Sanitary Survey Report
and
Sampling Plan
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).
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine environmental Pollution

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.
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 (EC) 854/2004	REGULATION (EC) No 854/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption
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. Executive Summary

Under Regulation (EC) 854/2004, 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 inform the sampling plan for the Official Control Microbiological Monitoring Programme, the results of which determine the annual classification for bivalve mollusc production areas. Other wider benefits of sanitary surveys include the potential to improve the identification of pollution events and the sources of those events so that in the future remedial action can be taken to the benefit of the fisheries in the 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.

This report documents and quantifies all known sources of pollution to the harbour. It was concluded that the main source of pollution in Killough Harbour comes from direct sewerage discharges from the town. Tourism, shipping and bird populations are not considered to be major contributors to pollution in the Harbour.

As the entire harbour area is intertidal, there is a complete exchange of water twice a day and this prevents the long-term build up of contaminants in the area. However there is still a notable contamination level within the harbour and this is reflected by the long term B classification. As the hydrodynamics of the area are simple and the contaminants get redistributed around the entire harbour area, only one Production Area is sufficient for official control monitoring purposes of Killough Harbour. Within this Production Area, there is a RMP for oysters and an RMP for mussels. Shellfish sampling is to occur monthly.

2. Overview of the Fishery/Production Area

2.1. Location/Extent of Growing/Harvesting Area

The shellfish designated waters in Killough Harbour (see Figure 2.1) cover an area of approximately 0.2km^2 and covers the outer part of the harbour area bounded to the south by two piers (DOENI, 2009a). Oysters are cultivated in Killough Harbour.

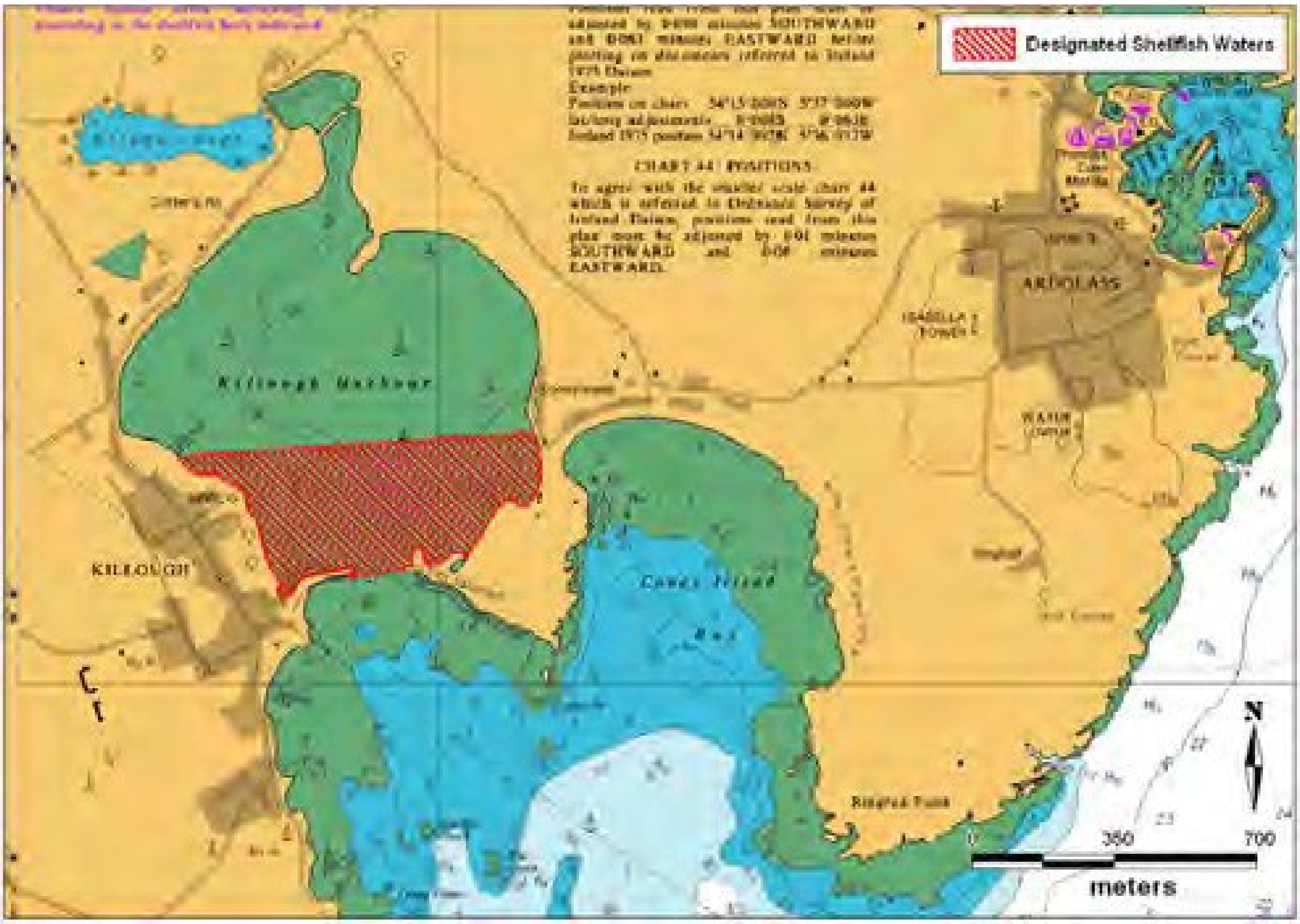

Figure 2.1: Shellfish designated waters within Killough Harbour (Source: DOENI, 2009a).

Figure 2.2 shows the current location of the licenced harvesting area within Killough Harbour. This harvesting area is currently licenced for Pacific oysters and native oysters; however, Pacific oysters are the only species produced. The licenced site covers an area of 0.05km^2. Mussels do naturally occur in the area but at present they are not seeded or cultivated. The area is currently classified by FSA for both oysters and mussels.

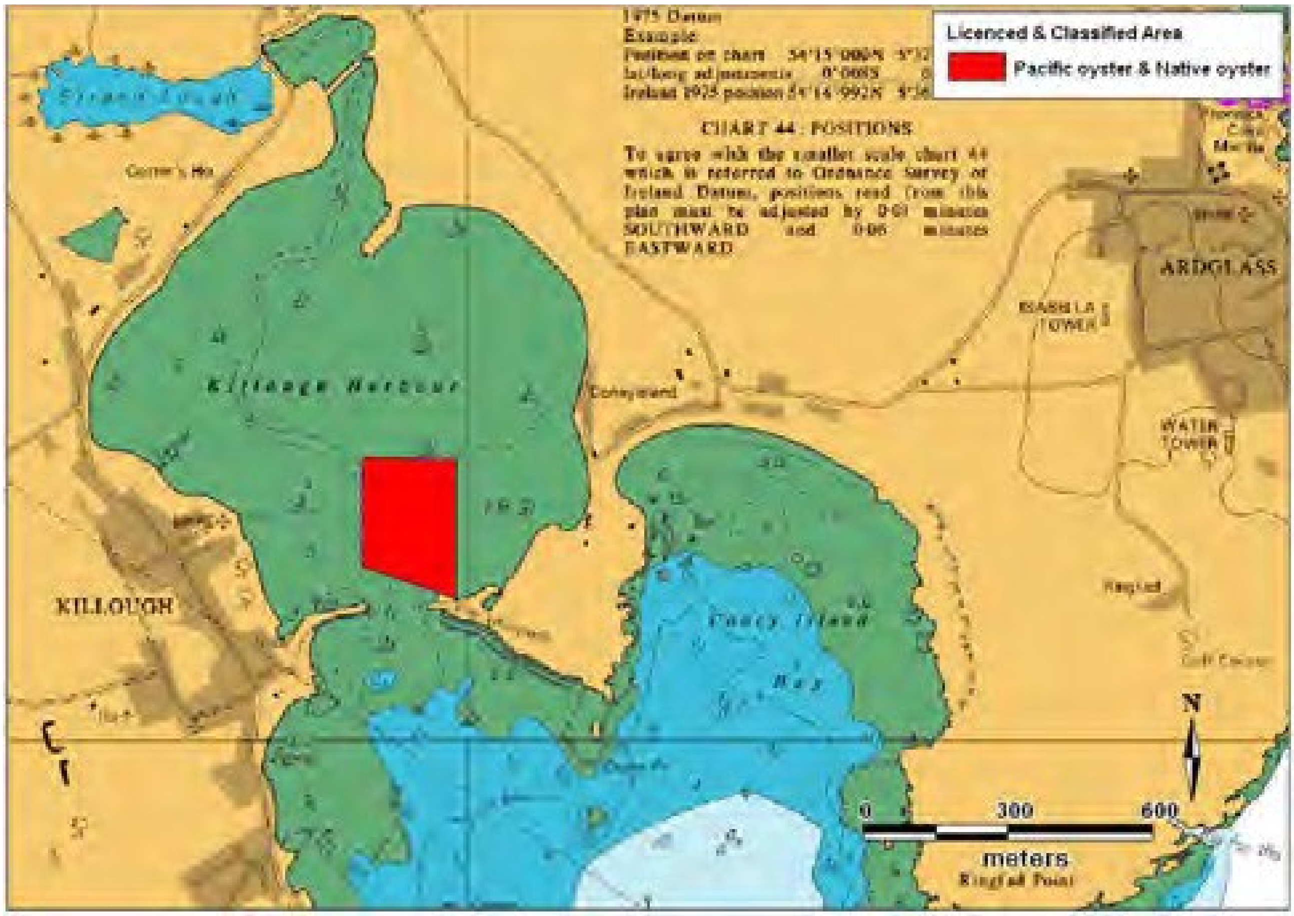

Figure 2.2: Licenced and classified harvesting area located within Killough Harbour (Source: DARD).

2.2. Description of the Area

Killough Harbour is located on the southeast coast of County Down between St. John’s Point and Ardglass (see Figure 2.3). Two piers, one approximately 200m on the Killough side and the other approximately 30m in length on the Coney Island side enclose the harbour. The harbor area is approximately 1.1km in width and in length and the entire lough is intertidal. Strand Lough (located approximately 1km north of Killough village) drains into Killough Harbour. Killough Bay lies outside the harbour and connects the harbour to the Irish Sea. Killough Bay encompasses the inter-tidal areas, and additional adjoining areas of notable habitat. These include mudflats, sand dominated beaches, gravel and cobble units and rocky shore. Killlough Harbour is a Special Protection Area (SPA) and a Ramsar Site and the boundary includes Coney Island Bay. The principal interest is the wintering population of light-bellied Brent goose, which feeds on the rich mats of the green alga, *Enteromorpha* spp. present especially in Killough Harbour. The birds find refuge here during late winter and spring, once the main wintering flock from Strangford Lough disperses due to lack of food. At Coney Island Bay, the moderately exposed sediment shore is an important example of its type. The rest of the bay is generally sheltered and rocky with rockpools and boulders, forming a species-rich area with a diverse range of seaweeds, such as toothed and knotted wrack and invertebrates, including the notable polychaete worm, *Sabellaria alveolata* at its northern limit. On the rocks, a sparse covering of sea campion, thrift and sea plantain gives way to a more species-rich maritime grassland community, typified by sea campion, wild carrot, thrift and red fescue.

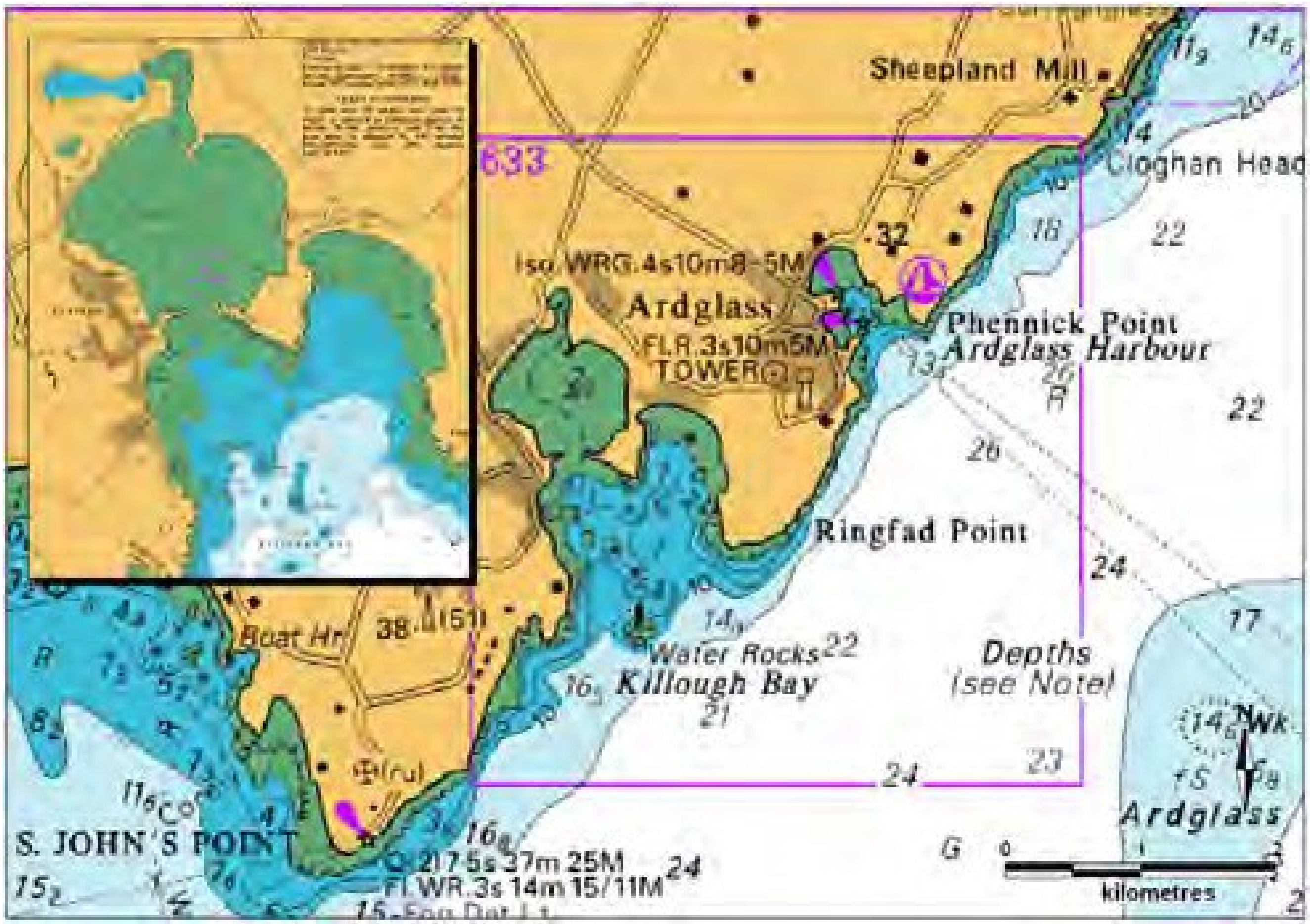

Figure 2.3: Location of Killough Harbour.

Land cover along the coastal regions of the catchment area is a mixture of discontinuous urban fabric, pastures and agricultural/natural vegetation. The inland regions of the catchment are dominated by a mix of pastures, complex cultivation patterns, agricultural/natural vegetation and non-irrigated arable land. The only freshwater input is through Strand Lough, which is located approximately 1km north of Killough village at the head of the harbour. It is a small lake, with a perimeter of approximately 1.26km and an area of 0.039km^2. It is fed by a number of small streams which ultimately flow into Killough Harbour.

The population of the catchment is approximated at between 6,800 and 7,300 people[1]. The largest population centre in the catchment area is the village of Ardglass, with a population of 1,605 people (NISRA, 2011b).

The designated shellfish area within the Harbour is 0.2km^2 and the licenced shellfish site covers an area of 0.05km^2. Pacific oysters are cultivated in Killough Harbour and mussels occur naturally in the area but are not seeded or cultivated.

Killough Harbour has numerous functions and processes, which are listed below:

- Dispersal of water quality characteristics brought about by the movement of water masses;
- Nutrient exchange;
- Bioturbation;
- Gas exchange;
- Primary and secondary production;
- Provision of habitats and ecosystems;
- Supports plankton populations, benthic infauna, epifauna, fish populations, bird populations;
- Propagule (e.g. seed stock/larvae) dispersion brought about by the movement of water masses;
- Fishing activities;
- Navigation;
- Aquaculture activities;
- Socio-economic activities; and
- Recreational activities.

Oyster beds themselves perform important ecological functions including supporting oyster populations, providing refuge for fish and invertebrates that retreat from exposed intertidal flats and estuarine marshes at low tide, and serving as spawning and nursery areas for numerous species of aquatic animals. Oysters are an important food source for many other animals including starfish, crabs, fishes, and waterfowl.

Beds of mussels provide substratum for epiflora and epifauna, while the mussel matrix provides interstices and refuges for a diverse community of organisms. The buildup of mussel muds under the bed supports infaunal species, and in sedimentary habitats, the underlying sediment may support an enriched infauna. The

[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.

diversity and species richness increases with the size and age of the mussel bed. In sedimentary habitats, mussel beds stabilise and modify the substratum, and mussel beds have a higher biodiversity than surrounding mudflats. Mussel beds may also form biogenic reefs and *Mytilus edulis* is considered to be a habitat engineer (Holt *et al*, 1998; Hild & Günther, 1999).

In addition, larval production represents a significant contribution to the zooplankton, forming an important food source for herring larvae and carnivorous zooplankton (Seed & Suchanek, 1992). Dense beds of bivalve suspension feeders increase turnover of nutrients and organic carbon in estuarine (and presumably coastal) environments by effectively transferring pelagic phytoplanktonic primary production to secondary production (pelagic-benthic coupling) (Dame, 1996).

The concept of carrying capacity of an ecosystem for natural populations is derived from the logistic growth curve in population ecology, and defined as the maximum standing stock that can be supported by a given ecosystem for a given time. Carrying capacity estimates in terms of aquaculture (production) may be defined as the stocking density at which production levels are maximised without having a negative impact on growth. Subsequently, carrying capacity for shellfish culture has been further defined as the standing stock at which the annual production of the marketable cohort is maximised. This will differ substantially from the ecological carrying capacity and is termed the sustainable aquaculture carrying capacity. For bivalve suspension feeders, the dominant factors determining the sustainable carrying capacity at the ecosystem scale are primary production, detrital inputs and exchange with adjacent ecosystems. At the local scale, carrying capacity depends on physical constraints such as substrate, shelter and food transported by tidal currents, and density- dependent food depletion. Mortality is a critical factor, and high seed mortality due to sub-optimal seed deployment, particularly in bottom culture, is a key factor in reducing production yield and economic competitiveness. The carrying capacity of Killough Harbour is unknown.

2.3. Description of Cultivated Species

2.3.1. Pacific Oysters (*Crassostrea gigas*)

2.3.1.1. General Biology

Pacific oysters are not native to Irish waters; they were introduced from the Pacific coasts of Asia. They are large cupped oysters with a deep, elongated shell, which is often very irregular. They can be found in intertidal and subtidal zones. They prefer to attach to hard or rocky surfaces in shallow or sheltered waters but have been known to attach to muddy or sandy areas when the preferred habitat is scarce. They can also be found on the shells of other animals. They can grow to approximately 30cm but is normally harvested at less than 15cm (Roberts *et al.,* 2004).

The sexes are separate, but as the oyster ages it may change sex with females being more numerous when conditions are favourable (Roberts *et al.,* 2004). Females discharge millions of eggs into the water column, where fertilisation occurs. The larvae are planktonic and develop within a few hours, swim actively for about two or three weeks and then drop out of the plankton and settle on material on the bottom, at which point it is known as 'spat'. The larvae often settles on the shells of adults, and great masses of oysters can grow together to form oyster reefs. The larvae spend the first year attached as a male, before eventually becoming female.

C. gigas does not spawn at temperatures below 20°C. It is very unusual for Pacific oysters to spawn in Ireland. However, they will ripen even in an average summer, and the gonads will become 'milky' with eggs or sperm. Unharvested oysters can live up to 30 years. The conservation status of *Crassostrea gigas* is not listed.

2.3.1.2. Distribution

Figure 2.4 shows the location of the licenced Pacific oyster trestles in Killough Harbour. Figure 2.5 shows an aerial image of these trestles (Source: www.nimap.net). The oyster trestles cover an area of 0.014km^2 and are located in the intertidal area northeast of Killough pier.

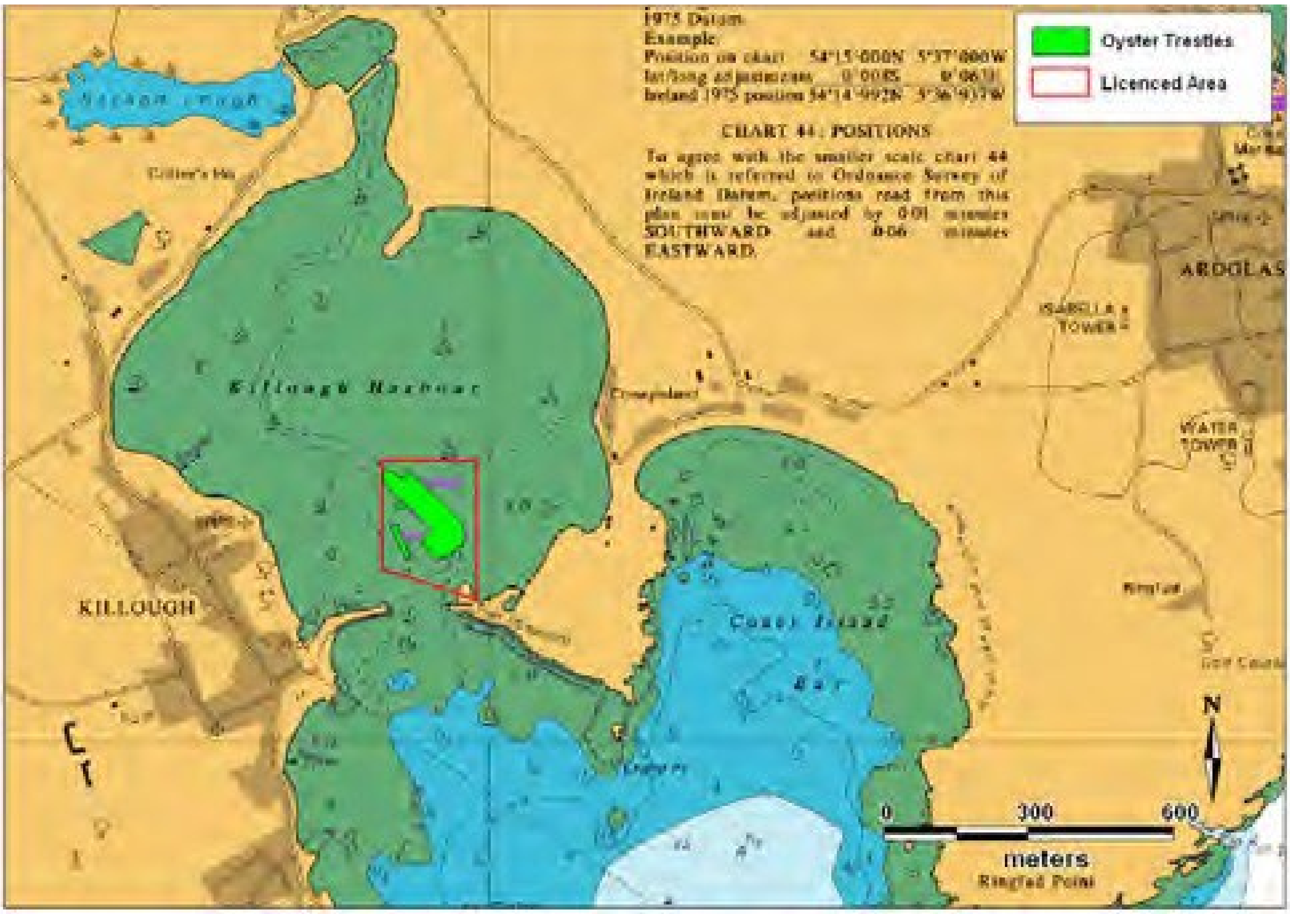

Figure 2.4: Licenced Pacific oyster production sites in Killough Harbour (Source: DARD).

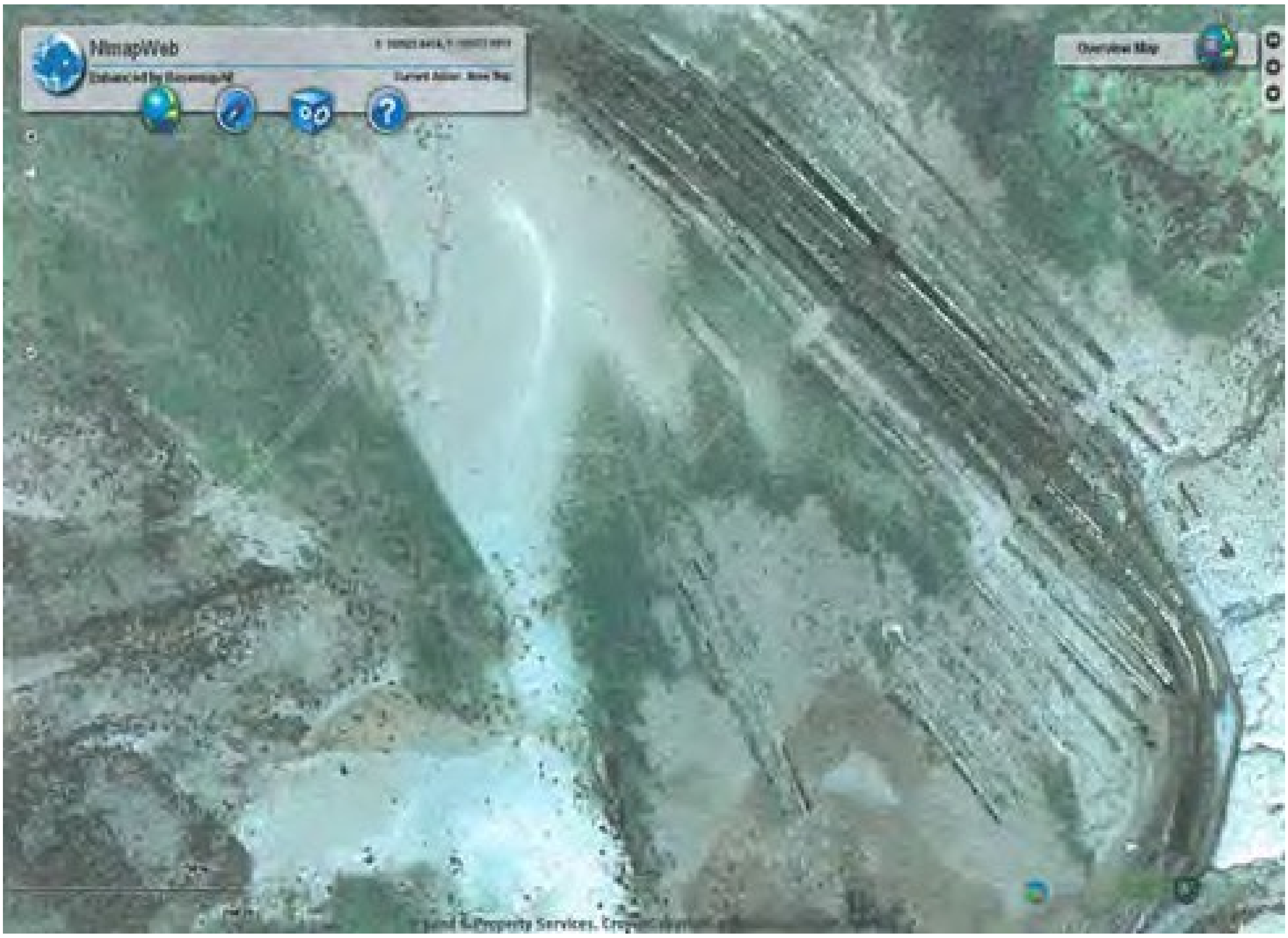

Figure 2.5: Aerial imagery of oyster trestles in Killough Harbour (Source: www.nimap.net © Land & Property Services. Crown Copyright and Database right 2009).

2.3.1.3. Fishery

All Pacific oysters grown in Ireland come from hatchery produced seed. *Crassostrea gigas* is both faster growing (reaches market size in 3-4 years), shows greater tolerance to disease and is tolerant of a wider range of conditions than the native or flat oyster (*Ostrea edulis*) (Roberts *et al.,* 2004). Seed can be purchased at a variety of sizes, small (G7) seed are placed in nursery trays until they reach a suitable size to be placed in bags (pouches) on trestles for on-growing (Roberts *et al.,* 2004). Seed taken at a larger size may be placed directly into the bags but as seed size increases so does the price. The trestles are made of 16mm steel tube and are usually approximately 300mm high and are 2.5-3.0m long by 1m wide. Each trestle can hold 5-6 oyster bags, which are held on by rubber bands and/or hooks. The bags vary in mesh size depending on the size of oyster being held. The bags and trestles are reusable and remain on the shore all year round. Oyster sites are accessed by farmers at low tide using a tractor and trailer. The farms are positioned between Mean Low Water Spring and Mean Low Water Neap, allowing 2.5-3.5 hrs exposure per day, depending on weather conditions. This in turn translates to approximately 15% visual exposure during day light hours over a typical month. When cultured off the bottom, oysters are protected from predators and tend to grow faster. Oysters grown in bags that are regularly turned are more evenly shaped and less bent and twisted than traditional bottom culture. If submerged for their full life-span oysters tend to have more fragile shells than those which have been 'hardened' by exposure to the air at major tides.

Figure 2.6 shows the total Pacific oyster production in Killough Harbour from 2006 to 2010 (Source: DARD). Output increased steadily from 12 tonnes in 2006 to 30 tonnes in 2008. There was a slight decrease of 4 tonnes in 2009 with a return to 2008 levels in 2010. Values increased significantly from 2006 to 2008 and while quantities in 2010 were the same as 2008, the values more than halved.

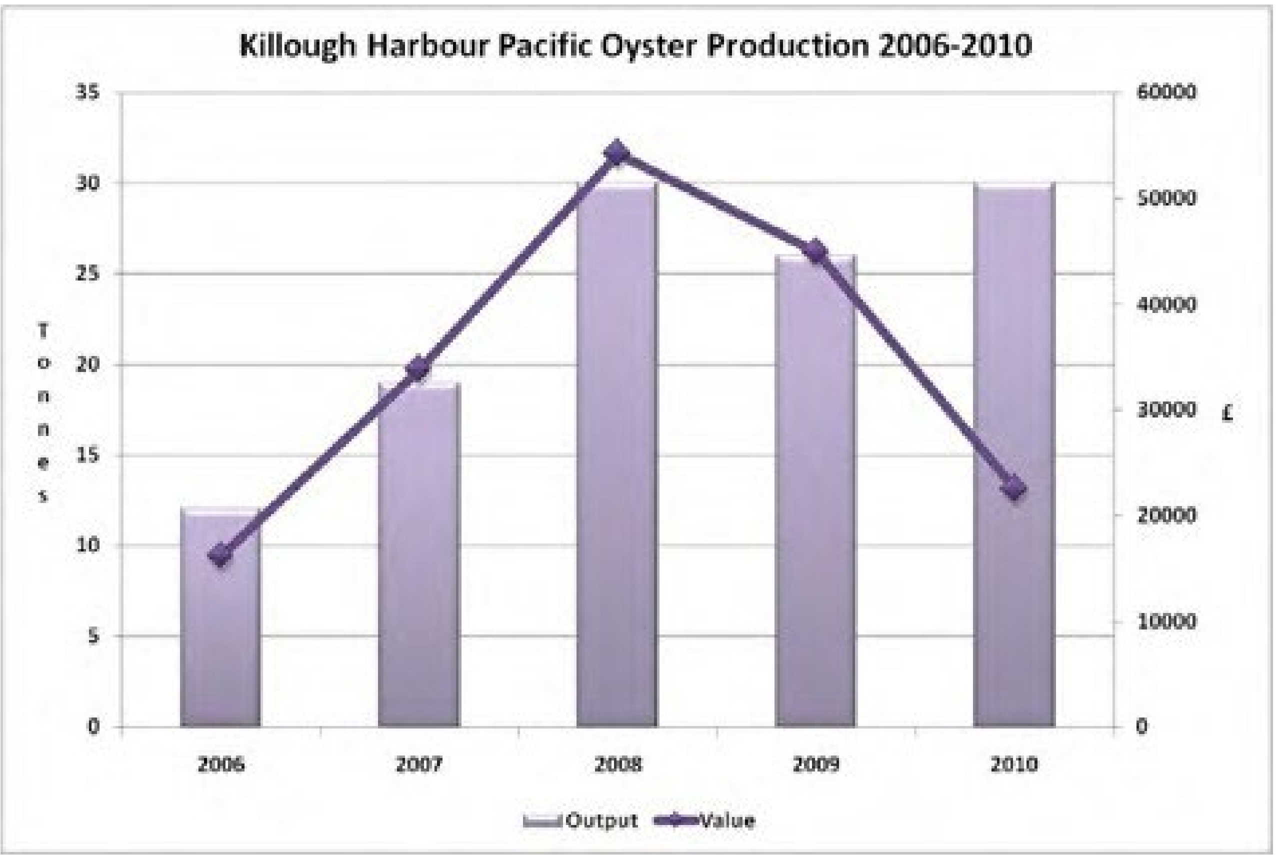

Figure 2.6: Pacific oyster production in Killough Harbour from 2006-2010 (Source: DARD).

3. Hydrography/Hydrodynamics

3.1. Simple/Complex Models

Unfortunately no hydrographic models exist for Killough Harbour. 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.

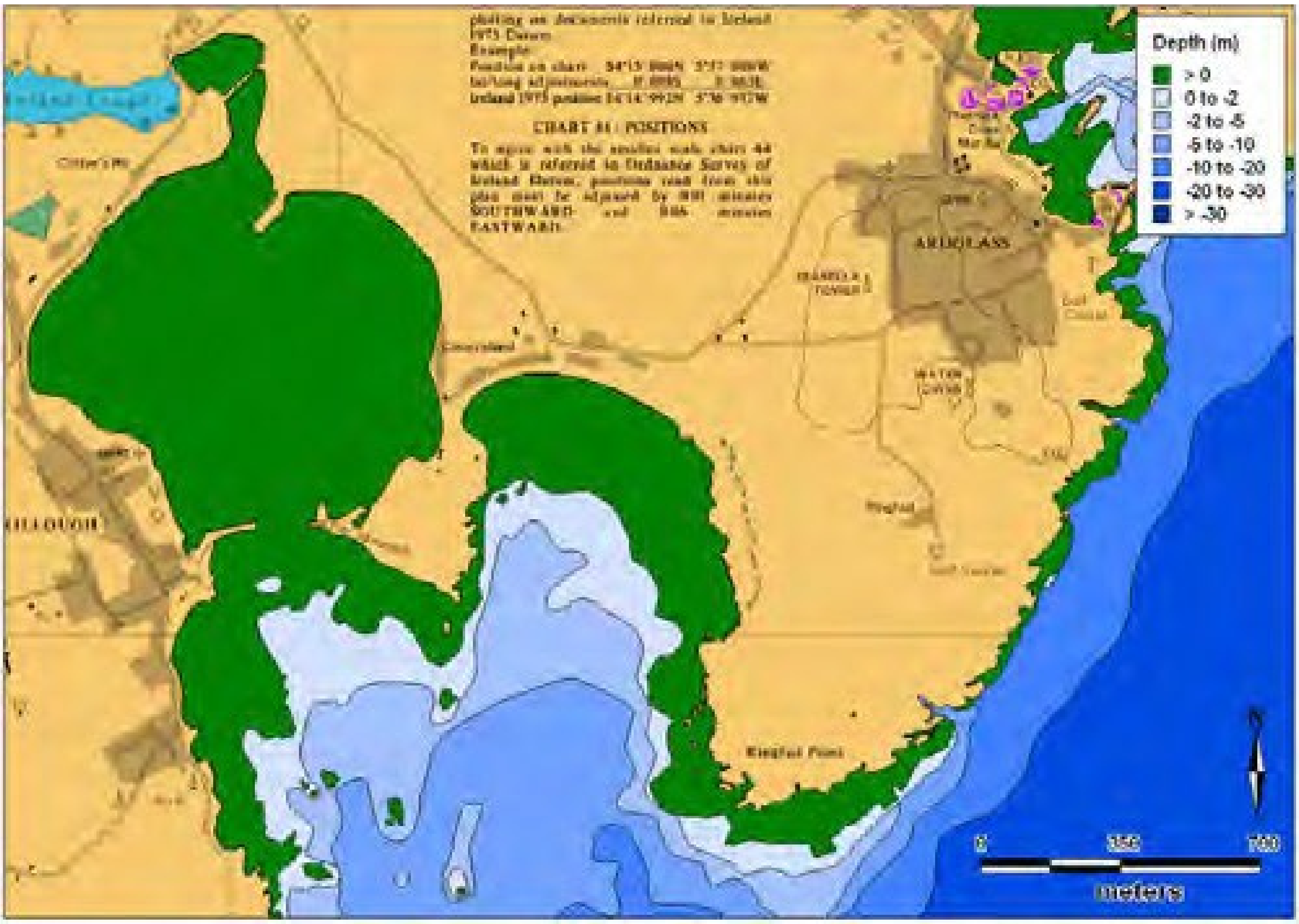

Figure 3.1: Depths in Killough Harbour and Bay (modified from The Loughs Agency data).

3.3. Tides & Currents

The characteristic tidal levels in Ardglass (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 very 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

Average wind speed data for Northern Ireland from 1971-2000 can be seen in Figure 3.2 (Met Office, 2011a). It can be seen from these maps that the eastern coast of Northern Ireland is one of the windiest areas. November to February experienced the strongest wind speeds (10-20kn) while July and August experienced the weakest winds (6-15kn). The strongest winds are associated with the passage of deep areas of low pressure close to or across the country. The frequency and strength of these depressions is greatest in the winter half of the year, especially from November to January, and this is when mean speeds and gusts (short duration peak values) are strongest (Met Office, 2011b). Figure 3.3 shows the seasonal averages in wind speed for Northern Ireland from 1971-2000, as expected summer experienced the weakest speeds (6-15kn) while winter experienced the strongest (10-20kn).

As Atlantic depressions pass the UK and Ireland the wind typically starts to blow from the south or south west, but later comes from the west or north-west as the depression moves away (Met Office, 2011b). The range of directions between south and north-west accounts for the majority of occasions and the strongest winds nearly always blow from these directions. Therefore the prevailing wind over Killough Harbour ranges from a southerly all the way around to a northwesterly.

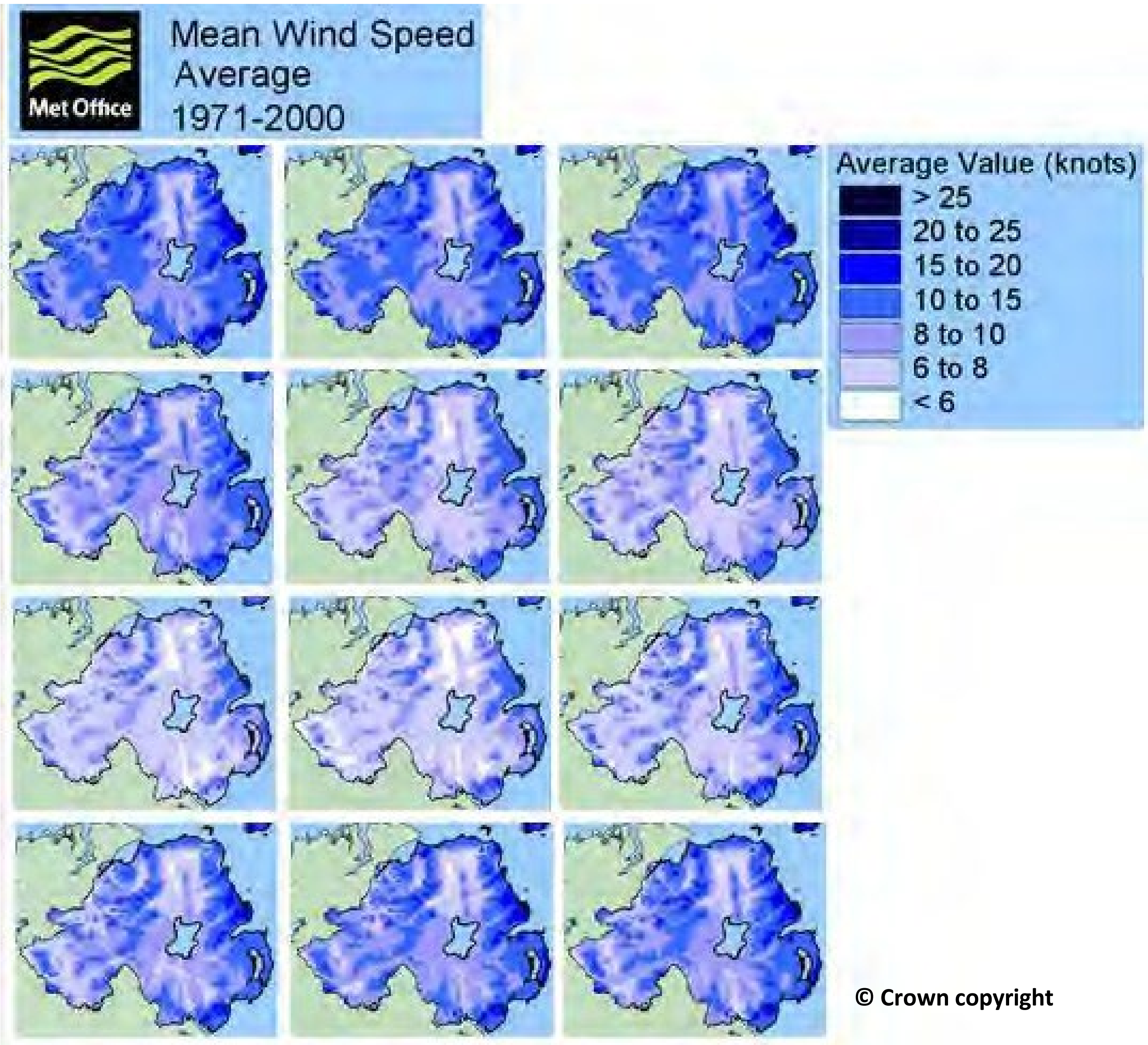

Figure 3.2: Average wind speed data for Northern Ireland from 1971 to 2000 (Source: Met Office, 2011a).

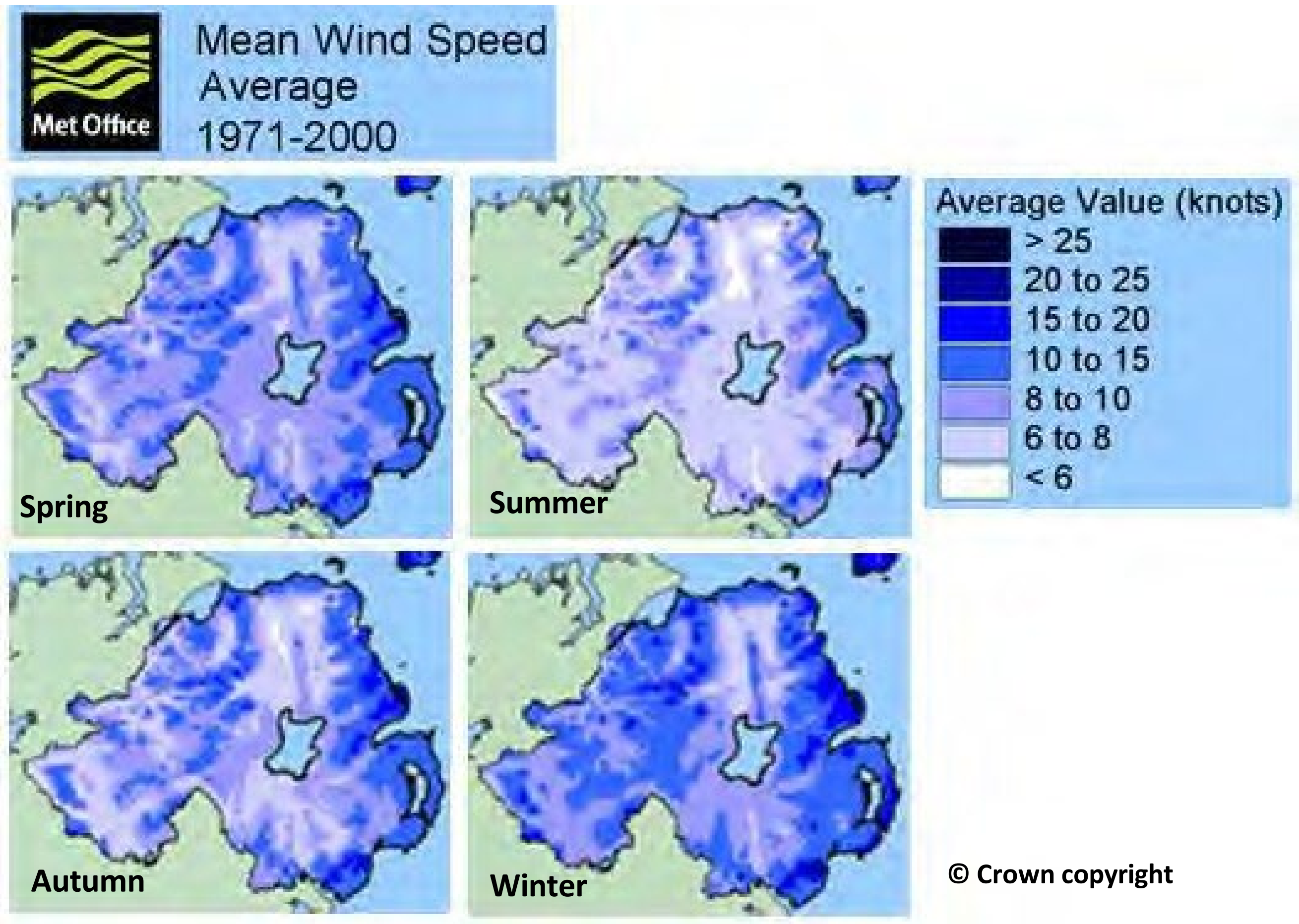

Figure 3.3: Average seasonal wind speed data for Northern Ireland from 1971-2000 (Source: Met Office, 2011a).

Wind conditions can affect the hydrodynamic conditions by generating wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Wind waves are produced by the local prevailing wind. They travel in a direction approximately 45° to the right of the direction of the prevailing wind (in the northern hemisphere), i.e. a westerly prevailing wind will produce southeasterly moving surface waves in Killough Harbour. The height of wind waves depends on:

- the strength of the wind;
- the time the wind has been blowing; and
- the fetch.

However, 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 a number of 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, 2011a).

3.6. Rainfall Data

3.6.1. Amount & Time of Year

Figures 3.5 and 3.6 show the average monthly rainfall data for Northern Ireland (Met Office, 2010) from 1971 to 2000. It is clear form these maps that the Killough Harbour area is one of the driest in Northern Ireland. Table 3.2 shows the average rainfall range and median values along the Killough Harbour coastline. During the period 1971 to 2000, the average rainfall around the coastline of Killough Harbour ranged from 30-130mm, with the lowest levels occurring in May and July (40-60mm) and the highest levels occurring in October (50- 130mm). The lowest median value was 50mm in May and July and the highest was 90mm in October. Figure 3.7 shows the seasonal averages from 1971 to 2000 for Northern Ireland. Table 3.3 shows the seasonal rainfall ranges and median values. Seasonally, spring and summer were the driest seasons (140mm) and autumn was the wettest season (240mm).

Table 3.2: **Rainfall range and median monthly rainfall (mm) data along the Killough Harbour coastline (Source: Met Office, 2010).**

Month	Rainfall Range (mm)	Median (mm)
Jan	60-100	80
Feb	30-70	50
Mar	50-80	65
Apr	45-60	52.5
May	40-60	50
Jun	40-65	52.5
Jul	40-60	50
Aug	50-80	65
Sept	50-80	65
Oct	50-130	90
Nov	50-90	70
Dec	60-100	80

Table 3.3: Seasonal rainfall range and median values (mm) from 1971-2000 (Source: Met Office, 2010).

Season	Rainfall Range (mm)	Median
Spring	140-200	170
Summer	140-200	170
Autumn	200-280	240
Winter	200-250	225

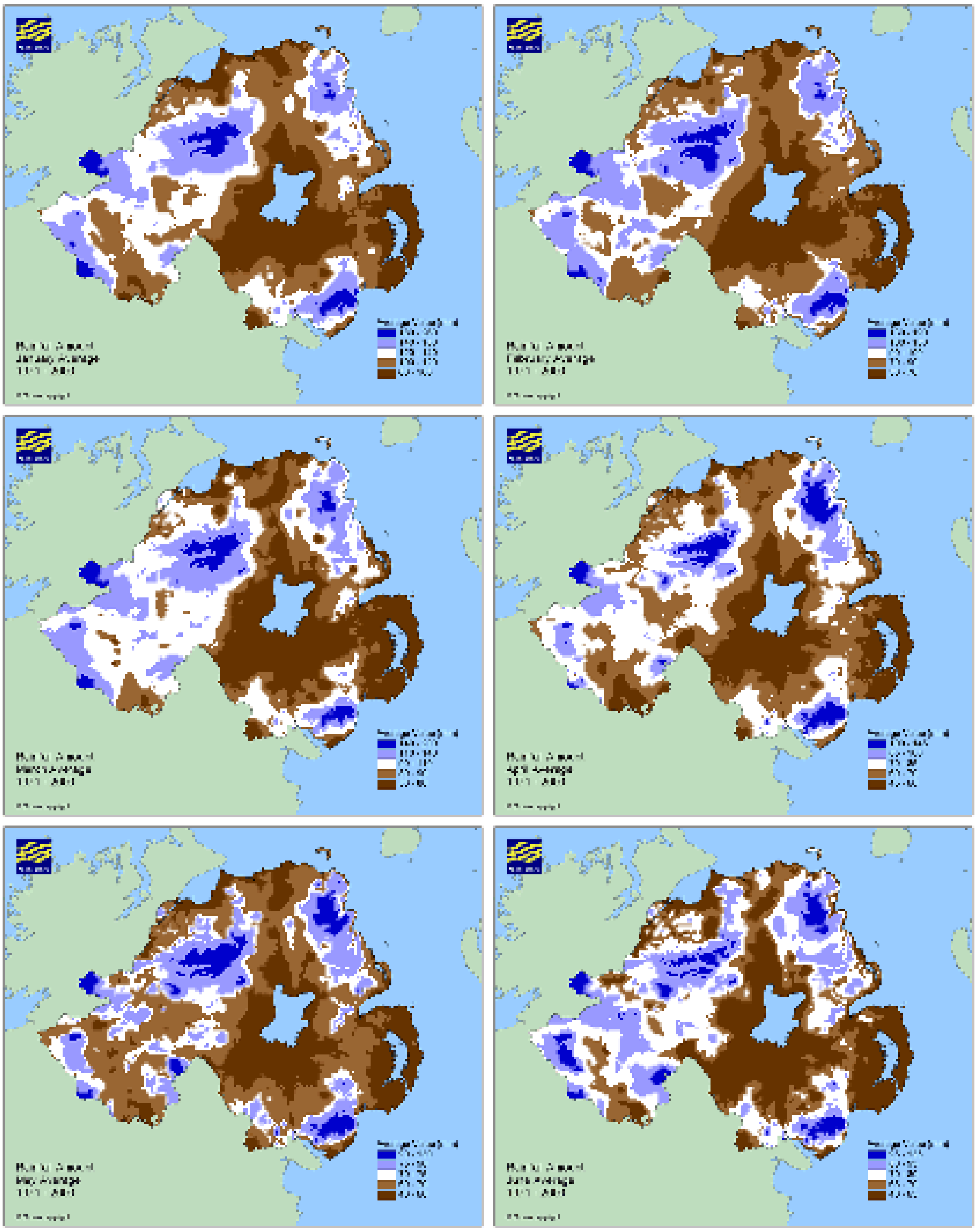

Figure 3.5: Average monthly rainfall (mm) data for January to June from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

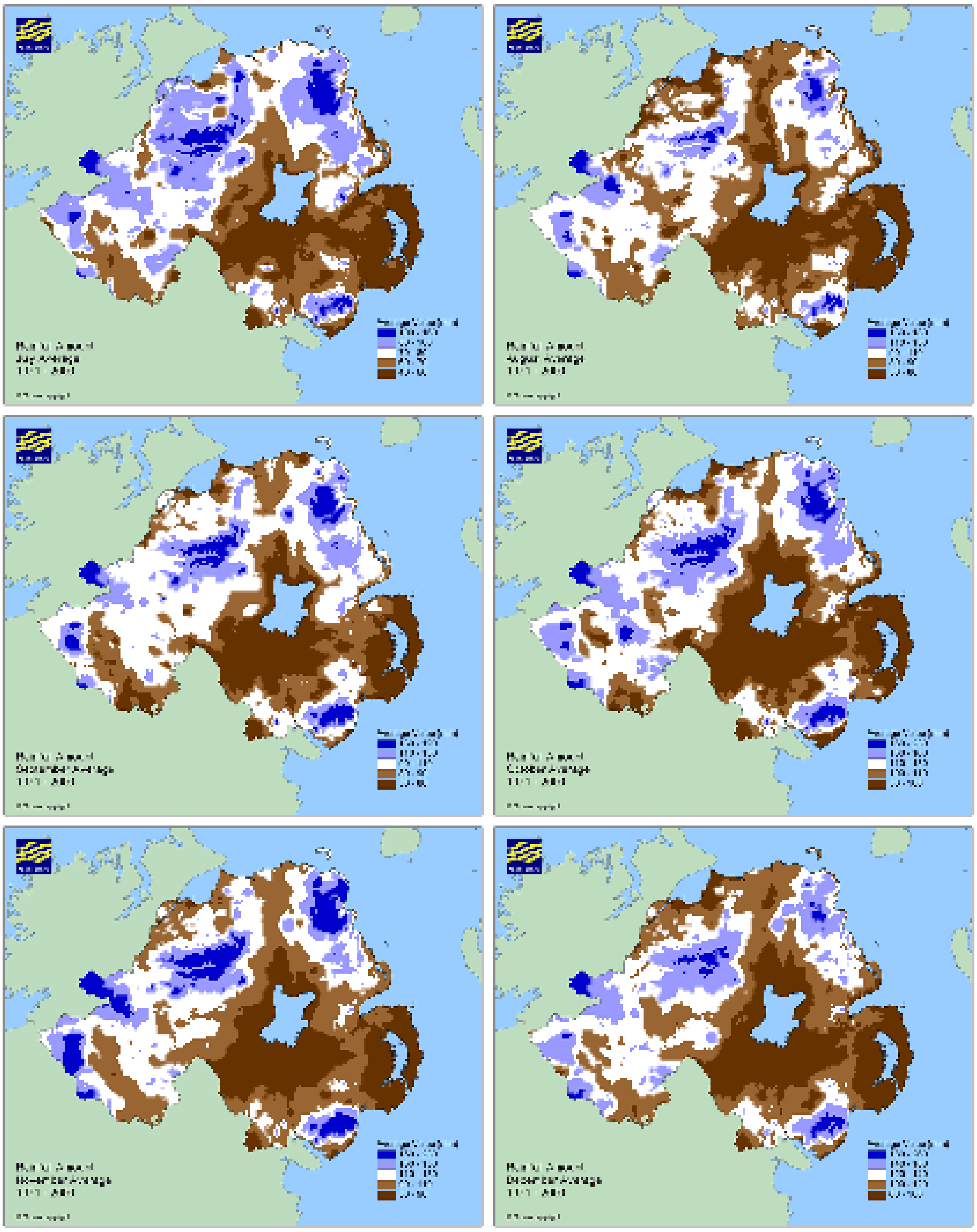

Figure 3.6: Average monthly rainfall (mm) data for July to December from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

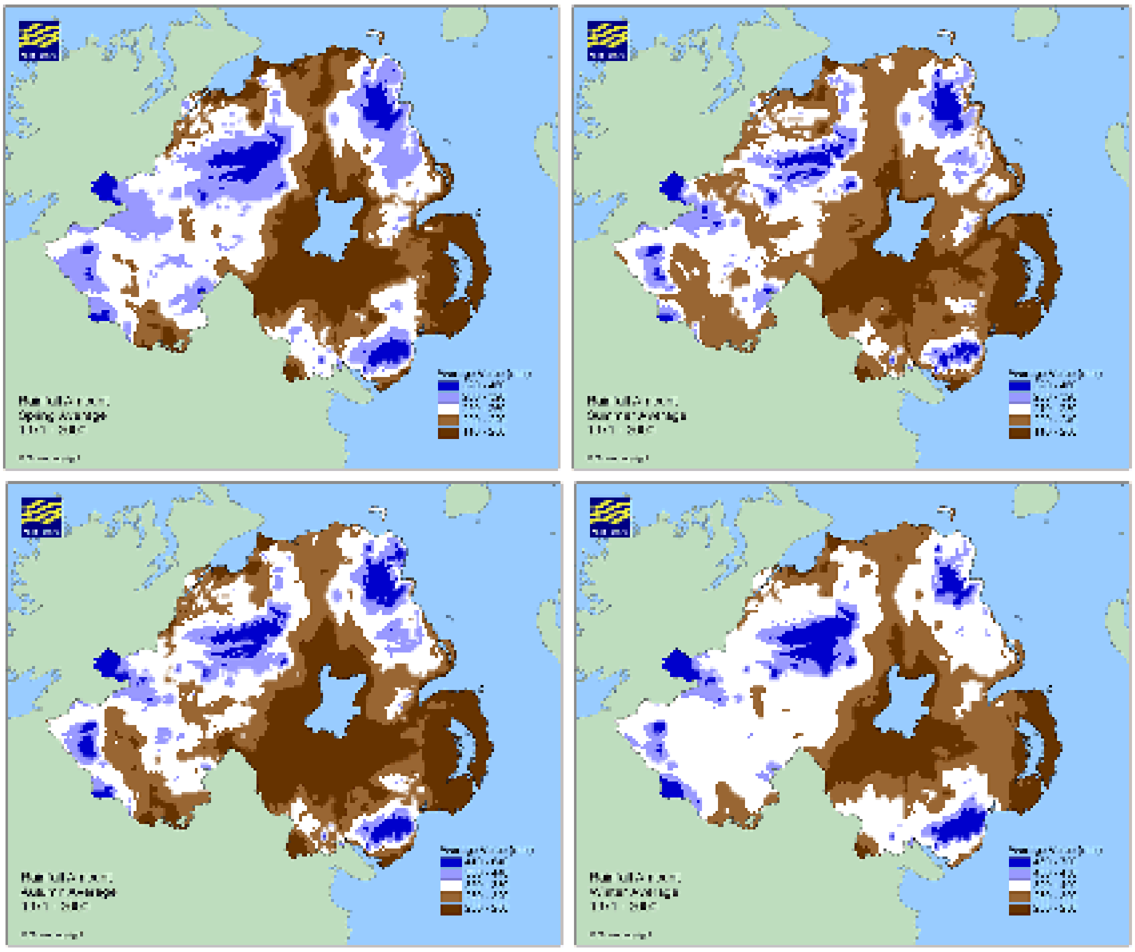

Figure 3.7: Seasonal rainfall averages (mm) from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

Tables 3.4 and 3.5 show the rainfall range and median values for the past 5 years for Killough Harbour (Met Office, 2011c). Lowest rainfall levels of 0-25mm were seen in April and September 2007, February 2009, May 2008 and April 2011 with the highest (150-200mm) occurring June 2007, August 2008, November 2009 and October 2011. Table 3.6 shows seasonal rainfall figures for the Killough Harbour area based on median rainfall values from 2007-2011 (Met Office, 2011c). The following seasonal fluctuations were observed from 2007-2001: In 2007 autumn and spring were the driest and summer was the wettest, in 2008 spring was the driest and summer was the wettest, in 2009 winter was the driest and autumn was the wettest, in 2010 spring and summer were the driest and autumn was the wettest and in 2011, spring was the driest and autumn was the wettest.

Table 3.4: Averaged monthly rainfall (mm) data summarised for the Killough Harbour area from 2006-2010 (Source: Met Office, 2011c).

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2011	25-50	100-150	25-50	0-25	50-75	50-75	25-50	25-50	75-100	150-200	100-150	50-75
2010	75-100	25-50	75-100	25-50	25-50	25-50	75-100	25-50	75-100	50-75	100-150	50-75
2009	75-100	0-25	25-50	75-100	75-100	25-50	100-150	100-150	25-50	100-150	150-200	75-100
2008	100-150	25-50	75-100	25-50	0-25	50-75	100-150	150-200	75-100	100-150	50-100	50-75
2007	50-75	50-75	50-75	0-25	50-75	150-200	75-100	75-100	0-25	25-50	75-100	75-100

Table 3.5: Median monthly rainfall (mm) data summarised for the Killough Harbour area from 2007-2011 (Source: Met Office, 2011c).

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2011	37.5	125	37.5	12.5	62.5	62.5	37.5	37.5	87.5	175	125	87.5
2010	87.5	37.5	87.5	37.5	37.5	37.5	87.5	37.5	87.5	62.5	125	62.5
2009	87.5	12.5	37.5	87.5	87.5	37.5	125	125	37.5	125	175	87.5
2008	125	37.5	87.5	37.5	12.5	62.5	125	175	87.5	125	75	62.5
2007	62.5	62.5	62.5	12.5	62.5	175	87.5	87.5	12.5	37.5	87.5	87.5

Table 3.6: Total seasonal rainfall (mm) values from 2007-2011 based on median rainfall values (Source: Met Office, 2011c).

Season/Year	2011	2010	2009	2008	2007
Spring	112.5	162.5	212.5	137.5	137.5
Summer	137.5	162.5	287.5	362.5	350
Autumn	387.5	275	337.5	287.5	137.5
Winter	250	187.5	187.5	225	212.5

3.6.2. Frequency of Significant Rainfalls

Figure 3.8 shows the average monthly median rainfall for the Killough Harbour area from 1971-2000 (Met Office, 2010). October to January were the wettest months. This is partly a reflection of the high frequency of winter Atlantic depressions and the relatively low frequency of summer thunderstorms in Northern Ireland (Met Office, 2011b). Figure 3.9 shows the monthly median rainfall for Killough Harbour from 2007 – 2011 (Met Office, 2011c). In these more recent years, October and November were joined by July and August as been the wettest months, and February and April were among the driest months. During these wetter months there may be an increased risk of contamination from land run-off and rainfall associated sewer overflows. These data highlight the fact that it is not just the winter months that are at risk of increased contamination.

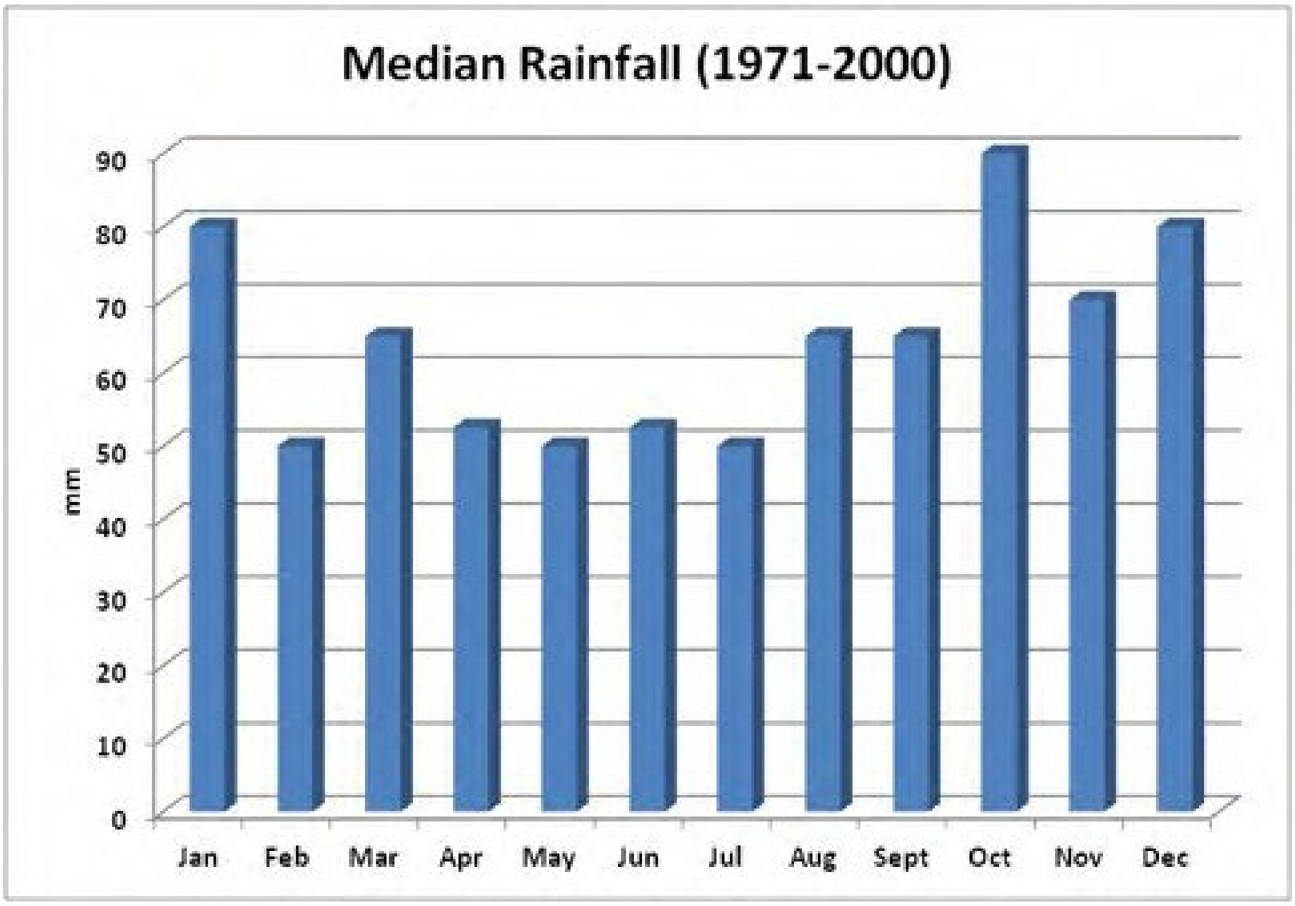

Figure 3.8: Average monthly median rainfall (mm) data along the Killough Harbour coast from 1971-2000 (Source: Met Office, 2010).

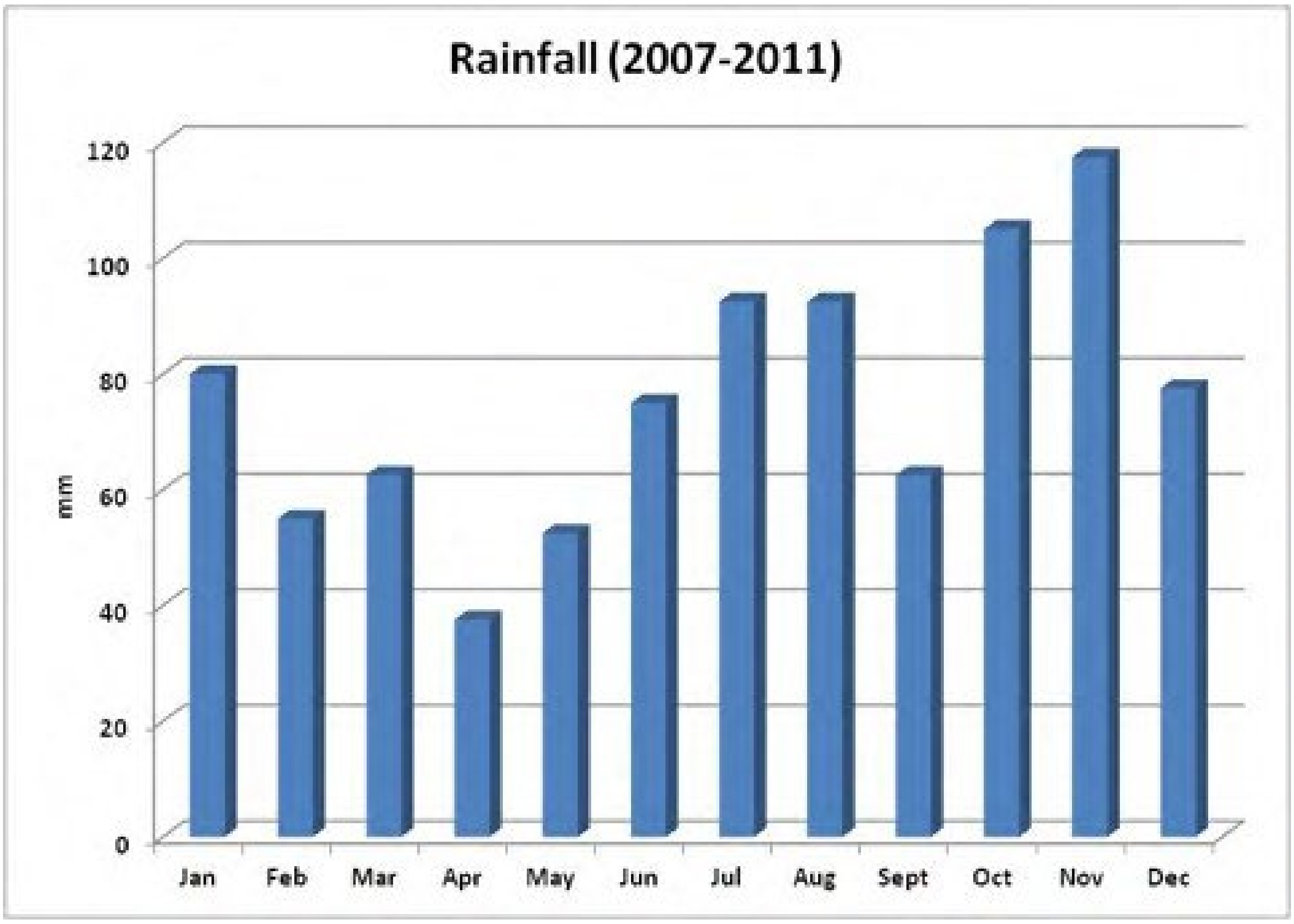

Figure 3.9: Average monthly rainfall (mm) data along the Killough Harbour coast from 2007-2011 (Source: Met Office, 2011c).

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 Northern Ireland Environment Agency (NIEA) 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.

4. Identification of Pollution Sources

4.1. Desktop Survey

Pollution sources were considered within the catchment area of Killough Harbour (see Figure 4.1). The catchment area covers an area of 62.14km^2 and it is approximately 11km east west at its widest point and 13.25km north south at its longest point. The rivers, which drain into the harbour, can also be seen in Figure 4.1. The entire catchment area (as shown in Figure 4.1) does not drain into the harbour. Only the pollution sources, flowing into the harbour or into a tributary of it were considered as part of this survey i.e. sources flowing into the Irish Sea, Ardglass Harbour or Dundrum Bay were not considered.

Figure 4.1: Killough Harbour catchment area and rivers used for assessment of the pollution sources (Source: NIEA, 2011a).

4.1.1. 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.

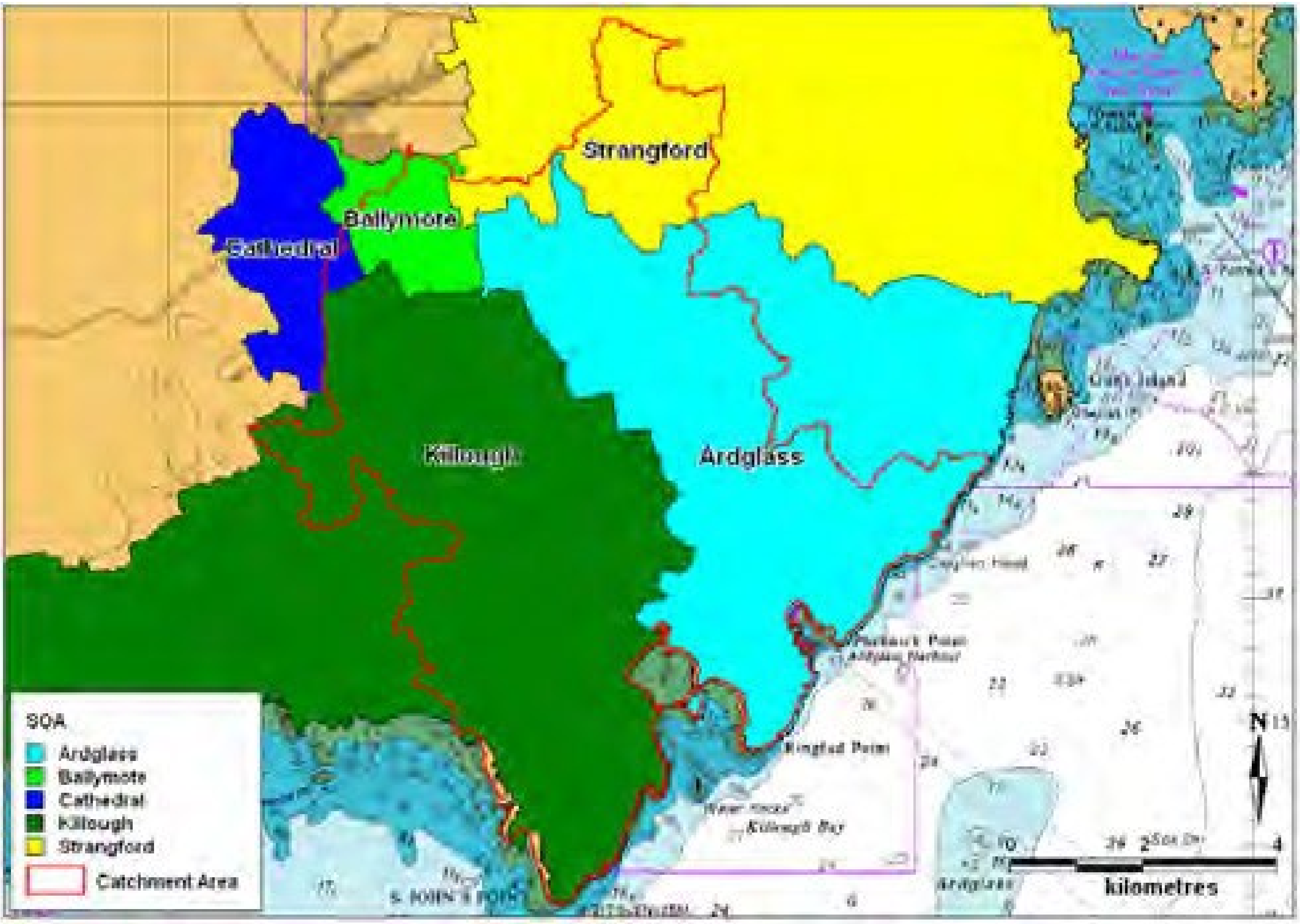

Figure 4.2: SOAs within the Killough Harbour Catchment Area.

Data on human populations for 2009 for Northern Ireland were obtained from The Northern Ireland Statistics and Research Agency (NISRA) website (NISRA, 2011a). Figure 4.3 shows the human population 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 3,095 people in Ardglass SOA (located along the eastern shore of the Harbour) to 4,206 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 1,605 people (NISRA, 2011b). The total population within the Killough Harbour catchment is approximated at between 6,800 and 7,300 people[2].

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.

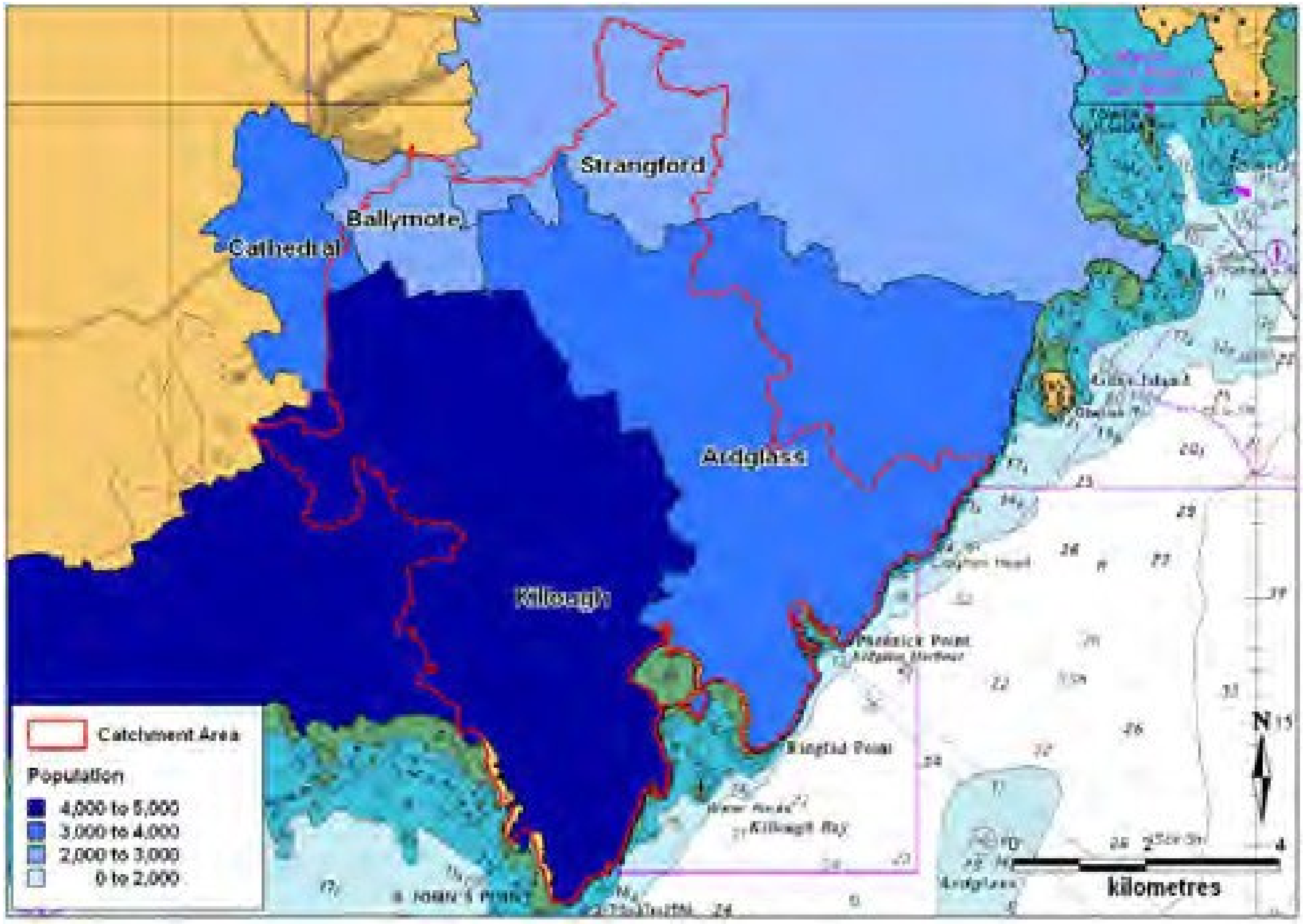

Figure 4.3: Human population within the Killough Harbour Catchment Area (Source: NISRA, 2011a).

Table 4.1: Human population within the Killough Harbour Catchment Area (Source: NISRA, 2011a).

SOA	Population
Strangford	2,524
Ballymote	2,756

[2] 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.

SOA	Population
Killough	4,206
Cathedral	3,410
Ardglass	3,095

4.1.2. Tourism

In 2009, 1,918,000 tourists visited Northern Ireland (NITB {Northern Ireland Tourist Board}, 2009) compared with 2,076,000 in 2008. This was the lowest figure recorded since 2004 and is a 3.4% decrease on 2004 figures and a 7.6% decrease on 2008 numbers. Of these tourists, 47% were visiting family and friends and 26% were holidaying, 32% of them arrived in between July and September and 26% of them arrived between April and June and 59% stayed with family or friends while 27% stayed in a hotel. A NITB local authority survey revealed that in 2009, 265,000 trips were made to Down[3] with an estimated value of £40.2 million (NITB, 2010). This represents approximately 11% of the visitors who visited Northern Ireland in 2009.

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 is very little in the way of tourist activities/facilities in the Killough Harbour catchment area (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 a number of slipways in the Harbour area.

[3] Killough Harbour makes up a very small part of the Down district council area.

Figure 4.4: 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). All seasons had ≥12 results and all were used in this analysis. Box-plots are frequently used to assess and compare sample distributions of microbiological data.

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. Outliers (large and small) are represented by an asterisk.

This analysis revealed that as expected there was no seasonal significant differences between *E. coli* levels in both oyster and mussel flesh. This implies that any population increases during the summer months due to tourists does not impact upon water and therefore shellfish quality.

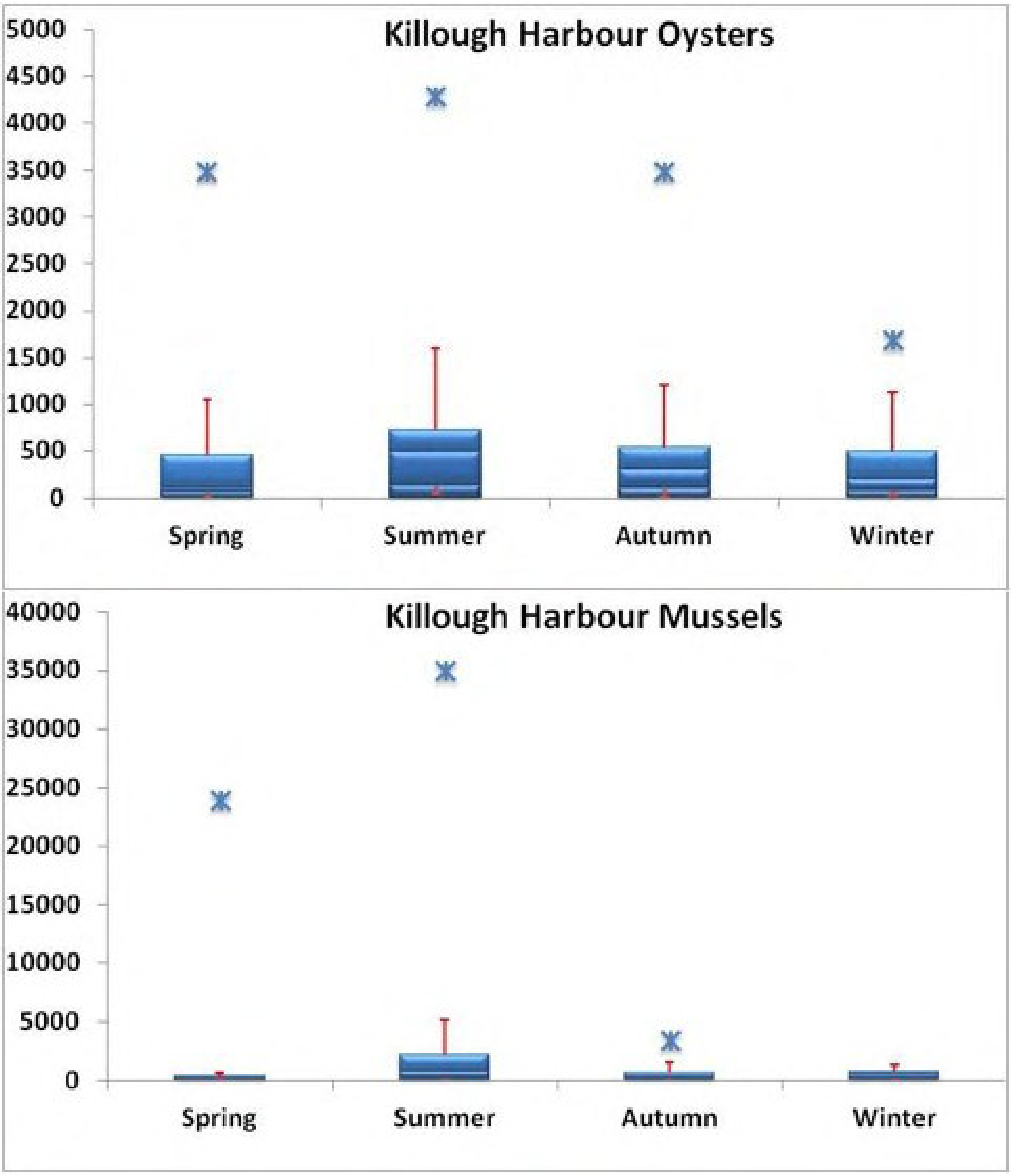

Figure 4.5: Seasonal variation of *E. coli* in oyster and mussel flesh from Killough Harbour.

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 (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.

4.1.3.1. Continuous Sewage Discharges

There are four 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. Figure 4.6 shows the locations of these WWTWs and the locations of their continuous sewage discharge pipes. Killough WWTW discharges into the outer part of Killough Bay, Coney Island WWTW discharges into Coney Island Bay and Donard View (Ballee) and Ballynagross WWTWs discharge into unnamed streams which flow ultimately into Strand Lough and then Killough Harbour. The p.e. (population equivalent) of Killough WWTW is 1445.

In addition, there are six Waste Water Pumping Stations (WWPSs) and three Sewage Pumping Stations (SPS) located within the catchment area. The locations of these pumping stations can also be seen in Figure 4.6.

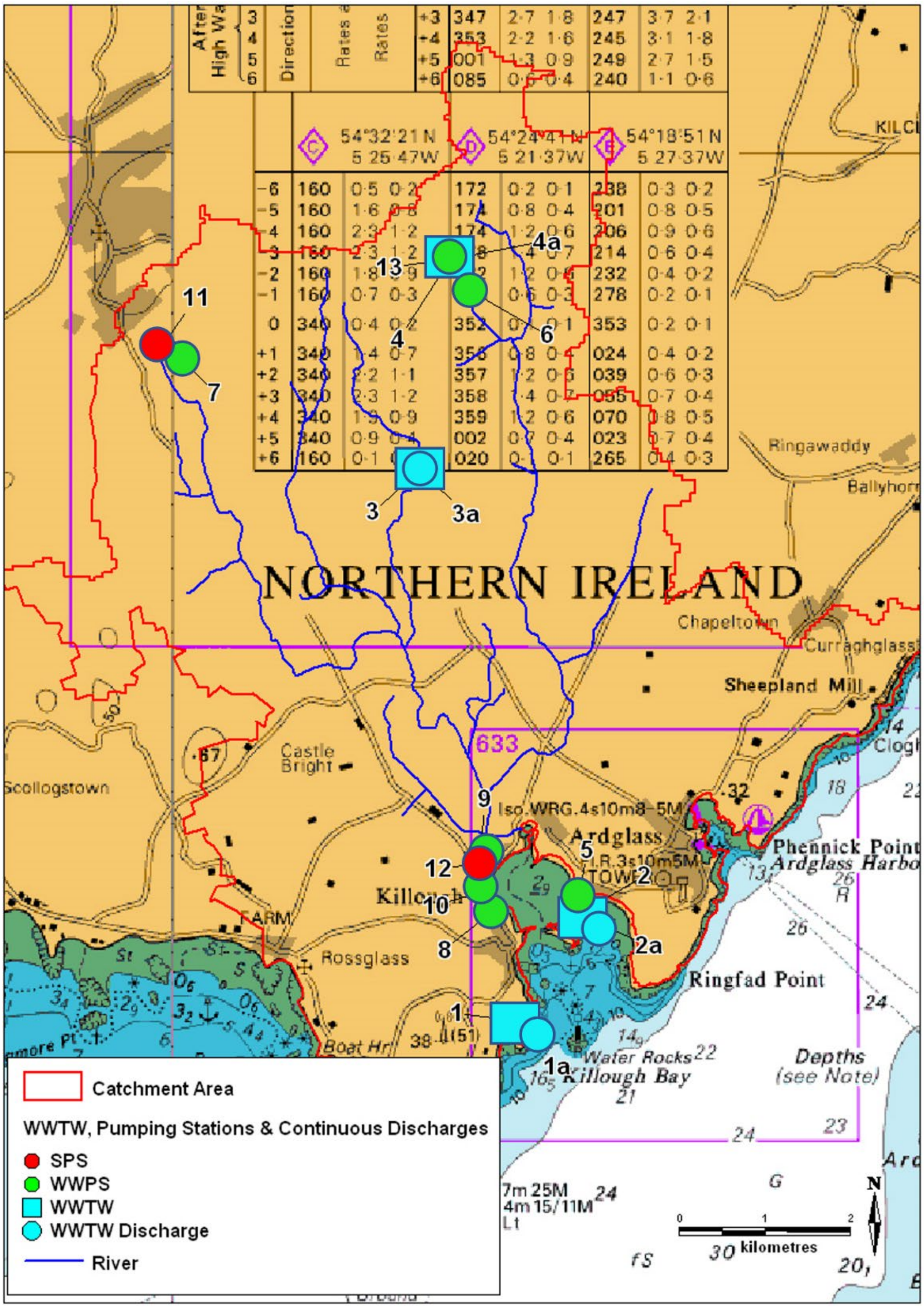

Figure 4.6: Location of WWTWs, WWPS, SPS and continuous discharges within the Killough Harbour Catchment Area (Source: NIEA Water Management Unit, NI Water, www.nimap.net).

Table 4.2: WWTWs, WWPS, SPS and continuous discharges within the Killough Harbour Catchment Area (Source: NIEA Water Management Unit,NI Water, www.nimap.net).

Map ID	Name	Feature	Easting	Northing	Longitude	Latitude	p.e	Treatment	FFT/m³ /day	DWF/m³ /day	Discharge Data
1	Killough WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1445	N/A	N/A	N/A	N/A
2	Coney Island WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
3	Donard View/Ballee WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
4	Ballynagross WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	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/Ballee WWTW	WWTW Discharge	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
4a	Ballynagross WWTW	WWTW Discharge	[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	Ballynagross WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
7	Flying Horse WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
8	Killough Village 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	Killough Shore WWPS*	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
11	Flying Horse Road SPS	SPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
12	Downpatrick Road SPS	SPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
13	Ballynagross SPS	SPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A

* Indicates the coordinates were estimated. N/A indicates data was Not Available. FFT = Flow to Full Treatment. DWF

4.1.3.2. Rainfall Dependent Sewage Discharges

Figure 4.7 shows the Combined Sewer Overflows (CSO) which discharge into Killough Harbour or a tributary of it and Table 4.3 gives their coordinates. Figure 4.7 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
14	Main Street Killough CSO	Combined Overflow	353636	336596	-5.64335	54.2552
15	Quay Lane	Combined Overflow	354019	336114	-5.63772	54.2507
16	Charlie Shiels	Septic Tank	353504.9	336088.8	-5.64562	54.2506

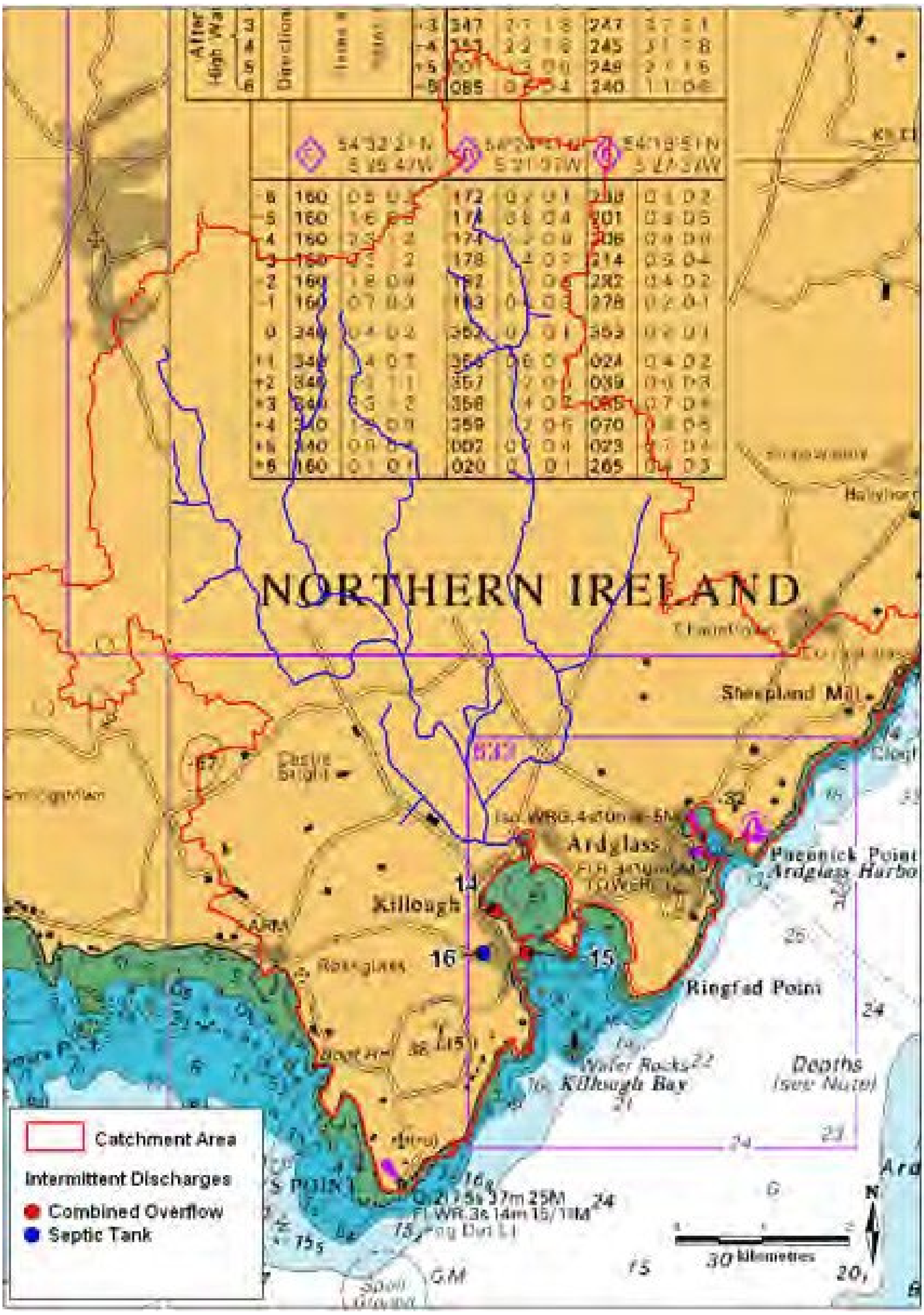

Figure 4.7: All intermittent discharges within the Killough Harbour Catchment Area (Source: NI Water, NIEA Water Management Unit).

4.1.3.3. 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 4.6 and 4.7 above have emergency flows associated with them.

4.1.4. Industrial Discharges

There are no industrial discharges for the Killough Harbour catchment area (NIEA, 2011b).

4.1.5. Landuse Discharges

Figure 4.8 shows the Corine land use within the Killough Harbour catchment area. Figure 3.4 (page 15) shows all rivers/streams within the catchment area.

Within the catchment area, land use is dominated by pastures (32.94km^2; 51.6%), followed by complex cultivation patterns (16.18km^2; 25.3%), agriculture/natural vegetation (5.37km^2; 8.4%) and non-irrigated arable land (5.22km^2, 8.2%) (see Figure 4.9). In total, agricultural activities (non-irrigated arable land, pastures, complex cultivation patterns and agriculture/natural vegetation) comprised 93.5% (59.71km^2) of the land use in the area.

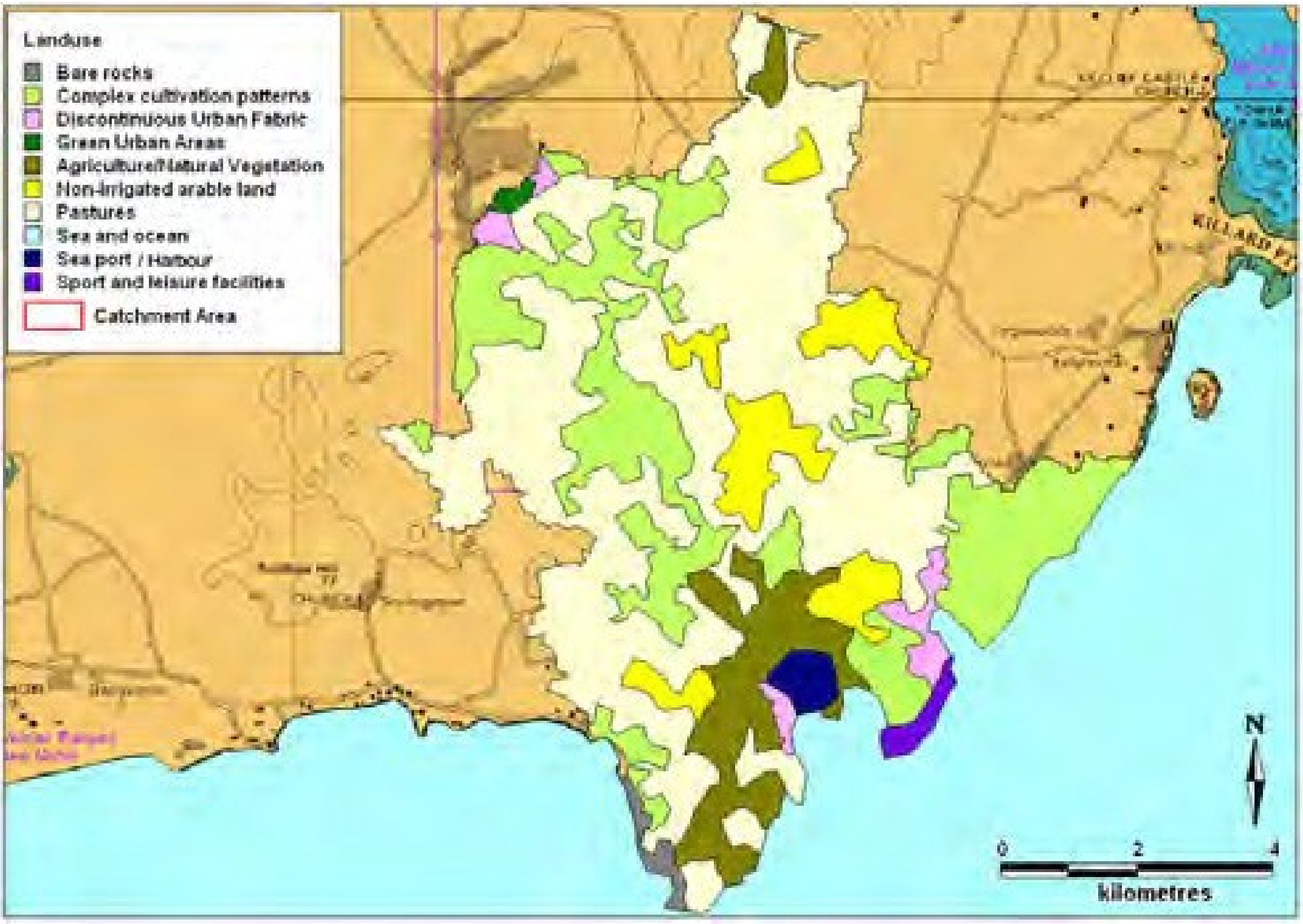

Figure 4.8: Corine land use within the Killough Harbour Catchment Area (Source: The Loughs Agency).

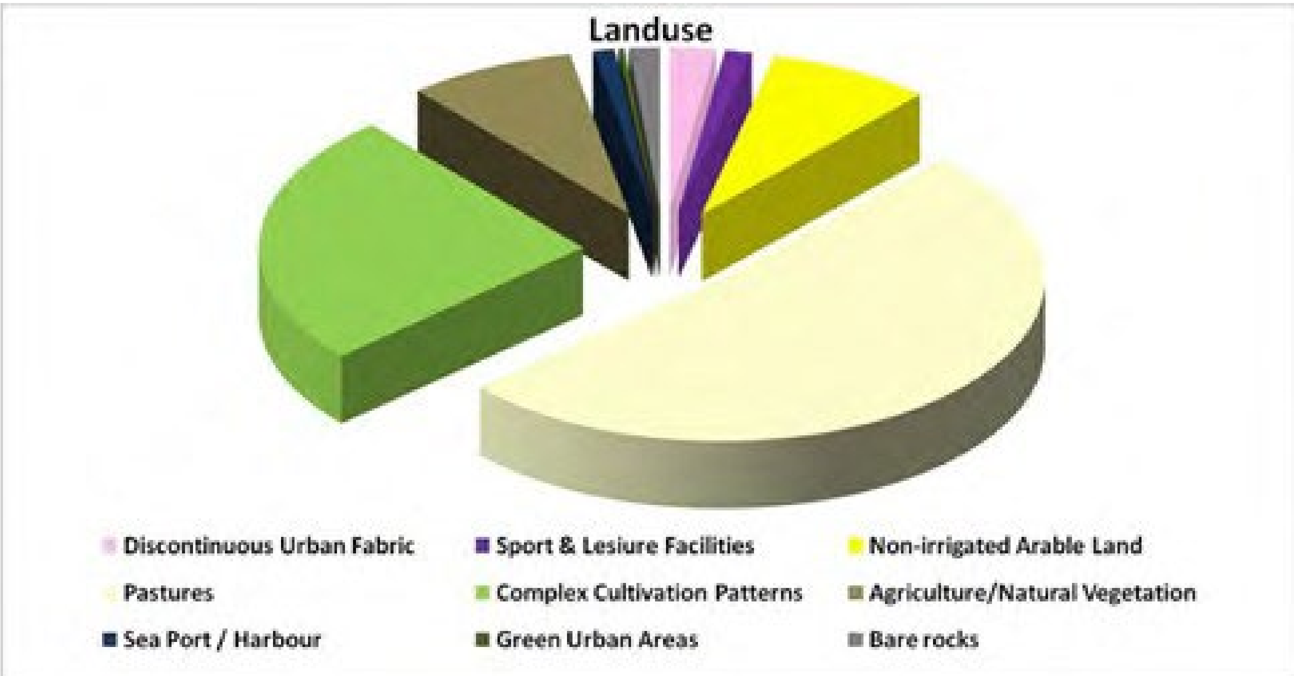

Figure 4.9: Breakdown of land use within the Killough Harbour Catchment Area.

Data from the Department of Agriculture and Rural Development Farm Census 2010 (DARD, 2010) can be seen in Table 4.4 below. Figures 4.10 to 4.17 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, this is of particular importance in relation to Strangford as it contains the highest numbers for a number of the parameters discussed but only 10% of the area lies within the catchment area.

There are no farms or agricultural activity in Ballymote.

Numbers of farms within the catchment area ranged from 7 in Cathedral to 84 in Strangford. The total area farmed within the catchment area varied from 353ha in Cathedral to 4,591ha in Killough. The total crops farmed within the catchment area varied from 173ha in Cathedral to 771 in Killough. Total grass and rough grazing areas within the catchment area ranged from 170ha in Cathedral to 3,783ha in Killough. The total number of cattle within the catchment area ranged from 121 in Cathedral to 10,049 in Strangford. The total number of sheep within the catchment area ranged from 378 in Cathedral to 13,116 in Killough.

Numbers of pigs within the catchment area ranged from 0 in Hollywood Cathedral to 3,915 in Killough. Poultry is only farmed in one of the SOAs: Killough where 41,000 poultry are farmed.

Table 4.4: Farm census data for all SOAs within the Killough Harbour Catchment Area (Source: DARD, 2010).

SOA	No. Farms	Area Farmed (ha)	Total Crops (ha)	Total Grass & Rough Grazing (ha)	Cattle	Sheep	Pigs	Poultry ('000s)
Strangford	84	4445	619	3673	10049	3996	15	0
Ballymote	0	0	0	0	0	0	0	0
Killough	79	4591	771	3783	7827	13116	3915	41
Cathedral	7	353	173	170	121	378	0	0
Ardglass	52	2520	593	1893	4601	2413	5	0

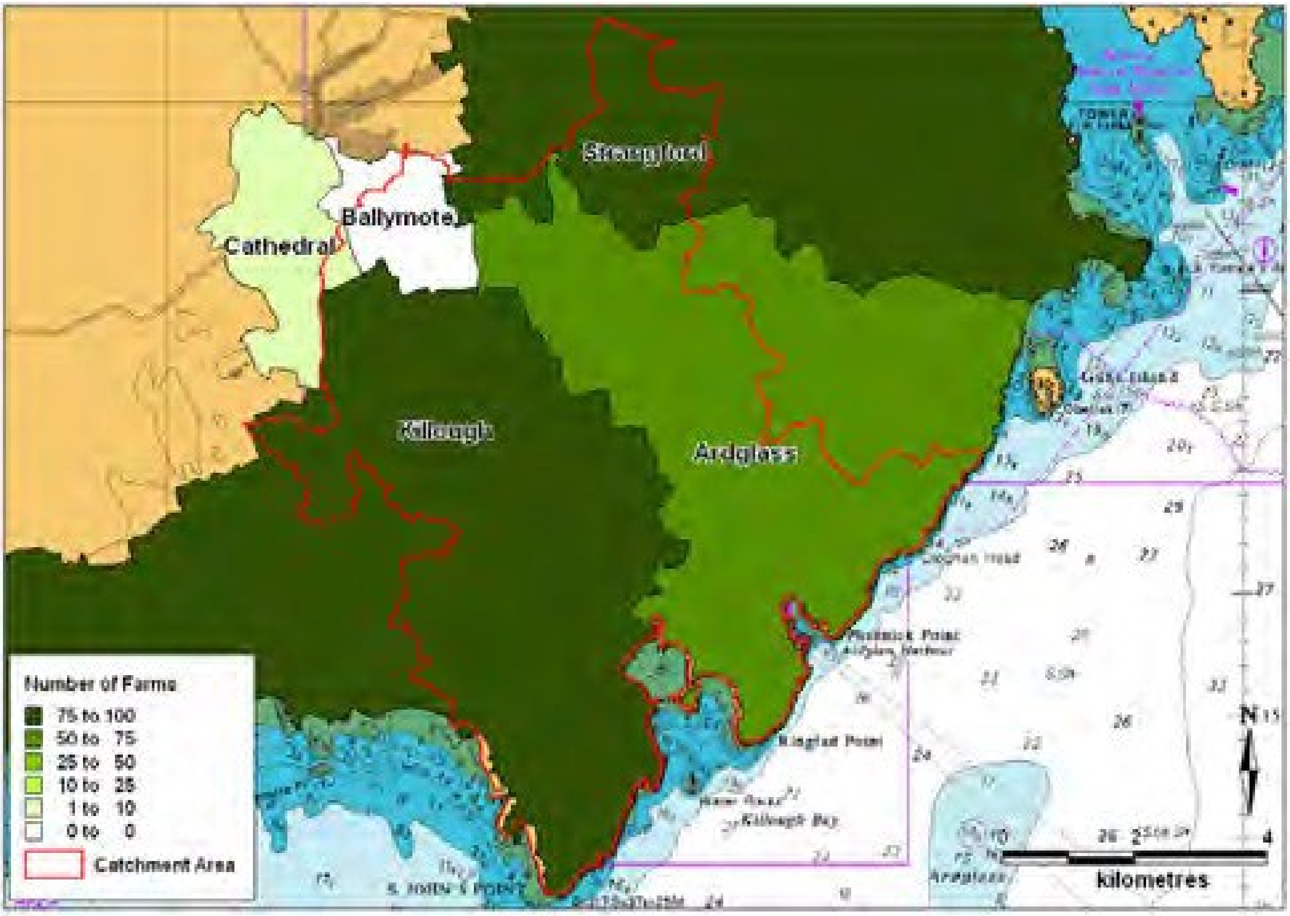

Figure 4.10: Number of farms within the Killough Harbour Catchment Area (Source: DARD, 2010).

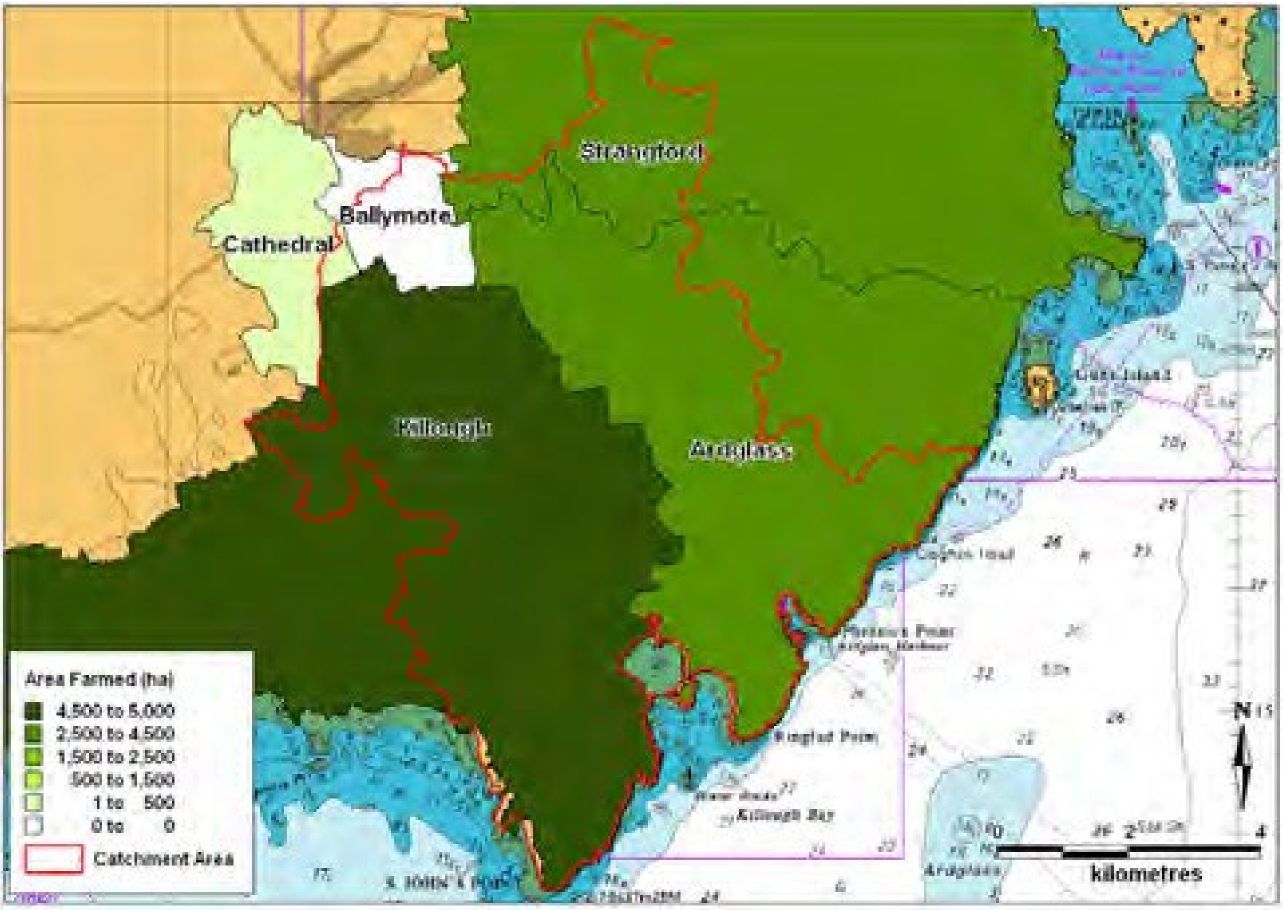

Figure 4.11: Area farmed (ha) within the Killough Harbour Catchment Area (Source: DARD, 2010).

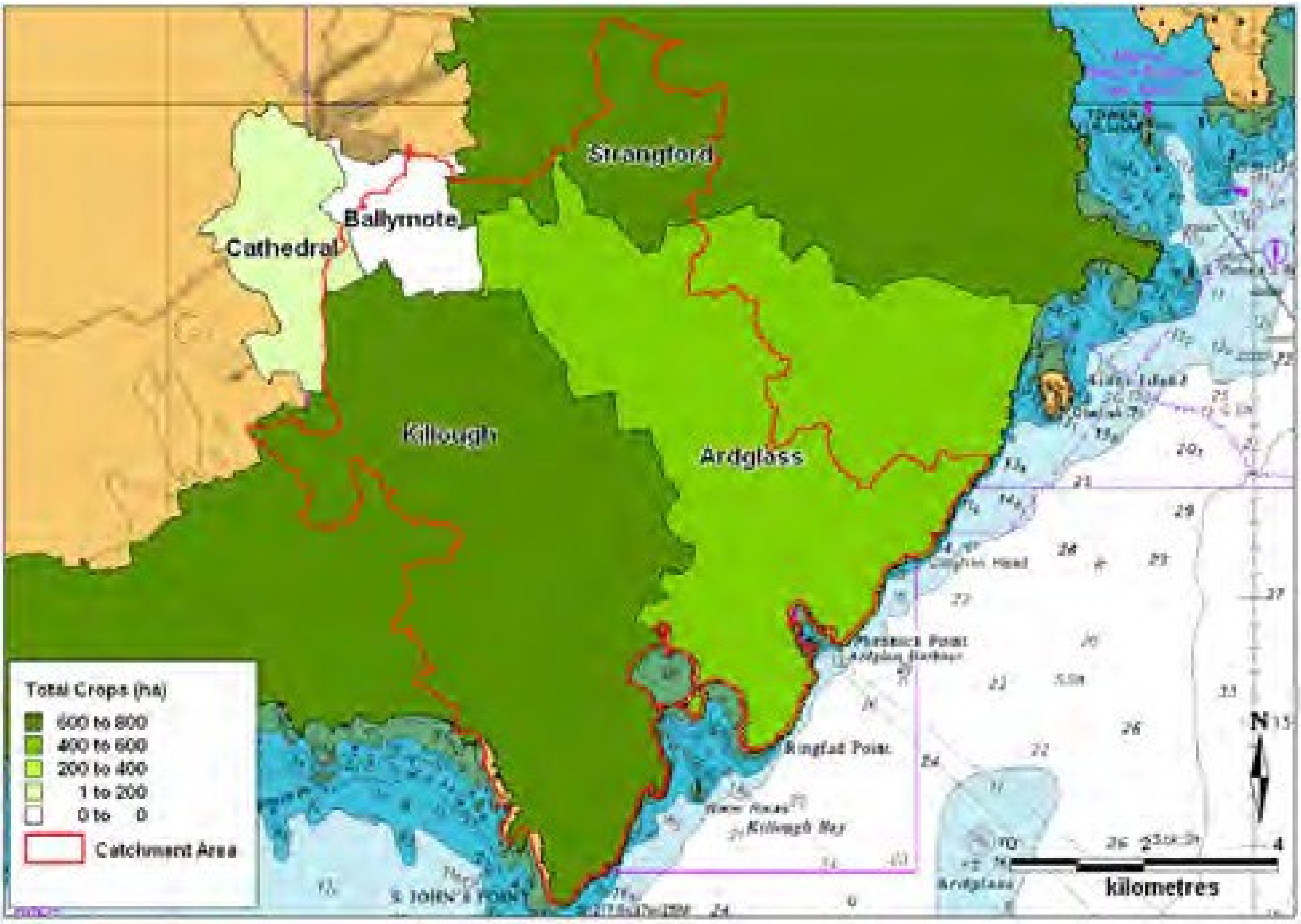

Figure 4.12: Total crops within the Killough Harbour Catchment Area (Source: DARD, 2010).

Figure 4.13: Total grass and rough grazing within the Killough Harbour Catchment Area (Source: DARD, 2010).

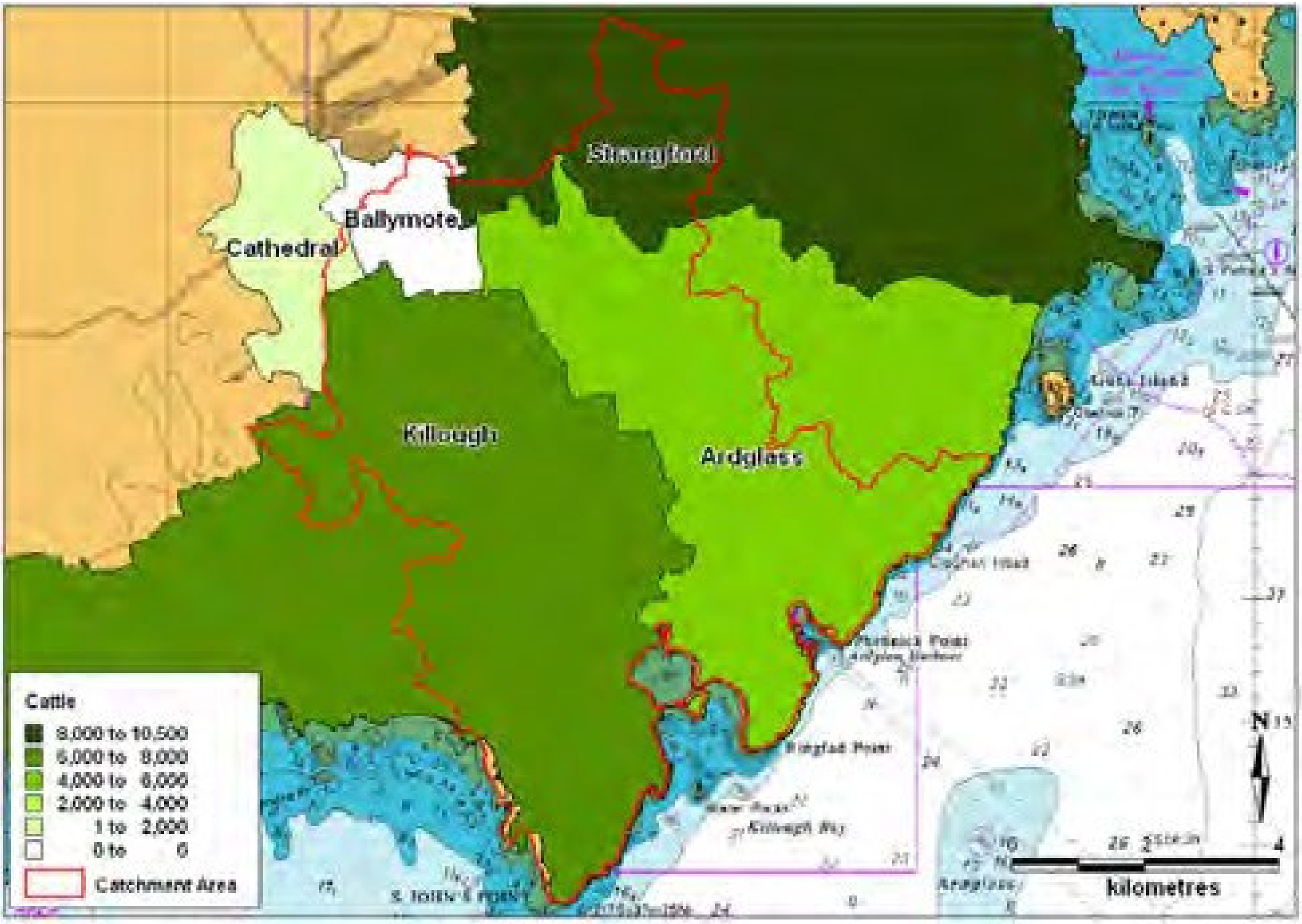

Figure 4.14: Cattle within the Killough Harbour Catchment Area (Source: DARD, 2010).

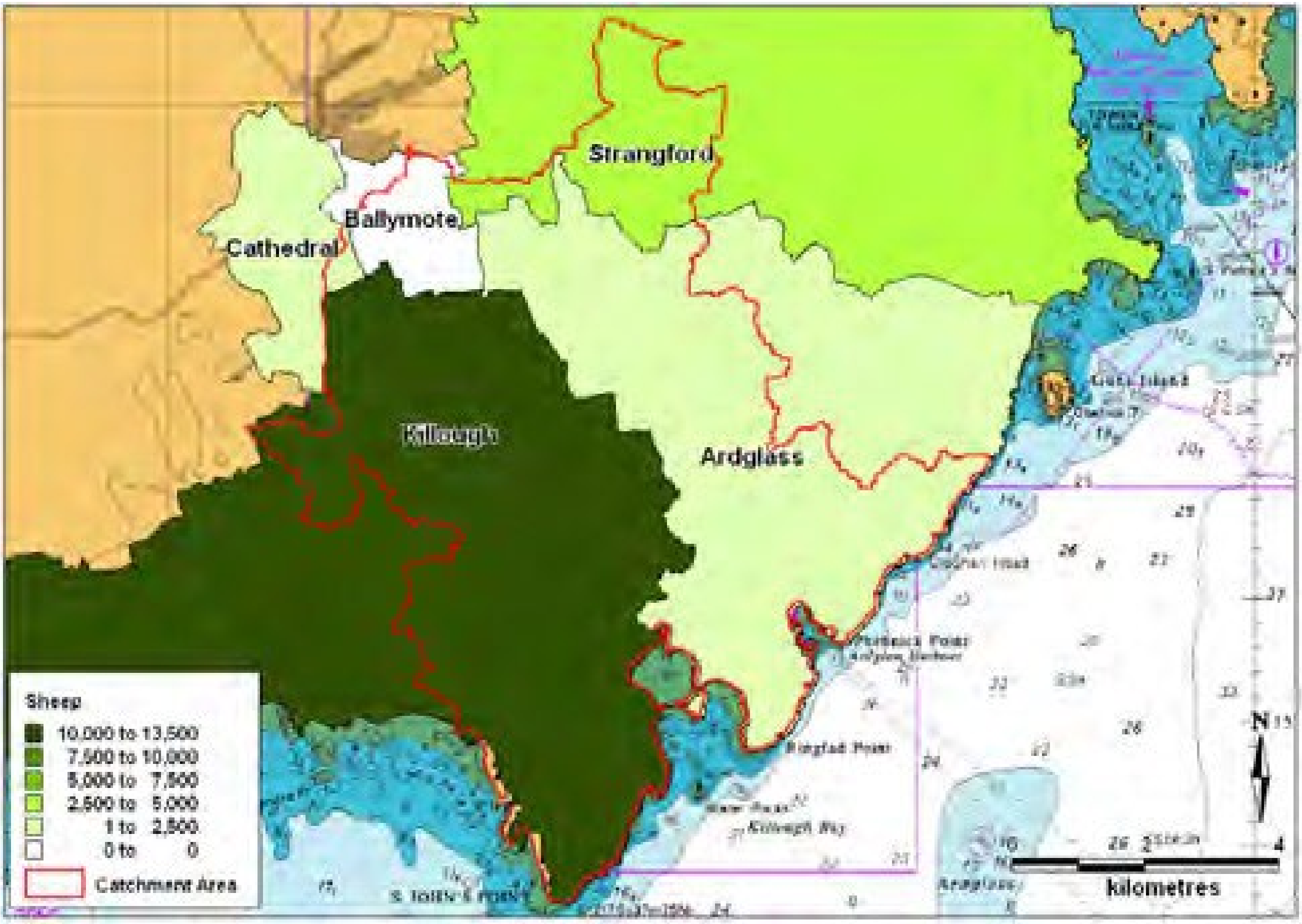

Figure 4.15: Sheep within the Killough Harbour Catchment Area (Source: DARD, 2010).

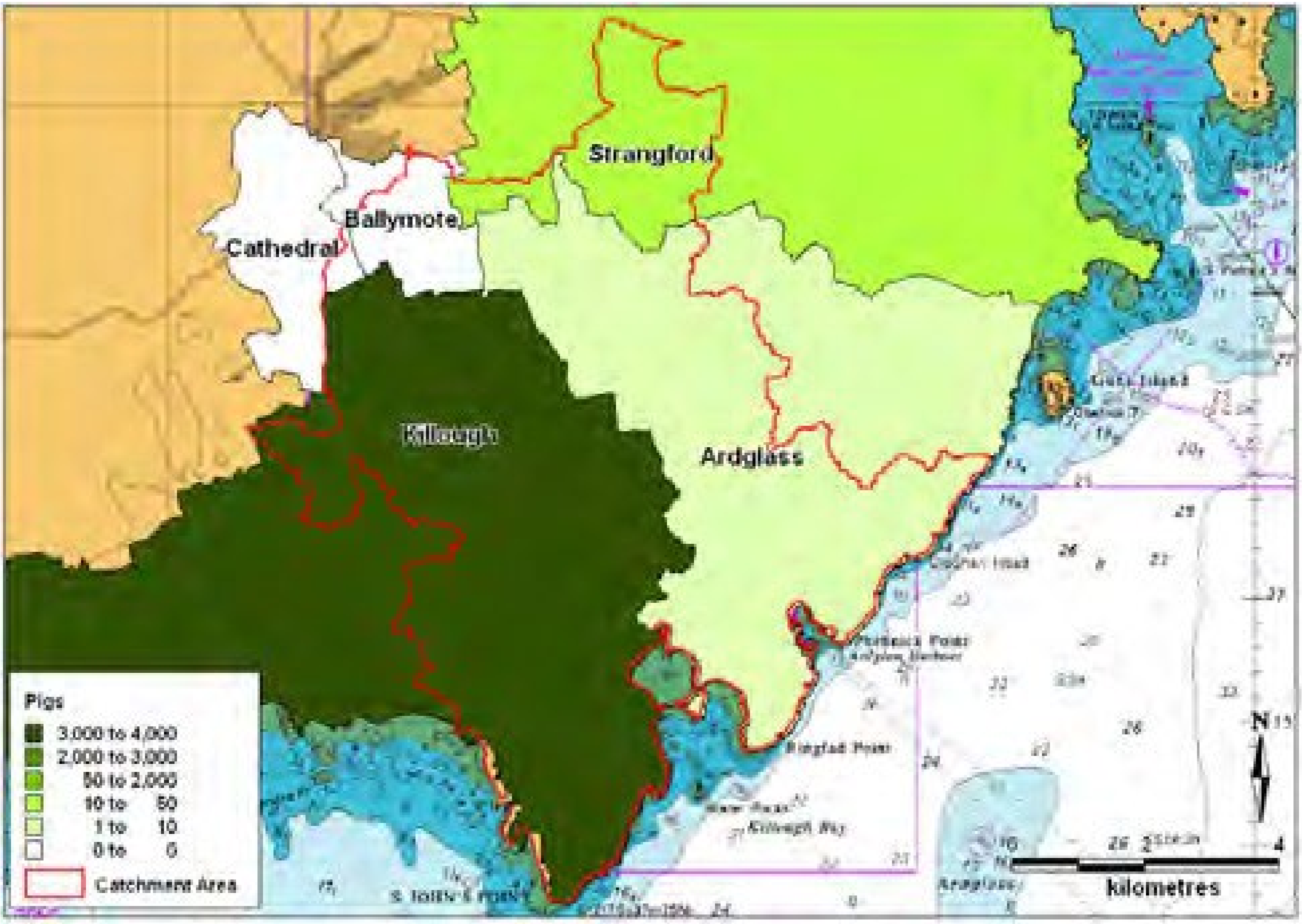

Figure 4.16: Pigs within the Killough Harbour Catchment Area (Source: DARD, 2010).

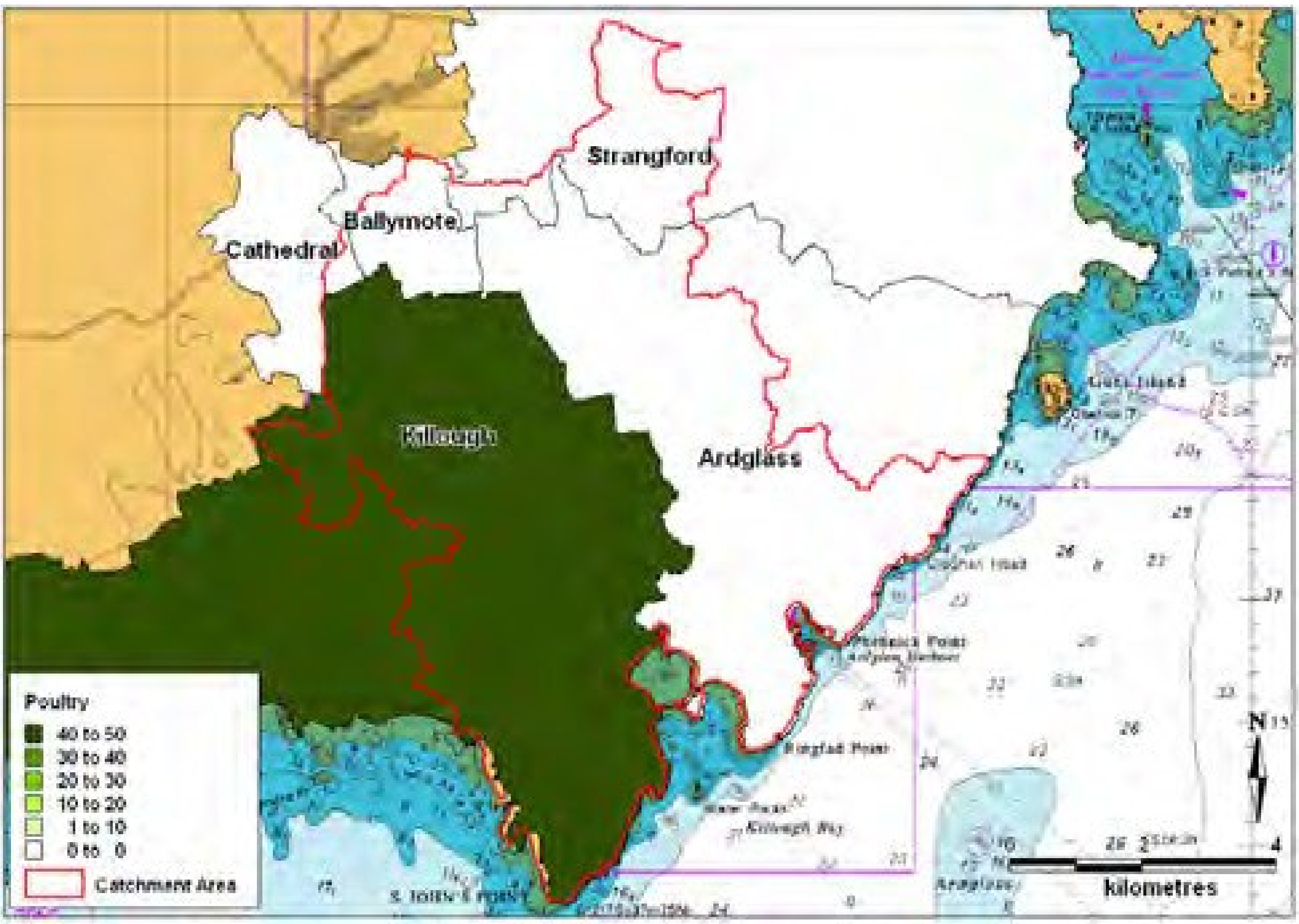

Figure 4.17: Poultry within the Killough Harbour Catchment Area (Source: DARD, 2010).

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).

The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil; SSAFO) Regulations, which came into effect in Northern Ireland on the 21st July 2003 are designed to stop water pollution from agriculture. The purpose of these regulations are to minimise the risk of water pollution from silage, slurry and agricultural fuel oils by setting minimum standards for the construction and maintenance of structures used to store these substances and improve the environment for rural communities in Northern Ireland.

The Nitrates Action Programme (NAP) Regulations (NI) 2006 was introduced on 1st January 2007 to improve the use of nutrients on farms and as a result improve water quality. While this Directive does not legislate for faecal coliform contamination, they do place restrictions on manure spreading. Farmers can spread manure between 1st February and the 15th October each year, weather and ground conditions permitting:

- $50m^3$/ha is permitted on a single application and no further application for 3 weeks;
- Crop nitrogen requirements must be taken into consideration when the manure is spread;
- The farm nitrogen loading must not exceed 170 kg/ha/yr or 250 kg/ha/yr for a derogated farm;
- The manure must be spread 10m back from waterways (except for a number of exceptions); and
- Manure must be spread in a uniform manner.

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 harbour 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).

There is only one operational pier in Killough Harbour and there is one slipway beside it. The pier is used for leisure and fishing activites 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.

4.1.6.2. Birds

It is important to document the bird populations in the Killough Harbour 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 4.18 shows the locations of the Killough Harbour Special Protection Areas (SPA) and Ramsar Site. The Killough Harbour SPA (Site Code: UK9020221) and the Killough Harbour Ramsar Site (Site Code: UK12012) encompass the entire harbour and extends out to cover Coney Island Bay also. This site is of importance as a wintering area for Light-bellied Brent geese (*Branta bernicla hrota*). This species had an average of 399 individuals representing 1.1% of the wintering Canada/Ireland population (WeBS [Wetland Bird Survey] 5yr peak mean 05/06-09/10; Holt *et al*., 2011). This species feeds on the rich mats of green algae *Entromorpha* spp. which are present especially in Killough Harbour (JNCC, 2008). The birds find refuge here during late winter and spring, once the main wintering flock from Strangford Lough disperses due to lack of food (JNCC, 2008).

Killough Harbour is routinely surveyed by the British Trust for Ornithology (BTO) through the WeBS Project. Table 4.5 shows the most recent results from the wetland bird surveys that are carried out each year.

Table 4.5: Total number of waterbirds in Killough Harbour between 2004/05 and 2008/09 (Source: Holt *et al*., 2011)

Site Name	2005/06	2006/07	2007/08	2008/09	2009/10	Mean
Killough Harbour	4,164	2,838	-	-	-	3,501

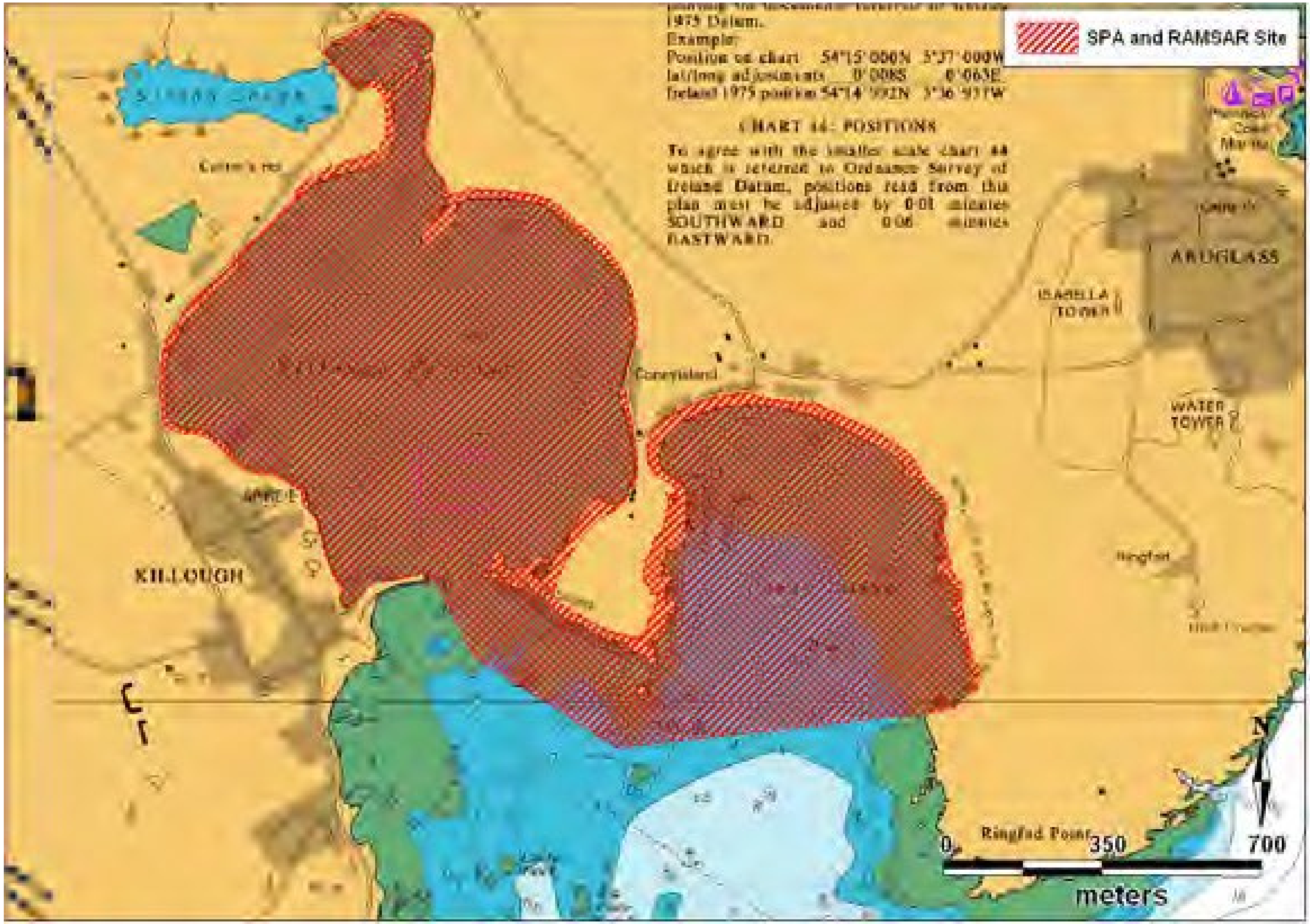

Figure 4.18: Killough Harbour SPA and Ramsar Site.

Bird populations in the Killough Harbour 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 highly probable that the contribution made by wildfowl to pollution levels in Killough Harbour is higher in the winter months. However, it is highly likely that these levels are low when compared with land-based discharges.

4.1.6.3. Pollution Incidences

In 2009, there were 143 substantiated water pollution incidents in the wider Strangford catchment area, which includes the Killough catchment area (NIEA, 2009). Eleven were from industrial source, 13 from farm sources, 71 were sourced from NI Water Ltd, 27 from domestic sources, 1 from transport sources and 20 from other sources. Twelve of the incidents were agricultural in nature, 90 were sewage related, 18 were oil related, 3 were non agricultural waste discharges, 1 was due to a breach of consent and 19 were classified as others. The cause of the incidents ranged from deliberate dumping (4), a breach of consent (4), an accident/emergency (22), equipment failure (44), inadequate equipment (9), negligence (7), poor work practice (21), the weather (10), unknown causes (18) and other causes (4). Of the 143 incidents, 107 were of low severity and 36 were of medium severity. The locations of these incidents were unavailable.

4.2. Shoreline Survey Report

The aim of this shoreline survey was to identify, confirm and mark all discharges, pollution sources, waterways and marinas along the shoreline. A desk-based review of all river/stream discharges, slipways/piers and outfall pipes was carried out using aerial photographs and OS planning maps accessed through www.nimap.net and from admiralty charts for the area. Figure 4.19 shows the freshwater flow, piers, sewers, discharge pipes, runoff, sinks and slipways in Killough Harbour. Figure 4.19 also shows a number of features which require groundtruthing in the field. The shoreline survey was carried out on the 31st January 2012 by Dr. Mark Costelloe and Gary Ridge (AQUAFACT). A number of the locations shown in Figure 4.19 were groundtruthed and photographed in the field. The shoreline survey was carried out by driving the coastal route around the Harbour and walking some sections of the intertidal (See Figure 4.20). All features seen in Figure 4.19 were pre-loaded on to a hand-held GPS (Global Positioning System) unit and were navigated to, confirmed and photographed. In addition, any new features not previously identified were photographed and a GPS reading taken. Notes were made on the numbers and types of farm animals obvious from the shoreline and on wild fowl/populations of wild animals with an estimation of their numbers.

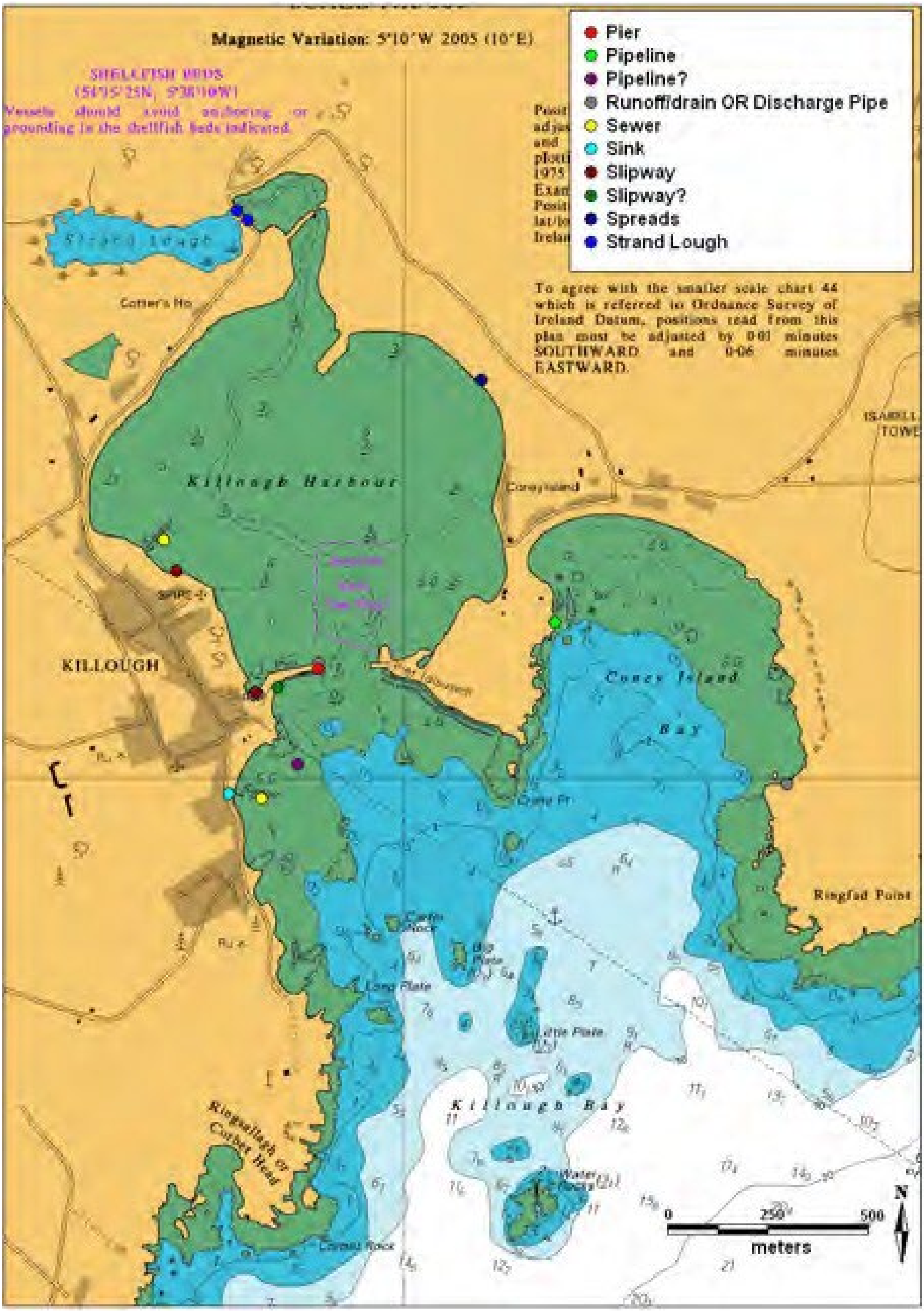

Figure 4.19: Locations of freshwater sources, piers, slipways, sinks, sewers, discharge pipes and runoff /drainage channels identified from the desk-based assessment.

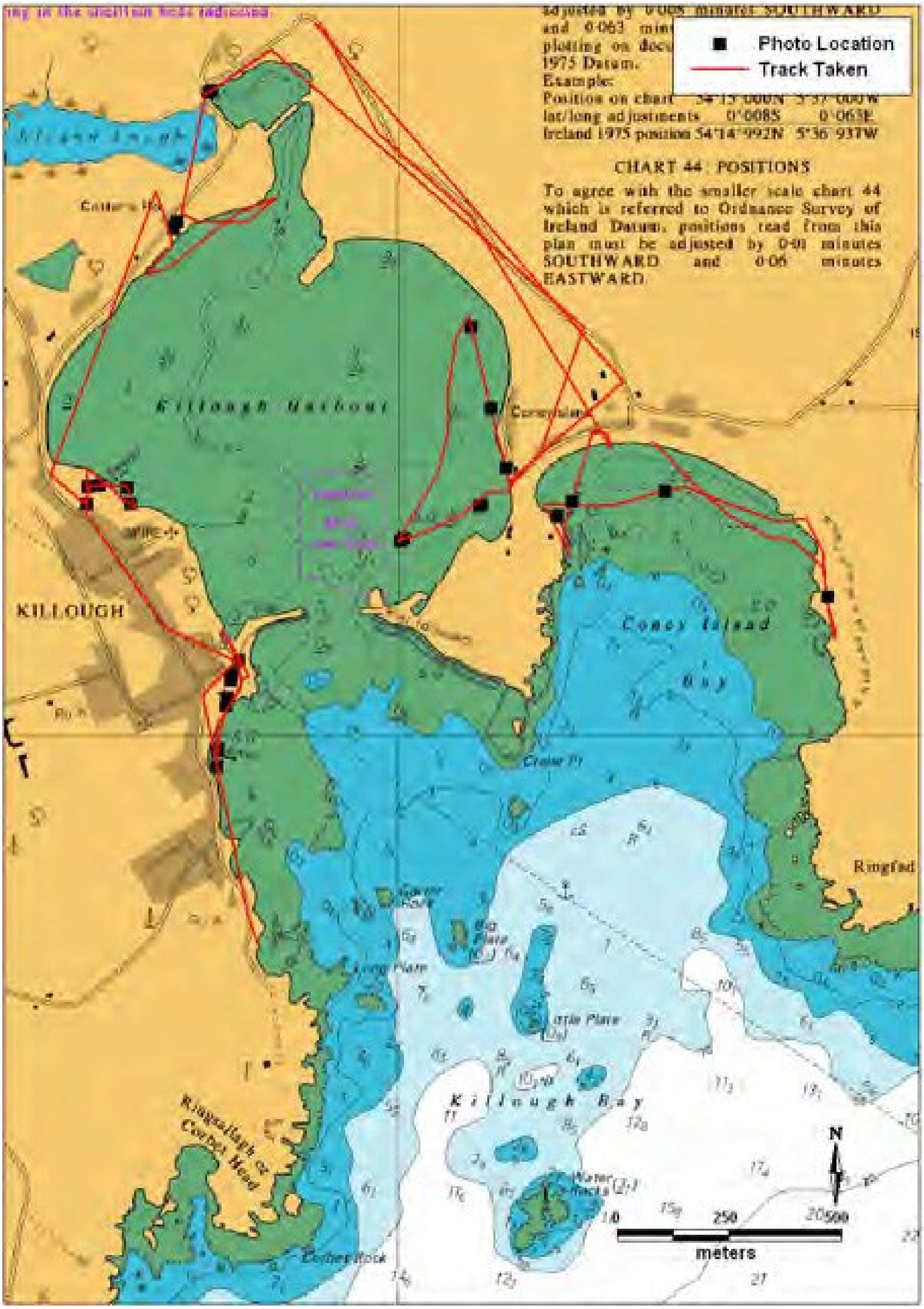

Figure 4.20: Shoreline survey track route and photograph locations.

Figure 4.21 shows the locations of the discharge pipes/outfalls located during the shoreline survey. In total, 12 were identified. Figures 4.22 and 4.23 show images of these outfall/discharge locations.

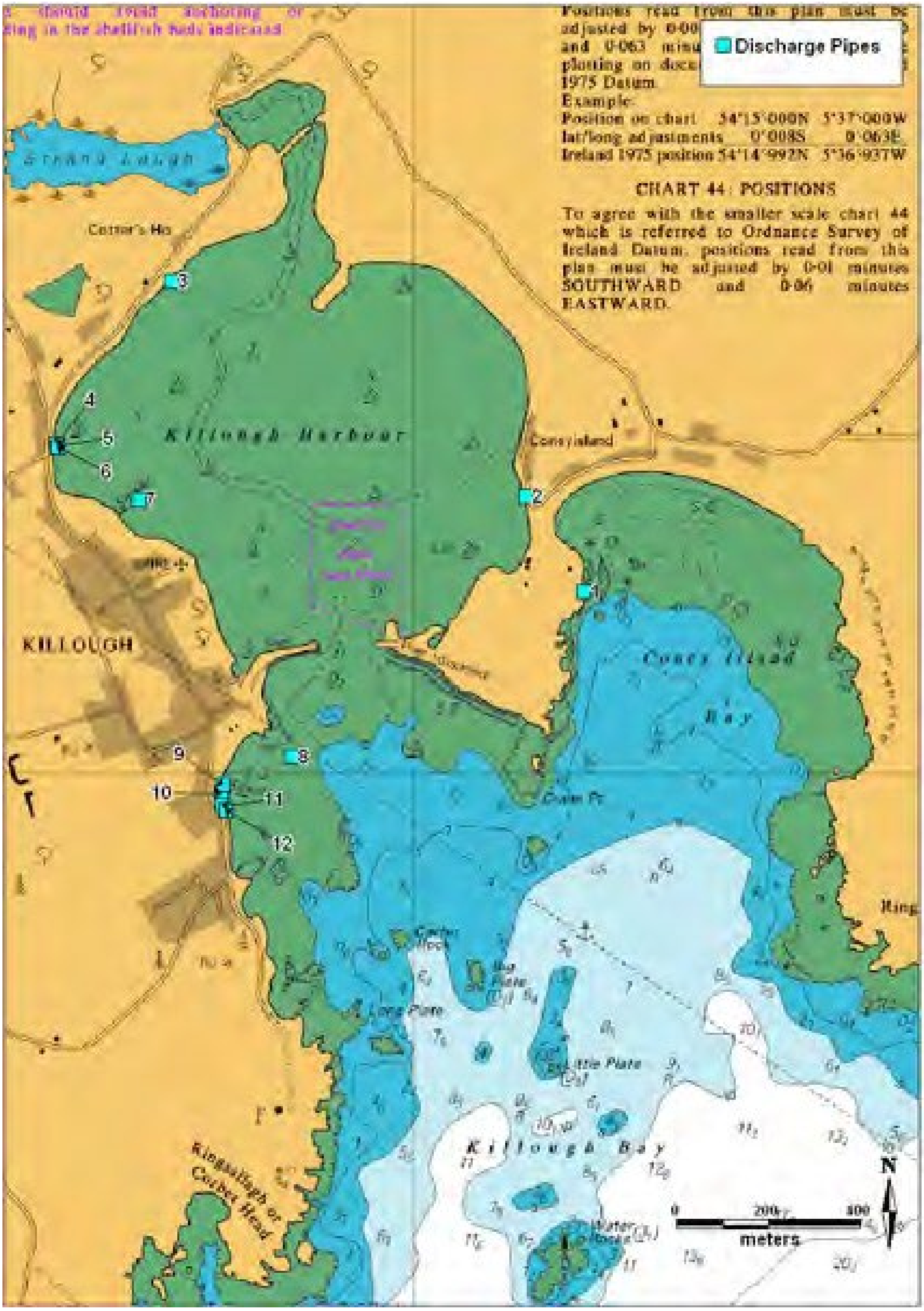

Figure 4.21: Locations of all discharge pipes and outfalls identified in Killough Harbour during the shoreline survey.

Figure 4.22: Discharges/Outfalls located during the shoreline survey. Refer to Figure 4.21 for locations.

Figure 4.23: Discharges/Outfalls located during the shoreline survey. Refer to Figure 4.21 for locations

Figure 4.24 shows the locations of the rivers, streams and runoff located during the shoreline survey. In total, 8 were identified. Figure 4.25 show images of these sites.

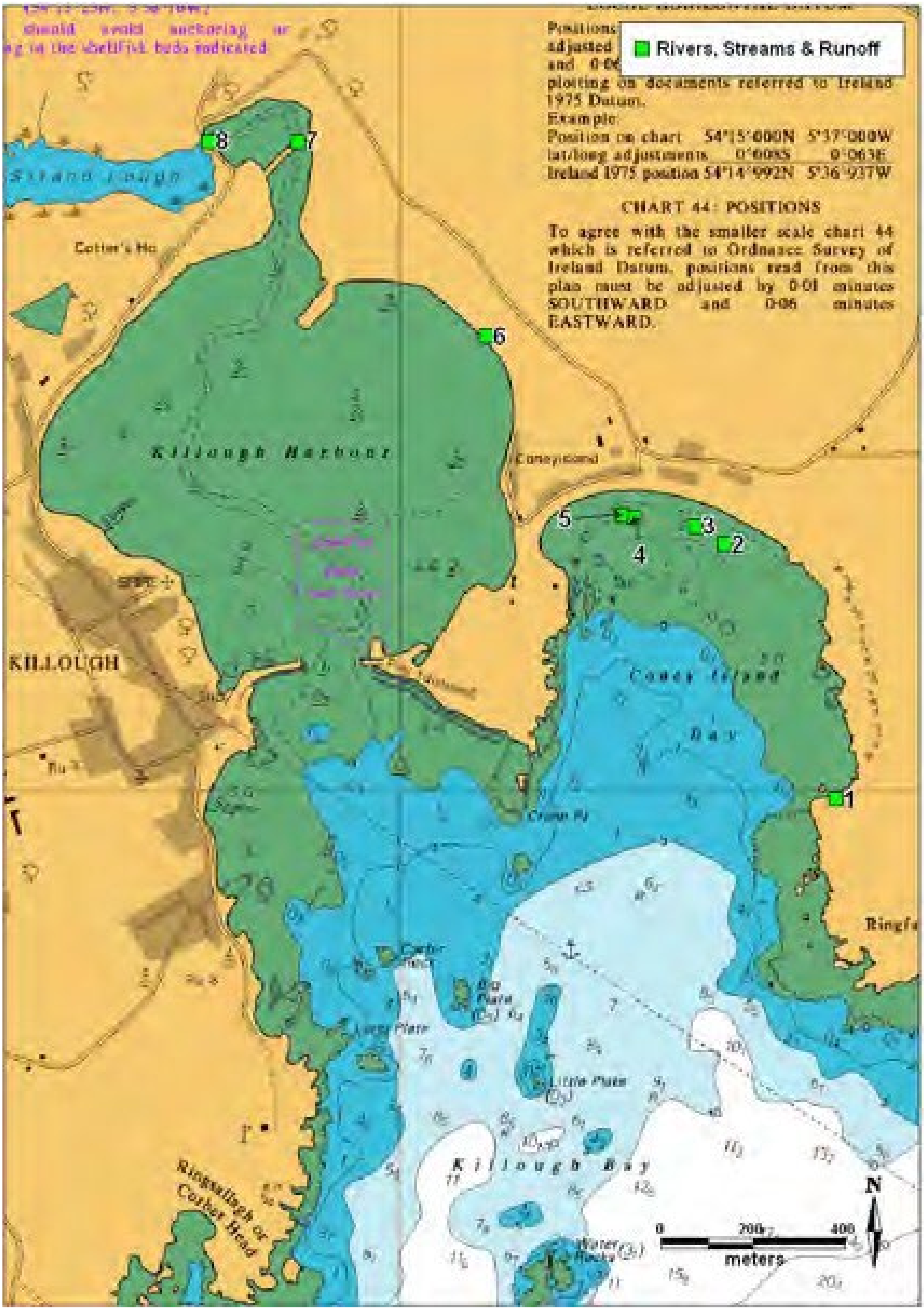

Figure 4.24: Rivers, streams and run-off located during the shoreline survey.

Figure 4.25: Rivers, Streams and Runoff located during the shoreline survey. Refer to Figure 4.24 for locations.

Figure 4.26 shows the locations of the piers, slipways and shore access points located during the shoreline survey. In total, 5 were identified. Figure 4.27 show images of these sites.

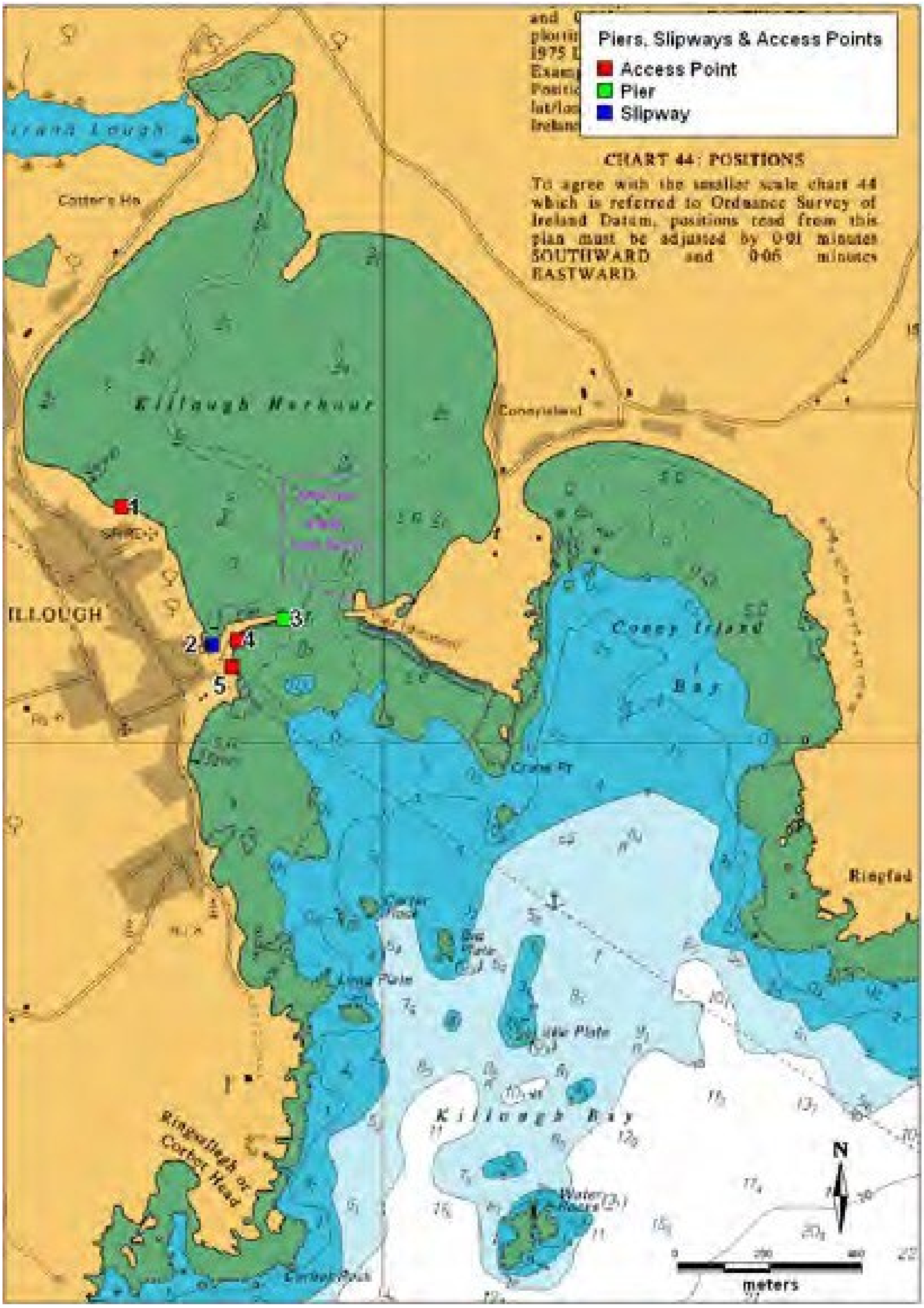

Figure 4.26: Piers, Slipways and Access Points located during the shoreline survey.

Figure 4.27: Piers, slipways and access points located during the shoreline survey. Refer to Figure 4.26 for locations.

4.3. Locations of sources

Figure 4.28 shows all watercourses discharging into Killough Harbour and Table 4.6 provides cross-referenced details for this map. Figure 4.29 shows all treatment and pumping stations (WWTW, WWPS and SPSs) and continuous discharges discharging into Killough Harbour or a tributary of it and Table 4.7 provides cross-referenced details for this map. All of the discharges identified from the shoreline survey were classified as intermittent (except those associated with sewage/water treatment works). Figure 4.30 shows all intermittent discharges, overflows and septic tanks discharging into Killough Harbour and Table 4.8 provides cross-referenced details for this map.

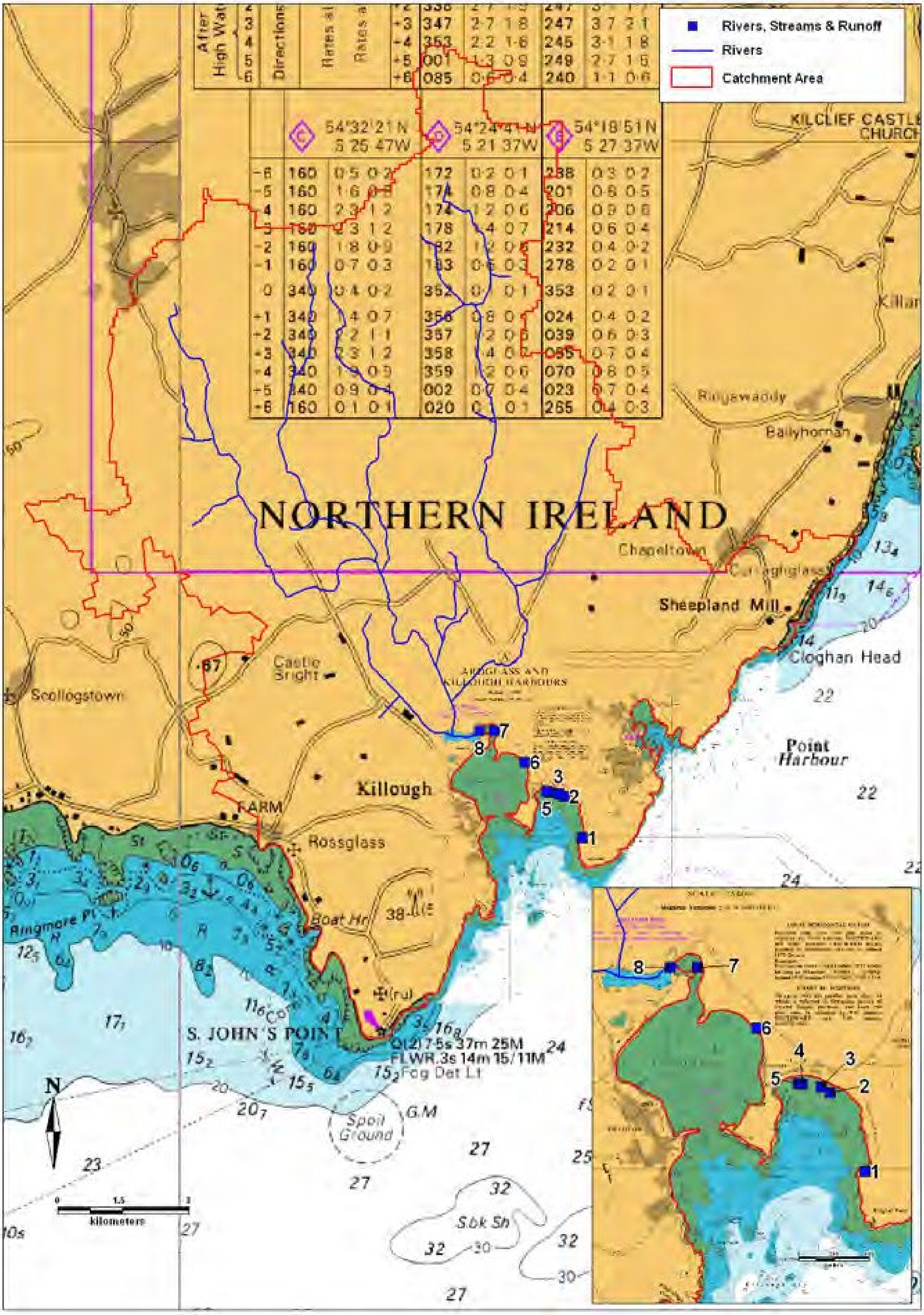

Figure 4.28: Location of all watercourses discharging into Killough Harbour.

Table 4.6: Cross-referenced table for Figure 4.28 Watercourses.

Map ID	Name	Longitude	Latitude	Easting	Northing
1	Golf Course Runoff	-5.61869	54.24984	355262.6	336058.9
2	Shore Runoff	-5.62245	54.25483	354999.1	336605.5
3	Shore Runoff	-5.62343	54.25519	354934	336643.2
4	Shore Runoff	-5.62547	54.25535	354800	336656.8
5	Shore Runoff	-5.62592	54.25541	354770.9	336662
6	Stream	-5.63039	54.2589	354466.3	337041.3
7	Strand Lough	-5.6367	54.26272	354040.9	337452
8	Strand Lough	-5.6397	54.26271	353845.9	337445.1

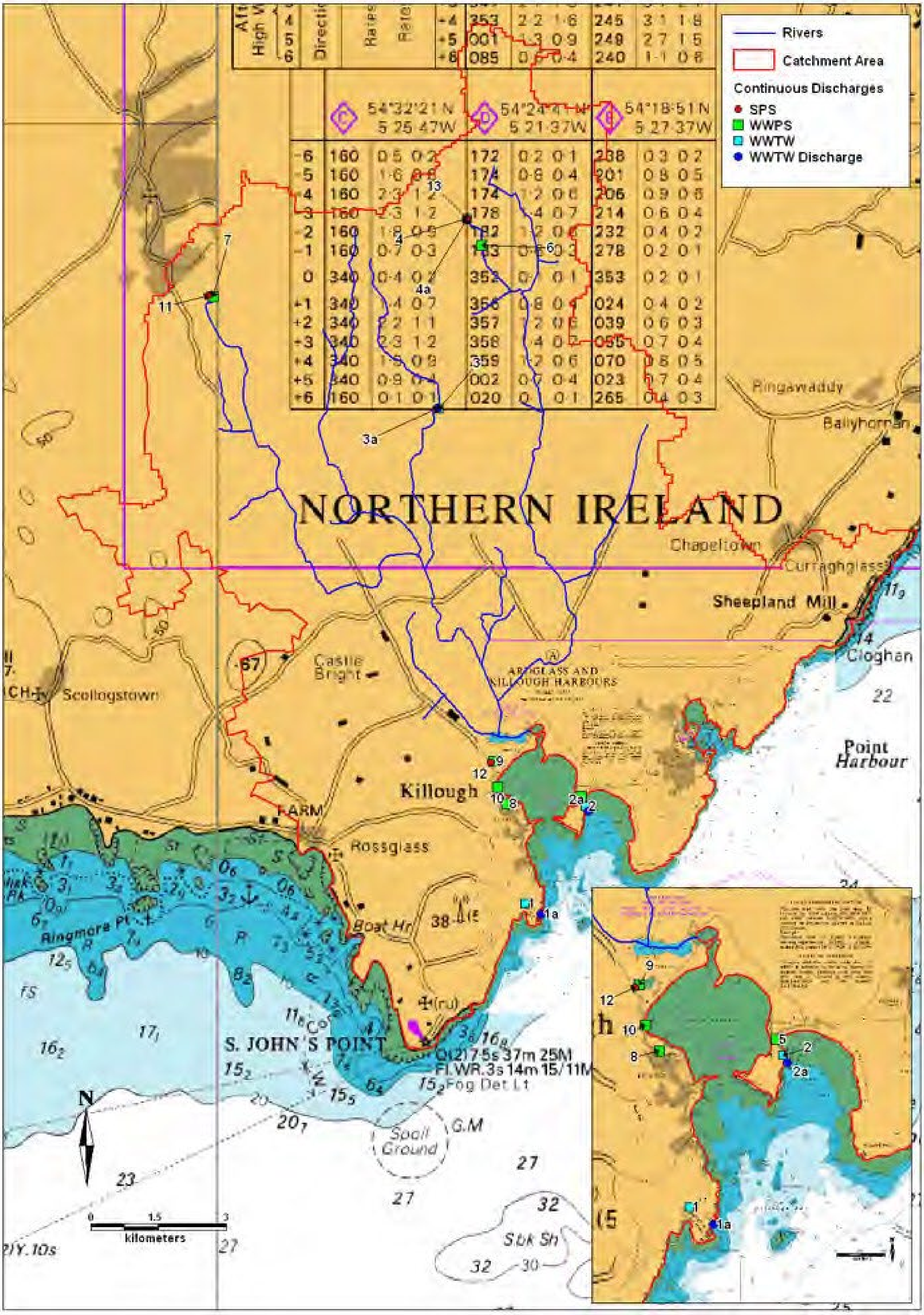

Figure 4.29: All WWTW, WWPS, SPS and continuous discharges flowing into Killough Harbour.

Table 4.7: WWTWs, WWPS, SPS and continuous discharges within the Killough Harbour Catchment Area (Source: NIEA Water Management Unit, I Water, www.nimap.net).

Map ID	Name	Feature	Easting	Northing	Longitude	Latitude	p.e	Treatment	FFT/m^3 /day	DWF/m^3 /day	Discharge Data
1	Killough WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1445	N/A	N/A	N/A	N/A
2	Coney Island WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
3	Donard View/Ballee WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
4	Ballynagross WWTW	WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	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/Ballee WWTW	WWTW Discharge	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
4a	Ballynagross WWTW	WWTW Discharge	[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	Ballynagross WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
7	Flying Horse WWPS	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
8	Killough Village 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	Killough Shore WWPS*	WWPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
11	Flying Horse Road SPS	SPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
12	Downpatrick Road SPS	SPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A
13	Ballynagross SPS	SPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A	N/A	N/A

* Indicates the coordinates were estimated. N/A indicates data were Not Available. FFT = Flow to Full Treatment. DW

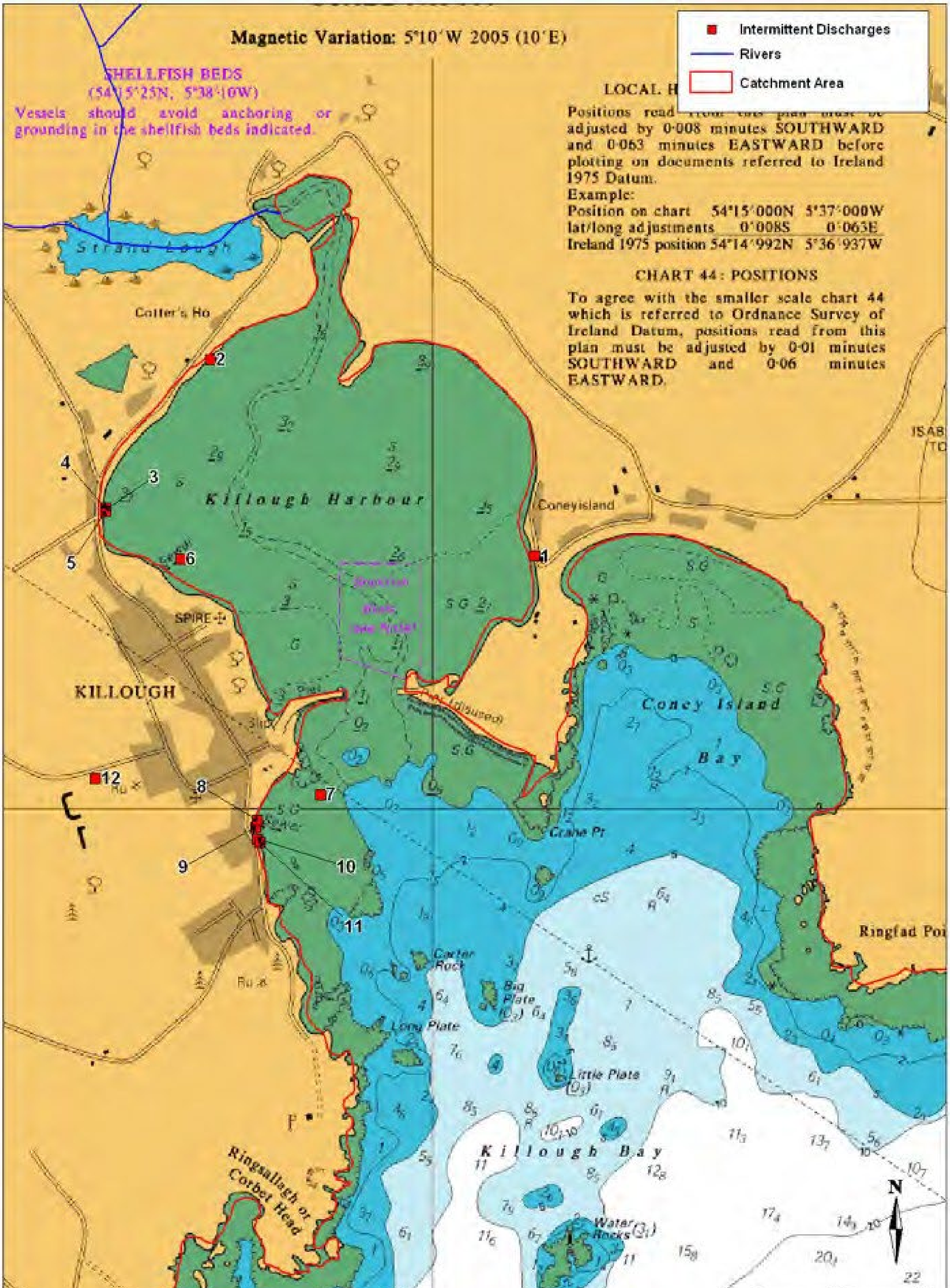

Figure 4.30: Intermittent discharges, overflows and septic tanks in the Killough Harbour area.

Table 4.8: Cross-referenced table for all intermittent discharges, overflows and septic tanks shown in Figure 4.30.

Map ID	Type	Longitude	Latitude	Easting	Northing
1	Domestic discharge	-5.62957	54.2554	354532.7	336653.5
2	Domestic discharge	-5.64143	54.2596	353744.5	337095.1
3	Domestic discharge	-5.64527	54.25638	353506.5	336728.4
4	Domestic discharge	-5.64527	54.25642	353506.1	336732.4
5	Domestic discharge	-5.64527	54.25635	353506.6	336724.7
6	Combined Overflow	-5.64253	54.25533	353688.8	336617.3
7	Combined Overflow	-5.63741	54.2503	354041.3	336068.3
8	Domestic discharge	-5.63971	54.24974	353893	336001.7
9	Domestic discharge	-5.63977	54.2496	353890.1	335986.2
10	Domestic discharge	-5.63971	54.24934	353894.6	335956.8
11	Domestic discharge	-5.63963	54.24926	353900.6	335948.4
12	Septic Tank	-5.64562	54.2506	353504.9	336088.8

5. Shellfish and Water Sampling

5.1. Historical Data

5.1.1. Shellfish Water Quality

The Northern Ireland Environment Agency (NIEA) Water Management Unit monitors a number of classified water bodies 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 Annex II of the EU Hygiene Regulation 854/2004, 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 and these results are reviewed annuallt 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 always been classified as a B harvesting area. Table 5.1 summarises this system. Table 5.2 shows the current and historical (back to 2003) classifications within Killough Harbour.

Table 5.1: Classification system for shellfish harvesting areas.

Classification			Permitted Levels	Outcome
(green)	**A**	<230	Less than 230 *E. coli*100g flesh	May go direct for human consumption if end product standard met.
(yellow)	**B**	<4600	Less than 4,600 *E. coli*100g flesh	Must be subject to purification, relaying in Class A area (to meet Category A requirements) or cooked by an approved method.
(red)	**C**	<46000	Less than 46,000 *E.coli*100g flesh	Must be subject to relaying for a period of at least 2 months or cooked by an approved method.
	Above 46,000 *E.coli*/100g flesh			Prohibited. Harvesting not permitted

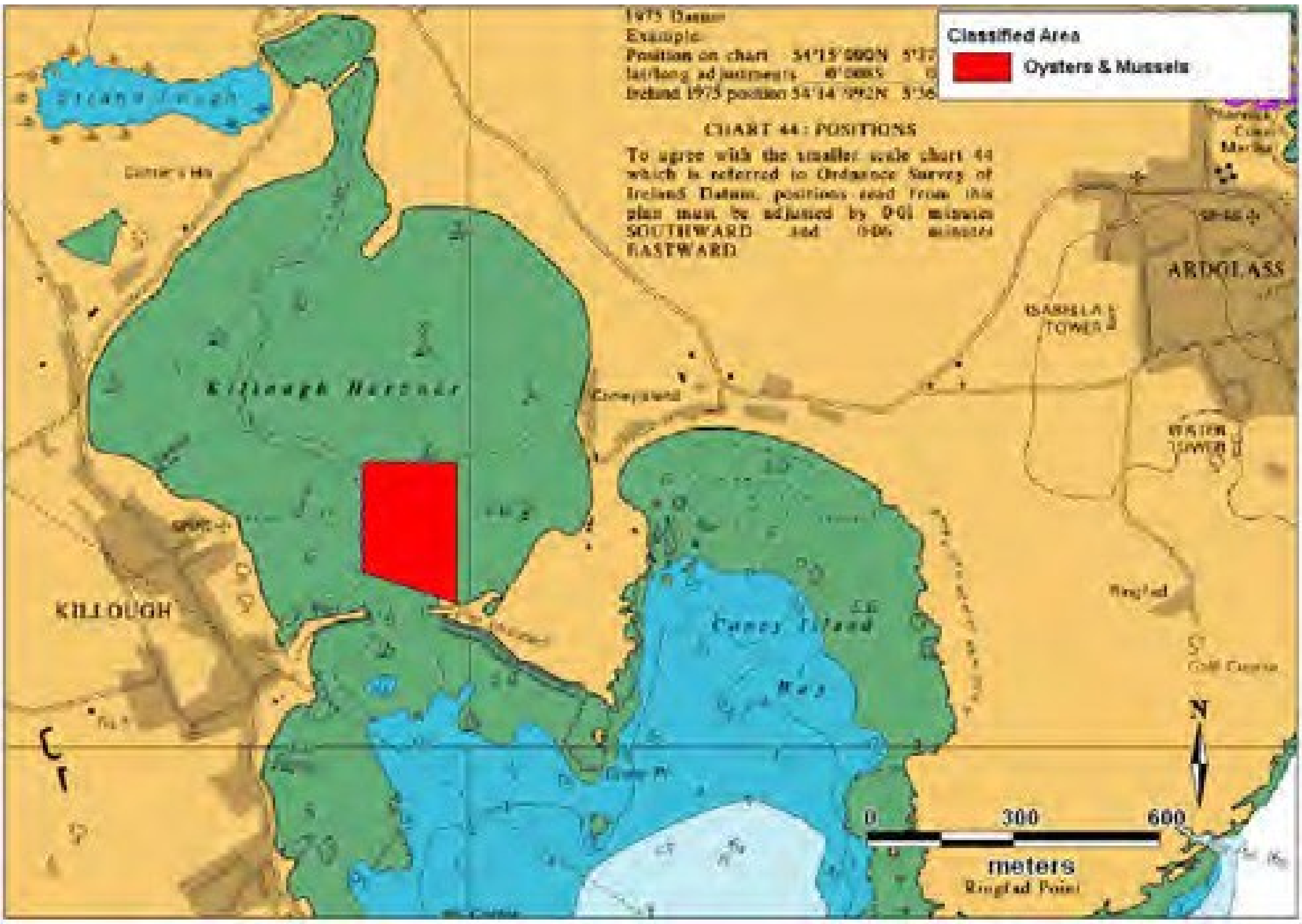

Figure 5.1: Locations of FSA in NI shellfish monitoring bed for classification purposes.

Table 5.2: Current and historical classification of shellfish beds in Killough Harbour (2003 – 2012).

Bed Name	Species	Classification									
		2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Killough Harbour	Oysters	B	B	B	B	B	B	B	B	B	B
Killough Harbour	Mussels	-	-	-	B provisional	B provisional	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.

In addition to *E. coli* monitoring, FSA in NI conduct monitoring for the presence of toxin producing phytoplankton in shellfish waters, including *Alexandrium spp* and *Dinophysis spp.* and for marine biotoxins (including DSP, PSP and ASP) in shellfish flesh. FSA in NI (in association with NIEA) also monitor shellfish flesh for chemical contaminants e.g. heavy metals, organochlorides, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), pentachlorophenol (PCP), Tributyl Tin Oxide (TBTO) and dioxins.

Tables 5.3 and 5.4 list the *E. coli* results for mussels and oysters from Killough Harbour from 2005 to February 2012. 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 38 instances of a **B** result (47.5% of the time) and 42 instances of an **A** result (52.5% of the time) for the Killough oyster harvesting bed. *E. coli* counts ranged from 310 to 4600 MPN/100g during the **B** result periods and from <20 to 220 MPN/100g during the **A** periods (See Figure 5.2). The most recent data for oysters in Killough (February 2012) gave an **A** result. Killough Harbour is classified as **B** for 2012 for oysters.

Mussels in Killough Harbour have been classified as B since 2008 and B provisional in 2006 and 2007 (see Table 5.2 above). Since 2006, there have been 37 instances of a **B** result (56.1% of the time), 25 instances of an **A** result (37.9% of the time) and 4 instances of a **C** result (6.1% of the time). It should be noted that one instance of a C results was queried due to concerns regarding the storage temperature (April 2010). *E. coli* counts ranged from 9100 to 35,000 MPN/100g during the C periods, from 310 to 3500 MPN/100g during the B periods and from <20 to 230 MPN/100g during the A periods (See Figure 5.3). The most recent data for mussels in Killough (February 2012) gave a **B** result. Killough Harbour is classified as **B** for 2012 for mussels.

Table 5.3: *E. coli* results from oysters from Killough Harbour from 2005 to February 2012 (Source: FSA in NI).

Date	*E.coli* (MPN/100g)	Classification	Date	*E.coli* (MPN/100g)	Classification
17-Jan-12	790	B	05-Mar-08	70	A
14-Feb-12	210	A	08-Apr-08	400	B
11-Jan-11	140	A	07-May-08	200	A
02-Feb-11	50	A	18-Jun-08	500	B
08-Mar-11	1100	B	07-Jul-08	750	B
06-Apr-11	170	A	19-Aug-08	4300	B
10-May-11	490	B	17-Sep-08	3500	B
08-Jun-11	170	A	07-Oct-08	310	B
05-Jul-11	50	A	05-Nov-08	400	B
15-Aug-11	170	A	03-Dec-08	500	B

Date	*E.coli* (MPN/100g)	Classification	Date	*E.coli* (MPN/100g)	Classification
12-Sep-11	490	B	10-Jan-07	1700	B
04-Oct-11	460	B	07-Feb-07	1300	B
08-Nov-11	110	A	07-Mar-07	430	B
05-Dec-11	800	B	17-Apr-07	110	A
12-Jan-10	80	A	23-May-07	110	A
10-Feb-10	50	A	20-Jun-07	1300	B
09-Mar-10	20	A	18-Jul-07	500	B
14-Apr-10	<20	A	22-Aug-07	2800	B
12-May-10	50	A	19-Sep-07	200	A
09-Jun-10	50	A	16-Oct-07	200	A
07-Jul-10	80	A	28-Nov-07	<20	A
24-Aug-10	790	B	11-Dec-07	750	B
15-Sep-10	700	B	25-Jan-06	160	A
14-Oct-10	80	A	23-Feb-06	310	B
11-Nov-10	490	B	22-Mar-06	70	A
09-Dec-10	80	A	13-Apr-06	3500	B
07-Jan-09	70	A	13-Jun-06	220	A
04-Feb-09	220	A	18-Jul-06	110	A
10-Mar-09	70	A	23-Aug-06	700	B
08-Apr-09	110	A	20-Sep-06	3500	B
06-May-09	110	A	25-Oct-06	70	A
03-Jun-09	700	B	28-Nov-06	40	A
07-Jul-09	110	A	25-Jan-05	50	A
04-Aug-09	350	B	22-Feb-05	160	A
24-Sep-09	220	A	19-Apr-05	750	B
07-Oct-09	310	B	03-May-05	2400	B
04-Nov-09	1400	B	27-Jun-05	500	B
02-Dec-09	40	A	06-Sep-05	750	B
22-Jan-08	500	B	30-Nov-05	70	A
06-Feb-08	200	A	13-Dec-05	500	B

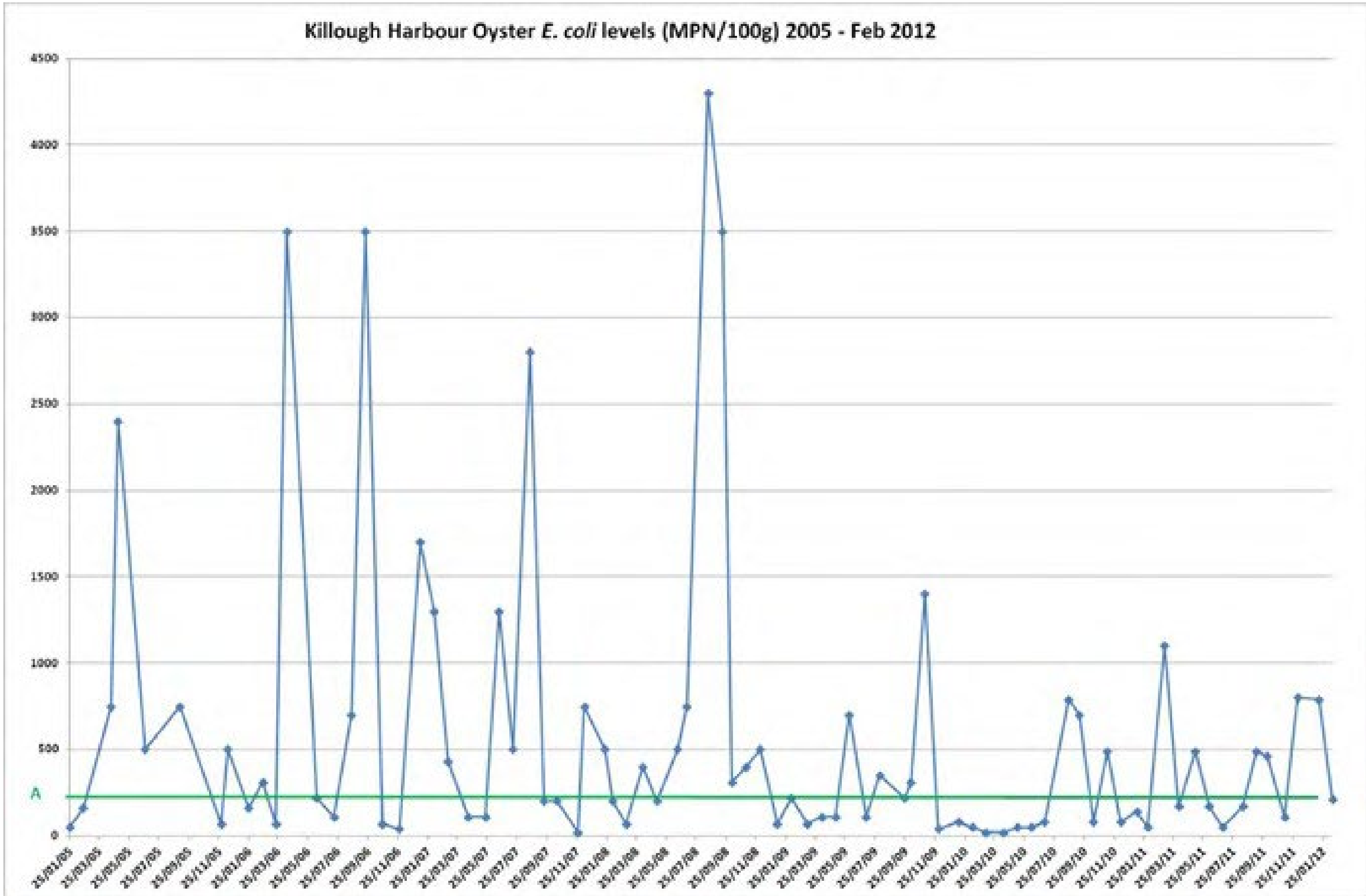

Figure 5.2: ***E.* coli results from oysters in Killough Harbour from 2005-Feb 2012 (Source: FSA in NI).**

Table 5.4: ***E. coli*** **results from mussels from Killough Harbour from 2005 to February 2011 (Source: FSA in NI).**

Date	*E.coli* (MPN/100g)	Classification	Date	*E.coli* (MPN/100g)	Classification
30-Jan-12	1300	B	18-Aug-09	2200	B
21-Feb-12	490	B	24-Sep-09	750	B
31-Jan-11	170	A	20-Oct-09	3500	B
22-Feb-11	700	B	17-Nov-09	70	A
24-Mar-11	790	B	17-Dec-09	500	B
20-Apr-11	230	A	22-Jan-08	750	B
24-May-11	330	B	19-Feb-08	500	B
22-Jun-11	90	A	19-Mar-08	40	A
25-Jul-11	70	A	22-Apr-08	310	B
30-Aug-11	330	B	20-May-08	220	A
28-Sep-11	1700	B	24-Jun-08	17000	C
18-Oct-11	490	B	7-Jul-08	430	B
22-Nov-11	220	A	6-Aug-08	1300	B
19-Dec-11	130	A	23-Sep-08	200	A
26-Jan-10	50	A	21-Oct-08	500	B
24-Feb-10	800	B	18-Nov-08	220	A
24-Mar-10	330	B	16-Dec-08	750	B
27-Apr-10	24000	C*	10-Jan-07	1300	B
25-May-10	330	B	7-Feb-07	<20	A
30-Jun-10	1700	B	7-Mar-07	430	B
27-Jul-10	800	B	3-Apr-07	50	A
5-Aug-10	460	B	9-May-08	310	B
27-Sep-10	1300	B	6-Jun-07	9100	C
27-Oct-10	230	A	4-Jul-07	40	A
23-Nov-10	20	A	14-Aug-07	35000	C
14-Dec-10	50	A	22-Aug-07	1300	B
28-Jan-09	1100	B	10-Sep-07	500	B
18-Feb-09	200	A	3-Oct-07	310	B
25-Mar-09	<20	A	14-Nov-07	110	A
21-Apr-09	310	B	18-Jul-06	220	A
19-May-09	1300	B	20-Sep-06	3500	B
23-Jun-09	<20	A	25-Oct-06	110	A
27-Jul-09	3500	B	28-Nov-06	20	A

* query with storage temperature.

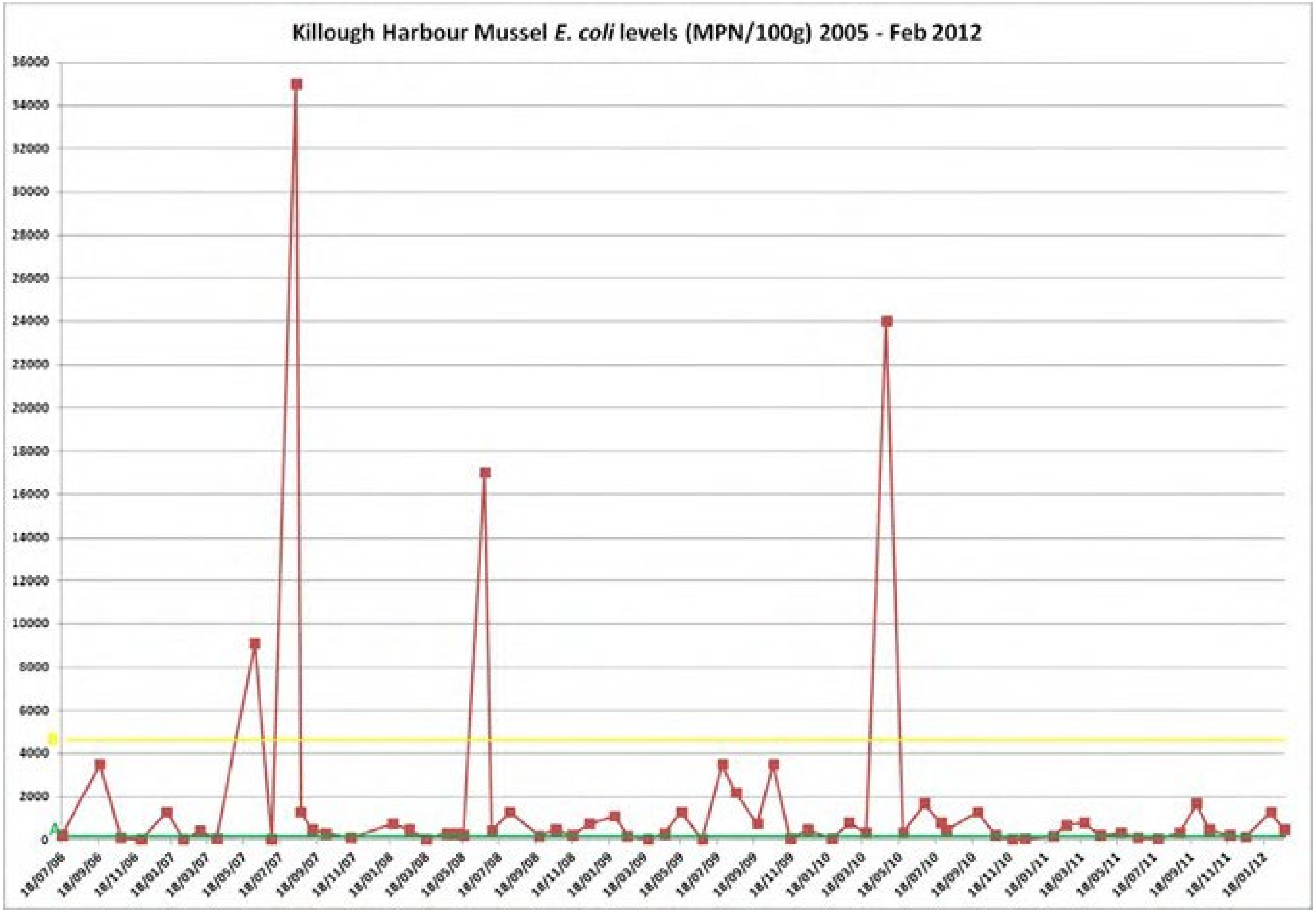

Figure 5.3: *E. coli* levels from oysters in Killough Harbour from 2005 to Feb 2012 (Source: FSA in NI).

Table 5.5 shows the summary statistics for the *E. coli* historical data (2005 to February 2012) from the Killough Harbour shellfish bed. The geometric mean of *E. coli* levels was approximately 1.5 times higher for mussels than for oysters (391.22 MPN/100g compared to 253.25 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	14/02/2012	<20	4300	220	253.25
Killough Harbour	**Mussels**	18/07/2006	21/02/2012	<20	35000	380	391.22

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 2011 for both species monitored in Killough Harbour. The geomean for 2012 was not included here as it only includes data for the first two months and is therefore not accurate for comparison purposes. The geometric mean for oysters and mussels was highest in 2008 (490.92 and 482.80 MPN/100g respectively). Oyster values were lowest in 2010 (94.8 MPN/100g) and mussel values were lowest in 2006 (202.88 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
Killough Harbour	**Oysters**	342.42	269.45	388.79	490.92	182.25	94.80	226.66
Killough Harbour	**Mussels**	-	202.88	435.46	482.80	410.12	405.14	289.97

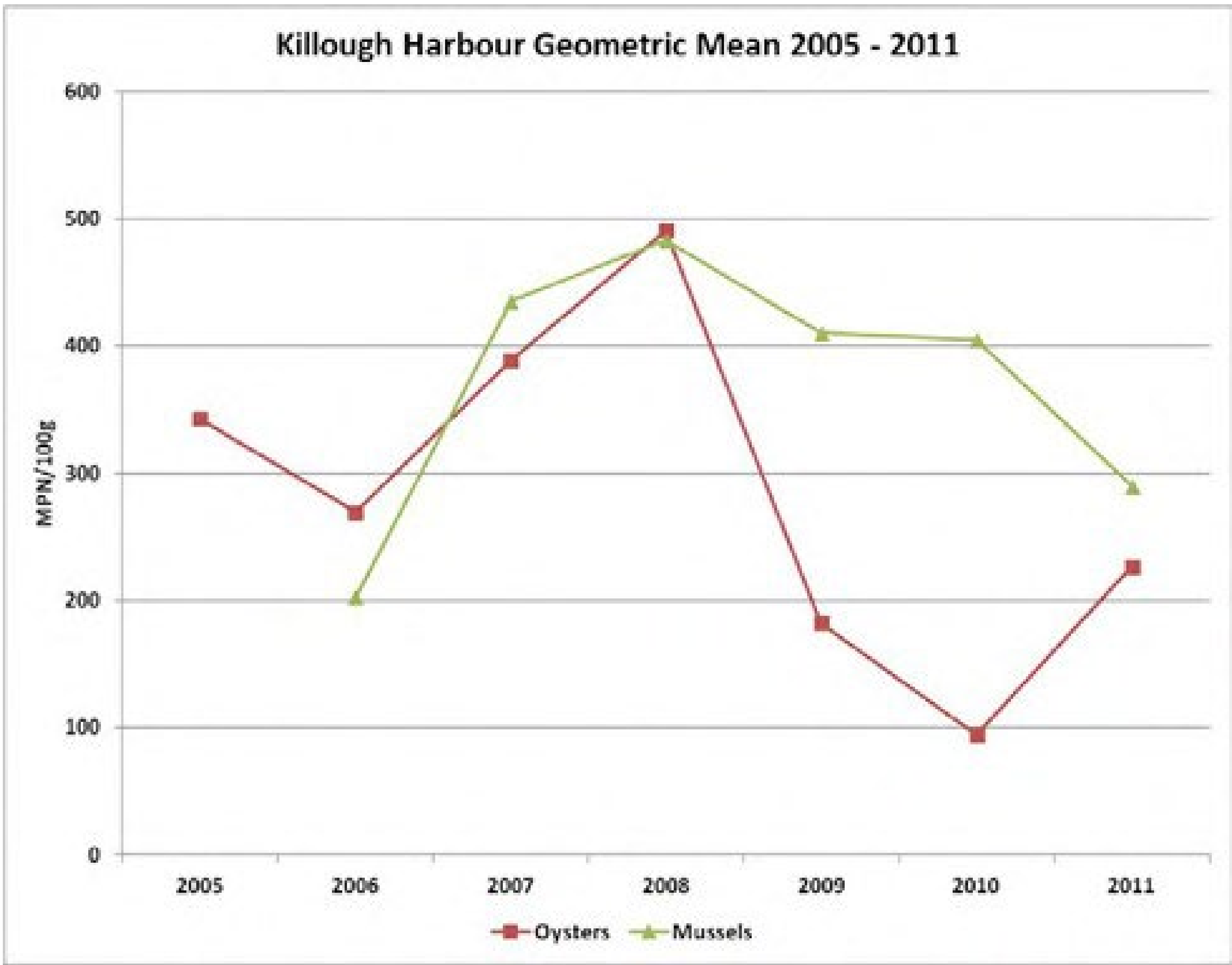

Figure 5.4: Trend in geometric mean of *E. coli* levels from 2005 to 2012 for oysters and mussels in Killough Harbour.

In order to identify any significant differences in *E. coli* levels annually from 2005 to 2011, a one-way analysis of variance (ANOVA) was performed on all oyster and mussel *E. coli* results from shellfish flesh in Killough Harbour. For this 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). Only the years with ≥8 results per species were used in this analysis, therefore mussels and oysters in 2012 and mussels in 2006 were not included in this analysis. The ANOVA analysis revealed that, with regards to the oysters, there was a significant difference between 2007 *E. coli* levels and the 2010 *E. coli* levels. No significant differences were observed between the *E. coli* levels in the mussels.

As seen in Section 4.1.2 Tourism, no seasonal significant differences were seen from the oyster flesh *E. coli* levels and from the mussel flesh *E. coli* levels. In addition, the seasonal *E. coli* levels observed between the 2 species were not significantly different.

5.2. Current Data

5.2.1. Sampling Sites & Methodology

Eleven water sampling points were sampled within Killough Harbour on the 30th January 2012. As there is only one licenced (and classified) site within Killough Harbour and it is sampled monthly by FSA in NI, there was no requirement to re-sample flesh samples from this area. The weather on the sampling days was dry with approximately 7/8th cloud cover.

The predicted high water levels on the 30th January 2012 were at 3:43am and at 15:59pm at Killough Harbour (4.8 and 5.0m respectively). Predicted low water levels on the 30th were at 9:47am and at 22:21pm.

The weather for the 10 days before sampling was a mixture of strong and light winds with rain occurring on all days (Met Office, 2012)

Of the 11 water samples collected, 9 were taken from the main body of the Harbour and 2 were taken from discharge pipes (K3 and K7).

All water samples were collected on the same day (30/01/2012) and collection was timed with high water in order to allow access to the Harbour area. AQUAFACT's RIB was used for the sampling. Sampling collection began at Station K11 and ended at Station K1. Figure 5.5 shows the water sampling sites. The coordinates of these stations can be seen in Table 5.7.

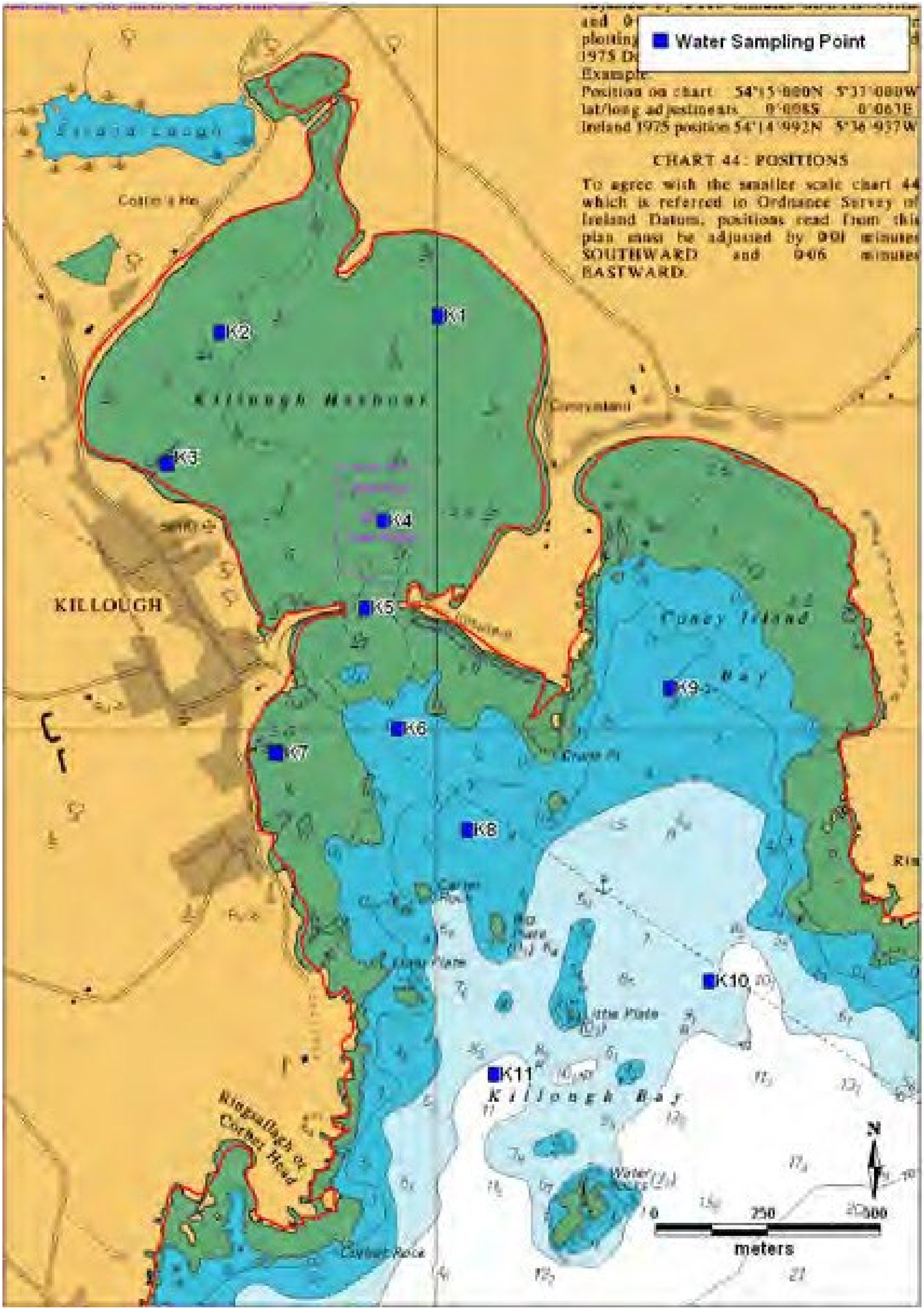

Figure 5.5: Location of the 11 water sampling sites in Killough Harbour sampled on the 30th January 2012.

Table 5.7: Water sampling coordinates.

Station	Longitude	Latitude	Easting	Northing
K1	-5.63318	54.2583	354286.6	336968.2
K2	-5.64068	54.25797	353799.5	336915.4
K3	-5.64253	54.25533	353688.8	336617.3
K4	-5.63512	54.2542	354176	336507.4
K5	-5.63569	54.25244	354144.9	336310.5
K6	-5.63456	54.25002	354228	336043.4
K7	-5.63878	54.24954	353954.4	335981.3
K8	-5.63218	54.24801	354390.6	335825.5
K9	-5.62526	54.25084	354830.6	336155.2
K10	-5.62393	54.24498	354939.7	335506
K11	-5.63126	54.2431	354468.5	335281.1

All water samples were collected in sterile plastic water bottles. These samples were stored in a cool box until delivery to Northern Ireland Water (within 24hrs of collection). *E. coli* analysis was carried out using the Colilert method). Northern Ireland Water is a UKAS (United Kingdom Accreditation Service) certified laboratory.

5.2.2. Microbial Analysis Results

Table 5.8 shows the water sample analysis results (Refer to Appendix 1 for result certificates). Figure 5.6 shows in graphical form the *E. coli* results from across the Harbour. Highest *E. coli* levels (3100 MPN/100ml) come from discharge pipe (K3) within the Harbour area. These levels dropped to 1800 MPN/100ml approximately 300m north of the discharge pipe and to 0 MPN/100ml approximately 500m southeast of the discharge pipe in the area of the shellfish beds. The inner harbour area overall had the highest *E. coli* levels, which decreased gradually out into Killough Bay.

Table 5.8: Water *E. coli* results from Killough Harbour.

Station	*E. coli* MPN/100ml	Total coliforms MPN/100ml
K1	2000	9600
K2	1800	4600
K3	3100	5600
K4	0	11
K5	2100	7800
K6	30	50
K7	0	9
K8	4	6

Station	*E. coli* MPN/100ml	Total coliforms MPN/100ml
K9	0	16
K10	0	11
K11	0	13

The *E. coli* results from the shellfish flesh collected in January 2012 can be seen in Table 5.9 below.

Table 5.9: Shellfish flesh *E. coli* results for Killough Harbour from December 2011 to February 2012.

Species	Date	*E. coli* (MPN/100g)
Oysters	05/12/2011	800
Mussels	19/12/2011	130
Oysters	17/1/2012	790
Mussels	30/1/2012	1300
Oysters	14/2/2012	210
Mussels	21/2/2012	490

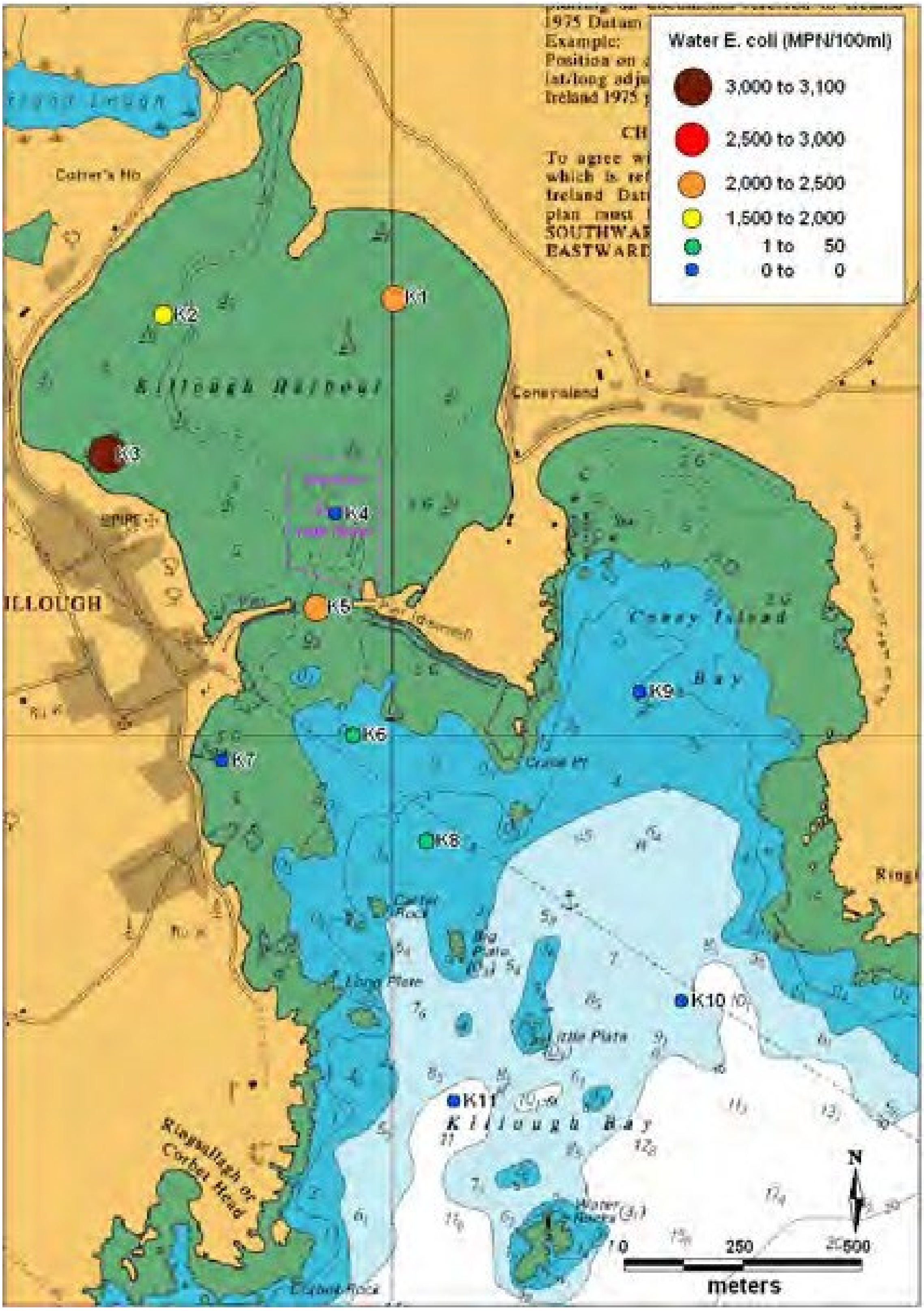

Figure 5.6: Water *E. coli* results from across Killough Harbour (sampled on the 30th January 2012).

6. Expert Assessment of the Effect of Contamination on Shellfish

Killough Harbour is located within a predominately rural catchment, mostly used for agricultural purposes. Killough town is the largest population centre in the catchment area and the population does not increase significantly due to tourist numbers. The pier is used by a small number of local leisure and fishing vessels. The main pollution sources in the harbour area arise from point source discharges from sewers in the town. There is very little in the way of freshwater entering the system, what does enter comes from the nearby Strand Lough.

Sewage has been known to lead to deterioration of water quality, alter floral and faunal assemblages near large outfalls and has been responsible for disease outbreaks attributed to faecal coliforms (Clarke, 2001). Faecal coliforms entering the marine environment from industrial discharges, wastewater and sewage discharges, contaminated freshwater input, agricultural run-off, wild fowl and shipping discharges can accumulate in bivalves that filter organic matter from the water column to feed. Varying levels of faecal coliforms in bivalve flesh determine the classification of shellfish harvesting waters. Killough Harbour has historically been categorised as a B classification for oysters and mussels.

No interannual or seasonal trends were identified from the historical shellfish data i.e. no significant variation in *E. coli* levels was evident since 2005. Depending on local hydrographic conditions, the fate of contaminants can vary from place to place. In Killough Harbour the following summarises the fate of contaminants.

Killough Harbour is a shallow intertidal harbour area with a complete exchange of water twice a day. Currents in the harbour area are low and the hydrodynamics of the area involve the simple flooding of water into the harbour on the rising tide and the subsequent ebbing out of water into the bay area on the falling tide. While the intertidal nature of the harbour allows for complete water exchange, the result of this is two-fold: firstly the flooding of the tide into the harbour can bring in contaminants from the wider bay area such as discharges from the sewage treatment point off Corbet Head and while the tide is out the discharges from the town's waste water pumping stations and sewers continue to flow into the intertidal area and accumulate there at low water. The rising tide then serves to distribute the contaminants around the harbour area. Also the flow from Strand Lough continually trickles into the harbour bring with it contaminants from the wider catchment area which gets redistributed over the course of a tidal cycle. Wind has a negligible influence on water movements and distribution of contaminants in the Harbour. This all explains why for the past 10 years Killough Harbour has been classified as a B area, which means that the shellfish must be subject to purification, relaying or cooked by an approved method.

As a result of this, Killough Harbour has been classified as one Production Area with RMPs for both cultivated oysters and naturally occurring mussels. Further details on the Production Area and the sampling sites can be seen in Section 7 Sampling Plan. This sampling plan is designed to properly reflect the control of the likely risk of pathogen contamination on the shellfish and will ensure that effective monitoring is carried out with respect to the potential polluting impacts and that public health is prioritised.

7. Sampling Plan

7.1. Identification of Production Area Boundaries & RMPs

As Killough Harbour is an isolated relatively sheltered harbour with a simple hydrographic regime and only 1 licenced and classified area, the identification of Production Area boundaries and Representative Monitoring Points (RMP) is a straightforward task. The proposed production area for Killough Harbour can be seen in Figure 7.1 below and the coordinates of this site can be seen in Table 7.1.

Production Area 1 (PA1) encompasses the entire Harbour area and it covers and area of 0.70km^2. The entire area is tidal with complete water exchange twice a day. Depths when the tide is in range from approximately 1.8 to 3.9m. There is a steady freshwater input from Strand Lough located at the head of the harbour. Two RMPs are recommended for this Production Area and their locations can be seen within the licenced/classified harvesting area in Figure 7.1 and their coordinates are given in Table 7.2. One of the RMPs (O1) is for oysters and the second is for the mussels growing naturally on the oysters (M1).

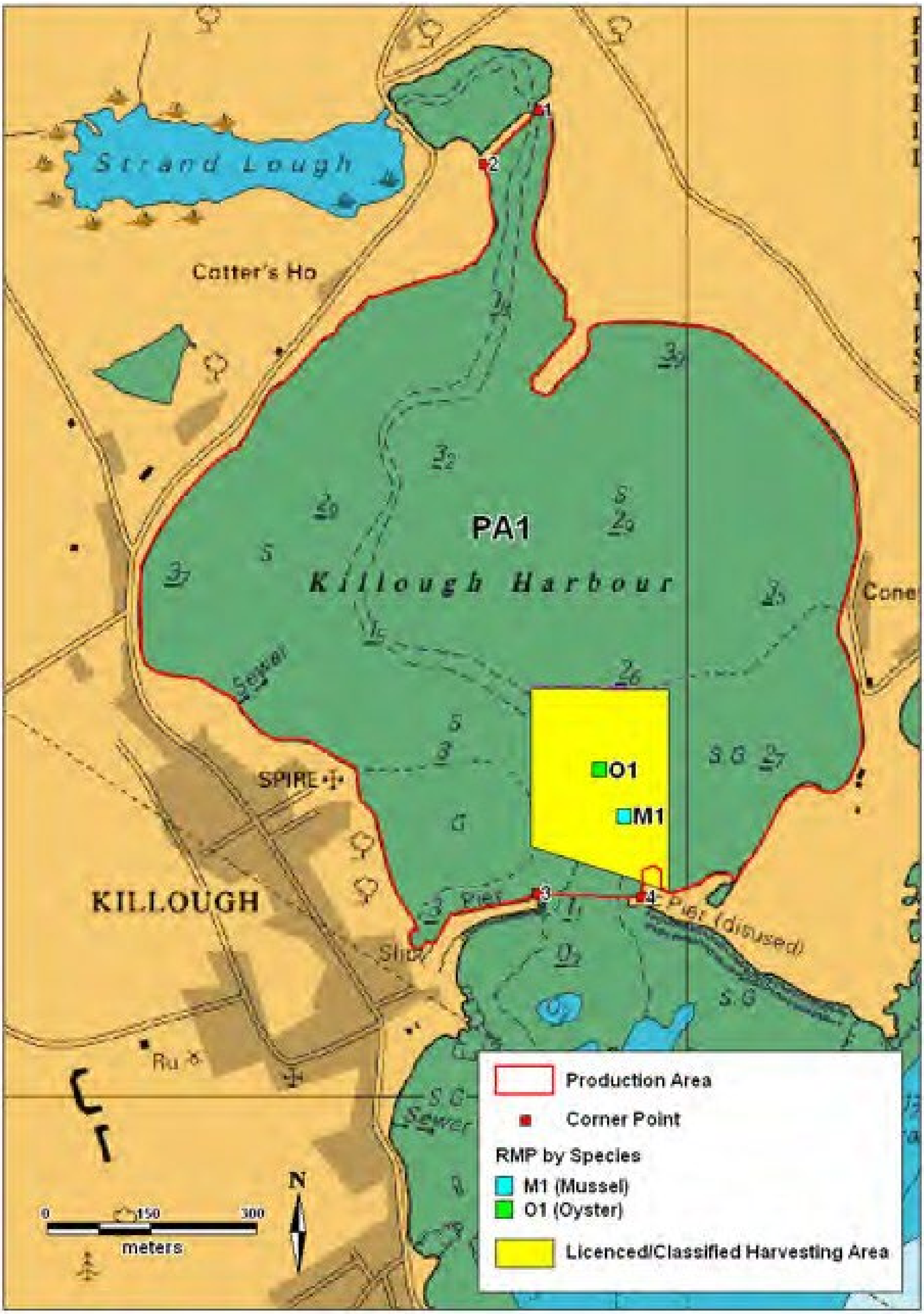

Figure 7.1: Production Area, Corner Points, RMPs and Licenced/Classified harvesting area in KIllough Harbour.

Table 7.1: Coordinates of Killough Harbour Production Area.

Corner Point	Easting	Northing	Longitude	Latitude
1	354050.9	337450.2	-5.63655	54.2627
2	353976.3	337369.3	-5.63774	54.26199
3	354087.7	336327.5	-5.63656	54.25261
4	354236.7	336328.1	-5.63428	54.25257

Table 7.2: Coordinates of Killough Harbour RMPs

RMP	Easting	Northing	Longitude	Latitude
O1	354169.9	336508.1	-5.63521	54.25421
M1	354208.6	336442.9	-5.63465	54.25361

7.2. Frequency of RMP Monitoring

All RMPs should be monitored monthly using the sampling methodology described in Section 7.3 below.

7.3. Sampling Methodology

All sampling should follow FSA's official control shellfish sampling and transport protocol. This protocol follows the UK NRL's (National Reference Laboratory) Recommendations for the collection and transport of bivalve molluscs for Microbiological monitoring, which outlines the following:

7.3.1. Time of Sampling

Sampling should 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.

7.3.2. Sampling Method

Wherever possible, shellfish should be sampled by the method normally used for commercial harvesting as this can influence the degree of contamination. The temperature of the surrounding seawater at the time of sampling should be recorded. Where intertidal shellfish are sampled dry, the temperature of the shellfish sample should be recorded immediately after collection. To do this the temperature probe should be placed in the centre of the bagged shellfish sample.

7.3.3. Equipment

Food grade polythene bags

Cable ties

Self adhesive labels

Absorbent paper towel

Cool box/Biotherm Box/Coleman Box

Ice packs

Insulating foam

Spray water bottle/bucket

Pocket wallet/ grip seal bag (for paperwork)

Strong adhesive tape

Return address labels

Gloves/antibacterial wipes

7.3.4. Size of Individual Animals

Samples should only consist of animals that are within the normal commercial size range. Immature/juvenile animals may provide *E.coli* results that are unrepresentative of mature stock that will be harvested for commercial sale/human consumption. In circumstances where less mature stock is being commercially harvested for human consumption then samples of these smaller bivalves may be collected for analysis.

7.3.5. Sample Composition

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

Oysters (*Crassostrea gigas* and *Ostrea edulis*)	12-18
Mussels (*Mytilus* spp.)	15-30

There is an absolute lower number of shellfish (10) and a minimum requirement of 50 g of flesh and intravalvular fluid for the test undertaken by the laboratory. The number of animals given above is intended to satisfy these requirements and to include a small additional allowance in case animals become moribund during transit.

7.3.6. Preparation and Packaging of Samples

Any mud and sediment adhering to the shellfish should be removed. This is best achieved by rinsing/scrubbing with fresh water of potable quality or seawater from the immediate area of sampling. Do not totally re-immerse the shellfish in water as this may cause them to open. Allow to drain. Shellfish must be placed inside a strong food grade plastic bag, sealed and labelled with a waterproof label bearing the relevant sample collection information – e.g. site name, location, site identification number (SIN), date and time of sampling, species. The labelled bag should be placed in a second bag and sealed. The bagged sample should be placed in a cool box between 2 layers of ice packs and foam packaging.

7.3.7. Sample Transport

Samples should be transported in cool boxes at a temperature between 1°C and 8°C. Samples should not be frozen and freezer packs should not come into direct contact with the samples or sample bags. The cool boxes used for transport should be validated using temperature probes to ensure that the recommended temperature is achieved and maintained. To aid in the regulation of temperature, cool boxes specified by the NRL must be used where time from sampling to receipt at the laboratory exceeds 12 hours. Samples should be delivered to the relevant laboratory for analysis as soon practicable.

7.3.8. Sample Submission Form

An individual sample submission form must accompany each sample to the laboratory. The information which must be recorded on the form includes; sample site name, location, sample identification number (SIN), OS Grid reference, time and date of collection, species sampled, method of collection and seawater/shellfish temperature. Any other information deemed relevant (e.g. adverse weather) should also be recorded.

7.3.9. Delivery of Samples

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

7.3.10. Receiving Laboratory

The laboratory to which the samples are sent must be part of the network identified by the competent authority. It must be UKAS-accredited for the testing of shellfish for *E. coli* by ISO 16649-3 and must take part in both the HPA/CEFAS Shellfish EQA scheme and appropriate NRL ring trials.

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Appendix 1

Water Sampling *E. coli* Results

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P.111'11Mltf					
E.COIP					
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r		0.0	MPN		
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NI Water Analytic.al Seiviccs

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Certificate of Analysis

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Killough Harbour,K5

Parameter	Method Reference		Unit	Pass/Fail	Fail Level
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Totafooikwms F'f O		noo.o	MPN		

Sample Coi.ntnh:

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rOW .itil:"l9 -H."1- --#IM-M• ·---•-- WSMCT" N11 [redacted]
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NIW-., c,-._ios..-su....,A-.g.Mn,l,.oiicb,..._.,,DT 7a0 Cor&\U>b01141 40088

NI Water Analytical **Services**

Certificate of Analysis

northern ireland water

.. Dalt! :\OJMI:011
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Agu3f(Prlv:ltSMippoint

C<"ltllk:Mtkl: 2012-02:01
&,iq)IO10: AOUAFT_4'N 12•1

Parameter	Method Reference		Unit	P.au Fall	r.auv.i
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MonllJ,IJMJ.-W•••,,,.._,tl M- (Wwt,... Kl/JillolJtll!W(t [redacted]
Q..IO _,,,,_,,..,,,,.1! f#,•. -tt,;,o,IJ,-. fil0Wf. .,.,_.-,,_,. Qlr,--
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Aqui'lft PriV:iJ!l 5.,mp&p p9ln,

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$.lmplolO: AOUAFT_4W 1i,15&36'J'J

Killough Harbour.K7

Parameter	Method Reference	••••••	!!!!!!	Pass/Fail	Fail Level
•••					
E.COIPI'		•••	MPN		
TOtilllcoMcwmt		•••	MPN		
Tot.11OOlbm!iPf«.ll'IIPINO		••	MPN		
		,•	MPN		

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CompWt«IOaW: 01 F.02012 10: A.OUAFl,..4W•l2-15MOOO

Agu:1f1PtlVMft St1mplft point

Kilough Harbour.K8

	Method Reference		••••	Pass/Fail	Fail Level
Pruamek!1		•	MPN		
E:.o:!11Pl'nu:,l)IMI		• •	MPN		
lo'Moollomn		• •	MPN		
T0\1111oollonm Pt -		• •	MPN		

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Agu. t1Priv/lfe S:vnppoint

Killough Harbour.K9

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P1l1mtttl					
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T Ol)t!offi$Pf		16.0	IIIII		
		16.0	IIIII		

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Certificate ol Analysis

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Parameter	Method Reference	Rttull	Unit	Pass/Fail	Fail Level
,••••		0.0	MPN		
E.c-,IPr		0.0	MPN		
TOCJlooikl'mS		"	MPN		
TIU OOi1otmo Pt		u»	MPN		

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HIW,--.OIMIl!Qr...._tMIMhSNot Affi.Il!)O_._fII,7n.D Col,_.No 0$4,$14...._

NI Water Analytical Services
Certificate of Analysis

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1 O: AOUAFT_,w.12.1

Killough Harbour,K11

Pa,""""	Mtl'hod At 'ffiN	ltuuh	lhb	P11u. r.-11	t11lLev.a
E.'''		Q.O	MPN		
E.OCIPI'8WflllOIM)		0.0	MPN		
fot "°'IOIWK		1,.0	MP1-I		
TOI.IIOOIIOO.PJ		13.0	MPH		

SOn,plO COmrlltflIS:

Issued bv: n,yMel.eul)hlin
SdM,Mic
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