# Sanitary Survey Report
# and
# Sampling Plan
# for Sligo Harbour

**Produced by**

## AQUAFACT International Services Ltd

**In conjunction with**

## The Sea Fisheries Protection Authority

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## Glossary

| | |
|---|---|
| AFBI | Agri-Food and Biosciences Institute |
| ANOVA | Analysis Of Variance |
| APP | Average Physical Product |
| 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 |
| CD | Chart Datum |
| CEFAS | Centre for Environmental, Fisheries & Aquaculture Science |
| Corine landuse | is a Pan-European landuse and landcover mapping programme. It supplies spatial data on the state of the European environmental landscape and how it is changing over time. Based on the interpretation of satellite imagery, Corine landuse provides national scale maps of landcover and landcover change on a six year basis for thirty nine countries in Europe. |
| CSO | Central Statistics Office |
| CSO | Combined Sewer Overflow |
| DARD | Department of Agriculture and Rural Development |
| DED | District Electoral Divisions |
| 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 |
| Fecundity | A measure of fertility or the capability to produce offspring |
| Fetch | The distance a wave can travel towards land without being blocked |

| | |
|---|---|
| FSA in NI | Food Standards Agency of Northern Ireland |
| Gamete | A reproductive cell that fuses with another gamete to produce a zygote, which develops into a new individual |
| Gametogenesis | The formation or production of gametes or reproductive cells |
| Genotype | The genetic makeup of an organism |
| 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 |
| GIS | Geographical Information Systems |
| GPS | Global Positioning System |
| GSM | Global System for Mobile Communication |
| Heterozygosity | Having two different alleles of the same gene |
| Hydrodynamic | Forces in or motions of liquids |
| Hydrography | The description and analysis of the physical conditions, boundaries, flows and related characteristics of water bodies |
| IID | Infectious Intestinal Disease |
| INAB | Irish National Accreditation Board |
| Interspecific Competition | Competition for resources between different species |
| Intraspecific competition | Competition for resources between members of the same species |
| Intervalvular | Between valves |
| I-WeBS | Irish Wetland Bird Survey |
| 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. |
| Metamorphosis | The transformation from the larval to the adult form that occurs in the life cycle of many invertebrates and amphibians |
| MPN | Most Probable Number |
| MSD | Marine Sanitation Device |
| Multilocus | Occurring at more than one position or locus on a chromosome |
| NAP | Nitrates Action Programme |
| ND | Not Detectable |
| $NH_4$ | 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 |
| NoV | Norovirus |
| NRFA | National River Flow Archive |
| NRL | National Reference Laboratory |
| OSPAR | Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic) |
| 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 |
| PMFSC | Pacific States Marine Fisheries Commission |
| Pseudofaeces | Material rejected by suspension or deposit feeders as potential food before entering the gut. |
| PSP | Paralytic Shellfish Poisoning |
| PSU | Practical Salinity Units |
| RAMSAR | A term adopted following an international conference, held in 1971 in Ramsar in Iran, to identify wetland sites of international importance, especially as waterfowl habitat. |
| Regulation (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 |
| RIB | Rigid Inflatable Boat |
| RMP | Representative Monitoring Point |
| RNA | Ribonucleic Acid |
| SAC | Special Area of Conservation |
| SFPA | Sea Fisheries Protection Authority |
| SMILE | Sustainable Mariculture in northern Irish Lough Ecosystems |

| | |
|---|---|
| SOA | Super Output Areas or ward |
| SPA | Special Protection Area |
| SPM | Suspended particulate Matter |
| SPS | Sewage Pumping Station |
| SS | Suspended Solids |
| STW | Sewage Treatment Works |
| Suspension feeders | Animals that feed on small particles suspended in water |
| TBTO | Tributyl Tin Oxide |
| Telemetry | The measurement and transmission of data from remote sources to receiving stations for recording and analysis |
| TPP | Total Physical Product |
| UKAS | United Kingdom Accreditation Service |
| UKHO | United Kingdom Hydrographic Office |
| Vector | A carrier, which transmits a disease from one party to another |
| WeBS | Wetland Bird Survey |
| WTP | Water Treatment Plant |
| WWTW | Waste Water Treatment Works |

# 1. Introduction

Consumption of raw or lightly cooked bivalve molluscs can results in illness due to the presence of micro-organisms, many of which are derived from faecal contamination of the marine environment. Shellfish contaminated with pathogenic microorganisms may cause infectious disease in humans and such outbreaks are more likely to occur close to our coasts where production areas are impacted by sources of human and animal faecal contamination.

The risk of contamination of bivalve molluscs with pathogen microorganisms is assessed through microbiological monitoring programmes. This assessment results in the classification of bivalve mollusc production areas, which in turn governs the level of treatment required before human consumption of the shellfish.

Under EU regulations sanitary surveys of bivalve mollusc production areas and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points for these monitoring programmes.

Specifically under regulation (EU) 2017/625 and its subsequent implementing regulation (EU) 2019/627 there is a requirement to carry out a sanitary survey before classifying any shellfish production or relaying area. Article 56 of Implementing Regulation 627 of 219 states:

1. Before classifying a production or relaying area, the competent authorities shall carry out a sanitary survey that includes:

- an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area;
- an examination of the quantities of organic pollutants released during the different periods of the year, according to the seasonal variations of human and animal populations in the catchment area, rainfall readings, waste-water treatment, etc.;
- determination of the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area.

2. The competent authorities shall carry out a sanitary survey fulfilling the requirements set out in paragraph 1 in all classified production and relaying areas, unless carried out previously.

3. The competent authorities may be assisted by other official bodies or food business operators under conditions established by the competent authorities in relation to the performance of this survey.

Currently the Sea Fisheries Protection Authority in conjunction with AQUAFACT International Services Ltd are conducting sanitary surveys for new bivalve mollusc production areas and for those existing classified production areas which were previously not surveyed.

This report contains the documents relevant to the sanitary survey of the bivalve mollusc production area at Sligo Harbour, County Sligo. It identifies the representative monitoring points and supporting sampling plans for pacific oysters in Sligo Harbour. It also sets out the production area boundaries in the Bay.

# 2. Overview of the Fishery/Production Area

## *2.1. Description of the Area*

Sligo Harbour BMCPA is located along the north western coast of Ireland and is one of three small bays within Sligo Bay. Sligo Harbour is an 18.5km$^2$ shallow tidal bay with extensive mud and sand flats extending from Sligo town in the east to Coney Island in the west. The area is approximately 6.6km E-W at its widest point and approximately 3.2km N-S. The catchment area of the BMCPA is 448km$^2$ and the main freshwater source from this catchment is the Garavogue River which flows through Sligo town. To the south of oyster Island there is a deep pool which is 20.4m at its deepest.

The majority of the bay is made up of intertidal sand and mudflats. A navigational channel runs from Sligo Town out towards Oyster Island following the northern shore with a retaining wall as far as Ballyweelin Point. Depths within the navigational channel vary from approximately 1 to 10m.

Sligo Harbour is designated as part of a Special Area of Conservation (SAC); Cummeen Strand/Drumcliff Bay (Sligo Bay) SAC (Site Code: IE000627) (see Figure 2.1) due to the presence of a number of important habitats and species. Sligo Harbour is also designated as a Special Protection Area (SPA): Cummeen Strand SPA (IE004035) (see Figure 2.1). The site is designated because of the presents of a number of important bird species, see section 3.1.6 for details.

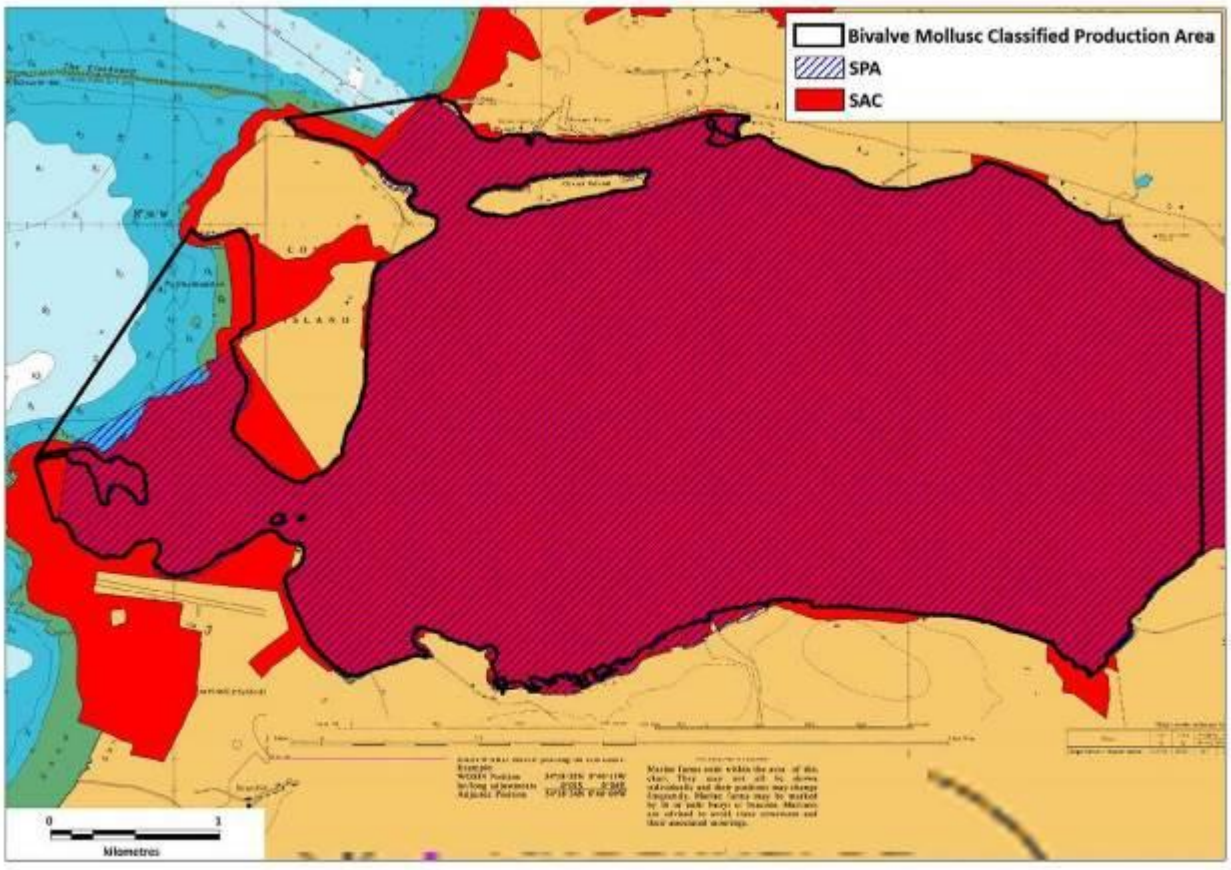



**Figure 2.1: Location of Natura 2000 sites overlapping with the Sligo Harbour BMCPA.**

The Sligo Harbour BMCPA supports a diversity of fish species. Species present include bass, mackerel, sea trout and flounder (IFI, 2019).

Land cover within the Sligo Harbour catchment is a mixture of land principally occupied by agriculture, with significant areas of natural vegetation, pastures, peat bogs, transitional woodland-shrub, moors and heathland, coniferous forest, intertidal flats, natural grasslands, broad-leaved forest, discontinuous urban fabric and mixed forest.

The population of the catchment is approximately 28,966. The main towns/urban centres within the catchment are Sligo town, Strandhill, Manorhamilton, Rosses Point, Dromahair and Ballintogher.

## *2.2. Sligo Harbour Fishery*

### 2.2.1. Location/Extent of Growing/Harvesting Area

The shellfish designated waters in Sligo Harbour cover an area of approximately 8.55km$^2$ and the Bivalve Mollusc Classified Production Area (BMCPA) covers c. 15.66km$^2$. Both can be seen in Figure 2.2. Oyster cultivation is predominant in Sligo Harbour.

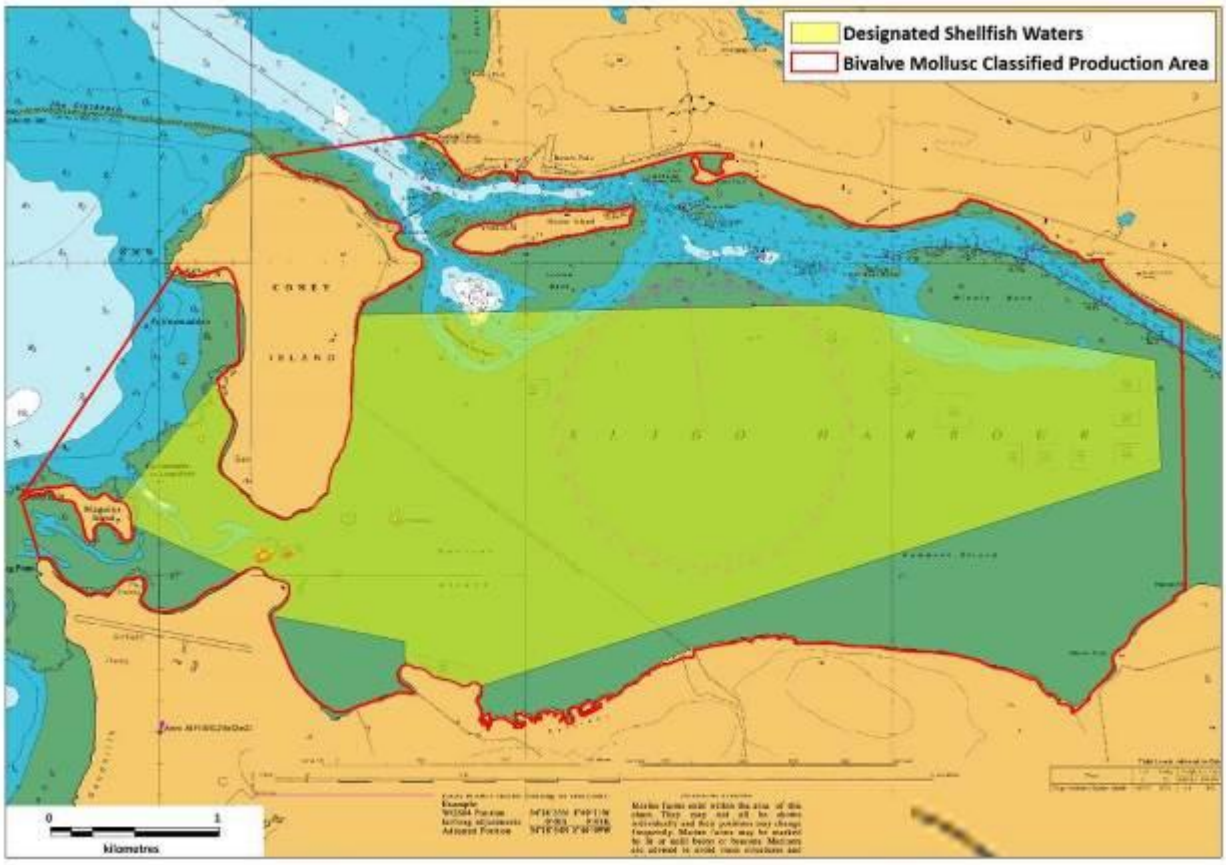



**Figure 2.2: Bivalve Mollusc Classified Production Area and Designated Shellfish Waters within Sligo Harbour.**

Figure 2.3 shows the current locations of licenced aquaculture sites within Sligo Harbour. The majority of the clam sites are located on the sand flats south of the Middle Bank with the exception of one site located on the south shore close to the Sligo airport runway. Currently none of these clam sites are active with marketable product.

The oyster license sites are located on the intertidal sandflats south of the Middle Bank extending westwards towards the Yellow Bank. There are two other oyster licences on the southern shore near Dorrin's Strand and the airport runway respectively. Approximately 80% of the licenses are for oysters (0.52km$^2$) and 20% for clams (0.13km$^2$).

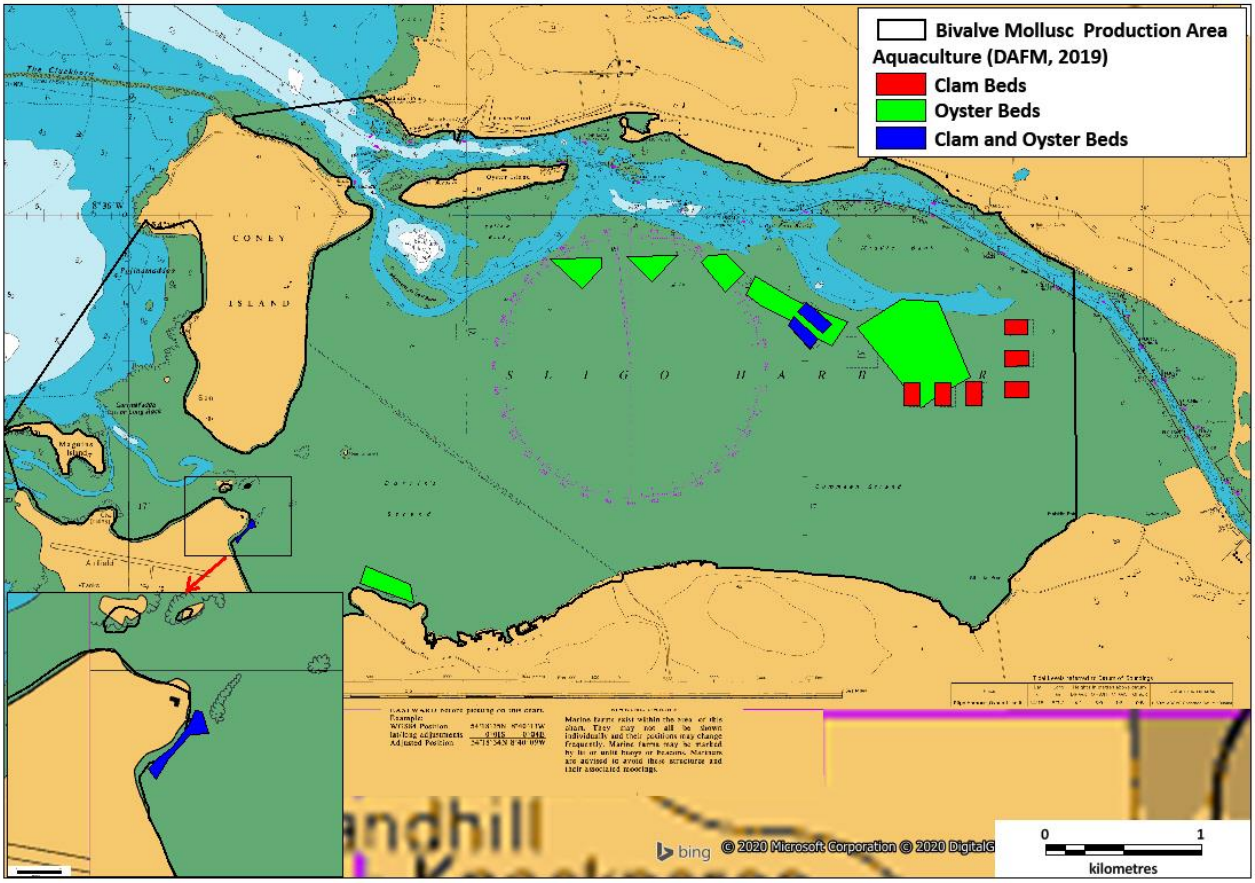



**Figure 2.3: Licenced aquaculture sites within Sligo Harbour (Source: DAFM, 2019).**

### 2.2.2. Description of Species

#### *2.2.2.1. Pacific Oysters (*Crassostrea gigas*)*

#### *Distribution*

Figure 2.4 shows the locations of licenced intertidal farmed Pacific oyster sites in Sligo Harbour. These farmed sites cover an area of 0.52km$^2$. The farms in Sligo Harbour are located on the intertidal mudflats south of the Middle Bank and extend westwards towards the Yellow Bank. There are two oyster sites in the south western end of the bay.

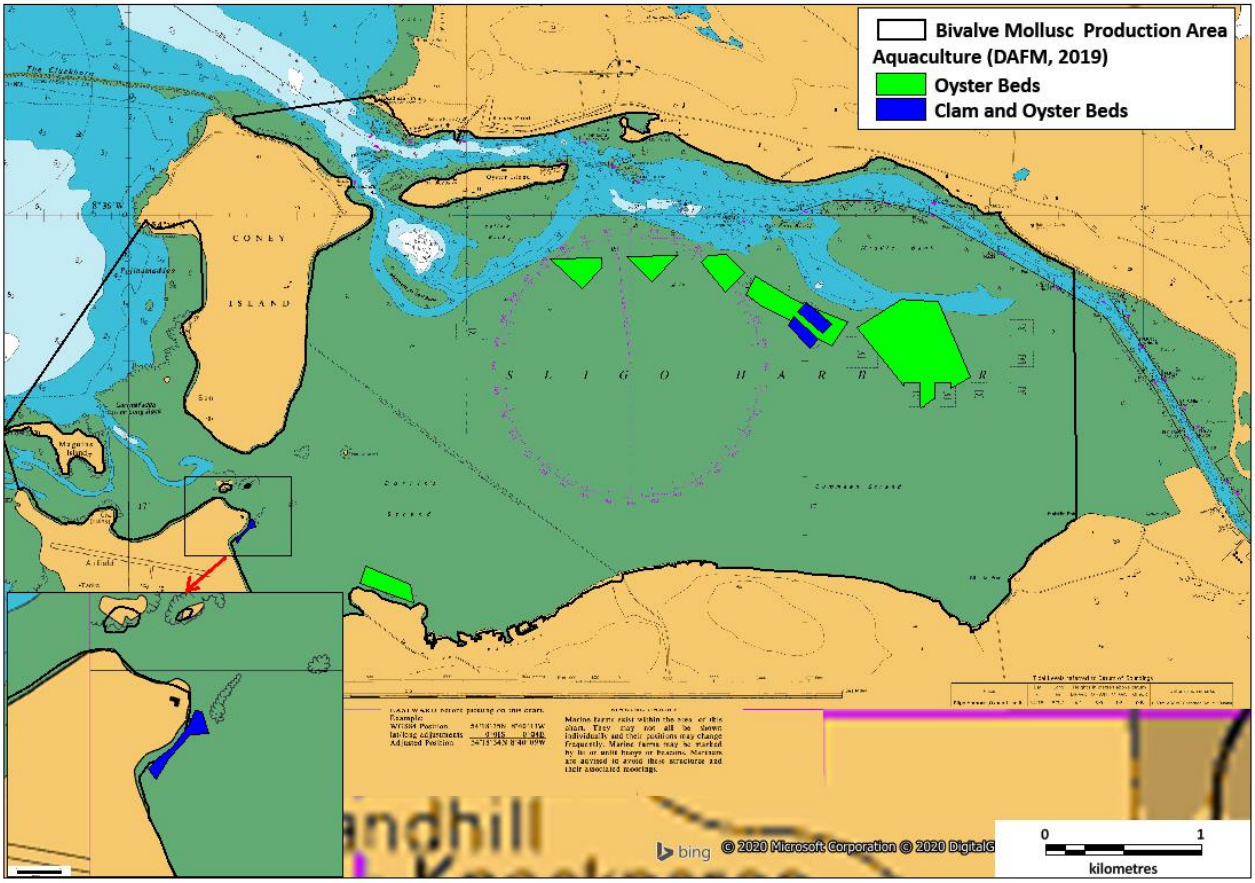



**Figure 2.4: Licenced Pacific oyster harvesting sites in Sligo Harbour (Source: DAFM, 2019).**

### *Fishery*

Intertidal oyster culture is carried out in bags on trestles in the intertidal zone. Depending upon the size of stock, the number of oyster in each bag will vary with lower numbers in bags with larger oysters.

#### *2.2.2.2. Clams*

### *Distribution*

Figure 2.5 shows the licensed clam sites in Sligo Harbour. These farmed sites cover an area of 0.13km$^2$. The farms in Sligo Harbour are located on the intertidal intertidal mudflats south of the Middle Bank. There is one clam site on the southern shore close to the airport.

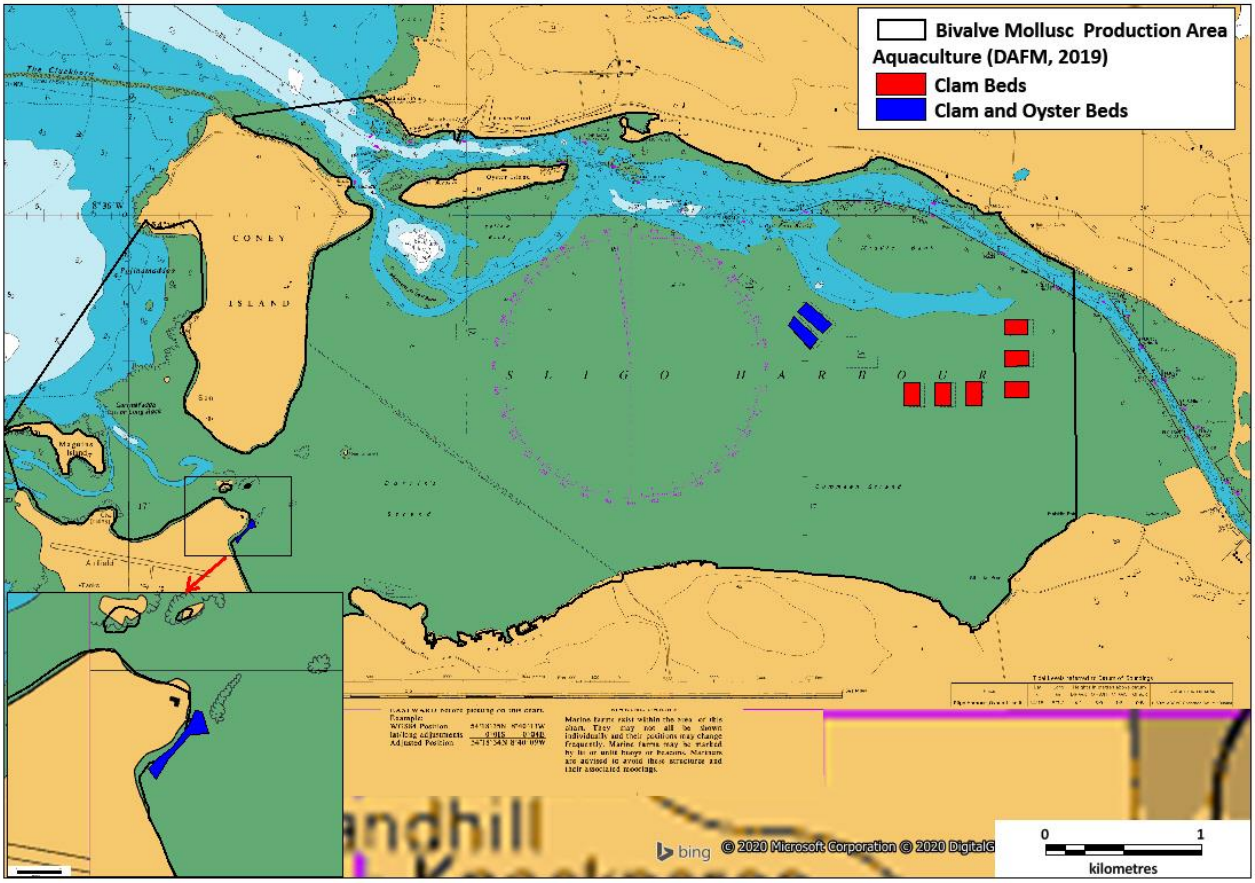



**Figure 2.5: Licenced clam harvesting sites in Sligo Harbour (Source: DAFM, 2019).**

### *Fishery*

Due to historic mortality issues there is currently no active clam fishery in the production area.

## 3. Identification of Pollution Sources

This section attempts to document all pollution sources within the Sligo Harbour catchment area.

### *3.1. Desktop Survey*

Pollution sources were considered within the catchment area of Sligo Harbour (see Figure 3.1). The catchment area covers an area of 448km$^2$, approximately 34km east west at its widest point and 28km north south at its longest point.

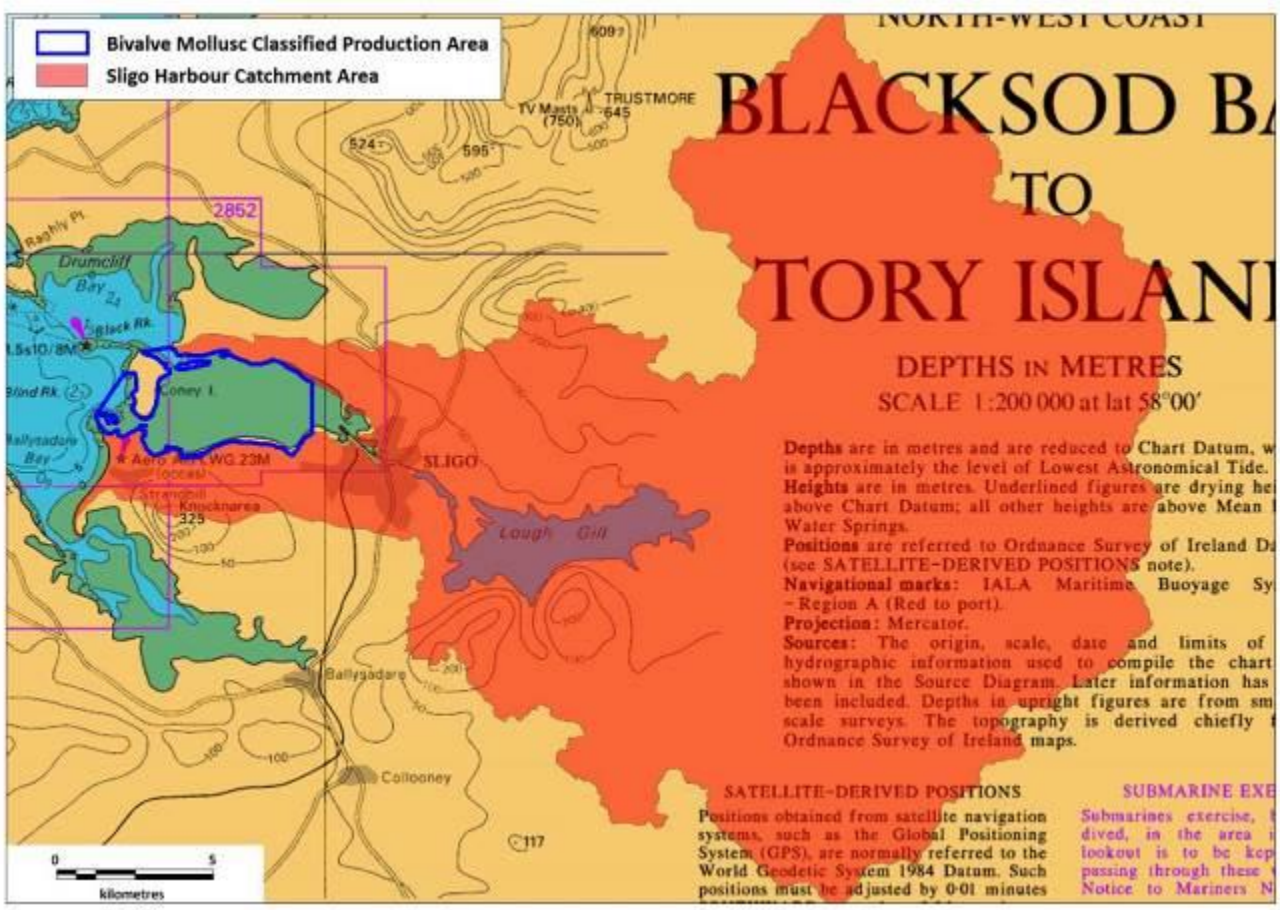



**Figure 3.1: Sligo Harbour catchment area used for assessment of the pollution sources.**

### 3.1.1. Human Population

Figure 3.2 shows all of the counties which fall within the Sligo Harbour catchment area: Sligo and Leitrim. Population census data used by the Central Statistics Office (CSO) is given in units of Electoral Divisions (ED). Figure 3.3 shows the EDs within the catchment areas. The population data was obtained through the Central Statistics Office (CSO) online Small Area Population Statistics (SAPS) (CSO, 2019a) for the year 2016. Town populations are not yet available for the 2016 Census therefore the 2011 Census data was used. Figure 3.4 shows the human population within Sligo Harbour catchment area and Table 3.1 shows these data in tabular form.

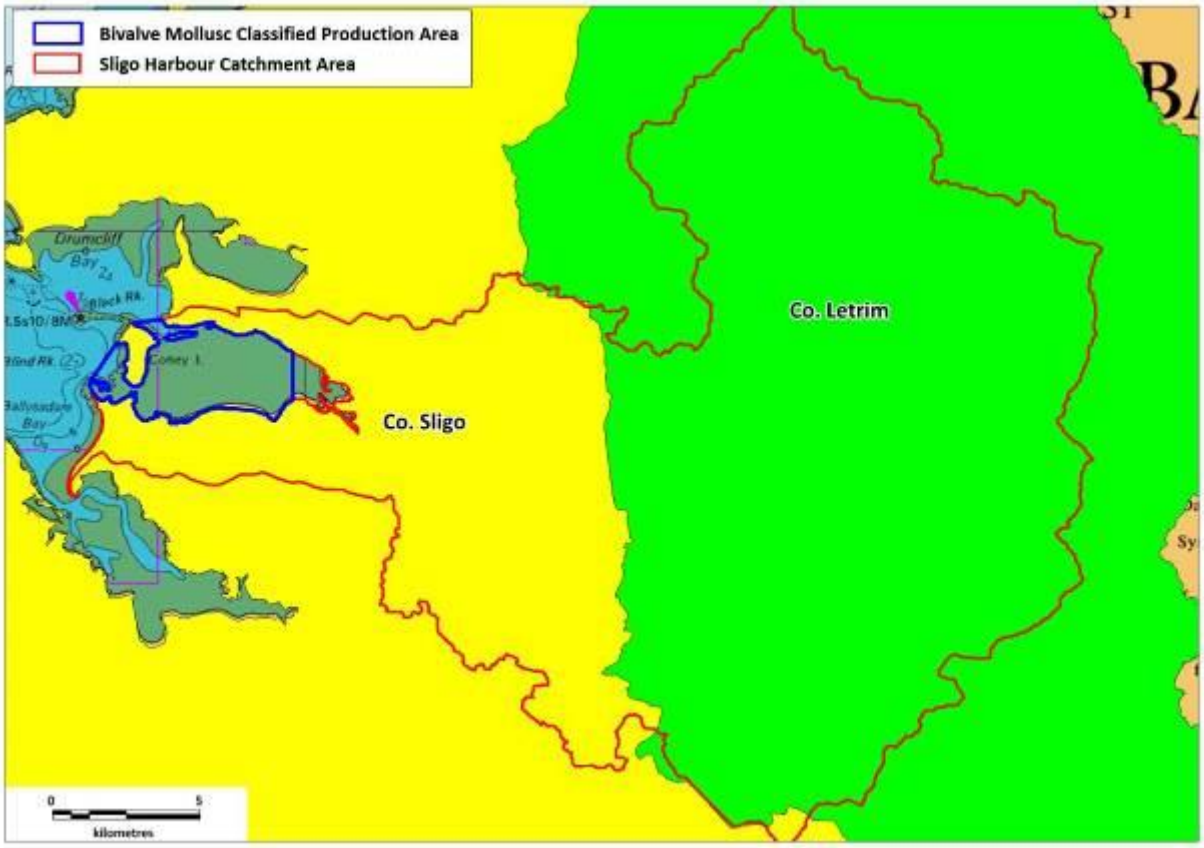



**Figure 3.2: Counties within the Sligo Harbour Catchment Area.**

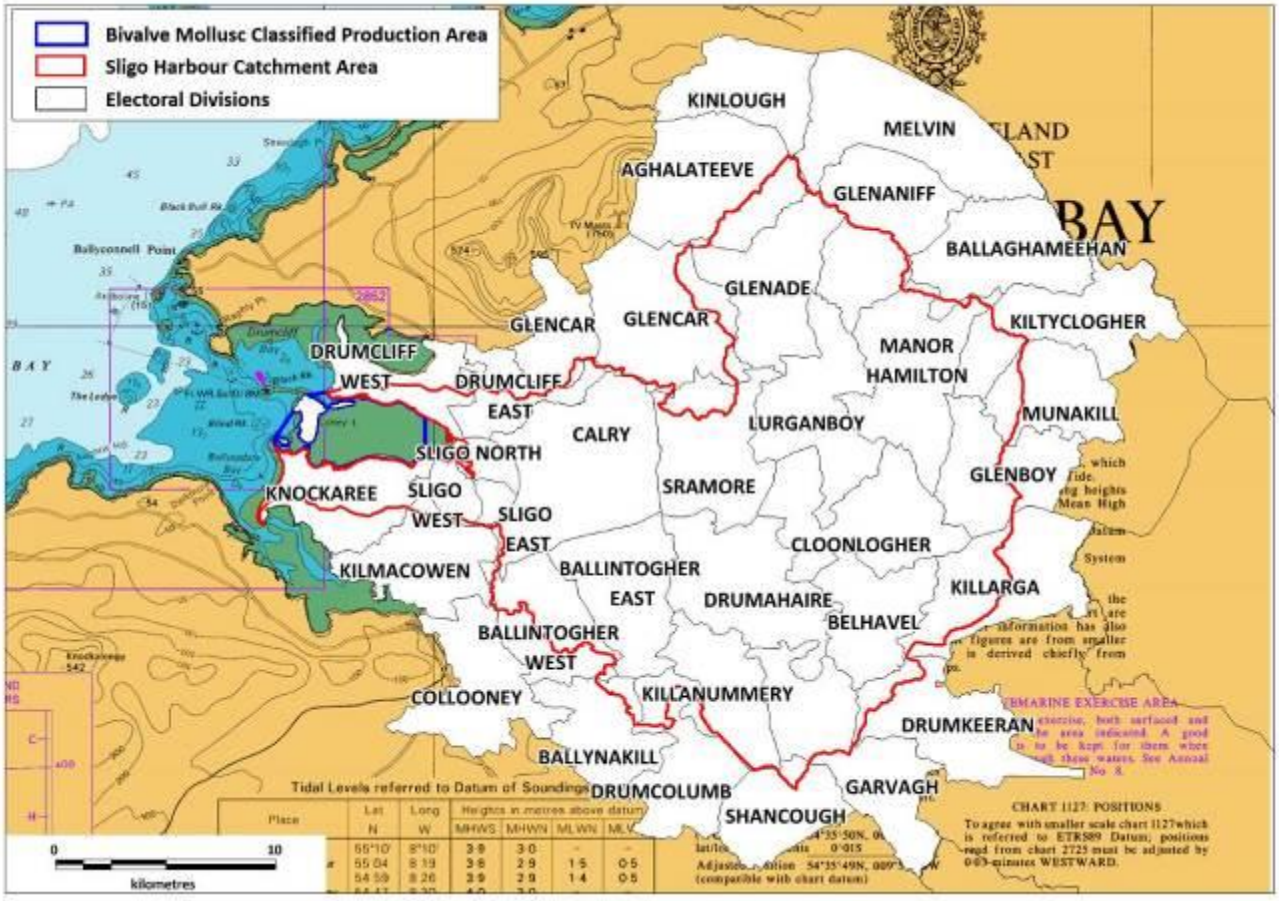



**Figure 3.3: Electoral Divisions within the Sligo Harbour Catchment Area.**

The Sligo Harbour Catchment Area overlaps 35 ED's (five in their entirety and 30 partially). The following ED's are entirely within the catchment Belhavel, Cloonlogher, Drumahaire, Lurganboy and Sligo North. The ED's that are partially within the catchment are Aghalateeve/Aghanlish, Ballaghameehan, Ballintogher East, Ballintogher West, Ballynakill, Calry, Collooney, Drumcliff East, Drumcliff West, Drumcolumb, Drumkeeran, Garvagh/Arigna, Glenade, Glenaniff, Glenboy, Glencar (Sligo), Glencar (Leitrim), Killanummery, Killarga, Kilmacowen, Kiltyclogher, Kinlough, Knockaree, Manorhamilton, Melvin, Munakill, Shancough, Sligo East, Sligo West, Sramore. Sligo town with its three ED's (West, North and East) contains by far the largest population (17,439) followed by Knockaree (3,690), Collooney (2,742) and Kilmacowen (2,161).

These 35 ED's accommodate a total population of 41,212. As most of these ED's only partially overlap the catchment area, an attempt was made to estimate the actual population within the catchment. The percentage of the ED lying within the catchment was calculated in GIS and from this value the population size was calculated *e.g.* if 50% of ED lies within catchment area then 50% of the total population was taken to be the population size of the area within the catchment. Using this method, the population of the catchment areas is estimated at 28,966 people. Table 3.1 shows this estimation.

There are six main towns/urban centres within the catchment area. Four (Sligo Town, Strandhill, Rosses Point and Ballintogher) are located in county Sligo and two (Manorhamilton and Dromahair) are located county Leitrim. Sligo town (19,452) has by far the largest population, followed by Strandhill (1,596), Manorhamilton (1,336), Rosses Point (824), Dromahair (748) and Ballintogher (313).

There are 20,470 households within the 35 ED's within the catchment area. Of this, 14% are vacant (2968) and a further 3% are holiday homes (596). Of the 14,521 houses actually within the catchment (based on the % of the ED within the catchment), 14% are vacant and 2% are holiday homes. Table 3.2 shows the number of households in each ED and the proportion actually within the catchment area.

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 Sligo Harbour system. Therefore, the highest levels of sewage and waste would be expected to enter through the Garavogue River which drains 89% of the catchment, with the majority coming from Sligo Town which accounts for 67% of the catchments population. As holiday homes only account for 2% of the dwellings in the catchment they are unlikely to cause a significant increase in the sewage and waste water levels relative to the permanent population.

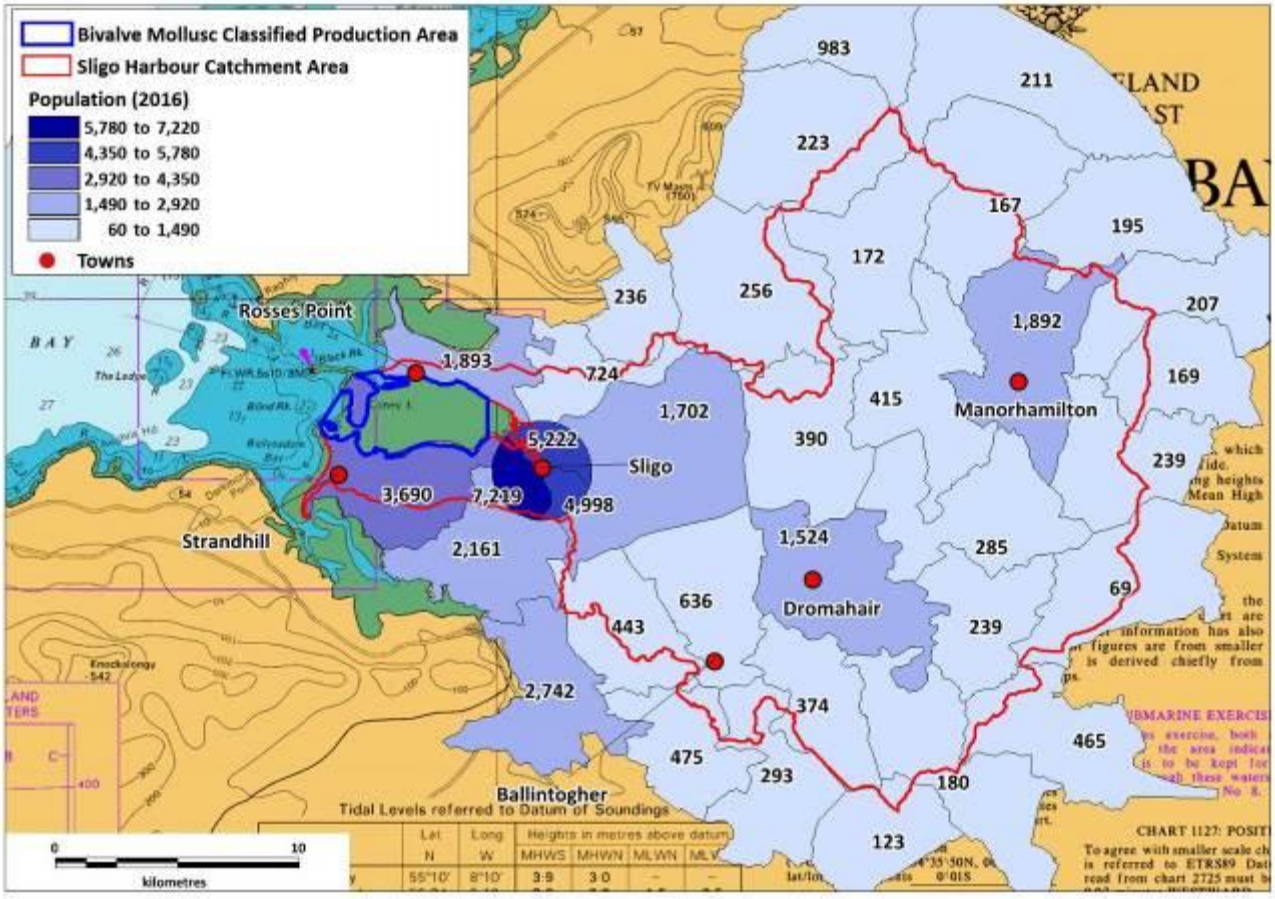



**Figure 3.4: Human population within the Sligo Harbour Catchment Area (Source: CSO, 2019a).**

**Table 3.1: Human population within the Sligo Harbour Catchment Area (Source: CSO, 2019a).**

| Electoral Division | Population (2016) | % ED in Catchment | Estimated Population |
|---|---|---|---|
| Aghalateeve | 223 | 21.0 | 47 |
| Ballaghameehan | 195 | 3.1 | 6 |
| Ballintogher East | 636 | 99.9 | 636 |
| Ballintogher West | 443 | 58.7 | 260 |
| Ballynakill | 475 | 9.3 | 44 |
| Belhavel | 239 | 100.0 | 239 |
| Calry | 1702 | 98.6 | 1678 |
| Cloonlogher | 285 | 100.0 | 285 |
| Collooney | 2742 | 0.1 | 2 |
| Drumahaire | 1524 | 100.0 | 1524 |
| Drumcliff East | 724 | 60.2 | 436 |
| Drumcliff West | 1893 | 40.5 | 767 |
| Drumcolumb | 293 | 17.6 | 52 |
| Drumkeeran | 465 | 12.6 | 59 |
| Garvagh | 180 | 48.6 | 87 |
| Glenade | 172 | 98.8 | 170 |
| Glenaniff | 167 | 39.1 | 65 |

| Electoral Division | Population (2016) | % ED in Catchment | Estimated Population |
|---|---|---|---|
| Glenboy | 239 | 60.9 | 145 |
| Glencar (Leitrim) | 256 | 16.6 | 43 |
| Glencar (Sligo) | 236 | 3.9 | 9 |
| Killanummery | 374 | 93.5 | 350 |
| Killarga | 69 | 41.7 | 29 |
| Kilmacowen | 2161 | 6.7 | 145 |
| Kiltyclogher | 207 | 23.2 | 48 |
| Kinlough | 983 | 0.0 | 0 |
| Knockaree | 3690 | 58.5 | 2160 |
| Lurganboy | 415 | 100.0 | 415 |
| Manorhamilton | 1892 | 96.1 | 1818 |
| Melvin | 211 | 0.2 | 0 |
| Munakill | 169 | 20.6 | 35 |
| Shancough | 123 | 6.4 | 8 |
| Sligo East | 4998 | 98.3 | 4914 |
| Sligo North | 5222 | 100.0 | 5222 |
| Sligo West | 7219 | 96.1 | 6938 |
| Sramore | 390 | 85.0 | 332 |

**Table 3.2: Households within the EDs in the Sligo Harbour Catchment Areas (Source: CSO, 2019a).**

| Electoral Division | Total Households | No. Occupied* | Unoccupied holiday homes | Vacant houses | Total Households in Catchment | No. Occupied in Catchment | Unoccupied holiday homes in Catchment | Vacant houses in Catchment |
|---|---|---|---|---|---|---|---|---|
| Aghalateeve | 133 | 87 | 5 | 41 | 28 | 18 | 1 | 9 |
| Ballaghameehan | 118 | 83 | 22 | 13 | 4 | 3 | 1 | 0 |
| Ballintogher East | 276 | 235 | 6 | 35 | 276 | 235 | 6 | 35 |
| Ballintogher West | 167 | 144 | 7 | 16 | 98 | 84 | 4 | 9 |
| Ballynakill | 191 | 161 | 5 | 25 | 18 | 15 | 0 | 2 |
| Belhavel | 160 | 108 | 5 | 47 | 160 | 108 | 5 | 47 |
| Calry | 774 | 684 | 21 | 69 | 763 | 674 | 21 | 68 |
| Cloonlogher | 159 | 118 | 8 | 33 | 159 | 118 | 8 | 33 |
| Collooney | 1381 | 1063 | 14 | 304 | 1 | 1 | 0 | 0 |
| Drumahaire | 815 | 595 | 61 | 159 | 815 | 595 | 61 | 159 |
| Drumcliff East | 322 | 295 | 3 | 24 | 194 | 178 | 2 | 14 |
| Drumcliff West | 845 | 697 | 71 | 77 | 342 | 282 | 29 | 31 |
| Drumcolumb | 133 | 107 | 8 | 18 | 23 | 19 | 1 | 3 |
| Drumkeeran | 311 | 203 | 7 | 101 | 39 | 26 | 1 | 13 |
| Garvagh | 100 | 64 | 7 | 29 | 49 | 31 | 3 | 14 |
| Glenade | 91 | 64 | 12 | 15 | 90 | 63 | 12 | 15 |
| Glenaniff | 107 | 68 | 18 | 21 | 42 | 27 | 7 | 8 |
| Glenboy | 112 | 91 | 3 | 18 | 68 | 55 | 2 | 11 |
| Glencar (Leitrim) | 124 | 94 | 9 | 21 | 21 | 16 | 1 | 3 |
| Glencar (Sligo) | 95 | 88 | 2 | 5 | 4 | 3 | 0 | 0 |
| Killanummery | 161 | 135 | 5 | 21 | 151 | 126 | 5 | 20 |
| Killarga | 46 | 30 | 1 | 15 | 19 | 13 | 0 | 6 |
| Kilmacowen | 894 | 832 | 7 | 55 | 60 | 56 | 0 | 4 |

| Electoral Division | Total Households | No. Occupied* | Unoccupied holiday homes | Vacant houses | Total Households in Catchment | No. Occupied in Catchment | Unoccupied holiday homes in Catchment | Vacant houses in Catchment |
|---|---|---|---|---|---|---|---|---|
| Kiltyclogher | 146 | 101 | 8 | 37 | 34 | 23 | 2 | 9 |
| Kinlough | 506 | 372 | 33 | 101 | 0 | 0 | 0 | 0 |
| Knockaree | 1657 | 1467 | 89 | 101 | 970 | 859 | 52 | 59 |
| Lurganboy | 198 | 162 | 10 | 26 | 198 | 162 | 10 | 26 |
| Manorhamilton | 1044 | 806 | 43 | 195 | 1003 | 774 | 41 | 187 |
| Melvin | 157 | 98 | 32 | 27 | 0 | 0 | 0 | 0 |
| Munakill | 97 | 71 | 15 | 11 | 20 | 15 | 3 | 2 |
| Shancough | 73 | 49 | 7 | 17 | 5 | 3 | 0 | 1 |
| Sligo East | 2430 | 2114 | 14 | 302 | 2389 | 2078 | 14 | 297 |
| Sligo North | 2828 | 2318 | 6 | 504 | 2828 | 2318 | 6 | 504 |
| Sligo West | 3649 | 3162 | 23 | 464 | 3507 | 3039 | 22 | 446 |
| Sramore | 170 | 140 | 9 | 21 | 145 | 119 | 8 | 18 |
| Total | 20470 | 16906 | 596 | 2968 | 14521 | 12137 | 330 | 2055 |

* This figure includes those houses temporarily unoccupied on census night.

### 3.1.2. Tourism

In 2017, 2.4 million tourists visited the Border Region of Ireland (Failte Ireland, 2018a). This figure was made up of 746,000 overseas tourists, 1,000,000 domestic tourists and 648,000 Northern Irish tourists. Of the overseas tourists, 173,000 visited Co. Sligo and 41,000 visited Co. Leitrim, and of the domestic tourists 247,000 visited Co. Sligo and 206,000 visited Co. Leitrim (Failte Ireland, 2018b). The main tourist attractions in the area are Knocknarea, Sligo Abbey, Lough Gill, Benbulben, Rossess Point, Lissadell House, Strandhill Beach and The Devils Chimney in Co. Sligo, along with Glencar waterfall and Parke's Castle in Co. Leitrim.

The attractions located inside the catchment area include: Knocknarea, Sligo Abbey, Lough Gill, Rosses Point, Strandhill Beach and Parke's Castle. For Ireland as a whole, in 2017 most tourists visited between July and September (31%), followed by April to June (27%), October to December (23%) and January to March (18%). There is no reason to expect this trend to be any different in the Border region.

Several operators use the natural amenities in and adjacent to Sligo Harbour as a focal point for their aqua-tourism businesses. Two sea angling and charter vessels (Sea Fishing Sligo and Ewing Sea Angling and Boat Charters) operate out of Rosses Point. There are two companies operating guided boat tours of the area one operates in Lough Gill (Rose of Innisfree) and the other provides a wide range of tours along the coast including Inishmurray Island (Wild West Sailing). Sligo Kayaking tours provide tours of both Lough Gill and along the coastline including Sligo Harbour. There are also two Surf schools at Strandhill, Sligo Yacht Club at Rosses Point and Seatrails which provided guided walking tours of the area including Knocknarea and Rosses Point.

In addition to the above there is also a number of beaches located along the shore of Sligo Harbour, Sligo Airport at Strandhill and a number of piers, quays and slips which provide sea access.

Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Sligo Harbour catchment 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. The only monitored swimming area near the production area is Rosses Point beach, which is a Blue Flag beach. Swimming is prohibited at Strandhill beach and is only used for water sports such as canoeing, windsurfing, kite surfing and surfing. Rosses Point is monitored for water quality by the EPA and has been classified as excellent for 2015, 2016 and 2017. No water quality

data was available for Strandhill.

### 3.1.3. Sewage Discharges

#### *3.1.3.1. Water Treatment Works*

There are seven waste water or sewage treatment works within the Sligo Harbour catchment, three of which discharge directly to the sea (Sligo, Rosses Point and Strandhill) and the remaining four discharge to rivers within the catchment (Ballintogher, Killarga, Dromahair and Manorhamilton). Figure 3.5 shows all 7 Treatment Works within the Sligo Harbour catchment area and Table 3.3 shows the coordinates and facility capacities of each works (EPA, 2019a).

#### *3.1.3.2. Continuous Discharges*

Strandhill WWTP is a secondary treatment facility with a design capacity of 1500 PE (Population Equivalent) and is currently over capacity at 2,371 PE. The maximum discharge for this facility is 3,038 $m^3$/day. Rosses Point WWTP is a primary treatment facility with a design capacity of 1,500 PE and is currently over capacity at 1,568 PE; at the time of writing there was no data for the maximum discharge from this facility. Sligo WWTP is a tertiary P removal facility with a design capacity of 50,000 PE and is currently under capacity at 28,158 PE; the maximum discharge for this facility is 37,500 $m^3$/day. Ballintogher & Environs WWTP is a secondary treatment facility with a design capacity of 350 PE and is currently over capacity at 360 PE and the maximum discharge for this facility is 143 $m^3$/day. Dromahair WWTP is a tertiary P removal facility with a design capacity of 2,200 PE and is currently below capacity at 1,349 PE. At the time of writing, there were no data for the maximum discharge from this facility. Killarga WWTP is a secondary treatment facility with a design capacity of 200 PE and is currently under capacity at 109 PE. The maximum discharge for this facility is 59 $m^3$/day. Manorhamilton WWTP is a tertiary P removal facility with a design capacity of 3,500 PE and is currently under capacity at 2,557 PE and the maximum discharge for this facility is 2,830 $m^3$/day. The locations of the discharges can be seen in Figure 3.6 and Table 3.4 provides details of the discharge. Strict emissions limits are set out in the discharge Licences for each facility in terms of BOD (Biological Oxygen Demand), Ortho-Phosphate, Suspended Solids, Nitrogen and Ammonia. These emissions limits comply with the parameters of Shellfish Directive (2006/113/EC) and the Quality of Shellfish Waters Regulations 2006.

The pollution reduction program for Sligo Bay recorded 3,908 on-site waste water treatment systems within the catchment and there density is higher than the national average. Using the average household size of 2.75 individuals gives 10,747 people on private treatment systems. Whereas, there are 36,472 people on the public sewer/treatment system.

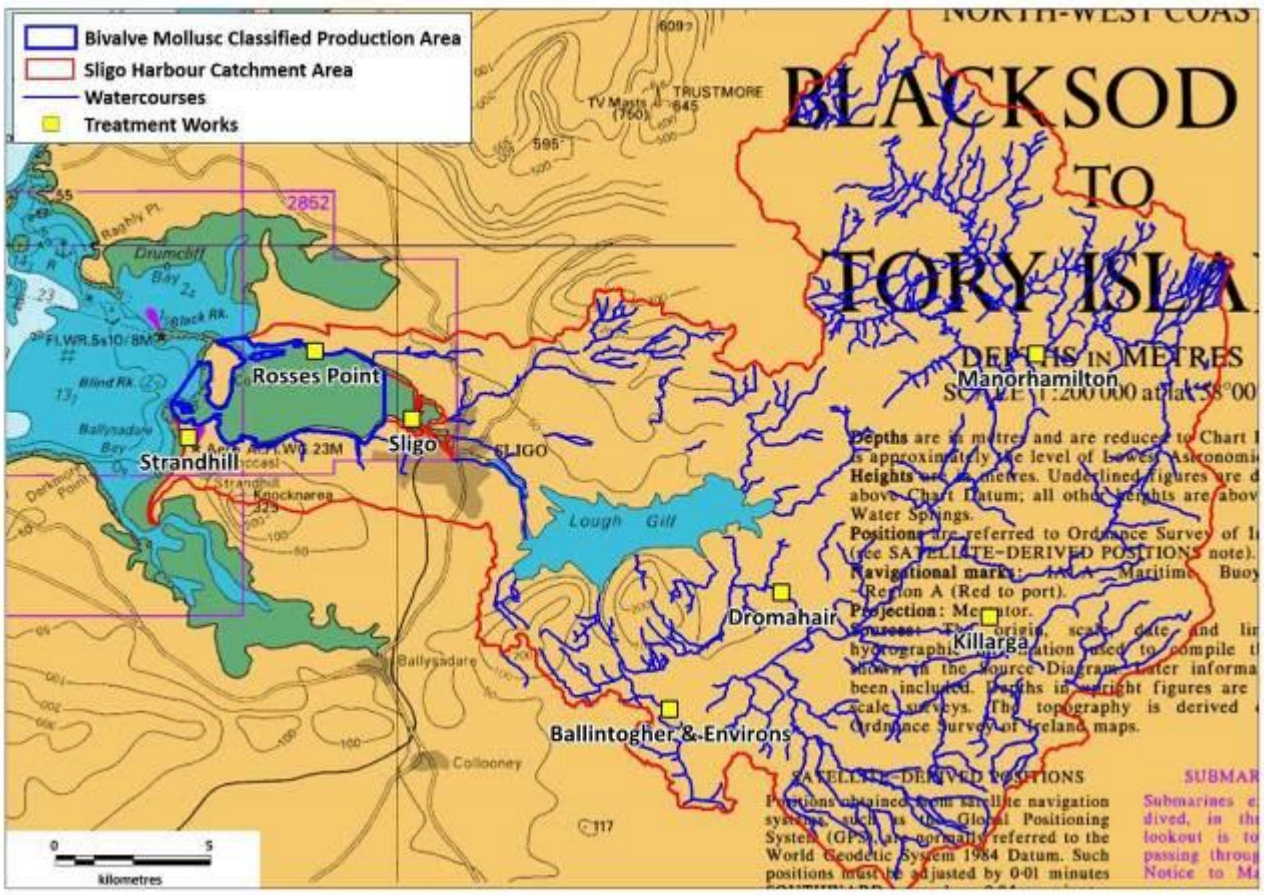



**Figure 3.5: Sewage Treatment Works within the Sligo Harbour Catchment Area (Source: The EPA, 2019a).**

**Table 3.3: Sewage Treatment Works within the Sligo Harbour Catchment Area (Source: EPA, 2019a).**

| Name | Easting | Northing | Longitude | Latitude | p.e. | Designed p.e. |
|---|---|---|---|---|---|---|
| Strandhill | 160611 | 336834 | -8.60469 | 54.27862 | 2371 | 1500 |
| Rosses Point | 164707 | 339575 | -8.54214 | 54.30354 | 1568 | 1500 |
| Sligo | 167816 | 337374 | -8.49415 | 54.28397 | 28158 | 50000 |
| Ballintogher & Environs | 176069 | 328000 | -8.36669 | 54.20021 | 360 | 350 |
| Dromahair | 179695 | 331717 | -8.31138 | 54.23376 | 1349 | 2200 |
| Killarga | 186411 | 330910 | -8.20835 | 54.22673 | 109 | 200 |
| Manorhamilton | 187950 | 339360 | -8.1851 | 54.30268 | 2557 | 3500 |

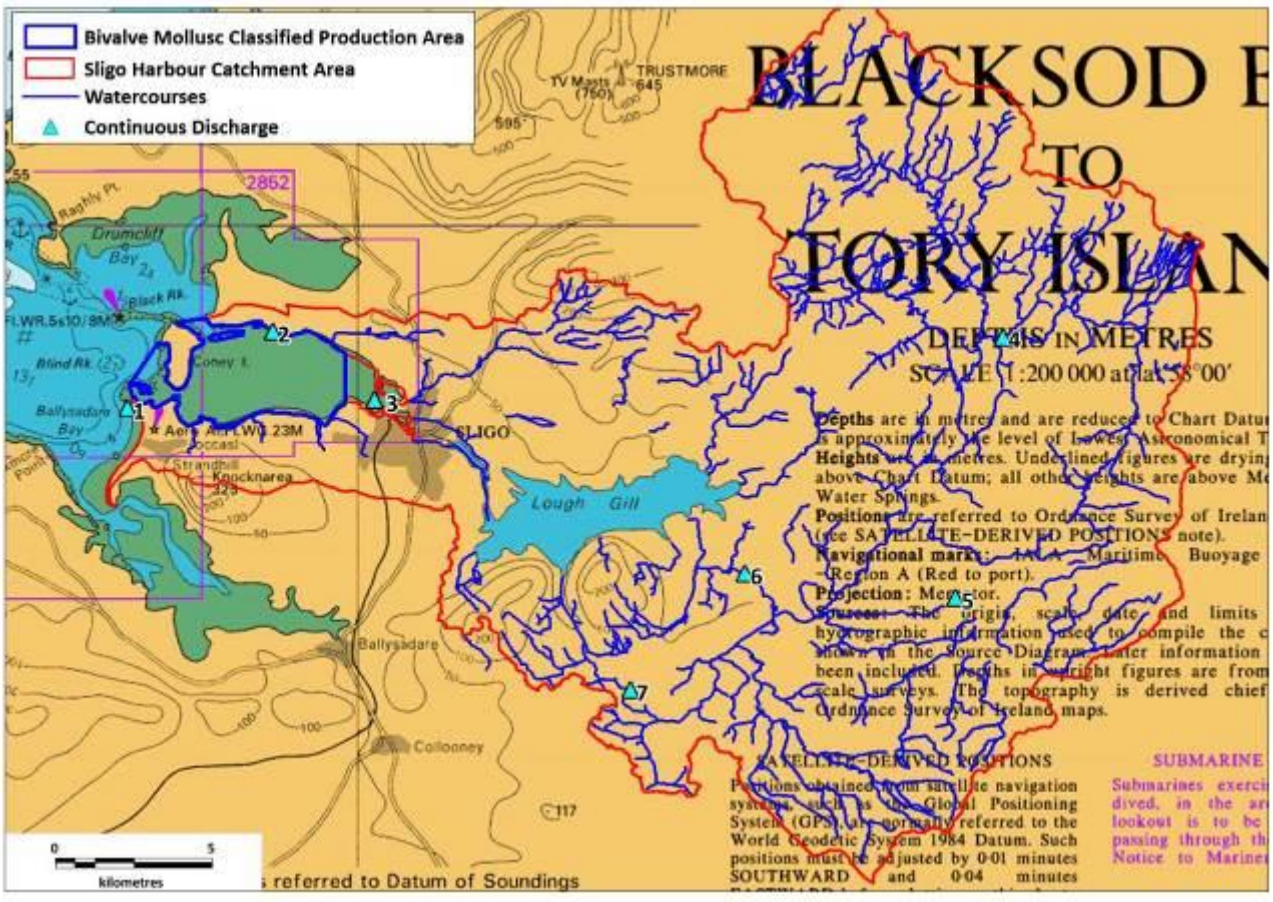



**Figure 3.6: Continuous Discharges associated with the Sewage Treatment Works within the Sligo Harbour Catchment Area (Source: The EPA, 2019a).**

**Table 3.4: Continuous Discharges within the Sligo Harbour Catchment area (Source: EPA, 2019a). Map Codes refer to Figure 3.6.**

| Map Code | Name | Treatment | Easting | Northing | Longitude | Latitude | Receiving Body | Max Discharge/ day (m3) | DWF/ day (m3) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Strandhill | 2 - Secondary Treatment | 160057 | 337116 | -8.61401 | 54.2813 | Sligo Bay | 3,038 | 336.96 |
| 2 | Rosses Point | 1 - Primary Treatment | 164692 | 339511 | -8.54313 | 54.30315 | Sligo Harbour | N/A | N/A |
| 3 | Sligo | 3P - Tertiary P Removal | 167889 | 337373 | -8.49309 | 54.28366 | Garavogue Estuary | 37,500 | 12,500 |
| 4 | Ballintogher & Environs | 2 - Secondary Treatment | 176033 | 328012 | -8.36801 | 54.20051 | Tiratick River | 143 | 47.52 |
| 5 | Dromahair | 3P - Tertiary P Removal | 179697 | 331702 | -8.31212 | 54.23382 | Bonet River | N/A | N/A |
| 6 | Killarga | 2 - Secondary Treatment | 186435 | 330892 | -8.20876 | 54.22677 | Unnamed Stream | 59 | 19.6 |
| 7 | Manorhamilton | 3P - Tertiary P Removal | 187964 | 339214 | -8.18565 | 54.30157 | Owenmore River | 2,830 | 501.12 |

### *3.1.3.3. Rainfall Dependent / Emergency Sewage Discharges*

In addition to WWTPs having a continuous discharge pipe, they also have intermittent or rainfall dependent discharge pipes in the form of storm water overflows. During storm flows in excess of a predetermined flow rate, the excess will bypass the works and flow directly to the outfall via the storm overflow discharge pipes. The details for the intermittent discharges can be seen in Table 3.5 and their locations can be seen in Figure 3.7.

**Table 3.5: Rainfall dependent discharges (storm water overflows) within the Sligo Harbour Catchment area (Source: EPA, 2019a). Map Codes refer to Figure 3.7.**

| Map Code | Name | Discharge Point Code | Easting | Northing | Longitude | Latitude | Receiving Body |
|---|---|---|---|---|---|---|---|
| 1 | Strandhill | SW002 | 160057 | 337116 | -8.61401 | 54.2813 | Sligo Bay |
| 2 | Rosses Point | SW002 | 164016 | 339696 | -8.56006 | 54.30454 | Sligo Harbour |
| 3 | Rosses Point | SW003 | 163880 | 339765 | -8.55564 | 54.30538 | Sligo Harbour |
| 4 | Rosses Point | SW004 | 163591 | 339674 | -8.55354 | 54.30477 | Sligo Harbour |
| 5 | Sligo | SW002 | 168467 | 336877 | -8.48487 | 54.27974 | Garavogue Estuary |
| 6 | Sligo | SW003 | 168981 | 336273 | -8.48532 | 54.27891 | Garavogue Estuary |
| 7 | Sligo | SW004 | 169678 | 335970 | -8.48532 | 54.27891 | Garavogue Estuary |
| 8 | Sligo | SW005 | 169351 | 335978 | -8.47692 | 54.27435 | Garavogue Estuary |
| 9 | Sligo | SW0010 | 168437 | 336785 | -8.47121 | 54.27172 | Garavogue Estuary |
| 10 | Sligo | SW0015 | 168437 | 336785 | -8.46619 | 54.27167 | Garavogue Estuary |
| 15 | Ballintogher & Environs | SW002 | 176058 | 328013 | -8.36763 | 54.20052 | Tiratick River |
| 14 | Dromahair | SW002 | 179714 | 331716 | -8.31186 | 54.23395 | Bonet River |
| 13 | Killarga | SW002 | 186430 | 330906 | -8.20883 | 54.22689 | Unnamed stream |
| 11 | Manorhamilton | SW002 | 187964 | 339214 | -8.18565 | 54.30157 | Owenmore River |
| 12 | Manorhamilton | SW004 | 188440 | 339433 | -8.17835 | 54.30354 | Owenmore River |

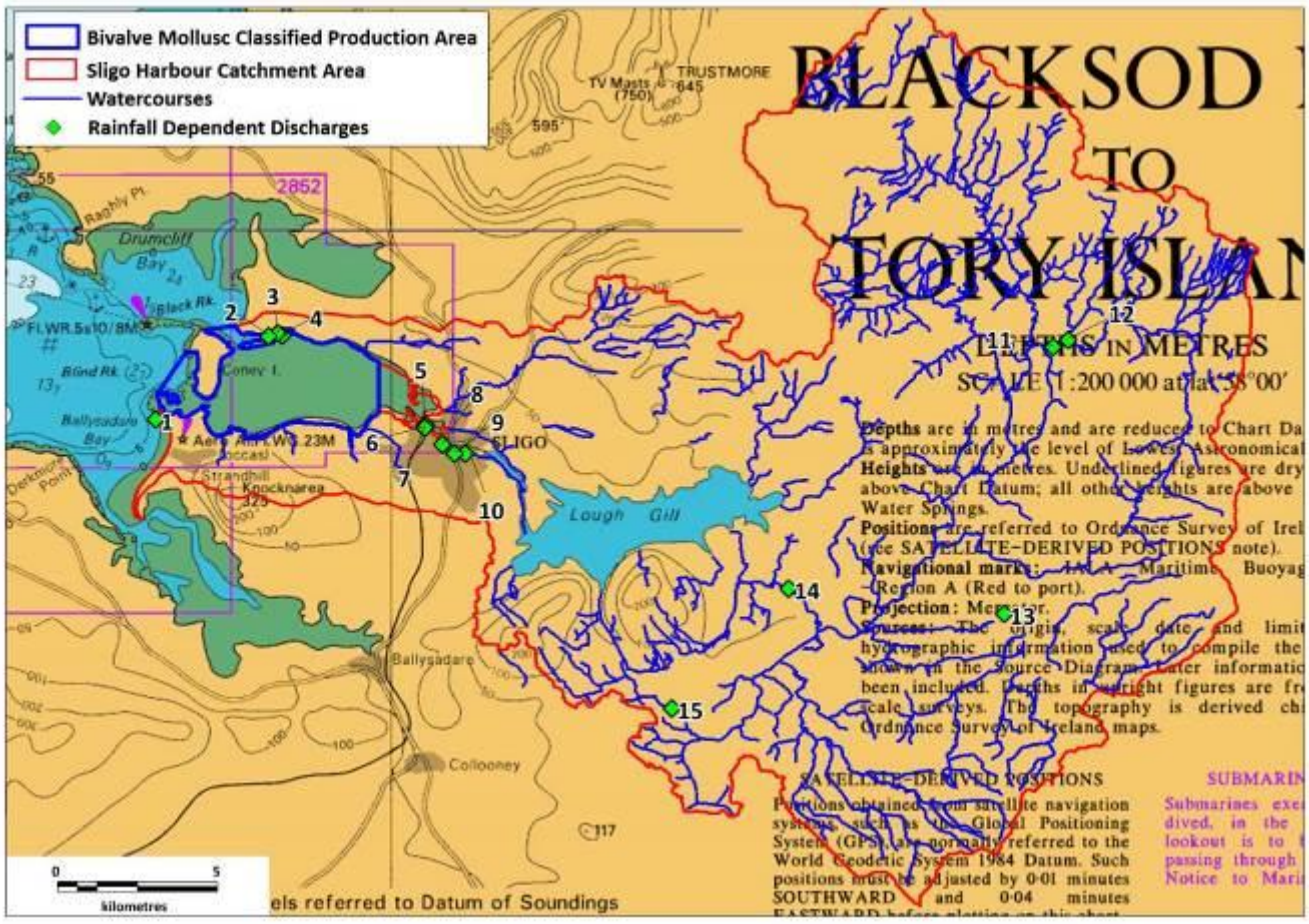



**Figure 3.7: Rainfall Dependent Discharges associated with the Sewage Treatment Works within the Sligo Harbour Catchment Area (Source: The EPA, 2019a).**

### 3.1.4. Industrial Discharges

Figure 3.8 shows the industrial discharges to water within the Sligo Harbour catchment area accounted for during the desk-based assessment (EPA, 2019c; EPA, 2019d). In total, there are six industrial discharges belonging to three facilities. The nature of the facilities is pharmaceutical, waste and video tape production, the latter closed down in 2002. Details on these industrial discharges can be seen in Tables 3.6 and 3.7. There are 18 Section 4 licences (see Figure 3.9) for the discharge of trade effluent, with 10 discharging directly into Sligo Harbour and the remaining 8 discharging to rivers within the catchment. Table 3.8 shows details of these Section 4 licences. Where known, the nature of the discharge is included in Table 3.8. The majority of the Section 4s do not have a sewage/waste water component. Only, three of the 10 Section 4s discharging directly into Sligo Harbour have a sewage/wastewater component. In addition, Leitrim County Council has confirmed that the four Licences in their jurisdiction are largely compliant with its Section 4 Licence limits and downstream sites are not showing any adverse effects. These sites are reviewed and monitored quarterly by Leitrim County Council.

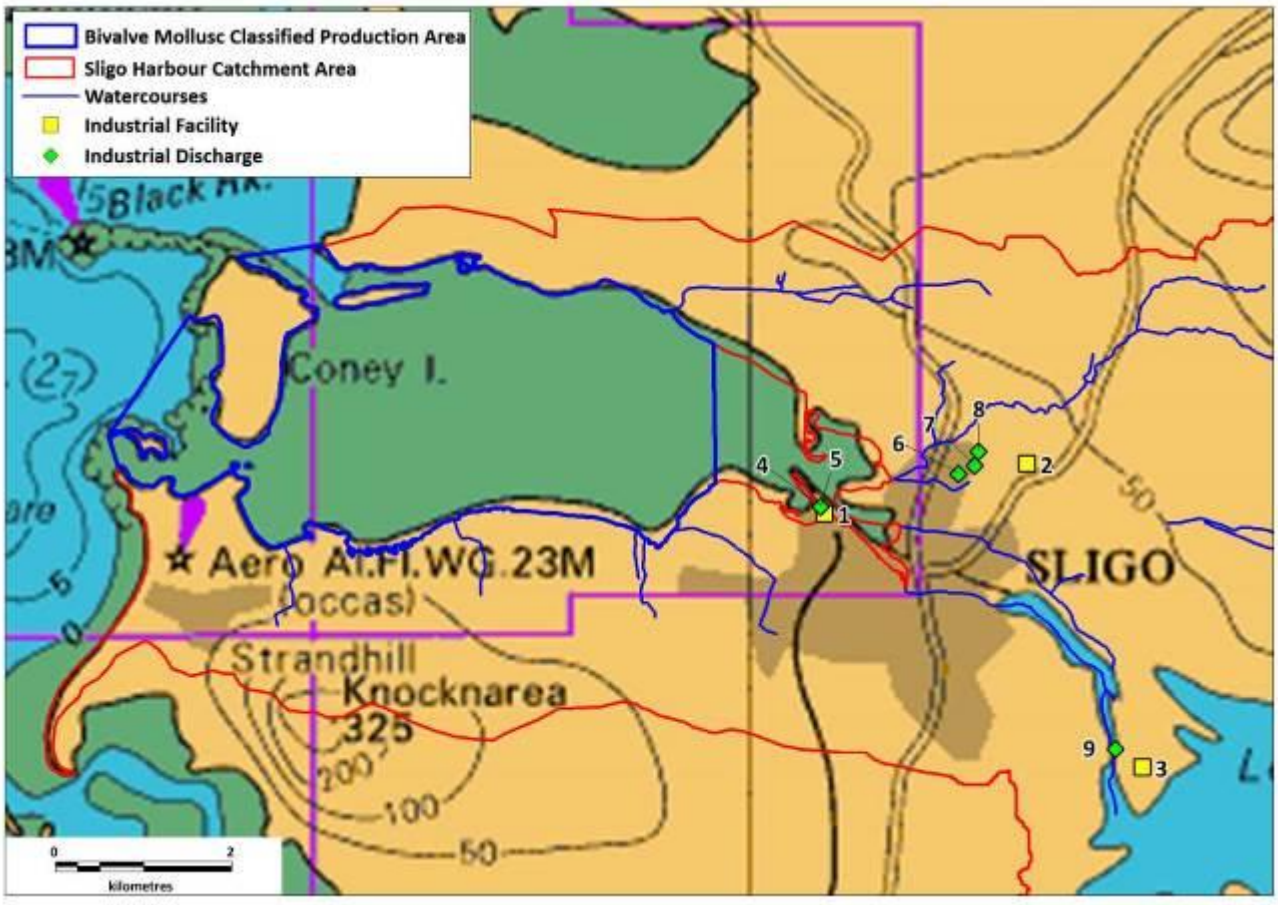



**Figure 3.8: All industrial discharges within the Sligo Harbour Catchment Area (Source: (EPA, 2019c; EPA, 2019d).**

**Table 3.6: Industrial Facilities with discharges to water within the Sligo Harbour Catchment Area (Source: EPA, 2019c). Map Codes refer to Figure 3.7.**

| Map Code | Licence No. | Licence Type | Licence holder | Facility ad | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|---|---|
| 1 | W0058 | IEL | Starrus Eco Holdings Limited (Sligo) | Deepwater Quay, Sligo | -8.48845 | 54.27982 | 168184 | 336910 |
| 2 | P0643 | IEL | AbbVie Ireland NL B.V. | Manorhamilton Road, Sligo | -8.45306 | 54.28492 | 170492 | 337462 |
| 3 | P0135 | IPPC | Saehan Media (Irl.) Limited | Hazelwood, Sligo | -8.43298 | 54.25394 | 171779 | 334005 |

**Table 3.7: Details of Industrial discharges to water within the Sligo Harbour Catchment Area (Source: EPA, 2019c). Map Codes refer to Figure 3.7.**

| Map I | Discharge Code | Licence Type | Licence holder | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|---|
| 4 | W0058-01_SE1_EW | IE | Starrus Eco Holdings Limited (Sligo) | -8.48904 | 54.28056 | 168196 | 336970 |
| 5 | W0058-01_SE2_EW | IE | Starrus Eco Holdings Limited (Sligo) | -8.48904 | 54.28056 | 168196 | 336970 |
| 6 | P1087-01_SW1_EW | IE | AbbVie Ireland NL B.V. | -8.46503 | 54.28389 | 169762 | 337408 |
| 7 | P1087-01_SW2_EW | IE | AbbVie Ireland NL B.V. | -8.46214 | 54.28473 | 169951 | 337423 |
| 8 | P1087-01_SW3_EW | IE | AbbVie Ireland NL B.V. | -8.46151 | 54.28619 | 169993 | 337585 |
| 9 | P0135-01_W1_EW | IPC | Saehan Media (Irl.) Limited | -8.43764 | 54.25581 | 171527 | 334193 |

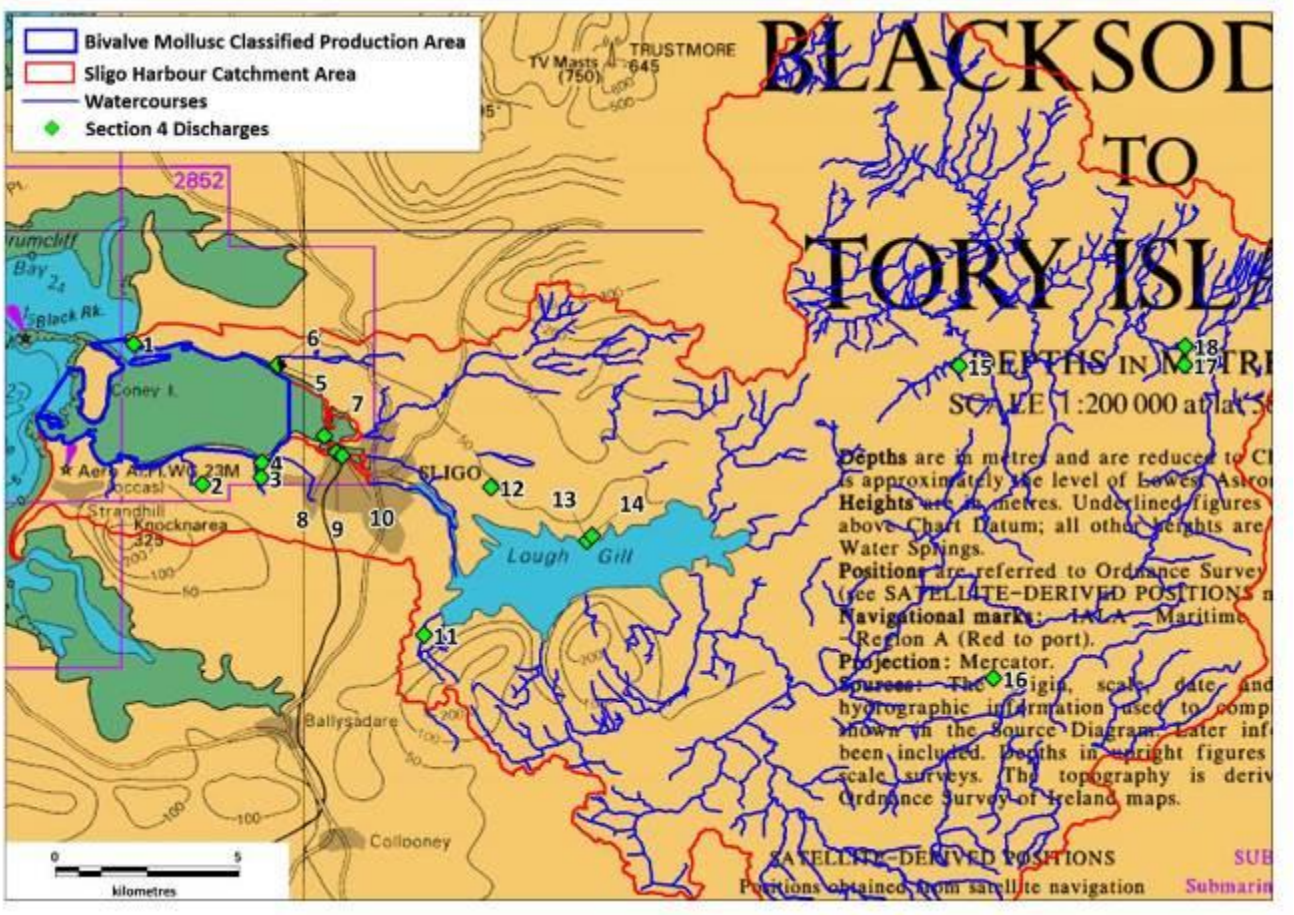



**Figure 3.9: Section 4 discharges within the Sligo Harbour Catchment Area (Source: (EPA, 2019c; EPA, 2019d).**

**Table 3.8: Details on Section 4 discharges within the Sligo Harbour Catchment Area (Source: EPA, 2019d). Map Codes refer to Figure 3.9.**

| Map Code | File Reference | Licence holder | Facility Type | Nature of Discharge | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|---|---|
| 1 | DL(W)137 | Sligo Yacht Club | Recreational/Commercial | Now discharging to IW Sewer (no discharge to waters licence) | -8.57239 | 54.30625 | 162740 | 339892 |
| 2 | DL (W) 24 | Scarden Court | Residential On-site WWTP | Discharging to groundwater /<5m$^3$/day (no licence required) | -8.54382 | 54.27186 | 164570 | 336050 |
| 3 | DL (W) 7 | James and Winifred Beirne | One off house | Discharging to surface waters via On-site WWP | -8.51913 | 54.2735 | 166180 | 336220 |
| 4 | DL (W) 3 | Sligo Dairies Ltd | Commercial | Premises has closed down (no/lapsed licence) | -8.51887 | 54.27709 | 166200 | 336620 |
| 5 | DL (W) 16R1 | Radisson Blu Hotel | Commercial | Mixed domestic and trade effluent discharging to surface water | -8.51232 | 54.30087 | 166646 | 339263 |
| 6 | DL (W) 22 | HSE Cregg House | Commercial residential | Mixed domestic and trade effluent discharging to surface water | -8.51218 | 54.3011 | 166655 | 339289 |
| 7 | DL (W) 39 | Erin Recyclers Ltd | Commercial | Now discharging to IW Sewer | -8.49273 | 54.28365 | 167908 | 337338 |
| 8 | DL(W)109 | Sligo Fuels Sales Limited | Commercial | Oil storage Depot/ no domestic effluent | -8.48752 | 54.27969 | 168244 | 336894 |
| 9 | DL (W) 90 | McCormack Fuels Ltd | Commercial | Oil Storage Depot/ no domestic effluent | -8.48728 | 54.27965 | 168260 | 336890 |
| 10 | DL(W)149 | Bord Na Mona fuels Ltd | Commercial | Fuel storage compound (coal). No domestic effluent. | -8.48524 | 54.27873 | 168392 | 336787 |
| 11 | DL (W) 139 | Cemex ROI Ltd | Commercial | Quarrying run-off (Septic tank on site discharges to groundwater) | -8.4507 | 54.23492 | 170611 | 331895 |
| 12 | DL (W) 34 | John Davey Motors Ltd | Commercial | Mixed domestic and trade effluent. Discharge is to groundwater via On-site WWTP. | -8.42271 | 54.27109 | 172460 | 335910 |
| 13 | DL (W) 13R | Saint Angela's College | Educational College | Mixed domestic and trade, discharge is to surface waters via | -8.38256 | 54.25805 | 175068 | 334444 |

| Map Code | File Reference | Licence holder | Facility Type | Nature of Discharge | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|---|---|
| | | | | On-site WWTP. | | | | |
| 14 | DL (W) 43 | Saint Angela's College Residences | Residential/ Student Accommodation | Mixed domestic and trade, discharge is to surface waters via On-site WWTP | -8.38027 | 54.25927 | 175218 | 334579 |
| 15 | WPL/07/04 | D.K Trotter | Quarry | | -8.2265 | 54.3009 | 185254 | 339169 |
| 16 | WPL/10/03 | Seamus Kerrigan Ltd | Quarry | | -8.21208 | 54.22434 | 186167 | 330644 |
| 17 | WPL/10/01 | Tates Quarry | Quarry | | -8.13199 | 54.30104 | 191407 | 339169 |
| 18 | WPL/10/06 | Mr Damien McPartland | Coal Depot | | -8.13174 | 54.30569 | 191424 | 339687 |

### 3.1.5. Landuse Discharges

Figure 3.10 shows the Corine landuse (EPA, 2019e) within the Sligo Harbour catchment area. Figure 4.4 (page 89) shows all rivers/streams within the catchment area. Within the catchment area, land use is dominated by land principally occupied by agriculture, with significant areas of natural vegetation (155.4km$^2$; 33.2%), followed by pastures (71.7km$^2$; 15.3%), peat bogs (60.4km$^2$; 12.9%), transitional woodland-shrub (35.3km$^2$; 7.6%) and moors and heathland (33.1km$^2$; 7.1%) (see Figure 3.11). Forestry (coniferous, broad-leafed and mixed) makes up 9.8% of the land use in the area (45.7km$^2$).

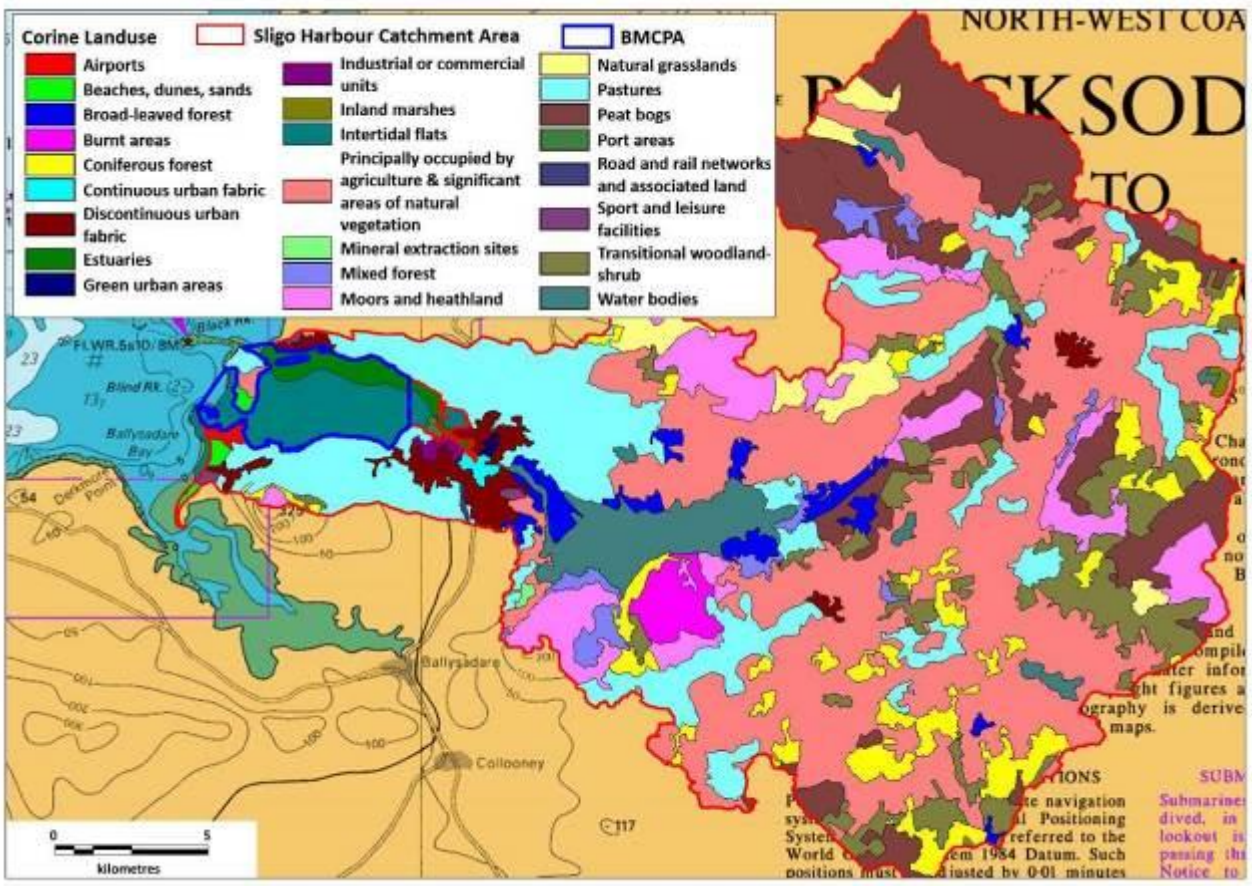



**Figure 3.10: Land use within the Sligo Harbour Catchment Area (Source: EPA, 2019e).**

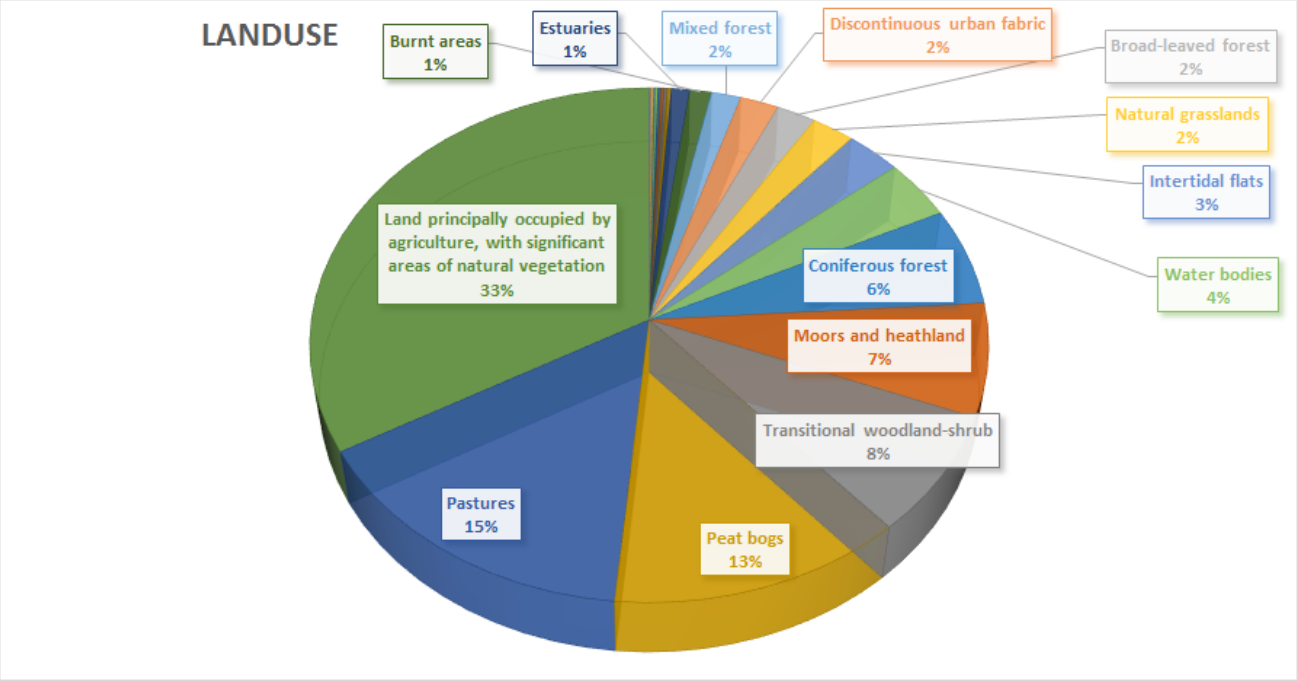



**Figure 3.11: Breakdown of landuse within the Sligo Harbour Catchment Area (only landuse ≥1% is labelled).**

Data from the Census of Agriculture 2010 (CSO, 2019b) can be seen in Table 4.10 below. Figures 3.12 to 3.19 show thematic maps for each category in Table 4.9. There are no farms or agricultural activity in the Aghalateeve / Aghanlish, Aghavoghill / Melvin and Garvagh / Arigna EDs which are located in the eastern extent of the catchment. Although there are a small number of farms in the Sligo East (2), Sligo North (2) and Sligo West (5) EDs no data are available as they have been suppressed for reasons of confidentiality, where individual farm details might be identifiable when results are presented at ED level.

Numbers of farms within the catchment range from 2 in Sligo East and Sligo North, Co. Sligo to 98 in Calry, Co. Sligo. The total area farmed within the catchment varies from 488 ha in Drumcliff West, Co. Sligo to 2,129 ha in Manorhamilton, Co. Leitrim. The average farm size ranges from 17.8 ha in Kilmacowen, Co. Sligo to 52.3 ha in Killarga, Co. Leitrim.

Total grass and rough grazing (combination of total pasture, total silage, total hay and rough grazing) accounted for almost all of the area farmed, ranging from 488 ha in Drumcliff West, Co. Sligo to 2,120 ha in Manorhamilton, Co. Leitrim. Total crops range from 0 ha in all areas with the exception of 1 ha in Drumcolumb, Co. Sligo, 3 ha Cloonlogher, Co. Leitrim, 5 ha in Calry, Co. Sligo, 7 ha in Kilmacowen, Co. Sligo and 9 ha in Manorhamilton, Co. Leitrim.

The total number of cattle within the catchment range from 168 in Glencar, Co. Sligo to 2,357 in Kilmacowen, Co. Sligo. The total number of sheep within the catchment range from 282 in Belhavel, Co. Leitrim to 10,333 in Glenaniff, Co. Leitrim. The total number of horses within the catchment range from 2 at Drumcliff East, Co. Sligo and Glencar, Co. Leitrim to 98 in Manorhamilton, Co. Leitrim.

The total area farmed in the entire ED's shown in Figures 3.12 to 3.19 amounts to 43,186 ha. However, as most of these ED's only partially overlap the catchment area, an attempt was made to estimate the actual area farmed within the catchment. The percentage of the ED lying within the catchment was calculated in GIS and from this value the area farmed was calculated *e.g.* if 50% of ED lies within catchment area then 50% of the area farmed was taken to be the area farmed within the catchment. Using this method, the area farmed within the catchment is estimated at 21,462 ha. This represents 36% of the area.

**Table 3.9: Farm census data for all EDs within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

| ED Name | County | No. Farms | Area Farmed (ha) | Avg. Farm Size (ha) | Total Crops (ha) | Total Grass & Rough Grazing (ha)* | Cattle | Sheep | Horses |
|---|---|---|---|---|---|---|---|---|---|
| Aghalateeve / Aghanlish | Leitrim | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Aghavoghill / Melvin | Leitrim | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Ballaghameehan | Leitrim | 67 | 1884 | 28.1 | 0 | 1885 | 988 | 4971 | 22 |
| Ballintogher East | Sligo | 55 | 1184 | 21.5 | 0 | 1184 | 1000 | 803 | 14 |
| Ballintogher West | Sligo | 56 | 1314 | 23.5 | 0 | 1314 | 1248 | 759 | 30 |
| Ballynakill | Sligo | 67 | 1574 | 23.5 | 0 | 1574 | 1458 | 1070 | 31 |
| Belhavel | Leitrim | 54 | 1230 | 22.8 | 0 | 1230 | 862 | 282 | 25 |
| Calry | Sligo | 98 | 2027 | 20.7 | 5 | 2022 | 1232 | 4779 | 20 |
| Cloonlogher | Leitrim | 70 | 1711 | 24.4 | 3 | 1710 | 1056 | 2373 | 17 |
| Collooney | Sligo | 49 | 1390 | 28.4 | 0 | 1389 | 1262 | 1146 | 31 |
| Drumahaire | Leitrim | 73 | 1752 | 24.0 | 0 | 1752 | 1319 | 1542 | 58 |
| Drumcliff East | Sligo | 40 | 1070 | 26.8 | 0 | 1069 | 1088 | 3927 | 2 |
| Drumcliff West | Sligo | 27 | 488 | 18.1 | 0 | 488 | 498 | 451 | 4 |
| Drumcolumb | Sligo | 58 | 1286 | 22.2 | 1 | 1285 | 974 | 291 | 3 |
| Drumkeeran | Leitrim | 67 | 1726 | 25.8 | 0 | 1726 | 1066 | 866 | 9 |
| Garvagh / Arigna | Leitrim | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Glenade | Leitrim | 50 | 1225 | 24.5 | 0 | 1225 | 281 | 5104 | 10 |
| Glenaniff | Leitrim | 44 | 1780 | 40.5 | 0 | 1780 | 356 | 10333 | 4 |
| Glenboy | Leitrim | 31 | 1138 | 36.7 | 0 | 1137 | 434 | 3935 | 6 |
| Glencar | Leitrim | 65 | 2090 | 32.2 | 0 | 2090 | 305 | 10166 | 2 |
| Glencar | Sligo | 28 | 811 | 29.0 | 0 | 810 | 168 | 6744 | 6 |
| Killanummery | Leitrim | 57 | 1283 | 22.5 | 0 | 1283 | 857 | 496 | 13 |
| Killarga | Leitrim | 33 | 1726 | 52.3 | 0 | 1726 | 365 | 3155 | 6 |
| Kilmacowen | Sligo | 86 | 1530 | 17.8 | 7 | 1522 | 2357 | 1919 | 46 |

| ED Name | County | No. Farms | Area Farmed (ha) | Avg. Farm Size (ha) | Total Crops (ha) | Total Grass & Rough Grazing (ha)* | Cattle | Sheep | Horses |
|---|---|---|---|---|---|---|---|---|---|
| Kiltyclogher | Leitrim | 45 | 1454 | 32.3 | 0 | 1454 | 678 | 2675 | 6 |
| Kinlough | Leitrim | 53 | 1697 | 32.0 | 0 | 1696 | 891 | 4940 | 15 |
| Knockaree | Sligo | 61 | 1697 | 27.8 | 0 | 1698 | 1786 | 5108 | 30 |
| Lurganboy | Leitrim | 65 | 1871 | 28.8 | 0 | 1871 | 1205 | 6202 | 12 |
| Manorhamilton | Leitrim | 74 | 2129 | 28.8 | 9 | 2120 | 1244 | 5793 | 98 |
| Munakill | Leitrim | 46 | 1378 | 30.0 | 0 | 1377 | 688 | 4407 | 9 |
| Shancough | Sligo | 33 | 919 | 27.8 | 0 | 919 | 704 | 783 | 12 |
| Sligo East # | Sligo | 2 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Sligo North # | Sligo | 2 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Sligo West # | Sligo | 5 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Sramore | Leitrim | 60 | 1822 | 30.4 | 0 | 1822 | 979 | 3699 | 19 |

* Total Grass and Rough Grazing was taken to be the sum of Total Pasture, Total Silage, Total Hay and Rough Grazing.

# Due to the small number of farms in these EDs some or all of the Census of Agriculture 2010 details are not being made available at the Electoral District level. Data has been suppressed for reasons of confidentiality, where individual farm details might be identifiable when results are presented at ED level.

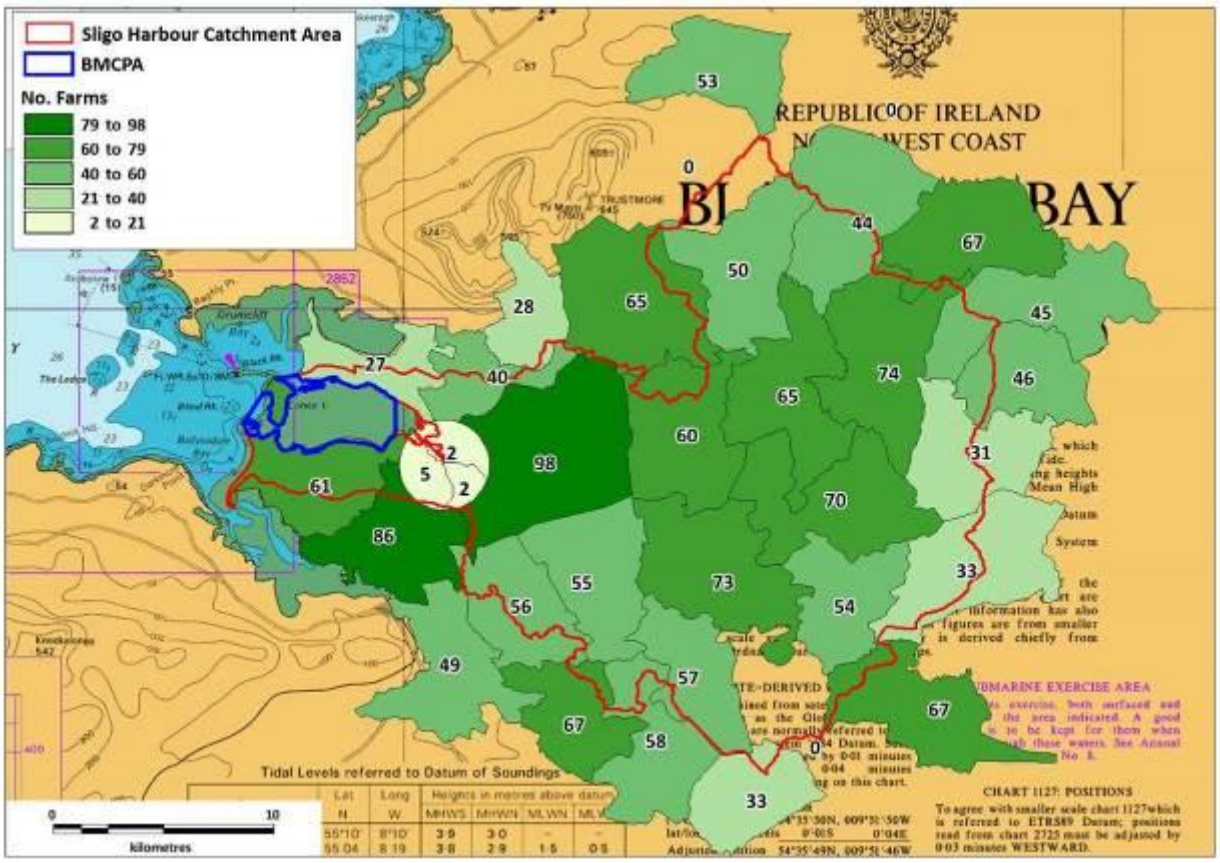



**Figure 3.12: Number of farms within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

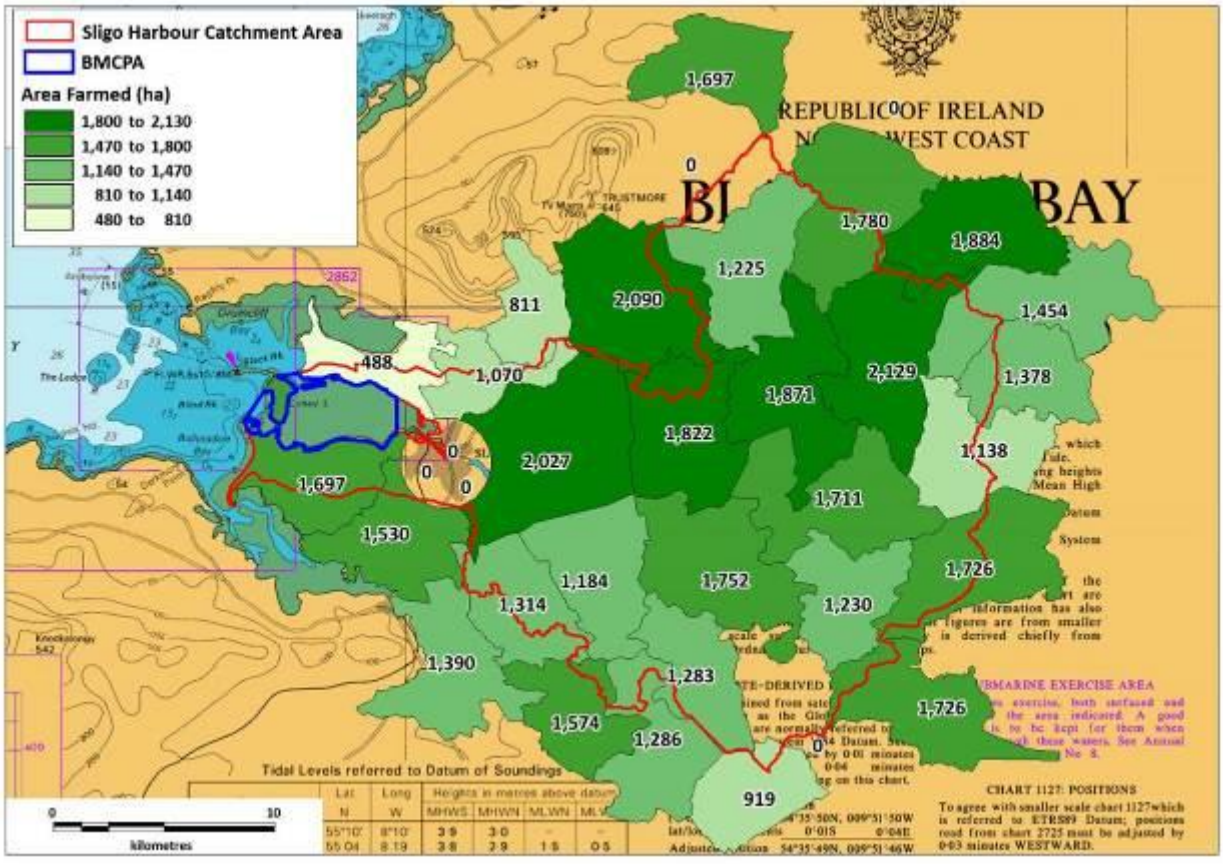



**Figure 3.13: Area farmed (ha) within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

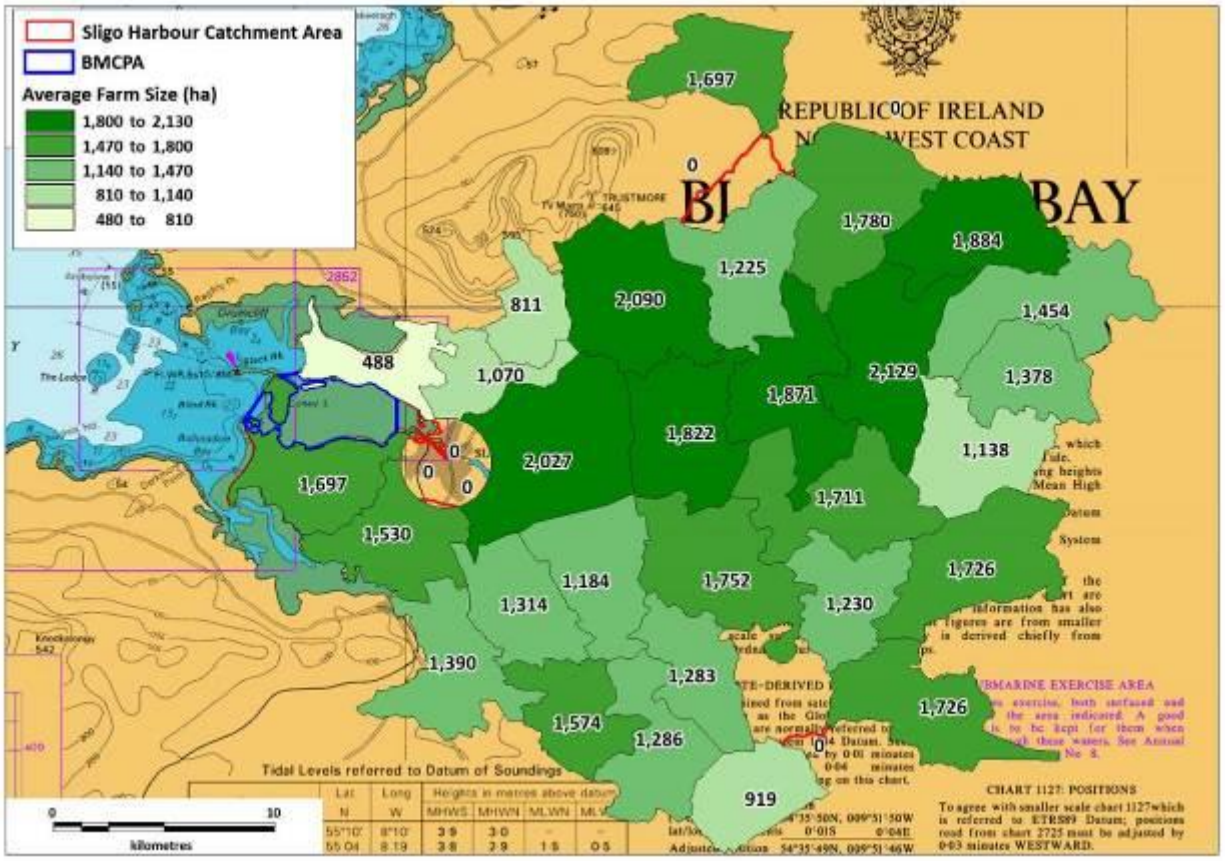



**Figure 3.14: Average farm size (ha) within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

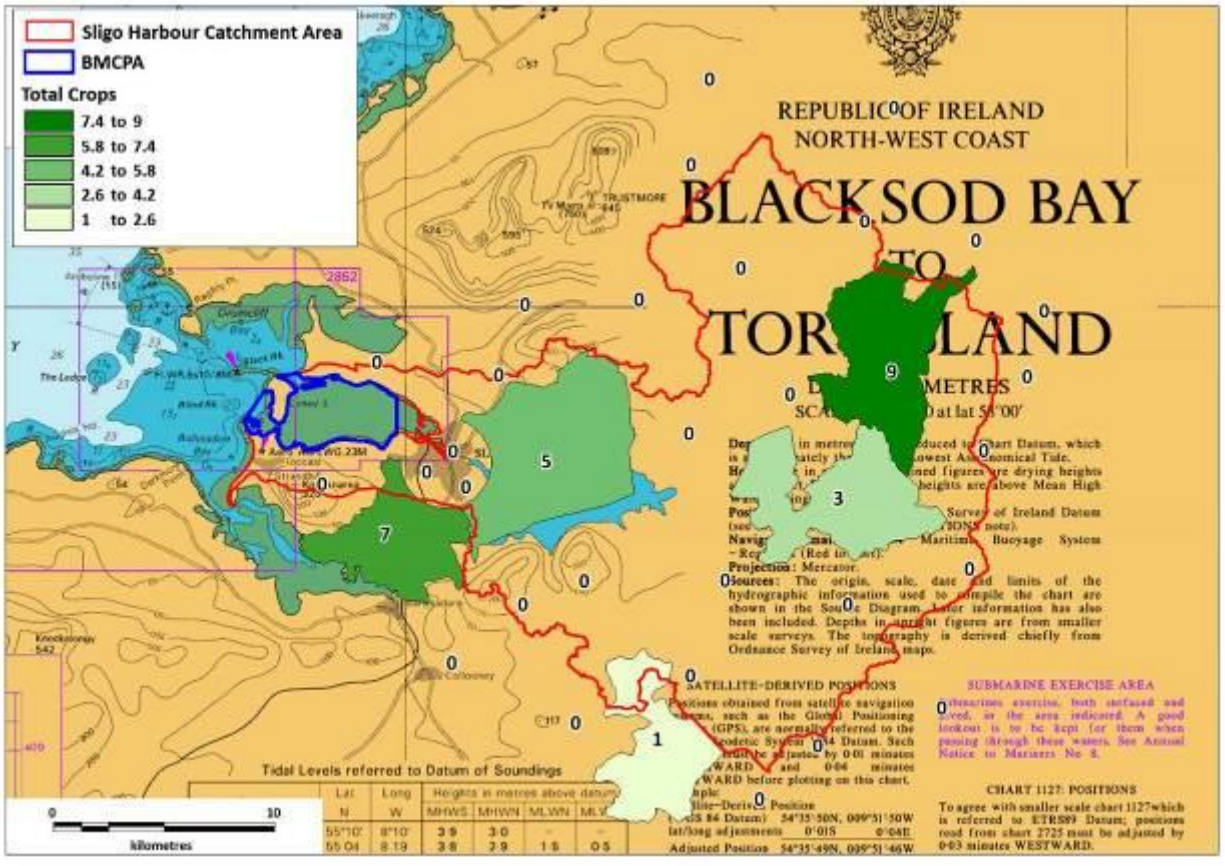



**Figure 3.15: Total crops within the Sligo Catchment Area (Source: CSO, 2019b).**

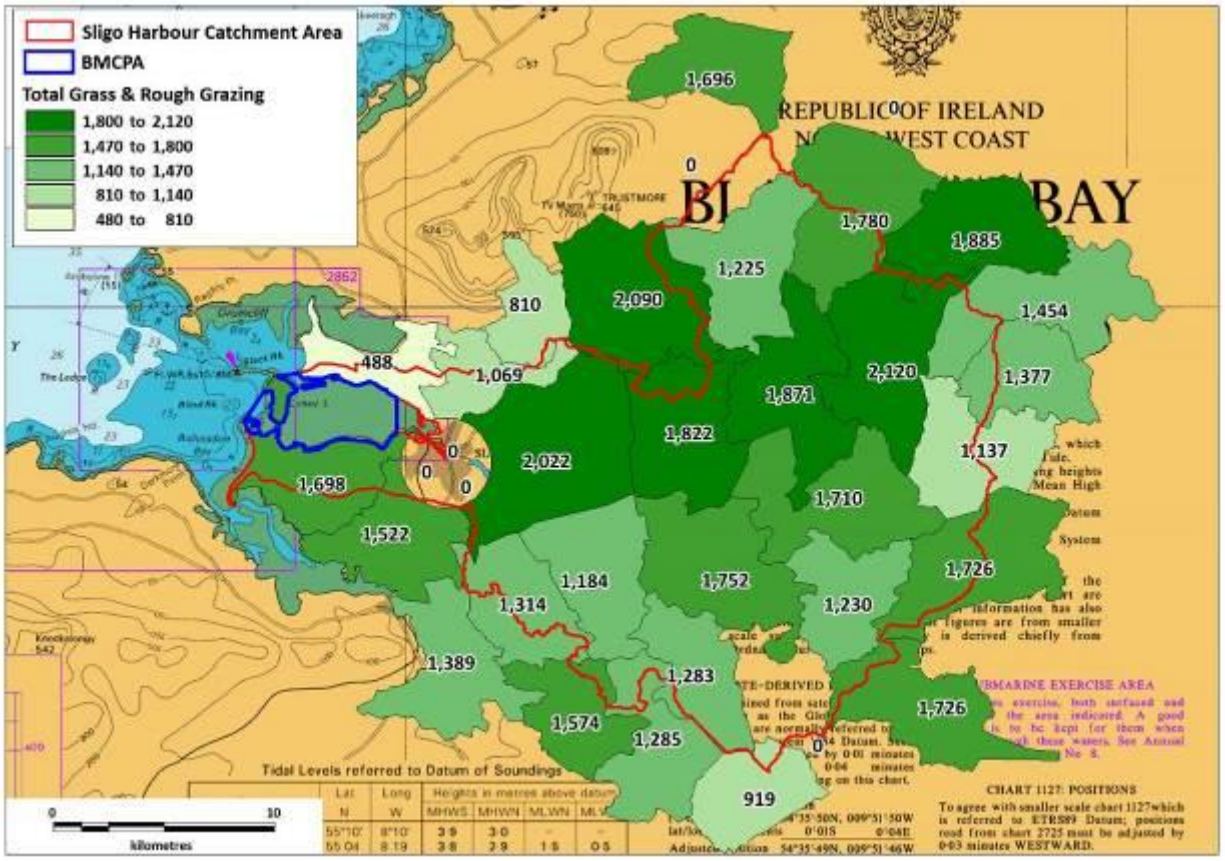



**Figure 3.16: Total grass and rough grazing within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

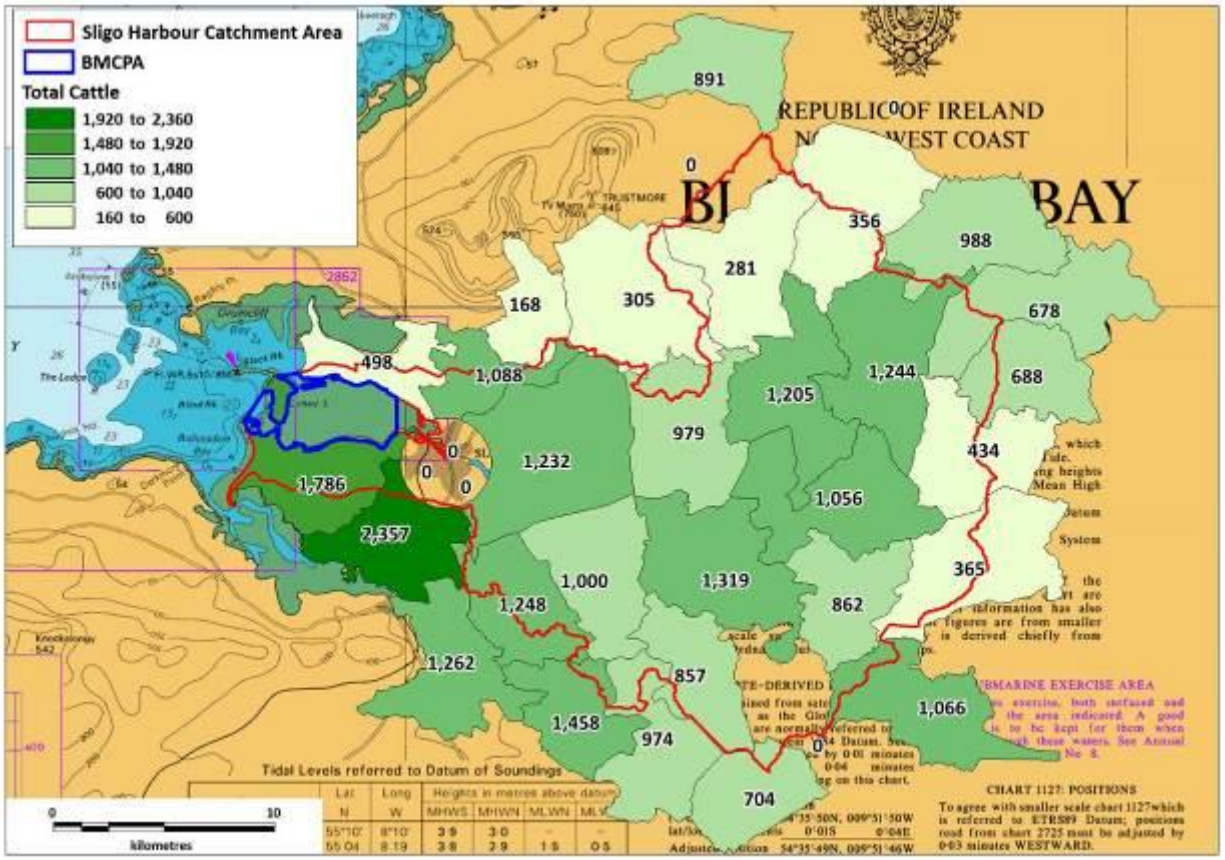



**Figure 3.17: Cattle within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

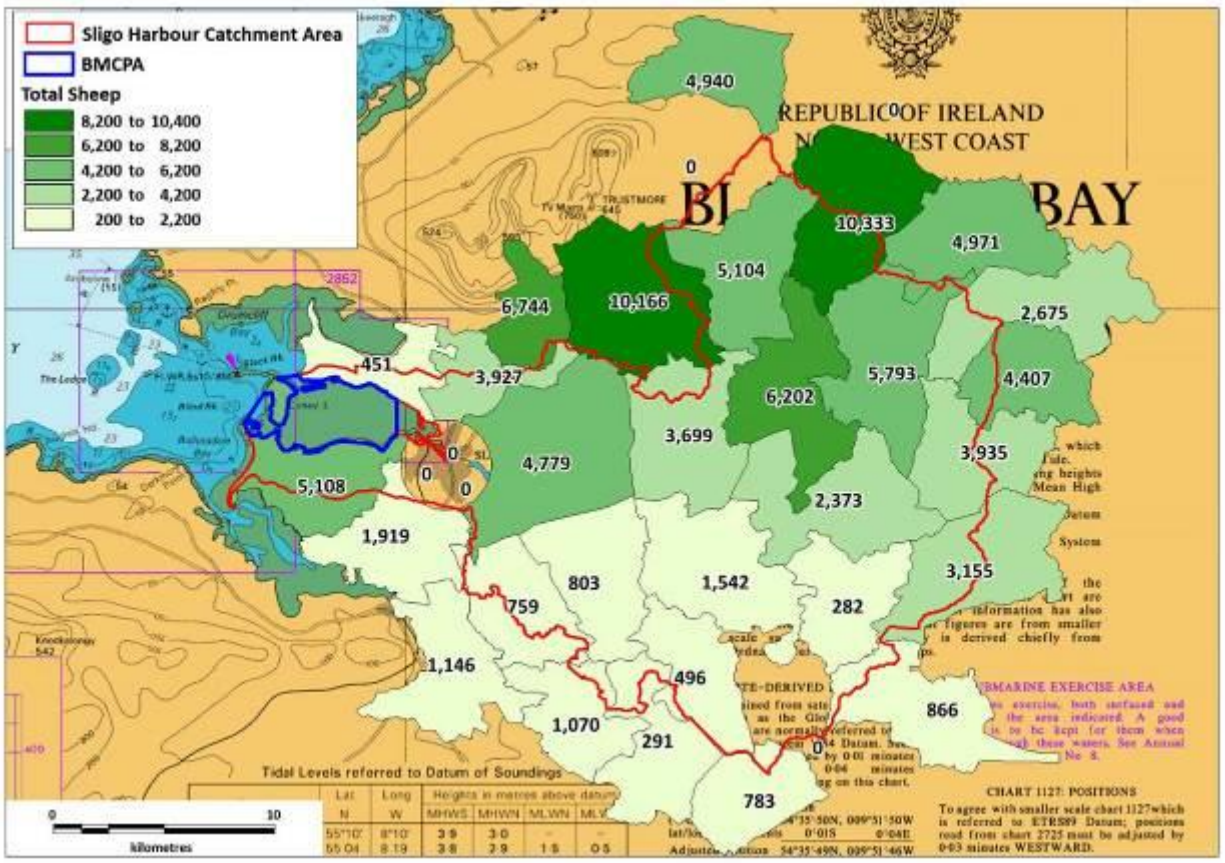



**Figure 3.18: Sheep within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

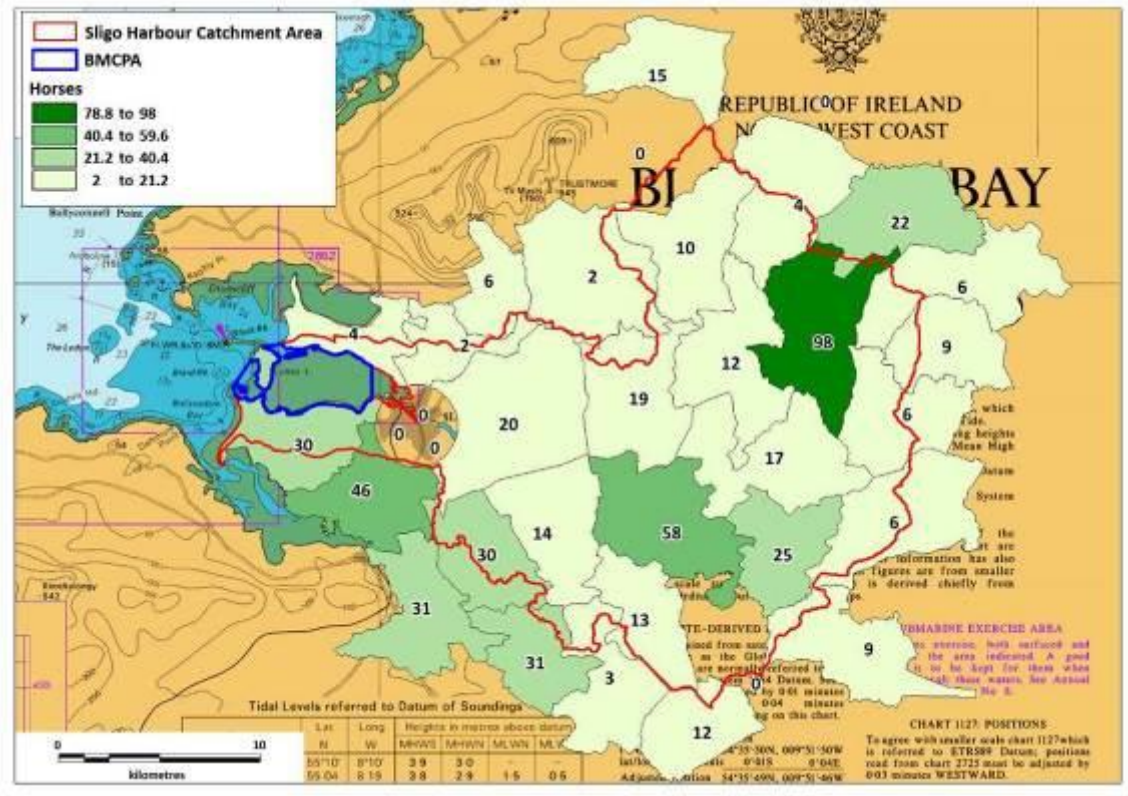



**Figure 3.19: Horses within the Sligo Harbour Catchment Area (Source: CSO, 2019b).**

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). Table 3.10 shows the potential daily loading of *E. coli* from livestock (compared to humans and birds). It can be seen that sheep rank the worst, followed by pigs, cows, birds, humans and poultry.

**Table 3.10: Potential daily loading of *E. coli* (Jones & White, 1984).**

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

The largest majority of livestock in the area are sheep. Cattle are also present but in lower numbers. The majority of agricultural land use in the area is total grass and rough grazing. Sheep are present in relatively large numbers throughout with the highest numbers in the northern half of the catchment which is more mountainous while the highest numbers of cattle are present in the southern flatter regions and in the valleys between the mountains. Sheep numbers would be expected to increase in spring following the birth of lambs and decrease in the autumn as they are sent to market. Therefore, larger quantities of livestock droppings will be deposited during this period, though it may not impact the fishery until washed into the sea during and/or after periods of rainfall unless deposited directly on the shoreline.

### 3.1.6. Wildlife

#### *3.1.6.1. Birds*

It is important to document the bird populations in the Sligo 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).

The Cummeen Strand SPA (Site Code: IE004035) is located within the Sligo Harbour area and can be seen in Figure 2.3.

The SPA is a large shallow bay which stretches from Sligo Town westwards to Coney Island (NPWS, 2014).

The Garavogue River flows into the bay and forms a permanent channel. At low tide, extensive sand and mud flats are exposed. Cummeen Strand supports important concentrations of wintering waterfowl, including an internationally important Light-bellied Brent Goose flock (223) and nationally important populations of Oystercatcher (680) and Redshank (408) (NPWS, 2014). Other species occurring include Shelduck (86), Wigeon (149), Teal (54), Mallard (145), Red breasted Merganser (15), Golden Plover (428), Lapwing (695), Knot (165), Sanderling (14), Dunlin (539), Bar-tailed Godwit (85), Curlew (430), Greenshank (13) and Turnstone (62) (NPWS, 2014). Golden Plover and Bar-tailed Godwit are regularly present, which is of particular note as these species are listed on Annex I of the E.U. Birds Directive (NPWS, 2014).

Sligo Harbour is routinely surveyed by Birdwatch Ireland (through the I-WeBS [Irish Wetland Bird Survey] Project). The total peak counts for each season from 2011 to 2016 can be seen in Table 3.11.

**Table 3.11: Total number of waterbirds in Sligo Harbour between 20011/12 and 2015/16 seasons (Source: BWI, 2019).**

| Site Name | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | Mean |
|---|---|---|---|---|---|---|
| Sligo Harbour | 3655 | 7306 | 5212 | 5217 | 4761 | 5230.2 |

Population levels of birds over the five years are fairly stable, with a low in the 2011/2012 season and a high in the following year 2012/2013. Bird numbers in the area increase during the winter months when the wintering waterfowl arrive. However, it is highly likely that these levels are low when compared with land-based discharges.

### *3.1.6.2. Aquatic mammals*

Both Coney and Oyster Islands are potential haul out sites for both Common (*Phoca vitulina)* and Grey seals (*Haliochoerus grypus*). Other aquatic mammals that may occur in Sligo Harbour include Otter (*Lutra lutra),* Bottle nosed Dolphin (*Tursiops truncatus)* and Harbour Porpoise (*Phocoena phocoena*). However, due to the shallow nature of the bay, the latter two species rarely occur there.

No estimates of the volumes of seal faeces are available although it is reasonable to assume that what is ingested and not assimilated in the gut must pass. Assuming 6% of a median body weight for grey seals of 185kg, that would equate to 11.1kg consumed per day and probably very nearly that defecated. The concentration of *E. coli* and other faecal indicator bacteria contained in seal faeces has been reported as being similar to that found in raw sewage, with counts showing up to 1.21 x 104 CFU *E. coli* per gram dry

weight of faeces (Lisle *et al.,* 2004). *Salmonella* and *Campylobacter* spp. have also been found in wild seals (Stoddard *et al.,* 2005).

All aquatic mammals that occur in the BMPA are likely to contribute to background levels of faecal contamination within the area particularly during the haul-out periods.

### 3.1.7. Other Pollution Sources

#### *3.1.7.1. Shipping*

Figure 3.20 shows all boat facilities and activities in Sligo Harbour. Table 3.12 details these facilities. The only commercial port in Sligo Harbour is Sligo Port. There were approximately 9 shipping arrivals in 2017 at the port of Sligo and these consisted of dry bulk cargo vessels (CSO, 2019c). All cargo vessels were of the size class 100-4,999 tonnes. In 2017, 18,000 tonnes of goods were received through the port (CSO, 2019c).

A jetty area is also located within Sligo Port which supports a number of small boats and yachts. During the time of the shoreline survey none of these boats appeared to be lived upon or used on an overnight basis.

There are no ferries operating in Sligo Harbour. There are several piers and slipways located along the shorelines of Sligo Harbour with the majority sited along the northern extent of the bay and also in the inner Sligo Port area. All the piers are used frequently by a wide number of groups including recreational groups.

While data on sewage discharge levels from boating activities in the area are not available, any discharges from the relatively small number of vessels in the area would have a limited impact on water quality.

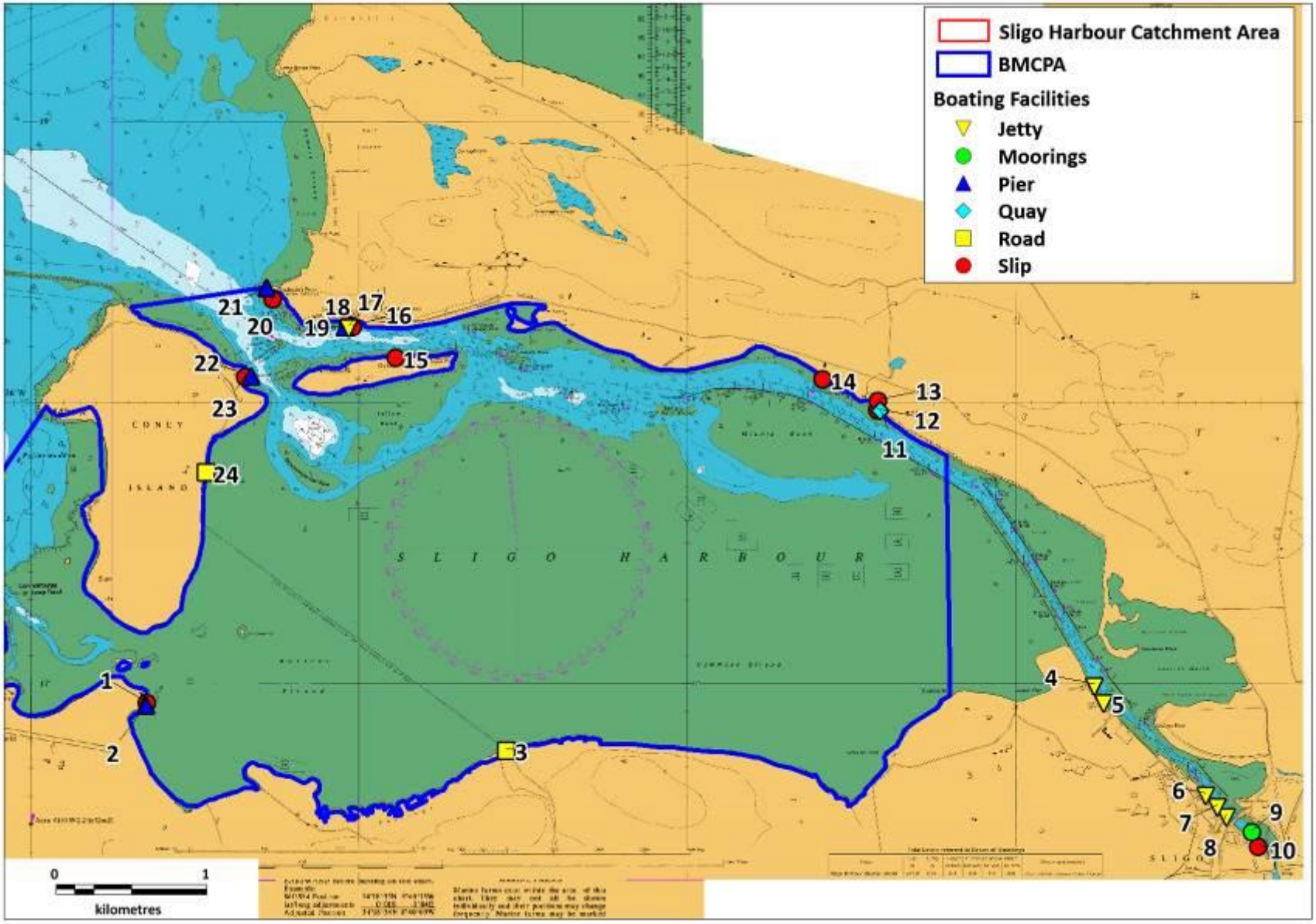



**Figure 3.20: Location of all boating facilities and activities in Sligo Harbour.**

**Table 3.12: Boating facilities in the Sligo Harbour. Map Code refers to Figure 4.20.**

| Map Code | Feature | Use (if known) |
|---|---|---|
| 1 | Slip | |
| 2 | Pier | |
| 3 | Access Road to Coney Island | Low tide access to Coney Island |
| 4 | Deep Water Jetty | Commercial Port |
| 5 | Oil Jetty | |
| 6 | Jetty No. 2 | |
| 7 | Jetty No. 1 | |
| 8 | Timber Jetty | Pleasure craft |
| 9 | Moorings | Pleasure craft |
| 10 | Quay Street Slip | Pleasure craft |
| 11 | Quay | |
| 12 | Private Slip and Quay | |
| 13 | Slip | |
| 14 | Private slip | |
| 15 | Oyster Island Old Slip | May no longer be in use |
| 16 | RNLI Slip | RNLI rescue boat |
| 17 | Rosses Point Jetty | Pleasure craft, Fishing, Aqua tourism |
| 18 | Rosses Point Slip | Pleasure craft, Fishing, Aqua tourism |
| 19 | Rosses Point Pier | Pleasure craft, Fishing, Aqua tourism |
| 20 | Sligo Yacht Club Slip | Sailing boats |
| 21 | Sligo Yacht Club Pier | |
| 22 | Coney Island Pier | |
| 23 | Coney Island Slip | |
| 24 | Road Access from Coney Island to Mainland | Low water Access from Coney Island to Mainland |

## *3.2. Shoreline Survey Report*

A shoreline survey was carried out by the Sea Fisheries Protection Authority. Figure 3.21 shows the GPS (Global Positioning System) and photography sites accounted for during the 7 survey days.

The aim of the survey was to confirm the location of the bivalve mollusc fishery and to confirm the presence of the sources of contamination already identified during the desktop study and to also identify any additional potential sources of contamination. GPS coordinates were recorded for all features and

marked on a map. In addition, all features were photographed digitally (where possible). 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.

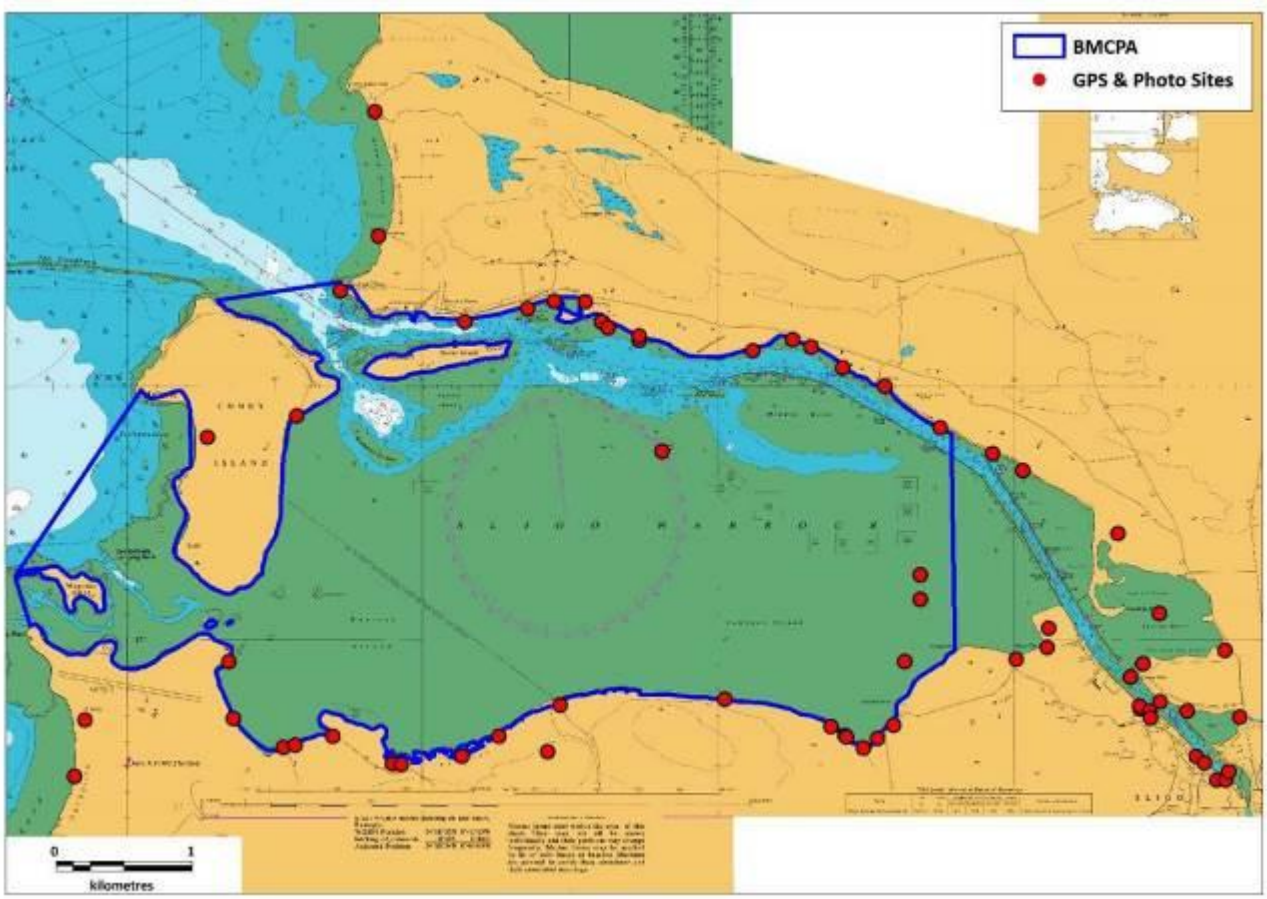



**Figure 3.21: Locations of GPS and Photograph Sites.**

Figure 3.22 shows the locations of all features observed during the shoreline survey. In total 65 features were identified, of which 16 rivers/streams were identified, 19 drains, 3 WWTP, 1 discharge from WWTP, 15 discharge pipes and 4 manholes. Figures 3.23 to 3.39 show aerial imagery of the location of the features and Figures 3.40 to 3.44 shows images of most of these features. Table 3.13 details all features identified and the numbering used is cross-referenced to Figures 3.22 to 3.44.

**Table 3.13: Features identified during the shoreline survey. Refer to Figures 3.23 – 3.39 for locations and Figures 3.40 to 3.44 for photographs.**

| Map Code | Observation | Comments | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|
| 1 | Large discharge pipe | Likely sewage related - odour | -8.60662 | 54.27458 | 160531.8 | 336364.3 |
| 2 | Waste water treatment plant | Under construction | -8.6055 | 54.2783 | 160608.1 | 336777.5 |
| 3 | Pipe | no discharge visible | -8.58925 | 54.28217 | 161670.2 | 337198.9 |
| 4 | Drainage ditch | | -8.58877 | 54.2784 | 161698.2 | 336779.4 |
| 5 | Field drain pipe | | -8.58308 | 54.2765 | 162066.7 | 336564.8 |
| 6 | Small stream | Some enrichment | -8.58175 | 54.27667 | 162153.6 | 336582.7 |
| 7 | Field drain | | -8.57755 | 54.27723 | 162427.8 | 336643.4 |
| 8 | Tiny stream | | -8.57077 | 54.27545 | 162868 | 336441.4 |
| 9 | Natural drainage stream underground | | -8.56973 | 54.2754 | 162935.3 | 336435.3 |
| 10 | Field drain | | -8.56292 | 54.27595 | 163379.8 | 336492.9 |
| 11 | Field drainage/tiny stream | | -8.55877 | 54.27725 | 163651.3 | 336635.5 |
| 12 | Pasture | Pasture land, grazing. | -8.55329 | 54.27624 | 164007.2 | 336520.2 |
| 13 | Small stream | | -8.55187 | 54.2793 | 164102.6 | 336860.1 |
| 14 | Field drain | | -8.53332 | 54.27967 | 165311.2 | 336891.7 |
| 15 | Field drain | Enrichment | -8.52132 | 54.27787 | 166091.4 | 336685.5 |
| 16 | Stream/small river | Enrichment | -8.51975 | 54.2773 | 166193 | 336621.6 |
| 17 | Man hole cover | | -8.51963 | 54.27722 | 166200.5 | 336612.3 |
| 18 | Stream/small river | | -8.51765 | 54.27647 | 166329.1 | 336527.9 |
| 19 | Stream | | -8.51613 | 54.27708 | 166428.4 | 336595.7 |
| 20 | Stream | | -8.51432 | 54.27798 | 166547.4 | 336695.1 |
| 21 | 120 + birds. Mix of waders, ducks and gulls. | | -8.51305 | 54.28217 | 166633.4 | 337160.2 |
| 22 | Birds | | -8.51125 | 54.28625 | 166753.9 | 337613.8 |
| 23 | 40 + mix of waders, gulls and duck. | | -8.51125 | 54.28785 | 166755.2 | 337791.9 |

| Map Code | Observation | Comments | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|
| 24 | Drain/upwelling | Enrichment, iron staining. Broken pipework | -8.50045 | 54.2823 | 167454.1 | 337169.1 |
| 25 | Drain hole pipe | Likely to be storm overflow from WWTP | -8.49697 | 54.28307 | 167681.6 | 337252.9 |
| 26 | WWTP Sligo | Treatment Plant | -8.4968 | 54.28435 | 167693.5 | 337395.6 |
| 27 | Large pipe | Opposite homeland | -8.48657 | 54.27925 | 168356 | 336823.3 |
| 28 | Upwellings | Upwellings, pipes unseen. Possibly wwtp related. | -8.48647 | 54.27907 | 168362.4 | 336802.9 |
| 29 | Large pipe | Adjacent waste water treatment plant, covered by high tide | -8.48538 | 54.27888 | 168432.9 | 336781.9 |
| 30 | Two pipes | Two pipes running in at same spot | -8.48533 | 54.27847 | 168435.8 | 336735.6 |
| 31 | Marina | Marina in Sligo town, 15 odd boats assembled here | -8.4802 | 54.27595 | 168768.3 | 336453.1 |
| 32 | Drain - Gated around exit point | Good flow, adjacent marina. Not possible to access. | -8.47925 | 54.27548 | 168829.8 | 336400.7 |
| 33 | Drain - likely storm water | No flow, no enrichment evident | -8.4778 | 54.27438 | 168923.5 | 336277.6 |
| 34 | Drain x 2 | Some flow, stormwater and another | -8.47687 | 54.27438 | 168984.2 | 336277.2 |
| 35 | Garavogue River | Large river, large flow of water | -8.47647 | 54.27492 | 169010.7 | 336336.5 |
| 36 | Copper River | Steady flow. | -8.47527 | 54.2785 | 169091.6 | 336734.8 |
| 37 | Pipe | Low flow, odour. Grey water colour | -8.48118 | 54.27888 | 168706.5 | 336780 |
| 38 | Man hole and pipe | No flow - pipe appears redundant | -8.48423 | 54.27953 | 168508.3 | 336853.7 |
| 39 | 70 + birds. Mix of waders, ducks and gulls. | | -8.48755 | 54.28115 | 168293.5 | 337035.2 |
| 40 | Man hole cover | Part of a number of such holes - Cartron Estate | -8.48613 | 54.282 | 168386.4 | 337129.2 |
| 41 | Small river | Steady flow, no signs of enrichment | -8.47693 | 54.2829 | 168986.3 | 337225.3 |
| 42 | 50 + mixed ducks. 50 assorted others. | | -8.48433 | 54.28535 | 168506.2 | 337501.3 |
| 43 | Field drains/reed bed | Number of drains combining into reedbed | -8.48895 | 54.29057 | 168209.6 | 338084.1 |
| 44 | Field drain/stream | Low flow, some algae | -8.49972 | 54.29473 | 167511.7 | 338552.7 |

| Map Code | Observation | Comments | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|
| 45 | Field Drain | Very little flow, some algae | -8.50308 | 54.29583 | 167293.4 | 338676.7 |
| 46 | Field Drain | Very little flow, some algae | -8.50903 | 54.29757 | 166907.4 | 338872.5 |
| 47 | Small river | Good flow | -8.51525 | 54.30027 | 166504.8 | 339176 |
| 48 | Manhole cover | No sign of pipe | -8.52003 | 54.30152 | 166194.4 | 339317.4 |
| 49 | Natural drain stream | Low flow, some enrichment | -8.52362 | 54.30287 | 165962.2 | 339469.4 |
| 50 | Natural drain stream | Some enrichment | -8.52568 | 54.30333 | 165828.1 | 339522.3 |
| 51 | Drain/stream | Steady flow, some enrichment not bad | -8.5302 | 54.30262 | 165533.4 | 339444.8 |
| 52 | Oyster farm | Oyster farm - two blocks | -8.54037 | 54.296 | 164865.9 | 338713.3 |
| 53 | Sewage pipe | Wastewater treatment plant | -8.54297 | 54.3033 | 164702.9 | 339527.2 |
| 54 | Wastewater treatment plant | Sewage fungus, strong flow, pipe burst, odour. | -8.543 | 54.30362 | 164701 | 339562.5 |
| 55 | Old pipe | No flow, redundant | -8.54648 | 54.30415 | 164474.7 | 339623.5 |
| 56 | Old pipe | No flow, redundant | -8.54725 | 54.30453 | 164425.1 | 339666.6 |
| 57 | Drain | Water welling through ground, sign of enrichment | -8.54907 | 54.30582 | 164307.9 | 339810.4 |
| 58 | Pipe/drain | Pipe with grill. Good flow. Sign of enrichment | -8.5526 | 54.30587 | 164078 | 339817.8 |
| 59 | Pipe/drain | Piped drain under road rock armour-no flow | -8.5556 | 54.30538 | 163882.3 | 339765.4 |
| 60 | Pipe/drain | Piped drain under road rock armour-no flow | -8.5626 | 54.30453 | 163425.9 | 339674.4 |
| 61 | Narrow pipe | Long narrow pipe running out into water | -8.57673 | 54.30653 | 162507.6 | 339904.5 |
| 62 | Old pipe | Old pipe - broken. Old system. No flow | -8.57238 | 54.31018 | 162794.1 | 340308.5 |
| 63 | Stream on beach | Two streams merging- good flow | -8.57283 | 54.31833 | 162772.2 | 341215.9 |
| 64 | Small stream draining lagoon | Flowing out onto sandbanks | -8.58165 | 54.29833 | 162180 | 338994.3 |
| 65 | Sheep | 40 + sheep on pasture land. | -8.59169 | 54.29689 | 161525 | 338839.2 |
| 66 | 100 + geese | 100+ geese | 8.562242 | 54.284068 | 163430.87 | 337395.87 |

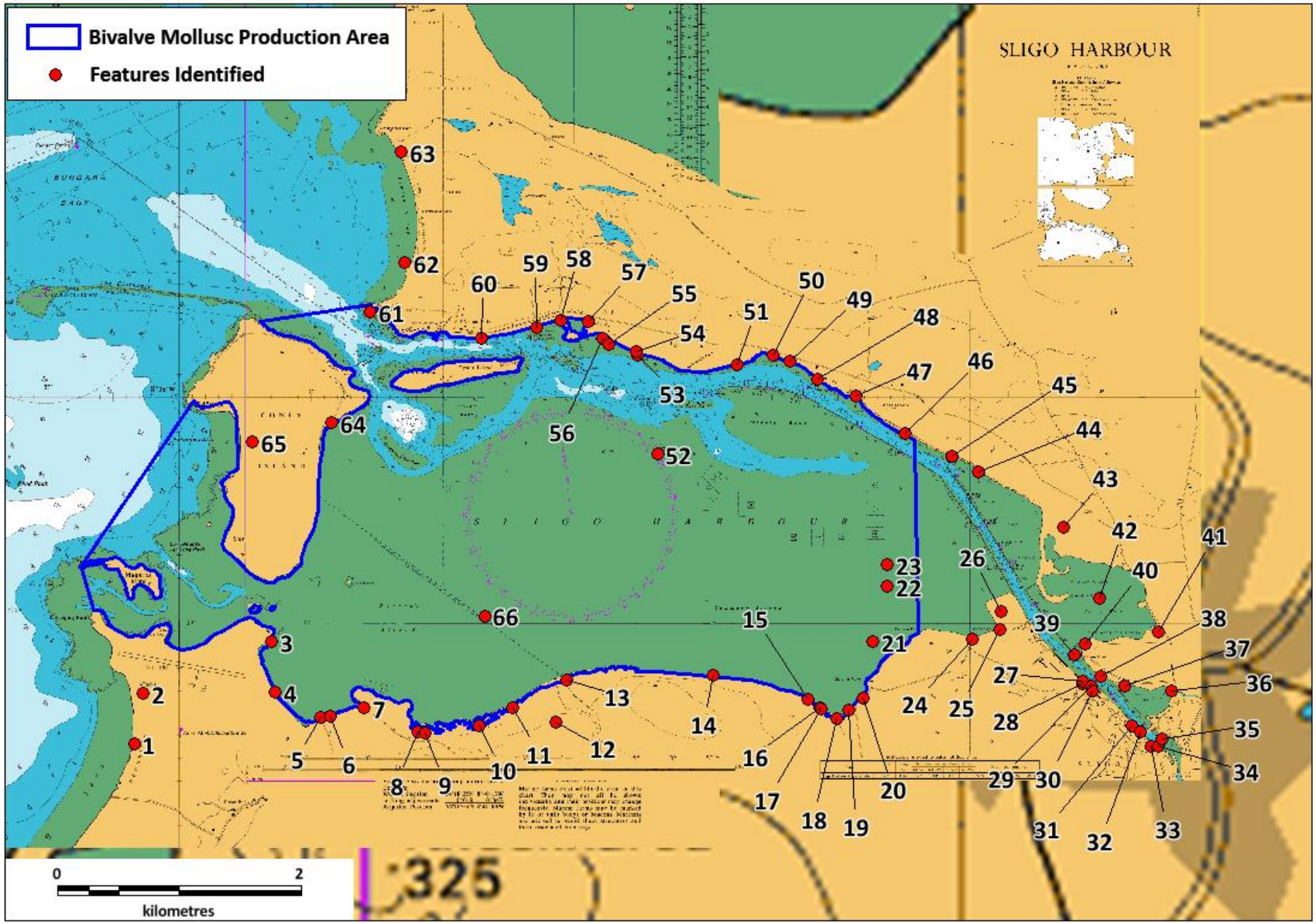



**Figure 3.22: All features (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.23: Features 1-2 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**

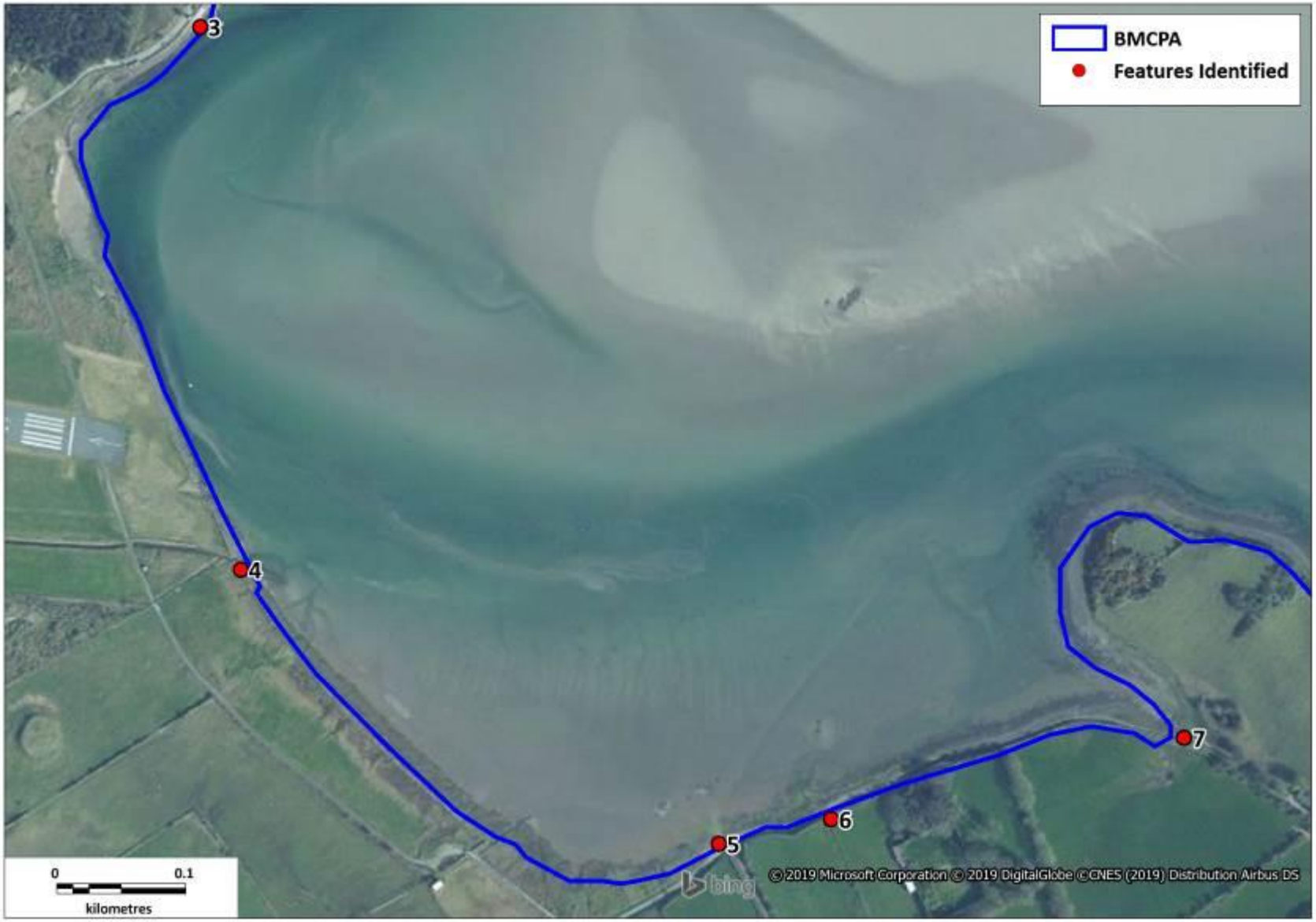



**Figure 3.24: Features 3-7 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.25: Features 8-11 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**

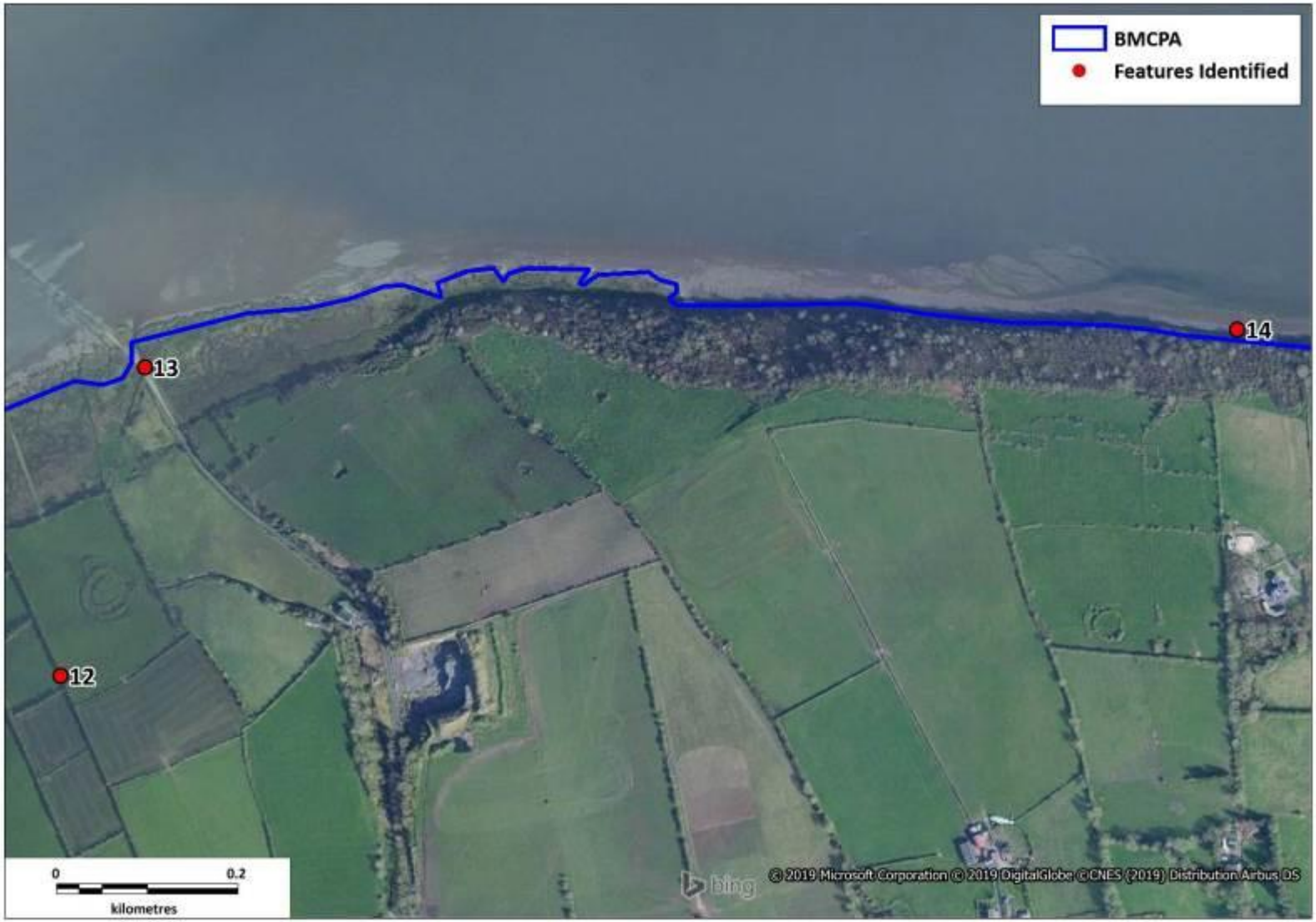



**Figure 3.26: Features 12-14 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.27: Features 15-20 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.28: Features 21-23 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.29: Features 24-26 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.30: Features 27-30 and 37-40 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**

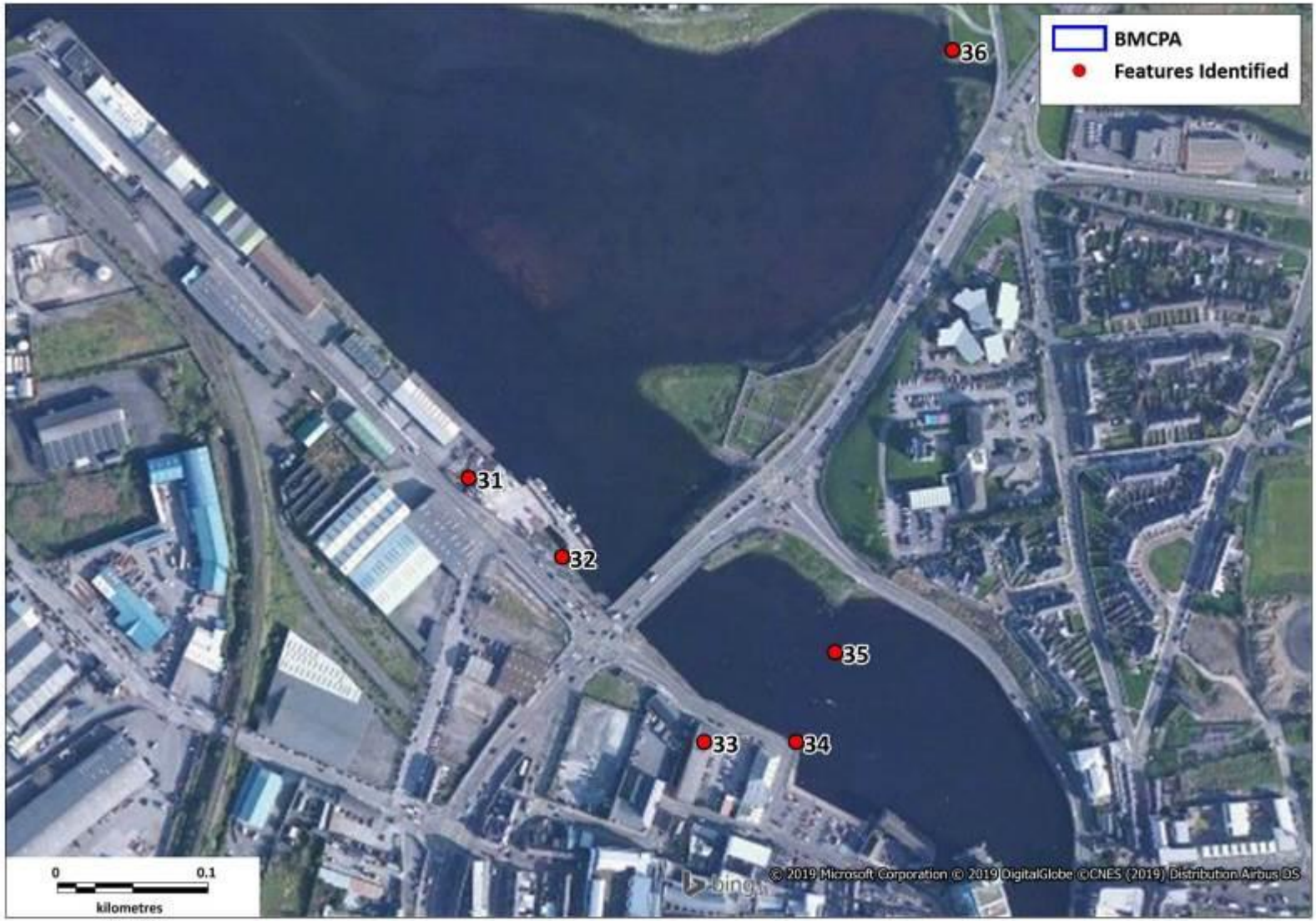



**Figure 3.31: Features 31-36 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.32: Features 41-42 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.33: Features 43-45 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**

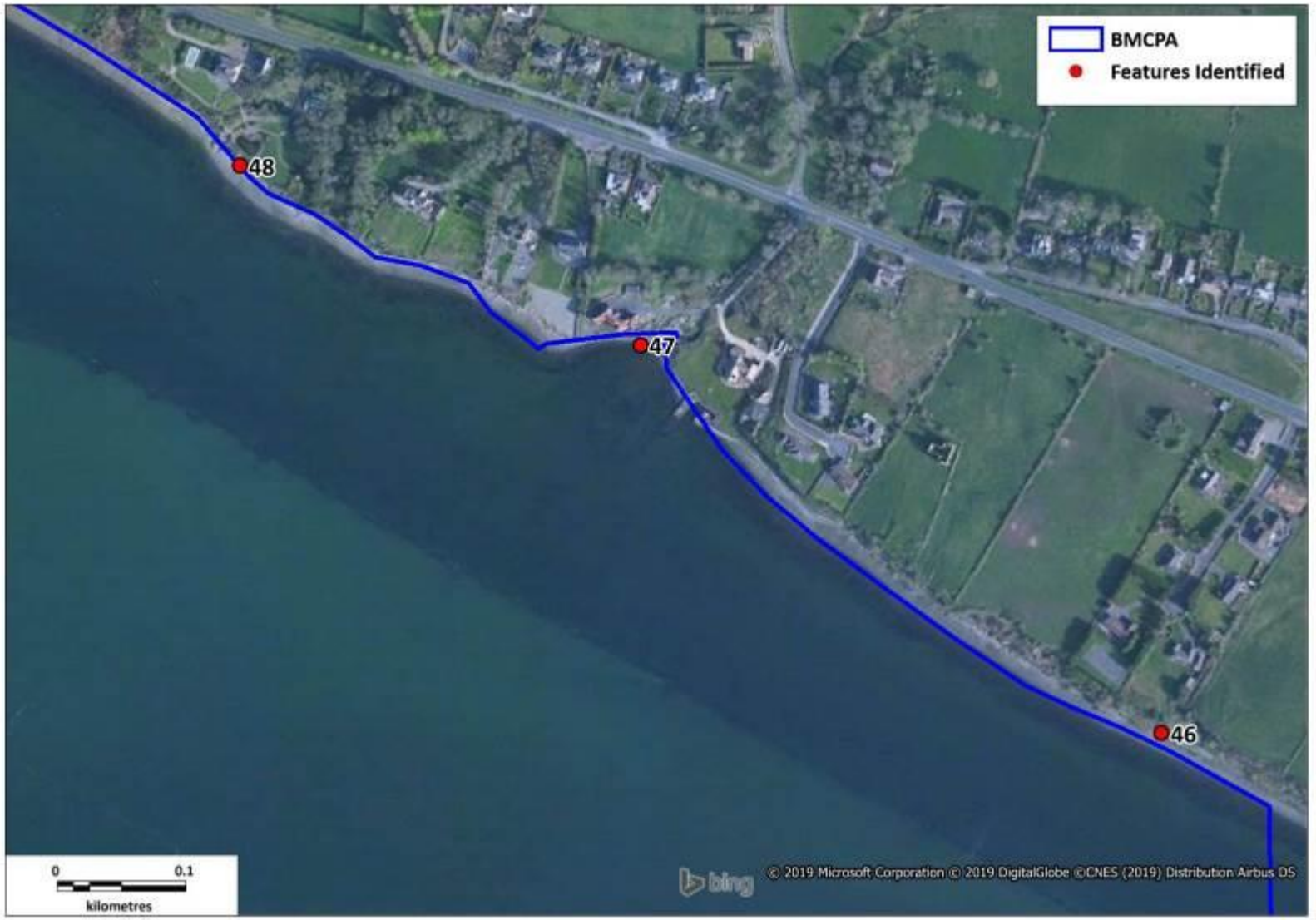



**Figure 3.34: Features 46-48 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.35: Features 49-51 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.36: Features 53-58 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.37: Features 59-60 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.38: Features 61-63 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.39: Features 64-65 (numbering cross-reference to Table 3.13) identified during the shoreline survey.**


**Figure 3.40: Features 1-10 located during the shoreline survey. Refer to Figures 3.22-3.25 for site locations.**


**Figure 3.41: Features 11-24 located during the shoreline survey. Refer to Figures 3.22 and 3.25 to 3.29 for site locations.**

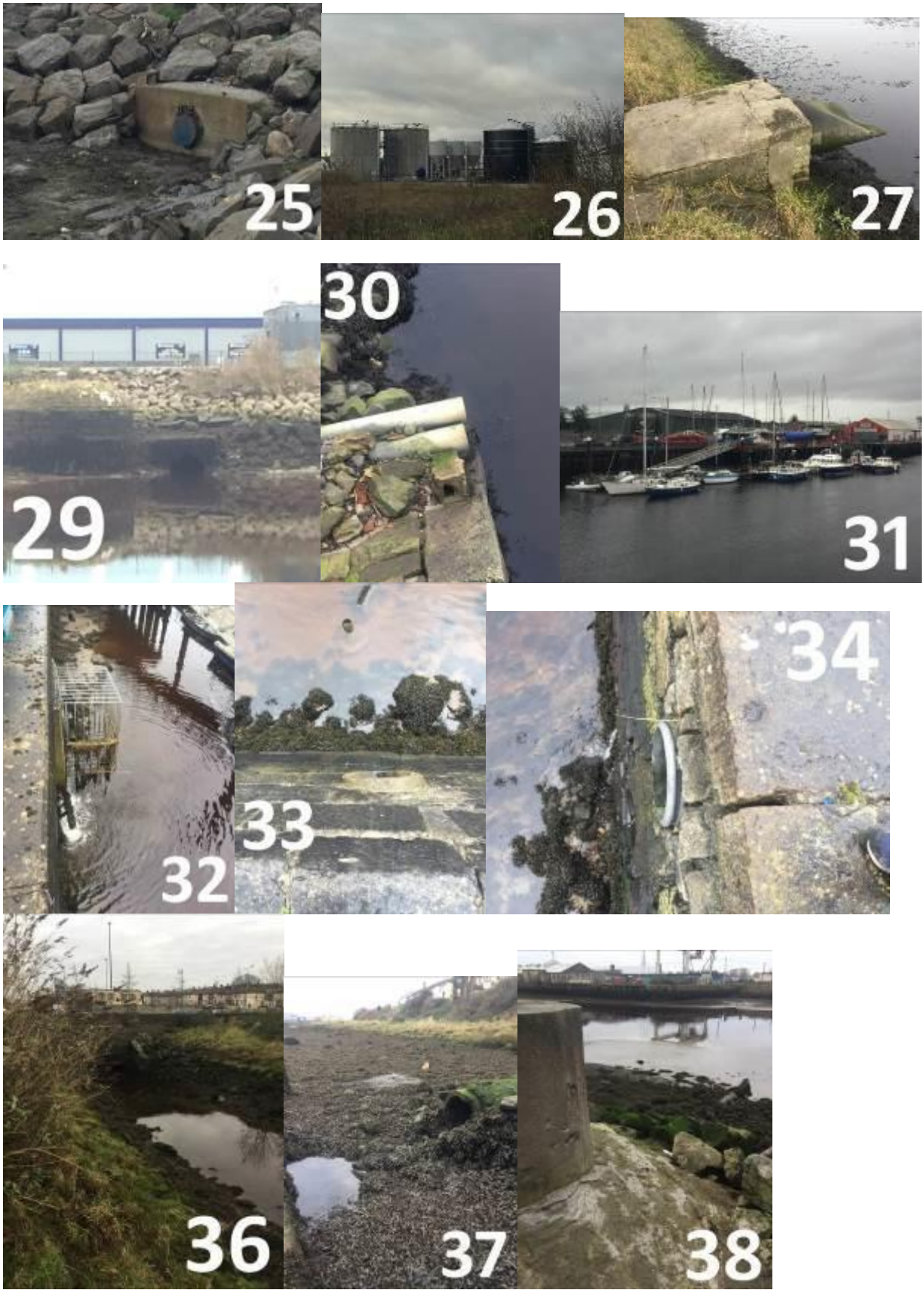



**Figure 3.42: Features 25-38 located during the shoreline survey. Refer to Figures 3.22 and 3.29 to 3.31 for site locations.**

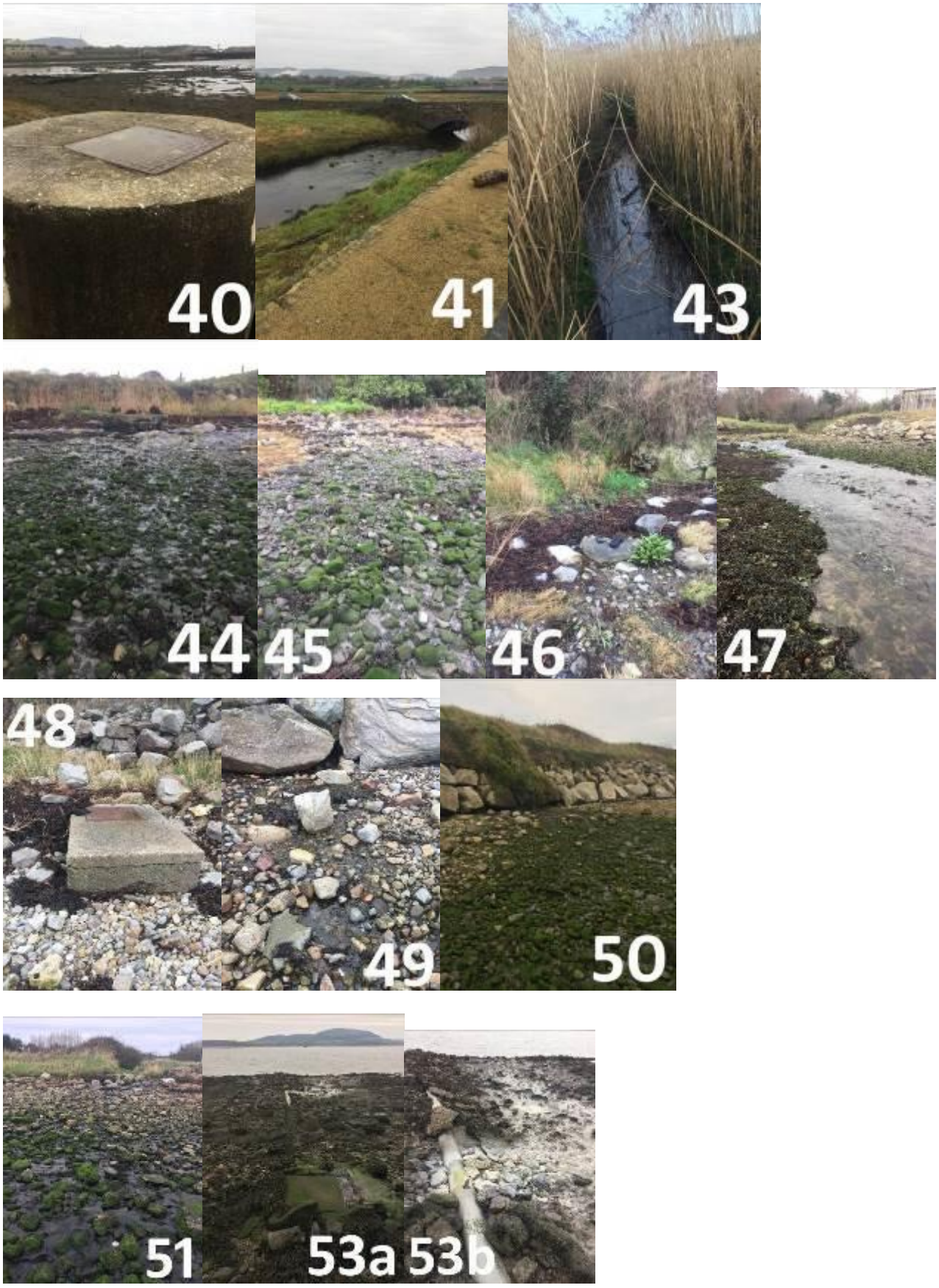



**Figure 3.43: Features 40-53 located during the shoreline survey. Refer to Figures 3.22, 3.30 and 3.32 to 3.36 for site locations.**


**Figure 3.44: Features 54-64 located during the shoreline survey. Refer to Figures 3.22 and 3.36 to 3.39 for site locations.**

### *3.3. Locations of Sources*

Figure 3.45 shows all watercourses discharging into Sligo Harbour and Table 3.14 provides cross-referenced details for this map. Figure 3.46 and 3.47 shows all discharges in the Sligo Harbour catchment area and Tables 3.15 provides cross-referenced details for the WWTP, drain and pipe discharges and Section 4 discharges.

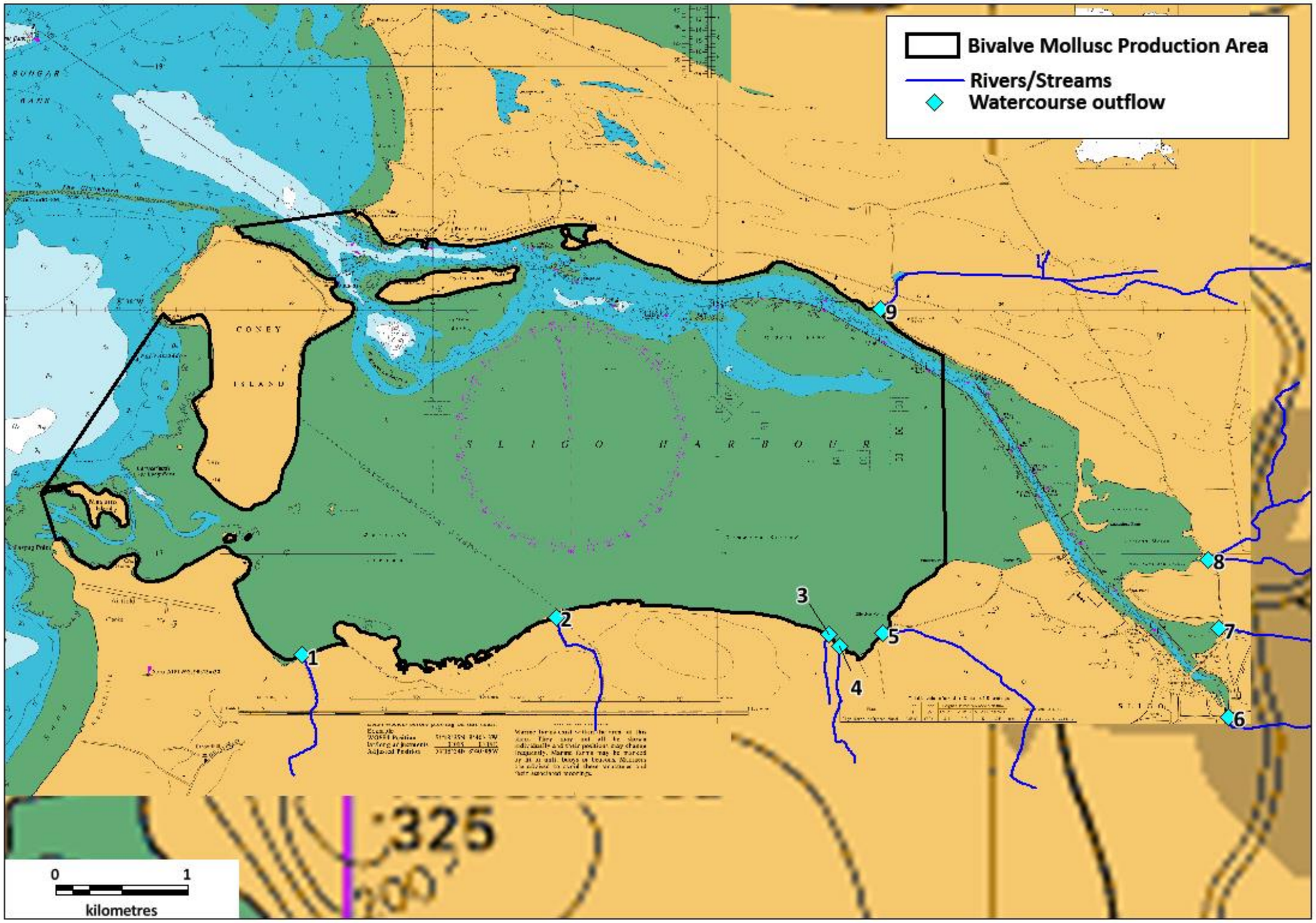



**Figure 3.45: Location of all watercourses discharging into Sligo Harbour.**

**Table 3.14: Cross-referenced table for Figure 3.45 Watercourses.**

| Map ID | Watercourse |
|---|---|
| 1 | Unnamed stream |
| 2 | Unnamed stream |
| 3 | Unnamed stream |
| 4 | Unnamed stream |
| 5 | Unnamed stream |
| 6 | Garavogue River |
| 7 | Copper River |
| 8 | Doonally Stream |
| 9 | Unnamed Stream |

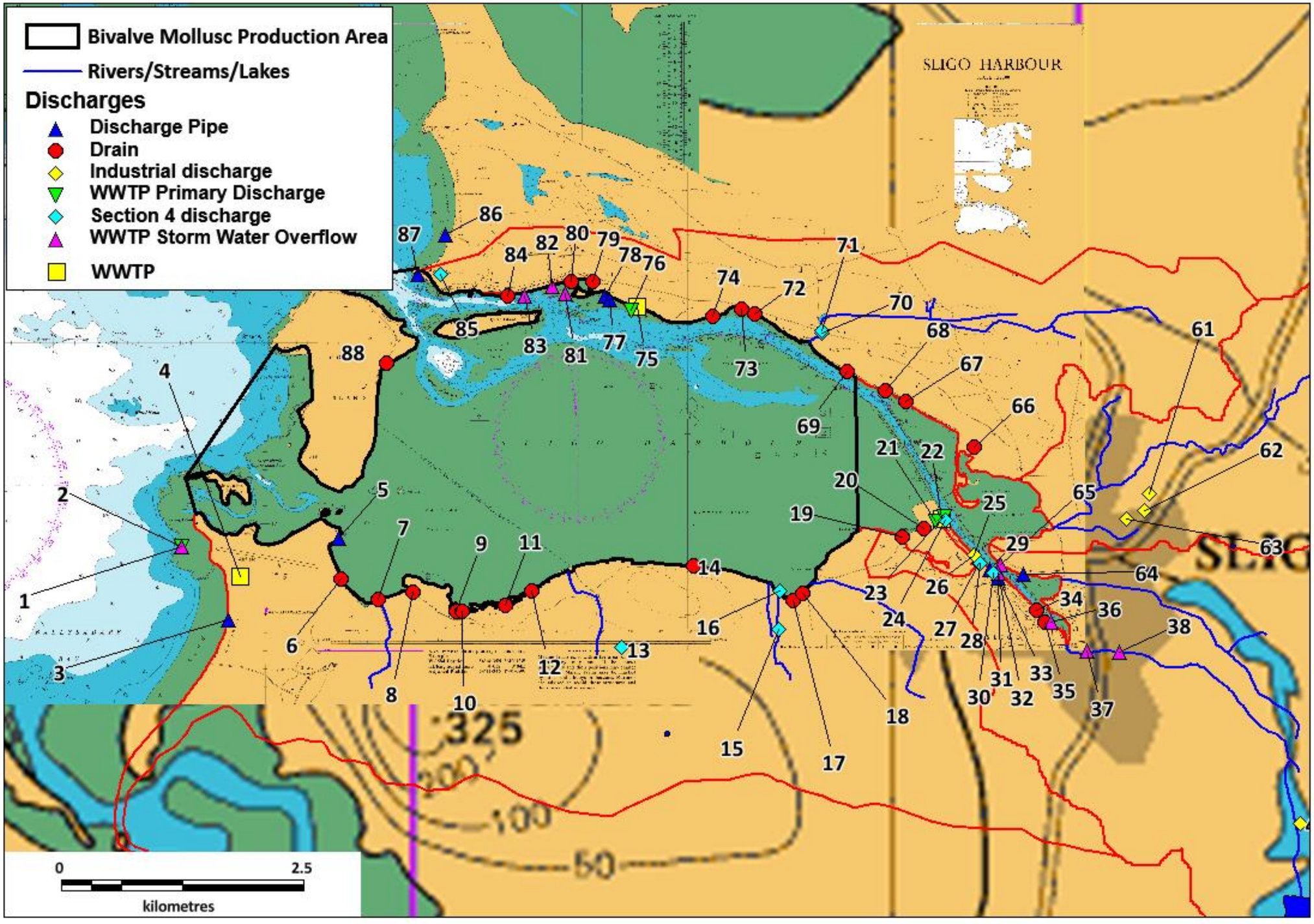



**Figure 3.46: Locations of all discharges within the western end Sligo Harbour Catchment Area.**

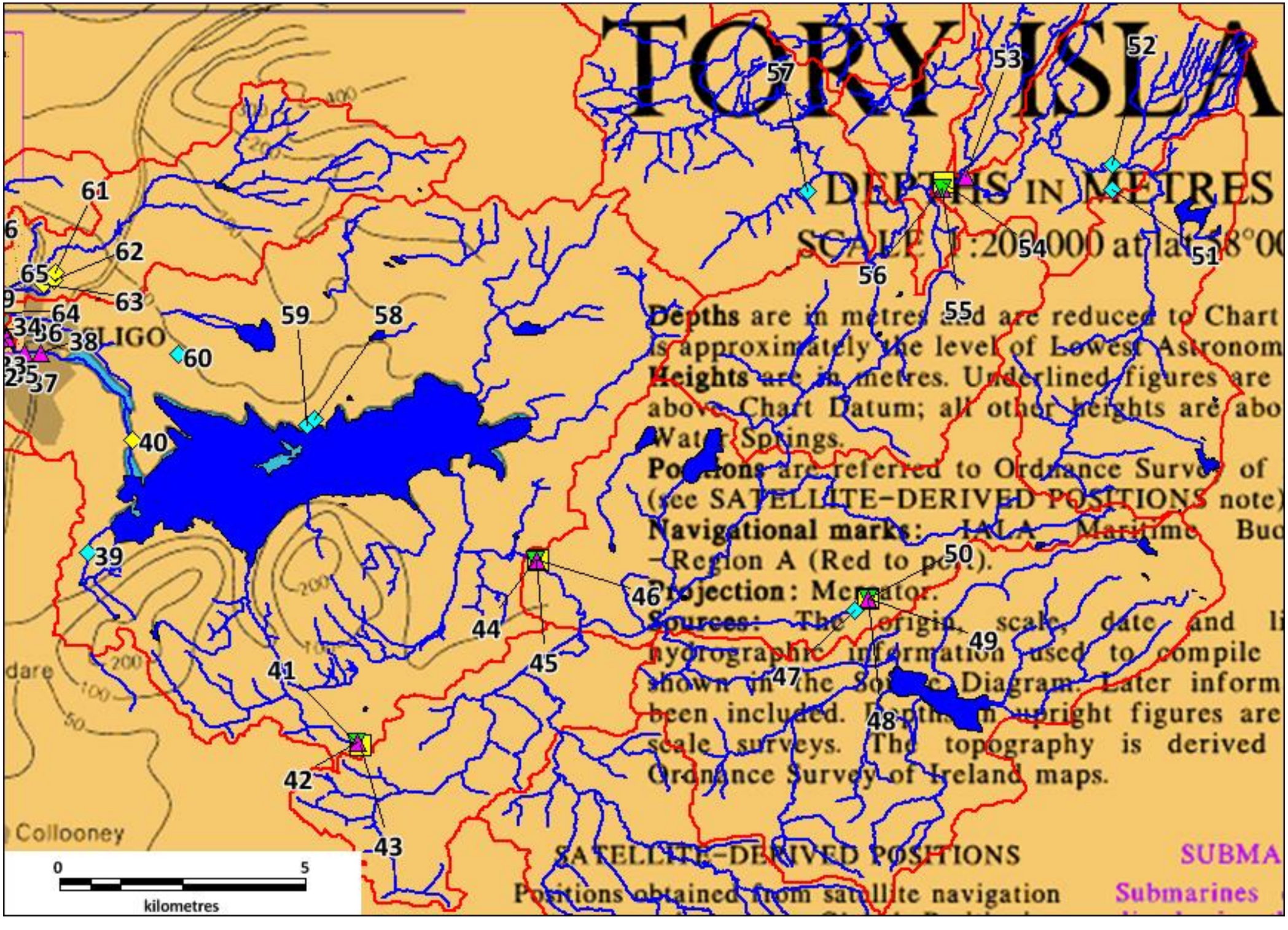



**Figure 3.47: Locations of all discharges within the eastern end Sligo Harbour Catchment Area.**

**Table 3.15: Cross-referenced table for Figures 3.46 and 3.47 Discharges.**

| Map ID | Discharge | Description | Latitude | Longitude | Easting | Northing |
|---|---|---|---|---|---|---|
| 1 | Strandhill | WWTP Primary Discharge | 54.28132 | -8.61398 | 160058.5 | 337117.8 |
| 2 | Strandhill | Storm Water Overflow | 54.28132 | -8.61398 | 160058.5 | 337117.8 |
| 3 | Large discharge pipe | Shore Survey | 54.27458 | -8.60662 | 160531.8 | 336364.3 |
| 4 | Strandhill | WWTP | 54.27862 | -8.60469 | 160661.1 | 336812.2 |
| 5 | Pipe | Shore Survey | 54.28217 | -8.58925 | 161670.2 | 337198.9 |
| 6 | Drainage ditch | Shore Survey | 54.27840 | -8.58877 | 161698.2 | 336779.4 |
| 7 | Field drain pipe | Shore Survey | 54.27650 | -8.58308 | 162066.7 | 336564.8 |
| 8 | Field drain | Shore Survey | 54.27723 | -8.57755 | 162427.8 | 336643.4 |
| 9 | Tiny stream | Shore Survey | 54.27545 | -8.57077 | 162868.0 | 336441.4 |
| 10 | Natural drainage stream underground | Shore Survey | 54.27540 | -8.56973 | 162935.3 | 336435.3 |
| 11 | Field drain | Shore Survey | 54.27595 | -8.56292 | 163379.8 | 336492.9 |
| 12 | Field drainage/tiny stream | Shore Survey | 54.27725 | -8.55877 | 163651.3 | 336635.5 |
| 13 | Scarden Court | Section 4 discharge | 54.27207 | -8.54457 | 164571.5 | 336051.9 |
| 14 | Field drain | Shore Survey | 54.27967 | -8.53332 | 165311.2 | 336891.7 |
| 15 | James and Winifred Beirne | Section 4 discharge | 54.27371 | -8.51988 | 166181.6 | 336221.8 |
| 16 | Sligo Dairies Ltd | Section 4 discharge | 54.27730 | -8.51962 | 166201.6 | 336621.9 |
| 17 | Stream/small river | Shore Survey | 54.27647 | -8.51765 | 166329.1 | 336527.9 |
| 18 | Stream | Shore Survey | 54.27708 | -8.51613 | 166428.4 | 336595.7 |
| 19 | Drain/upwelling | Shore Survey | 54.28230 | -8.50045 | 167454.1 | 337169.1 |
| 20 | Drain hole pipe | Shore Survey | 54.28307 | -8.49697 | 167681.6 | 337252.9 |
| 21 | Sligo | WWTP Primary Discharge | 54.28368 | -8.49501 | 167809.6 | 337319.9 |
| 22 | Sligo | WWTP | 54.28397 | -8.49415 | 167866.1 | 337352.2 |
| 23 | Sligo | WWTP Primary Discharge | 54.28418 | -8.49377 | 167890.6 | 337374.9 |
| 24 | Erin Recyclers Ltd | Section 4 discharge | 54.28386 | -8.49348 | 167909.6 | 337339.9 |
| 25 | Starrus Eco Holdings Limite | Industrial discharge | 54.28057 | -8.48902 | 168197.6 | 336971.9 |
| 26 | Starrus Eco Holdings Limite | Industrial discharge | 54.28057 | -8.48902 | 168197.6 | 336971.9 |
| 27 | Sligo Fuels Sales Limited | Section 4 discharge | 54.27990 | -8.48827 | 168245.6 | 336895.8 |
| 28 | McCormack Fuels Ltd | Section 4 discharge | 54.27986 | -8.48802 | 168261.6 | 336891.8 |
| 29 | Large pipe | Shore Survey | 54.27925 | -8.48657 | 168356.0 | 336823.3 |
| 30 | Bord Na Mona fuels Ltd | Section 4 discharge | 54.27894 | -8.48599 | 168393.6 | 336788.8 |
| 31 | Sligo | Storm Water Overflow | 54.27893 | -8.48530 | 168438.6 | 336786.9 |
| 32 | Sligo | Storm Water Overflow | 54.27893 | -8.48530 | 168438.6 | 336786.9 |
| 33 | Two pipes | Shore Survey | 54.27847 | -8.48533 | 168435.8 | 336735.6 |
| 34 | Drain - Gated around exit p | Shore Survey | 54.27548 | -8.47925 | 168829.8 | 336400.7 |
| 35 | Drain - likely stormwater | Shore Survey | 54.27438 | -8.47780 | 168923.5 | 336277.6 |
| 36 | Sligo | Storm Water Overflow | 54.27436 | -8.47689 | 168982.6 | 336274.9 |
| 37 | Sligo | Storm Water Overflow | 54.27173 | -8.47118 | 169352.6 | 335979.8 |
| 38 | Sligo | Storm Water Overflow | 54.27168 | -8.46616 | 169679.6 | 335971.9 |
| 39 | Cemex ROI Ltd | Section 4 discharge | 54.23513 | -8.45144 | 170612.6 | 331896.8 |
| 40 | Saehan Media (Irl.) Limited | Industrial discharge | 54.25583 | -8.43762 | 171528.3 | 334195.0 |

| Map ID | Discharge | Description | Latitude | Longitude | Easting | Northing |
|---|---|---|---|---|---|---|
| 41 | Ballintogher | WWTP Primary Discharge | 54.20053 | -8.36799 | 176034.6 | 328013.7 |
| 42 | Ballintogher | Storm Water Overflow | 54.20054 | -8.36760 | 176059.6 | 328014.8 |
| 43 | Ballintogher & Environs | WWTP | 54.20021 | -8.36669 | 176119.2 | 327978.1 |
| 44 | Dromahair | WWTP Primary Discharge | 54.23384 | -8.31209 | 179698.7 | 331703.7 |
| 45 | Dromahair | Storm Water Overflow | 54.23396 | -8.31183 | 179715.6 | 331717.7 |
| 46 | Dromahair | WWTP | 54.23376 | -8.31138 | 179745.3 | 331695.1 |
| 47 | Seamus Kerrigan Ltd | Section 4 discharge | 54.22455 | -8.21283 | 186168.7 | 330645.7 |
| 48 | Killarga | Storm Water Overflow | 54.22691 | -8.20881 | 186431.7 | 330907.7 |
| 49 | Killarga | WWTP Primary Discharge | 54.22678 | -8.20873 | 186436.7 | 330893.7 |
| 50 | Killarga | WWTP | 54.22673 | -8.20835 | 186461.2 | 330888.1 |
| 51 | Tates Quarry | Section 4 discharge | 54.30125 | -8.13274 | 191408.8 | 339170.7 |
| 52 | Mr Damien McPartland | Section 4 discharge | 54.30590 | -8.13249 | 191425.8 | 339688.8 |
| 53 | Manorhamilton | Storm Water Overflow | 54.30356 | -8.17832 | 188441.8 | 339434.8 |
| 54 | Manorhamilton | WWTP | 54.30268 | -8.18510 | 188000.3 | 339338.2 |
| 55 | Manorhamilton | Storm Water Overflow | 54.30158 | -8.18562 | 187965.8 | 339215.8 |
| 56 | Manorhamilton | WWTP Primary Discharge | 54.30158 | -8.18562 | 187965.8 | 339215.8 |
| 57 | D.K Trotter | Section 4 discharge | 54.30111 | -8.22725 | 185255.7 | 339170.7 |
| 58 | Saint Angelas College Residences | Section 4 discharge | 54.25948 | -8.38102 | 175219.7 | 334580.8 |
| 59 | Saint Angela's College | Section 4 discharge | 54.25826 | -8.38331 | 175069.6 | 334445.8 |
| 60 | John Davey Motors Ltd | Section 4 discharge | 54.27130 | -8.42346 | 172461.6 | 335911.8 |
| 61 | AbbVie Ireland NL B.V. | Industrial discharge | 54.28621 | -8.46149 | 169994.8 | 337586.9 |
| 62 | AbbVie Ireland NL B.V. | Industrial discharge | 54.28475 | -8.46212 | 169952.8 | 337424.9 |
| 63 | AbbVie Ireland NL B.V. | Industrial discharge | 54.28390 | -8.46501 | 169763.8 | 337331.9 |
| 64 | Pipe | Shore Survey | 54.27888 | -8.48118 | 168706.5 | 336780.0 |
| 65 | Sligo | Storm Water Overflow | 54.27976 | -8.48485 | 168468.6 | 336878.8 |
| 66 | Field drains/reed bed | Shore Survey | 54.29057 | -8.48895 | 168209.6 | 338084.1 |
| 67 | Field drain/stream | Shore Survey | 54.29473 | -8.49972 | 167511.7 | 338552.7 |
| 68 | Field Drain | Shore Survey | 54.29583 | -8.50308 | 167293.4 | 338676.7 |
| 69 | Field Drain | Shore Survey | 54.29757 | -8.50903 | 166907.4 | 338872.5 |
| 70 | Radisson Blu Hotel | Section 4 discharge | 54.30107 | -8.51307 | 166647.6 | 339264.9 |
| 71 | HSE Cregg House | Section 4 discharge | 54.30131 | -8.51293 | 166656.6 | 339290.9 |
| 72 | Natural drain stream | Shore Survey | 54.30287 | -8.52362 | 165962.2 | 339469.4 |
| 73 | Natural drain stream | Shore Survey | 54.30333 | -8.52568 | 165828.1 | 339522.3 |
| 74 | Drain/stream | Shore Survey | 54.30262 | -8.53020 | 165533.4 | 339444.8 |
| 75 | Rosses Point | WWTP | 54.30354 | -8.54214 | 164757.1 | 339553.1 |
| 76 | Rosses Point | WWTP Primary Discharge | 54.30317 | -8.54311 | 164693.6 | 339512.9 |
| 77 | Old pipe | Shore Survey | 54.30415 | -8.54648 | 164474.7 | 339623.5 |
| 78 | Old pipe | Shore Survey | 54.30453 | -8.54725 | 164425.1 | 339666.6 |
| 79 | Drain | Shore Survey | 54.30582 | -8.54907 | 164307.9 | 339810.4 |
| 80 | Pipe/drain | Shore Survey | 54.30587 | -8.55260 | 164078.0 | 339817.8 |
| 81 | Rosses Point | Storm Water Overflow | 54.30479 | -8.55351 | 164017.5 | 339697.9 |
| 82 | Rosses Point | Storm Water Overflow | 54.30540 | -8.55561 | 163881.6 | 339766.9 |

| Map ID | Discharge | Description | Latitude | Longitude | Easting | Northing |
|---|---|---|---|---|---|---|
| 83 | Rosses point | Storm Water Overflow | 54.30456 | -8.56004 | 163592.6 | 339675.9 |
| 84 | Pipe/drain | Shore Survey | 54.30453 | -8.56260 | 163425.9 | 339674.4 |
| 85 | Sligo Yacht Club | Section 4 discharge | 54.30645 | -8.57314 | 162741.6 | 339893.9 |
| 86 | Old pipe | Shore Survey | 54.31018 | -8.57238 | 162794.1 | 340308.5 |
| 87 | Narrow pipe | Shore Survey | 54.30653 | -8.57673 | 162507.6 | 339904.5 |
| 88 | Small stream draining lagoon | Shore Survey | 54.29833 | -8.58165 | 162180.0 | 338994.3 |

# 4. Hydrography/Hydrodynamics

## *4.1. Simple/Complex Models*

Two hydrodynamic models of Sligo Harbour have been developed for the Sligo Harbour area, one by Irish Hydrodata Ltd. modelling the mercury discharges from Sligo WWTP and the other was lodged to the EPA as part of a dredging and dumping at sea licence application to model the dispersion of sediment released during dredging (RPS, 2015). The results from these models have been used to describe the hydrodynamics of Sligo Harbour below.

## *4.2. Depth*

The majority of the bay is made up of intertidal sand and mudflats. A navigational channel runs northwesterly from Sligo town towards Oyster Island and out into Sligo Bay between Coney Island and Deadman's Point. The navigational channel is flanked by a training wall out as far as Ballyweelin Point. Depths within the navigation channel range from 0.7 to 3.6m (Admiralty Chart 2852). Beyond Ballyweelin Point the channel widens and deepens to 10m, before shallowing again as it reaches Oyster Island. Water depths in the channel north of Oyster Island reach a maximum of *c.* 7.5m before exiting into Sligo Bay. There is also a channel south of Oyster Island, where depths range from 0.2 to 2m throughout, with a deep pool (known as Deep Pit) of 20.4m deep between the Island and Shrunamoyle Seal Bank. There is also a channel south of the Middle Bank, with depths ranging from 0.3 to 5.8m. Figure 4.1 shows water depth in the area.

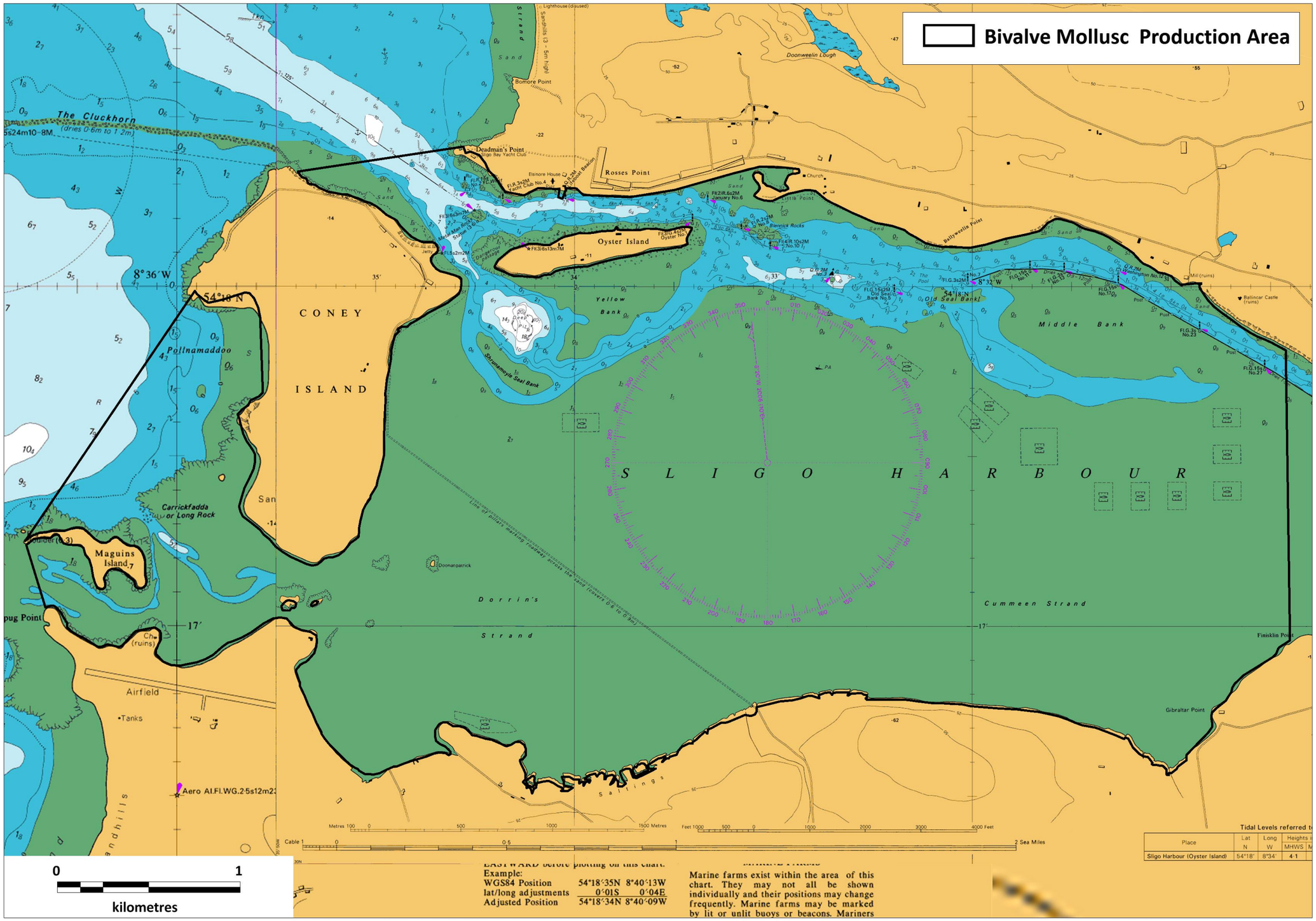



**Figure 4.1: Depths in Sligo Harbour (Source: Admiralty Chart 2852).**

### *4.3. Tides & Currents*

Predicted spring and neap tidal ranges in Sligo Harbour are in the region of 3.6 and 1.5m respectively (Admiralty Chart 2852). Irish Hydrodata Ltd. (2012) found that current speeds generally ranged from 0.2 to 0.9m/s, with currents at Rosses Point channel reaching 2.5m/s. These velocities compare well with those featured in British Admiralty Chart No. 2858 for the area where velocities of 5 to 6kn (2.57-3.09 m/s) are recorded on ebb and flood tides between Oyster Island and Rosses Point and velocities of 4 to 5kn (2.06-3.57 m/s) within the navigational channel. The direction of flow on an ebb tide is northwesterly along the navigation channel from Sligo town to Rosses Point. Current velocities increase as water is forced through the narrow channels to the north and south of Oyster Island (RPS, 2015). There is a circular flow pattern within the deep pit south of Oyster Island. There is less water movement in the southern half of the bay due to its shallow nature and so current velocities are lower. In the south western end of the bay water moves westerly through the narrow passage between Coney Island and Strandhill. However, current velocities are not as high as at Oyster Island as the volume of water is much less (RPS, 2015). The highest velocities on a flooding tide are once again either side of Oyster Island and between Coney Island and Strandhill (RPS, 2015). The flow direction from Oyster Island is south easterly and easterly from between Coney Island and Strandhill. As with the ebb tide flow rates are lower along the southern half of the bay due to its shallowness (RPS, 2015). The volume of water within the bay ranges from 22 to 39 million $m^3$ from neap HW to spring HW and 7.3 to 2.5 million $m^3$ from neap LW to spring LW (Irish Hydrodata Ltd, 2012).

**Table 4.1: Sligo Harbour tidal characteristics (Source: Admiralty Chart No. 2858).**

| Admiralty Chart 2800 Levels (m CD) | MHWS | MHWN | MLWN | MLWS |
|---|---|---|---|---|
| Oyster Island | 4.1 | 3.0 | 1.5 | 0.5 |

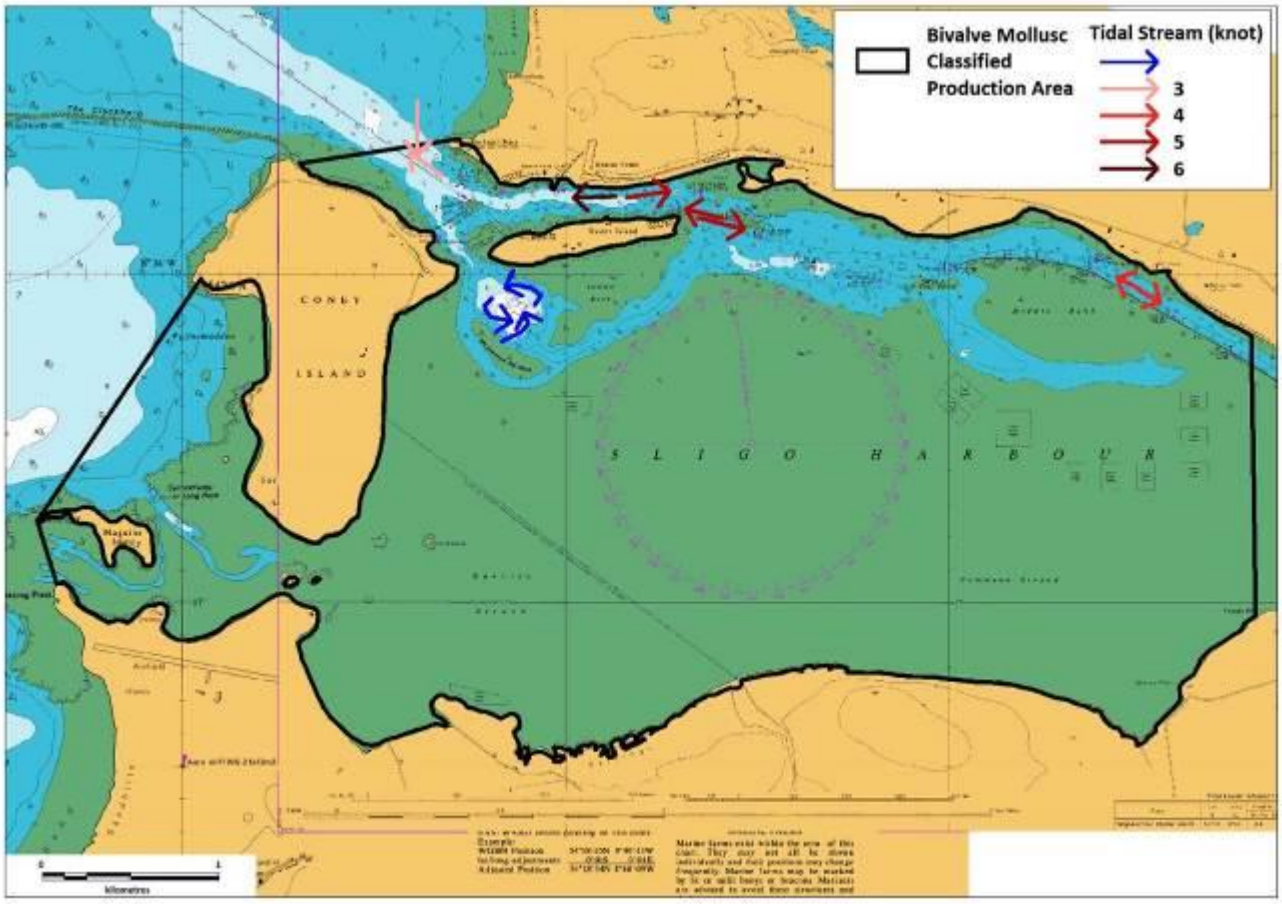



**Figure 4.2: Tidal streams within Sligo Harbour (Admiralty Chart No. 2858).**

## *4.4. Wind and Waves*

Wind data from 2014 to 2018 from the Finner station (Met Eireann, 2019a) (Co. Donegal, located approximately 28km north east of Sligo Harbour) are displayed in Table 4.2 below and wind roses for each year can be seen in Figure 4.3 below. In 2014, 19.8% of the wind came from the west, while 16.8% came from the south and 16.5% from the east. The strongest winds came from the west (44kn). In 2015, 21.6% of the wind came from the west, 18.4% from the southwest and 18% from the south. The strongest winds (39kn) came from the west. In 2016, 19.4% of the wind came from the east, 19% came from the west and 17.3% came from the south. The strongest winds (38kn) came from the southwest. In 2017, 24.2% of the winds came from the west, with 17.1% coming from the south and 16.6% coming from the southwest. The strongest winds (39kn) came from the northwest. In 2018, 20.3% of the wind came from the west, 16.6% came from the southwest, 16.5% came from the southeast and 16.4% came from the south. The strongest winds (37kn) came from the west. It can be seen from the 2014-2018 wind rose diagram that the prevailing wind direction is southwest.

Table 4.3 shows the seasonal averages from 2014 to 2018. Seasons were selected by grouping the results from the following periods: spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). Seasonal averages over the past 5 years indicate that winds are typically strongest in the winter months (12.6kn), followed by spring (10.2kn) and autumn (10kn), with 9.1kn in summer.

**Table 4.2: Wind speed and direction data for Finner from 2014-2018 (Source: Met Eireann, 2019a).**

| | 2014 | | 2015 | | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Mean Speed (knots)** | **Max 10-min Mean Direction (°)** | **Mean Speed (knots)** | **Max 10-min Mean Direction (°)** | **Mean Speed (knots)** | **Max 10-min Mean Direction (°)** | **Mean Speed (knots)** | **Max 10-min Mean Direction (°)** | **Mean Speed (knots)** | **Max 10-min Mean Direction (°)** |
| January | 11.7 | 195 | 16.4 | 251 | 12.5 | 188 | 10.9 | 209 | 14.5 | 213 |
| February | 14.0 | 213 | 10.9 | 216 | 12.1 | 207 | 12.2 | 185 | 11.1 | 218 |
| March | 11.3 | 208 | 13.8 | 222 | 10.2 | 198 | 10.8 | 177 | 9.8 | 144 |
| April | 9.8 | 183 | 9.0 | 224 | 10.2 | 195 | 10.8 | 255 | 9.8 | 168 |
| May | 8.9 | 202 | 13.0 | 235 | 8.6 | 188 | 8.1 | 205 | 8.2 | 194 |
| June | 7.3 | 203 | 10.3 | 249 | 8.0 | 219 | 10.2 | 227 | 7.8 | 236 |
| July | 8.6 | 235 | 9.4 | 223 | 9.5 | 254 | 8.9 | 227 | 7.3 | 236 |
| August | 10.9 | 243 | 8.7 | 239 | 10.2 | 212 | 9.5 | 247 | 9.6 | 261 |
| September | 6.3 | 206 | 8.8 | 220 | 9.7 | 198 | 10.5 | 240 | 10.8 | 270 |
| October | 11.0 | 181 | 8.2 | 184 | 8.0 | 153 | 12.3 | 232 | 11.5 | 234 |
| November | 8.0 | 183 | 14.1 | 234 | 8.8 | 184 | 10.8 | 265 | 10.9 | 165 |
| December | 14.8 | 237 | 14.1 | 190 | 11.1 | 183 | 11.3 | 249 | 11.0 | 214 |

Degrees Direction Key: 0°/360° = N; 23° = NNE; 45° = NE; 68° = ENE; 90° = N; 113° = ESE; 135° = SE; 158° = SSE; 180° = S; 203° = SSW; 225° = SW; 248° = WSW; 270° = W; 293° = WNW; 315° = NW; 338° = NNW

**Table 4.3: Seasonal averages (knots) for Finner wind data (Source: Met Eireann, 2019a).**

| Season | 2014 | 2015 | 2016 | 2017 | 2018 | 5 Year Average |
|---|---|---|---|---|---|---|
| Winter | 13.5 | 13.8 | 11.9 | 11.5 | 12.2 | 12.6 |
| Spring | 10.0 | 11.9 | 9.7 | 9.9 | 9.3 | 10.2 |
| Summer | 9.0 | 9.5 | 9.2 | 9.5 | 8.2 | 9.1 |
| Autumn | 8.5 | 10.4 | 8.8 | 11.2 | 11.1 | 10.0 |

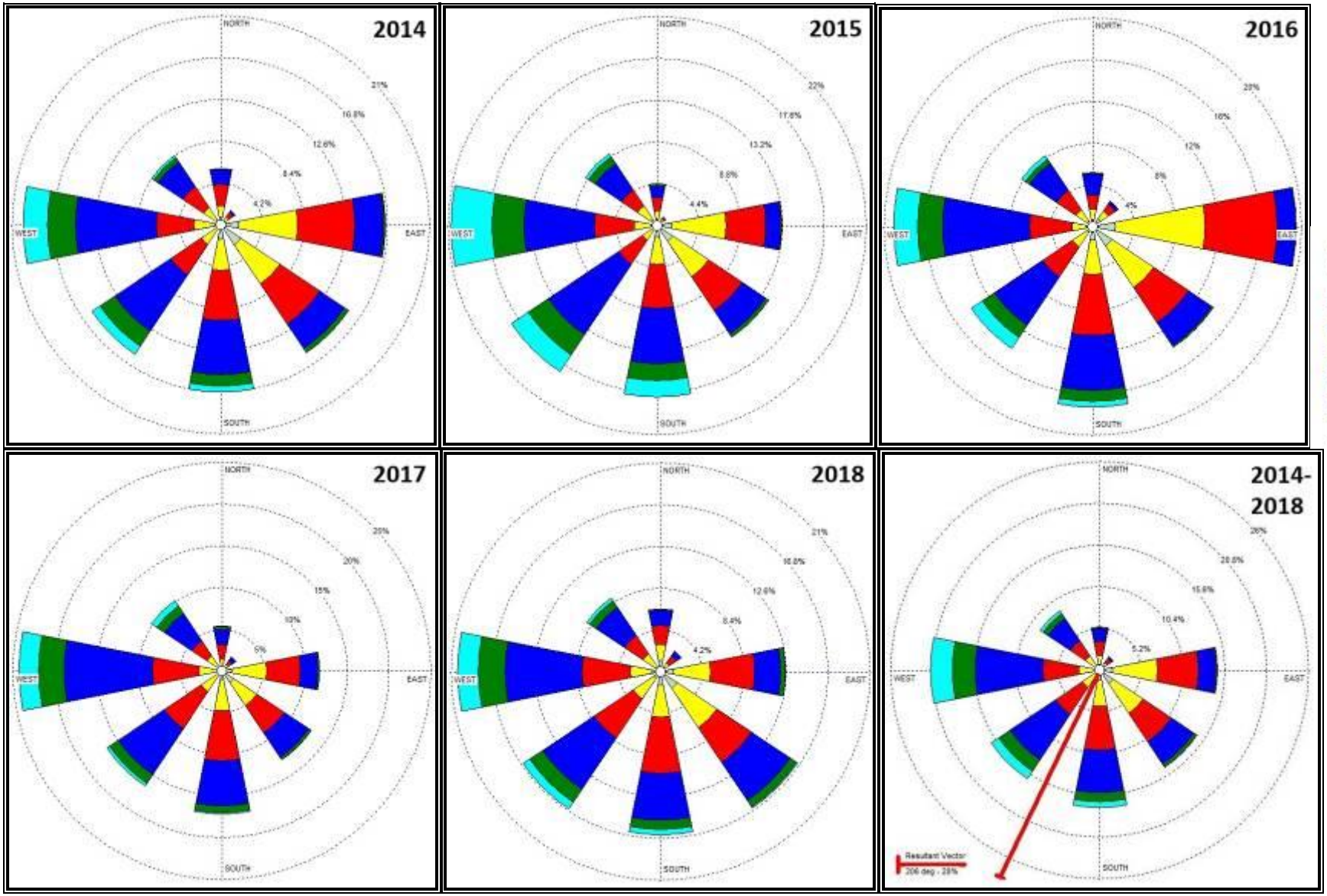



**Figure 4.3~~4.3~~: Wind roses for Finner from 2014 to 2018 (Source: Met Eireann, 2019a).**

Wind conditions affect the hydrodynamic conditions in Sligo Harbour 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 the direction of the prevailing wind, *i.e.* a southwesterly wind will produce northeasterly moving waves. The height of wind waves depends on:

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

### *4.5. River Discharges*

Sligo Harbour drains a catchment of 448km$^2$, 89% of this flows through the Garavogue River. The Garavogue River is approximately 5km long and flows from Lough Gill into the harbour. The Garavogue River has a mean flow of 12.7 m$^3$/s, with flows generally ranging from 2 to 60 m$^3$/s (Irish Hydrodata Ltd., 2012). Just north of the Garavogue River, the Copper River flows into the harbour and further north the Doonally Stream enters the harbour. The Doonally Stream drains an area of 19.7 km$^2$. There is one small stream flowing into the harbour from the north shore and this drains a catchment of approximately 9.6km$^2$. Five small streams flow into Sligo Harbour from the south shore draining a catchment of 18.5km$^2$.

Lough Gill is a medium sized lake of 13.81km$^2$ and is partially fed by small streams which flow directly into the lake. However, the majority of the inflow comes from the Bonet River which accounts for 73% of the Garavogue's catchment. Figure 4.4 shows the Sligo Harbour catchment and rivers and lakes. There is a hydrometric station on the Bonet River in Dromahair, operated by the OPW and this can also be seen in Figure 4.4. The Bonet River has a 95% flow of 1.039 m$^3$/s for the years 1986 to 2013. The annual average max flow for the Bonet is 108.3 m$^3$/s (years 1957-2016) with a highest recorded flow of 188 m$^3$/s in 1987 (OPW, 2019). Figure 4.5 shows the averaged and total flow of the Bonet River at Dromahair from 2015 to 2018. Over the past 4 years, May to July has had the least flow with flow levels at their highest from November to February/March.

The current (2010-2015) WFD status of Sligo Harbour and its associated freshwater sources can be seen in Figure 4.4. Of the river and lake systems flowing directly into the Sligo Harbour BMCPA, the Garavogue is of Poor status and the Doonally Stream is of Good status. Lough Gill is of Poor status. The streams flowing into the harbour from the north and south shores are not assigned a WFD status. The Bonet River ranges from Poor where it enters Lough Gill to Moderate and then Good in the upper reaches. Sligo Harbour is a transitional water body and is currently assigned as Good and the Sligo Bay coastal waterbody has a High

status.

The Garavogue, sections of the Bonet and most streams/rivers flowing into Lough Gill are at risk of not meeting their WFD objectives as is Lough Gill itself.

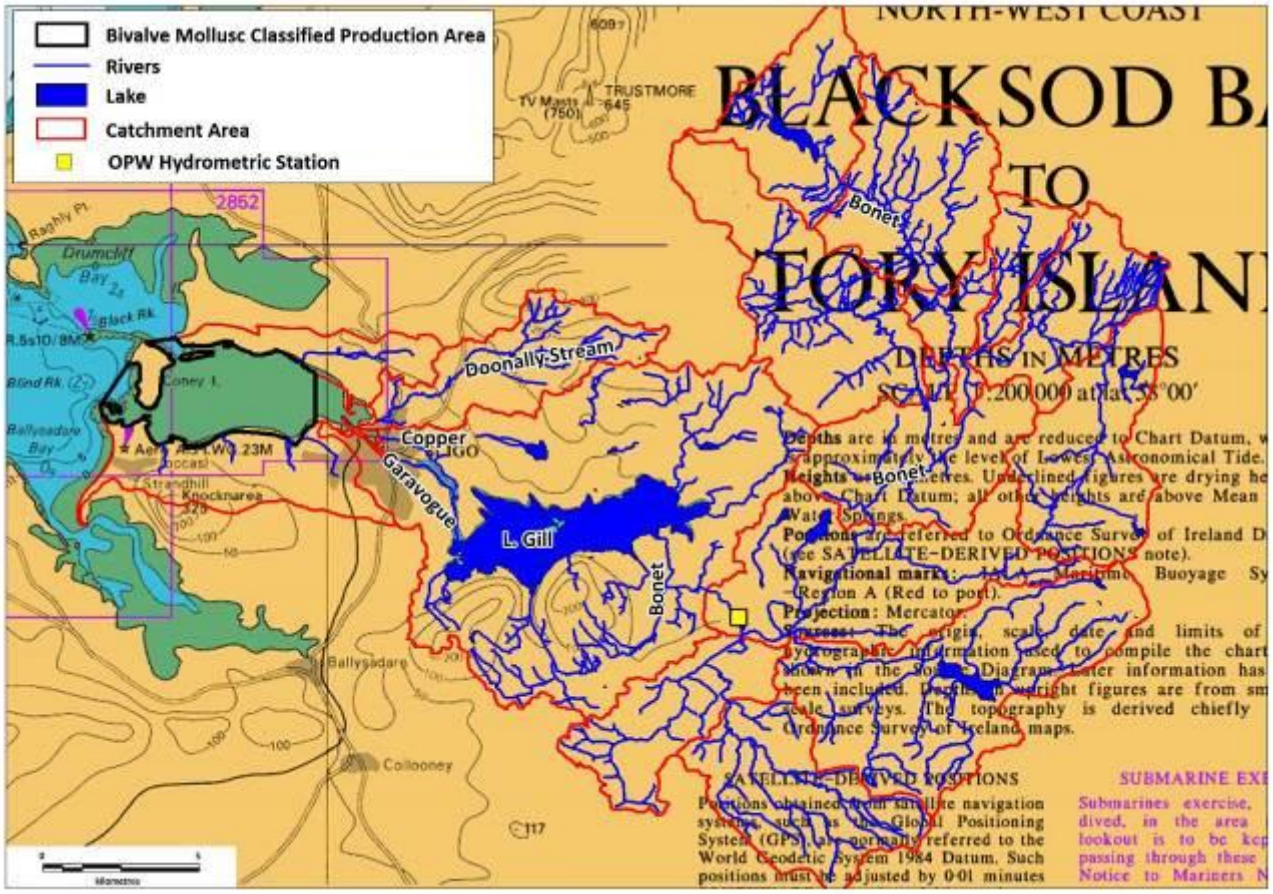



**Figure 4.4: Rivers, streams and lakes in the catchment areas including hydrometric station locations (Source: EPA, 2019).**

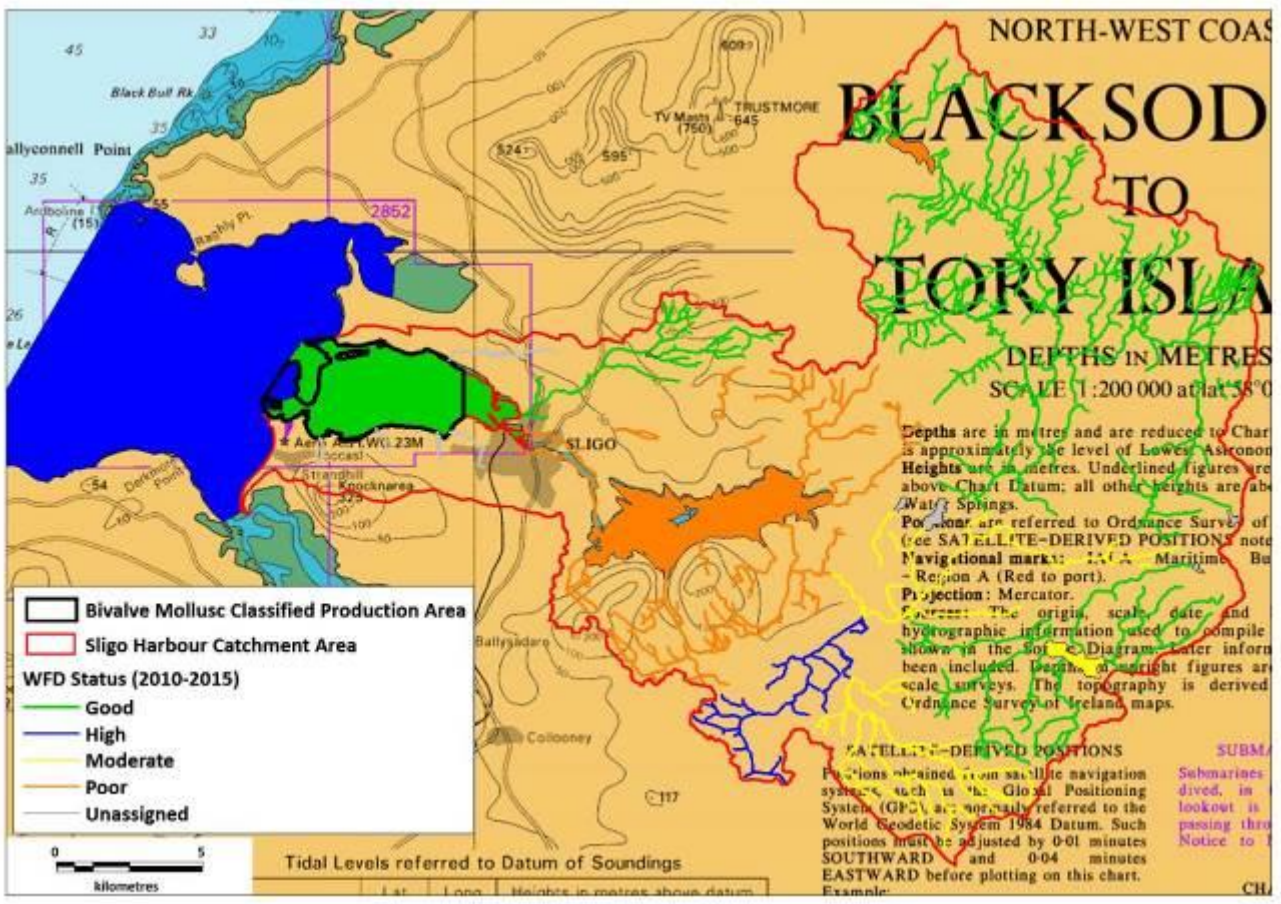
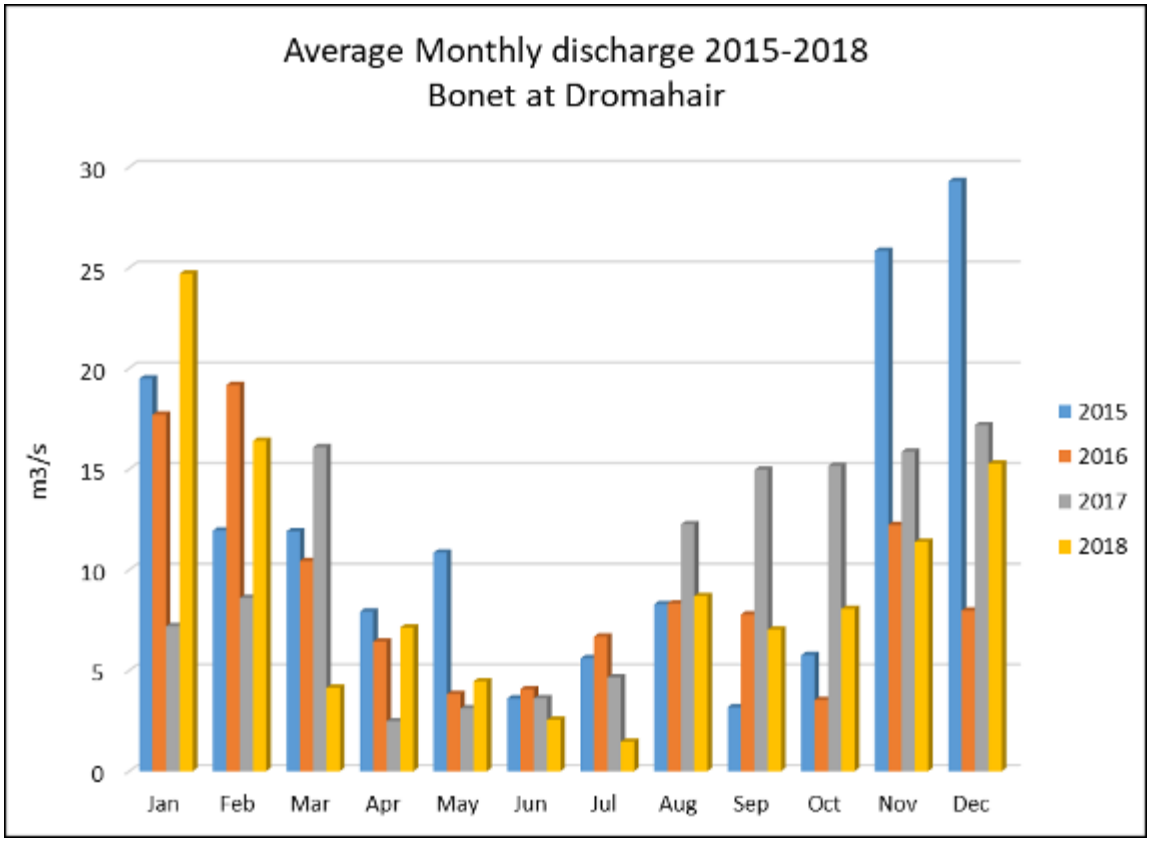



**Figure 4.5: WFD Status of the coastal, transitional, lake and river waterbodies in the catchment area (Source EPA, 2019).**



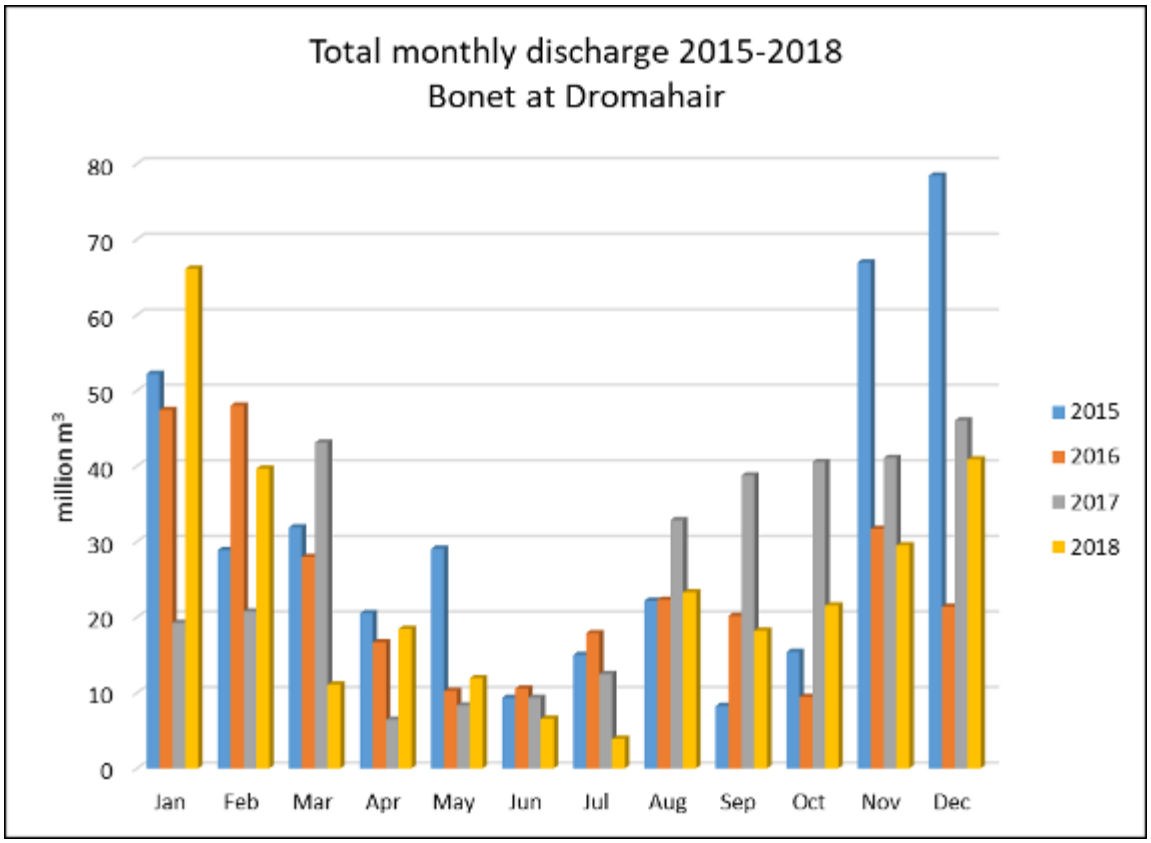




**Figure 4.6: Average and monthly flow data from the Bonet River at Dromahair (Source: OPW, 2019). *Total discharge calculated from monthly average.**

## *4.6. Rainfall Data*

### 4.6.1. Amount & Time of Year

Figure 4.7 shows the average monthly rainfall data for Ireland (Met Eireann, 2019b) from 1981 to 2010. The wettest months in the Sligo Harbour region over this 30-year period were October to January with the driest months from April to July. Table 4.4 shows the 30-year average monthly rainfall at the Belmullet station which is located c. 92km west of the Sligo Harbour production area (Figure 4.8 shows the location of the Belmullet station). During the period 1981 to 2010, average rainfall at Belmullet was lowest in May (70.4mm) and highest in October (145.9mm). The greatest daily total ranged from a low of 25.6 in March to a high of 79.6mm in October. Table 4.5 shows the seasonal averages at Belmullet from 1981 to 2010. Lowest average rainfall over the 30 year period was in spring (80.5mm) with the highest average rainfall experienced in autumn (127.2mm).

**Table 4.4: Monthly average rainfall at Belmullet from 1981 to 2010 (Source: Met Eireann, 2019c).**

| Average Rainfall (mm) | Month | Greatest Daily Total (mm) |
|---|---|---|
| 134.0 | January | 44.7 |
| 97.1 | February | 31.3 |
| 99.2 | March | 25.6 |
| 72.0 | April | 25.9 |
| 70.4 | May | 42.2 |
| 72.1 | June | 38.9 |
| 79.0 | July | 33.2 |
| 101.9 | August | 49.5 |
| 101.8 | September | 62.6 |
| 145.9 | October | 79.6 |
| 134.0 | November | 43.0 |
| 137.4 | December | 41.7 |
| 1244.8 | Year | 79.6 |

**Table 4.5: Average seasonal rainfall values (mm) from 1981-2010 at Belmullet (Source: Met Eireann, 2019c).**

| Season | Average |
|---|---|
| Spring | 80.5 |
| Summer | 84.3 |
| Autumn | 127.2 |
| Winter | 122.8 |

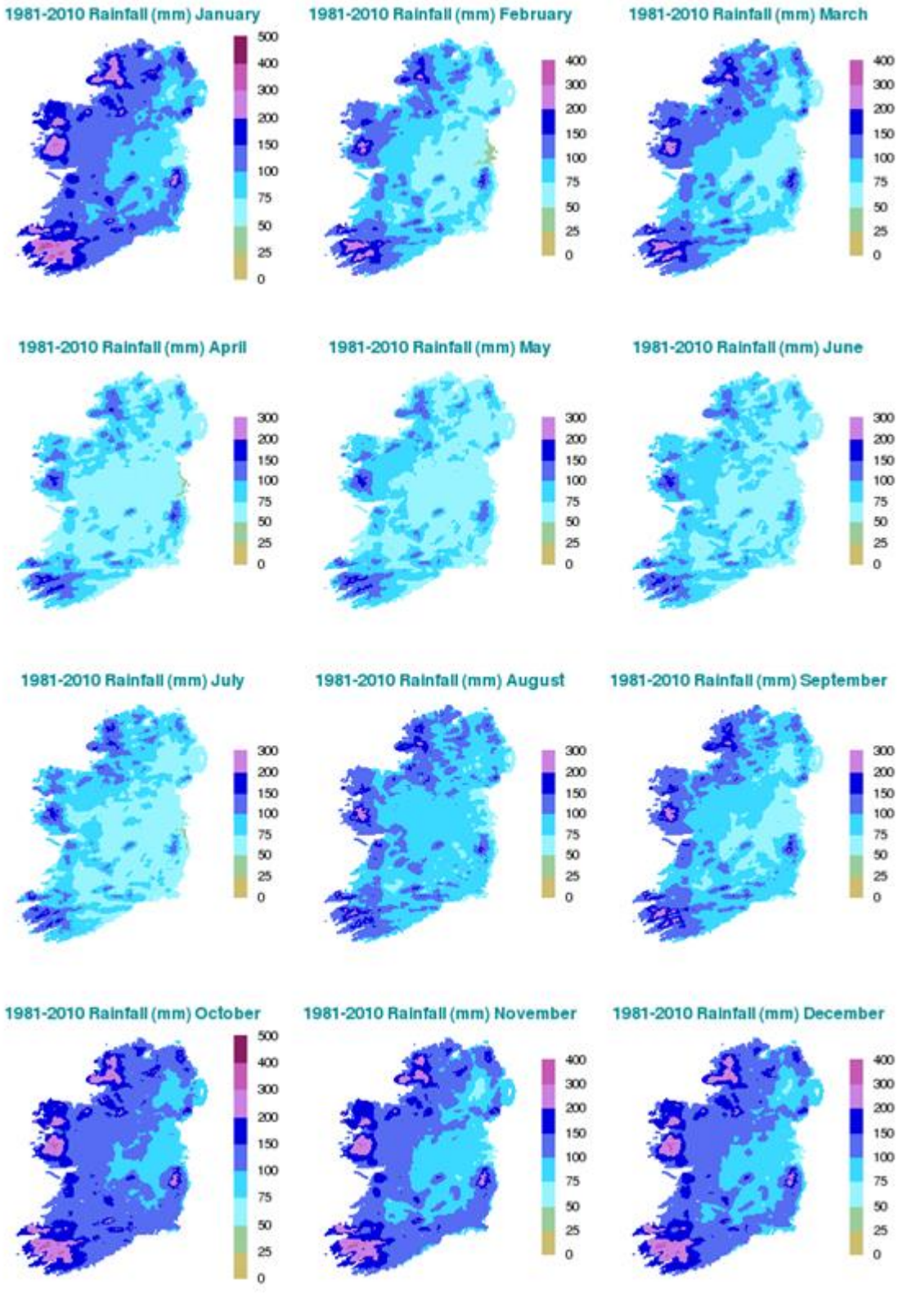



**Figure 4.7 Average monthly rainfall (mm) data from 1981 to 2010 for Ireland (Source: Met Eireann, 2019b).**

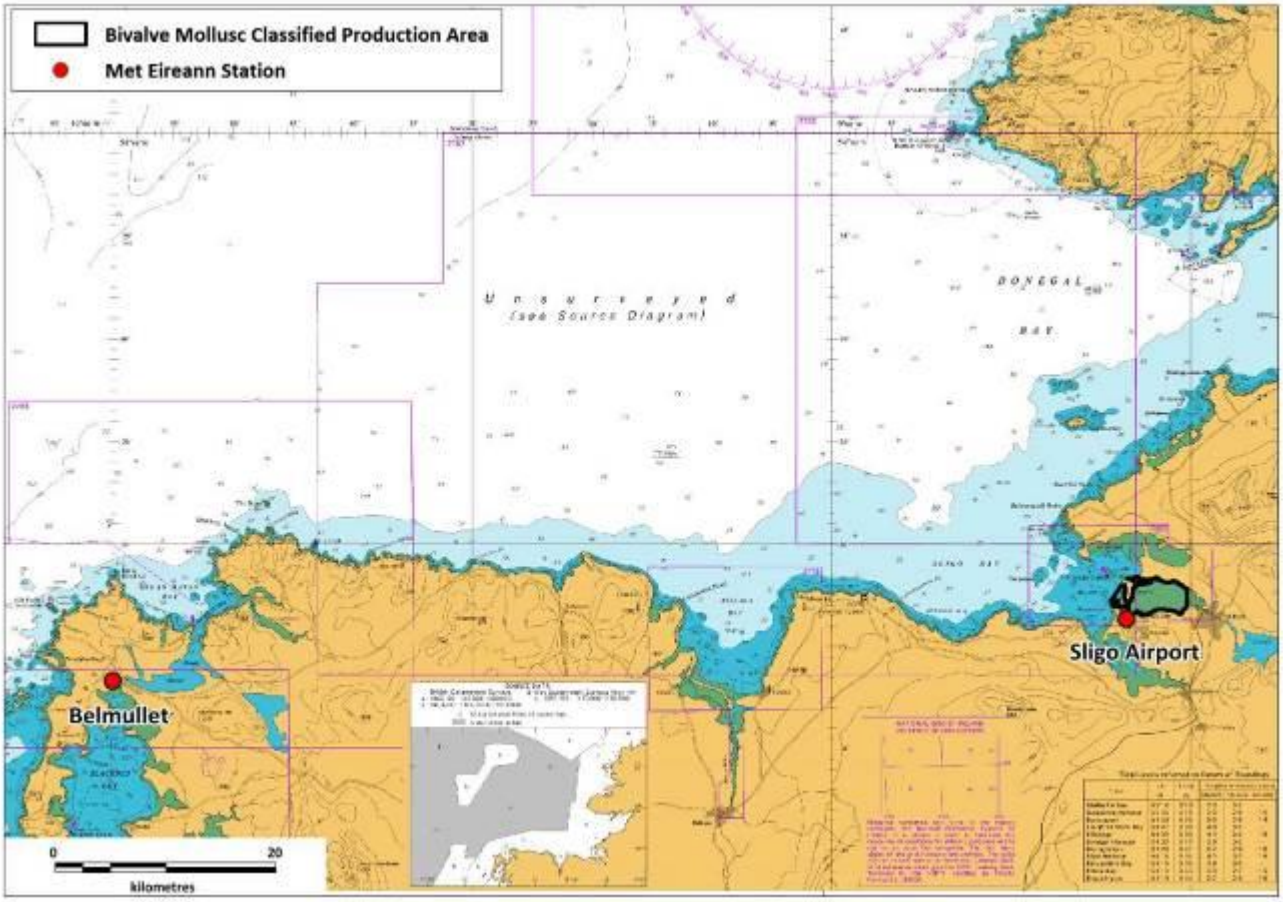



**Figure 4.8: Location of Met Eireann weather stations in relation to the Sligo Harbour production area.**

Table 4.6 shows total monthly rainfall at the Sligo Airport Met Eireann station (see Figure 4.8), located at the entrance to Sligo Harbour production area from 2014 to 2018 (Met Eireann, 2019d).

Sligo Airport weather station is located at Strandhill along the southwestern shore of Sligo Harbour. Maximum monthly rainfall was in December 2015 (267.6mm) and the lowest monthly rainfall was September 2014 (8.9mm). The 5-year average monthly rainfall ranged from a low of 56.6mm in June to a high of 170.6mm in January. Annual averages ranged from 86.5mm in 2018 to 122.7mm in 2015.

Table 4.7 shows the total seasonal rainfall at Sligo Airport from 2014-2018 (Met Eireann, 2019d). The following seasonal fluctuations were observed from 2014-2017 (as a complete data set was not available for 2018, this year was excluded from the summary): In 2014, spring was the driest season and winter was the wettest, in 2015 summer was the driest and winter was the wettest. In 2016, spring was the driest and winter was the wettest and in 2017 spring was the driest and autumn was the wettest. Over the four years spring 2017 was the driest season and winter 2014 was the wettest season.

**Table 4.6: Total monthly rainfall (mm) data at Sligo Airport Co. Sligo, from 2014 to 2018 (Source: Met Eireann, 2019d).**

| Year | 2014 | 2015 | 2016 | 2017 | 2018 | Monthly 5-yr Average |
|---|---|---|---|---|---|---|
| Jan | 220.6 | 193.8 | 184.3 | 46.1 | 208 | 170.6 |
| Feb | 175.8 | 87 | 128.7 | 75.2 | 93.1 | 112.0 |
| Mar | 78.7 | 109.5 | 90.7 | 106.5 | 36.9 | 84.5 |
| Apr | 34.5 | 84.5 | 64.7 | 23.7 | 76.3 | 56.7 |
| May | 94.9 | 116.5 | 55.4 | 66.6 | 48.4 | 76.4 |
| Jun | 48.7 | 45.6 | 78 | 79.5 | 31.2 | 56.6 |
| Jul | 65.9 | 118.3 | 85.1 | 88.5 | 64.1 | 84.4 |
| Aug | 101.7 | 97.8 | 93.2 | 110.3 | 119.2 | 104.4 |
| Sep | 8.9 | 62.6 | 119.3 | 155.6 | 78.8 | 85.0 |
| Oct | 101.1 | 64.8 | 44.4 | 88.2 | 80.2 | 75.7 |
| Nov | 131 | 224.8 | 90.9 | 137.2 | 115.2 | 139.8 |
| Dec | 173.3 | 267.6 | 69.3 | 151.4 | n/a | 165.4 |
| Annual Average | 102.9 | 122.7 | 92.0 | 94.1 | 86.5 | - |

**Table 4.7: Total seasonal rainfall (mm) at Sligo Airport from 2014-2018 (Source: Met Eireann, 2019d).**

| Station | Season/Year | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| Sligo Airport | Spring | 208.1 | 310.5 | 210.8 | 196.8 | 161.6 |
| | Summer | 216.3 | 261.7 | 256.3 | 278.3 | 214.5 |
| | Autumn | 241.0 | 352.2 | 254.6 | 381.0 | 274.2 |
| | Winter | 569.7 | 548.4 | 382.3 | 272.7 | 301.1# |

# No data available for December 2018.

### 4.6.2. Frequency of Significant Rainfalls

Figure 4.9 shows the average monthly rainfall at Belmullet from 1981-2010 and Figure 4.10 shows the 5 year monthly average rainfall at Sligo Airport weather station. Over the 30-year period from 1981 to 2010, October was the wettest month followed closely by December and then November and January. Over this period, October followed by September had the greatest daily rainfall. Over the past 5 years at Sligo Airport, January has been the wettest month followed closely by December, with November the next wettest. April and June were the driest months followed by May.

For the 5-year 2014-2018 period, average greatest daily rainfall at Sligo Airport was 18.6mm, with a maximum of 51.3mm. Over the same period, the number of wet days (rainfall >1mm) a month averaged at 16 with the maximum number of 26 days/month.

Met Eireann have developed a depth duration frequency model for the estimation of point rainfall frequencies (Fitzgerald, 2007; Met Eireann, 2019e). For a 1 in 100 year return period, 36mm of rain would be expected over 1 hour and 95.3mm over 24 hours. Whiles these would be extreme uncommon events, the model predicts that once a year 10.2mm would fall in 1 hour and 34.3mm over a 24 hour period.

Increased faecal contamination of coastal waters is typically associated with high rainfall and storm events through surface water run-off from livestock or other animals present and through sewer and waste water treatment plant overflows (Mallin *et al.,* 2001; Lee & Morgan, 2003). It is therefore expected that run-off due to rainfall will be higher during the November to February period. However, as can be seen in the data below, extreme rainfall events leading to episodes of high run-off can occur in most months of the year and it is therefore not just the winter months that are at risk of increased contamination. When these occur during generally drier periods in spring and summer months, they are likely to carry higher loadings of faecal material which has accumulated on pastures where greater numbers of livestock are present.

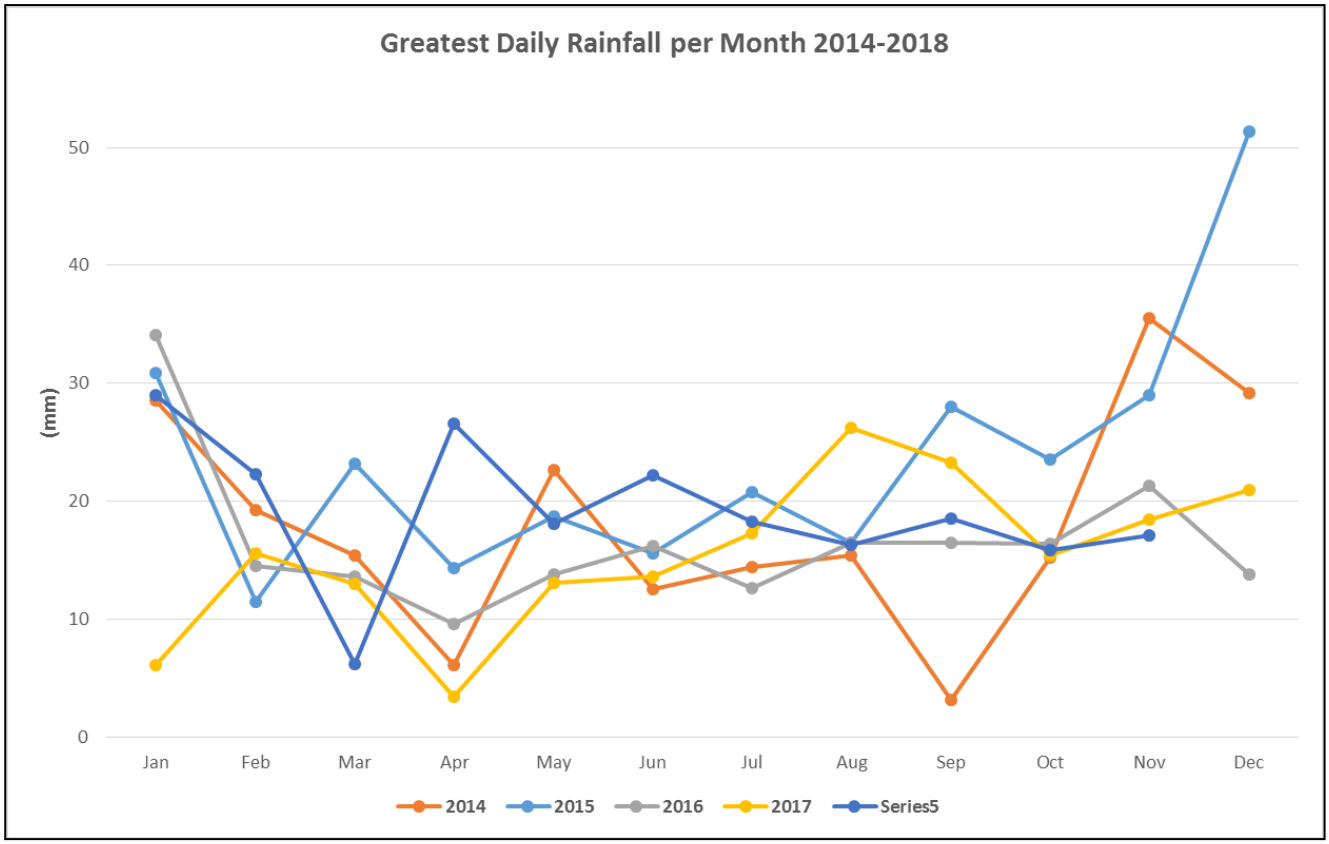



**Figure 4.9: Greatest daily rainfall per month for Sligo Airport from 2014-2018 (Source: Met Eireann, 2019c).**

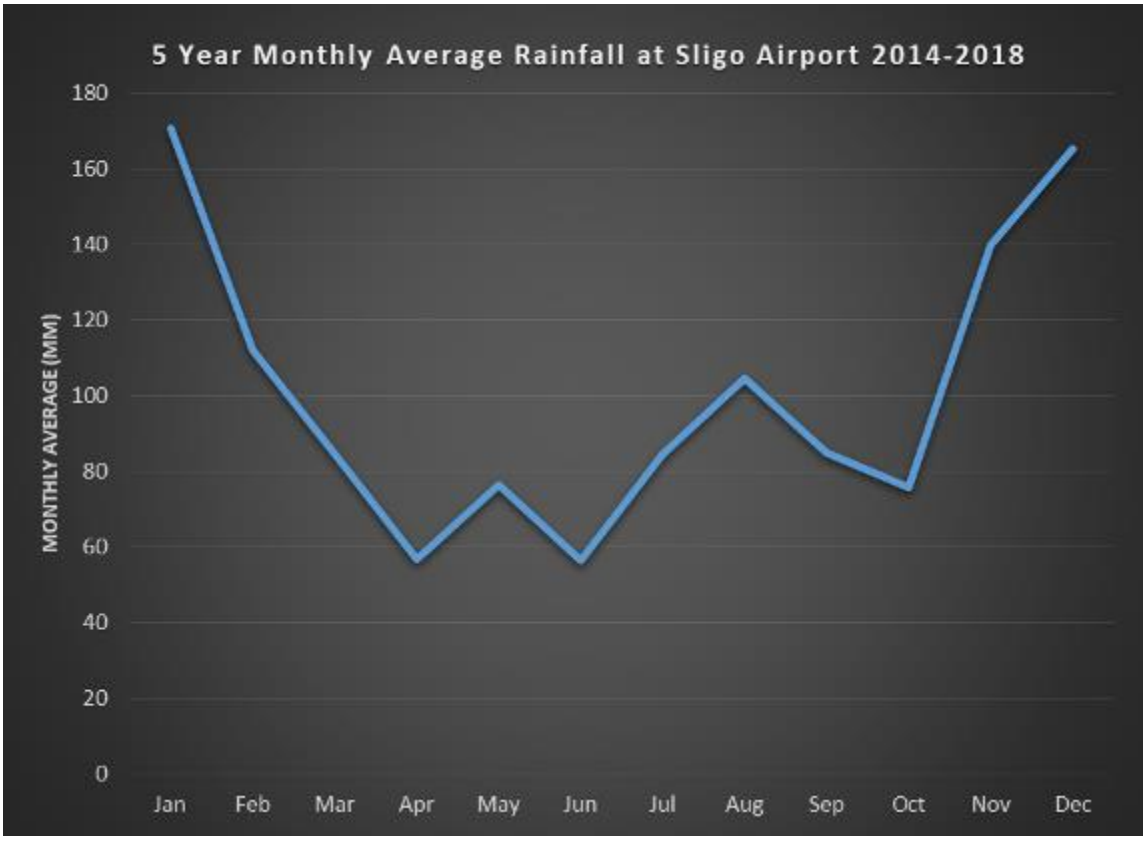



**Figure 4.10: 5 year monthly average rainfall (mm) at Sligo Airport weather station from 2014-2018 (Source: Met Eireann, 2019d).**

## *4.7. Salinity*

The Sligo Harbour production area has a highly variable salinity due to tidal and freshwater influences. The salinity is effected by the stage of the tide and the flow rate of the Garavogue, along with a handful of other small rivers. The salinity at Rosses Point can vary from 25 to 32 PSU, while at the eastern end of the bay at the mouth of the Garavogue salinity can range from 0 to 17 PSU (AQUAFACT, 2014a, b, c, d;. 2015a, b, c, d;. 2016a, b, c, d;. 2017a, b, c, d;. 2018a, b, c, d).

## *4.8. Turbidity*

The turbidity of Sligo Harbour can vary significantly depending on the tide, levels of freshwater input and weather conditions. Turbidity at Rosses Point can range from 0 to 10.7 NTU, while levels at the eastern inner extent of the bay can range from 0 to 191.1 NTU at Deepwater Quay and 0 to 311.9 NTU at Cummeen Strand (AQUAFACT, 2014a, b, c, d;. 2015a, b, c, d;. 2016a, b, c, d;. 2017a, b, c, d;. 2018a, b, c, d).

## *4.9. Residence Time*

Residence time can be defined as the average amount of time that a molecule of water spends in a

particular system. Residence times are important because of the way they govern productivity rates as well as the vulnerability to water quality degradation. The currents within the bay are dominated by the shallow bathymetry and generally flow parallel to the channel. Irish Hydrodata (2012) carried out a modelling study of the estuary and this study estimated the flushing time estimated to be about 13 days. However, the report goes on to say that "*even though the estuary inside Rosses Point almost empties with each tide, the data suggested that there may be a slow exchange with the open coastal waters. This was not fully proven however, as no field data was obtained in the outer bay area*". Given the fact that a considerable area of Sligo Bay dries out at low water, it seems highly unlikely that a figure of as high as 13 days represents the flushing time of the bay.

Mr. Tony Cawley of Hydroenvironmental Ltd., a mathematical modeller, examined the hydraulic residence time (HRT) of Sligo Harbour based on the volumes in the bay at Spring and Neap tides and calculated that for Spring tides, the HRT is 13.25 hrs and for Neaps, it is 18.6 hrs. A flushing time of 24hrs is therefore used.

### *4.10. Discussion*

The majority of the bay is made up of intertidal sand and mudflats. A navigational channel runs northwesterly from Sligo town towards Oyster Island following the northern shore with a retaining wall as far as Ballyweelin Point. Depths within this channel Range from 0.7 to 10m. Sligo Harbour has a flushing time of 24 hrs which indicates a high exchange rate of water in the bay and this would cause contamination entering the area to be flushed out of it in a short period of time. The main direction of water flow is to the northwest during the mid-ebb period. Current flows during a flooding tide are mainly south-easterly in direction. Freshwater input from the Garavogue is the main source of salinity variation with salinity ranging from 0-17 PSU near its mouth and 25-32 PSU at Rosses Point.

# 5. Shellfish and Water Sampling

## *5.1. Historical Data*

### 5.1.1. Shellfish Water Quality

The Marine Institute carries out quarterly water quality monitoring as part of the Shellfish Waters Directive in Sligo Harbour. Sampling is confined to the oyster aquaculture area. The EPA carries out monitoring under the Water Framework Directive. However, *E. coli* is not routinely measured under these programmes.

As part of Sligo Main Drainage project AQUAFACT has been taking quarterly *E. coli* samples at a number of locations in Sligo Harbour since 2014 (AQUAFACT, 2014 a, b, c, d; AQUAFACT, 2015 a, b, c, d; AQUAFACT, 2016 a, b, c, d; AQUAFACT, 2017a, b, c, d; AQUAFACT, 2018a, b, c, d). Station locations can be seen in Figure 5.1 and Table 5.1 provides a summary of the results (Appendix 1 contains the complete results). Table 5.2 shows the averaged seasonal *E. coli* levels from 2014 to 2018 and Figure 5.2 shows the seasonal averages in graphical form.

A significant difference was found between the *E. coli* results from the 8 stations (one-way ANOVA, p = 0.0000003, Appendix 2). A significant difference was observed between Station 1 in the Garavogue and Stations 3 (2 sample t-Test assuming equal variance, p = 0.0001, Appendix 2), 4 (2 sample t-Test assuming equal variance, p = 0.0000002, Appendix 2), 5 (2 sample t-Test assuming equal variance, p = 0.000006, Appendix 2), 6 (2 sample t-Test assuming unequal variance, p = 0.0003, Appendix 2) and 7 (2 sample t-Test assuming unequal variance, p = 0.02, Appendix 2).

A significant difference was observed between Station 2 in the Garavogue and Stations 3 (2 sample t-Test assuming equal variance, p = 0.007, Appendix 2), 4 (2 sample t-Test assuming equal variance, p = 0.00009, Appendix 2), 5 (2 sample t-Test assuming equal variance, p = 0.0004, Appendix 2) and 6 (2 sample t-Test assuming equal variance, p = 0.01, Appendix 2).

A significant difference was observed between Station 8 (mouth of the harbour) and Stations 3 (2 sample t-Test assuming equal variance, p = 0.003, Appendix 2), 4 (2 sample t-Test assuming unequal variance, p = 0.0001, Appendix 2), 5 (2 sample t-Test assuming equal variance, p = 0.0003, Appendix 2) and 6 (2 sample t-Test assuming equal variance, p = 0.005, Appendix 2).

These data show a spike in *E. coli* levels in the dock area and on the northeastern coastline of Sligo Harbour. Significant differences in *E. coli* levels were evident between the dock area (Stations 3, 4 and 5) and northeastern shoreline (Station 6) and the 2 stations further upstream in the Garavogue (Stations 1 and 2) and the station at the mouth of the harbour (Station 8). The mean and the median *E. coli* levels showed an increase in *E. coli* levels from the Garavogue River, peaking at the dock and northeastern coastline area and decreasing again moving further out towards the mouth.

When these data were examined for seasonality, no clear pattern emerged and no significant difference was found between the results by season (one-way ANOVA, p = 0.4373, Appendix 2). St. 5 in the Garavogue had highest average *E. coli* levels in Winter followed by Summer, St. 6 on the north shore had highest average *E. coli* levels in Spring followed by Autumn, St. 7 on the south shore had highest levels in Autumn followed by Winter and St. 8 levels at the mouth of the harbour had highest average *E. coli* levels in Winter followed closely by Summer. Figure 5.3 shows a boxplot of *E. coli* results by season. The high maximum results during each season appear to be isolated events with far lower variability seen between seasons when the average and quartile values are examined.

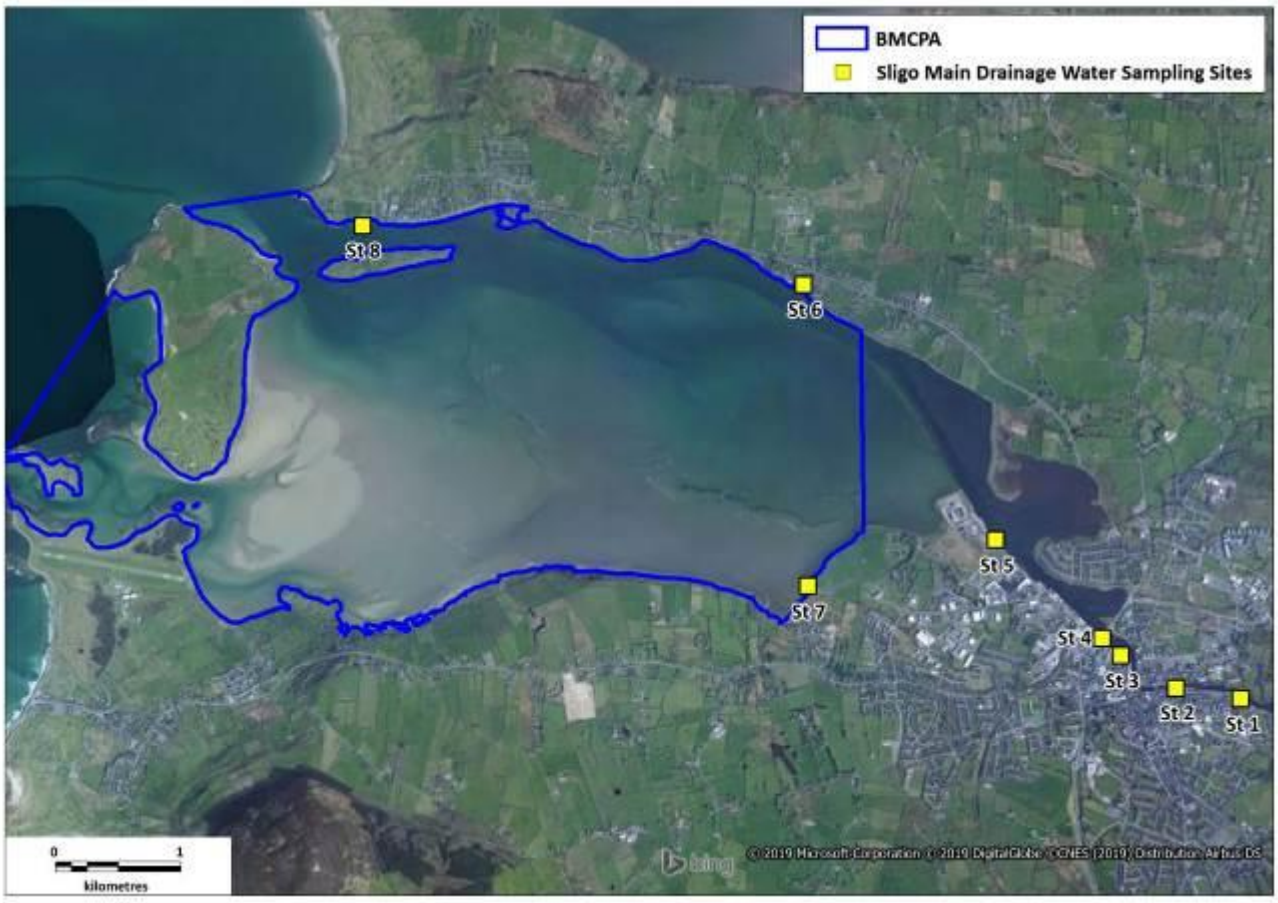



**Figure 5.1: Sligo Main Drainage Water Sampling sites.**

**Table 5.1: Faecal coliforms at in Sligo Harbour from 2014-2018 (Source: AQUAFACT).**

| Station | Mean | Median | Min | Max |
|---|---|---|---|---|
| Station 1 | 55.85 | 14 | 2 | 428 |
| Station 2 | 351.6 | 28.5 | 2 | 5475 |
| Station 3 | 778.58 | 292 | 10 | 7270 |
| Station 4 | 552 | 307 | 46 | 2359 |
| Station 5 | 1386.35 | 220 | 31 | 8164 |
| Station 6 | 1194.1 | 193 | 0 | 9804 |
| Station 7 | 602.35 | 98 | 0 | 5172 |
| Station 8 | 131.25 | 26 | 0 | 677 |

**Table 5.2: Averaged seasonal *E. coli* levels from 2014-2018.**

| Season | Spring | Summer | Autumn | Winter |
|---|---|---|---|---|
| Station 1 | 30.6 | 124 | 50.4 | 18.4 |
| Station 2 | 28.8 | 36 | 36.4 | 1305.2 |
| Station 3 | 554.2 | 1664.8 | 631.6 | 135 |
| Station 4 | 862 | 327.4 | 414.4 | 604.2 |
| Station 5 | 409 | 1698.6 | 1076.4 | 2361.4 |
| Station 6 | 2561.4 | 86 | 1719 | 410 |
| Station 7 | 155.6 | 92.4 | 1400.6 | 760.8 |
| Station 8 | 124.4 | 158.4 | 75.4 | 166.8 |
| Overall Average | 590.75 | 523.45 | 675.525 | 720.225 |

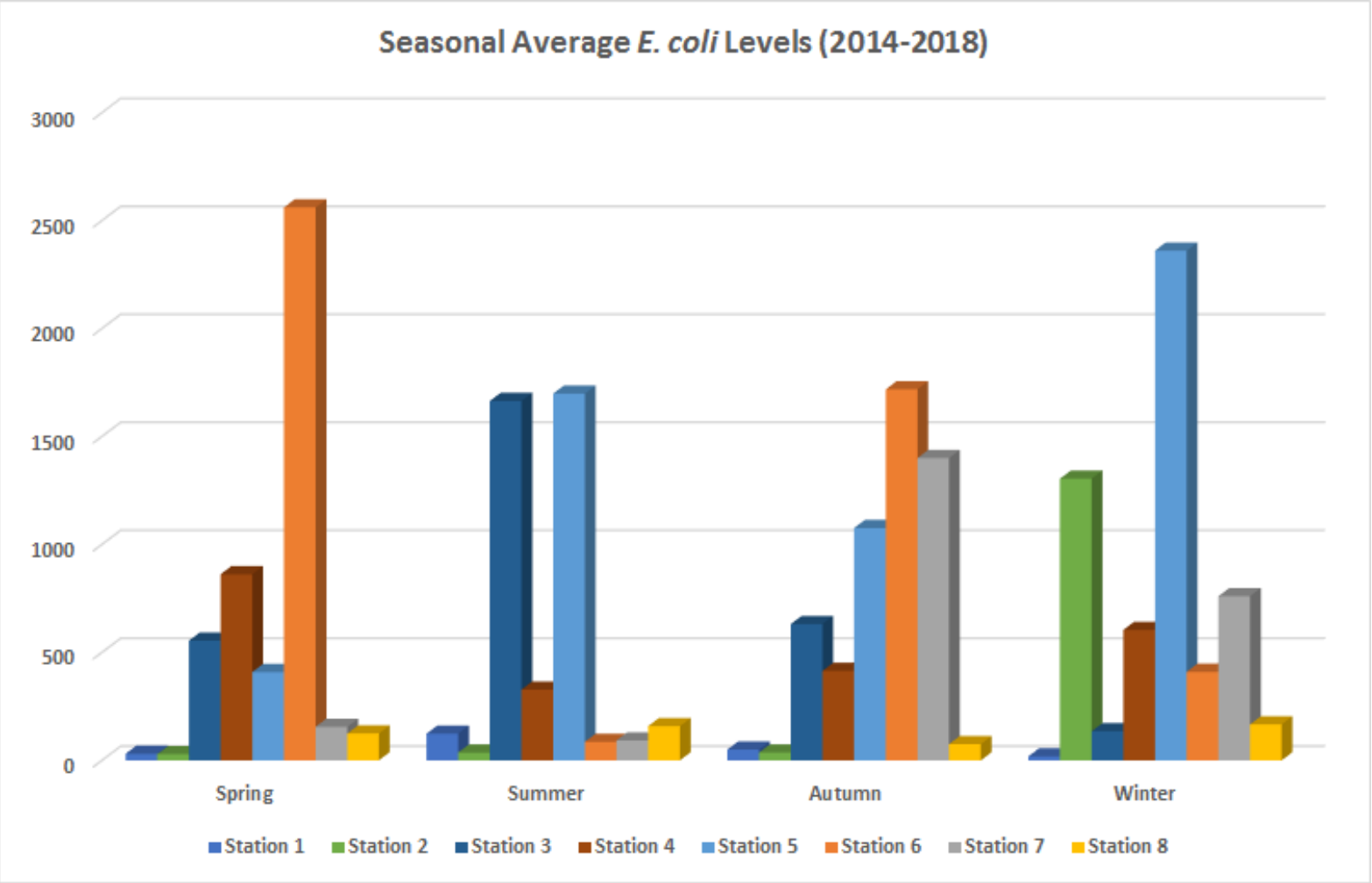



**Figure 5.2: Averaged seasonal *E. coli* levels from 2014 to 2018 (Source: AQUAFACT).**

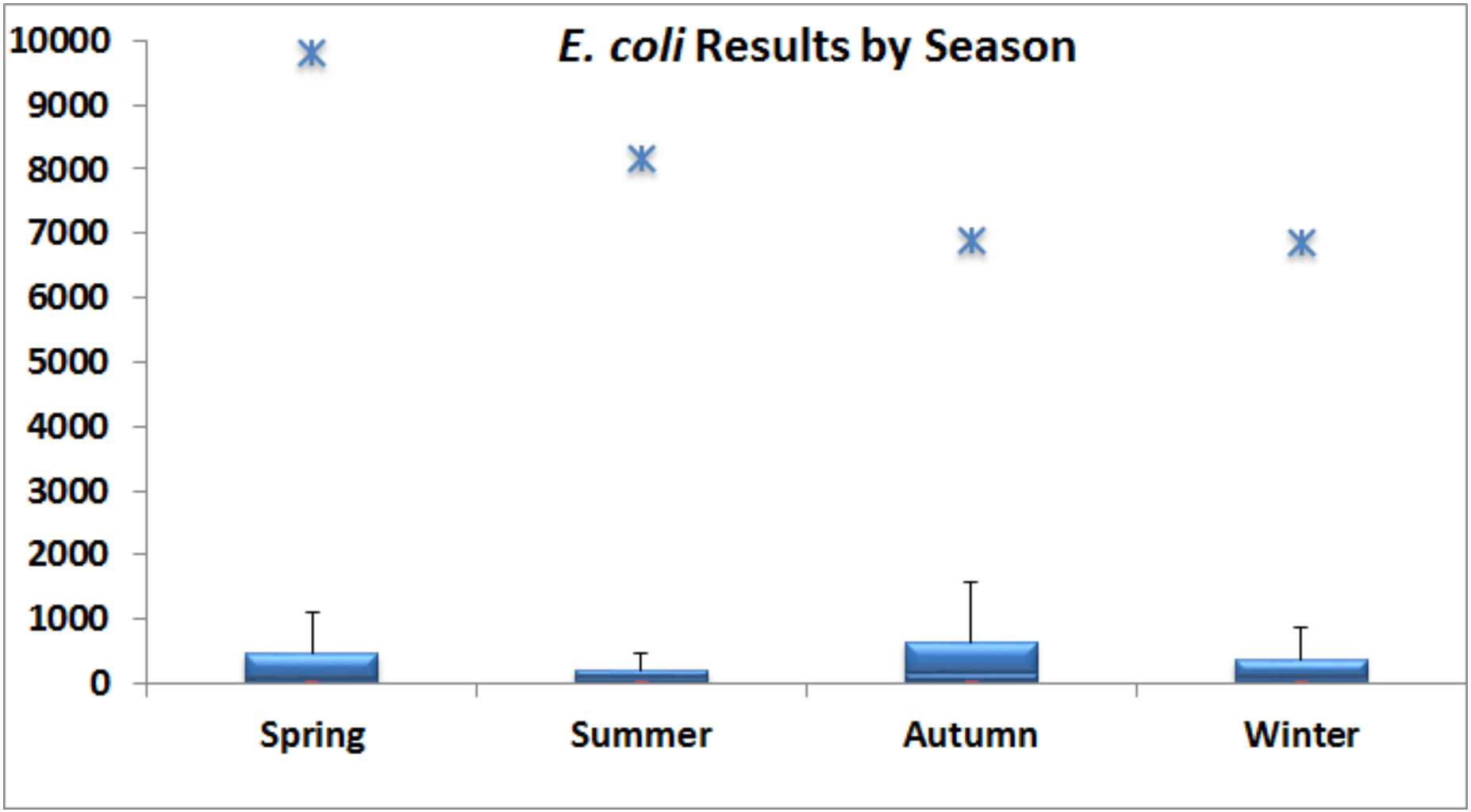



**Figure 5.3: Boxplot of *E. coli* results by season.**

### 5.1.2. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and the subsequent implementing regulation (EU) 2017/627 the Sea Fishery Protection Authority is required to classify bivalve mollusc production areas and to fix the boundaries thereof. The process involves regular sampling of shellfish from each area to be classified in order to establish levels of microbiological contamination which subsequently determines which classification should be awarded for that particular area. The Sea Fishery Protection Authority currently sample shellfish flesh at one location in the Sligo Harbour production area for classification purposes. Figure 5.4 shows this location of this sampling site Table 5.3 shows the coordinates. The Sea Fishery Protection Authority monitored clams in Sligo Harbour up until January 2015, after which point clams were declassified in Sligo Harbour due in part to disease and mortality issues and a lack of current production. The location of the clam monitoring site can also be seen in Figure 5.4 and the coordinate is shown in Table 5.3. Clams may be reclassified in the future.

**Table 5.3: Coordinates of sampling sites within the Sligo Harbour Production Area.**

| Sample Code | Species | Latitude | Longitude |
|---|---|---|---|
| SO-SH-SH | Pacific Oysters | 54.293461 | -8.534783 |
| SO-SH-SH | Clams | 54.291667 | -8.5219445 |

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. Table 5.4 summarises this system. Table 5.5 shows the current and historical (back to 2014) classifications within Sligo Harbour. For the 2018-2019 period, Sligo Harbour is classified as B for Oysters.

**Table 5.4: Classification system for shellfish harvesting areas.**

| Classification | | | Permitted Levels | Outcome |
|---|---|---|---|---|
| | A | ≤230 | Not exceeding 230 *E. coli* per 100 g flesh and intravalvular liquid in 80% of the samples in the review period | May go direct for human consumption if end product standard met. |
| | B | ≤4600 | not exceeding 4600 E. coli per 100 g flesh and intravalvular liquid in 90% of the samples | Must be subject to purification, relaying in Class A area (to meet Category A requirements) or cooked by an approved method. |
| | C | ≤46000 | Less than 46,000 *E.coli*100g flesh Not exceeding 46,000 E. coli per 100 g of flesh and intravalvular liquid | 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 |

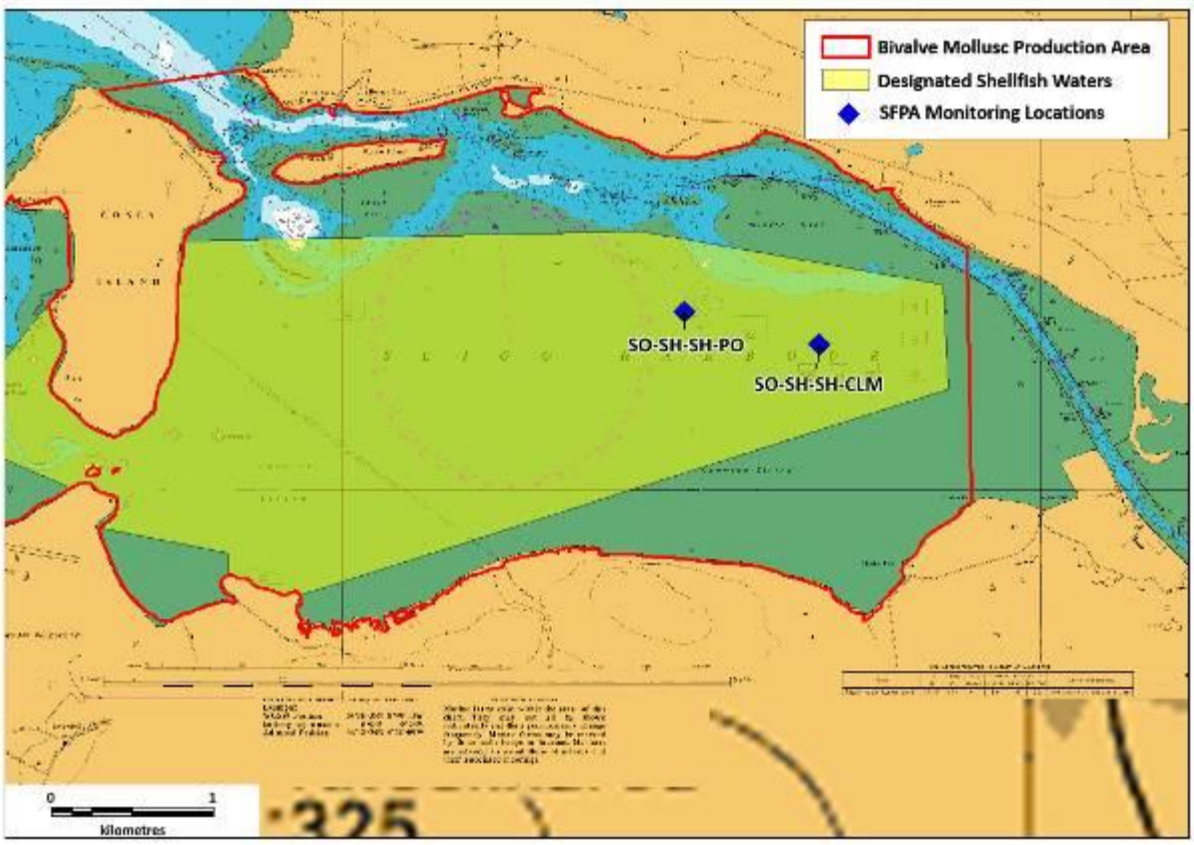



**Figure 5.4: Locations of SFPA shellfish monitoring points for classification purposes.**

**Table 5.5: Current and historical classification of shellfish beds in Sligo Harbour (2014 – 2019).**

| Boundaries | Bed Name | Species | Classification | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Deadman's Point to Killaspug Point | All Beds | Oysters | B | B | B | A** | B | B |
| | | Clams | B | B | B* | N/A | N/A | N/A |

* Dormant Fishery. Contact SFPA if re-activating.

**Seasonal A 01 July- 01 Feb drops to Class B at other times.

Tables 5.6 and 5.7 list the *E. coli* results for oysters and clams from Sligo Harbour from 2014 to January 2019 (where available). Figures 5.5 and 5.6 show these data in graphical form.

As shown in Table 5.5 above, Sligo Harbour has had a **B** classification for Clams from 2014 to 2016, in 2016 the fishery was declared dormant and has not been sampled since. The monthly classification trends for clams can be seen in Table 5.6 and Figure 5.5. Sligo Harbour oysters had a seasonal **A** classification in 2017 from 01 July to 01 February, for all other years between 2014 and 2018 it had a **B** classification. The monthly classification trends for oysters can be seen in Table 5.7 and Figure 5.6.

Table 5.8 shows the summary statistics for the *E. coli* historical data from the 2 shellfish monitoring sites from 2014 to January 2019. The geometric mean of *E. coli* levels was highest for Clams, however, Clams were only monitored from January 2014 to January 2015. Table 5.9 shows the variations of the annual geometric means of *E. coli* for the shellfish beds that had at least 5 samples per year from the year 2014. Figure 5.7 shows the trend in geometric mean from 2014 to 2018 for both species in Sligo Harbour. The geometric mean for oysters ranged from 29.1 MPN/100ml in 2018 to 61.8 MPN/100ml in 2014. The geometric mean for clams could only be calculated for 2014 due to insufficient data and was 194.8 MPN/100ml.

There was no statistical difference between the oyster *E. coli* results and season (one-way ANOVA, p = 0.9215, Appendix 2).

**Table 5.6: *E. coli* results from Sligo Harbour Clams from 2014 to January 2015 (Source: SFPA).**

| Date | MPN *E. coli* /100g | Category |
|---|---|---|
| 13-Jan-14 | 1100 | B |
| 27-Aug-14 | 130 | A |
| 29-Oct-14 | 330 | B |
| 24-Nov-14 | 330 | B |
| 4-Dec-14 | 18 | A |
| 22-Jan-15 | 490 | B |

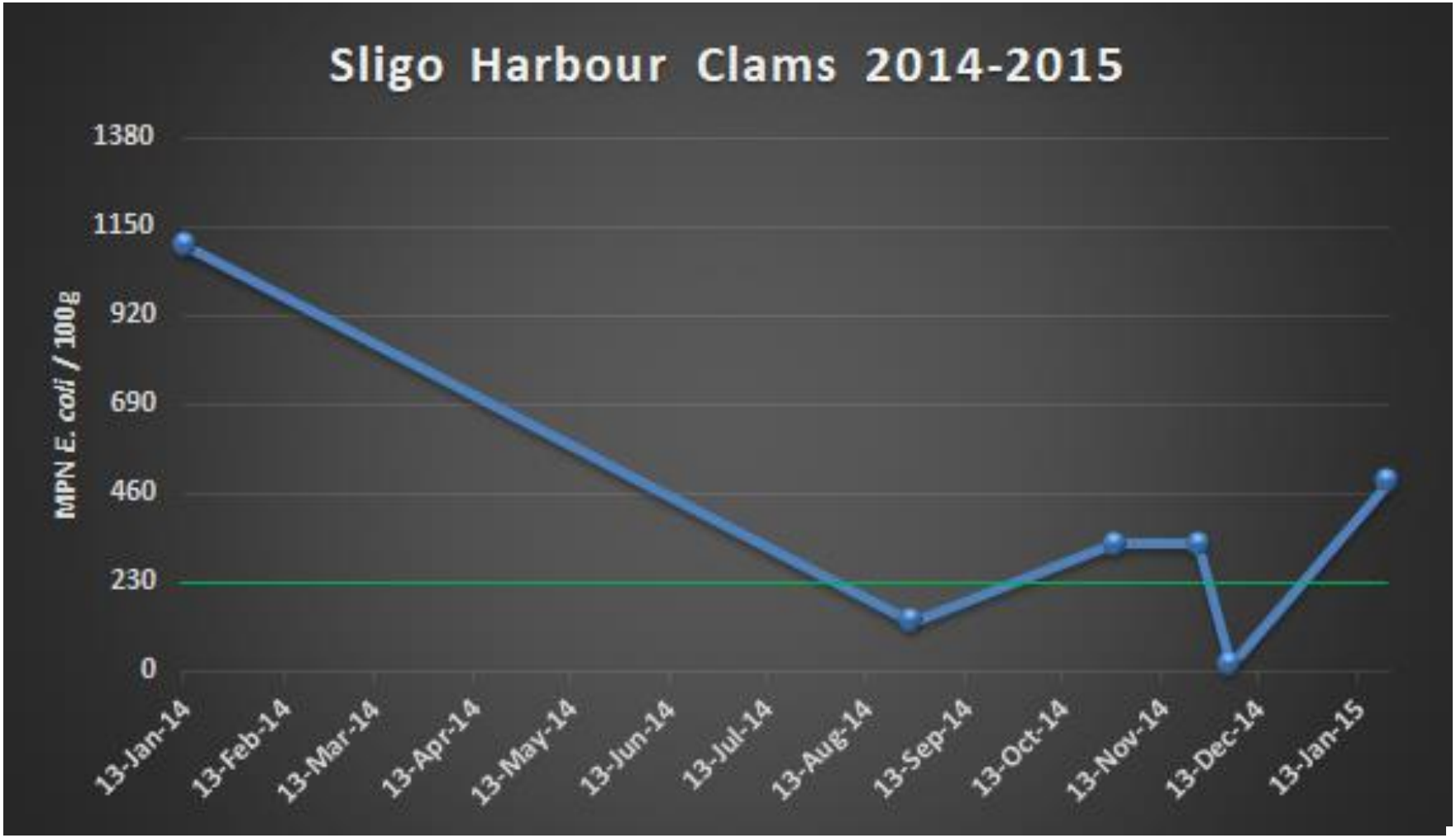



**Figure 5.5: *E*. coli results from Clams at Sligo Harbour from 2014 to January 2015 (Source: SFPA).**

**Table 5.7: *E. coli* results from Sligo Harbour oysters from 2014 to January 2019 (Source: SFPA).**

| Date | MPN *E. coli* /100g | Category | Date | MPN *E. coli* /100g | Category |
|---|---|---|---|---|---|
| 13-Jan-14 | 50 | A | 13-Sep-16 | 45 | A |
| 20-Feb-14 | 50 | A | 27-Oct-16 | 18 | A |
| 29-Apr-14 | 20 | A | 14-Nov-16 | 130 | A |
| 27-May-14 | 170 | A | 19-Dec-16 | 110 | A |
| 30-Jun-14 | 20 | A | 9-Jan-17 | 78 | A |
| 27-Aug-14 | 68 | A | 27-Feb-17 | 18 | A |
| 29-Oct-14 | 110 | A | 14-Mar-17 | 78 | A |
| 24-Nov-14 | 45 | A | 19-Apr-17 | 18 | A |
| 4-Dec-14 | 230 | A | 8-May-17 | 40 | A |
| 22-Jan-15 | 20 | A | 24-Jul-17 | 460 | B |
| 25-Feb-15 | 18 | A | 16-Aug-17 | 40 | A |
| 19-Mar-15 | 490 | B | 18-Sep-17 | 78 | A |
| 29-Apr-15 | 18 | A | 5-Oct-17 | 18 | A |
| 20-May-15 | 1700 | B | 6-Nov-17 | 78 | A |
| 30-Jun-15 | 18 | A | 4-Dec-17 | 490 | B |
| 23-Jul-15 | 20 | A | 14-Dec-17 | 20 | A |
| 20-Aug-15 | 20 | A | 15-Jan-18 | 18 | A |
| 28-Sep-15 | 130 | A | 19-Feb-18 | 45 | A |
| 21-Oct-15 | 20 | A | 27-Mar-18 | 20 | A |
| 24-Nov-15 | 45 | A | 15-Apr-18 | 18 | A |
| 14-Dec-15 | 78 | A | 28-May-18 | 40 | A |
| 20-Jan-16 | 18 | A | 26-Jun-18 | 18 | A |
| 23-Feb-16 | 45 | A | 18-Jul-18 | 18 | A |
| 10-Mar-16 | 18 | A | 14-Aug-18 | 18 | A |
| 18-Apr-16 | 78 | A | 23-Sep-18 | 45 | A |
| 9-May-16 | 20 | A | 8-Oct-18 | 20 | A |
| 14-Jun-16 | 130 | A | 26-Nov-18 | 78 | A |
| 4-Jul-16 | 230 | A | 10-Dec-18 | 78 | A |
| 9-Aug-16 | 18 | A | 7-Jan-19 | 18 | A |

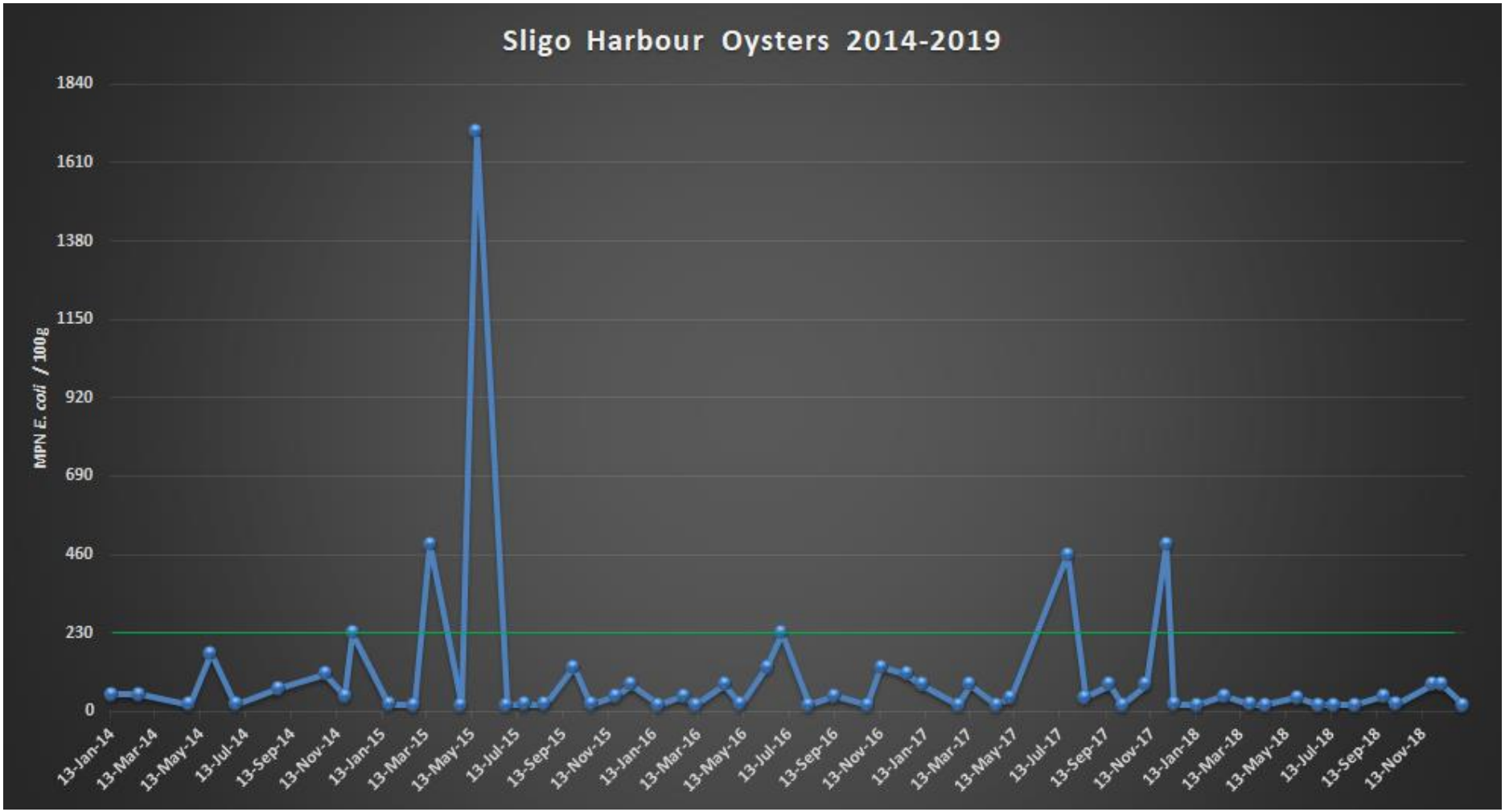



**Figure 5.6: *E. coli* levels from oysters at Sligo Harbour from 2014 to 2019 (Source: SFPA).**

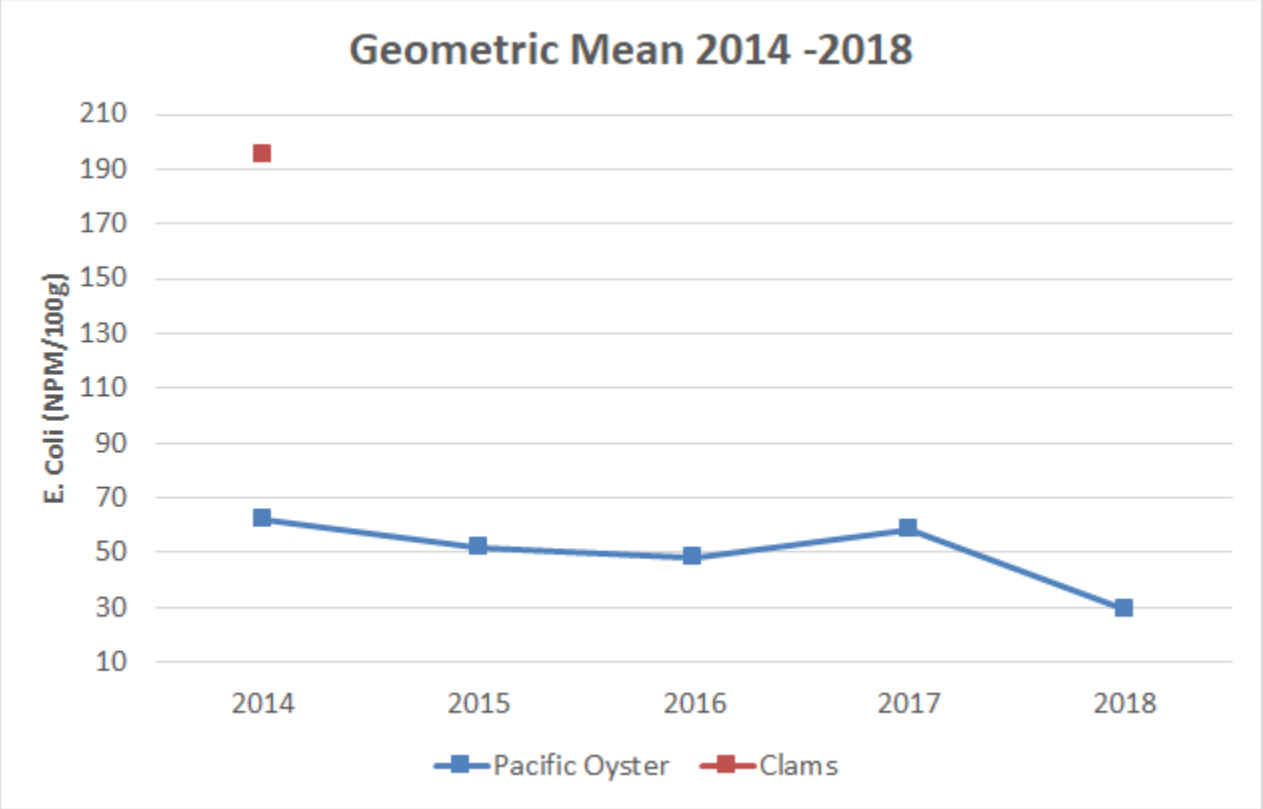



**Figure 5.7: Trend in geometric mean of *E. coli* levels from 2014 to 2018 for all both species in Sligo Harbour.**

**Table 5.8: Summary statistics of historical *E. coli* data monitored from shellfish beds in Sligo Harbour.**

| Code | 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) |
|---|---|---|---|---|---|---|---|
| SO-SH-SH-PO | Pacific Oyster | 13/01/2014 | 07/01/2019 | 18 | 1700 | 42.5 | 46.7 |
| SO-SH-SH | Clams | 13/01/2014 | 22/01/2015 | 18 | 1100 | 330 | 227.1 |

**Table 5.9: Variation of annual geometric means of *E. coli* (MPN/100g) from shellfish beds monitored in Sligo Harbour.**

| Code | Species | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| SO-SH-SH-PO | Pacific Oyster | 61.8 | 51.6 | 47.8 | 58.3 | 29.1 |
| SO-SH-SH | Clams | 194.8 | | | | |

In addition to *E. coli* monitoring carried out by SFPA, the Marine Institute (MI) conducts monthly 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. The MI also monitors shellfish flesh for chemical contaminants *e.g.* heavy metals, organochlorides, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), pentachlorophenol (PCP) and Tributyl Tin Oxide (TBTO).

Over the period 2014 to 2018, there have been 6 biotoxin related closures. There have been no closures since May 2015 for Pacific Oysters.

### 5.1.3. Norovirus (NoV)

**Norovirus contamination – Sligo Harbour classified production area**

Oysters from Sligo Harbour have been tested by the Marine Institute using the ISO standard method, ISO 15216-1:2017[1] for norovirus[2] since November 2015 during the high risk winter months (October to April). This sampling has been conducted by the Producers in the area as part of a number of research projects. The samples have been collected from two separate locations within the harbour SH1 and SH2.

#### a) SH1

Samples have been collected for norovirus testing from this part of the classified production area since November 2015. However, regular sampling has occurred since December 2017 until April 2020 (n = 49) which provides a repeated assessment of the rate of norovirus contamination in the area over three consecutive winter periods. Having norovirus data for three consecutive winters provides a very robust data set for understanding the rate of norovirus contamination in a production area. Table 5.10 outlines the geometric mean norovirus concentrations observed for the months of October through to April over the winters 2017/18, 2018/19 and 2019/20.

**Table 5.10: Norovirus prevalence and concentrations in SH1 during winter months (2017 – 2020)**

| Details | Observation |
|---|---|
| Total number of samples | 49 |
| % Positive samples | 95.9% |
| % samples >1000 copies/g | 40.8% |
| Geometric mean conc. | 580 copies/g |
| Minimum conc. | Not detected |
| Maximum conc. | 13048 copies/g |

#### b) SH2

Samples have been collected from this part of the classified production area on a much less frequent basis compared to SH1. Samples (n = 10) have been collected between the period of December 2019 until March 2020. Table 5.11 outlines the prevalence and concentrations of norovirus in SH2 for this time period.

**Table 5.11: Norovirus prevalence and concentrations observed in SH2 between December 2019 and March 2020**

[1] ISO 15216-1:2017 Microbiology of the food chain – Horizontal method for determination of hepatitis A virus and norovirus using real-time RT-PCR – Part 1: Method for quantification

[2] Norovirus refers to total norovirus i.e. the combined total of genogroups I and II. The LOQ for both test methods is 100 copies/g; where a test result of <LOQ is obtained the value is substituted by half the LOQ (50 copies/g) before combining both test results.

| | SH2 |
|---|---|
| No of samples (n) | 10 |
| % Positive | 100.0 |
| Geometric mean conc. | 1889 |
| Min conc. | 662 |
| Max conc. | 5041 |

**Summary**

The norovirus testing undertaken in the Sligo Harbour production area demonstrates a high prevalence of norovirus in the production areas during the winter months (October to April). Regular and continual testing over three separate winter periods confirms consistent contamination at site SH1. Testing undertaken at site SH2 also indicates that this part of the production is also at high risk of norovirus contamination, although there is significantly less data compared to SH1. In general, the norovirus testing from the Sligo Harbour production area indicates that the production area is generally at high risk of norovirus contamination.

## *5.2. Current Data*

### 5.2.1. Sampling Sites & Methodology

Nine water sampling sites were sampled within the Sligo Harbour BMCPA between November 2018 and February 2019. The locations of these sites can be seen in Figure 5.8 and Table 5.12 shows the station coordinates.

Two stations were sampled on the 20th November 2018 (Stations 1, 2), there was no rain on the previous day. Three stations were sampled on the 21st November 2018 (Stations 3-5). There was 20.1 mm of rain over the two previous days. One station was sampled on the 4th January 2019 (Stations 6). There was 0.5mm of rain over the two previous days. Two station was sampled on the 10th January 2019 (Stations 7, 8). There was 2.4mm of rain over the two previous days. One station was sampled on the 5th February 2019 (Stations 9). There was 0.5mm of rain on the two previous days. Of the 9 water samples collected, 8 were taken from river/stream outflows (Stations 2-9) and 1 was from a drainage ditch (Station 1).

In addition, a bacteriological survey for shellfish flesh was carried out over a three month period (Feb-April 2020). Three locations were sampled which were located within pacific oyster harvesting areas. This survey was carried out to aid in the selection of the most appropriate RMP location for oysters. The locations of these sites can be seen in Figure 5.8 and Table 5.13 shows the station coordinates.

All stations were sampled on the 26th February, 16th of March and 7th of April 2020. Rainfall for the previous 48 hours was 23.5mm on the 26th of February, 10.6mm on the 16th of March and 5.7mm on the 7th of April.

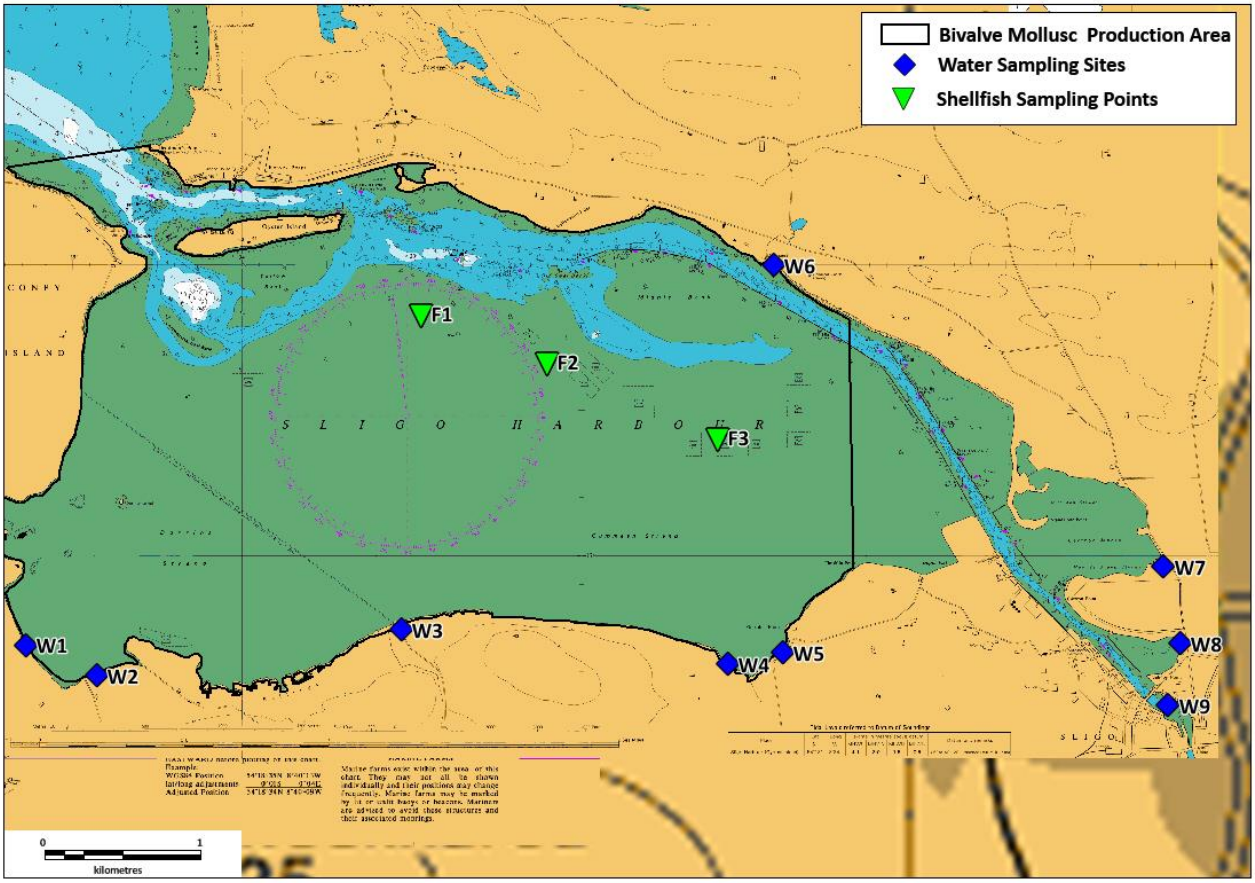



**Figure 5.8: Water and Shellfish sampling sites.**

**Table 5.12: Water sample coordinates with date of sampling.**

| Station | Feature | Latitude | Longitude | Easting | Northing | Sampling Date |
|---|---|---|---|---|---|---|
| W1 | Drainage ditch | 54.2784 | -8.58877 | 161698.2 | 336779.4 | 20/11/2018 |
| W2 | Small stream | 54.27667 | -8.58175 | 162153.6 | 336582.7 | 20/11/2018 |
| W3 | Small stream | 54.2793 | -8.55187 | 164102.6 | 336860.1 | 21/11/2018 |
| W4 | Stream/small river | 54.2773 | -8.51975 | 166193 | 336621.6 | 21/11/2018 |
| W5 | Stream | 54.27798 | -8.51432 | 166547.4 | 336695.1 | 21/11/2018 |
| W6 | Small river | 54.30027 | -8.51525 | 166504.8 | 339176 | 04/01/2019 |
| W7 | Doonally stream | 54.2829 | -8.47693 | 168986.3 | 337225.3 | 10/01/2019 |
| W8 | Copper River | 54.2785 | -8.47527 | 169091.6 | 336734.8 | 10/01/2019 |
| W9 | Garavogue River | 54.27492 | -8.47647 | 169010.7 | 336336.5 | 05/02/2019 |

**Table 5.13: Shellfish sample coordinates with date of sampling.**

| Station | Feature | Latitude | Longitude | Easting | Northing | Sampling Date |
|---|---|---|---|---|---|---|
| F1 | Oyster trestle | 54.29746 | -8.54995 | 164243.2 | 338880.6 | 26 Feb, 16th March & 7th April 2020 |
| F2 | Oyster trestle | 54.29469 | -8.53758 | 165046.3 | 338566.1 | 26 Feb, 16th March & 7th April 2020 |
| F3 | Oyster trestle | 54.29034 | -8.52081 | 166134.6 | 338073.7 | 26 Feb, 16th March & 7th April 2020 |

All water samples were collected in sterile plastic water bottles. These samples were delivered at chilled temperatures to Aqualab, Killybegs, County Donegal within 24 hours of collection. AQUALAB is INAB accredited.

### 5.2.2. Microbial Analysis Results

Table 5.14 shows the water sample analysis results and Figure 5.9 shows the location and magnitude of the results. Highest *E. coli* levels were recorded from an unnamed river on the northern shore (Station 6; 1,700 cfu/100ml), followed by an unnamed stream on the southern shore (Station 5; 1,300 cfu/100ml). The next two highest *E. coli* results were recorded at Stations 7 (870 cfu/100ml) and 8 (850 cfu/100ml) from the Doonally Stream and Copper River respectively, both located opposite Sligo port area. The station from the Garavogue River had a value of 220 cfu/100ml (Station 9). The lowest *E. coli* levels came from a drainage ditch (Station 1, 4 cfu/100ml) in the southwestern corner of the harbour and from a small stream (Station 4, 64 cfu/100ml) on the southeastern corner of the site.

**Table 5.14: Water *E. coli* results for Sligo Harbour.**

| Station No. | *E. coli* (cfu/ 100ml) |
|---|---|
| 1 | 4 |
| 2 | 410 |
| 3 | 64 |
| 4 | 160 |
| 5 | 1300 |
| 6 | 1700 |
| 7 | 870 |
| 8 | 850 |
| 9 | 220 |

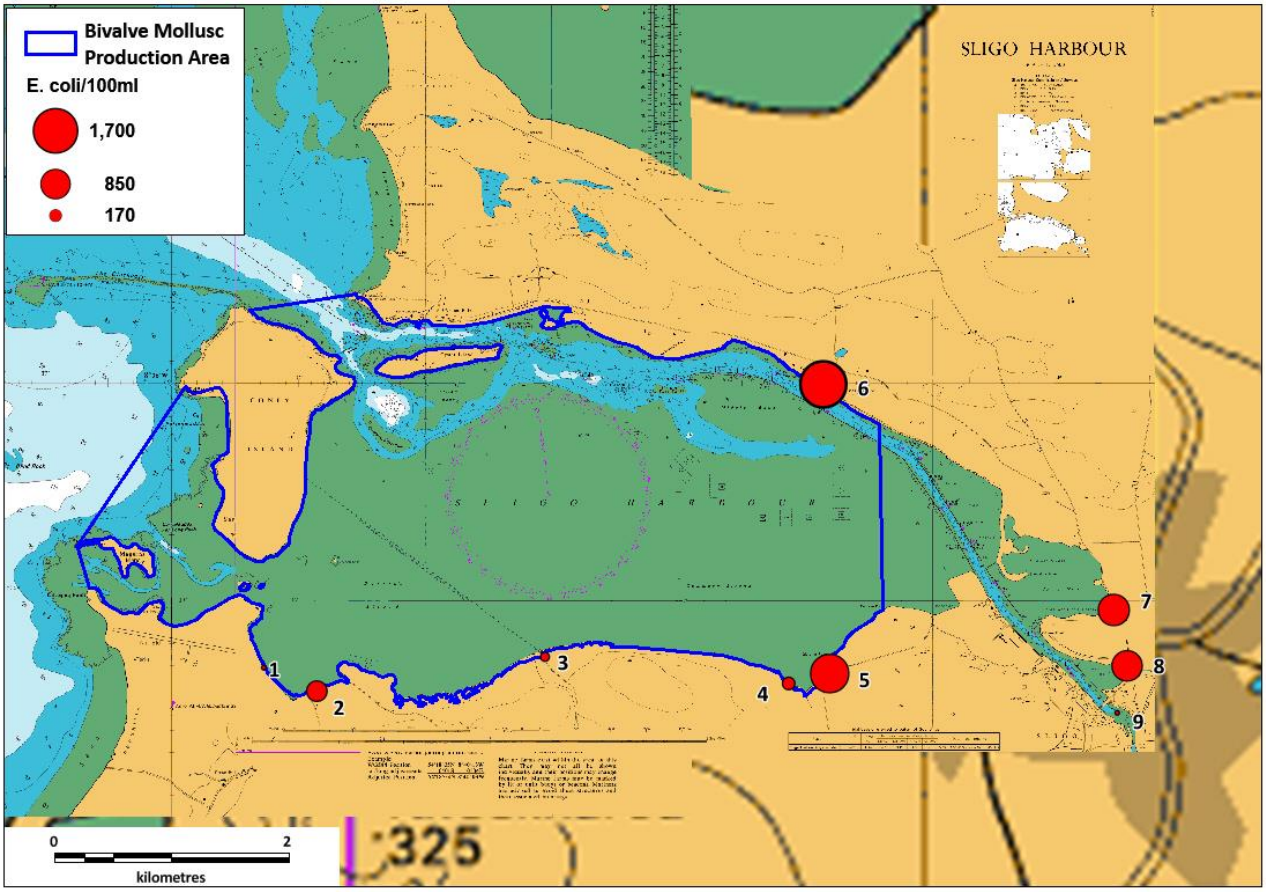



**Figure 5.9: *E. coli* levels recorded during the Sligo Harbour shore survey.**

Table 5.15 shows the results of the three month shellfish monitoring survey and Figure 5.10 gives a graphical representation of the data. Results ranged from <18 MPN/100g in April at F3 to 790 MPN/100g in March at F3. The location with the highest average result over the three month period was F3. Figure 5.10 also shows the relationship between rainfall and *E. coli* concentrations.

**Table 5.15: Shellfish flesh *E. coli* results (MPN/100g) for Sligo Harbour.**

| Date /Location | F1 | F2 | F3 |
|---|---|---|---|
| **26th Feb** | 230 | 490 | 330 |
| **16th Mar** | 330 | 78 | 790 |
| **7th Apr** | 20 | 40 | <18 |
| **Average** | 193.3 | 202.7 | 379.3 |

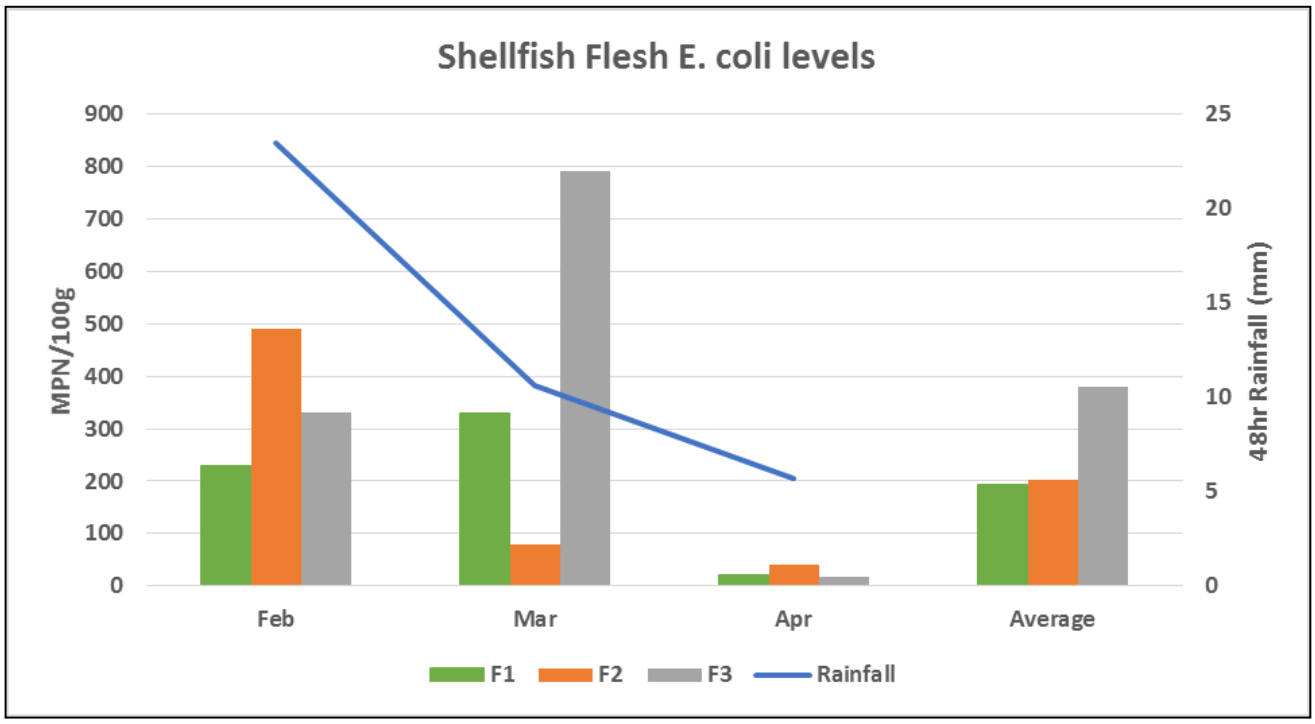



**Figure 5.10: Shellfish flesh *E. coli* results for Sligo Harbour with previous 48 hour rainfall levels.**

# 6. Overall Assessment of the Effect of Contamination on Shellfish

## *6.1. Human sewage/Human population*

The area in the vicinity of Sligo Harbour has relatively high population concentrations with Sligo Town and its hinterland having a population of *ca* 17,000. Other towns/villages in the catchment include Manorhamilton, Rosses Point, Strandhill and Dromahair. The total population of the entire catchment area of Sligo Harbour is just over 41,000. This population concentration is evidenced by the number of WwTPs in the catchment, seven in total with three discharging directly into the production area itself.

Four of these WwTPs (Ballintogher, Killarga, Dromahair and Manorhamilton) discharge into rivers much higher in the catchment and there impacts will be diluted to a large extent by the receiving waters having to pass through the large water body of Lough Gill before finally reaching the production area adjacent Sligo Town. It is anticipated though that they will add to the background contaminant levels already reaching the production area through the Garavaogue River.

Strandhill WwTP discharges to the open ocean adjacent the production area. This discharge point, including a storm water overflow facility is located to the west of the actual treatment works in an area of open sea and it is expected that waste water from here will be well diluted and dispersed. If any contamination was to enter the production area from this discharge it would likely be contained within the south western extent of

the bay. The tidal road that allows access to Coney Island at low water would act as a barrier preventing significant mixing of water either side of this road. Therefore, the only shellfish beds that are likely to be impacted are the two smaller ones located to the south west of the road. Contamination could only enter from this source on flooding tides and the high salinity of the receiving water will also limit the level of contamination from this source.

The Rosses Point WwTP is currently over capacity and offers only primary treatment and discharges directly into the production area. During the shoreline survey the discharge pipe from the treatment works was found to be broken and was discharging sewage waste upon the foreshore. The site is located to the north of the main pacific oyster growing area, directly opposite but separated by the main navigation channel, and may impact upon the shellfish due to its proximity and low treatment levels.

The Sligo Town WwTP also discharges directly to the harbour upstream of the actual production area boundaries at or near to the quay in Sligo Town. With a current population equivalent of 28,158 and a maximum daily discharge of 37,000 $m^3$ this is the biggest treatment works within the catchment and is likely the main impacting source of contamination levels in the harvesting area. This plant capacity is greater than the six other WwTPs in the catchment combined.

Sligo WwTP treats waste to tertiary level but this is negated due to the population equivalent, the potential maximum flow rates, the associated storm water overflows discharges and the proximity of the site to the shellfish beds. Discharge from the plant is to the inner harbour area is carried westward towards the harvesting area on the ebbing tidal stream.

In addition to the treatment works themselves, there are a number of stormwater overflows also discharging either directly into the production area or immediately upstream. There are three associated with the Rosses Point system, all located to the west of the treatment plant and along the northern shore of the production area. In addition there are six separate such overflows associated with the Sligo treatment works. It is expected that all of these overflows will affect contamination levels within the production area during or after periods of heavy rainfall.

Separately, there are 18 section 4 trade discharge licences and 9 industrial discharge licences within the catchment. Many of these carry no domestic effluent and discharge to either groundwater or the existing sewer network. A number though discharge to surface waters within the catchment and a smaller number again to surface waters adjacent the production area itself. Those licences belonging to Radisson Blu Hotel and Cregg House are discharging mixed trade and domestic effluent to surface waters adjacent the production area. The latter was identified as posing a risk to the shellfish waters due to insufficient assimilative capacity in the surface waters to which it discharged

The majority of households in the catchment are connected to the public sewer system, however, the 2009 pollution reduction program stated that there were 3,908 on-site waste water treatment systems within the catchment which is a density higher than the national average.

In terms of shipping there are 24 boating related infrastructural points within Sligo Harbour. Generally with the exception of the port of Sligo itself vessel traffic is low with most activity being confined to the summer months and that being primarily small leisure craft. The port itself, whilst a commercial port, tends to have low numbers of vessels arriving such as in 2017 where there were 9 commercial arrivals. No data are available regarding any discharges but the low vessel numbers would negate any significant impacts on water quality.

### *6.2. Agriculture*

Land use in the Sligo catchment, particularly in the upper parts away from the urban areas around Sligo Town, is largely agricultural. The lower lying areas are used for cattle production and the higher areas for sheep. An estimate was made of the amount of land in the catchment under agricultural use and it was calculated that 21, 462 ha were being utilised which amounts to 36% of the total area of the catchment.
In terms of animal numbers, sheep are most prevalent particularly in the northern part of the catchment which is on the whole more mountainous and more suitable for sheep; sheep were also recorded at Coney Island during the shoreline survey. Cattle numbers are higher in the better lands to the south and in the valleys between the mountains. The number of animals within the catchment is difficult to calculate in total as many of the electoral divisions overlap the catchment boundary but it is worth noting the figures none the less with 98,719 sheep and 27,349 cattle being recorded from the CSO 2019 figures. These are significant livestock numbers and contamination from them will find its way into the production area, primarily through the Garavogue River and to a lesser degree through the smaller streams and rivers.

### *6.3. Rivers and Streams*

The Garavogue River is the most significant freshwater input into the production area and is likely the main source of diffuse and point source contamination into the production area also. Sligo Harbour drains a catchment of 448 $km^2$ and 89% of this flows through this one river underlying its importance. The current WFD status of the Garavogue River is poor and sampling conducted during the shoreline survey gave a result of 220 cfu/100ml which is in itself not excessive but combined with a mean flow rate of 12.7 $m^3/s$ and highs up to 60 $m^3/s$ mean this will have a direct impact on contamination levels in the production area.

The Doonally and Copper Rivers are two smaller waters that enter the production area alongside the

Garavogue and during the shoreline survey showed moderate levels of contamination with results of 870 cfu/100m and 850 cfu/100ml respectively. Contamination from these two small rivers will combine with the main freshwater flow of the Garavogue when entering the production area through the main navigation channel.

An unnamed river that enters the production area on the northern shore and which is geographically nearest the shellfish beds showed the highest level of contamination from the survey with 1700 cfu/100 ml being recorded. It is unclear what is impacting contamination levels to this stream but there are two section 4 discharge licences nearby and the stream also runs through agricultural land. It is expected this river, albeit of low volume size, may impact contamination levels in proximity to the shellfish beds on the middle bank of the production area. A small stream near Gibraltar Point in the south eastern end of the production area showed elevated levels of faecal contamination. This runs through an urban area west of Sligo Town.

Almost all water courses sampled during the shoreline survey showed levels of faecal contamination ranging from moderate to high with the exception of two small streams to the south west of the production area where levels were low.

### *6.4. Movement of Contaminants*

The majority of the harbour is made up of intertidal sand and mudflats. A navigational channel runs north westerly from Sligo Town towards Oyster Island following the northern shore. It is this channel that is the main conduit for contamination from the upper catchment and Sligo Town to reach the shellfish beds.

RPS (2015) carried out a modelling study of Sligo Harbour in relation to a proposed navigational channel dredging plan. This showed that except for the area at the north western part of the harbour at Rosses Point, north of Coney Island and around Oyster Island where velocities were predicted to be in the region of 1 m sec, velocities in the remaining part of the harbour were less than 0.5 m sec. Admiralty Chart tidal streams indicated current speeds of up to 5 knots within the main navigational channel on both the flood and ebb tides.

The ebb tide flows in a north westerly direction along the main navigation channel with tidal flows in the southern half of the harbour lower in velocity due to the fact that much of it is very shallow. It is expected that the ebbing tide and the freshwater flush from the Garavagoe River will carry faecal contamination west wards and towards the shellfish beds located along the main navigational channel edge. This will include contamination from the Doonally and Copper Rivers as evidenced during the shoreline survey and more

importantly the Sligo Town Wwtp and it's associated stormwater overflows. The channel retaining wall that terminates near Ballincar may influence retention of this flow but beyond this, the channel widens and it is likely that the shellfish beds nearest this point will be impacted.

Contamination from the small stream near Gibraltar Point identified in the shoreline survey may also be brought towards the shellfish beds on the ebbing tide although due to the small size and volume it may simply add to background levels.

Based on sampling carried out as of the Sligo Main Drainage Project, turbidity levels within Sligo Harbour vary significantly depending on tidal conditions, the amount of freshwater entering the system and wave action. Levels were higher in the inner harbour and in the Cummeen Strand area. High turbidity levels and current velocities in the inner harbour where the Sligo main WwTP discharges may facilitate transport of larger amounts of faecal contamination into the shellfish harvesting area.

There is little data on retention or flushing times in Sligo Harbour although the modelling study carried out by Irish Hydrodata suggested a figure of 13 days; however, this is tempered by a lack of field data. This study suggests a much shorter flushing time of 24 hours although this is similarly constrained by a lack of field data. It is likely though that levels of contaminants from the ebb cycle will be re-introduced into the area of the shellfish beds on the flood tide. The Rosses Point WwTP located at Ballyweelin will likely impact contamination levels on the same beds on the flood tide as it flows in a south easterly direction towards them. This may also be the case for those stormwater discharges associated with the same WwTP. The small river at Ballyweelin which showed elevated levels of contamination during the shoreline survey may similarly influence contamination on the shellfish beds on the flooding tide.

The predominant wind direction in the production area is from the south west. Surface flows would be enhanced/retarded by winds blowing out or into the harbour particularly from this dominating south-westerly direction which may also lead to an increase in the dispersion of surface contaminants.

Work carried out by AQUAFACT on the Sligo Main Drainage project from 2014 to 2018 included the taking of water samples for *E.coli*, salinity and turbidity analysis at a number of stations throughout the production area. A pattern of contamination was evident with mean *E.coli* levels peaking in the inner harbour area and the north-eastern shoreline of the production area before declining rapidly towards the mouth of the bay at Rosses Point. It would appear that faecal contamination levels are heavily influenced within the inner harbour and Sligo Town area, remain significant along the north-eastern shoreline towards

Ballincar before becoming more dispersed and declining at the mouth of the outer bay. These data suggest that contamination levels decline in a linear fashion the further west water travels from the inner harbour area. A correlating pattern of decline in freshwater intrusion is evident from the same work with salinity at the inner harbour ranging from 0 – 17 PSU with that at Rosses Point varying between 25 to 32 PSU.

### *6.5. Wildlife*

With regard to birds, it has been noted above (Section 4.1.6) bird faeces are rich in faecal bacteria and have been shown to be a source of faecal contamination in the marine environment. Cummeen Strand SPA (Site Code: IE004035) is located within the Sligo Harbour area and stretches from Sligo Town westwards to Coney Island. At low tide, extensive sand and mud flats are exposed. Cummeen Strand supports important concentrations of wintering waterfowl, including an internationally important Light-bellied Brent Goose flock (223) and nationally important populations of Oystercatcher (680) and Redshank (408) (NPWS, 2014). Other species occurring include Shelduck (86), Wigeon (149), Teal (54), Mallard (145), Red breasted Merganser (15), Golden Plover (428), Lapwing (695), Knot (165), Sanderling (14), Dunlin (539), Bar-tailed Godwit (85), Curlew (430), Greenshank (13) and Turnstone (62) (NPWS, 2014). Golden Plover and Bar-tailed Godwit are regularly present, which is of particular note as these species are listed on Annex I of the E.U. Birds Directive. As the distribution of these bird species all overlap with production sites, they therefore have the potential to add to background contamination levels.

Seabird droppings are typically far more liquid in character than solid in consistency and at low water, droppings from the birds will fall on to the exposed sea bed. Ultraviolet light from the sun will eradicate much of the coliform bacteria in the faeces and when the tide returns, the faeces will dilute and disperse in the water column. The large number of Brent geese that visit the site though may have an impact on background contamination levels but it is particularly difficult to accurately predict the levels and distribution of this contamination.

A haul out site in nearby Drumcliff and Ballisodare (outside of the production area) is used by both harbour and grey seas but marine mammal numbers are relatively low in Sligo Harbour and none were identified during the shoreline survey, it is considered unlikely that they are significant source of microbial pollution to shellfish being cultured within Sligo production area.

### *6.6. Seasonality*

Tourism infrastructure in the immediate vicinity of the production area is centred around Rosses Point, Sligo

Town and to a lesser degree Strandhill and it would be anticipated that there would be a slight rise in population levels during the busy tourism months of July, August and September. Numbers of holiday homes though in the catchment are relatively low.

In terms of agriculture, numbers of sheep would be expected to be higher in Spring/Summer when lambs would be present but at this time of the year there will also be more extensive grazing in the hills and thus impacts would be more widely spread.

There will also be a distinct seasonal flux in numbers of wintering wildfowl during the autumn/winter period. This was noted during the shoreline survey when large conglomerations of mixed bird species were noted in the Cummeen Strand area and the inner harbour areas. Impacts from these birds will be most apparent where they graze nearby the shellfish beds adjoining the main channel but will otherwise add to background contamination levels.

To be expected, the analysis of rainfall data shows a clear seasonal trend between the drier summer months and the wetter autumn/winter however as can be seen from the data, extreme rainfall events leading to episodes of high run-off can occur in most months of the year and it is therefore not just the winter months that are at risk of increased contamination.

Analysis of the historical microbiological shellfish for both clam and pacific oyster data showed no clear seasonal trends in terms of higher results. Similarly analysis of *E.coli* i water sampling carried out as part of the Sligo Main Drainage project showed no clear seasonal pattern emerging in results with high maximum results during each season appearing to be isolated events.

### *6.7. Shoreline survey*

The SFPA carried out a survey of the shoreline of Sligo Harbour to document any outfalls *etc.* that could give rise to pollution entering the sea. In total, 65 features were identified. Figure 3.22 (above) shows the locations of these features noted during the survey. Of these 65 features, 16 were rivers/streams, 19 were drains, 3 were WWTPs, 1 was a discharge from a WwTP, 15 were discharge pipes and 4 were manholes. Figures 4.23 to 4.39 (above) show aerial imagery of the location of each of the features and Figures 3.40 to 3.44 (above) show images of most of these features. Table 3.14 (see above) details all features identified and the numbering used is cross-referenced to Figures 3.22 to 3.44 (see above). The survey also recorded four sightings of flocks of birds and species included geese, waders and gulls. One flock of sheep was also noted.

Of all of these features, the discharge pipes from the waste water treatment plants (Nos 1, 53 and 26 on Fig.3.22 above) are regarded as the most significant single structures that could impact on sea water quality.

However, as the Strandhill discharge pipe opens out into the open sea to the west of Sligo Harbour, it is expected to be well diluted and dispersed. Any possible contamination from this source could only enter the production area on a flooding tide and is further restricted to the south western extent of the harbour due to the high ground which acts as a tidal road connecting the mainland to Coney Island. Therefore, the only shellfish beds that could be impacted by Strandhill WwTP are the two beds located to the south west of the Bay. The potential impact on these beds is reduced due to contamination entering only on flooding tides and the high salinity of the discharge receiving water.

The effluent pipe discharging into Sligo Harbour from the Sligo treatment plant (No. 26, Fig. 3.22 above) opens into the sea near the harbour at Finisklin while the effluent pipe from the Rosses Point treatment plant (No. 53, Fig.3.22 above) discharges to the sea in the townland of Ballyweelin.

A number of pipes were observed within the confines of the docks and Sligo Town area. It was not possible to firmly identify the origin of all of these as most were not flowing at the time of the survey but it would seem probable that most were rainfall related discharges. One discharge pipe at the rear of the Cartron area appeared to be sewage related.

Sampling of water courses during the shoreline survey indicated generally moderate to high levels of contamination with the exception of those smaller watercourses entering the south west of the production area. Faecal contamination was predominantly higher in those water courses draining through urban areas around Sligo Town. The small river at Ballyweelin bucked this trend and gave the highest count of the survey.

Observations of wildlife were limited to birds with high numbers present particularly in the Cummeen Strand area of the harbour.

### *6.8. Pacific Oysters*

There are nine separate licensed areas for pacific oyster cultivation within the production area but not all are currently being utilised. During the shoreline survey, there was no stock on the site at Rinn in the southern western section of the production area.

Oyster flesh was tested once monthly from February to April for *E coli* levels at three locations (See section 5.2.2). The survey concluded that on average the location with the highest *E. coli* results was the most easterly of the three locations. Therefore, the original RMP has been relocated to this location as it is the oyster bed which is likely to have the highest level of contamination. (See figure 7.1 below).

# 7. RMPS and Sampling Plan

## *7.1.* Pacific Oysters (*Crassostrea gigas)*

The location of the new RMP for oysters is 54.29066, -8.521002 (166,122.4E, 338,109.3N) and is shown in Figure 7.2. Samples should be taken from trestles at the sampling location and sampling will be on a monthly basis. Samples should be taken from this point or no more than 100 metres maximum from it.

10 individuals of market size (minimum shell length 8 cms) should be collected for bacteriological analysis.

**Table 7.1: Coordinates of the Production Area.**

| Corner | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|
| NW | -8.576697 | 54.307046 | 162,510.4 | 339,961.6 |
| NW | -8.590588 | 54.305816 | 161,605.1 | 339,832.1 |
| NW | -8.599180 | 54.299941 | 161,040.2 | 339,182.9 |
| SW | -8.613393 | 54.287656 | 160,103.0 | 337,823.4 |
| SW | -8.613307 | 54.287467 | 160,108.4 | 337,802.3 |
| SW | -8.611677 | 54.284402 | 160,211.6 | 337,460.2 |
| SE | -8.507376 | 54.282810 | 167,003.4 | 337,229.1 |
| NE | -8.507750 | 54.297046 | 166,990.5 | 338,813.9 |

**Table 7.2: Coordinates of each RMP and its relevant species.**

| RMP | Site Code | Species | Longitude | Latitude | Easting | Northing |
|---|---|---|---|---|---|---|
| RMP 1 | SO-SH-SH | Pacific Oyster | -8.521002 | 54.29066 | 166,122.4 | 338,109.3 |

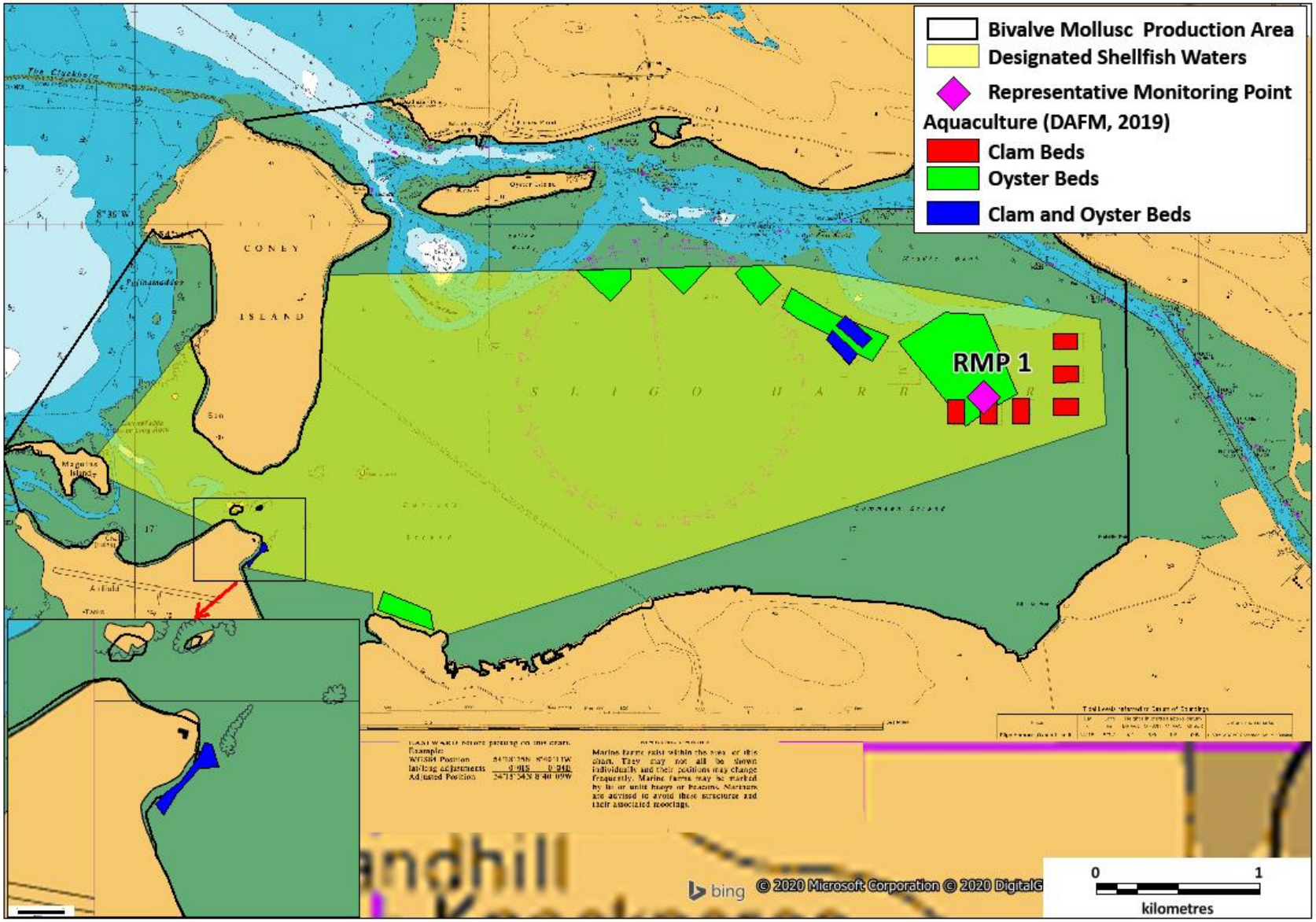



**Figure 7.1: Bivalve Mollusc Classified Production Area and Designated Shellfish Waters within Sligo Harbour.**

## *7.2. Species Specific RMP maps*

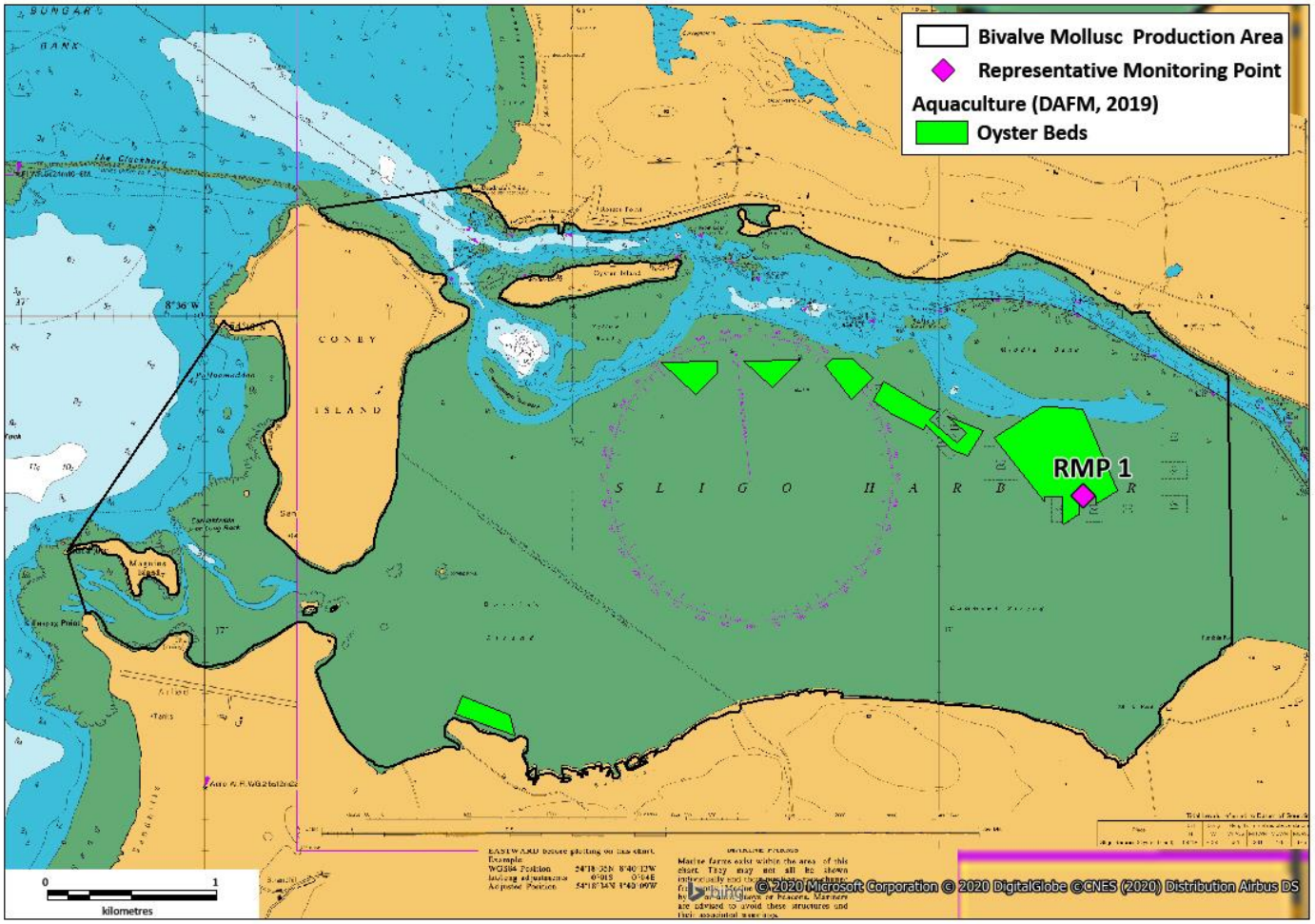



**Figure 7.2: Location of the Oyster RMP within Sligo Harbour.**

### *7.3. General Sampling Method*

All collection and transport of shellfish samples for E.coli testing under the Sampling Plan identified as part of the Sligo Harbour Sanitary Survey should follow the Sea Fisheries Protection Authority's own Code of Practice for the Microbiological Monitoring of Bivalve Mollusc Production Areas (SFPA, 2017). The guidance notes are found at Appendix 9.2 of that document.

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# Appendix 1

## Sligo Main Drainage *E. coli* Results 2014-2018

| Station 5 | Deepwater Quay | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Survey Month/Year | 2014 | 2015 | 2016 | 2017 | 2018 | Min | Max | Mean |
| March | 390 | 52 | 794 | 738 | 71 | 52 | 794 | 409 |
| June | 105 | 37 | 31 | 156 | 8164 | 31 | 8164 | 1698.6 |
| September/October | 32 | 279 | 594 | 1722 | 2755 | 32 | 2755 | 1076.4 |
| December | 93 | 6867 | 4611 | 75 | 161 | 75 | 6867 | 2361.4 |
| Station 6 | 1 mile down stream | | | | Station 5, 5 year mean | | | 1386.35 |
| Survey Month/Year | 2014 | 2015 | 2016 | 2017 | 2018 | Min | Max | Mean |
| March | 210 | 2247 | 359 | 187 | 9804 | 187 | 9804 | 2561.4 |
| June | 97 | 26 | 98 | 199 | 10 | 10 | 199 | 86 |
| September/October | 0 | 185 | 203 | 6893 | 1314 | 0 | 6893 | 1719 |
| December | 319 | 79 | 44 | 43 | 1565 | 43 | 1565 | 410 |
| Station 7 | Cummeen Strand | | | | Station 6, 5 year mean | | | 1194.1 |
| Survey Month/Year | 2014 | 2015 | 2016 | 2017 | 2018 | Min | Max | Mean |
| March | 16 | 617 | 41 | 47 | 57 | 16 | 617 | 155.6 |
| June | 0 | 326 | 20 | 4 | 112 | 0 | 326 | 92.4 |
| September/October | 0 | 187 | 1046 | 598 | 5172 | 0 | 5172 | 1400.6 |
| December | 236 | 3076 | 387 | 21 | 84 | 21 | 3076 | 760.8 |
| Station 8 | Rosses Point | | | | Station 7, 5 year mean | | | 602.35 |
| Survey Month/Year | 2014 | 2015 | 2016 | 2017 | 2018 | Min | Max | Mean |
| March | 13 | 594 | 0 | 2 | 13 | 0 | 594 | 124.4 |
| June | 39 | 1 | 75 | 0 | 677 | 0 | 677 | 158.4 |
| September/October | 1 | 292 | 41 | 41 | 2 | 1 | 292 | 75.4 |
| December | 210 | 435 | 13 | 164 | 12 | 12 | 435 | 166.8 |
| | | | | | Station 8, 5 year mean | | | 131.25 |

| **Station 1** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Season** | **2014** | **2015** | **2016** | **2017** | **2018** | **Min** | **Max** | **Mean** |
| **March** | **Spring** | 120 | 10 | 8 | 10 | 5 | 5 | 120 | 30.6 |
| **June** | **Summer** | 49 | 2 | 428 | 7 | 134 | 2 | 428 | 124 |
| **September/October** | **Autumn** | 115 | 3 | 2 | 52 | 80 | 2 | 115 | 50.4 |
| **December** | **Winter** | 23 | 13 | 15 | 35 | 6 | 6 | 35 | 18.4 |
| **5 year mean** | | | | | | | | | **55.85** |
| **Station 2** | | | | | | | | | |
| **Month** | **Season** | **2014** | **2015** | **2016** | **2017** | **2018** | **Min** | **Max** | **Mean** |
| **March** | **Spring** | 110 | 16 | 11 | 5 | 2 | 2 | 110 | 28.8 |
| **June** | **Summer** | 49 | 4 | 20 | 22 | 85 | 4 | 85 | 36 |
| **September/October** | **Autumn** | 21 | 5 | 68 | 41 | 47 | 5 | 68 | 36.4 |
| **December** | **Winter** | 97 | 910 | 5475 | 35 | 9 | 9 | 5475 | 1305.2 |
| **5 year mean** | | | | | | | | | **351.6** |
| **Station 3** | | | | | | | | | |
| **Month** | **Season** | **2014** | **2015** | **2016** | **2017** | **2018** | **Min** | **Max** | **Mean** |
| **March** | **Spring** | 410 | 28 | 770 | 1553 | 10 | 10 | 1553 | 554.2 |
| **June** | **Summer** | 196 | 133 | 479 | 7270 | 246 | 133 | 7270 | 1664.8 |
| **September/October** | **Autumn** | 613 | 435 | 96 | 960 | 1054 | 96 | 1054 | 631.6 |
| **December** | **Winter** | 43 | 292 | 38 | n/a | 167 | 38 | 292 | 135 |
| **5 year mean** | | | | | | | | | **778.58** |
| **Station 4** | | | | | | | | | |
| **Month** | **Season** | **2014** | **2015** | **2016** | **2017** | **2018** | **Min** | **Max** | **Mean** |
| **March** | **Spring** | 50 | 275 | 1300 | 2359 | 326 | 50 | 2359 | 862 |
| **June** | **Summer** | 216 | 84 | 613 | 93 | 631 | 84 | 631 | 327.4 |
| **September/October** | **Autumn** | 67 | 816 | 288 | 134 | 767 | 67 | 816 | 414.4 |
| **December** | **Winter** | 71 | 46 | 359 | 980 | 1565 | 46 | 1565 | 604.2 |
| **5 year mean** | | | | | | | | | **552** |
| **Station 5** | | | | | | | | | |
| **Month** | **Season** | **Month** | **Season** | **Month** | **Season** | **Month** | **Season** | **Month** | **Season** |
| **March** | **Spring** | 390 | 52 | 794 | 738 | 71 | 52 | 794 | 409 |
| **June** | **Summer** | 105 | 37 | 31 | 156 | 8164 | 31 | 8164 | 1698.6 |

| Month | Season | Month | Season | Month | Season | Month | Season | Month | Season |
|---|---|---|---|---|---|---|---|---|---|
| **September/October** | **Autumn** | 32 | 279 | 594 | 1722 | 2755 | 32 | 2755 | 1076.4 |
| **December** | **Winter** | 93 | 6867 | 4611 | 75 | 161 | 75 | 6867 | 2361.4 |
| **5 year mean** | | | | | | | | | **1386.35** |
| **Station 6** | | | | | | | | | |
| **Month** | **Season** | **2014** | **2015** | **2016** | **2017** | **2018** | **Min** | **Max** | **Mean** |
| **March** | **Spring** | 210 | 2247 | 359 | 187 | 9804 | 187 | 9804 | 2561.4 |
| **June** | **Summer** | 97 | 26 | 98 | 199 | 10 | 10 | 199 | 86 |
| **September/October** | **Autumn** | 0 | 185 | 203 | 6893 | 1314 | 0 | 6893 | 1719 |
| **December** | **Winter** | 319 | 79 | 44 | 43 | 1565 | 43 | 1565 | 410 |
| **5 year mean** | | | | | | | | | **1194.1** |
| **Station 7** | | | | | | | | | |
| **Month** | **Season** | **2014** | **2015** | **2016** | **2017** | **2018** | **Min** | **Max** | **Mean** |
| **March** | **Spring** | 16 | 617 | 41 | 47 | 57 | 16 | 617 | 155.6 |
| **June** | **Summer** | 0 | 326 | 20 | 4 | 112 | 0 | 326 | 92.4 |
| **September/October** | **Autumn** | 0 | 187 | 1046 | 598 | 5172 | 0 | 5172 | 1400.6 |
| **December** | **Winter** | 236 | 3076 | 387 | 21 | 84 | 21 | 3076 | 760.8 |
| **5 year mean** | | | | | | | | | **602.35** |
| **Station 8** | | | | | | | | | |
| **Month** | **Season** | **2014** | **2015** | **2016** | **2017** | **2018** | **Min** | **Max** | **Mean** |
| **March** | **Spring** | 13 | 594 | 0 | 2 | 13 | 0 | 594 | 124.4 |
| **June** | **Summer** | 39 | 1 | 75 | 0 | 677 | 0 | 677 | 158.4 |
| **September/October** | **Autumn** | 1 | 292 | 41 | 41 | 2 | 1 | 292 | 75.4 |
| **December** | **Winter** | 210 | 435 | 13 | 164 | 12 | 12 | 435 | 166.8 |
| **5 year mean** | | | | | | | | | **131.25** |

# Appendix 2

# Statistical Analysis

**One way ANOVA: Log *E. coli* vs Station Location (Water results 2014-2018)**

Anova: Single Factor

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| Station 1 | 20 | 26.6482 | 1.33241 | 0.378261 |
| Station 2 | 20 | 31.13604 | 1.556802 | 0.595517 |
| Station 3 | 20 | 45.90034 | 2.295017 | 0.728598 |
| Station 4 | 20 | 49.47163 | 2.473581 | 0.278348 |
| Station 5 | 20 | 50.14182 | 2.507091 | 0.62217 |
| Station 6 | 20 | 45.69487 | 2.284744 | 0.880757 |
| Station 7 | 20 | 39.22839 | 1.961419 | 1.028381 |
| Station 8 | 20 | 28.09187 | 1.404593 | 0.885271 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 32.86771 | 7 | 4.695387 | 6.959602 | 3.43E-07 | 2.070311 |
| Within Groups | 102.5488 | 152 | 0.674663 | | | |
| | | | | | | |
| Total | 135.4165 | 159 | | | | |

**t-Test: Two sample assuming equal variance: Log *E. coli* vs Station Location (Water results 2014-2018)**

| | *Station 8* | *Station 5* |
|---|---|---|
| Mean | 1.404593 | 2.507091 |
| Variance | 0.885271 | 0.62217 |
| Observations | 20 | 20 |
| Pooled Variance | 0.753721 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | -4.0158 | |
| P(T<=t) one-tail | 0.000135 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 0.000269 | |
| t Critical two-tail | 2.024394 | |

| | *Station 8* | *Station 6* |
|---|---|---|
| Mean | 1.404593 | 2.284744 |
| Variance | 0.885271 | 0.880757 |
| Observations | 20 | 20 |
| Pooled Variance | 0.883014 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |

| | *Station 8* | *Station 6* |
|---|---|---|
| t Stat | -2.96192 | |
| P(T<=t) one-tail | 0.002624 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 0.005248 | |
| t Critical two-tail | 2.024394 | |

| | *Station 3* | *Station 1* |
|---|---|---|
| Mean | 2.295017 | 1.33241 |
| Variance | 0.728598 | 0.378261 |
| Observations | 20 | 20 |
| Pooled Variance | 0.55343 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | 4.091833 | |
| P(T<=t) one-tail | 0.000107 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 0.000215 | |
| t Critical two-tail | 2.024394 | |

| | *Station 1* | *Station 4* |
|---|---|---|
| Mean | 1.33241 | 2.473581 |
| Variance | 0.378261 | 0.278348 |
| Observations | 20 | 20 |
| Pooled Variance | 0.328305 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | -6.29814 | |
| P(T<=t) one-tail | 1.11E-07 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 2.22E-07 | |
| t Critical two-tail | 2.024394 | |

| | *Station 5* | *Station 1* |
|---|---|---|
| Mean | 2.507091 | 1.33241 |
| Variance | 0.62217 | 0.378261 |
| Observations | 20 | 20 |
| Pooled Variance | 0.500216 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | 5.252202 | |
| P(T<=t) one-tail | 3.01E-06 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 6.02E-06 | |

| | *Station 5* | *Station 1* |
|---|---|---|
| t Critical two-tail | 2.024394 | |

| | *Station 3* | *Station 2* |
|---|---|---|
| Mean | 2.295017 | 1.556802 |
| Variance | 0.728598 | 0.595517 |
| Observations | 20 | 20 |
| Pooled Variance | 0.662058 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | 2.869029 | |
| P(T<=t) one-tail | 0.003344 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 0.006688 | |
| t Critical two-tail | 2.024394 | |

| | *Station 2* | *Station 4* |
|---|---|---|
| Mean | 1.556802 | 2.473581 |
| Variance | 0.595517 | 0.278348 |
| Observations | 20 | 20 |
| Pooled Variance | 0.436933 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | -4.38589 | |
| P(T<=t) one-tail | 4.42E-05 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 8.85E-05 | |
| t Critical two-tail | 2.024394 | |

| | *Station 5* | *Station 2* |
|---|---|---|
| Mean | 2.507091 | 1.556802 |
| Variance | 0.62217 | 0.595517 |
| Observations | 20 | 20 |
| Pooled Variance | 0.608844 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | 3.85126 | |
| P(T<=t) one-tail | 0.000219 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 0.000438 | |
| t Critical two-tail | 2.024394 | |

| | *Station 6* | *Station 2* |
|---|---|---|
| Mean | 2.284744 | 1.556802 |

| | *Station 6* | *Station 2* |
|---|---|---|
| Variance | 0.880757 | 0.595517 |
| Observations | 20 | 20 |
| Pooled Variance | 0.738137 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | 2.679342 | |
| P(T<=t) one-tail | 0.005421 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 0.010843 | |
| t Critical two-tail | 2.024394 | |

| | *Station 8* | *Station 3* |
|---|---|---|
| Mean | 1.404593 | 2.295017 |
| Variance | 0.885271 | 0.728598 |
| Observations | 20 | 20 |
| Pooled Variance | 0.806935 | |
| Hypothesized Mean Difference | 0 | |
| df | 38 | |
| t Stat | -3.13457 | |
| P(T<=t) one-tail | 0.001656 | |
| t Critical one-tail | 1.685954 | |
| P(T<=t) two-tail | 0.003312 | |
| t Critical two-tail | 2.024394 | |

**t-Test: Two sample assuming unequal variance: Log *E. coli* vs Station Location (Water results 2014-2018)**

| | *Station 8* | *Station 4* |
|---|---|---|
| Mean | 1.404593 | 2.473581 |
| Variance | 0.885271 | 0.278348 |
| Observations | 20 | 20 |
| Hypothesized Mean Difference | 0 | |
| df | 30 | |
| t Stat | -4.43182 | |
| P(T<=t) one-tail | 5.76E-05 | |
| t Critical one-tail | 1.697261 | |
| P(T<=t) two-tail | 0.000115 | |
| t Critical two-tail | 2.042272 | |

| | *Station 7* | *Station 1* |
|---|---|---|
| Mean | 1.961419 | 1.33241 |
| Variance | 1.028381 | 0.378261 |
| Observations | 20 | 20 |

| | *Station 7* | *Station 1* |
|---|---|---|
| Hypothesized Mean Difference | 0 | |
| df | 31 | |
| t Stat | 2.371813 | |
| P(T<=t) one-tail | 0.012046 | |
| t Critical one-tail | 1.695519 | |
| P(T<=t) two-tail | 0.024093 | |
| t Critical two-tail | 2.039513 | |

| | *Station 6* | *Station 1* |
|---|---|---|
| Mean | 2.284744 | 1.33241 |
| Variance | 0.880757 | 0.378261 |
| Observations | 20 | 20 |
| Hypothesized Mean Difference | 0 | |
| df | 33 | |
| t Stat | 3.795668 | |
| P(T<=t) one-tail | 0.000299 | |
| t Critical one-tail | 1.69236 | |
| P(T<=t) two-tail | 0.000599 | |
| t Critical two-tail | 2.034515 | |

**One way ANOVA: Log *E. coli* vs Season (Water results 2014-2018)**

Anova: Single Factor

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| Spring | 40 | 76.92858 | 1.923214 | 0.900048 |
| Summer | 40 | 73.22604 | 1.830651 | 0.787791 |
| Autumn | 40 | 82.95352 | 2.073838 | 0.997196 |
| Winter | 39 | 83.205 | 2.133462 | 0.644456 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 2.277857 | 3 | 0.759286 | 0.910867 | 0.437262 | 2.662945545 |
| Within Groups | 129.2057 | 155 | 0.833585 | | | |
| | | | | | | |
| Total | 131.4836 | 158 | | | | |

**One way ANOVA: Log *E. coli* vs Season (Oyster Flesh results 2014-2019)**

Anova: Single Factor

SUMMARY

| Groups | Count | Sum | Average | Variance |
|---|---|---|---|---|
| Spring | 14 | 24.25728 | 1.732663 | 0.371209 |
| Summer | 13 | 20.95664 | 1.612049 | 0.232078 |
| Autumn | 14 | 23.82572 | 1.701837 | 0.094652 |
| Winter | 17 | 28.57176 | 1.680692 | 0.176767 |

ANOVA

| Source of Variatio | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Between Groups | 0.105029 | 3 | 0.03501 | 0.162007 | 0.921457 | 2.775762 |
| Within Groups | 11.66942 | 54 | 0.2161 | | | |
| | | | | | | |
| Total | 11.77444 | 57 | | | | |

# Appendix 3

# Species Specific Sampling Plan

# Sligo Harbour

## Bivalve Mollusc Classified Production Area

## Oyster Sampling Plan

**Site Name:** Sligo Harbour

**Site Identifier:** SO-SH-SH

**Monitoring Point Coordinates**

**Latitude:** 54.29066 **Longitude:** -8.521002

**Species:** *Crassostrea gigas*

**Sample Depth:** Surface **Sample Frequency:** Monthly

**Responsible Authority:** Sea Fisheries Protection Authority

**Authorised Samplers:** SFPA Port Office Killybegs

**Maximum Allowed Distance from Sampling Point:** The sample must be taken from within 100m of the sampling point.

**Sampling Size:** Minimum 10 market sized (8cm) animals

**Sampling Method:** Taken from trestles at point