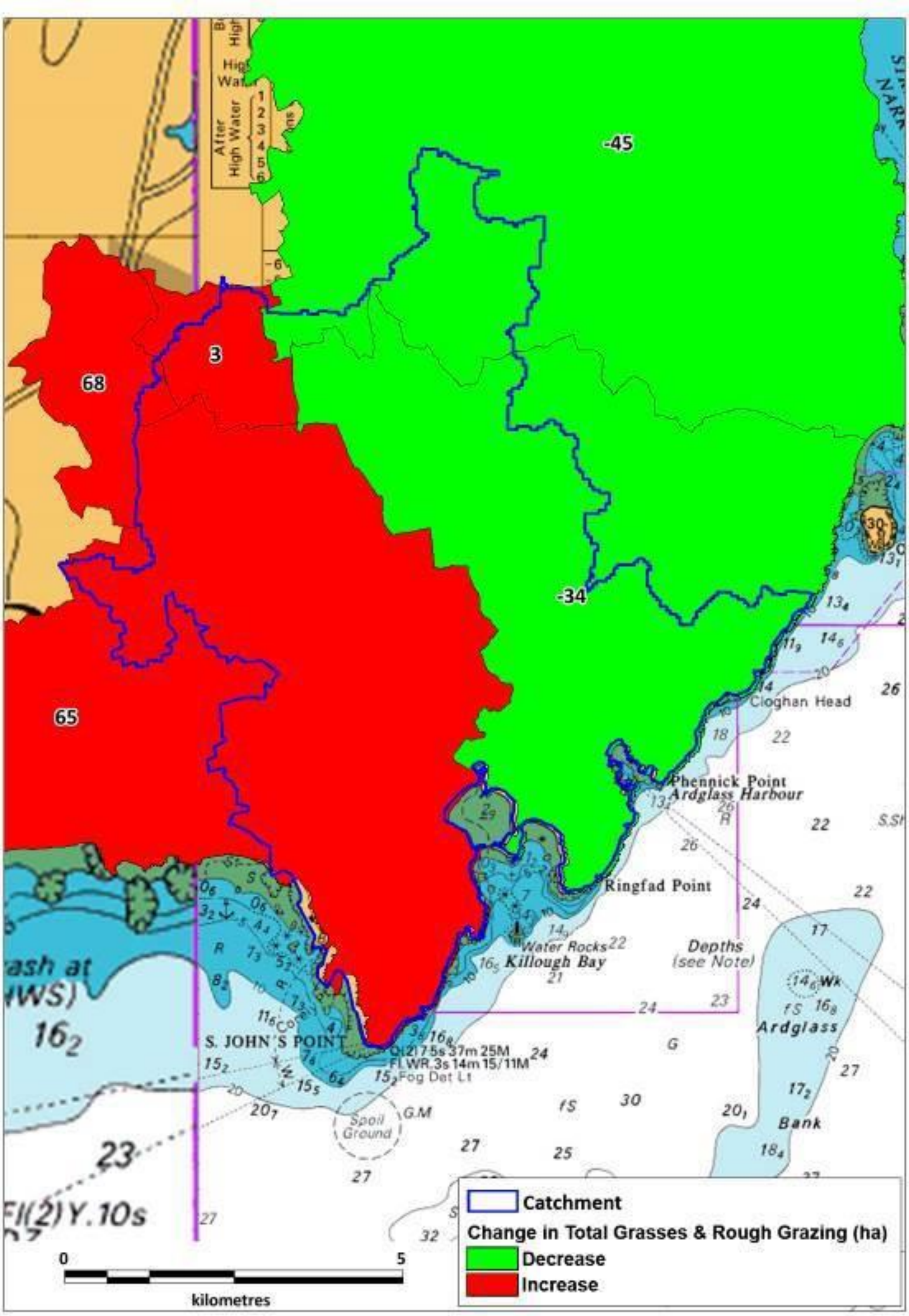


Figure 4.12: Change in total grass and rough grazing within the Killough Harbour Catchment Area since the last sanitary survey (Source: DAERA-NI, 2019).

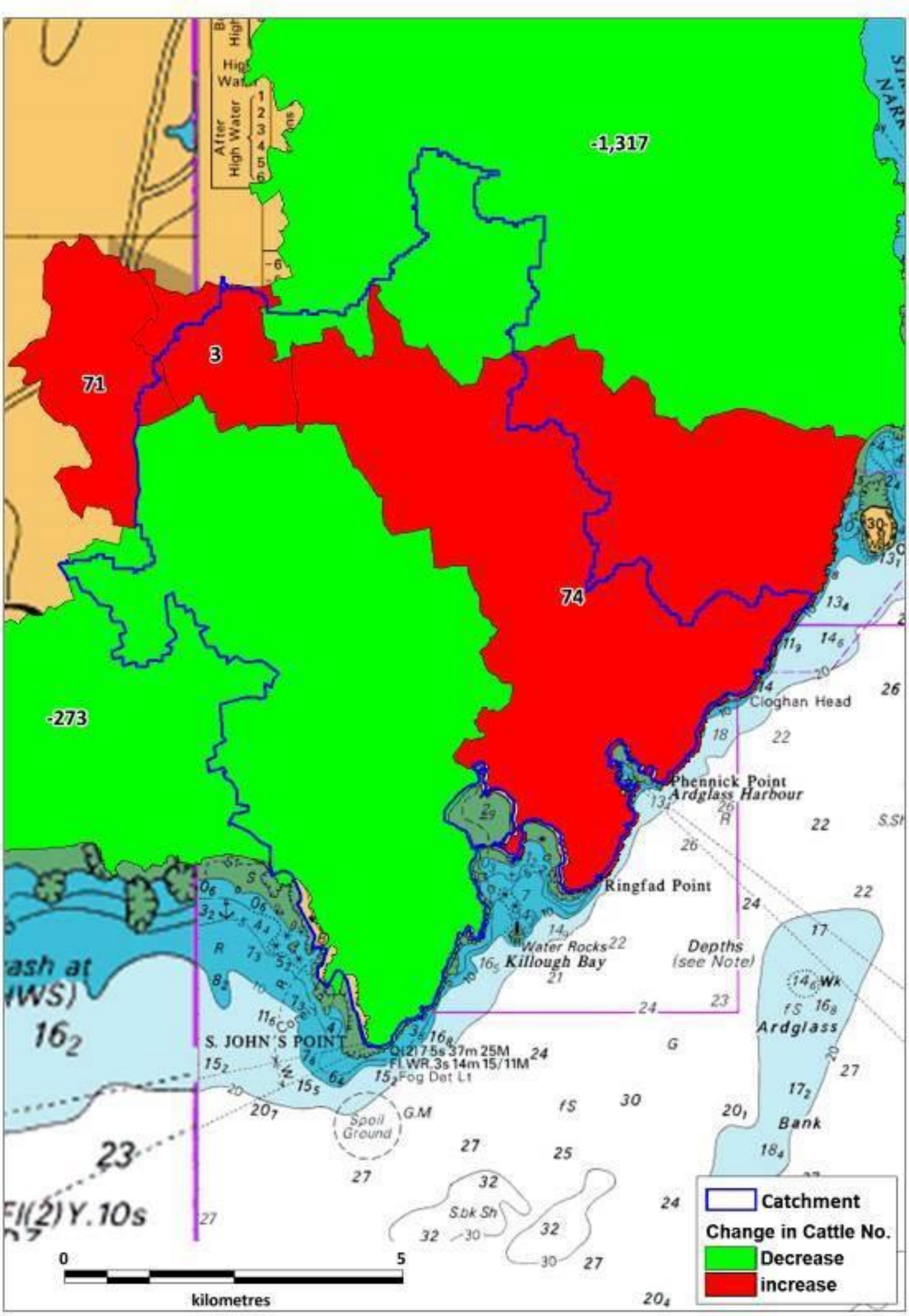


Figure 4.13: Change in cattle No. within the Killough Harbour Catchment Area since the last sanitary survey (Source: DAERA-NI, 2019).

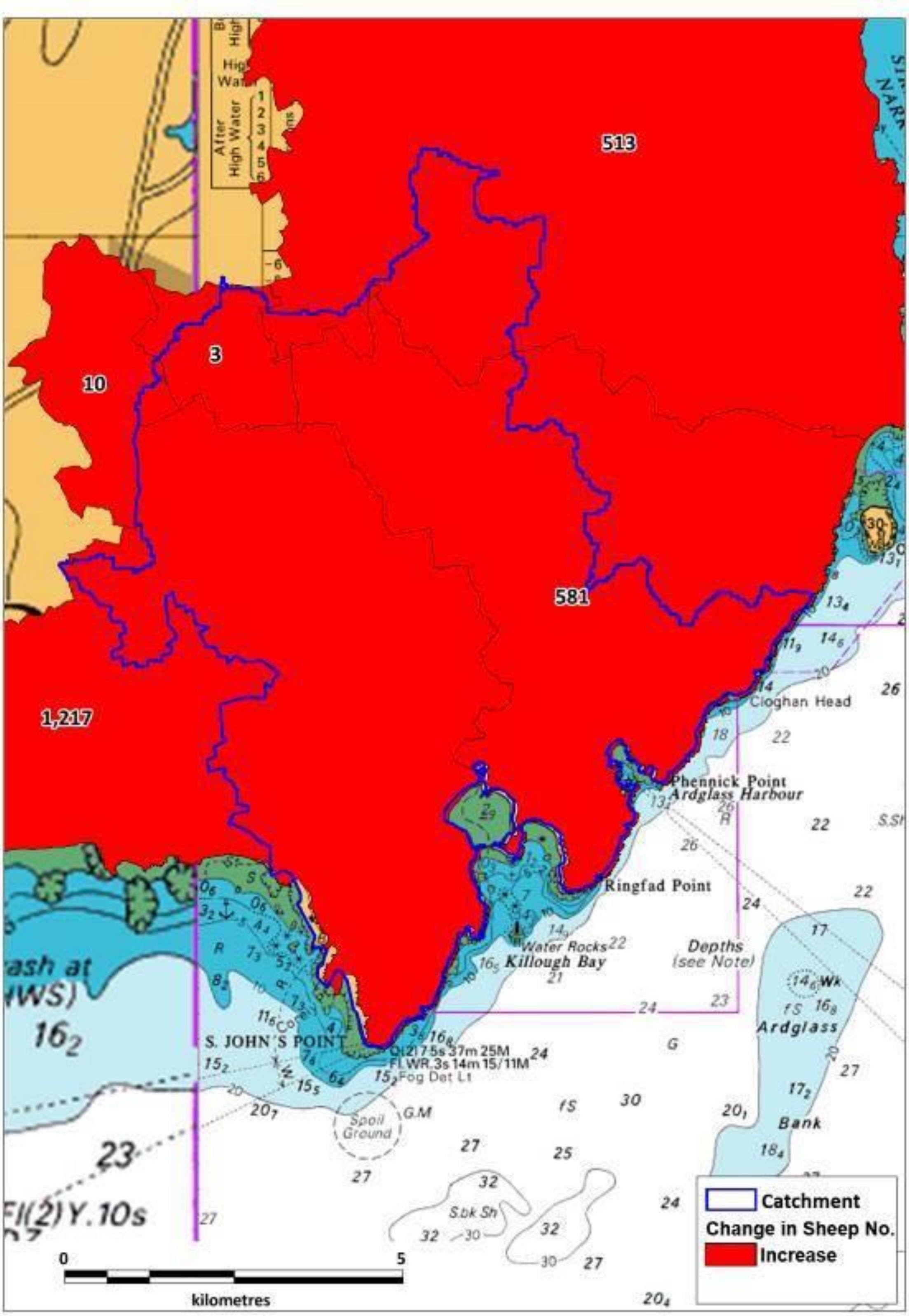


Figure 4.14: Change in sheep No. within the Killough Harbour Catchment Area since the last sanitary survey (Source: DAERA-NI, 2019).

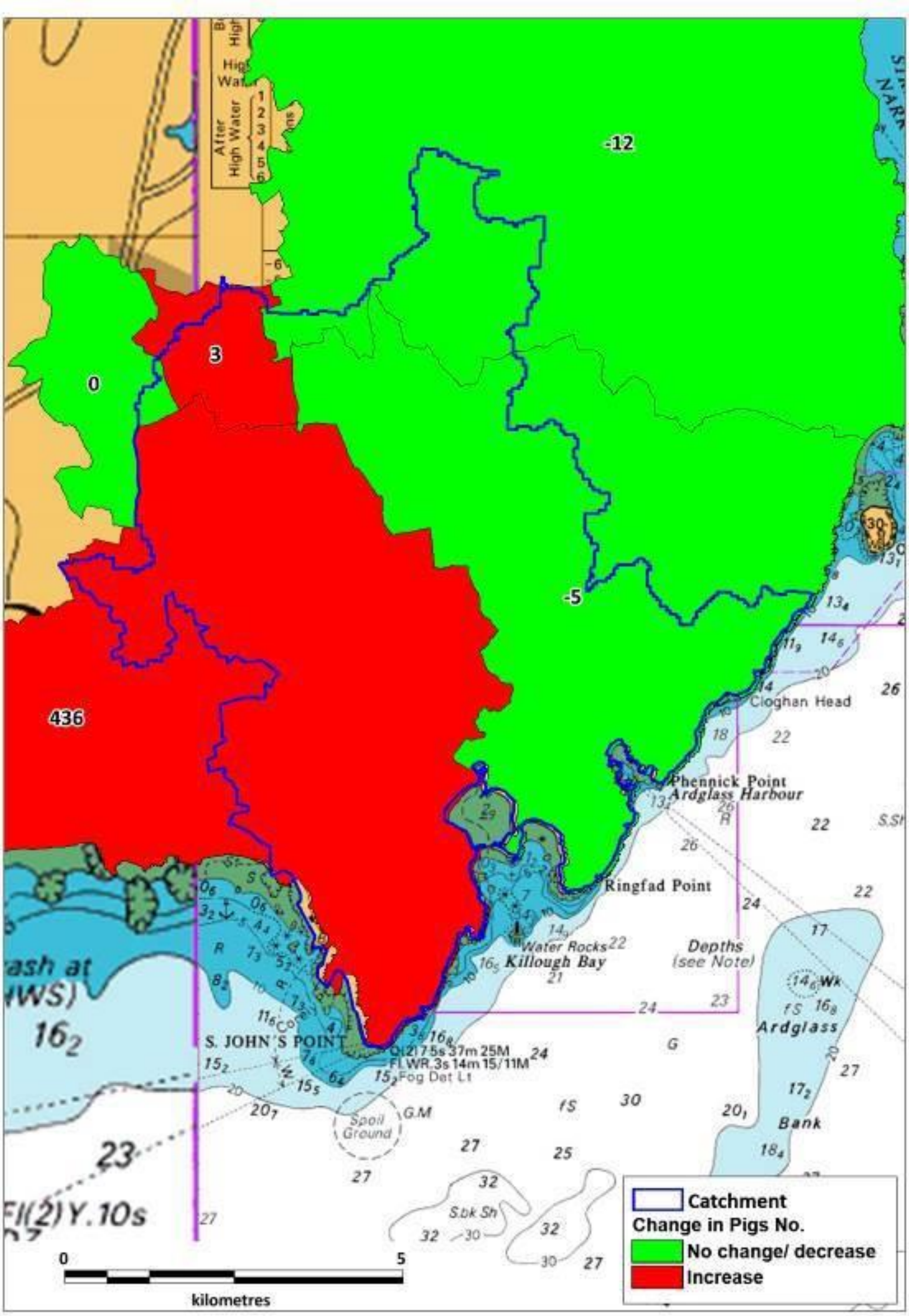


Figure 4.15: Change in Pig No. within the Killough Harbour Catchment Area since the last sanitary survey (Source: DAERA-NI, 2019).

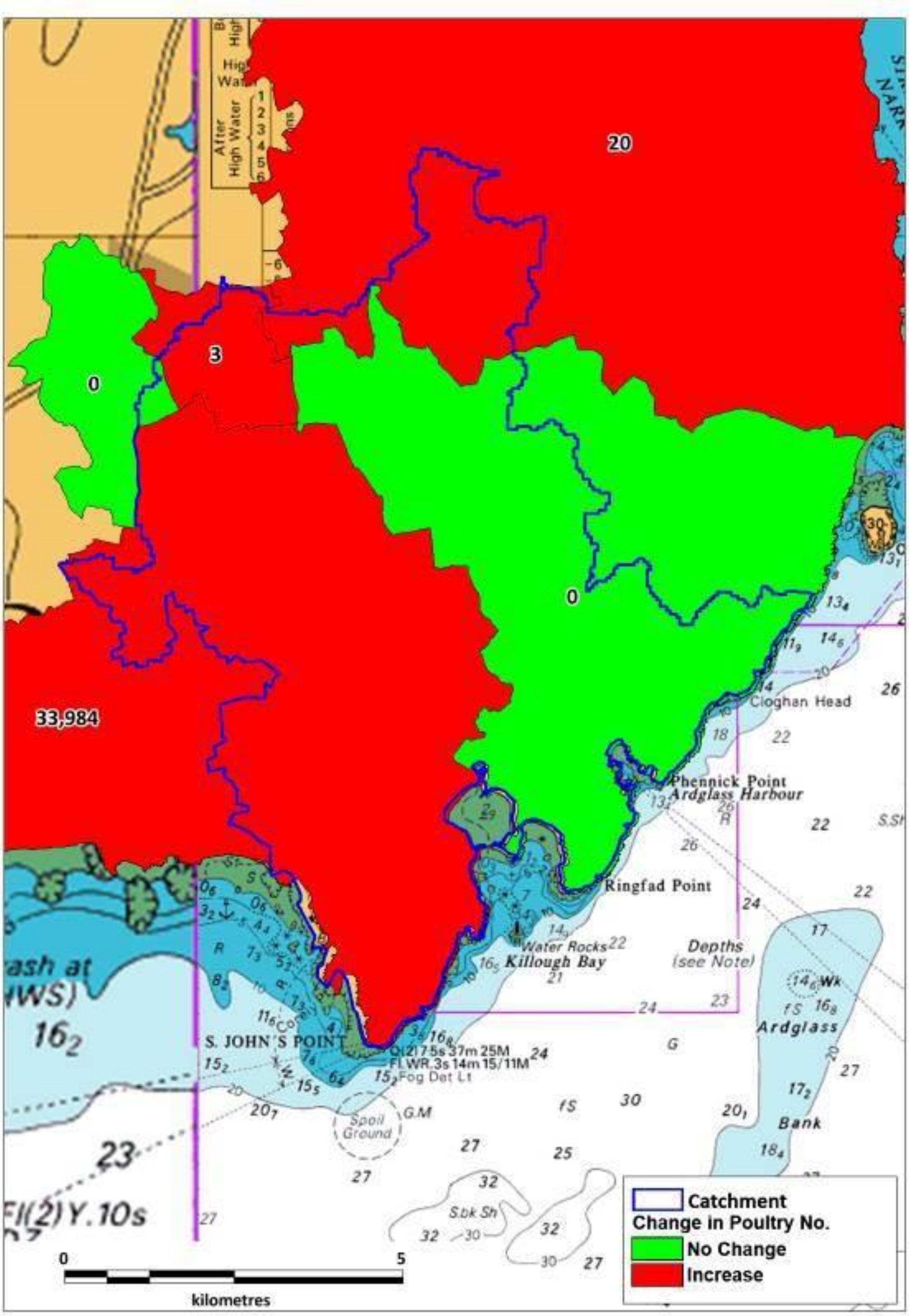


Figure 4.16: Change in Poultry No. within the Killough Harbour Catchment Area since the last sanitary survey (Source: DAERA-NI, 2019).

4.6. Other Pollution Sources

4.6.1. Shipping

There remains only one operational pier in Killough Harbour and there is one slipway beside it. The pier is used for leisure and fishing activities by a small number of local vessels. Given the low numbers of vessels using this harbour, pollution from shipping is insignificant compared with point source discharges from the land.

4.6.2. Birds

Killough Harbour is routinely surveyed by the British Trust for Ornithology (BTO) through the WeBS Project. Table 4.6 shows the yearly results from the wetland bird surveys that were carried out between 2005 and 2019.

Table 4.6: Total number of waterbirds in Killough Harbour between 2005/06 and 2019/09 (Source: Frost et al., 2020).

Site Name	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**	**2012/13**
Killough Harbour	4,164	2,838	-	-	-	-	-	1,386
Site Name	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**Mean**	
Killough Harbour	2,101	983	-	-	-	-	2,294	

Bird populations in the Killough Harbour appear to be decreasing since 2005. However, surveys of the area in frequent with 2012/13 data made up of three visits, 2013/14 had two visits and 2014/15 had only one visit.

4.6.3. Pollution Incidences

There were seven pollution incidents within the Killough catchment area from 2013 to 2017 (DAERA-NI, 2020). Three were from industrial sources, two from farm sources and two were sourced from NI Water Ltd. Six of these incidences were categorised as low level of pollution severity and one as medium.

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, Killough Harbour is not one of these monitored areas and as a result historical water quality data for Killough Harbour are not available.

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.

FSA in NI currently monitors shellfish flesh in Killough Harbour for microbiological contamination on a monthly basis and these results are reviewed annually to determine the classification award. FSA in NI monitors both oysters and mussels from within the classified area shown in Figure 5.1.

Killough Harbour has historically been classified as a B harvesting area. Table 5.1 summarises the classification criteria as outlined in EU legislation. Table 5.2 shows the current and historical (back to 2003) classifications of Killough Harbour.

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 4600 E. Coli/100g with none exceeding 46000 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 EC 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.

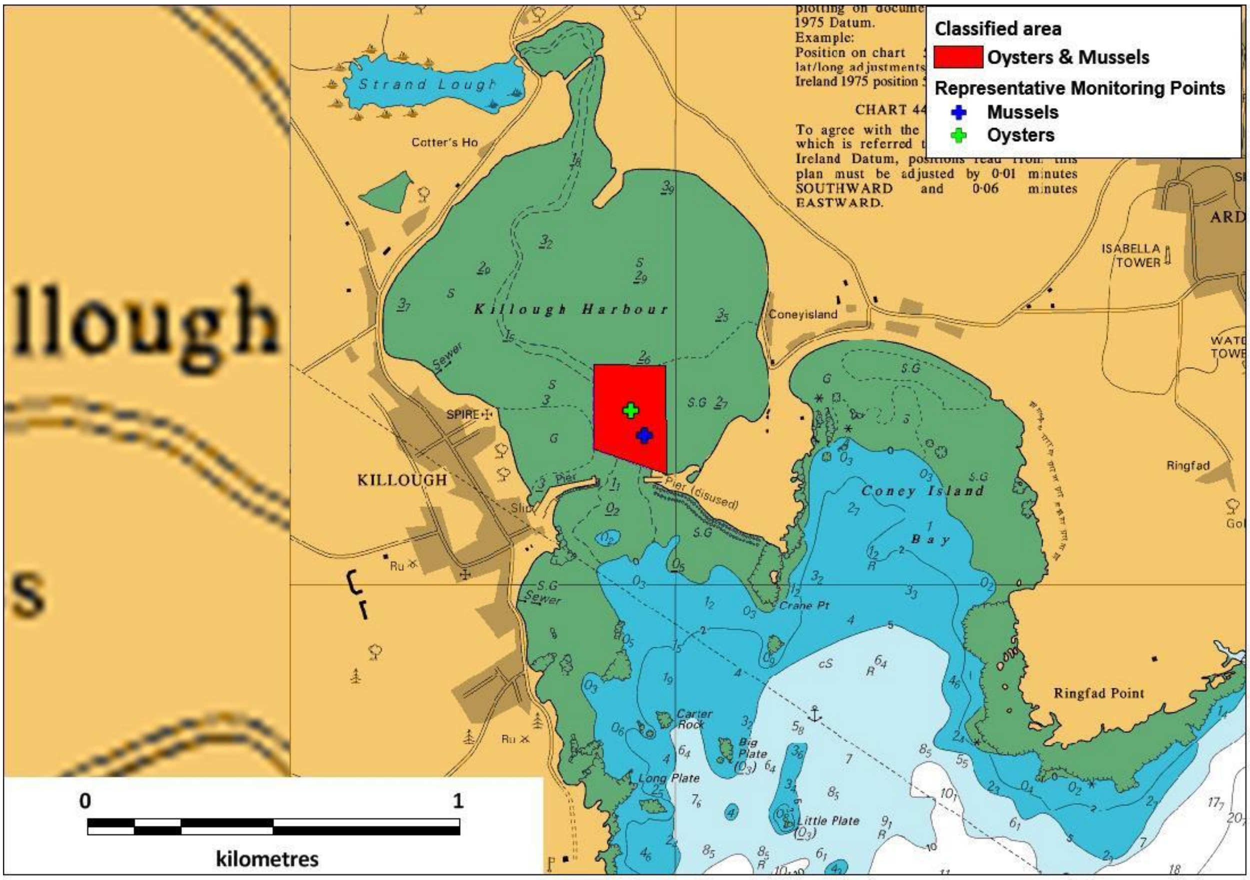


Figure 5.1: Location of classified production area.

Table 5.2: Current and historical classification of shellfish in Killough Harbour (2003 – 2019).

Site	Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Killough Harbour	Oysters	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Killough Harbour	Mussels	N/A	N/A	N/A	B*	B *	B	B	B	B	B	N/A	N/A	N/A	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.

Tables 5.3 and 5.4 list the E. coli results for oysters and mussels from Killough Harbour from 2005 to 2019. Figures 5.2 to 5.3 show these data in graphical form.

As seen in Table 5.2 above, oysters in Killough Harbour have always had a B classification. Since 2005, there have been 93 instances of a **B** result (53.1% of the time), 80 instances of an **A** result (45.7% of the time) and 2 instances of a **C** result for the Killough oyster harvesting bed.

Mussels in Killough Harbour had a provisional B classification in 2006, 2007and a B classification from 2008 to 2012. Mussels were declassified from 2013 to 2015. In 2016 and 2017 mussels were classified as B provisional and as B since 2018 (see Table 5.2 above). Since 2006, there have been 70 instances of a **B** result (60.9% of the time), 36 instances of an **A** result (31.3% of the time) and 8 instances of a **C** result (7% of the time).

Table 5.3: E. coli results from oysters from Killough Harbour from 2005 to 2019 (Source: FSA in NI).

Date	E.coli (MPN/100g)	Classification
25-Jan-05	50	A
22-Feb-05	160	A
19-Apr-05	750	B
03-May-05	2400	B
27-Jun-05	500	B
06-Sep-05	750	B
30-Nov-05	70	A
13-Dec-05	500	B
25-Jan-06	160	A
23-Feb-06	310	B
22-Mar-06	70	A
13-Apr-06	3500	B
13-Jun-06	220	A
18-Jul-06	110	A
23-Aug-06	700	B
20-Sep-06	3500	B
25-Oct-06	70	A

Date	E.coli (MPN/100g)	Classification
28-Nov-06	40	A
10-Jan-07	1700	B
07-Feb-07	1300	B
07-Mar-07	430	B
17-Apr-07	110	A
23-May-07	110	A
20-Jun-07	1300	B
18-Jul-07	500	B
22-Aug-07	2800	B
19-Sep-07	200	A
16-Oct-07	200	A
28-Nov-07	19	A
11-Dec-07	750	B
22-Jan-08	500	B
06-Feb-08	200	A
05-Mar-08	70	A
08-Apr-08	400	B
07-May-08	200	A
18-Jun-08	500	B
07-Jul-08	750	B
19-Aug-08	4300	B
17-Sep-08	3500	B
07-Oct-08	310	B
05-Nov-08	400	B
03-Dec-08	500	B
07-Jan-09	70	A
04-Feb-09	220	A
10-Mar-09	70	A
08-Apr-09	110	A
06-May-09	110	A
03-Jun-09	700	B
07-Jul-09	110	A
04-Aug-09	350	B
24-Sep-09	220	A
07-Oct-09	310	B
04-Nov-09	1400	B
02-Dec-09	40	A
12-Jan-10	80	A

Date	E.coli (MPN/100g)	Classification
10-Feb-10	50	A
09-Mar-10	20	A
14-Apr-10	19	A
12-May-10	50	A
09-Jun-10	50	A
07-Jul-10	80	A
24-Aug-10	790	B
15-Sep-10	700	B
14-Oct-10	80	A
11-Nov-10	490	B
09-Dec-10	80	A
11-Jan-11	140	A
02-Feb-11	50	A
08-Mar-11	1100	B
06-Apr-11	170	A
10-May-11	490	B
08-Jun-11	170	A
05-Jul-11	50	A
15-Aug-11	170	A
12-Sep-11	490	B
04-Oct-11	460	B
08-Nov-11	110	A
05-Dec-11	800	B
17-Jan-12	790	B
14-Feb-12	210	A
13-Mar-12	490	B
16-Apr-12	20	A
14-May-12	130	A
12-Jun-12	490	B
09-Jul-12	330	B
13-Aug-12	3500	B
10-Sep-12	330	B
09-Oct-12	490	B
06-Nov-12	20	A
03-Dec-12	170	B
14-Jan-13	20	A
12-Feb-13	50	A
11-Mar-13	20	A

Date	E.coli (MPN/100g)	Classification
08-Apr-13	20	A
13-May-13	50	A
11-Jun-13	230	A
09-Jul-13	80	A
06-Aug-13	110	A
03-Sep-13	330	B
30-Sep-13	330	B
06-Nov-13	330	B
03-Dec-13	3300	B
06-Jan-14	110	A
04-Feb-14	80	A
04-Mar-14	220	A
01-Apr-14	130	A
06-May-14	490	B
03-Jun-14	230	A
01-Jul-14	78	A
29-Jul-14	1300	B
26-Aug-14	1300	B
23-Sep-14	1700	B
28-Oct-14	110	A
24-Nov-14	130	A
30-Dec-14	3300	B
27-Jan-15	45	A
03-Mar-15	170	A
31-Mar-15	170	A
28-Apr-15	18	A
26-May-15	490	B
23-Jun-15	690	B
21-Jul-15	930	B
25-Aug-15	4900	C
22-Sep-15	330	B
19-Oct-15	220	A
17-Nov-15	330	B
16-Nov-15	490	B
18-Jan-16	1100	B
15-Feb-16	130	A
14-Mar-16	110	A
11-Apr-16	45	A

Date	E.coli (MPN/100g)	Classification
11-May-16	490	B
13-Jun-16	1300	B
14-Jul-16	450	B
08-Aug-16	780	B
27-Sep-16	780	B
10-Oct-16	330	B
07-Nov-16	45	A
05-Dec-16	690	B
03-Jan-17	1100	B
06-Feb-17	270	B
06-Mar-17	930	B
03-Apr-17	78	A
09-May-17	78	A
14-Jun-17	170	A
11-Jul-17	690	B
14-Aug-17	4900	C
11-Sep-17	450	B
10-Oct-17	330	B
13-Nov-17	490	B
11-Dec-17	330	B
16-Jan-18	170	A
20-Feb-18	110	A
21-Mar-18	330	B
23-Apr-18	330	B
21-May-18	1100	B
18-Jun-18	330	B
16-Jul-18	1300	B
20-Aug-18	1300	B
17-Sep-18	220	A
15-Oct-18	130	A
19-Nov-18	490	B
17-Dec-18	1700	B
28-Jan-19	78	A
25-Feb-19	330	B
25-Mar-19	78	A
24-Apr-16	1100	B
28-May-16	490	B
24-Jun-19	330	B

Date	E.coli (MPN/100g)	Classification
22-Jul-19	3300	B
19-Aug-19	1300	B
23-Sep-19	780	B
21-Oct-19	330	B
18-Nov-19	40	A
17-Dec-19	690	B

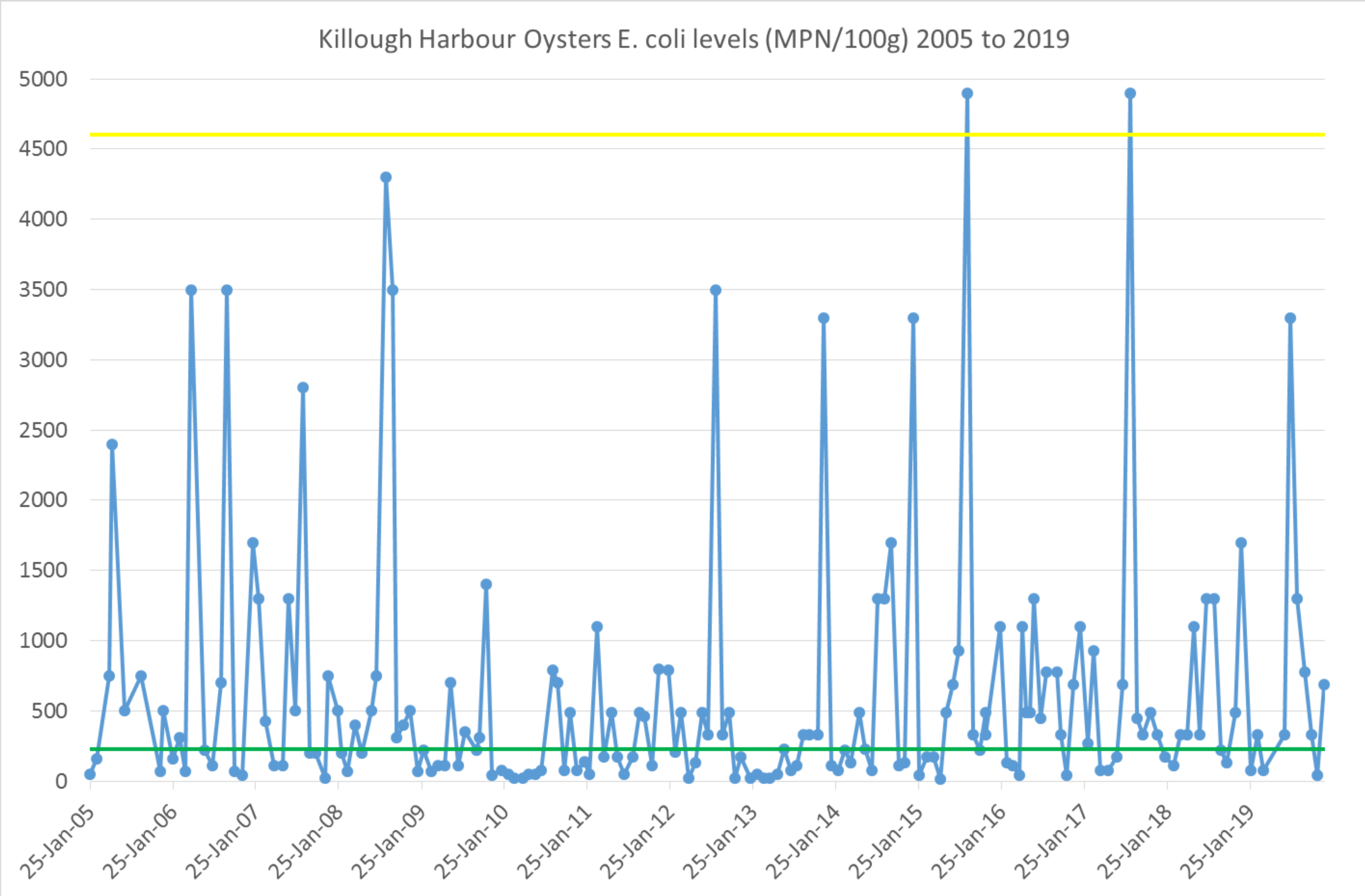


Figure 5.2: **E. coli results from oysters in Killough Harbour from 2005- 2019 (Source: FSA in NI).**

Table 5.4: E. coli results from mussels from Killough Harbour from 2005 to 2019 (Source: FSA in NI).

Date	E.coli (MPN/100g)	Classification
18-Jul-06	220	A
20-Sep-06	3500	B
25-Oct-06	110	A
28-Nov-06	20	A
10-Jan-07	1300	B
07-Feb-07	20	A
07-Mar-07	430	B
03-Apr-07	50	A
06-Jun-07	9100	C
04-Jul-07	40	A
14-Aug-07	35000	C
22-Aug-07	1300	B
10-Sep-07	500	B
03-Oct-07	310	B
14-Nov-07	110	A
22-Jan-08	750	B
19-Feb-08	500	B
19-Mar-08	40	A
22-Apr-08	310	B
09-May-08	310	B
20-May-08	220	A
24-Jun-08	17000	C
07-Jul-08	430	B
06-Aug-08	1300	B
23-Sep-08	200	A
21-Oct-08	500	B
18-Nov-08	220	A
16-Dec-08	750	B
28-Jan-09	1100	B
18-Feb-09	200	A
25-Mar-09	20	A
21-Apr-09	310	B
19-May-09	1300	B
23-Jun-09	20	A
27-Jul-09	3500	B

Date	E.coli (MPN/100g)	Classification
18-Aug-09	2200	B
24-Sep-09	750	B
20-Oct-09	3500	B
17-Nov-09	70	A
17-Dec-09	500	B
26-Jan-10	50	A
24-Feb-10	800	B
24-Mar-10	330	B
27-Apr-10	24000	C
25-May-10	330	B
30-Jun-10	1700	B
27-Jul-10	800	B
05-Aug-10	460	B
27-Sep-10	1300	B
27-Oct-10	230	B
23-Nov-10	20	A
14-Dec-10	50	A
31-Jan-11	170	A
22-Feb-11	700	B
24-Mar-11	790	B
20-Apr-11	230	A
24-May-11	330	B
22-Jun-11	90	A
25-Jul-11	70	A
30-Aug-11	330	B
28-Sep-11	1700	B
18-Oct-11	490	B
22-Nov-11	220	A
19-Dec-11	130	A
30-Jan-12	1300	B
21-Feb-12	490	B
26-Mar-12	130	A
30-Apr-12	20	A
29-May-12	80	A
26-Jun-12	1400	B
24-Jul-12	1700	B
28-Aug-12	54000	C*
24-Sep-12	330	B
02-Oct-12	790	B

Date	E.coli (MPN/100g)	Classification
13-Jun-16	2200	B
14-Jul-16	490	B
08-Aug-16	780	B
27-Sep-16	330	B
10-Oct-16	490	B
07-Nov-16	40	A
05-Dec-16	2300	B
03-Jan-17	450	B
06-Feb-17	1700	B
06-Mar-17	45	A
03-Apr-17	780	B
09-May-17	18	A
14-Jun-17	330	B
11-Jul-17	1300	B
14-Aug-17	1400	B
11-Sep-17	4900	C
10-Oct-17	490	B
13-Nov-17	490	B
11-Dec-17	490	B
16-Jan-18	1100	B
20-Feb-18	170	A
21-Mar-18	170	A
23-Apr-18	170	A
21-May-18	330	B
18-Jun-18	330	B
16-Jul-18	780	B
20-Aug-18	1300	B
24-Sep-18	490	B
15-Oct-18	930	B
19-Nov-18	450	B
17-Dec-18	7900	C
28-Jan-19	140	A
25-Feb-19	45	A
25-Mar-19	330	B
24-Apr-19	35000	C
29-Apr-19	130	A
28-May-19	490	B
24-Jun-19	330	B
21-Oct-19	450	B

Date	E.coli (MPN/100g)	Classification
18-Nov-19	330	B
17-Dec-19	2700	B

* Prohibited. Harvesting not permitted.

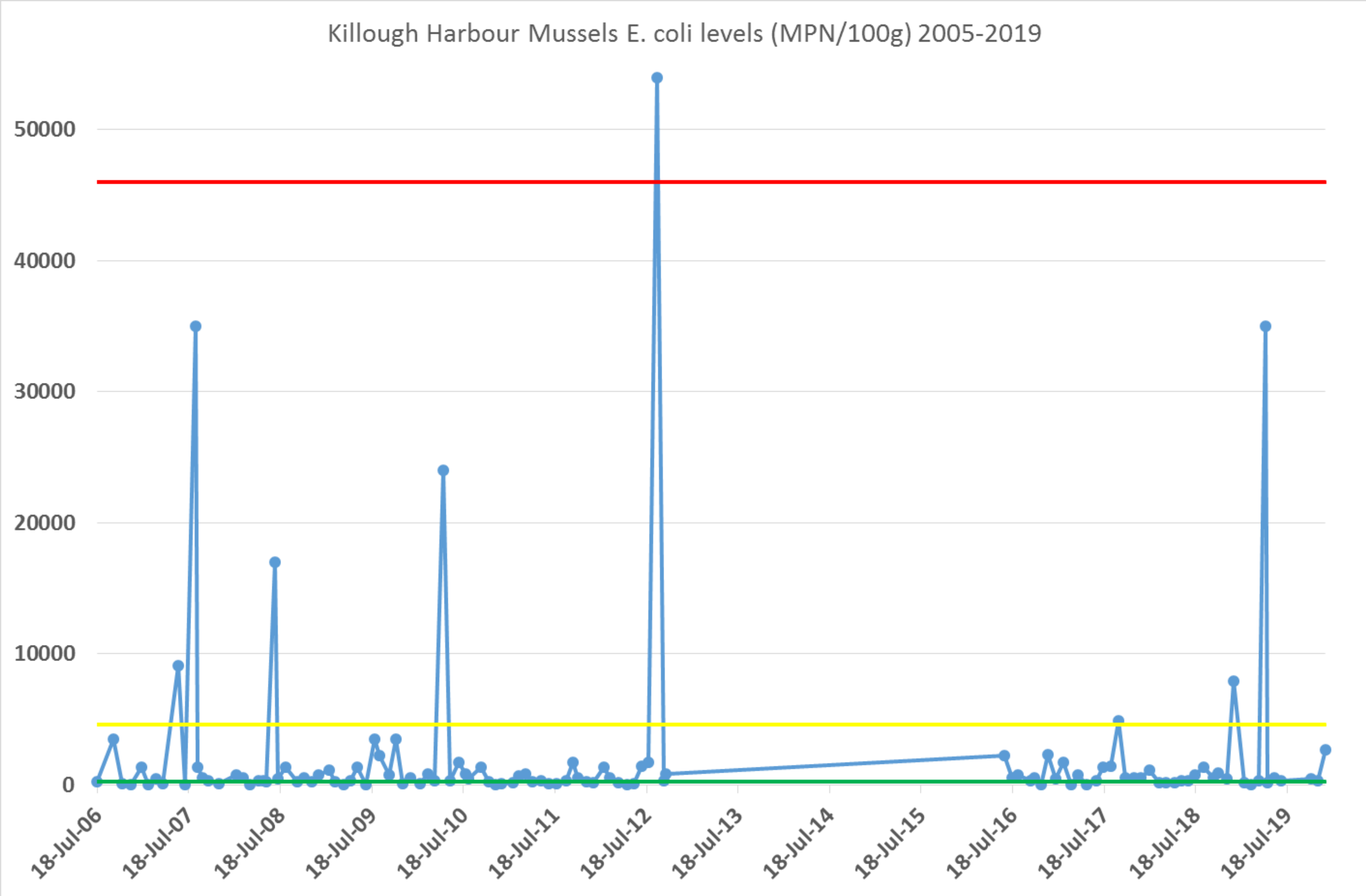


Figure 5.3: ***E. coli*** **levels from Mussels in Killough Harbour from 2005 to Feb 2019 (Source: FSA in NI).**

Table 5.5 shows the summary statistics for the E. coli historical data (2005 to 2019) from the Killough Harbour shellfish bed. The geometric mean of E. coli levels was approximately 1.6 times higher for mussels than for oysters (440.9 MPN/100g compared to 274.1 MPN/100g).

Table 5.5: Summary statistics of historical E. coli data monitored from shellfish beds in Killough Harbour.

Site	Species	Date of 1st Sample	Date last Sample	Minimum E. coli (MPN/100g)	Maximum E. coli (MPN/100g)	Median E. coli (MPN/100g)	Geometric Mean E. coli (MPN/100g)
Killough Harbour	**Oysters**	25/01/2005	17/12/2019	<18	4900	330	274.1
Killough Harbour	**Mussels**	18/07/2006	17/12/2019	<18	54000	450	440.9

Table 5.6 shows the variations of the annual geometric means of E. coli for the shellfish beds monitored in Killough Harbour.

Figure 5.4 shows the trend in geometric mean from 2005 to 2019 for both species monitored in Killough Harbour. The geometric mean for oysters was highest in 2008 (491 MPN/100g) and 2012 for mussels (582 MPN/100g) the year the production area was declassified for mussels. Oyster values were lowest in 2010 (95 MPN/100g) and mussel values were lowest in 2006 (203 MPN/100g).

Table 5.6: Variation of annual geometric means of E. coli from shellfish beds monitored in Killough Harbour.

Site	Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Killough Harbour	Oysters	342	269	389	491	182	95	227	252	114	315	294	322	411	420	386
Killough Harbour	Mussels	N/A	203	451	467	414	405	290	582	N/A	N/A	N/A	535	485	561	477

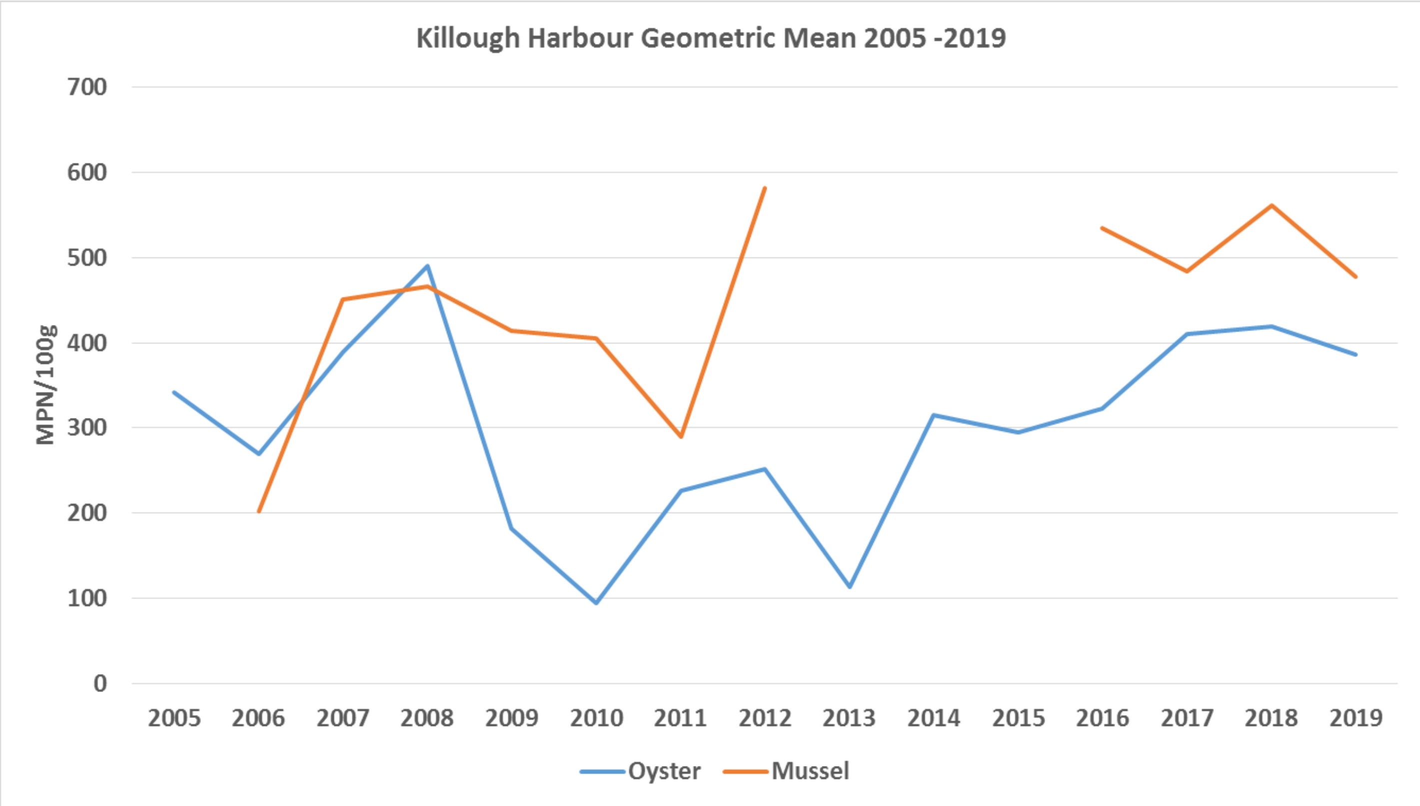


Figure 5.4: Trend in geometric mean of E. coli levels from 2005 to 2019 for oysters and mussels in Killough Harbour.

In order to identify any significant differences in E. coli levels annually from 2005 to 2019, a one-way analysis of variance (ANOVA) was performed on all oyster and mussel E. coli results from shellfish flesh in Killough Harbour. Only the years with ≥8 results per species were used in this analysis, therefore mussels in 2006 and 2016 were not included in this analysis. The ANOVA analysis found no significant difference between years for the E. coli levels in the mussels or oysters (see Appendix 1).

As seen in Section 4.2 Tourism, it was found that summer had significantly higher flesh E. coli levels for oysters and mussels. Summer oyster E. coli levels were higher than all other seasons and summer mussel E. coli levels were higher than spring and autumn. The seasonal E. coli levels observed between the 2 species were not significantly different.

6. Discussion/Conclusion

The monthly and seasonal wind patterns for the Killough catchment area have remained constant over time. The eastern coast of Northern Ireland remains the windiest area. November to February experienced the strongest wind speeds, while July and August experienced the weakest winds. The rainfall patterns for the catchment area have also remained the same with February to May being the driest period, with rainfall increasing through summer to the wettest period between October and January. However, the 30 year monthly average rainfall from 1981-2010 was dryer that from 1971-2000 for every month. This suggests that the area is becoming dryer.

The population in the Killough catchment has increased overall by 1.5%. However, two SOAs which account for 80% of the catchment had varying changes. The population of Ardglass increased by 1.2%, while Killough population decreased by 16.4%. This equates to a decrease of 8.2% over 80% of the catchment. As only a small proportion of the other SOAs are present within the catchment only a fraction of their populations will be present in the catchment. Therefore, it is likely that the overall population of the catchment may have decreased. However, it is difficult to accurately calculate this as the boundaries for the SOAs for which population statistics are available do not match up with the catchment boundary.

Tourism increased 46.5% in Northern Ireland between 2009 and 2018. Due to a reform of the Local government districts in 2011, tourism statistics from the previous sanitary survey cannot be compared to the current statistics. The Killough catchment is now in the Newry, Mourne & Down district which accounts for approximately 9% of the visitors who visited Northern Ireland in 2018. The three main tourist attractions in the district are Quoile Countryside Centre, The Saint Patrick Centre and National Trust Castle Ward. None of these attractions are located within the Killough catchment. Therefore, only a small number of these tourists are likely to visit the Killough catchment area.

There has been little change to the sewage infrastructure in the catchment. Killough WWTW P.E.

has increased slightly by 4.6% since the 2012 survey, the design P.E for the plant was not available. The two other small WWTW are within their designed P.E. The Corine land cover for the area has changed little with agriculture still being the dominated land use (94.2% up marginally from 93.5% in 2012). Bird numbers appear to be dropping; however, the harbour is surveyed infrequently. There have been seven pollution incidences in the catchment between 2013 and 2017. Six of these were categorised as low level pollution severity and one as medium.

There has been a reduction in the area of land used for crops (224ha) and there are 1,442 less cattle being farmed in the catchment. However, both sheep (+2,324) and poultry (+34007) numbers have increased. Most of this increase has been in the Killough SOA. Therefore, there is an increased E. coli loading from livestock in the catchment since the original sanitary survey

There has been no change to the B classification in Killough Harbour which has remained from 2003 to present. Mussels have on average higher E. coli levels in the bay with the geomean for mussels from 2005-2019 being 1.6 times higher than for that of oysters. Analysis of the E. coli levels in shellfish flesh between 2005 and 2019 found no significant difference between years for mussels or oysters.

However, analysis of seasonal E. coli results for shellfish in the bay showed statistically higher levels in summer. The increased population during the summer from tourism could be a factor in this. However, other factors such as increased rainfall in mid to late summer may cause animal waste which have built up on the land during the dryer period of February to May to be flushed into the system.

The most significant change with regards to the sanitary load on the production area is the increase in sheep and poultry numbers. However, this is somewhat curtailed by the reduction of cattle numbers. There has been no other significant change to the Killough Harbour shellfish production or the greater catchment. Also, there has been no significant increase in the E. coli levels recorded in the shellfish in the production area. Therefore, the increase in livestock loading does not appear to have affected the E. coli levels in the production area. For these reasons a new shoreline survey is not required. The RMP locations (outlined below) or monthly sampling frequency does not need to be adjusted and no alterations to the production area boundary are required.

RMP for oysters -

54°.25421 N	5°.63521 W

RMP for mussels -

54°.25361 N	5°.63465 W

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Appendix 1

Statistical Analysis

E. coli levels in oysters V year (2005-2019)

Anova: Single Factor Summary

Groups	Count	Sum	Average	Variance
2005	8	20.29700189	2.537125	0.322987
2006	10	24.33870431	2.43387	0.466922
2007	12	31.11459502	2.592883	0.382732
2008	12	32.30961427	2.692468	0.246487
2009	12	27.1702777	2.26419	0.197249
2010	12	23.81487589	1.984573	0.294063
2011	12	28.29995452	2.35833	0.19227
2012	12	28.87425751	2.406188	0.38878
2013	12	24.77734772	2.064779	0.432584
2014	13	32.50829084	2.500638	0.318728
2015	12	29.67242733	2.472702	0.379638
2016	12	30.1340407	2.51117	0.264437
2017	12	31.38663336	2.615553	0.2498
2018	12	31.49159436	2.6243	0.171195
2019	12	31.06544273	2.588787	0.312171

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	6.928441	14	0.494889	1.618824	0.079125	1.754042
Within Groups	48.9134	160	0.305709			
Total	55.84184	174				

Null hypotheses = is no differences between years

If F > Fcrit, then reject null hypotheses i.e. there is a difference between years

If ANOVA shows there is a difference, it won't say what causes it, to find that out need to do a t-test.

No difference in oyster E. coli levels between years.

E. coli levels in Mussels V year (2007-2012, 2017-2019)

Anova: Single Factor Summary

Groups	Count	Sum	Average	Variance
2007	11	29.2467	2.658791	0.985159
2008	13	34.72047	2.670805	0.353933
2009	12	31.4542	2.621183	0.618214
2010	12	31.3368	2.6114	0.66479
2011	12	29.57391	2.464492	0.164387
2012	10	27.68088	2.768088	0.85256
2017	12	32.26312	2.688593	0.43631
2018	12	32.99925	2.749937	0.229436
2019	10	26.8096	2.68096	0.638945

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.731774	8	0.091472	0.171171	0.994217	2.03737
Within Groups	50.76682	95	0.534388			
Total	51.49859	103				

Null hypotheses = is no differences between years

If F > Fcrit, then reject null hypotheses i.e. there is a difference between years

If ANOVA shows there is a difference, it won't say what causes it, to find that out need to do a t-test.

No difference in mussel E. coli levels between years.

E. coli levels in oysters V Season (2005-2019)

F-Test Two-Sample for Variances

Factor	Spring	Summer
Mean	2.234528	2.702634
Variance	0.340554	0.291144
Observations	44	44
df	43	43
F	1.169709	
P(F<=f) one-tail	0.304774	
F Critical one-tail	1.660744	
Result	Equal variance	

t-Test: Two-Sample Assuming Equal Variances

Factor	Spring	Summer
Mean	2.234528	2.702634
Variance	0.340554	0.291144
Observations	44	44
Pooled Variance	0.315849	
Hypothesized Mean Difference	0	
df	86	
t Stat	-3.90675	
P(T<=t) one-tail	9.29E-05	
t Critical one-tail	1.662765	
P(T<=t) two-tail	0.000186	
t Critical two-tail	1.987934	

Result: -1.9879 < -3.90675 < 1.9879

Reject – the is a difference

F-Test Two-Sample for Variances

Factor	Spring	Autumn
Mean	2.234528	2.4398
Variance	0.340554	0.249328
Observations	44	45
df	43	44
F	1.365888	
P(F<=f) one-tail	0.153388	
F Critical one-tail	1.654447	
Result	Equal variance	

t-Test: Two-Sample Assuming Equal Variances

Factor	Spring	Autumn
Mean	2.234528	2.4398
Variance	0.340554	0.249328
Observations	44	45
Pooled Variance	0.294417	
Hypothesized Mean Difference	0	
df	87	
t Stat	-1.78437	
P(T<=t) one-tail	0.038925	
t Critical one-tail	1.662557	
P(T<=t) two-tail	0.077849	
t Critical two-tail	1.987608	

Result: -1.9876 < -1.78437 < 1.9876

Do not reject - means are equal

F-Test Two-Sample for Variances

Factors	Spring	Winter
Mean	2.234528	2.396622
Variance	0.340554	0.301318
Observations	44	44
df	43	43
F	1.130214	
P(F<=f) one-tail	0.344988	
F Critical one-tail	1.660744	
Result	Equal variance	

t-Test: Two-Sample Assuming Equal Variances

Factor	Spring	Winter
Mean	2.234528	2.396622
Variance	0.340554	0.301318
Observations	44	44
Pooled Variance	0.320936	
Hypothesized Mean Difference	0	
df	86	
t Stat	-1.34204	
P(T<=t) one-tail	0.091557	
t Critical one-tail	1.662765	
P(T<=t) two-tail	0.183114	
t Critical two-tail	1.987934	

Result: -1.9879 < -1.34204 < 1.9879

Do not reject - means are equal

F-Test Two-Sample for Variances

Factor	Summer	Autumn
Mean	2.702634	2.4398
Variance	0.291144	0.249328
Observations	44	45
df	43	44
F	1.167715	
P(F<=f) one-tail	0.305233	
F Critical one-tail	1.654447	
Result	Equal variance	

t-Test: Two-Sample Assuming Equal Variances

Factors	Summer	Autumn
Mean	2.702634	2.4398
Variance	0.291144	0.249328
Observations	44	45
Pooled Variance	0.269996	
Hypothesized Mean Difference	0	
df	87	
t Stat	2.385839	
P(T<=t) one-tail	0.009605	
t Critical one-tail	1.662557	
P(T<=t) two-tail	0.01921	
t Critical two-tail	1.987608	

Result: -1.9876 < 2.3858 < 1.9876

Reject – there is a difference

F-Test Two-Sample for Variances

Factors	Summer	Winter
Mean	2.702634	2.396622
Variance	0.291144	0.301318
Observations	44	44
df	43	43
F	0.966235	
P(F<=f) one-tail	0.455426	
F Critical one-tail	0.60214	
Result	Unequal variance	

t-Test: Two-Sample Assuming Unequal Variances

Factor	Summer	Winter
Mean	2.702634	2.396622
Variance	0.291144	0.301318
Observations	44	44
Hypothesized Mean Difference	0	
df	86	
t Stat	2.637155	
P(T<=t) one-tail	0.00496	
t Critical one-tail	1.662765	
P(T<=t) two-tail	0.00992	
t Critical two-tail	1.987934	

Result: -1.9879 < 2.637155 < 1.9879

Reject – There is a difference

F-Test Two-Sample for Variances

Factor	Autumn	Winter
Mean	2.4398	2.396622
Variance	0.249328	0.301318
Observations	45	44
df	44	43
F	0.827457	
P(F<=f) one-tail	0.267007	
F Critical one-tail	0.604431	
Result	Unequal variance	

t-Test: Two-Sample Assuming Unequal Variances

Factor	Autumn	Winter
Mean	2.4398	2.396622
Variance	0.249328	0.301318
Observations	45	44
Hypothesized Mean Difference	0	
df	86	
t Stat	0.387931	
P(T<=t) one-tail	0.349513	
t Critical one-tail	1.662765	
P(T<=t) two-tail	0.699026	
t Critical two-tail	1.987934	

Result: -1.9879 < 0.3879 < 1.9879

Do not reject - means are equal

E. coli levels in Mussels V year (2007-2012, 2017-2019)

F-Test Two-Sample for Variances		
Factor	Spring	Summer
Mean	2.409133	2.958469
Variance	0.571823	0.598936
Observations	28	30
df	27	29
F	0.954731	
P(F<=f) one-tail	0.453495	
F Critical one-tail	0.528912	
Result	Unequal variance	

t-Test: Two-Sample Assuming Unequal Variances

Factor	Spring	Summer
Mean	2.409133	2.958469
Variance	0.571823	0.598936
Observations	28	30
Hypothesized Mean Difference	0	
df	56	
t Stat	-2.7335	
P(T<=t) one-tail	0.004186	
t Critical one-tail	1.672522	
P(T<=t) two-tail	0.008372	
t Critical two-tail	2.003241	

Result: -2.0032 < -2.7335 < 2.0032

Reject - there is a difference

F-Test Two-Sample for Variances

Factor	Spring	Autumn
Mean	2.409133	2.56893
Variance	0.571823	0.323126
Observations	28	31
df	27	30
F	1.76966	
P(F<=f) one-tail	0.065239	
F Critical one-tail	1.861827	
Result	Equal variance	

t-Test: Two-Sample Assuming Equal Variances

Factor	Spring	Autumn
Mean	2.409133	2.56893
Variance	0.571823	0.323126
Observations	28	31
Pooled Variance	0.44093	
Hypothesized Mean Difference	0	
df	57	
t Stat	-0.92303	
P(T<=t) one-tail	0.179941	
t Critical one-tail	1.672029	
P(T<=t) two-tail	0.359881	
t Critical two-tail	2.002465	

Result: -2.0025 < -0.9230 < 2.0025

Do not reject - means are equal

F-Test Two-Sample for Variances

Factor	Spring	Winter
Mean	2.409133	2.638708
Variance	0.571823	0.379031
Observations	28	26
df	27	25
F	1.508643	
P(F<=f) one-tail	0.152385	
F Critical one-tail	1.9395	
Result	Equal variance	

t-Test: Two-Sample Assuming Equal Variances

Factor	Spring	Winter
Mean	2.409133	2.638708
Variance	0.571823	0.379031
Observations	28	26
Pooled Variance	0.479134	
Hypothesized Mean Difference	0	
df	52	
t Stat	-1.21777	
P(T<=t) one-tail	0.114405	
t Critical one-tail	1.674689	
P(T<=t) two-tail	0.22881	
t Critical two-tail	2.006647	

Result: -2.0066 < -1.2178 < 2.0066

Do not reject - means are equal

F-Test Two-Sample for Variances

Factor	Summer	Autumn
Mean	2.958469	2.56893
Variance	0.598936	0.323126
Observations	30	31
df	29	30
F	1.853569	
P(F<=f) one-tail	0.049103	
F Critical one-tail	1.847428	
Result	Unequal variance	

t-Test: Two-Sample Assuming Unequal Variances

Factor	Summer	Autumn
Mean	2.958469	2.56893
Variance	0.598936	0.323126
Observations	30	31
Hypothesized Mean Difference	0	
df	53	
t Stat	2.234606	
P(T<=t) one-tail	0.014841	
t Critical one-tail	1.674116	
P(T<=t) two-tail	0.029683	
t Critical two-tail	2.005746	

Result: -2.0057 < 2.2346 < 2.0057

Reject - is a difference

F-Test Two-Sample for Variances

Factor	Summer	Winter
Mean	2.958469	2.638708
Variance	0.598936	0.379031
Observations	30	26
df	29	25
F	1.580176	
P(F<=f) one-tail	0.12436	
F Critical one-tail	1.925538	
Result	Equal variance	

t-Test: Two-Sample Assuming Equal Variances

Factor	Summer	Winter
Mean	2.958469	2.638708
Variance	0.598936	0.379031
Observations	30	26
Pooled Variance	0.497128	
Hypothesized Mean Difference	0	
df	54	
t Stat	1.692565	
P(T<=t) one-tail	0.048151	
t Critical one-tail	1.673565	
P(T<=t) two-tail	0.096301	
t Critical two-tail	2.004879	

Result: -2.0049 < 1.6926 < 2.0049

Do not reject - means are equal

F-Test Two-Sample for Variances

Factor	Autumn	Winter
Mean	2.56893	2.638708
Variance	0.323126	0.379031
Observations	31	26
df	30	25
F	0.852504	
P(F<=f) one-tail	0.335293	
F Critical one-tail	0.532411	
Results	Unequal variance	

t-Test: Two-Sample Assuming Unequal Variances

Factor	Autumn	Winter
Mean	2.56893	2.638708
Variance	0.323126	0.379031
Observations	31	26
Hypothesized Mean Difference	0	
df	52	
t Stat	-0.4413	
P(T<=t) one-tail	0.330412	
t Critical one-tail	1.674689	
P(T<=t) two-tail	0.660824	
t Critical two-tail	2.006647	

Result: -2.0066 < -0.4413 < 2.0066

Do not reject - means are equal