Sanitary Survey Report

and

Sampling Plan

for Drumcliff Bay

Produced by

AQUAFACT International Services Ltd

In conjunction with

The Sea Fisheries Protection Authority

July 2020

AQUAFACT INTERNATIONAL SERVICES Ltd.,

12 KILKERRIN PARK,

GALWAY.

www.aquafact.ie

info@aquafact.ie

tel +353 (0) 91 756812

Report Approval Sheet

Client	Sea Fisheries Protection Authority
Report Title	Sanitary Survey & Sampling Plan for Drumcliff Bay
Job Number	JN1520
Report Status	Draft Final
Issue Date	17/07/2020

Rev	Status	Issue Date	Document File Name	Author (s)	Approved by:
1	Draft	17/05/2019	JN1520 Drumcliff Bay Interim Report	Kevin McCaffrey	
2	Draft	24/10/19	JN1520 Drumcliff Bay Draft Final Report	Kevin McCaffrey	
3	Draft	14/04/2020	JN1520 Drumcliff Bay Draft Final Report	Kevin McCaffrey	
4	Draft	15/05/2020	JN1520 Drumcliff Bay Draft Final Report	Kevin McCaffrey	
5	Draft	15/05/2020	JN1520 Drumcliff Bay Draft Final Report	Kevin McCaffrey	
6	Draft	8/06/2020	JN1520 Drumcliff Bay Draft Final Report	Kevin McCaffrey	
7	Draft	17/07/2020	JN1520 Drumcliff Bay Draft Final Report	Kevin McCaffrey	

AQUAFACT

Table of Contents

List of Figures

List of Tables

List of Appendices

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
CFU	Colony Forming Units
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 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 Drumcliff Bay, County Sligo. It identifies the representative monitoring points and supporting sampling plans for pacific oysters, mussels, clams and cockles in Drumcliff Bay. It also sets out the production area boundaries in the Bay.

2. Overview of the Fishery/Production Area

2.1. Description of the Area

Drumcliff Bay is a 15.1km^2 shallow tidal bay with extensive muddy sand flats. The inner half of the bay is sheltered by a spit containing sand dunes which splits the bay in half with a narrow passage to the north connecting the two halves of the bay. The mouth of the bay extends from Raghly Point to Rosses Point. The area is approximately 9.5km E-W at its widest point and approximately 2.7km N-S. The catchment area of the BMPA is 112.4km^2 and the main freshwater source from this catchment is the Drumcliff River which flows through Drumcliff village.

A channel runs from the Drumcliff River along the north of the bay past Finned Point at which point it turns north-westerly and passes through the narrow passage between the spit and the north shore. After this point the channel turns south-westerly and travels down the middle of the outer bay to about half way between Raghly Point and Rosses Point. Depths in the outer bay range from 0 to 8m while all of the inner bay is drained at low water except for the main channel. Depths in the channel range from 1 to 7m.

Drumcliff Bay 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 including *Phoca vitulina* (Harbour Seal) (NPWS, 2016).

Drumcliff Bay is also designated as a Special Protection Area (SPA): Drumcliff Bay SPA (IE004013) (see Figure 2.1). Drumcliff Bay is designated due to the presence of important bird species, see section 3.1.6.2 for details.

Cummeen Strand SPA (IE004035) and Ballintemple and Ballygilgan SPA (IE004234) are adjacent to Drumcliff bay and are designated as SPA's due to the high occurrence of important bird species (see Figure 2.1).

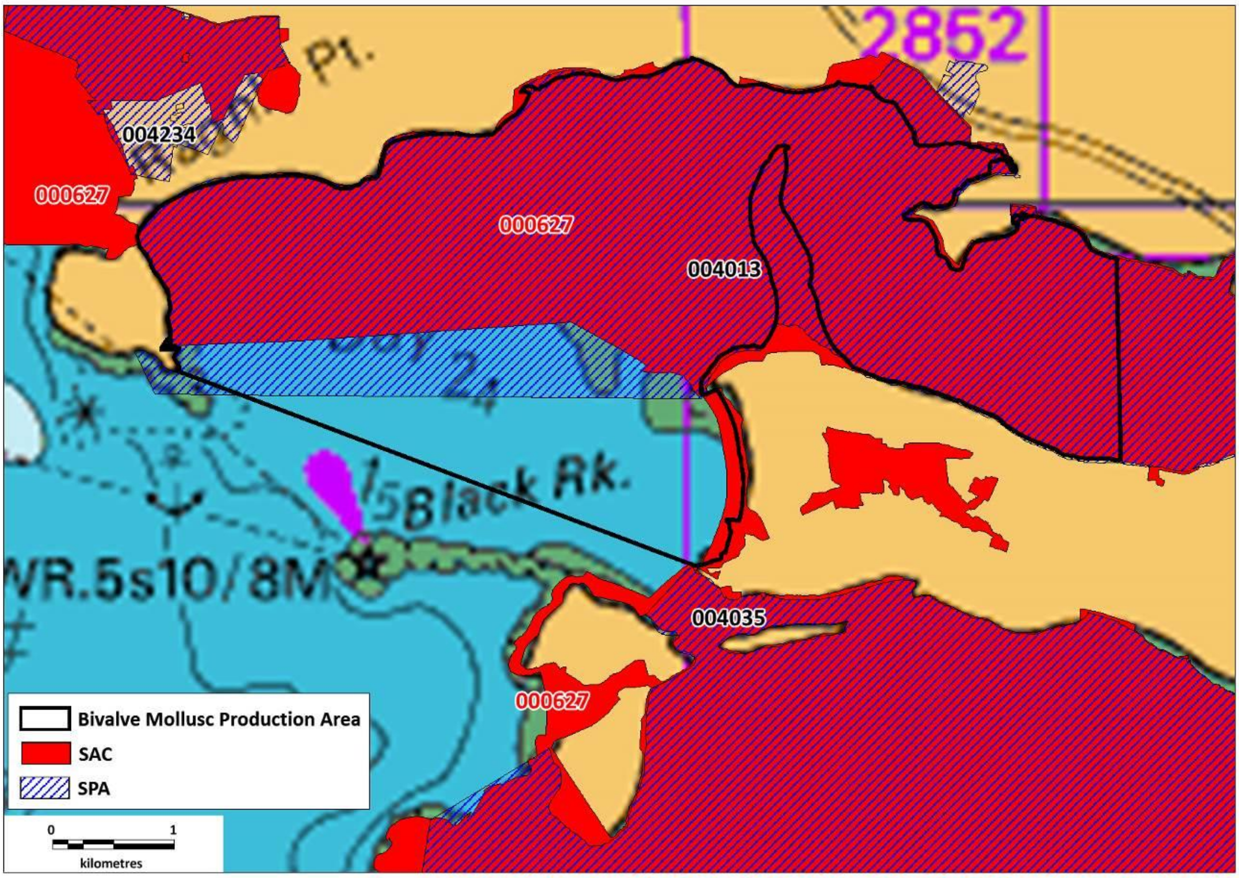


Figure 2.1: Location of Natura 2000 sites overlapping with the Drumcliff Bay BMPA.

The Drumcliff Bay BMCPA supports a diversity of fish species. Species present include bass, mackerel, salmon and sea trout (IFI, 2019).

Land cover within the Drumcliff Bay catchment is a mixture of pastures, Land principally occupied by agriculture, peat bogs, intertidal sand flats, moors and heathland, natural grasslands and forestry (coniferous, broad-leafed and mixed)

The population of the catchment is approximately 3,742. The largest village is Carney which has a population of 395 people.

2.2. Drumcliff Bay Fishery

2.2.1. Location/Extent of Growing/Harvesting Area

The designated shellfish waters in Drumcliff Bay cover an area of approximately 15.1km^2 and can be seen in Figure 2.2. Pacific oyster (*Crassostrea Gigas*), Cockles (*Cerastoderma edule*), Mussels (*Mytilus edulis*) and clam (*Clam* spp) production sites occur in Drumcliff Bay.

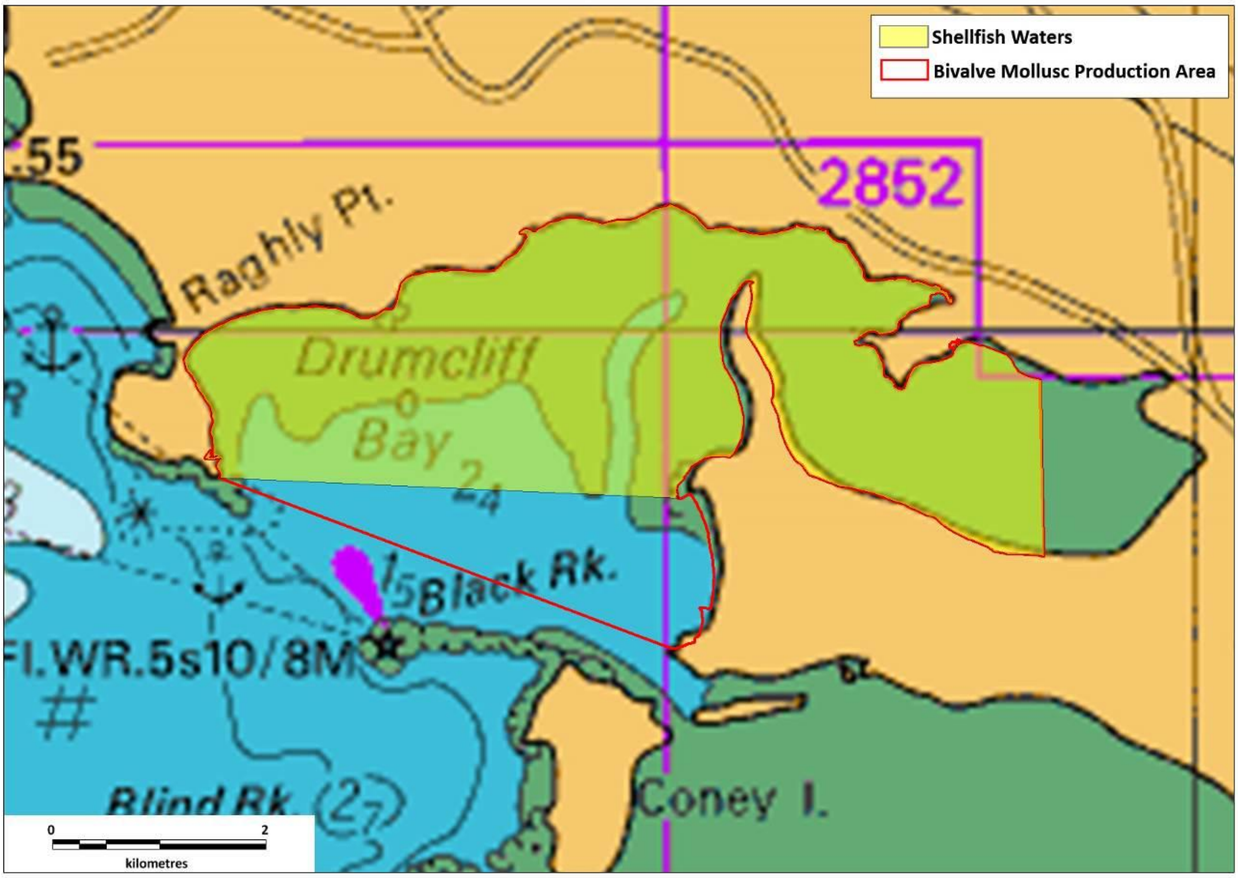


Figure 2.2: Bivalve Mollusc Classified Production Area and Designated Shellfish Waters within Drumcliff Bay.

Figure 2.3 shows the current locations of licenced aquaculture sites within Drumcliff Bay. There are 3 licences exclusively for clams and they occupy 17.32ha. There are 2 licences exclusively for oysters and they occupy 94.69ha. There are 3 sites licenced for oysters as the primary species and clams as the secondary species and they occupy 7.11ha (of which 5.92ha overlaps with a licenced oyster site). There are 5 sites licenced for clams as the primary species and oysters as the secondary species and they occupy 32.02ha (of which 10.5 overlaps with a licenced oyster site). Overall, 67.4% of the licences are for oysters[1] and 32.6% of the sites are licenced for clams[2]. Wild fisheries exist for mussels and cockles within the bay which can be seen in Figure 2.4 below.

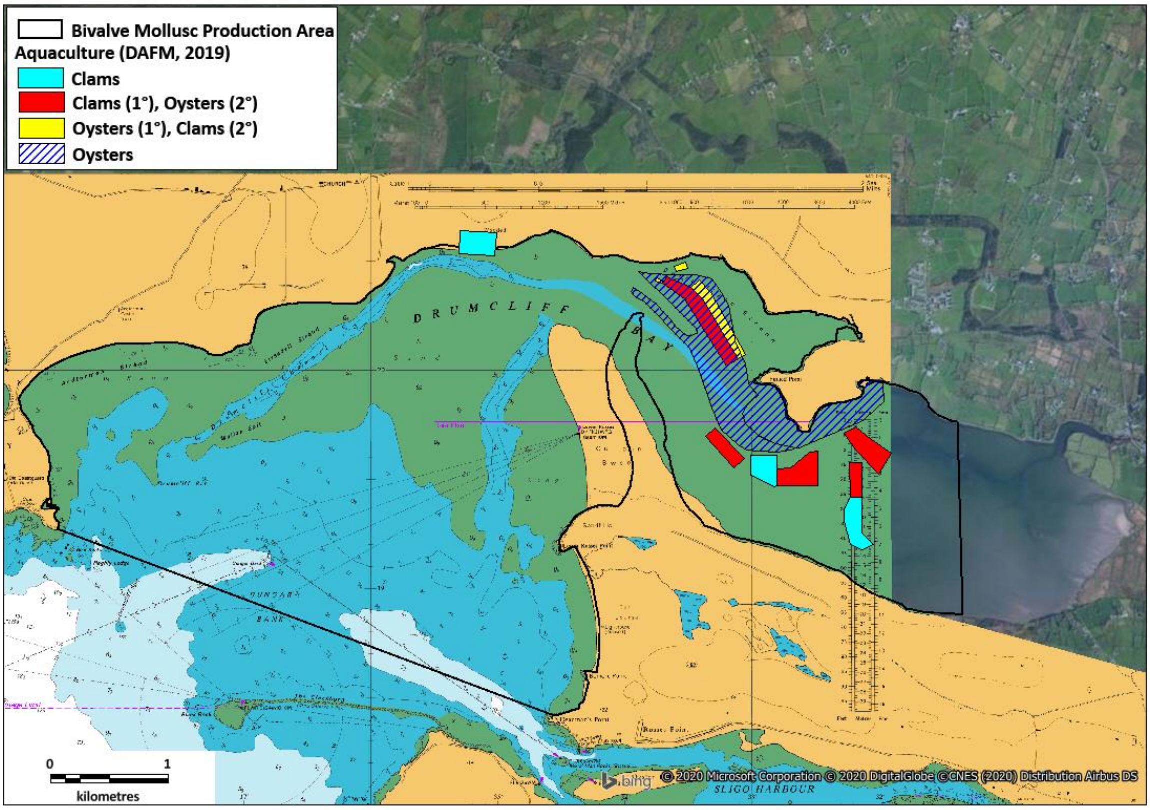


Figure 2.3: Licenced aquaculture sites within Drumcliff Bay (Source: DAFM, 2019).

[1] Includes sites where oysters are the primary species
[2] Includes sites where clams are the primary species

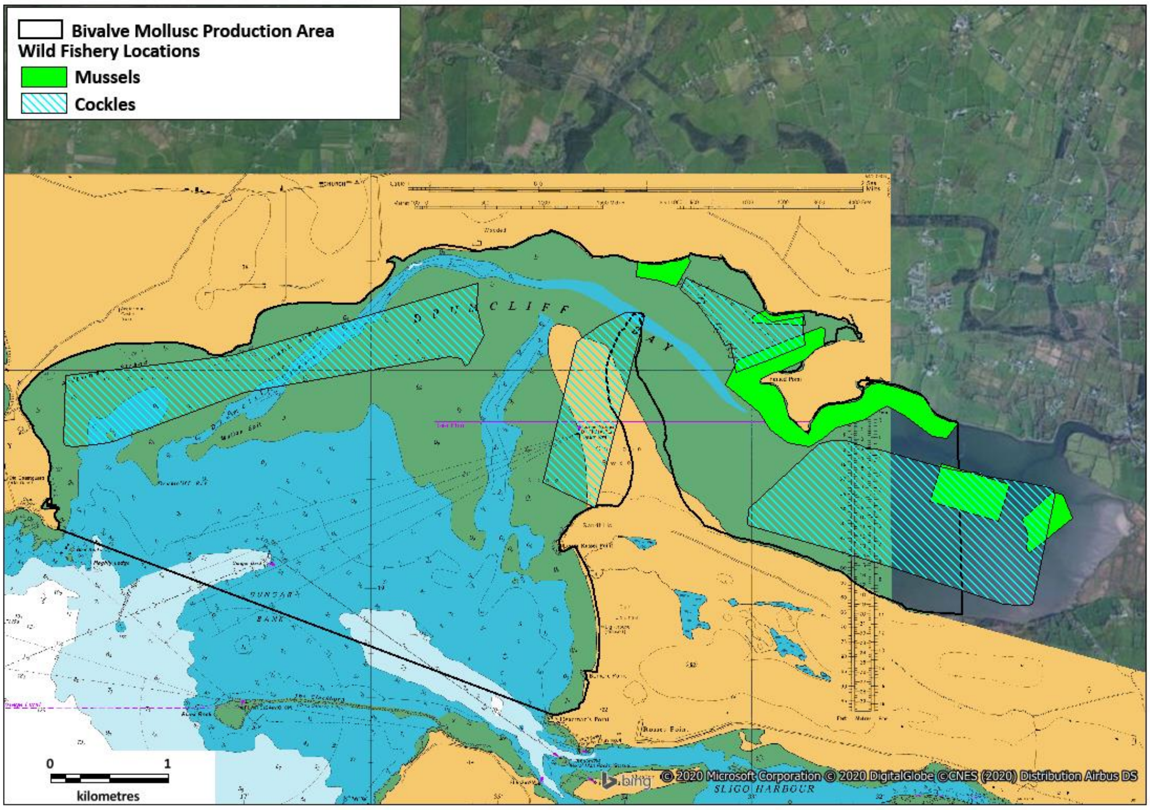


Figure 2.4: Wild fishery locations within Drumcliff Bay.

2.2.2. Description of Species

2.2.2.1. Blue Mussels (Mytilus edulis)

Distribution

Figure 2.5 shows the locations of wild fisheries for Mussels within Drumcliff Bay. These sites cover an area of 1.02km^2. All sites are inside of the Spit that divides the bay.

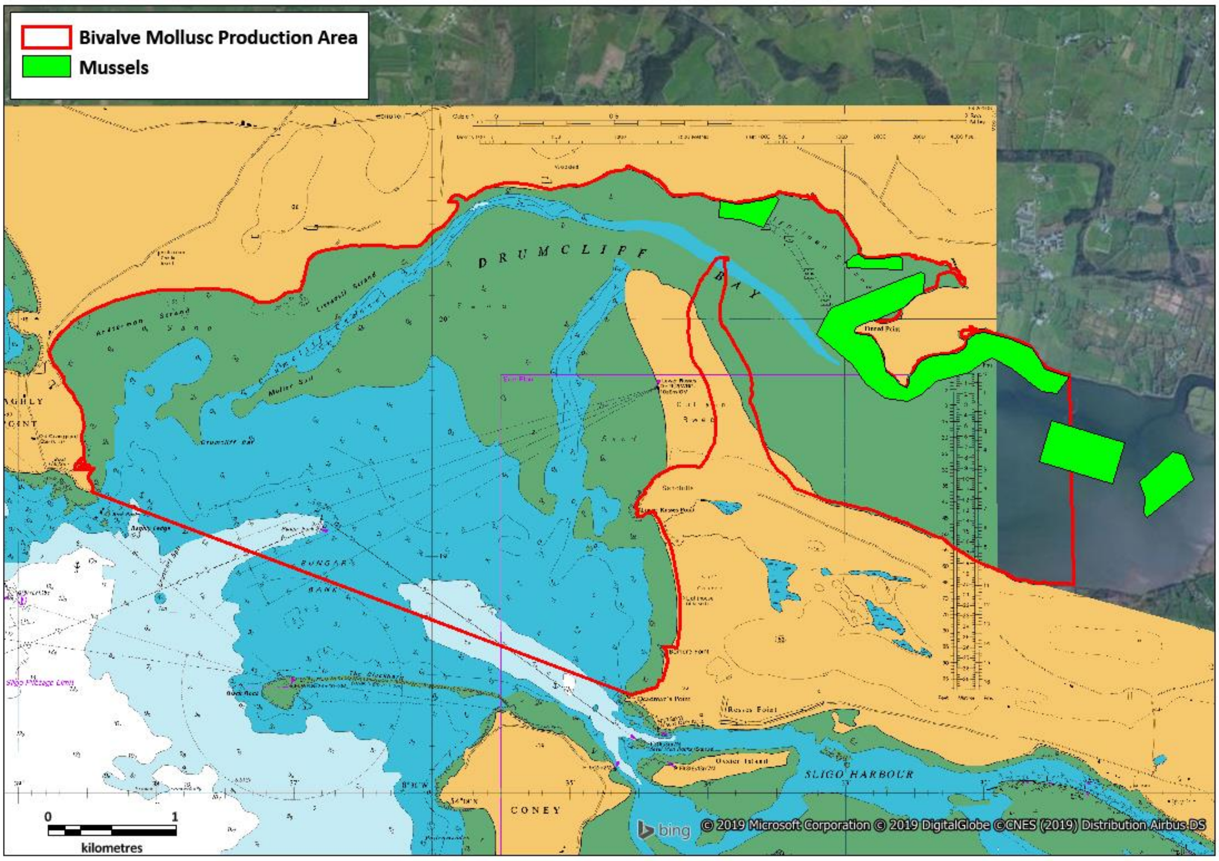


Figure 2.5: Wild mussel harvesting sites in Drumcliff Bay

Fishery

Mussels are harvested from a number of naturally occurring wild beds the largest of which stretches along the shore out and around Finned. Two smaller beds occur along the rocky shore at Ballygilgan. Lastly there are two beds located in the inner Drumcliff area where natural rocky outcrops occur.

Mussels are gathered by hand, picked from the rocky substrate and harvesting takes place all year round. These are wild stocks with no management or farming. Average annual production is approximately five tonnes.

2.2.2.2. Pacific Oysters (Crassostrea gigas)

Distribution

Figure 2.6 shows the locations of licenced intertidal farmed Pacific oyster sites in Drumcliff Bay (including those where oysters are also listed as a secondary species). These farmed sites cover an area of 1.34km^2. The farms in Drumcliff Bay are located along Ballygilgan Strand extending around Finned Point.

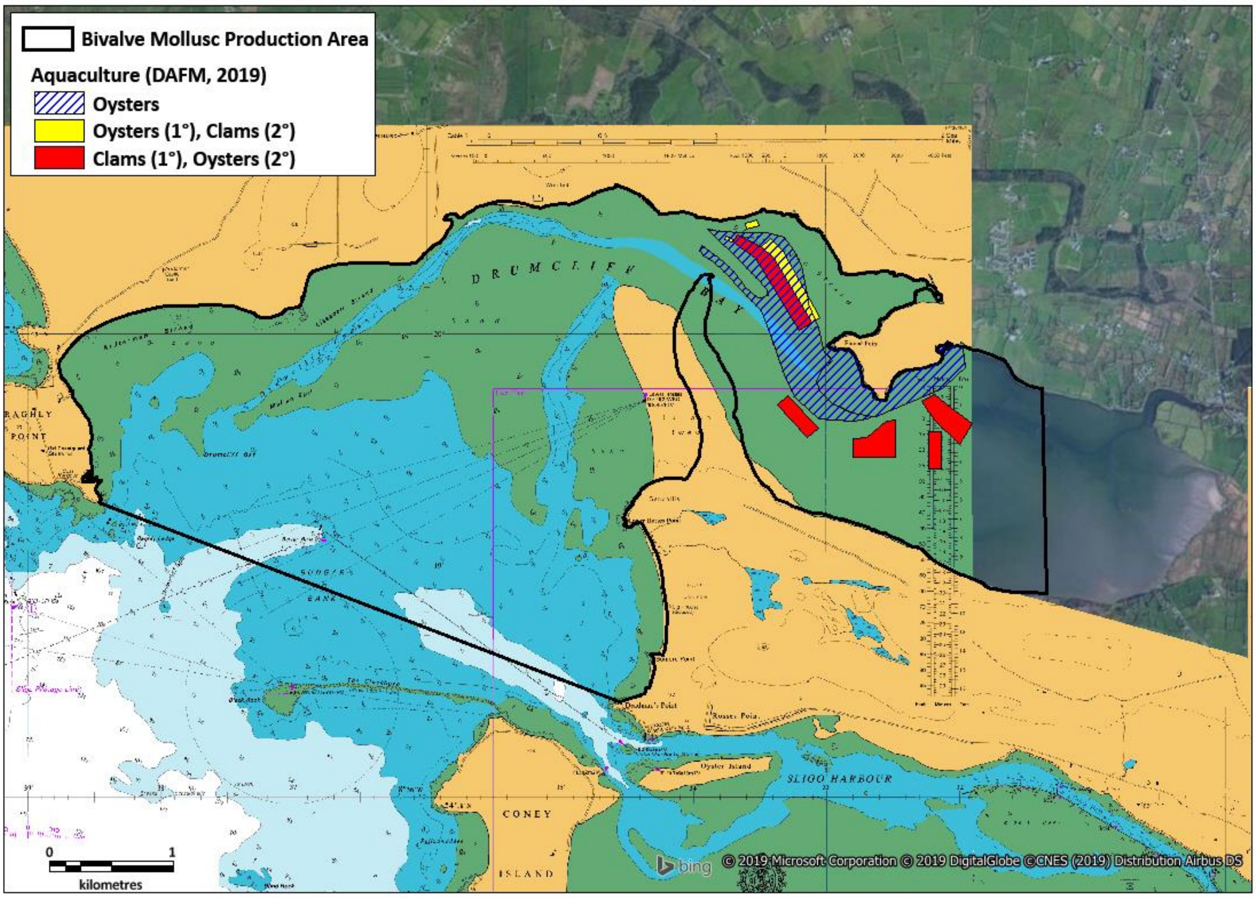


Figure 2.6: Licenced Pacific oyster harvesting sites in Drumcliff Bay (Source: DAFM, 2019).

Fishery

Current production is concentrated in those licensed areas at Ballygilgan Strand and on the opposite side of the main channel from Finned Point. There is currently no active production from those licensed areas in the inner Drumcliff Bay section. All market size oysters are farmed using the bag and trestle system. Average annual production is around 90.7 tonnes and harvesting takes place all year round.

2.2.2.3. Clams

Distribution

Figure 2.7 shows the licensed clam sites (including those where clams are also farmed as a secondary species) in Drumcliff Bay. These farmed sites cover an area of 0.57km^2. The farms in Drumcliff Bay extend from the inner bay east of Finned Point around to Ballygilgan Strand with one site in the outer bay area, on the north shore.

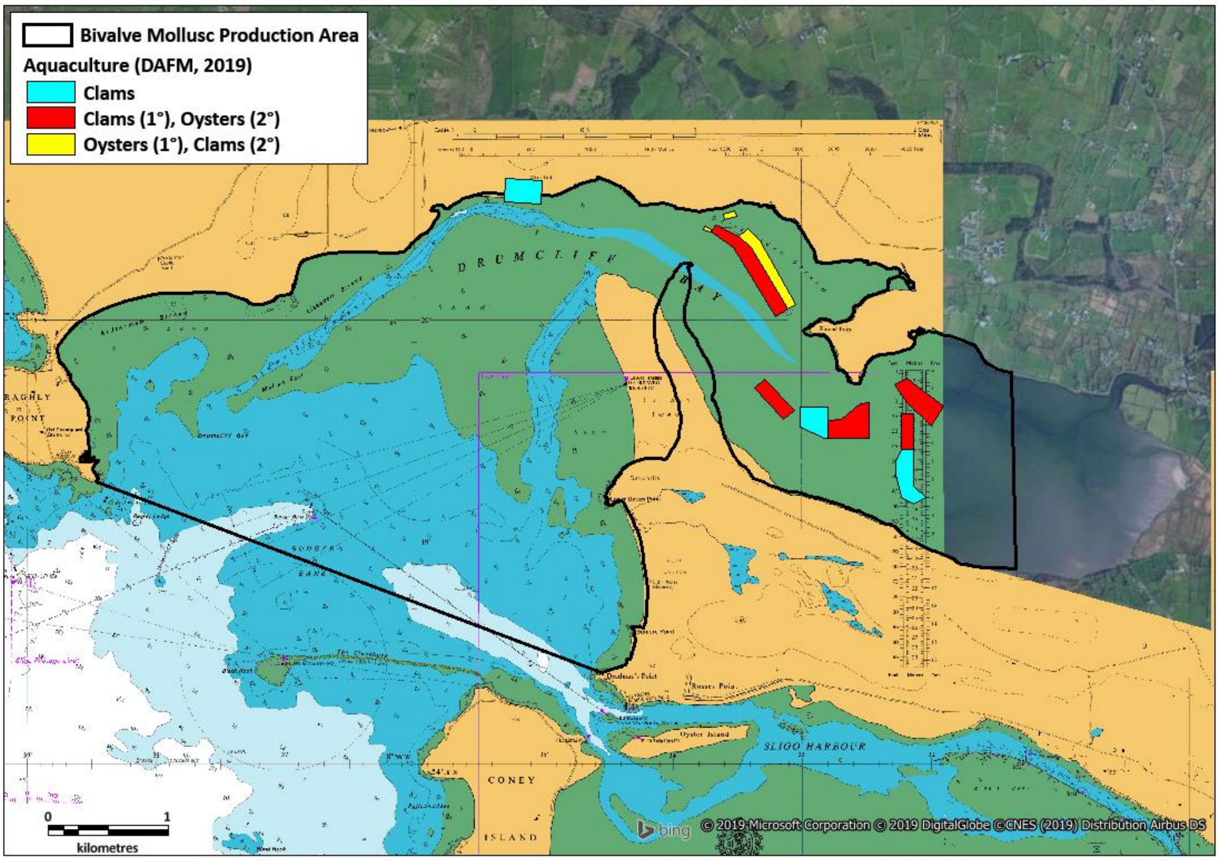


Figure 2.7: Licenced clam harvesting sites in Drumcliff Bay (Source: DAFM, 2019).

Fishery

Currently there is no active clam production in Drumcliff. In previous years, clams, in particular Manilla clams, were grown on a number of sites in the bay. The recurring problem of brown ring disease though proved a disincentive and no production has taken place in the past three years.

Utilising hatchery reared pulled carpet shell clams (Venerupis corrugate) a producer has commenced on-growing of a small stock of these clams. All stock is still below market size and it is not expected that clams will be ready for harvesting until 2021. The clams are grown on only one site, that adjacent Lissadell Woods. None of the other farms licensed for clams currently contain any stock.

2.2.2.4. Cockles (Cerastoderma edule)

Distribution

Figure 2.8 shows the locations of wild fisheries for Cockle in Drumcliff Bay. These sites cover an area of 5.05km^2. The sites are spread between the inner and outer bay.

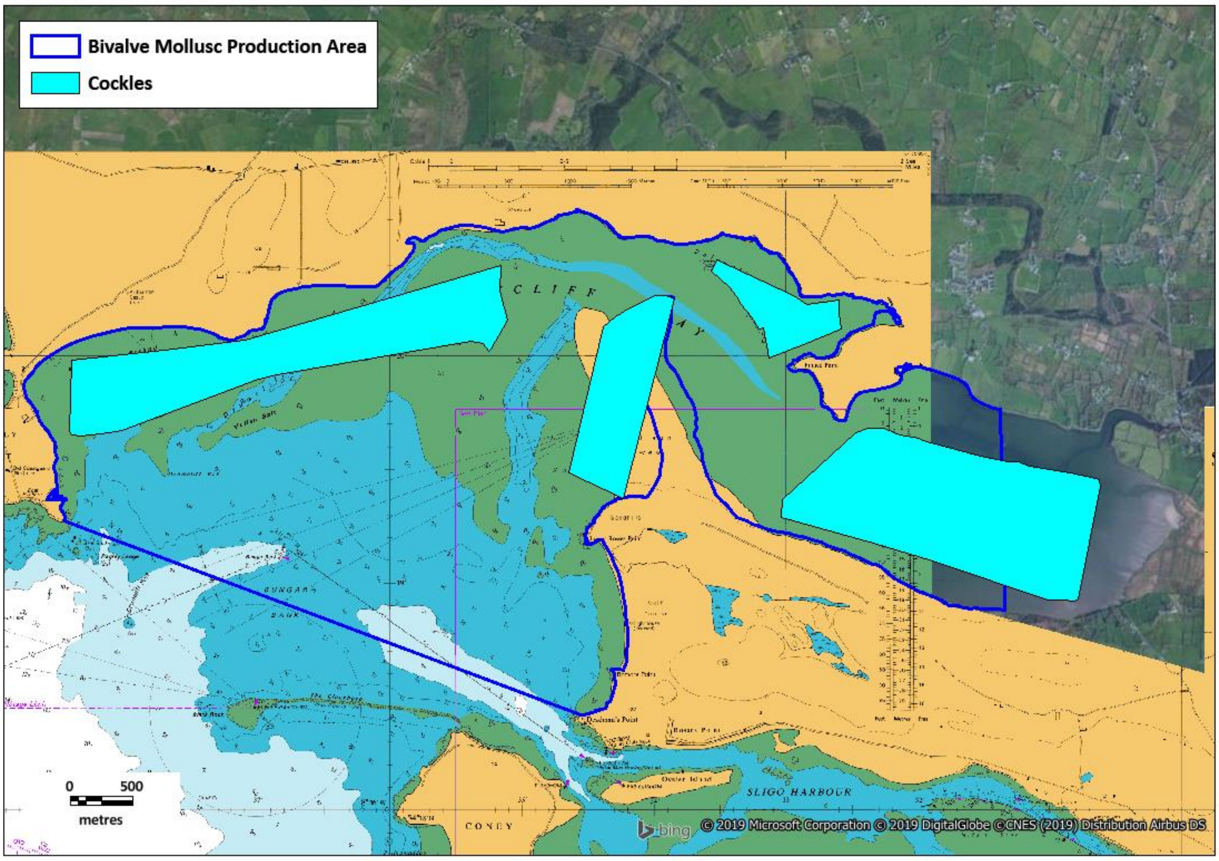


Figure 2.8 Cockle harvesting areas in Drumcliff Bay.

Fishery

Cockles are spread throughout the inter-tidal areas of the bay. Three main areas though are recognised;

a) Inner Drumcliff

b) Ballygilgan Strand

c) Ardtermon/Lissadell Strands Outer

Cockles are gathered by hand raking and harvesting takes place all year round with an annual production averaging around 15 tonnes.

3. Identification of Pollution Sources

This section attempts to document all pollution sources within the Drumcliff Bay catchment area.

3.1. Desktop Survey

Pollution sources were considered within the catchment area of Drumcliff Bay (see Figure 3.1 below).

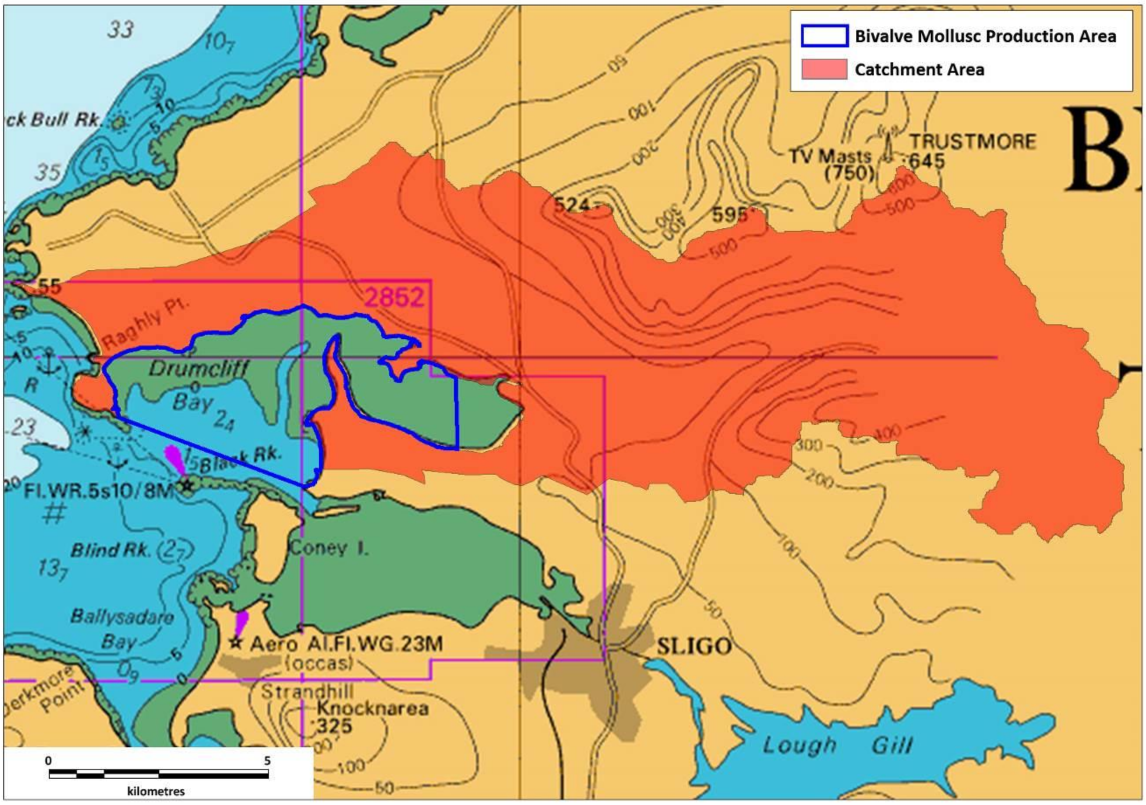


Figure 3.1: Drumcliff Catchment area used for assessment of the pollution sources.

3.1.1. Human Population

Figure 3.2 shows all of the counties that fall within the Drumcliff Bay 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 area. The population data were obtained through the Central Statistics Office (CSO) online Small Area Population Statistics (SAPS) (CSO, 2019a) for the year 2016. Figure 3.4 shows the human population within Drumcliff Bay catchment area and Table 3.1 shows this data in tabular form.

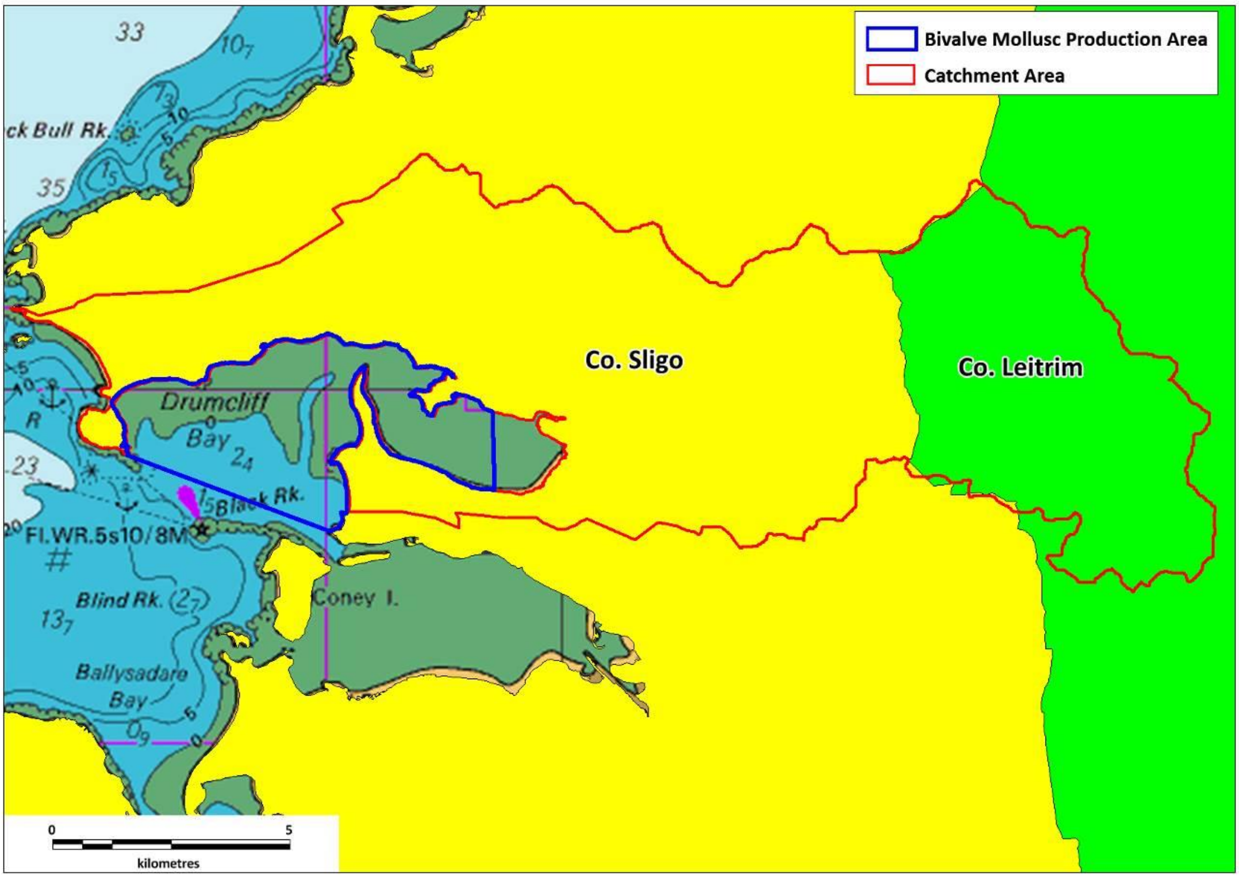


Figure 3.2: Counties within the Drumcliff Bay Catchment Area.

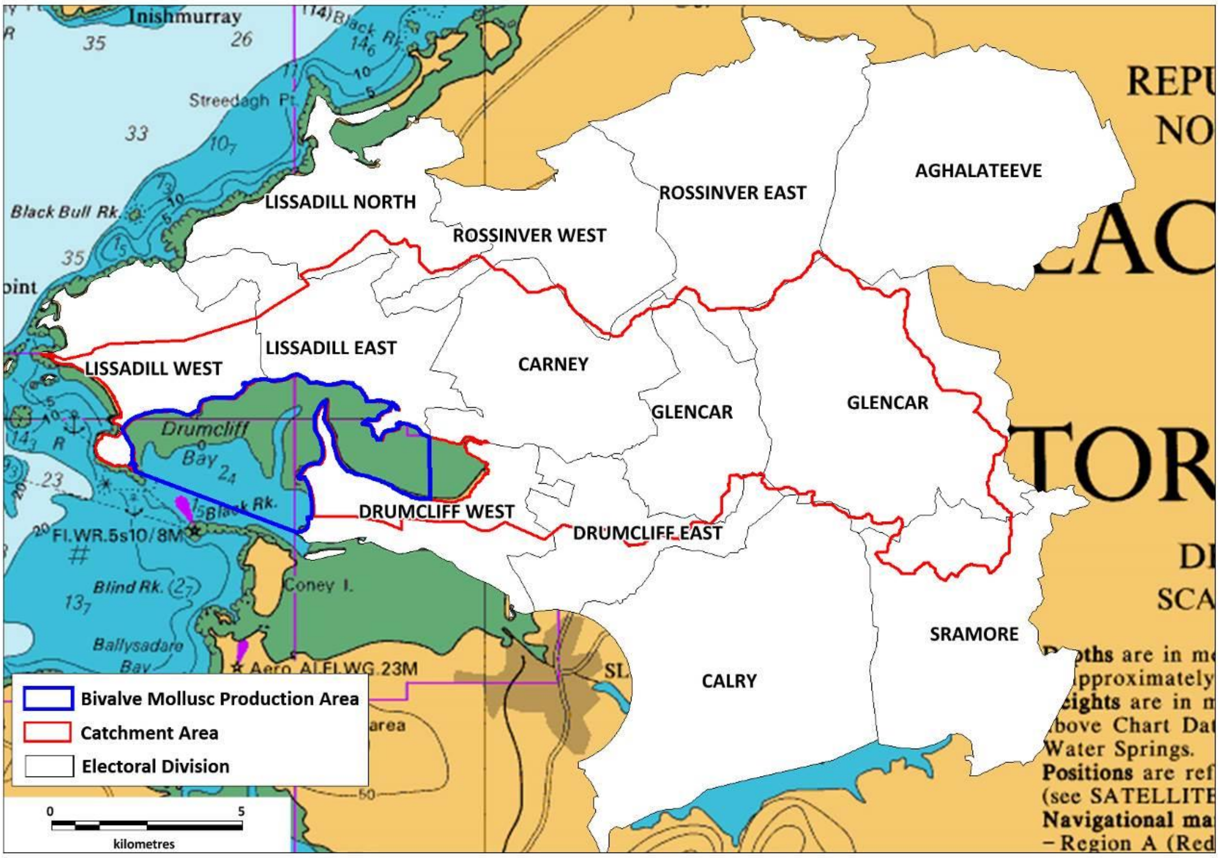


Figure 3.3: Electoral Divisions within the Drumcliff Bay Catchment Area.

The Drumcliff Bay Catchment Area overlaps 13 ED's (all partially). The ED's that are within the catchment are Aghalateeve/Aghanlish, Calry, Carney, Drumcliff East, Drumcliff West, Glencar (Sligo), Glencar (Leitrim), Lissadell East, Lissadell North, Lissadell west, Rossinver East, Rossinver West and Sramore. Drumcliff West contains largest population (1,893) followed by Calry (1,702), Lissadell North (1,475) and Lissadell East (864).

These 13 ED's accommodate a total population of 9,498. As the 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 3,742 people. Table 3.1 shows this estimation. There are no large towns/urban centres within the catchment area. The largest village is Carney which has a population of 395 people.

There are 4,252 households within the 13 ED's within the catchment area. Of this, 10% are vacant (428) and a further 6% are holiday homes (262). Of the 1,631 houses actually within the catchment (based on the % of the ED within the catchment), 8% are vacant and 6% 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 Drumcliff Bay system. Therefore, the highest levels of sewage and waste would be expected to enter through the Drumcliff and Carney Rivers which drain over half of the catchment. The catchment is mostly made up of disperse dwellings with no significant urban areas and only two small WWTP. Therefore, highest loading of microbial contamination from humans in the catchment is from septic tanks and other private treatment methods (76.6% of dwelling), while a lower proportion comes from the two WWTPs (19.9% of dwelling). However, it is unclear which of these has the biggest impact on the microbial levels for shellfish purposes (i.e. private treatment is dispersed throughout the catchment while the WWTPs discharge directly to the two rivers.) As holiday homes only account for 6% 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.

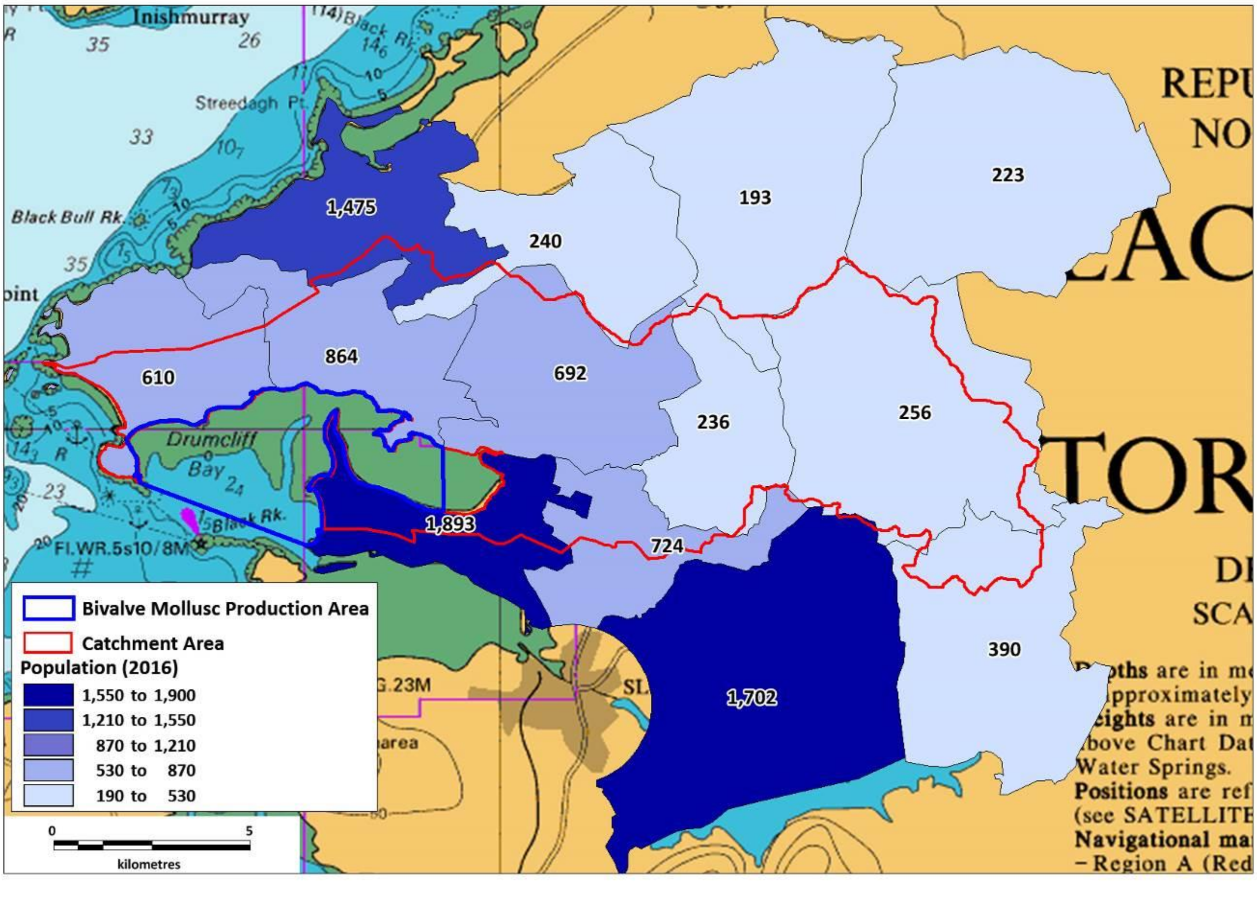


Figure 3.4: Human population within the Drumcliff Bay Catchment Area (Source: CSO, 2019a).

Table 3.1: Human population within the Drumcliff Bay Catchment Area (Source: CSO, 2019a).

Electoral Division	Population (2016)	% ED in Catchment	Estimated Population
Aghalateeve / Aghanli	223	0.04	0
Calry	1702	0.17	3
Carney	692	94.45	654
Drumcliff East	724	39.82	288
Drumcliff West	1893	56.08	1062
Glencar (Leitrim)	256	81.58	209
Glencar (Sligo)	236	95.33	225
Lissadell East	864	81.41	703
Lissadell North	1475	12.68	187
Lissadell West	610	52.58	321
Rossinver East	193	4.90	9
Rossinver West	240	9.44	23
Sramore	390	14.96	58

Table 3.2: Households within the EDs in the Drumcliff Bay 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 / Aghanlish	133	87	5	41	0	0	0	0
Calry	774	684	21	69	1	1	0	0
Carney	282	263	7	12	266	248	7	11
Drumcliff East	322	295	3	24	128	117	1	10
Drumcliff West	845	697	71	77	474	391	40	43
Glencar (Leitrim)	124	94	9	21	101	77	7	17
Glencar (Sligo)	95	88	2	5	91	84	2	5
Lissadell East	353	307	17	29	287	250	14	24
Lissadell North	620	520	52	48	79	66	7	6
Lissadell West	308	231	48	29	162	121	25	15
Rossinver East	120	72	14	34	6	4	1	2
Rossinver West	106	84	4	18	10	8	0	2
Sramore	170	140	9	21	25	21	1	3
Total	4252	3562	262	428	1631	1388	105	138

* 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 Devil's Chimney in Co. Sligo, along with Glencar waterfall in Co. Leitrim.

The attractions located inside the catchment area include; Rosses Point Beach, Devil's Chimney Waterfall, Glencar Waterfall, the grave of W. B. Yeats G, Benbulben Walking trail and Lissadell House and Gardens. 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 Drumcliff Bay as a focal point for their aqua-tourism businesses. Two sea angling and charter vessels operate out of Rosses Point. There are also businesses offering activities such as Kayaking, sailing and guided tours.

The only monitored swimming area near the production area is Rosses Point beach, which is a Blue Flag beach. Rosses point is monitored for water quality by the EPA and has been classified as excellent for 2015, 2016 and 2017. In addition, waste can enter the area from recreational vessels.

3.1.3. Sewage Discharges

3.1.3.1. Water Treatment Works

There are two waste water or sewage treatment works within the Drumcliff Bay catchment, both of which discharge to rivers <1km upstream of the bay (Carney and Drumcliff). Figure 4.5 shows both Treatment Works within the Drumcliff Bay catchment area and Table 4.3 shows the coordinates and facility capacities of each works (EPA, 2019a).

3.1.3.2. Continuous Discharges

Carney WWTP is a tertiary P removal facility with a design capacity of 2000 PE (Population Equivalent) and is currently under capacity at 387 PE, the maximum discharge for this facility is 3,038 m^3/day. Drumcliff and

Environs WWTP is a secondary treatment facility with a design capacity of 150 PE and is currently under capacity at 93 PE; at the time of writing there were no data for the maximum discharge from this facility. 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 Drumcliff Bay recorded 1,149 on-site waste water treatment systems within the catchment, using the average household size of 2.75 individuals gives 3,159 people on private treatment systems. Whereas, there are 480 people on the public sewer/treatment system.

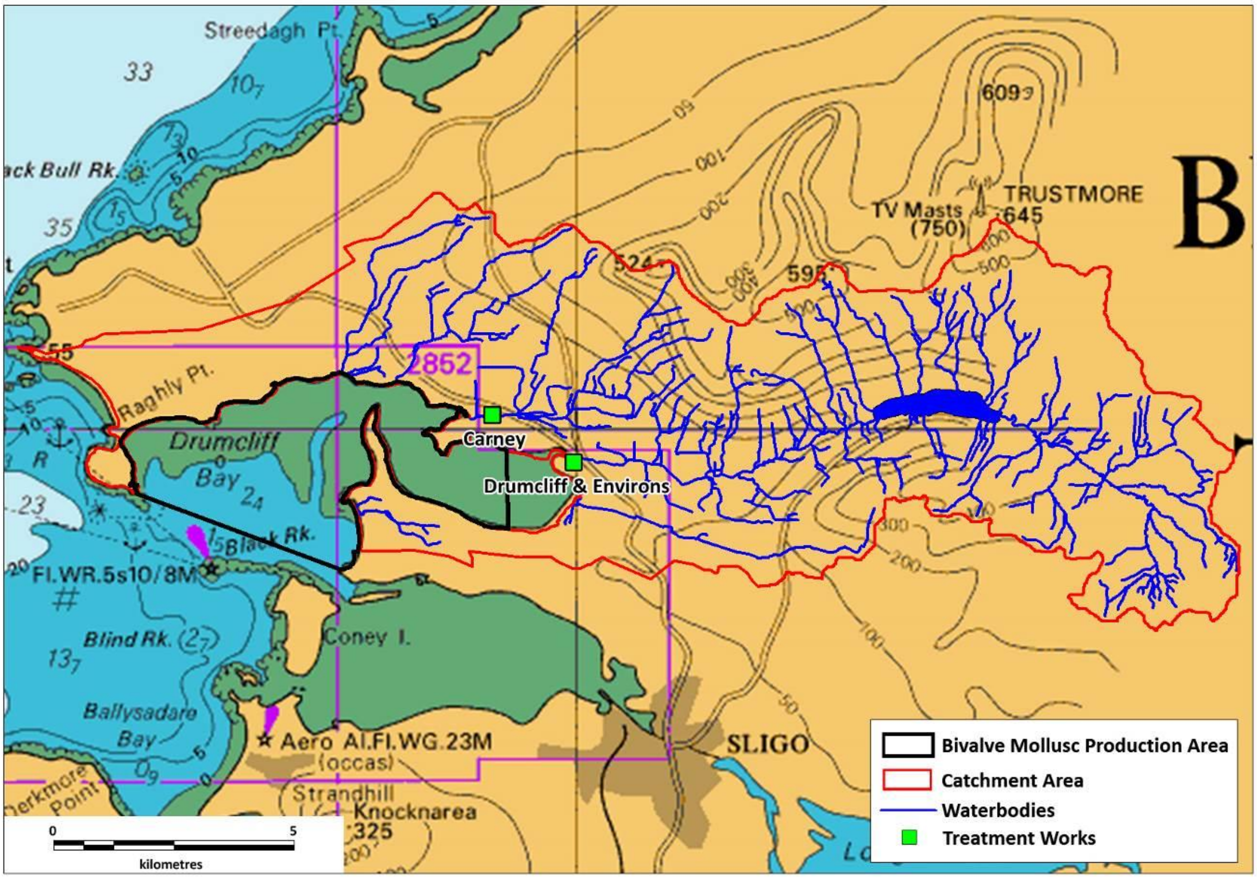


Figure 3.5: Wastewater Treatment Works within the Drumcliff Bay Catchment Area (Source: The EPA, 2019a).

Table 3.3: Wastewater Treatment Works within the Drumcliff Bay Catchment Area (Source: EPA, 2019a).

Name	Easting	Northing	Longitude	Latitude	p.e.	Designed p.e.
Carney	565642.4	843205	-8.5283	54.33639	387	2000
Drumcliff & Environs	567333	842207.2	-8.5022	54.32754	93	150

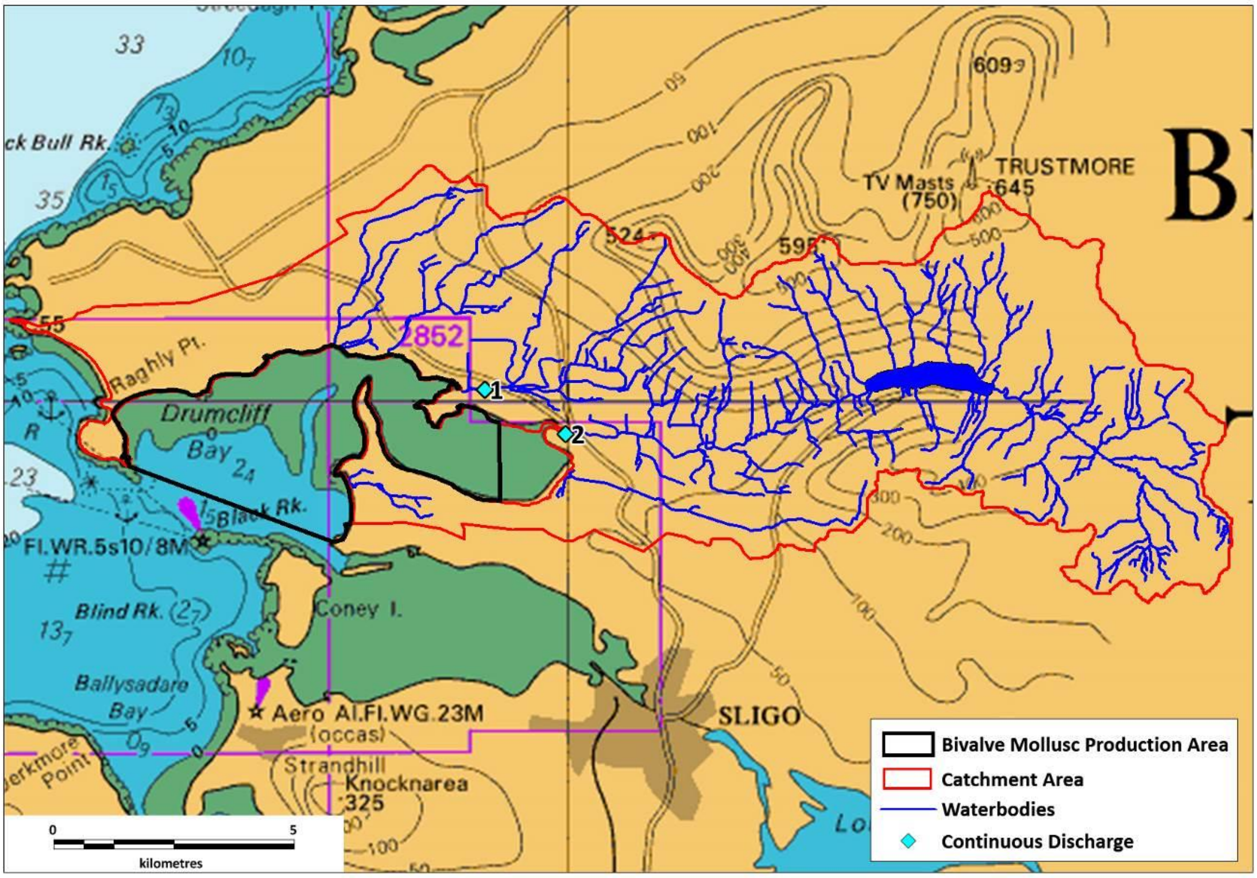


Figure 3.6: Continuous Discharges associated with the Wastewater Treatment Works within the Drumcliff Bay Catchment Area (Source: The EPA, 2019a).

Table 3.4: Continuous Discharges within the Drumcliff Bay Catchment area (Source: EPA, 2019a). Map Codes refer to Figure 4.6.

Map Code	Name	Treatment	Easting	Northing	Longitude	Latitude	Receiving Body	Max Discharge/ day (m3)	DWF/ day (m3)
1	Carney	3P - Tertiary P Removal	165638	343185	-8.52825	54.33603	Drumcliff Bay	3,038	336.96
2	Drumcliff & Environs	2 - Secondary Treatment	167311	342246	-8.50243	54.32771	Drumcliff Bay	N/A	N/A

Table 3.5: Sewage facilities at permanent households in the EDs that overlap Drumcliff catchment area (CSO, 2019a).

Electoral Division	Entire ED					
	Permanent Private Household	Public Sewage Scheme	Individual Septic Tank	Other individual treatment	Other /Not Stated	No sewage facility
Aghalateeve / Aghanlish	84	3	74	4	3	0
Calry	620	22	526	49	23	0
Carney	255	5	223	21	6	0
Drumcliff East	285	18	232	29	5	1
Drumcliff West	666	290	326	23	26	1
Glencar (Leitrim)	93	6	75	9	3	0
Glencar (Sligo)	82	2	68	3	8	1
Lissadell East	298	138	136	15	9	0
Lissadell North	504	180	286	23	14	1
Lissadell West	227	12	197	13	5	0
Rossinver East	70	0	63	3	2	2
Rossinver West	80	0	72	7	1	0
Sramore	140	2	119	13	6	0
Total	3404	678	2397	212	111	6

3.1.3.3. Rainfall Dependent / Emergency Sewage Discharges

In addition to WWTPs having a continuous discharge pipe some 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 4.6 and their locations can be seen in Figure 3.7.

Table 3.6: Rainfall dependent discharges (storm water overflows) within the Drumcliff Bay Catchment area (Source: EPA, 2019a). Map Codes refer to Figure 4.7.

Map Code	Name	Discharge Point Code	Easting	Northing	Longitude	Latitude	Receiving Body
1	Carney	SW01	165638	343185	-8.52825	54.33603	Drumcliff Bay

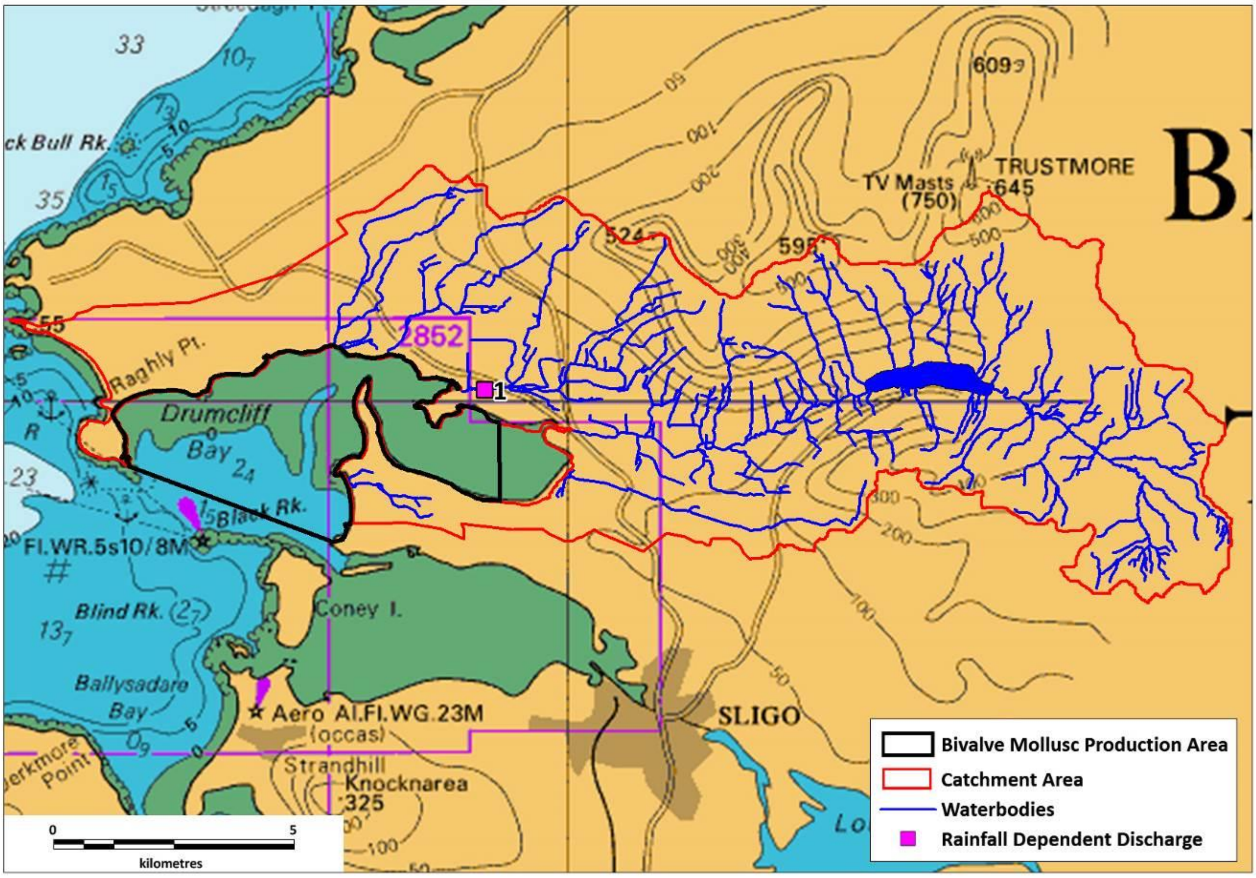


Figure 3.7: Rainfall Dependent Discharges associated with the Wastewater Treatment Works within the Drumcliff Bay Catchment Area (Source: The EPA, 2019a).

3.1.4. Industrial Discharges

There are no IPC or IEL facilities with discharges to water within the Drumcliff Bay catchment area accounted for during the desk-based assessment (EPA, 2019c).

There are 2 Section 4 licences (see Figure 3.8) for the discharge of trade effluent (EPA, 2019d). Discharge 1 on the below map belongs to an oyster depuration/discharge centre and does not contain any domestic waste. The discharge to the east (Point 2) is that of a large restaurant/lounge business and includes waste water. No volumes or flows were available at the time of the report. Table 3.7 shows details of these Section 4 licences. Specifics of the discharges are unknown.

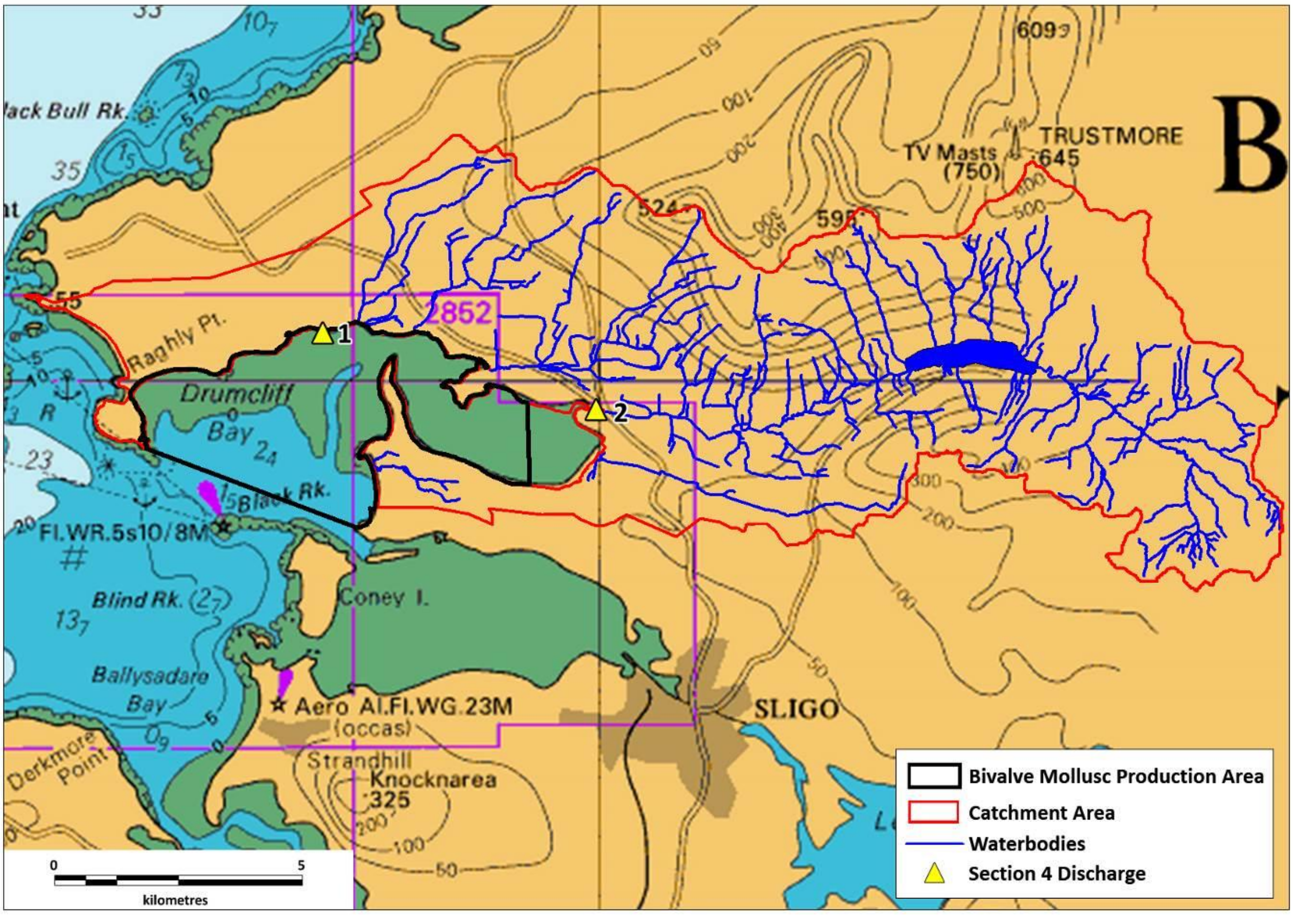


Figure 3.8: Section 4 discharges within the Drumcliff Bay Catchment Area (Source: (EPA, 2019c; EPA, 2019d).

Table 3.7: Details on Section 4 discharges within the Drumcliff Bay Catchment Area (Source: EPA, 2019d). Map Codes refer to Figure 4.8.

Map Code	File Reference	Licence holder	Facility Type	Nature of Discharge	Longitude	Latitude	Easting	Northing
1	DL(W) 4(rev1)	Ltd. Company	Commercial	Trade	-8.58734	54.34218	561808.2	843879.8
2	DL (W) 75	Ltd. Company	Commercial	Mixed domestic and trade	-8.50244	54.32833	567318	842295.2

3.1.5. Landuse Discharges

Figure 3.9 shows the Corine landuse (EPA, 2019e) within the Drumcliff Bay catchment area. Figure 4.4 (page shows all rivers/streams within the catchment area. Within the catchment area, land use is dominated by pastures (50.9km^2, 41%), followed by Land principally occupied by agriculture, with significant areas of natural vegetation (18.6km^2, 15%), peat bogs (17km^2; 14%), Intertidal Flats (8.9km^2; 7%), moors and heathland (7.6km^2; 6%) and Natural Grasslands (7.5km^2, 6%) (see Figure 4.10). Forestry (coniferous, broad-leafed and mixed) makes up 4.3% of the land use in the area (5.3km^2).

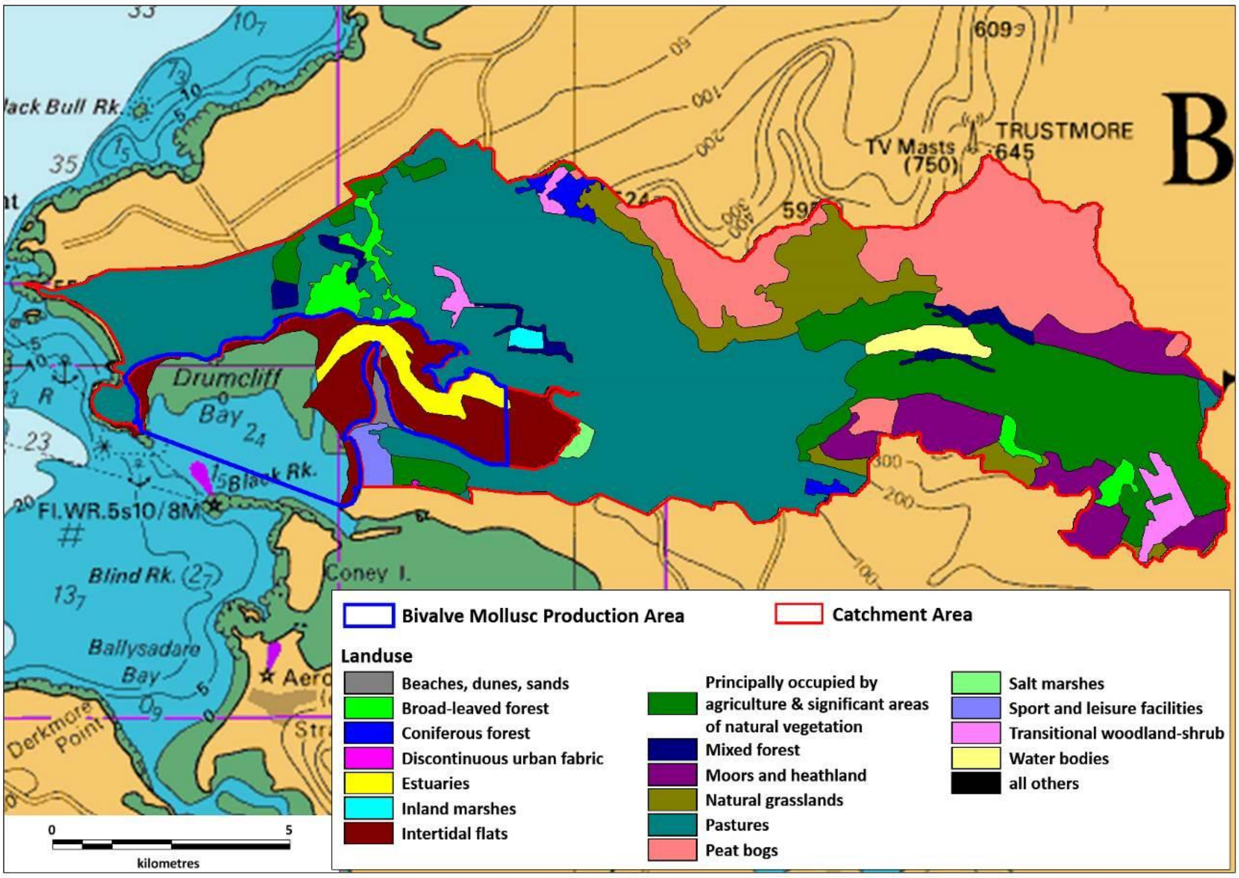


Figure 3.9: Land use within the Drumcliff Bay Catchment Area (Source: EPA, 2019e).

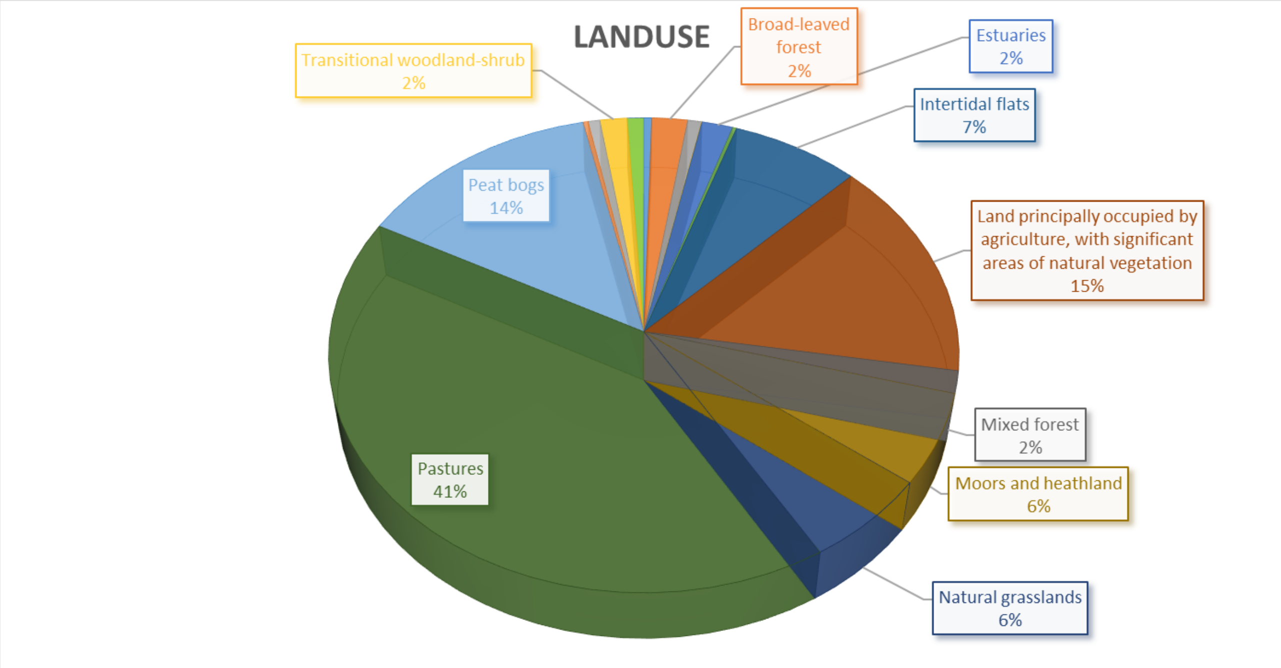


Figure 3.10: Breakdown of landuse within the Drumcliff Bay Catchment Area (only landuse ≥1% is labelled).

Data from the Census of Agriculture 2010 (CSO, 2019b) are presented in Table 3.8 below. Figures 3.11 to 3.18 show thematic maps for each category in Table 3.10. There are no farms or agricultural activity in the Aghalateeve / Aghanlish ED which is located in the north eastern extent of the catchment.

Numbers of farms within the catchment range from 27 in Drumcliff West, 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 2,133 ha in Rossinver East, Co. Sligo. The average farm size ranges from 18.1 ha in Drumcliff West, Co. Sligo to 38.1 ha in Rossinver East, Co. Sligo.

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 2,133 ha in Rossinver East, Co. Sligo. Total crops range from 0 ha in all areas with the exception of 5 ha in Calry, Co. Sligo and 10 ha in Lissadell West, Co. Sligo.

The total number of cattle within the catchment range from 168 in Glencar, Co. Sligo to 2,689 in Lissadell West, Co. Sligo. The total number of sheep within the catchment range from 314 in Lissadell West, Co. Sligo to 10,444 in Rossinver East, Co. Sligo. The total number of horses within the catchment range from 0 at Lissadell East, Co. Sligo to 45 in Rossinver West, Co. Sligo.

The total area farmed in the entire EDs shown in Figures 3.11 to 3.19 amounts to 16,618 ha. However, as all of these EDs 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 6,598 ha. This represents 39.7% of the area.

Table 3.8: Farm census data for all EDs within the Drumcliff Bay 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	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Calry	Sligo	98	2027	21	5	2022	1232	4779	20
Carney	Sligo	43	1252	29	0	1252	766	6757	8
Drumcliff East	Sligo	40	1070	27	0	1069	1088	3927	2
Drumcliff West	Sligo	27	488	18	0	488	498	451	4
Glencar	Leitrim	65	2090	32	0	2090	305	10166	2
Glencar	Sligo	28	811	29	0	810	168	6744	6
Lissadell East	Sligo	39	942	24	0	942	1439	343	0
Lissadell North	Sligo	75	1383	18	0	1384	1575	2551	28
Lissadell West	Sligo	54	1551	29	10	1541	2689	314	7
Rossinver East	Sligo	56	2133	38	0	2133	649	10444	6
Rossinver West	Sligo	39	1049	27	0	1049	528	4705	45
Sramore	Leitrim	60	1822	30	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.

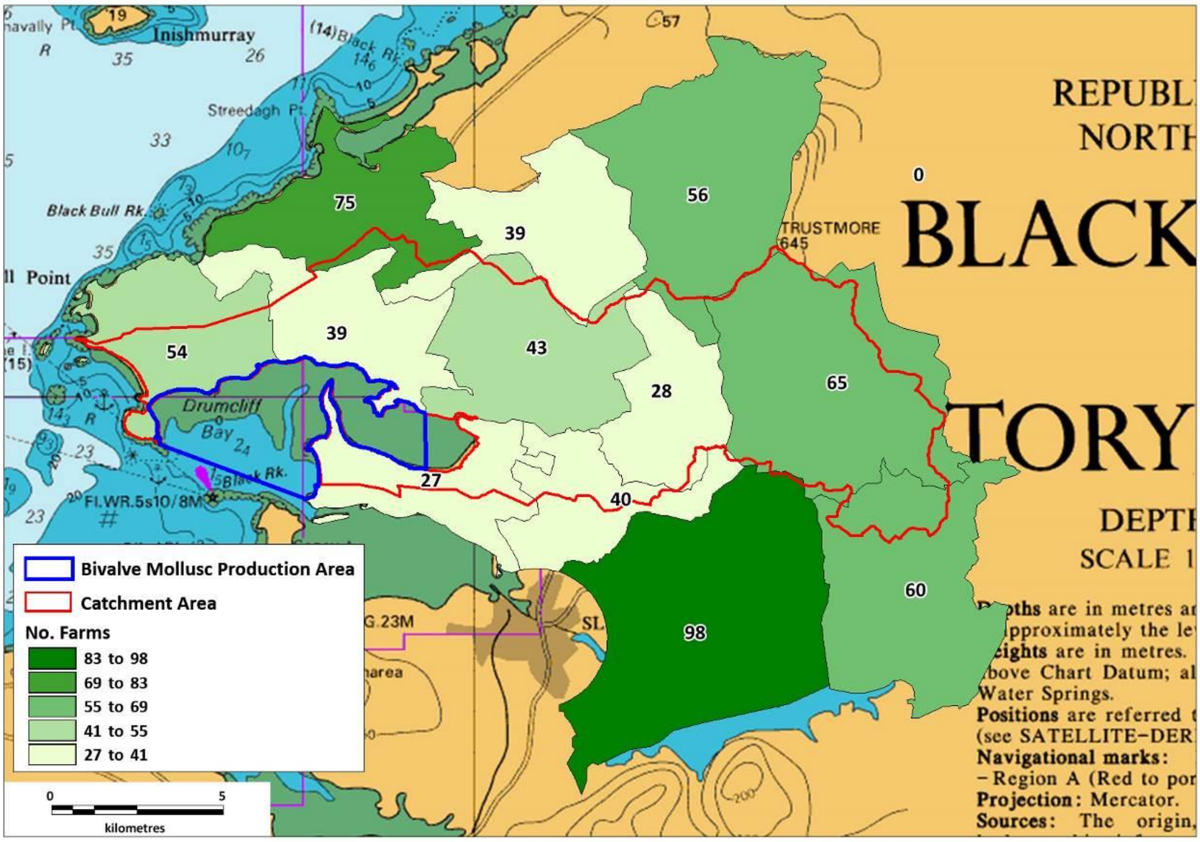


Figure 3.11: Number of farms within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

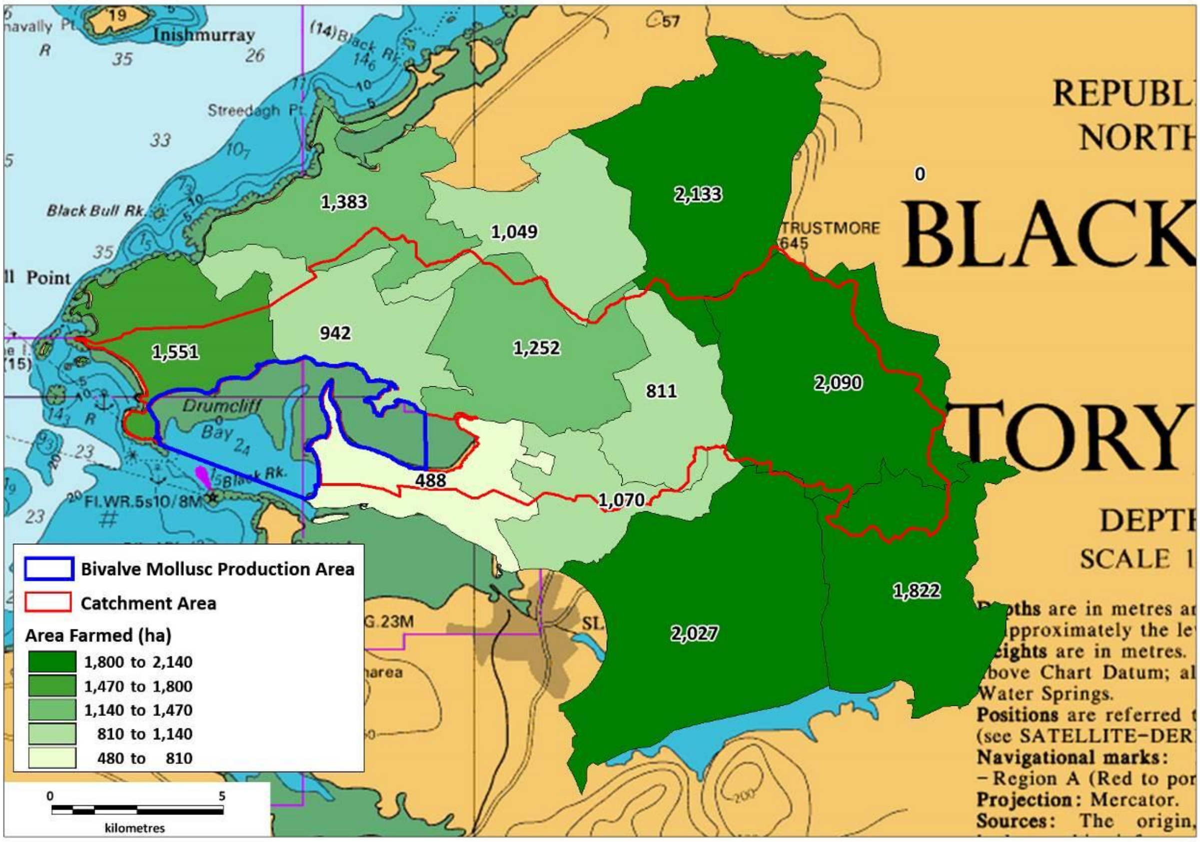


Figure 3.12: Area farmed (ha) within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

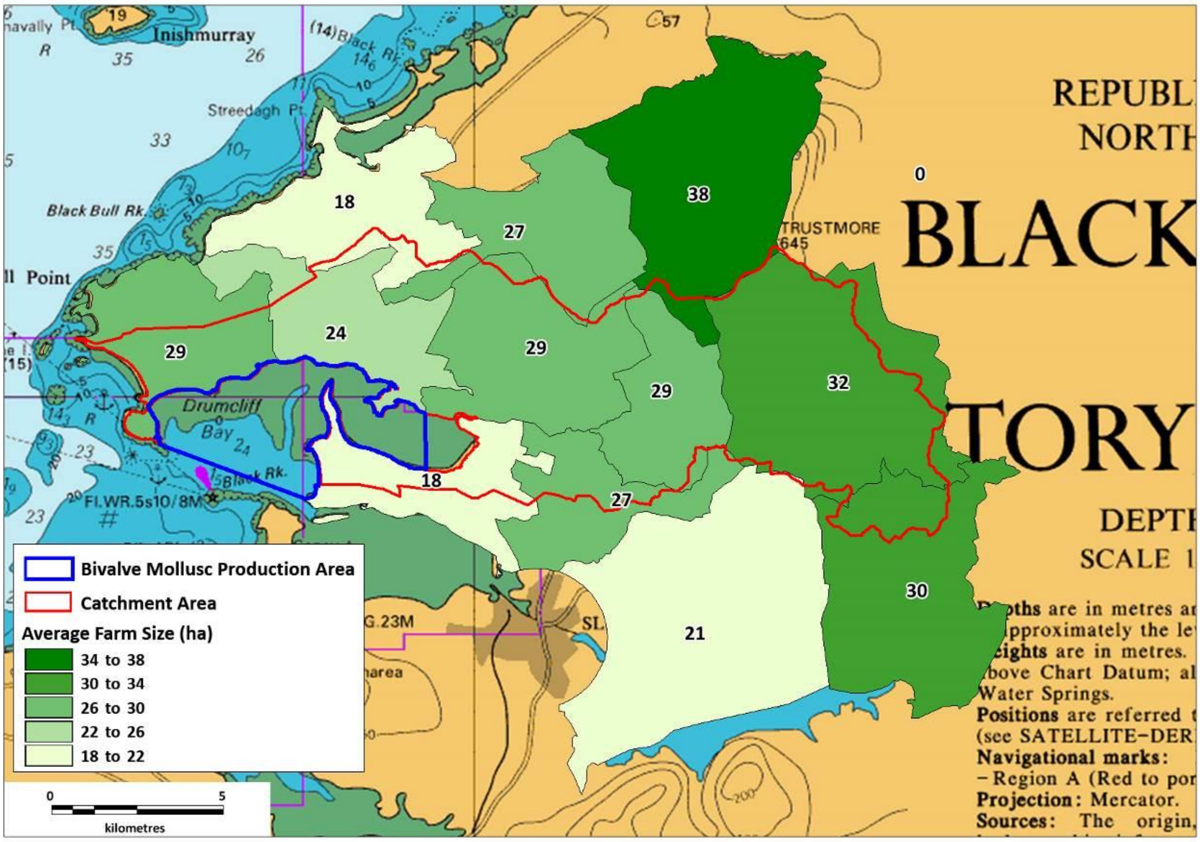


Figure 3.13: Average farm size (ha) within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

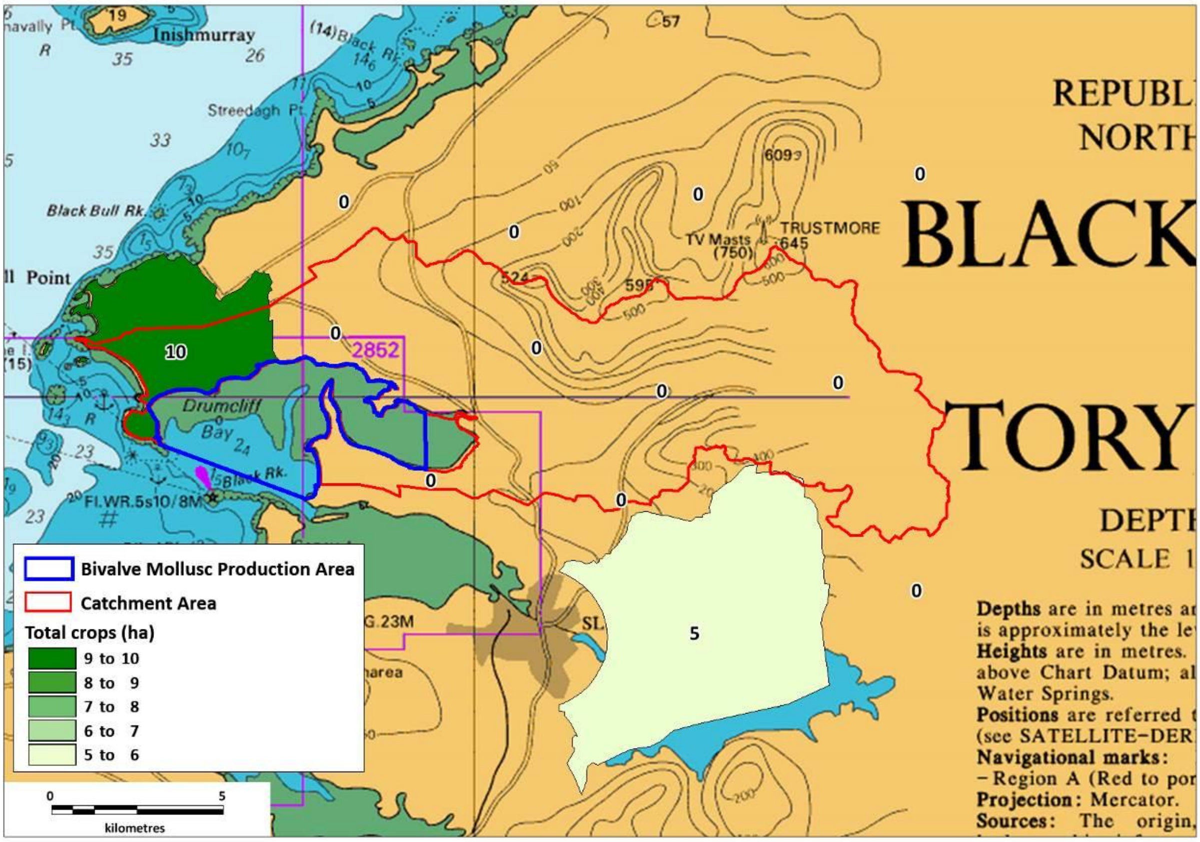


Figure 3.14: Total crops within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

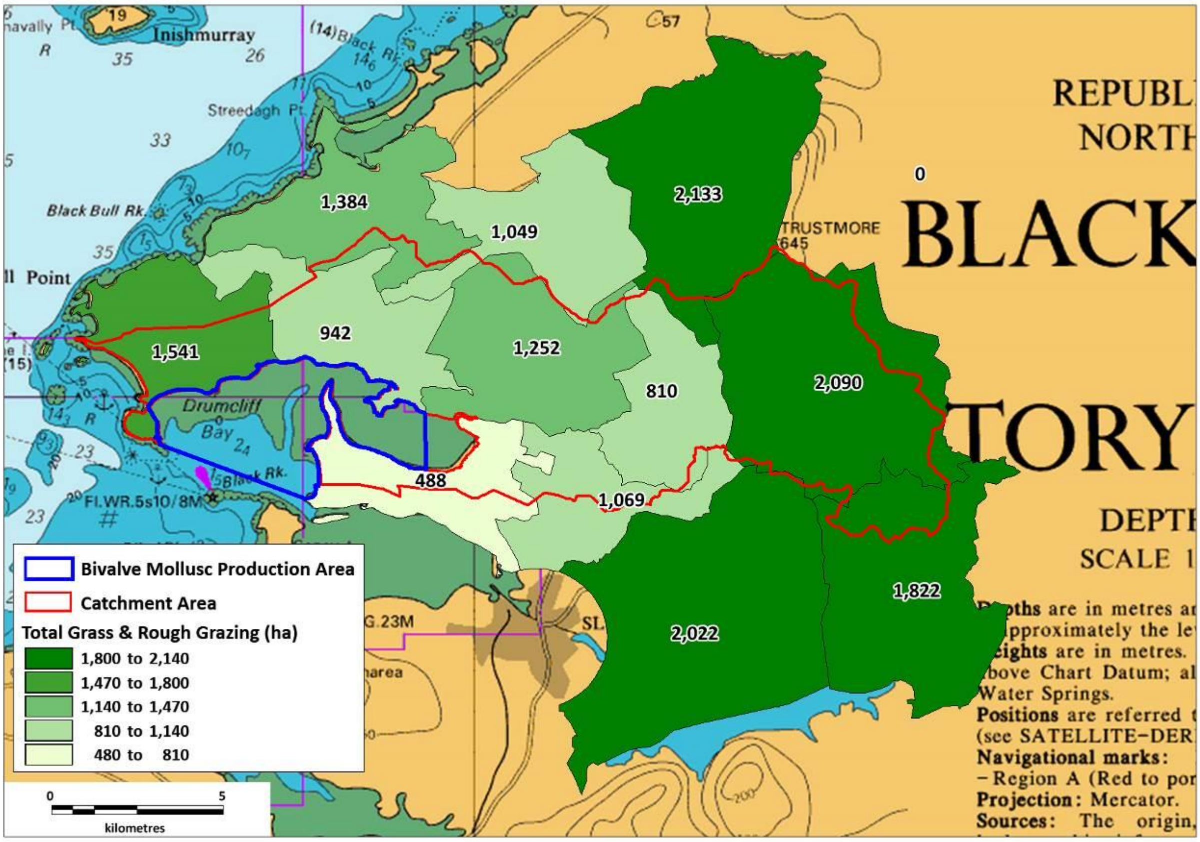


Figure 3.15: Total grass and rough grazing within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

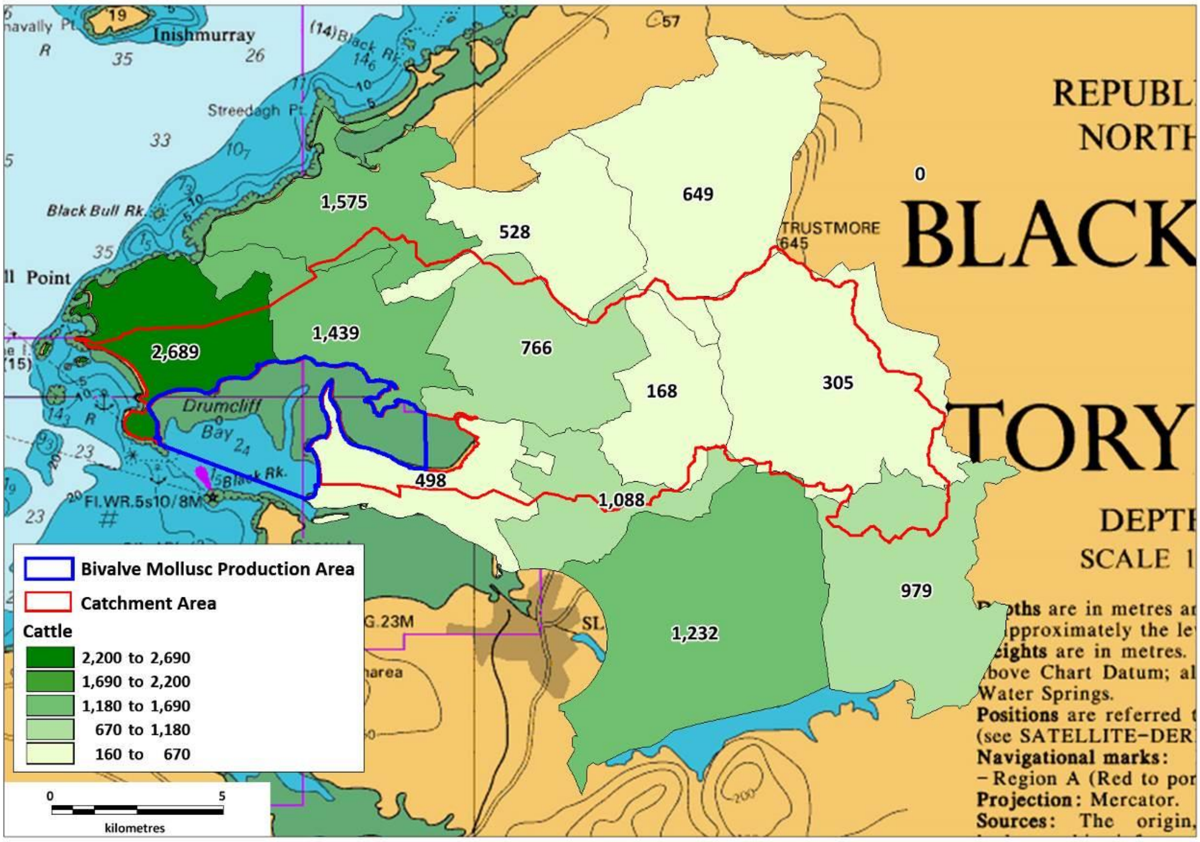


Figure 3.16: Cattle within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

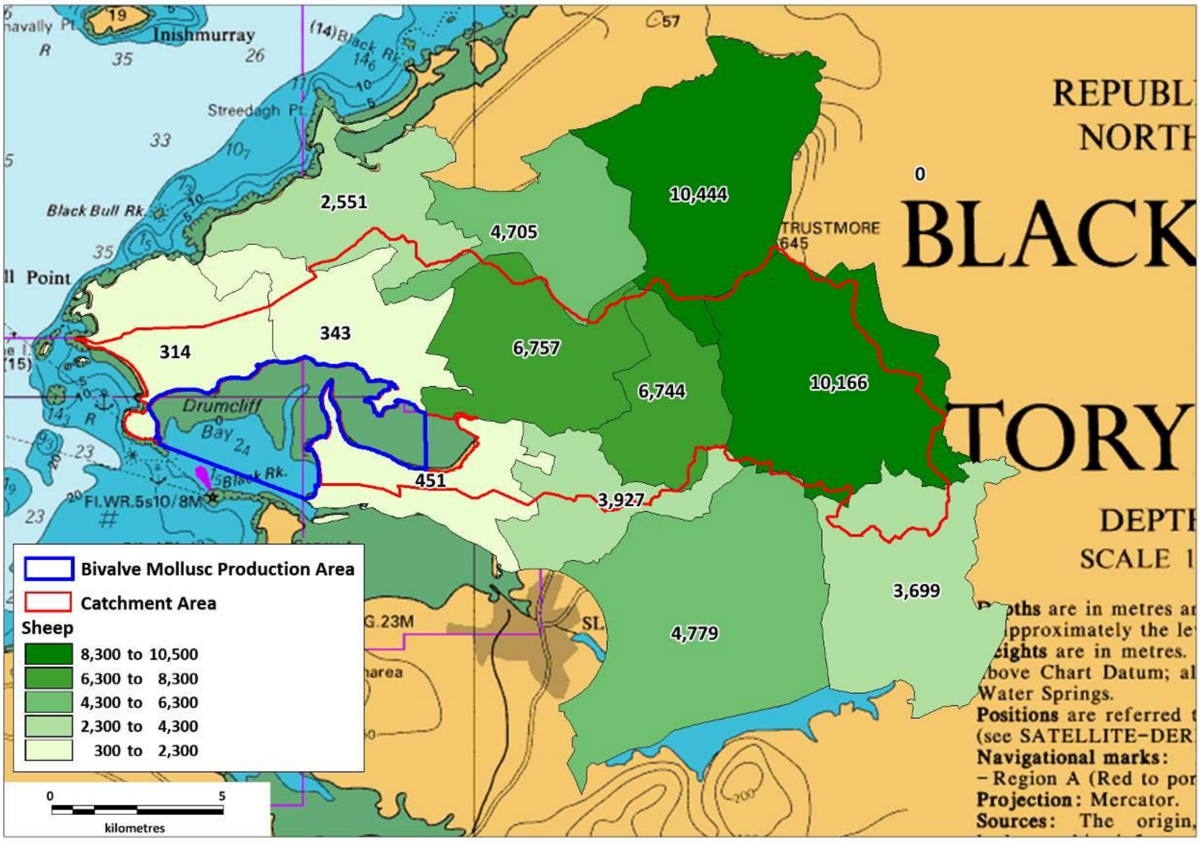


Figure 3.17: Sheep within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

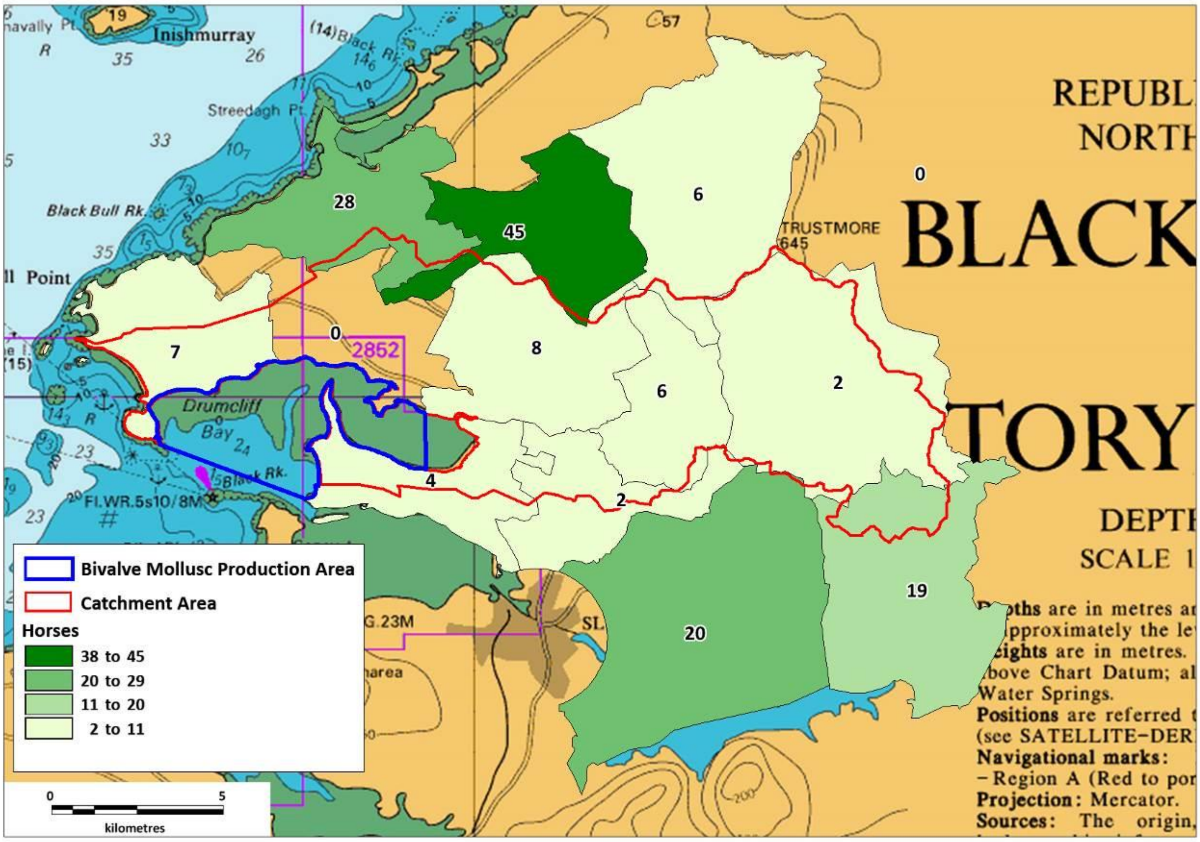


Figure 3.18: Horses within the Drumcliff Bay Catchment Area (Source: CSO, 2019b).

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 3.9 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 3.9: Potential daily loading of *E. coli* (Jones & White, 1984).

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

The large 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 eastern half of the catchment which is more mountainous while the highest numbers of cattle are present in the western flatter regions. 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. Birds and livestock were recorded on a number of occasions during the shoreline survey (see section 4). 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. Other Pollution Sources

3.1.6.1. Shipping

Figure 3.19 shows all boat facilities and activities in Drumcliff Bay. Table 4.10 details these facilities. There are no commercial ports in Drumcliff Bay.

There are no ferries operating in Drumcliff Bay. There are several piers, slipways and other shore access points located along the shorelines of Drumcliff Bay. Drumcliff Bay is an inshore dredge fishing area for cockles; however, currently no vessels are recorded as fishing the area (Marine Institute, 2015b). All the access points 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, it is highly unlikely that any discharges from the relatively small number of vessels in the area would have any negative impacts on water quality.

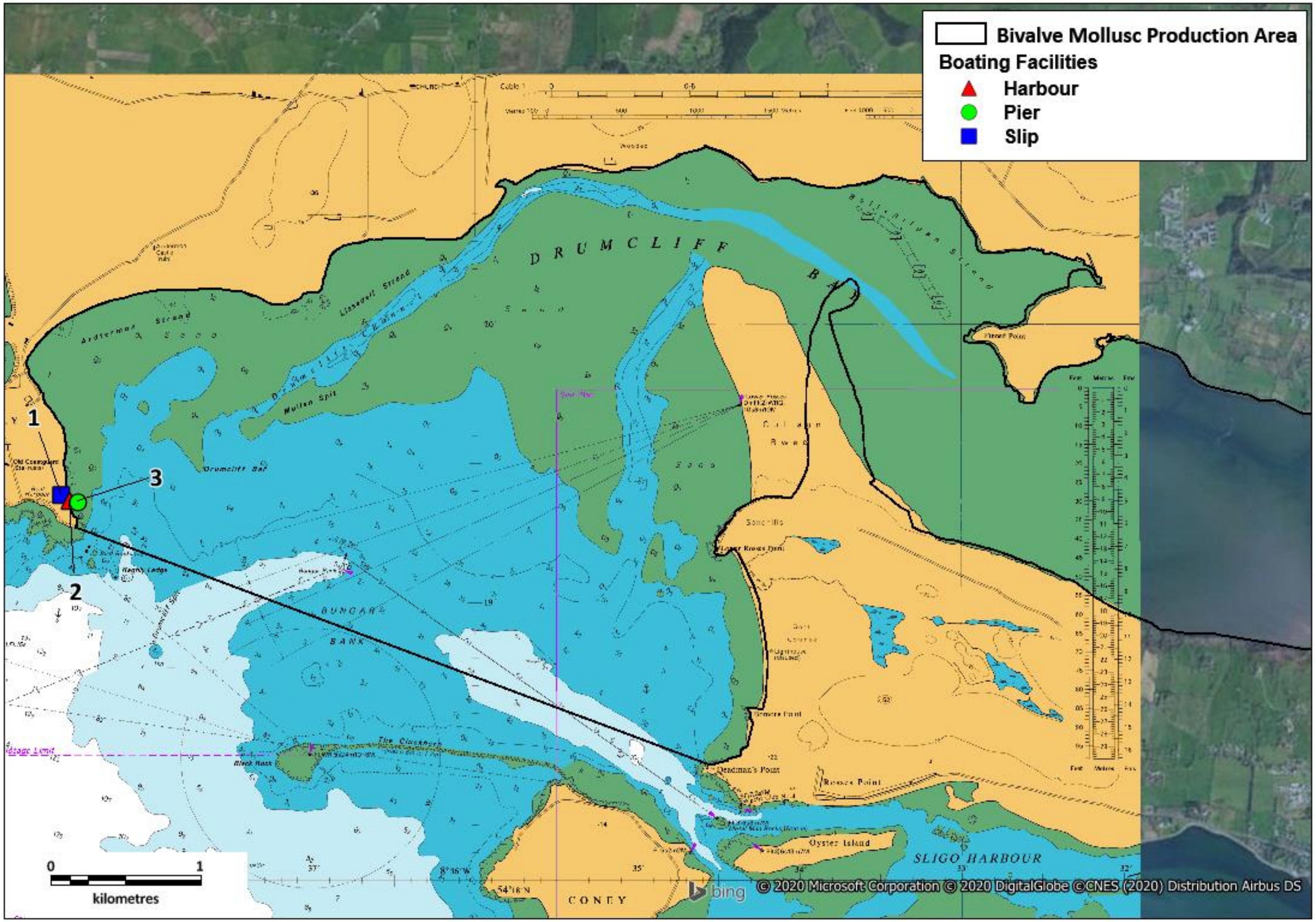


Figure 3.19: Location of all boating facilities and activities in Drumcliff Bay.

Table 3.10: Boating facilities in Drumcliff Bay. Map Code refers to Figure 4.19.

Map Code	Feature	Use (if known)
1	Slip	Pleasure craft, Fishing, Aqua tourism
2	Harbour	Pleasure craft, Fishing, Aqua tourism
3	Pier	Pleasure craft, Fishing, Aqua tourism

3.1.6.2. Birds

It is important to document the bird populations in the Drumcliff Bay 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).

Drumcliff Bay is also designated as a Special Protection Area (SPA): Drumcliff Bay SPA (IE004013) (See Figure 2.1). Drumcliff Bay supports nationally important populations of Sanderling (237) and Bar-tailed Godwit (336). Other species that occur regularly include Whooper Swan (45), Light-bellied Brent Goose (74), Shelduck (75), Wigeon (138), Teal (57), Long-tailed Duck (14), Red breasted Merganser (20), Great Northern Diver (13), Oystercatcher (356), Ringed Plover (139), Lapwing (155), Knot (107), Dunlin (559), Curlew (177) and Redshank (138) (NPWS, 2014a).

Cummeen Strand SPA (IE004035) is located to the south of Drumcliff Bay in Sligo Harbour (see Figure 2.1). 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, 2014b).

Ballintemple and Ballygilgan SPA (IE004234) is located to the north west of Drumcliff Bay. The site is designated due to the presence of an internationally important population of Barnacle Goose (c. 5,000 in 2011). It is the most important site in the country for this species (NPWS, 2014c).

Drumcliff Bay 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 Drumcliff Bay between 20011/12 and 2015/16 seasons (Source: BWI, 2019).

Site Name	2011/12	2012/13	2013/14	2014/15	2015/16	Mean
Drumcliff Bay	7101	4557	3822	5851	4522	5170.6

Population levels of birds over the five years are fairly stable, with a low in the 2013/2014 season and a high in the following year 2011/2012. 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.

3.1.6.3. Aquatic mammals

There is one seal haul out sites in Drumcliff Bay at the tip of Cullaun Bwee, the spit north of Rosses Point. They may also on occasion forage at high water with in the bay. Otter (*Lutra lutra),* will certainly forage along the edge of the bay. Due to the shallow nature of Drumcliff Bay, Bottlenose Dolphin (*Tursiops truncatus)* and Harbour Porpoise (*Phocoena phocoena*) may only very rarely occur there.

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.

3.1.6.4. *Deer*

There are populations of both red and fallow deer within the Drumcliff catchment particularly in the Lissadell House area. No data on deer abundance in the areas was available at the time of writing of this report.

3.2. Shoreline Survey Report

A shoreline survey was carried out by the Sea Fisheries Protection Authority over 4 days between September 2018 and October 2018. Figure 3.20 shows the GPS (Global Positioning System) and photography sites accounted for during the 4 survey days.

The aim of this survey was to identify/confirm and mark all discharges, pollution sources, waterways and marinas along the shoreline. 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.

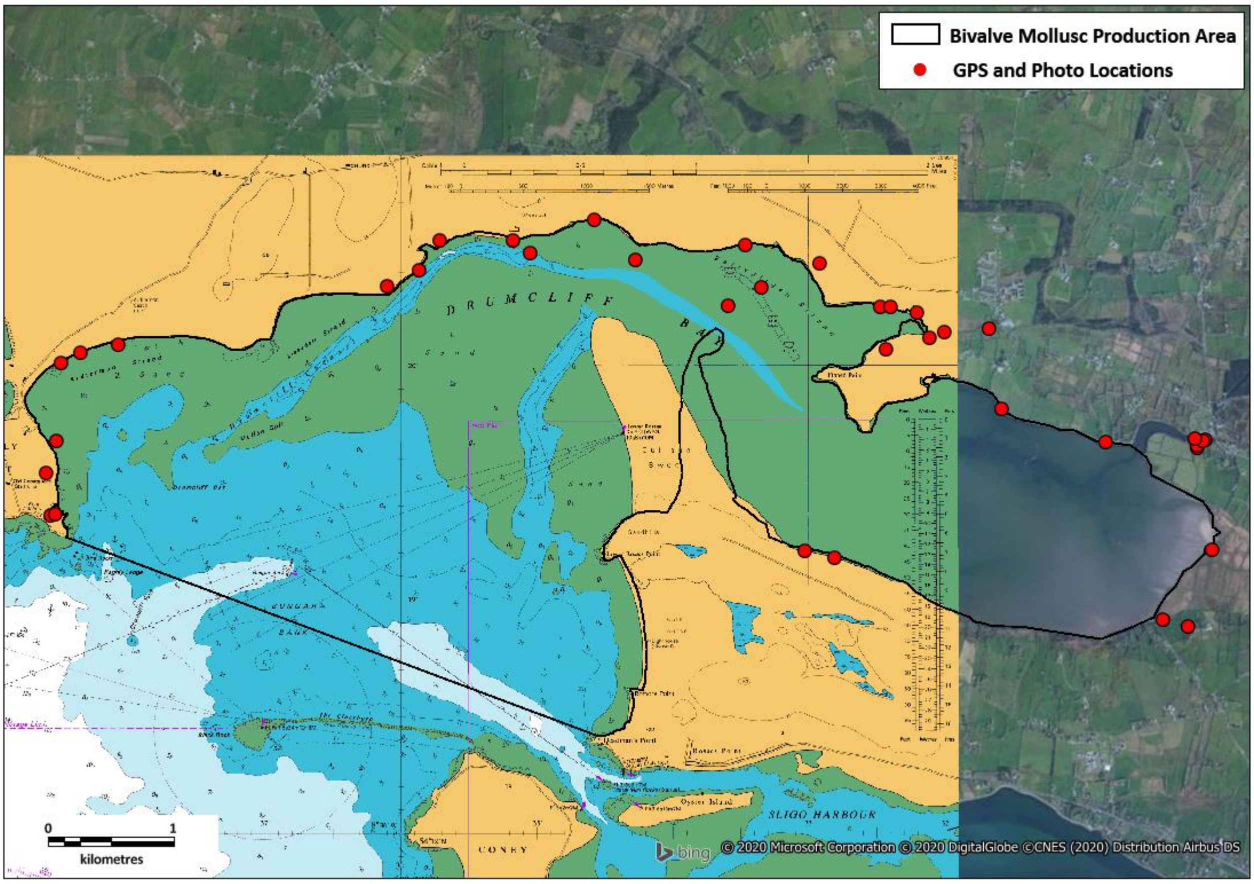


Figure 3.20: Locations of GPS and Photograph Sites.

Figure 3.20 shows the locations of all features observed during the shoreline survey. In total 32 features were identified, of which 7 rivers/streams were identified, 9 drains, 2 WWTP, 2 discharge pipes, 1 WWTP discharge, 1 intake pipe, 1 lagoon discharge, 1 harbour and 8 were in relation to landuse (bird usage, agriculture). Figures 3.21 to 3.32 show aerial imagery of the location of the features and Figures 3.33 and 3.34 shows images of most of these features. Table 3.12 details all features identified and the numbering used is cross-referenced to Figures 3.21 to 3.34.

Table 3.12: Features identified during the shoreline survey. Refer to Figures 3.21 – 3.33 for locations and Figures 3.34 to 3.36 for photographs.

Map ID	Observation	Latitude	Longitude	Easting	Northing
1	Lagoon Discharge, good flow, likely only saltwater from tide	54.32293	-8.64389	158152.7	341767.5
2	Raghly Harbour	54.32304	-8.64335	158188.0	341779.4
3	Pasture Land, 20 cows	54.326	-8.64443	158120.7	342109.6
4	Birds, mixed species 150 +	54.32828	-8.64319	158203.7	342362.6
5	Field drainage pipe, no discharge or flow, no signs of enrichment	54.33382	-8.64257	158249.7	342978.9
6	Field drainage pipe, no discharge or flow, no signs of enrichment	54.3346	-8.64023	158402.7	343064.4
7	Stream, small discharge, some algal growth	54.33515	-8.63556	158707.0	343122.8
8	Pasture Land, no animals	54.33929	-8.60265	160851.7	343564.9
9	Natural stream, low flow	54.34043	-8.59875	161106.5	343689.6
10	Natural stream, low flow	54.34259	-8.59615	161277.6	343928.6
11	Unknown pipe, likely outflow pipe from nearby oyster plant	54.34259	-8.58715	161863.0	343923.7
12	Intake pipe network - Oyster Depuration, Likely intake for nearby oyster plant	54.34172	-8.58513	161993.5	343825.8
13	Small river, normal flow	54.34408	-8.57721	162510.8	344084.2
14	Birds, geese 40 +	54.34122	-8.57211	162839.9	343763.2
15	Small river, normal flow, some algal growth	54.34228	-8.55871	163712.4	343874.2
16	Birds, geese 300+	54.34091	-8.54956	164306.3	343717.0
17	Field drainage pipe, no discharge or flow, no signs of enrichment	54.33787	-8.54209	164789.5	343374.9
18	Sheep feeding on shore	54.33781	-8.54081	164872.7	343367.5
19	Field drain, very low flow, no signs of enrichment	54.33739	-8.53759	165081.8	343319.2
20	Field drain, low flow, no signs of enrichment	54.33606	-8.5343	165294.7	343169.5
21	Carney River, normal flow	54.33559	-8.53602	165182.4	343118.0
22	Pasture Land	54.33483	-8.54148	164826.6	343036.2
23	Carney WWTP	54.33628	-8.52875	165655.9	343191.3
24	Field drain, low flow, enrichment evident	54.33059	-8.5272	165752.0	342557.1
25	Field drain, small flow, enrichment evident	54.3282	-8.51446	166578.9	342285.0
26	WWTP discharge pipes, Two pipes, very low flow. Enrichment evident	54.32792	-8.50319	167311.9	342248.5

Map ID	Observation	Latitude	Longitude	Easting	Northing
27	Drumcliff WWTP	54.32775	-8.50322	167309.8	342229.6
28	Small river, normal flow, some algal growth	54.3205	-8.50135	167425.7	341421.7
29	Cows, 10+	54.315	-8.50432	167228.1	340810.9
30	Field drain, no discharge or flow, no signs of enrichment	54.31548	-8.50749	167022.2	340865.8
31	Drainage pipe, some enrichment evident	54.31989	-8.54772	164407.8	341376.2
32	Field drainage pipe, low flow	54.3204	-8.55141	164168.1	341434.9
33	Seals (approx. 10)	54.33795	-8.56088	163569.6	343392.6
34	Man hole cover	54.32834	8.50226	167372.7	342294.8
35	Stream	54.32825	8.50259	167351.2	342285.0
36	Drain	54.32842	8.5035	167292.1	342304.3
37	Clam nets	54.33923	-8.55673	163,838.46	343,533.66

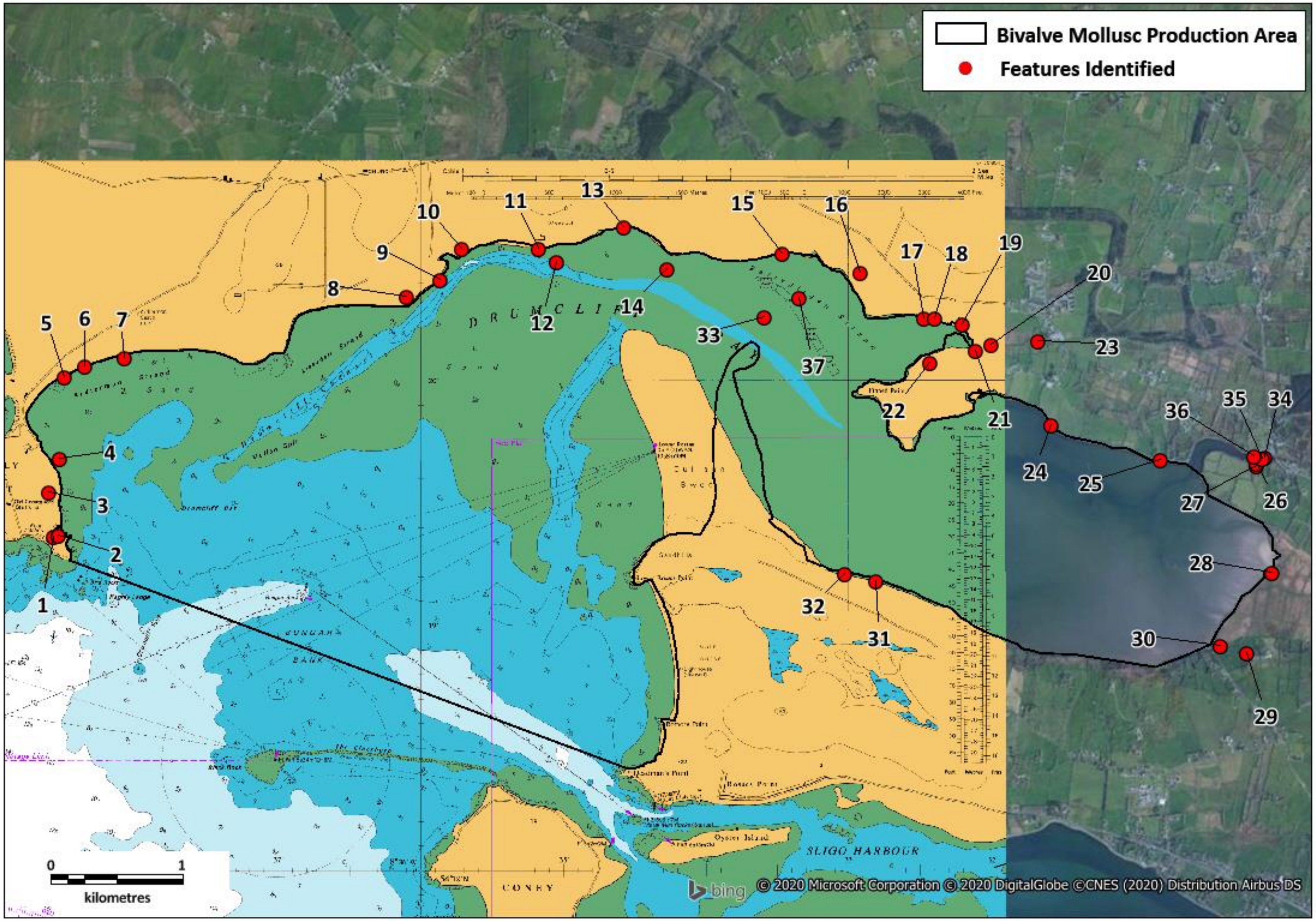


Figure 3.21: All features (numbering cross-reference to Table 3.12) identified during the shoreline survey.

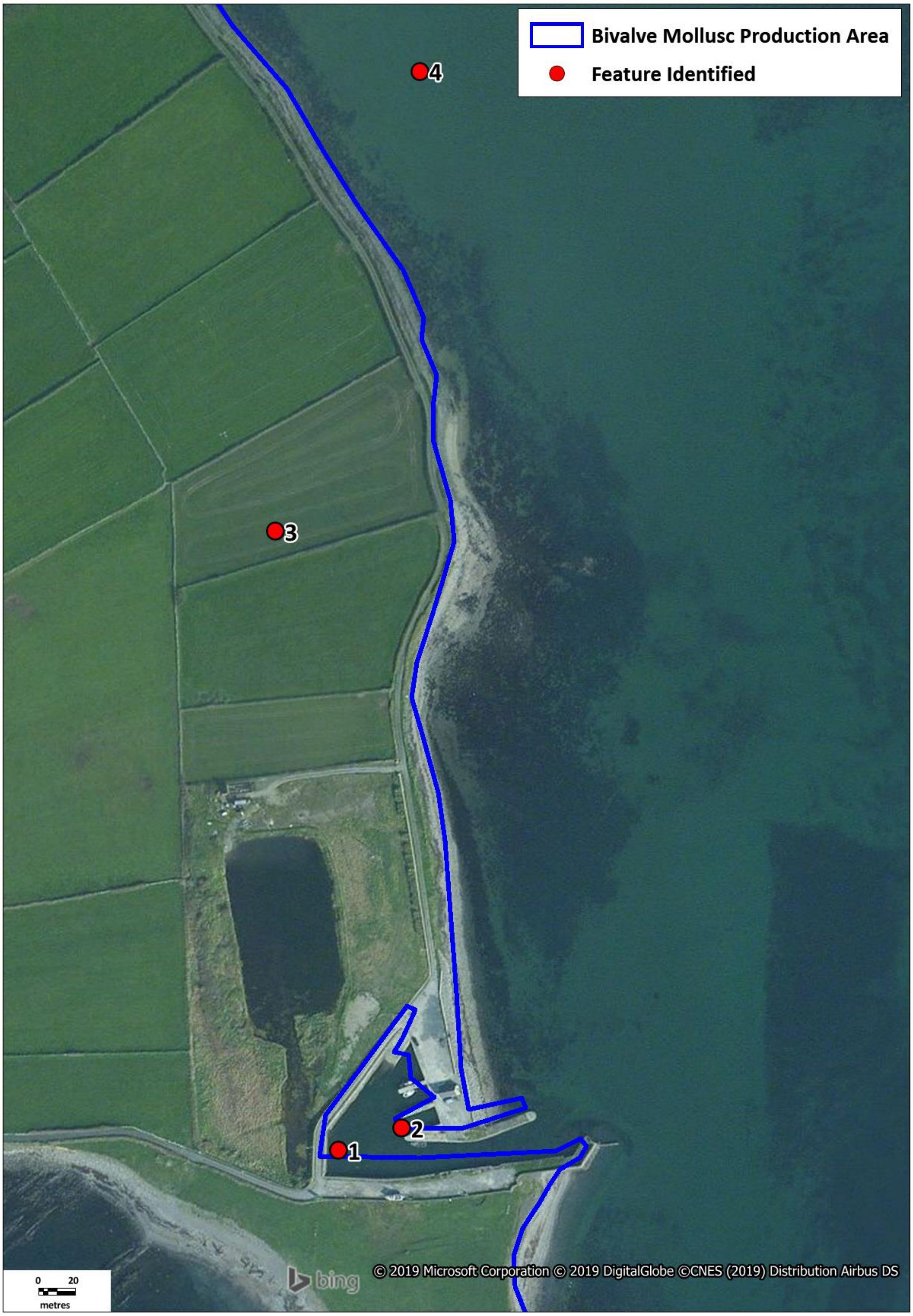


Figure 3.22: Features 1-4 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

Figure 3.23: Features 5-7 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

Figure 3.24: Features 8-10 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

Figure 3.25: Features 11-14 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

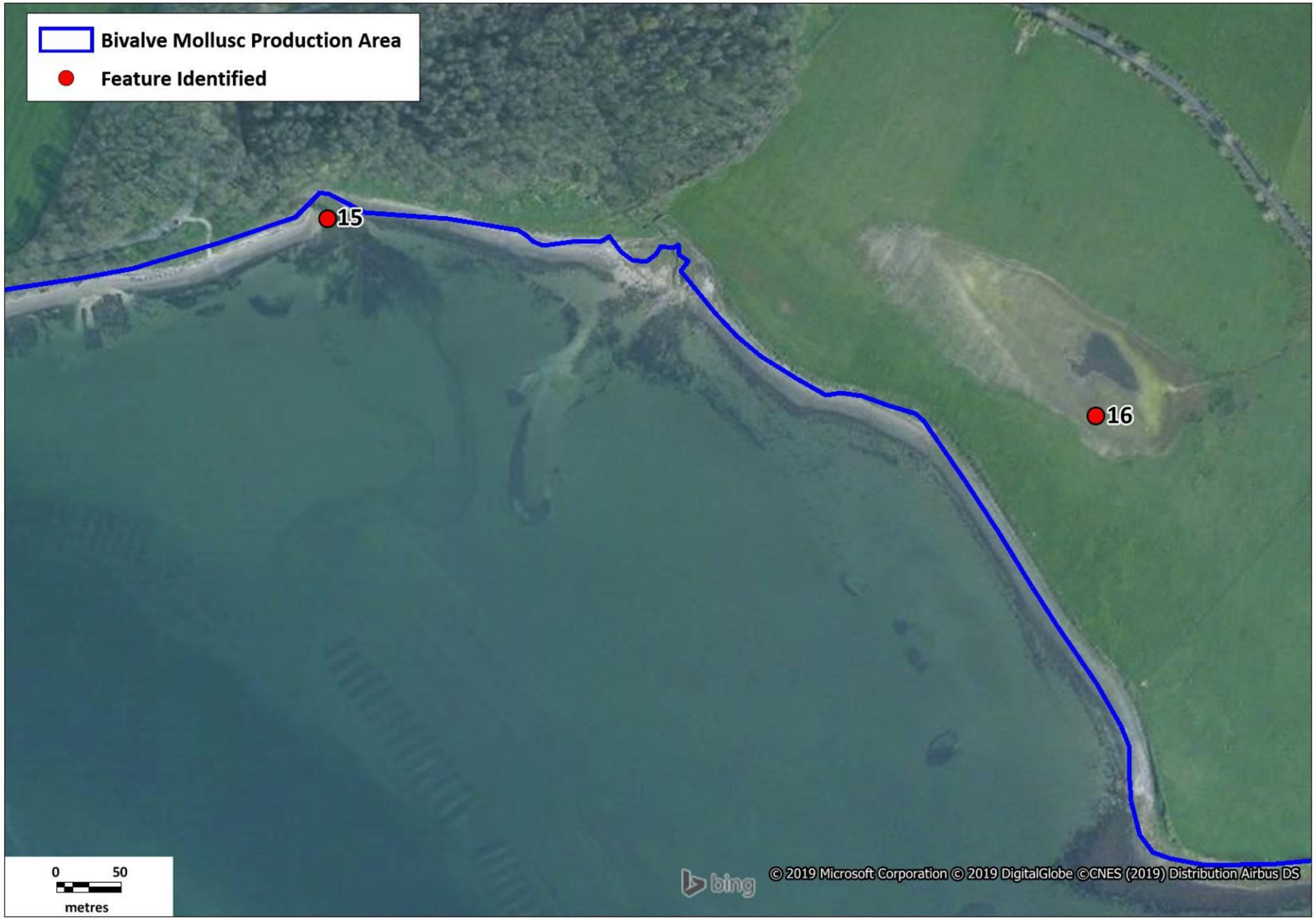


Figure 3.26: Features 15-16 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

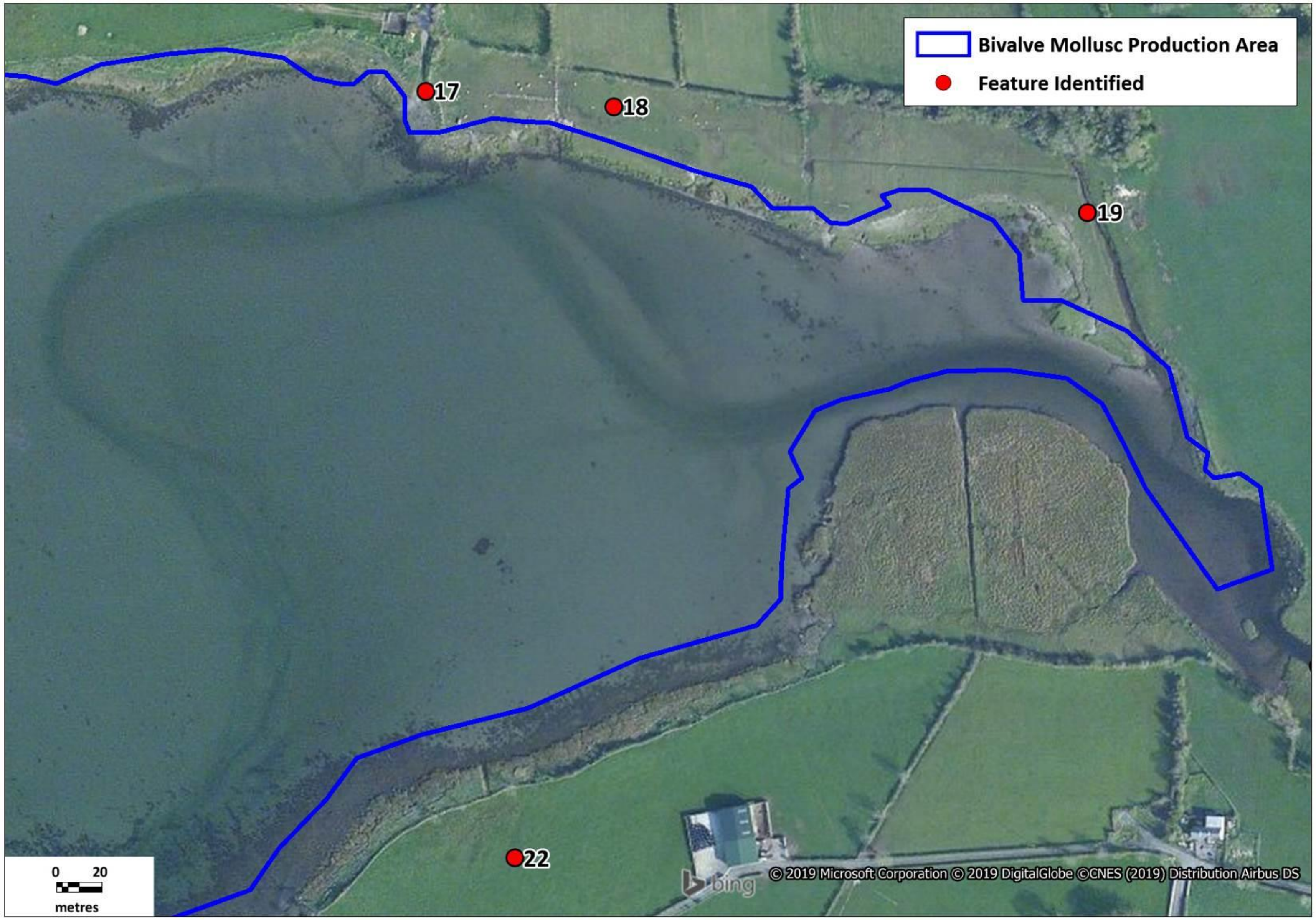


Figure 3.27: Features 17-19 and 22 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

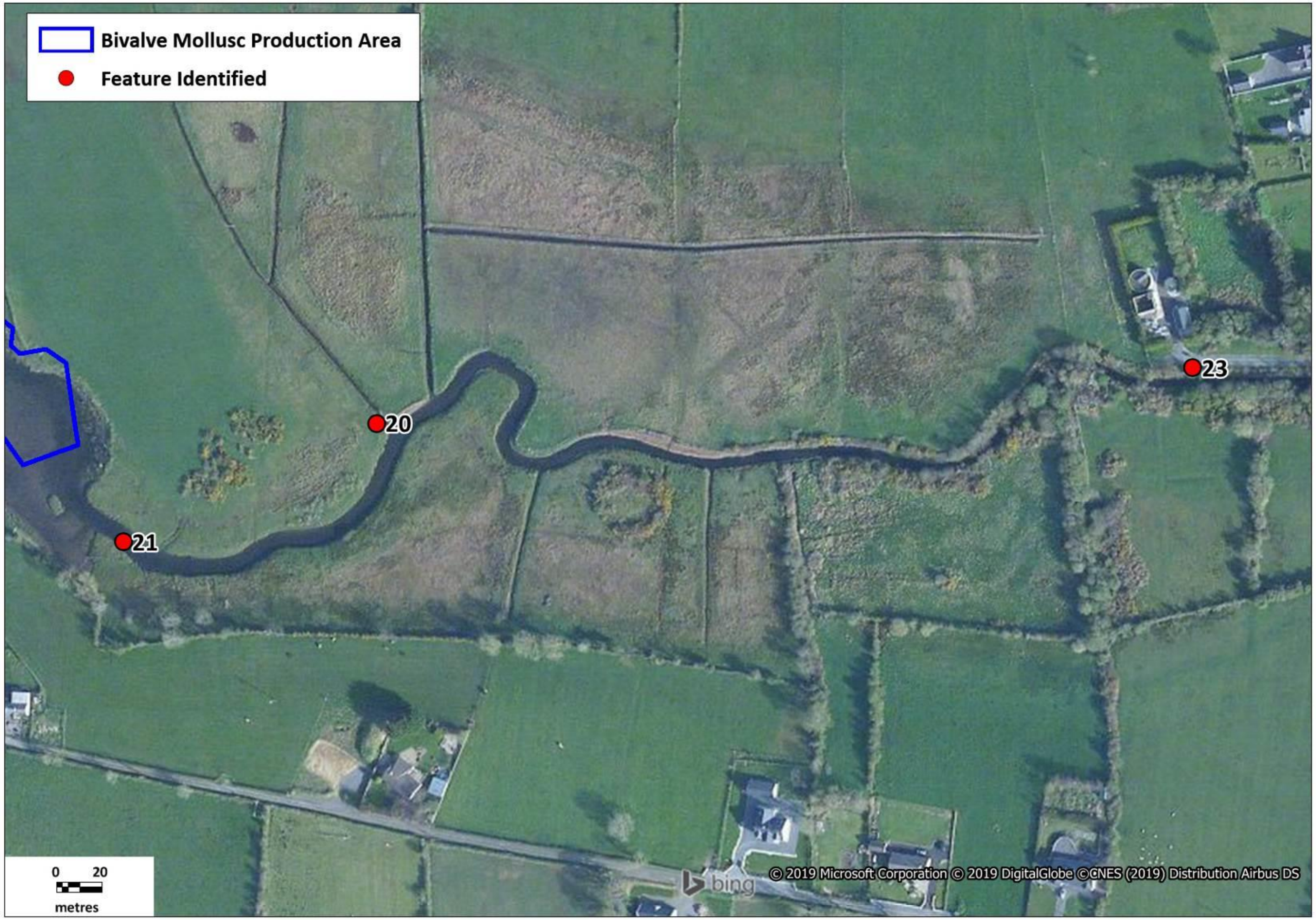


Figure 3.28: Features 20-21 and 23 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

Figure 3.29: Features 24-25 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

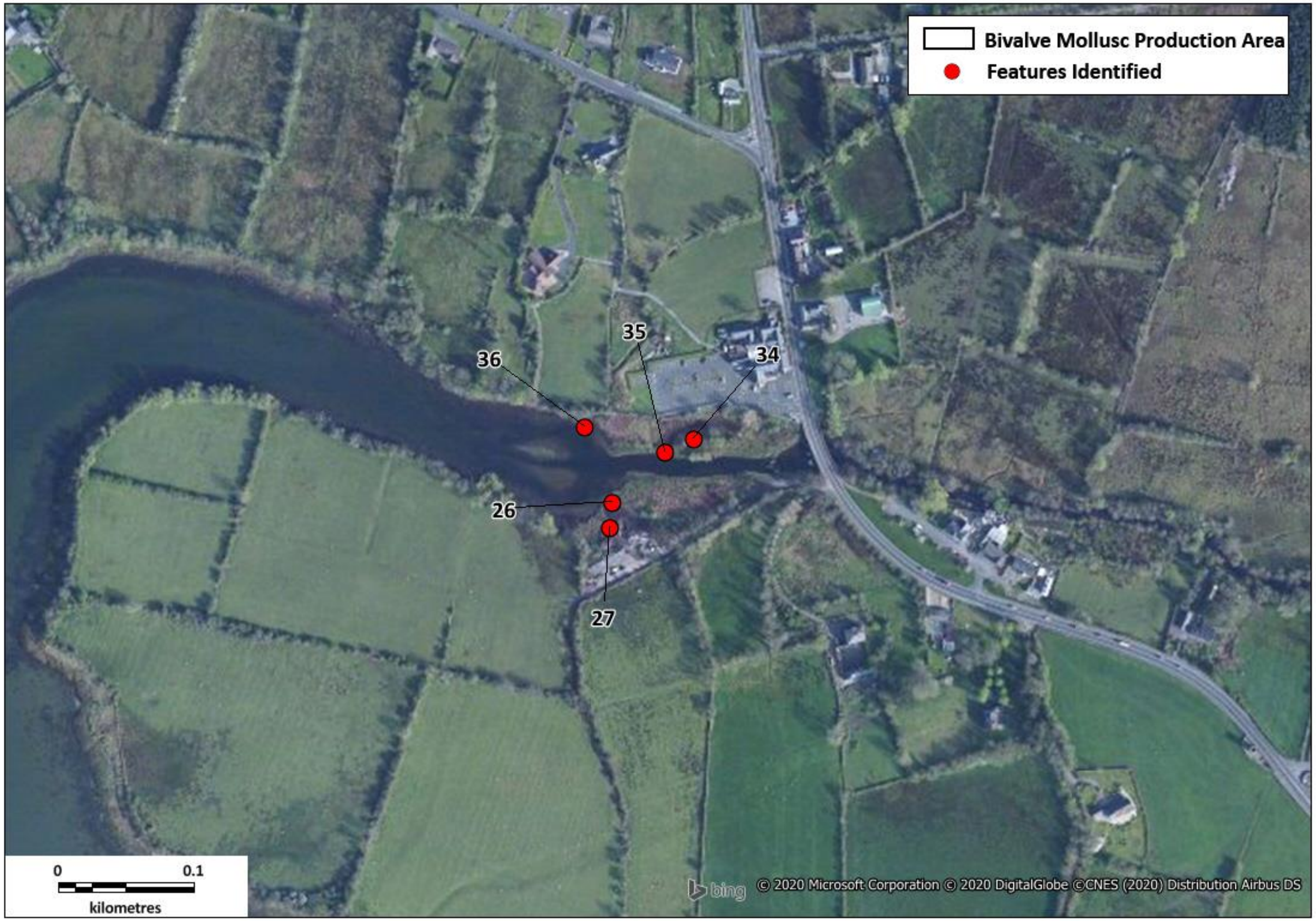


Figure 3.30: Features 26-27 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

Figure 3.31: Features 28-30 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

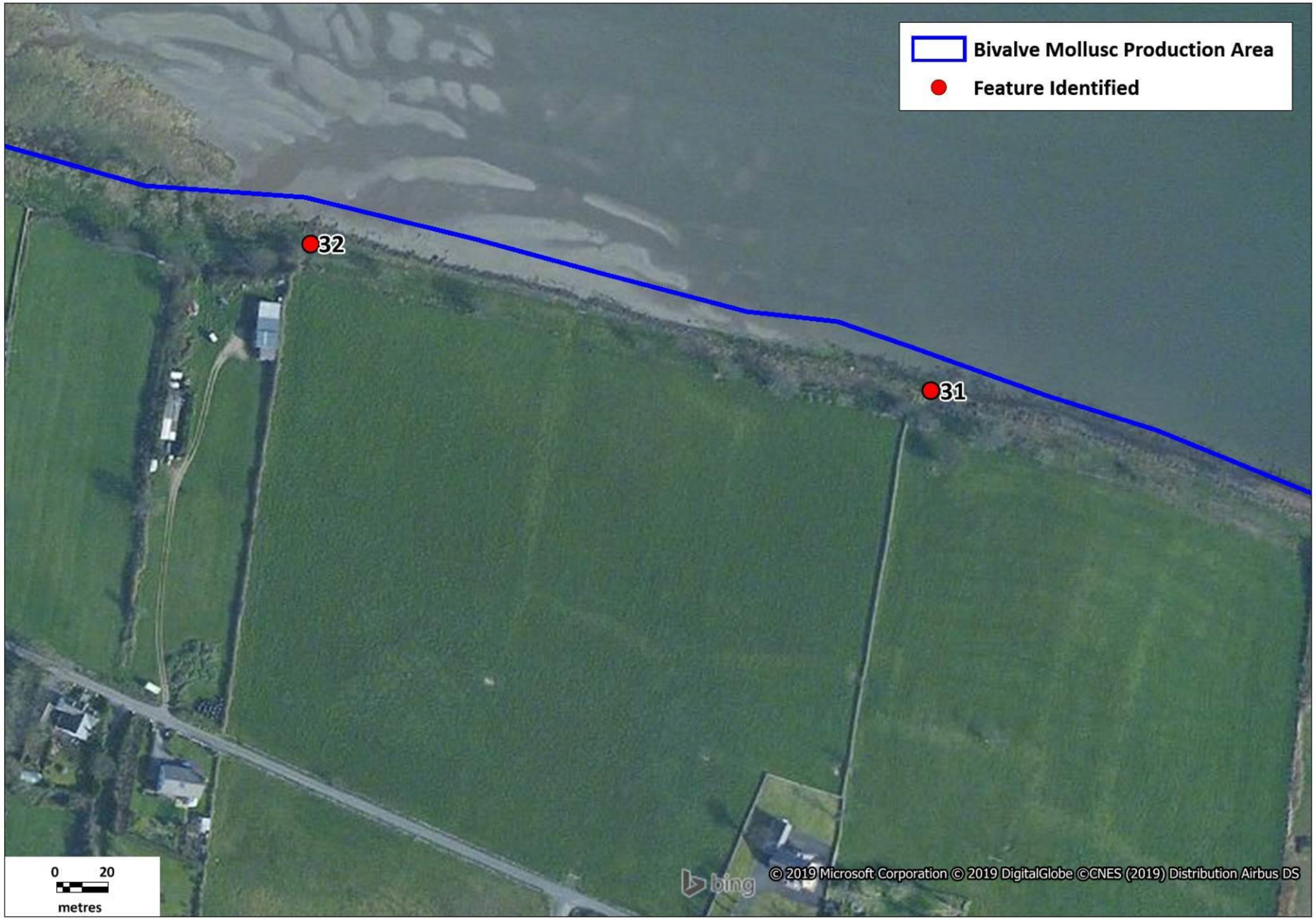


Figure 3.32: Features 31-32 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

Figure 3.33: Features 33 & 37 (numbering cross-reference to Table 3.12) identified during the shoreline survey.

Figure 3.34: Features 1-15 located during the shoreline survey. Refer to Figures 3.21-3.33 for site locations.

Figure3.35: Features 16-32 located during the shoreline survey. Refer to Figures 3.21 - 3.33 for site locations.

Figure 3.36: Features 34-37 located during the shoreline survey. Refer to Figures 3.21-3.33 for site locations.

3.2.1. Locations of Sources

Figure 3.37 shows all watercourses discharging into Drumcliff Bay and Table 3.13 provides cross-referenced details for this map. Figure 3.38 shows all discharges in the Drumcliff Bay catchment area and Table 3.14 provides cross-referenced details for the WWTP, drain and pipe discharges and Section 4 discharges.

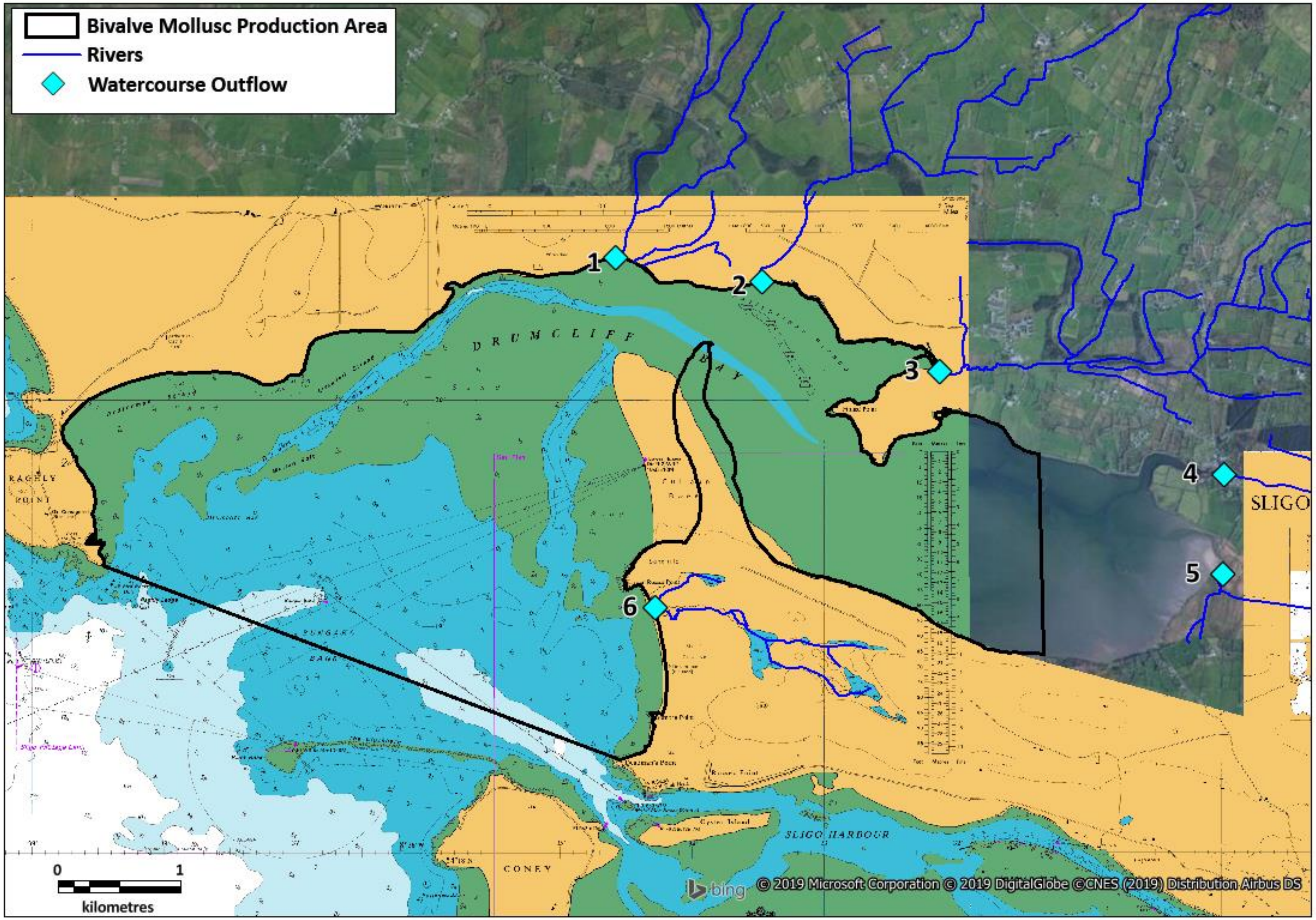


Figure 3.37: Location of all watercourses discharging into Drumcliff Bay.

Table 3.13: Cross-referenced table for Figure 3.31 Watercourses.

Map I.D.	Watercourse
1	Unnamed stream
2	Unnamed stream
3	Carney River
4	Drumcliff River
5	Unnamed stream
6	Unnamed stream

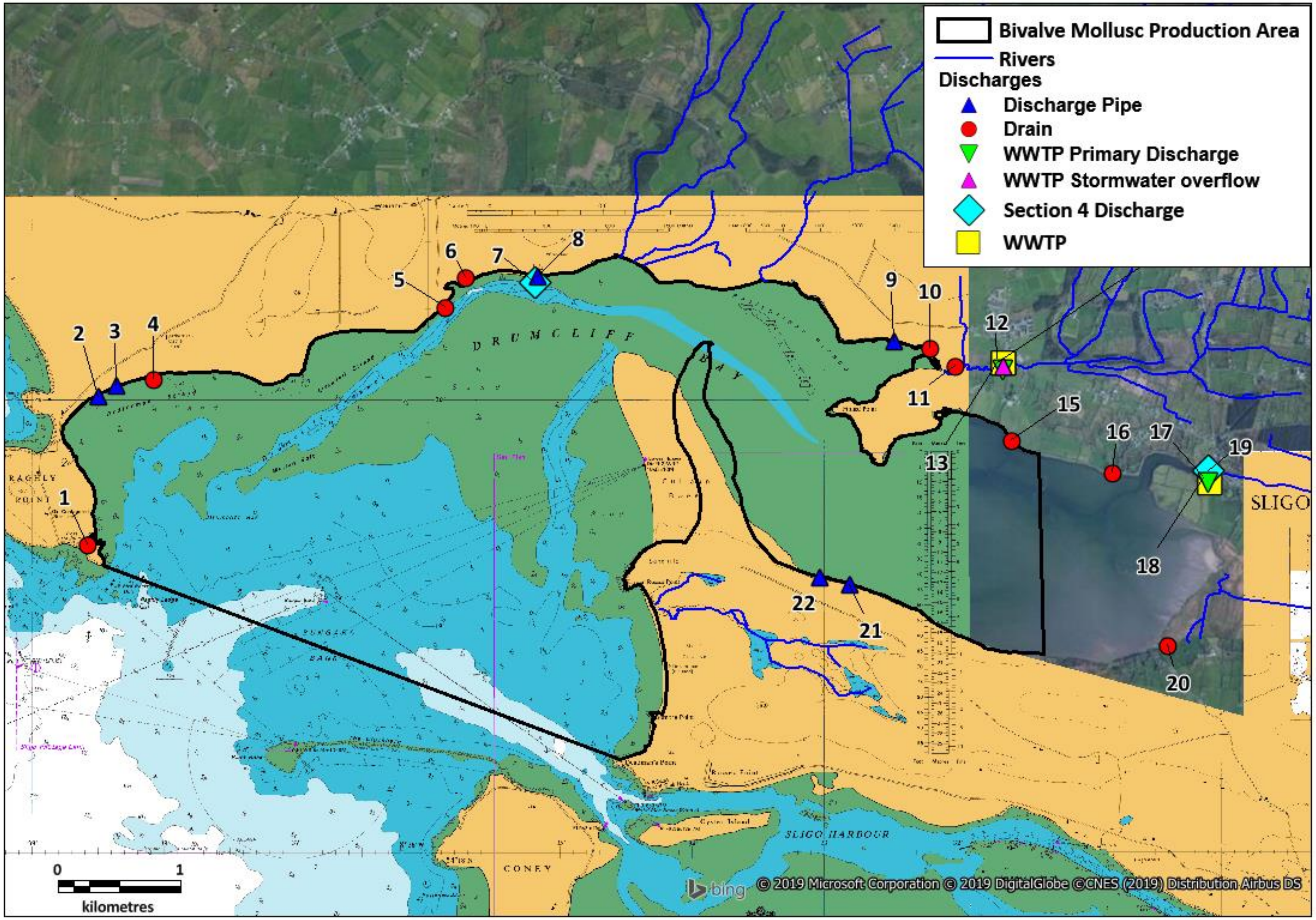


Figure 3.38: Locations of all discharges within the Drumcliff Bay Catchment Area.

Table 3.14: Cross-referenced table for Figure 3.32 Discharges.

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
1	Drain	Lagoon Discharge	54.32293	-8.64389	158152.7	341767.5
2	Discharge Pipe	Field drainage pipe	54.33382	-8.64257	158249.7	342978.9
3	Discharge Pipe	Field drainage pipe	54.3346	-8.64023	158402.7	343064.4
4	Drain	Stream	54.33515	-8.63556	158707.0	343122.8
5	Drain	Natural stream	54.34043	-8.59875	161106.5	343689.6
6	Drain	Natural stream	54.34259	-8.59615	161277.6	343928.6
7	Section 4 Discharge	Section 4 Discharge	54.34218	-8.587342	161850.1	343878.2
8	Discharge Pipe	Unknown pipe	54.34259	-8.58715	161863.0	343923.7
9	Discharge Pipe	Field drainage pipe	54.33787	-8.54209	164789.5	343374.9
10	Drain	Field drain	54.33739	-8.53759	165081.8	343319.2
11	Drain	Field drain	54.33606	-8.5343	165294.7	343169.5
12	WWTP	WWTP	54.336599	-8.529051	165636.6	343226.9
13	WWTP Storm Water Overflow	WWTP Storm Water Overflow	54.33624	-8.529	165639.6	343186.9
14	WWTP Primary Discharge	WWTP Primary Discharge	54.33624	-8.529	165639.6	343186.9
15	Drain	Field drain	54.33059	-8.5272	165752.0	342557.1
16	Drain	Field drain	54.3282	-8.51446	166578.9	342285.0
17	WWTP Primary Discharge	WWTP Primary Discharge	54.327914	-8.503179	167312.6	342247.8
18	WWTP	WWTP	54.327745	-8.502947	167327.6	342228.9
19	Section 4 Discharge	Section 4 Discharge	54.328325	-8.502439	167361.1	342293.3
20	Drain	Field drain	54.31548	-8.50749	167022.2	340865.8
21	Discharge Pipe	Drainage pipe	54.31989	-8.54772	164407.8	341376.2
22	Discharge Pipe	Field drainage pipe	54.3204	-8.55141	164168.1	341434.9

4. Hydrography/Hydrodynamics

4.1. Simple/Complex Models

No hydrodynamic model exists for Drumcliff Bay; however, as it is a relatively simple system, its operational oceanography can be readily described based upon water depths, freshwater inputs and on the way the tide rises and falls in the area.

4.2. Depth

The majority of the bay is made up of intertidal sand and mudflats. The admiralty chart bathymetry for the area (see Figure 4.1), although collected in the early 1840's, is still regarded as relatively accurate by local fish farmers (Kelly, pers. comm.). INFOMAR LIDAR survey data (see Figure 4.2) was also examined to describe the bay's bathymetry. A channel runs from the Drumcliff River along the north of the bay past Finned Point at which point it turns up north-westerly and passes through the narrow passage between the spit and the north shore. After this point the channel turns south-westerly and travels down the middle of the outer bay to about half way between Raghly Point and Rosses Point. Depths in the outer bay range from 0 to 8m while all of the inner bay is drained at low water except for the main channel. Depths in the channel range from 1 to 7m.

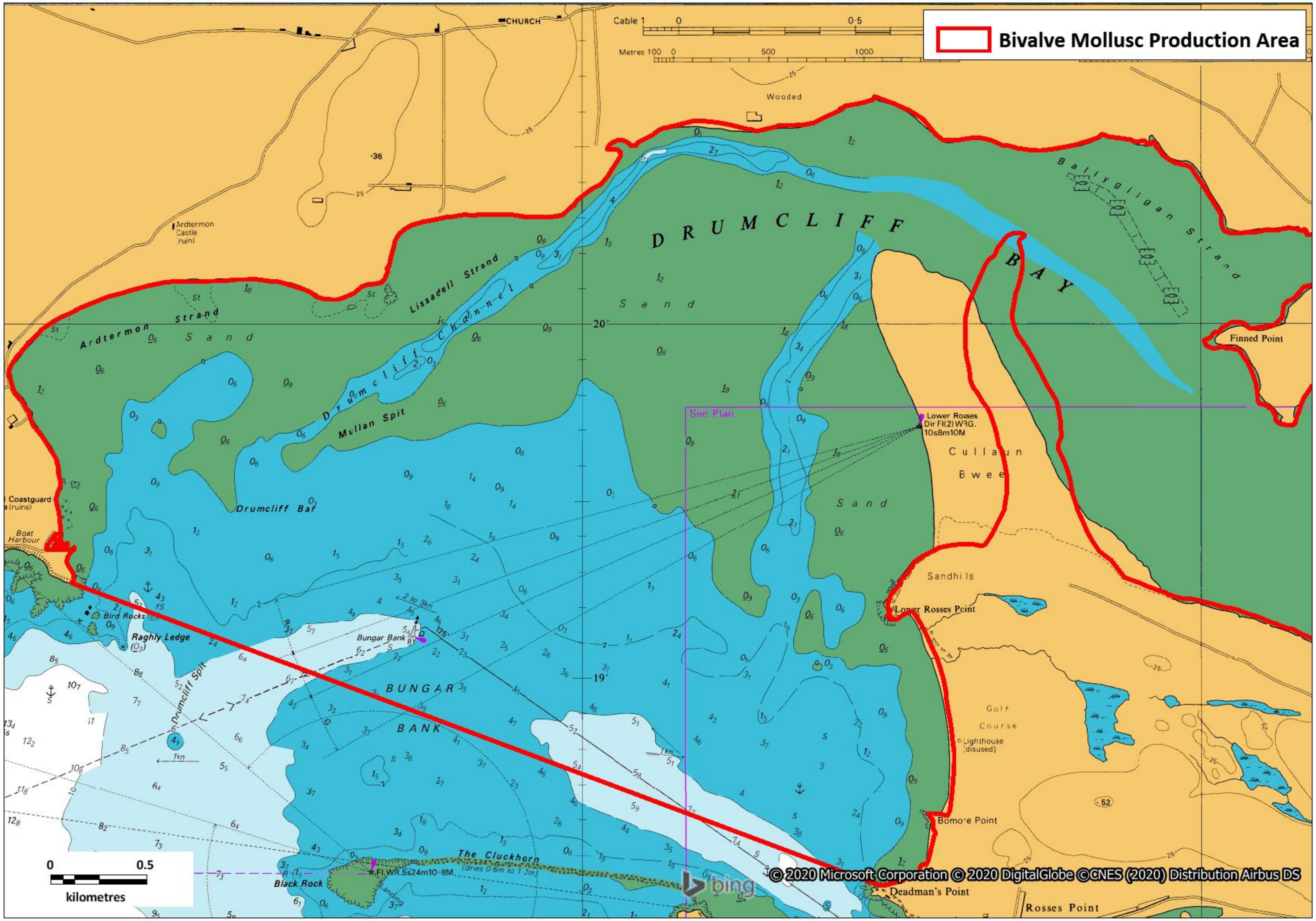


Figure 4.1: Depths in Drumcliff Bay (Source: Admiralty Chart 2852).

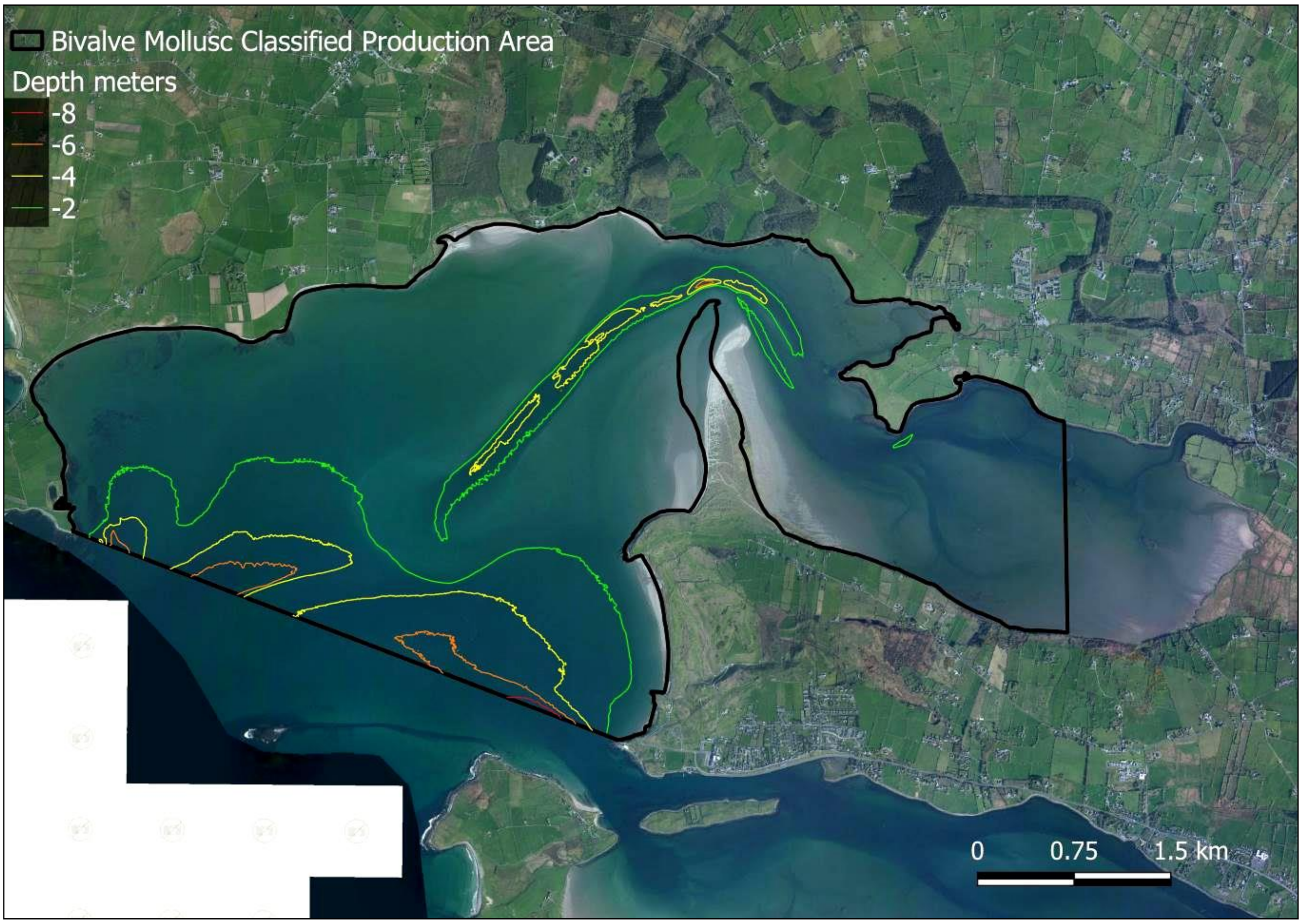


Figure 4.2 Drumcliff Bivalve Mollusc Classified Production Area bathymetry (Contains Irish Public Sector Data (Geological Survey) licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) licence).

4.3. Tides & Currents

Drumcliff Bay tidal cycle ranges from a mean high water of 4.1m to a mean low water of 0.5m during spring tides (UKHO, 2004). The characteristic tidal levels for Drumcliff Bay can be seen in Table 4.1. These are taken from the Admiralty Chart 2852. Levels are presented in metres Chart Datum, which is approximately equal to Lowest Astronomical Tide (LAT). On a flooding tide the water enters at the mouth of the bay moving northeasterly towards the narrow passage in the middle of the bay and then turns eastwards to the inner part of the bay. On an ebbing tide, the water moves westwards towards the narrow passage and then southwesterly out of the bay. The currents within the bay are likely to run parallel to the main channel. The highest currents during both flood and ebb tides will occur as the water is forced through the narrow passage north of the spit. This is supported by the bathymetry in Figure 4.2 that shows the deepest part of the channel is in this narrow passage between the spit and the north shore.

Table 4.1: Drumcliff Bay tidal characteristics (Source: Admiralty Chart No. 2852).

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

4.4. Wind and Waves

Wind data from 2014 to 2018 from the Finner station (Met Eireann, 2019a) (Co. Donegal, located approximately 26km north east of Drumcliff Bay) are presented 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% can 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 diagramme 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

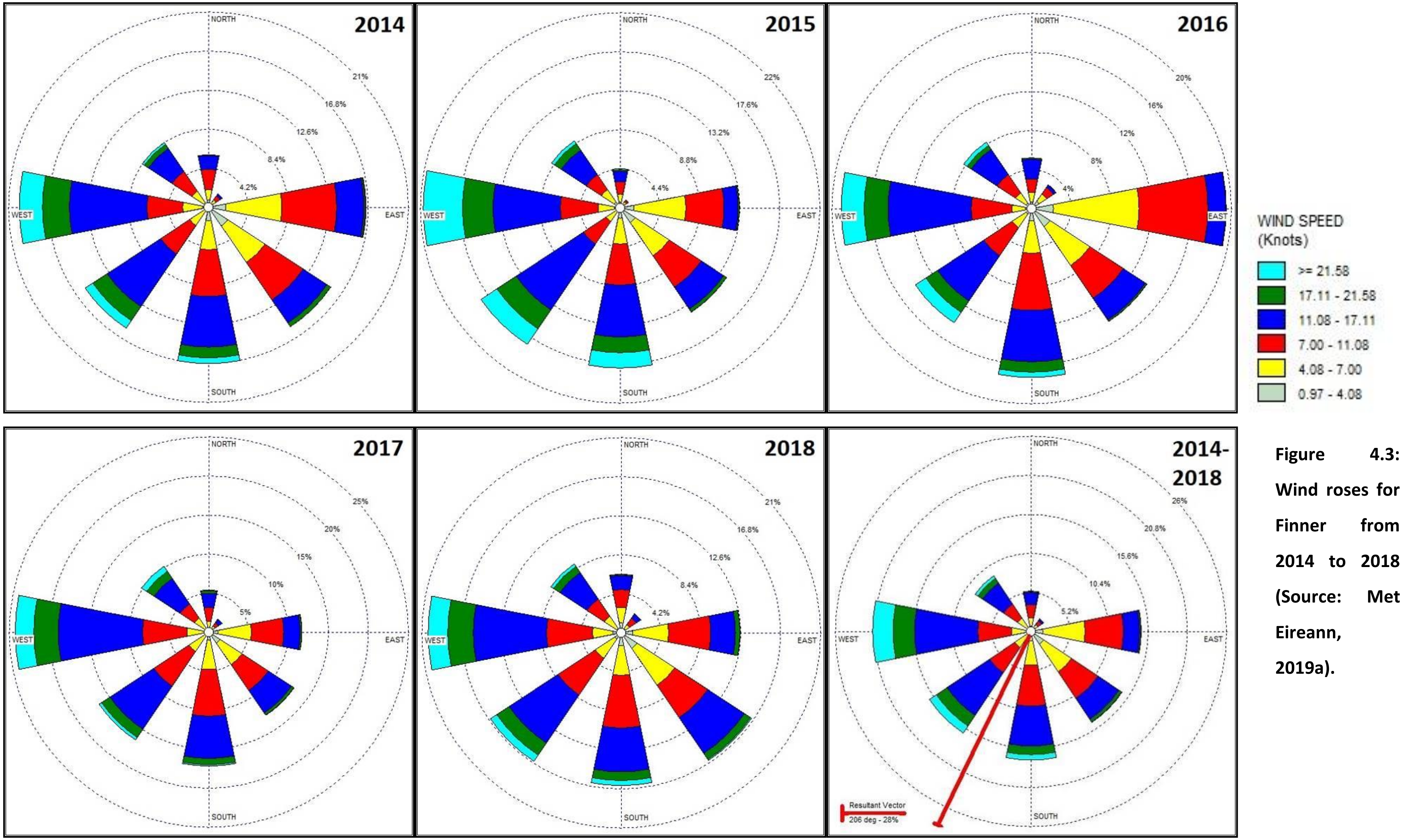


Figure 4.3: Wind roses for Finner from 2014 to 2018 (Source: Met Eireann, 2019a).

Wind conditions affect the hydrodynamic conditions in Drumcliff Bay 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

Drumcliff Bay drains a catchment of 112.4km^2, 55% (61.6km^2) of this flows through the Drumcliff River. The Drumcliff River is approximately 7km long and flows from Glencar Lough into the eastern end of the Bay. Northwest of the Drumcliff River, the Carney River flows into the bay and further west two unnamed streams flow into the bay north of where the spit divides the inner and outer bay. The Carney along with the two unnamed rivers drain a catchment of 34.75km^2. There are two further unnamed rivers on the southern shore, one enters south of Drumcliff and the other is located south of Rosses Point just outside of the Bay. These two streams drain an area of approximately 11.8Km^2. Glencar Lough is a small lake of 1.15km^2, which drains Glencar valley through a series of small streams on the steep slopes to the north and south of the lake (See Figure 4.4).

Once the freshwater from these sources empties into Drumcliff Bay, on an ebbing tide, this lower salinity water will be deflected along the north shore of the bay due to the Coriolis effect.

The current (2010-2015) WFD status of Drumcliff Bay and its associated freshwater sources can be seen in Figure 4.5. Of the river and lake systems flowing directly into the Drumcliff Bay BMCPA, the Drumcliff River is of Good status, all other streams flowing into the Bay have not been assigned a WFD status. Glencar Lough is of moderate status, while the streams that feed it are Good status and high status further upstream. Drumcliff Bay has not been assigned a WFD status.

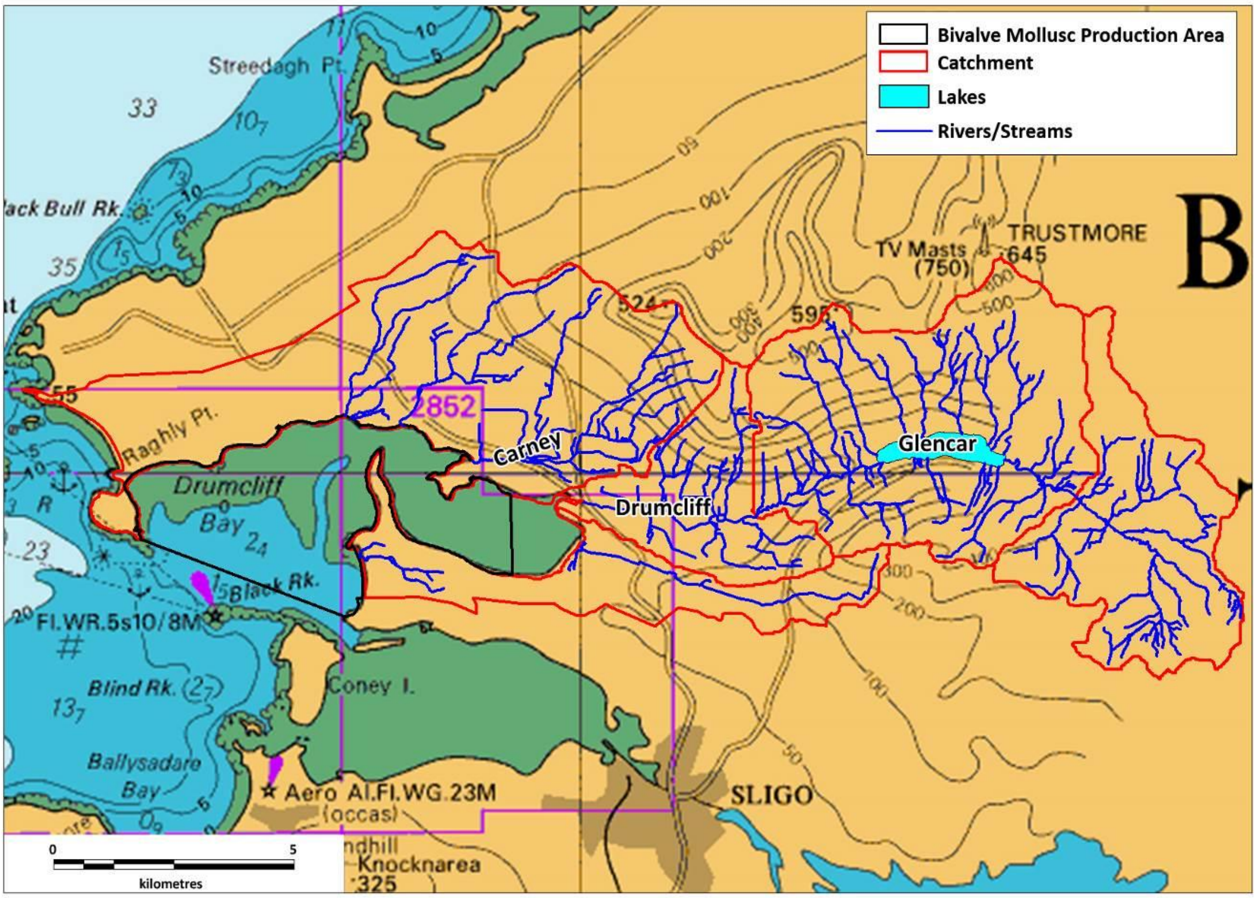


Figure 4.4: Rivers, streams and lakes in the catchment areas (Source: EPA, 2019).

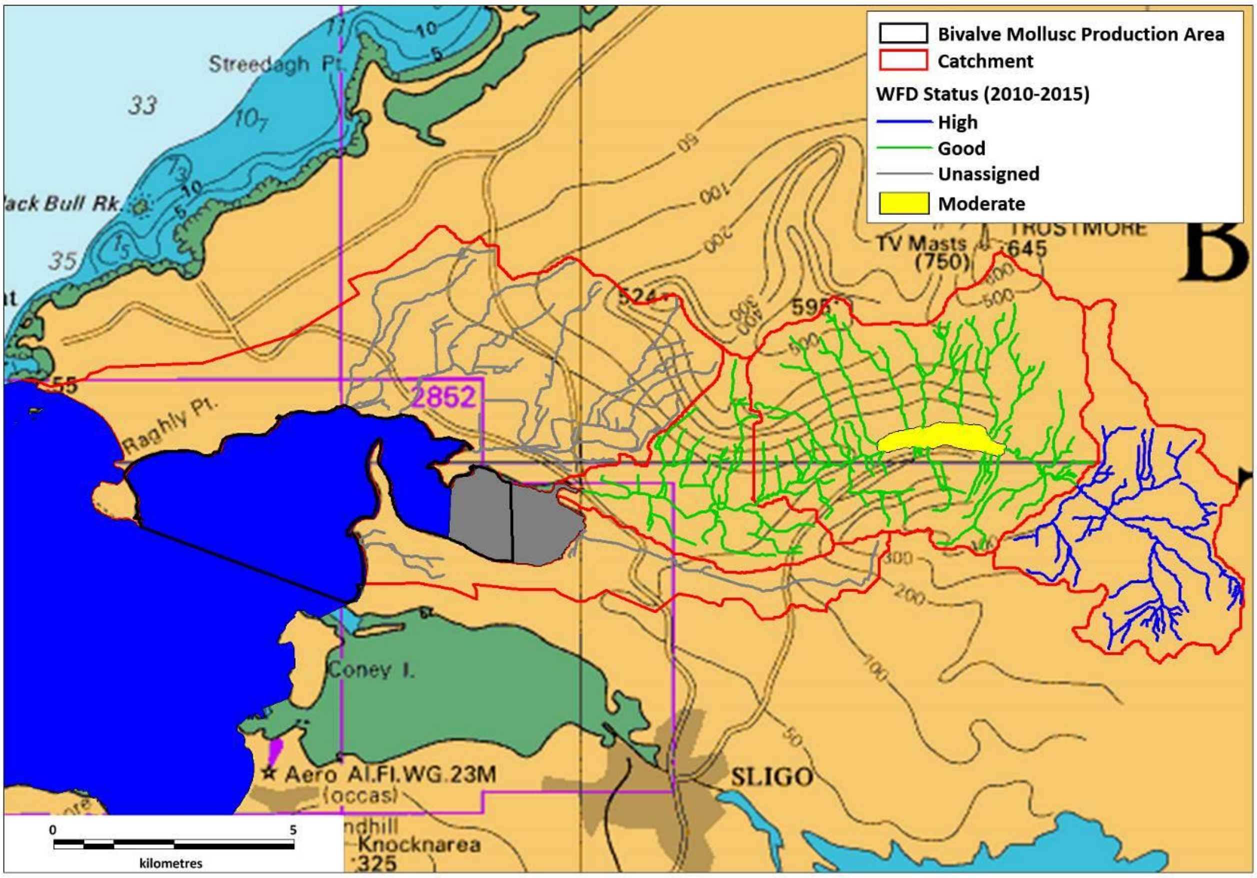


Figure 4.5: WFD Status of the coastal, transitional, lake and river water bodies in the catchment area (Source EPA, 2019).

4.6. Rainfall Data

4.6.1. Amount & Time of Year

Figure 4.6 shows the average monthly rainfall data for Ireland (Met Eireann, 2019b) from 1981 to 2010. The wettest months in the Drumcliff Bay 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. 89km west of the Drumcliff Bay production area (Figure 4.7 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

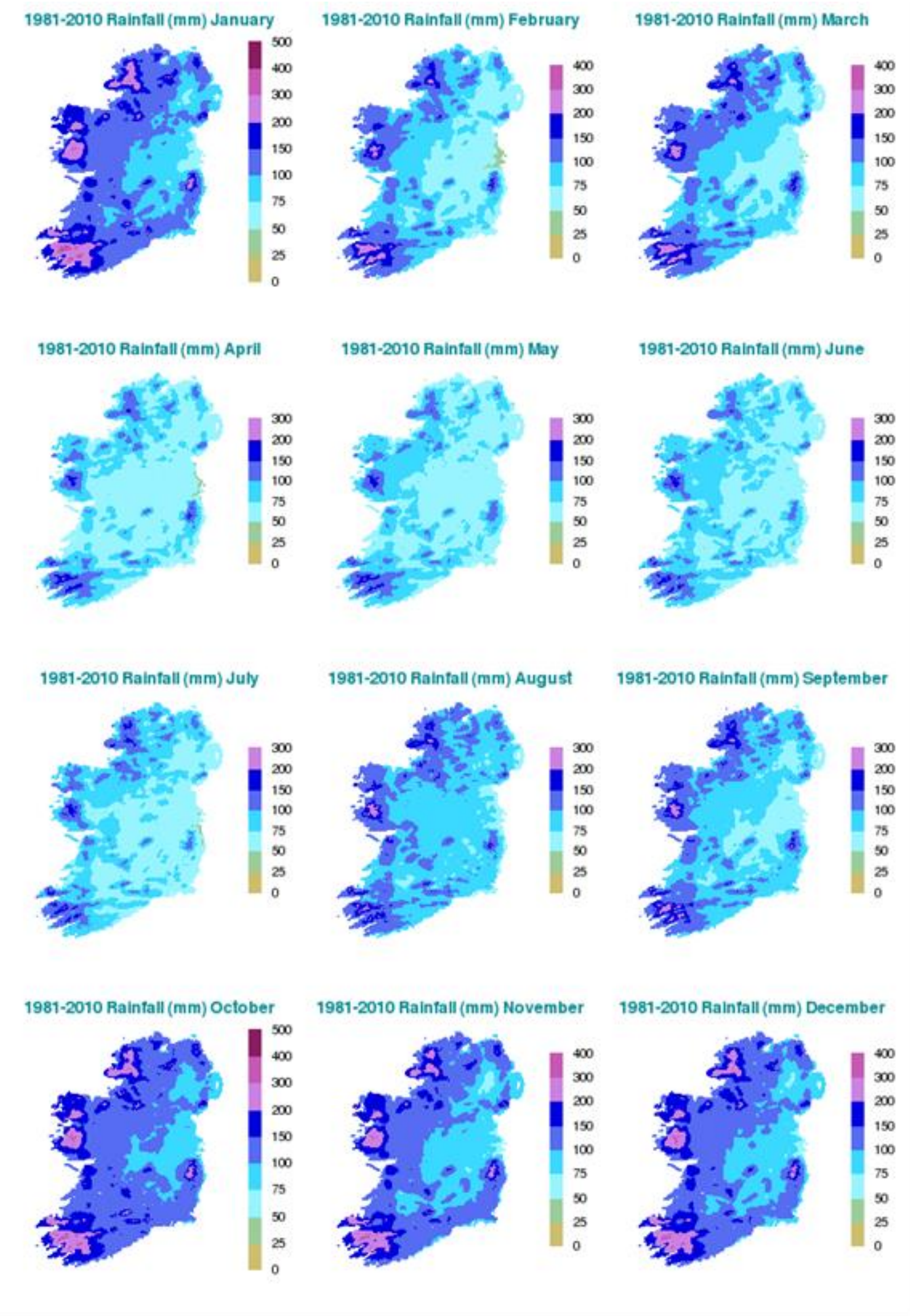


Figure 4.6 Average monthly rainfall (mm) data from 1981 to 2010 for Ireland (Source: Met Eireann, 2019b).

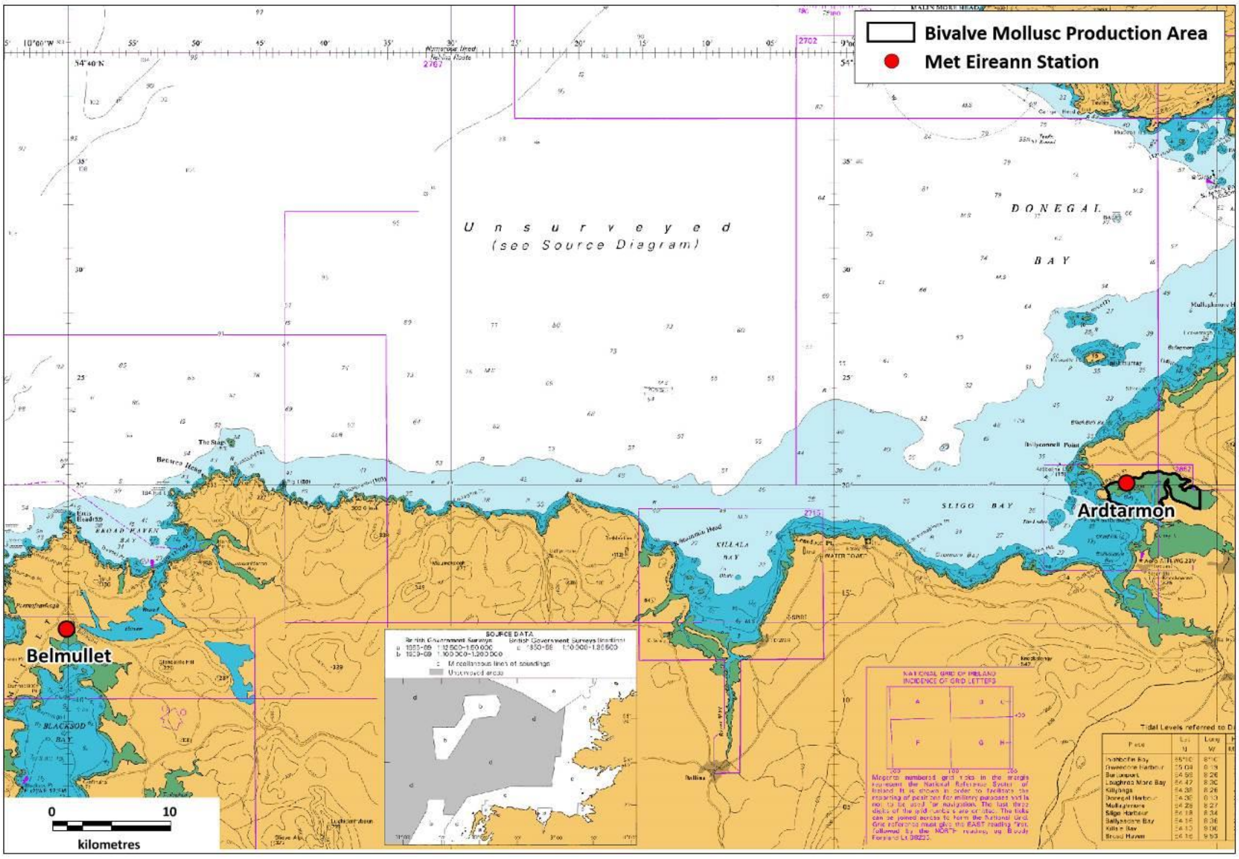


Figure 4.7: Location of Met Eireann weather stations in relation to the Drumcliff Bay production area.

Table 4.6 shows total monthly rainfall at the Ardtarmon Met Eireann station (see Figure 4.7), located just inside of Raghly Point in Drumcliff Bay production area from 2014 to 2018 (Met Eireann, 2019d).

Ardtarmon weather station is located on the north-western shore of Drumcliff Bay. Maximum monthly rainfall was in November 2015 (219.1mm) and the lowest monthly rainfall was September 2014 (11.4mm). The 5-year average monthly rainfall ranged from a low of 50.6mm in April to a high of 154.3mm in January. Annual averages ranged from 84.8mm in 2018 to 115.1mm in 2015.

Table 4.7 shows the total seasonal rainfall at Ardtarmon from 2014-2018 (Met Eireann, 2019d). The following seasonal fluctuations were observed from 2014-2018: 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, in 2017 spring was the driest and autumn was the wettest and in 2018 spring was the driest and winter was the wettest. Over the five years spring 2016 was the driest season and winter 2014 was the wettest season.

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

Year	2014	2015	2016	2017	2018	Monthly 5-yr Average
Jan	189.5	177.8	159.5	47.1	197.6	154.3
Feb	164.7	83.7	117.6	66.6	87.6	104.0
Mar	73.7	116.5	74.3	130.3	36.7	86.3
Apr	28	74.9	58.3	21.2	70.6	50.6
May	92.7	115	55.4	54.8	48.4	73.3
Jun	57.2	38.7	116.7	58.6	35.6	61.4
Jul	74.4	111.1	91.3	96.8	67.6	88.2
Aug	84.2	98	86.4	96.6	124.4	97.9
Sep	11.4	64.3	96.2	138.1	71.1	76.2
Oct	87.2	70.2	35.1	87.7	91.4	74.3
Nov	135.9	219.1	95.8	138.6	98.4	137.6
Dec	191	211.5	73	119.4	87.8	136.5
Annual Average	99.2	115.1	88.3	88.0	84.8	-

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

Station	Season/Year	2014	2015	2016	2017	2018
Ardtarmon	Spring	194.4	306.4	188	206.3	155.7
	Summer	215.8	247.8	294.4	252	227.6
	Autumn	234.5	353.6	227.1	364.4	260.9
	Winter	545.2	473	350.1	233.1	373

4.6.2. Frequency of Significant Rainfalls

Figure 4.8 shows the average monthly rainfall at Belmullet from 1981-2010 and Figure 4.9 shows the 5 year monthly average rainfall at Ardtarmon 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 Ardtarmon, January has been the wettest month followed by November and December. April was the driest month followed by June and May.

For the 5-year 2014-2018 period, average greatest daily rainfall at Ardtarmon was 17.3mm, with a maximum of 43.3mm. 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 has 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, 29.1mm of rain would be expected over 1 hour and 78.1mm over 24 hours. While these would be extremely uncommon events, the model predicts that once a year 10.9mm would fall in 1 hour and 31.5mm 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.

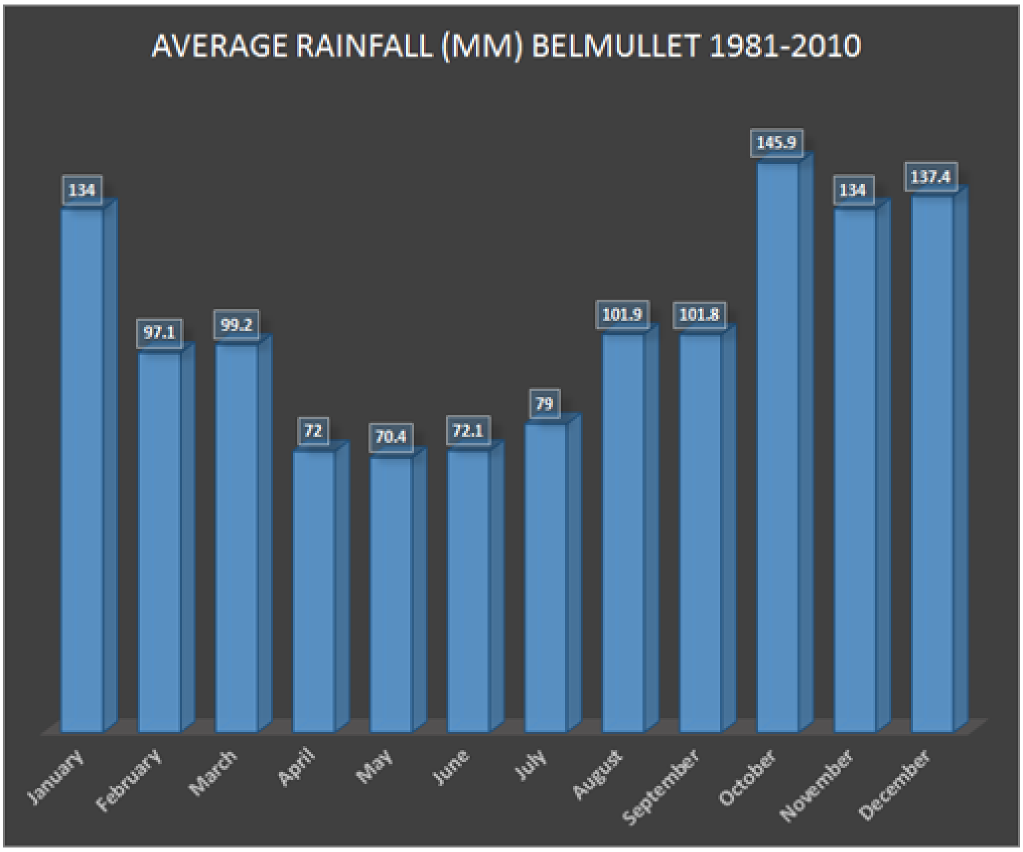


Figure 4.8: Average monthly rainfall (mm) at Belmullet from 1981-2010 (Source: Met Eireann, 2019c).

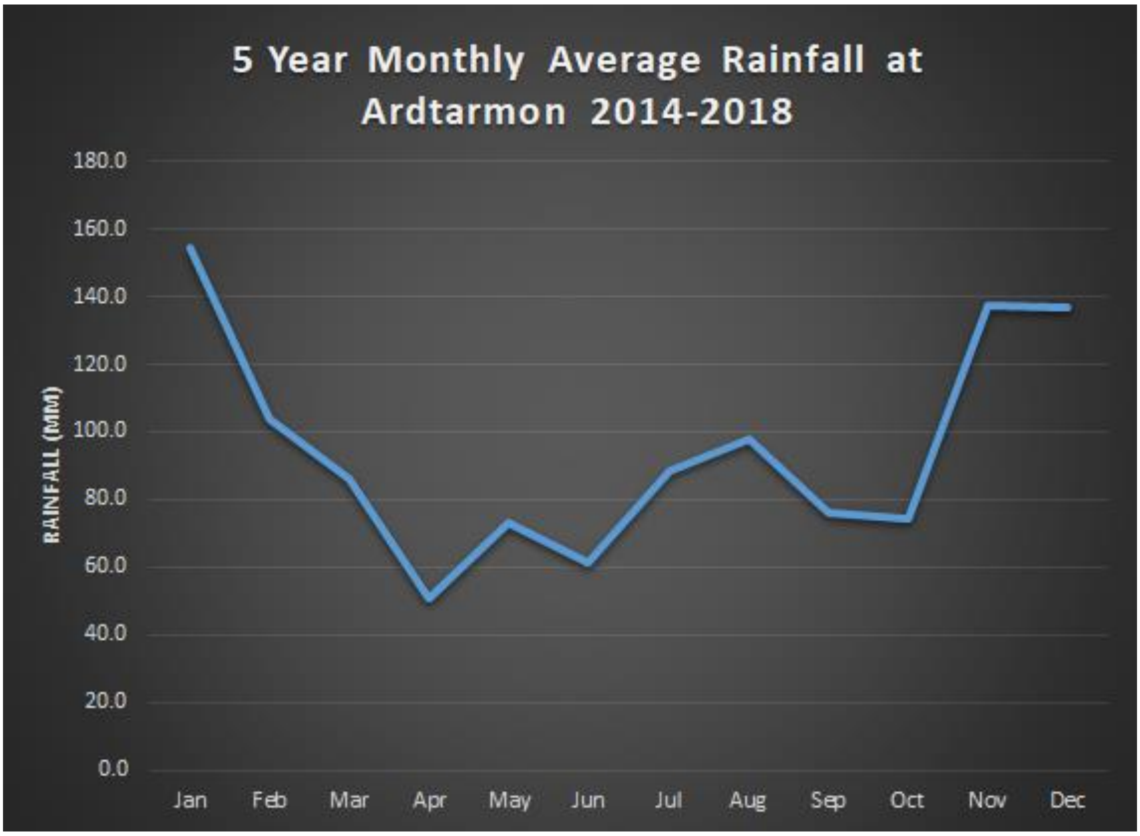


Figure 4.9: 5 year monthly average rainfall (mm) at Ardtarmon weather station from 2014-2018 (Source: Met Eireann, 2019d).

4.7. Salinity

Drumcliff Bay production area salinity is affected by the stage of the tide and the flow rate of the Drumcliff and Carney Rivers, along with a handful of other smaller rivers. The inner part of Drumcliff Bay, east of Finned Point is classified as a transitional water body and so is likely to have a highly varied salinity, although no data are currently available. The outer part of the bay is classified as a Coastal Water Body (CWB) and so has a higher more stable salinity. There are two monitoring stations in the bay, a WFD (Water Framework Directive) station at the mouth of the bay and a SWD (Shellfish Waters Directive) station in the channel just north of the spit (Drumcliff) (see Figure 4.10). Salinities at the outer station range from 29.4 to 32.8PSU and from 26.3 to 30.1PSU at the inner station (Marine Institute, 2019).

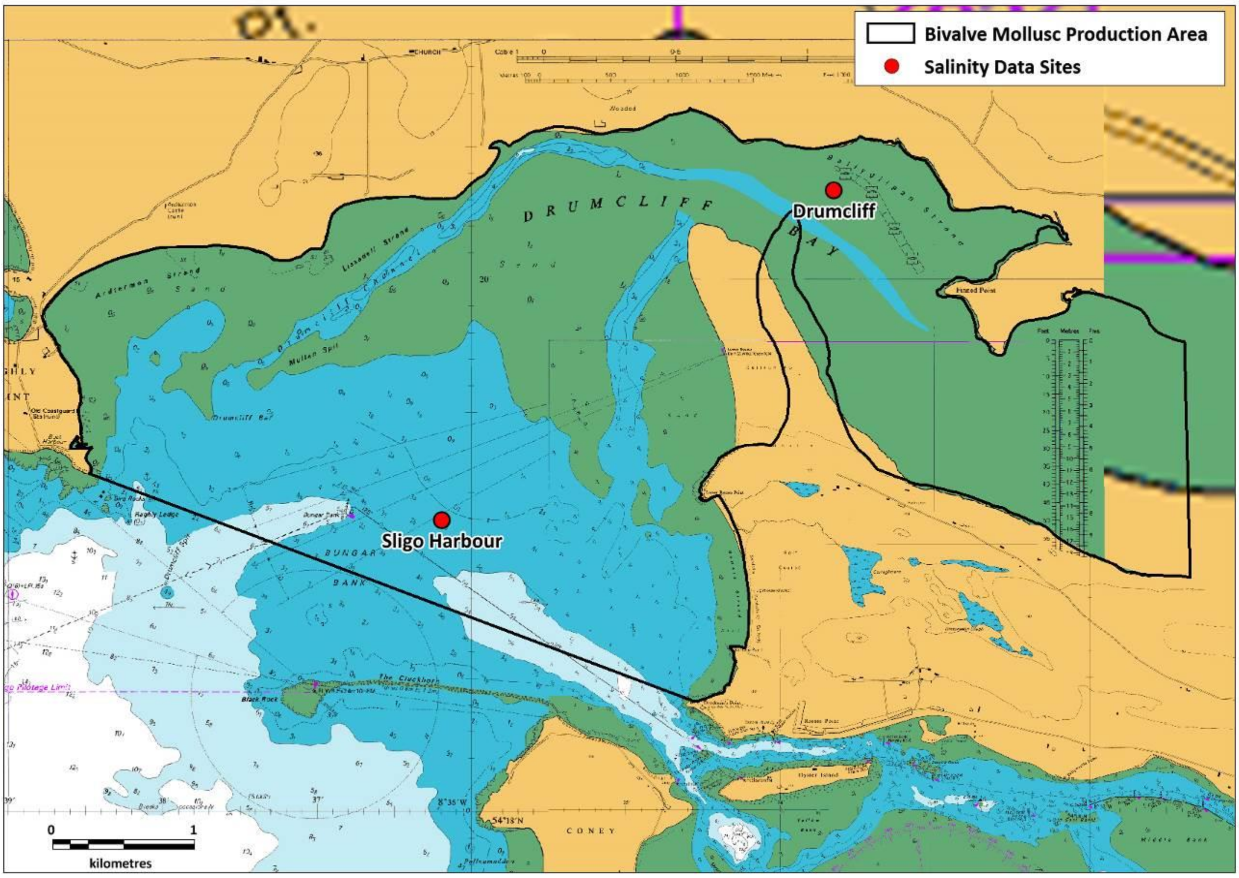


Figure 4.10: WFD and SWD water monitoring stations in Drumcliff Bay.

4.8. Turbidity

The turbidity of Drumcliff Bay varies significantly depending on the tide, levels of freshwater input and weather conditions. There are no available turbidity data for the inner bay; however, due to its tidal nature and the presence of extensive mud and sand flats, the turbidity is likely to be variable depending on the stage of the tide, weather conditions and freshwater input. Turbidity is measured at the Sligo Harbour (WFD) and the Drumcliff (SWD) water sampling stations (See Figure 4.10) levels at the outer site can range from 0 to 46.4NTU and from 2.2 to 35.9NTU at the inner site (Marine Institute, 2019).

4.9. Residence Times

Residence time can be defined as the average amount of time that a molecule of water of a particle 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 estimated residence time within Drumcliff Bay ranges from 1 to 7 days (Marine Institute, 2015a).

4.10. Discussion

The majority of the bay is made up of intertidal sand and mudflats. A channel runs from the Drumcliff River along the north of the bay past Finned Point at which point it turns up north-westerly and passes through the narrow passage between the spit and the north shore. After this point the channel turns south-westerly and travels down the middle of the outer bay to about half way between Raghly Point and Rosses Point. Depths within this channel Range from 1 to 7m. Drumcliff Bay has a residence time of 1 to 7 days and this indicates a relatively high exchange rate of water within the bay that will aid in the removal of contamination from the shellfish production sites. The main direction of water flow is to the southwest during an ebbing tide and north easterly on a flooding tide. Freshwater input from the Drumcliff and Carney Rivers is the main source of salinity variation with salinity ranging from 29.4 to 32.8PSU at the mouth of the bay and from 26.3 to 30.1PSU in the middle of the bay just north of the spit.

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 Drumcliff Bay. All 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.

5.1.2. Shellfish Flesh Quality

In accordance with Commission Implementing Regulation (EU) 2019/627 the competent authority is required to fix the location and boundaries of the shellfish production areas. In addition the authority is required to classify each production area for which they authorise the harvesting of live bivalve molluscs as Class A, B or C depending on the levels of faecal contamination. This process involves regular sampling of shellfish from each area classified in order to establish the levels of contamination. The Sea Fishery Protection Authority currently samples shellfish flesh at three locations in the Drumcliff Bay production area as part of this classification process. Figure 5.1 shows the location of the sampling sites Table 5.1 shows the coordinates.

Table 5.1: Coordinates of sampling sites within the Drumcliff Bay Production Area.

Sample Code	Species	Latitude	Longitude
SO-DB-DB	Pacific Oyster	54.340158	-8.561552
SO-DB-DB	Cockles	54.337097	-8.544616
SO-DB-DB	Mussels	54.33115	-8.5361

An A classification allows for the product to be placed directly on the market, whereas a B or C classification requires the product to go through a process of depuration, heat treatment or relaying before it can be placed on the market. Table 5.2 summarises this system. Table 5.3 shows the current and historical (back to 2014) classifications within Drumcliff Bay. For the 2018-2019 period, Drumcliff Bay is classified as B for cockles and mussels. Oysters were classified as A seasonally from the 1st of January to the 1st of June changing back to B at other times. Oysters were classified as A in 2017, all other species were classified as B from 2014 to 2017. Clams were classified as B from 2014 to 2017, but were recorded as a dormant fishery in 2018. Fisheries are recorded as dormant when they are dormant for 12 months and limited monitoring data are available.

Table 5.2: Classification system for shellfish harvesting areas.

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

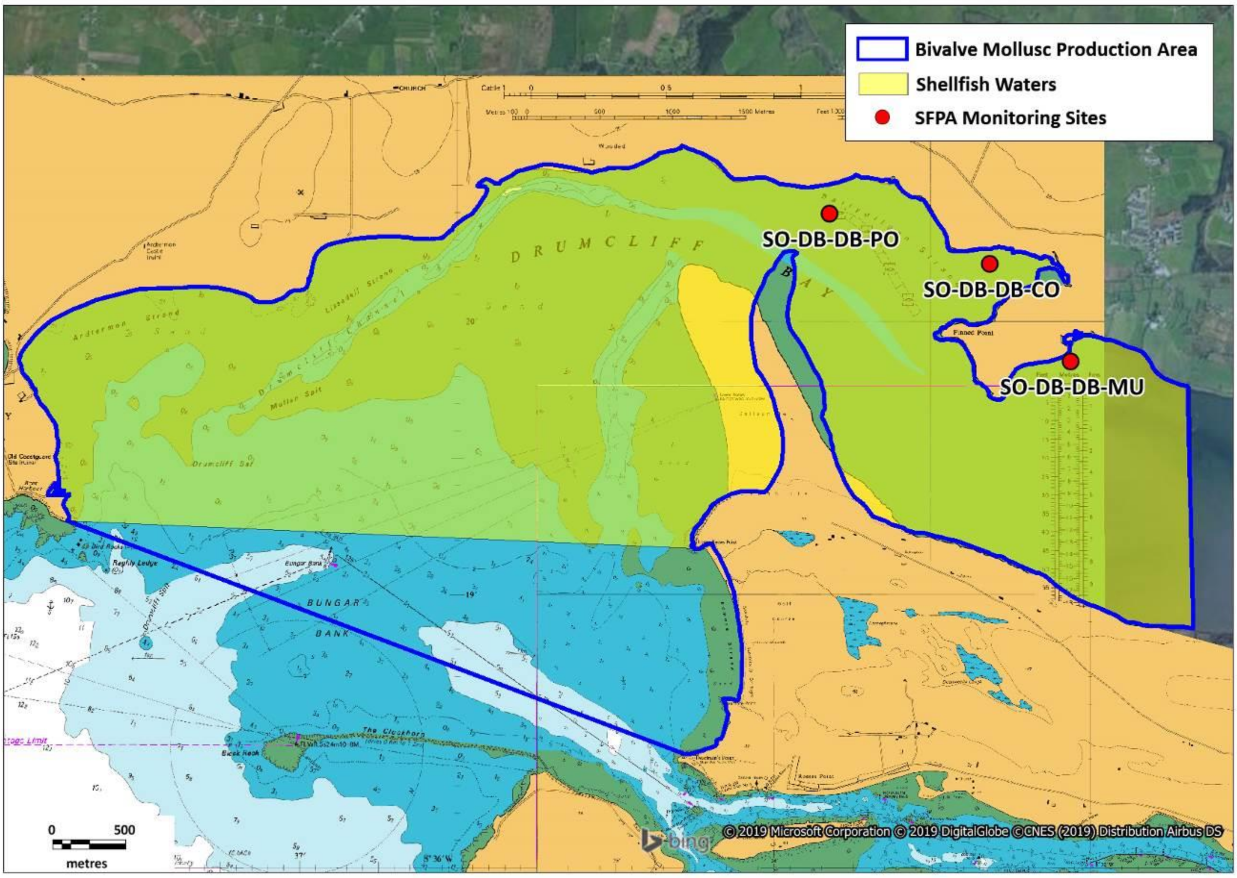


Figure 5.1: Locations of existing SFPA shellfish representative monitoring points.

Table 5.3: Current and historical classification of shellfish beds in Drumcliff Bay (2014 – 2019).

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

*Seasonal A 01 Jan- 01 June changes to Class B at other times.

** Dormant Fishery.

Table 5.4: Specific requirements for the classification of production and relaying areas for live bivalve molluscs (EU) 2019/627

Classification Status	Limits	Limits
Class A Production Areas	Shall not exceed 230 E.coli per 100 g flesh and intravalvular liquid in 80% of samples	Shall not exceed 700 E.coli per 100 g flesh and intravalvular liquid in the remaining 20 % of the samples
Class B Production Areas	Shall not exceed 4,600 E.coli per 100 gram of flesh and intravalvular in 90% of samples	Shall not exceed 46,0000 per 100 g flesh and intravalvular liquid in the remaining 10% of the samples
Class C Production Areas	Shall not exceed 46,000 E.coli per 100 gram of flesh and intravalvular liquid in all samples	

Tables 5.5, 5.6 and 5.7 list the *E. coli* results for oysters, cockles and mussels from Drumcliff Bay from 2014 to 2019 (where available). Figures 5.2, 5.3 and 5.4 show these data in graphical form.

As shown in Table 5.3 above, Drumcliff Bay has had a **B** classification for clams from 2014 to 2017, in 2018 the fishery was declared dormant and has not been sampled since. The monthly classification trends for clams from 2014 to 2017 are not available. Drumcliff Bay oysters had an **A** classification in 2017 and a seasonal **A** classification in 2018 from 01 January to 01 June, for all other years between 2014 and 2019 it had a **B** classification. The monthly classification trends for oysters can be seen in Table 5.5 and Figure 5.2. Drumcliff Bay cockles have had a **B** classification from 2014 and 2019. The monthly classification trends for cockles can be seen in Table 5.6 and Figure 5.3. Drumcliff Bay mussels have had a **B** classification from 2014 and 2019. The monthly classification trends for mussels can be seen in Table 5.7 and Figure 5.4.

Table 5.8 shows the summary statistics for the *E. coli* historical data from the three shellfish monitoring sites from 2014 to 2019. The geometric mean of *E. coli* levels was highest for mussels then cockles, with oysters having the lowest. Table 5.9 shows the variations of the annual geometric means of *E. coli* from the year 2014 to 2019. Figure 5.5 shows the trend in geometric mean from 2014 to 2019 for all species in Drumcliff Bay. The geometric mean for oysters ranged from 52 MPN/100ml in 2014 to 162 MPN/100ml in 2018. The geometric mean for cockles ranged from 88 MPN/100ml in 2014 to 168 MPN/100ml in 2017. The geometric mean for mussels ranged from 134 MPN/100ml in 2014 to 204 MPN/100ml in 2017. Table 5.10 shows a summary of the Sea Fishery Protection Authority's 'Shellsan Elevated Micro Result Reports' for the 2017 to 2019 time period. These reports are generated during the routine monitoring programme in response to results which are above the upper limit for the classification of the production area. Analysis of these reports suggests a direct link between episodic heavy rainfall and elevated contamination levels within the shellfish.

There was no significant differences in *E. coli* levels based on season (spring, summer, autumn and winter) for oysters, cockles and mussels (one-way ANOVA, $p = 0.2139$, $p = 0.7279$ and $p = 0.2815$ respectively, Appendix 1). There was a significant difference in *E. coli* levels between species (one-way ANOVA, $p = 0.0218$, Appendix 1). There was no significant difference observed between oysters and cockles (2 sample t-Test assuming equal variance, $p = 0.1706$, Appendix 1) or cockles and mussels (2 sample t-Test assuming unequal variance, $p = 0.1594$, Appendix 1).A significant difference was observed between oysters and mussels (2 sample t-Test assuming equal variance, $p = 0.0073$, Appendix 1). These data show that *E. coli* levels in mussels are significantly higher than in oysters.

Table 5.5: *E. coli* results from Drumcliff Bay Oysters from 2014 to 2019 (Source: SFPA).

Date	MPN *E. coli* /100g	Category	Date	MPN *E. coli* /100g	Category
13-Jan-14	170	A	8-May-17	78	A
20-Feb-14	20	A	12-Jun-17	45	A
20-Mar-14	220	A	29-Jun-17	20	A
10-Apr-14	20	A	6-Jul-17	330	B
27-May-14	330	B	16-Aug-17	1100	B
30-Jun-14	20	A	31-Aug-17	20	A
27-Aug-14	18	A	18-Sep-17	78	A
29-Oct-14	230	A	5-Oct-17	1100	B
24-Nov-14	20	A	10-Oct-17	1100	B
4-Dec-14	18	A	6-Nov-17	220	A
22-Jan-15	230	A	4-Dec-17	93	A
25-Feb-15	78	A	15-Jan-18	18	A
19-Mar-15	18	A	19-Feb-18	230	A
29-Apr-15	78	A	27-Mar-18	45	A
30-Jun-15	490	B	15-Apr-18	78	A
23-Jul-15	18	A	28-May-18	170	A
20-Aug-15	18	A	26-Jun-18	170	A
28-Sep-15	490	B	18-Jul-18	790	B
21-Oct-15	18	A	14-Aug-18	210	A
26-Nov-15	130	A	23-Sep-18	45	A
14-Dec-15	130	A	8-Oct-18	18000	C
20-Jan-16	130	A	26-Nov-18	45	A
23-Feb-16	130	A	10-Dec-18	130	A
10-Mar-16	18	A	7-Jan-19	45	A
18-Apr-16	45	A	18-Feb-19	130	A
9-May-16	45	A	**19-Mar-19**	490	**B**
14-Jun-16	110	A	25-Mar-19	20	A
4-Jul-16	93	A	16-Apr-19	18	A
9-Aug-16	18	A	27-May-19	18	A
13-Sep-16	78	A	27-Jun-19	20	A
27-Oct-16	18	A	15-Jul-19	78	A
14-Nov-16	330	B	**29-Aug-19**	3500	**B**
19-Dec-16	130	A	12-Sep-19	230	A
9-Jan-17	18	A	29-Oct-19	45	A
27-Feb-17	230	A	25-Nov-19	68	A
14-Mar-17	110	A	09-Dec-19	18	A
19-Apr-17	20	A			

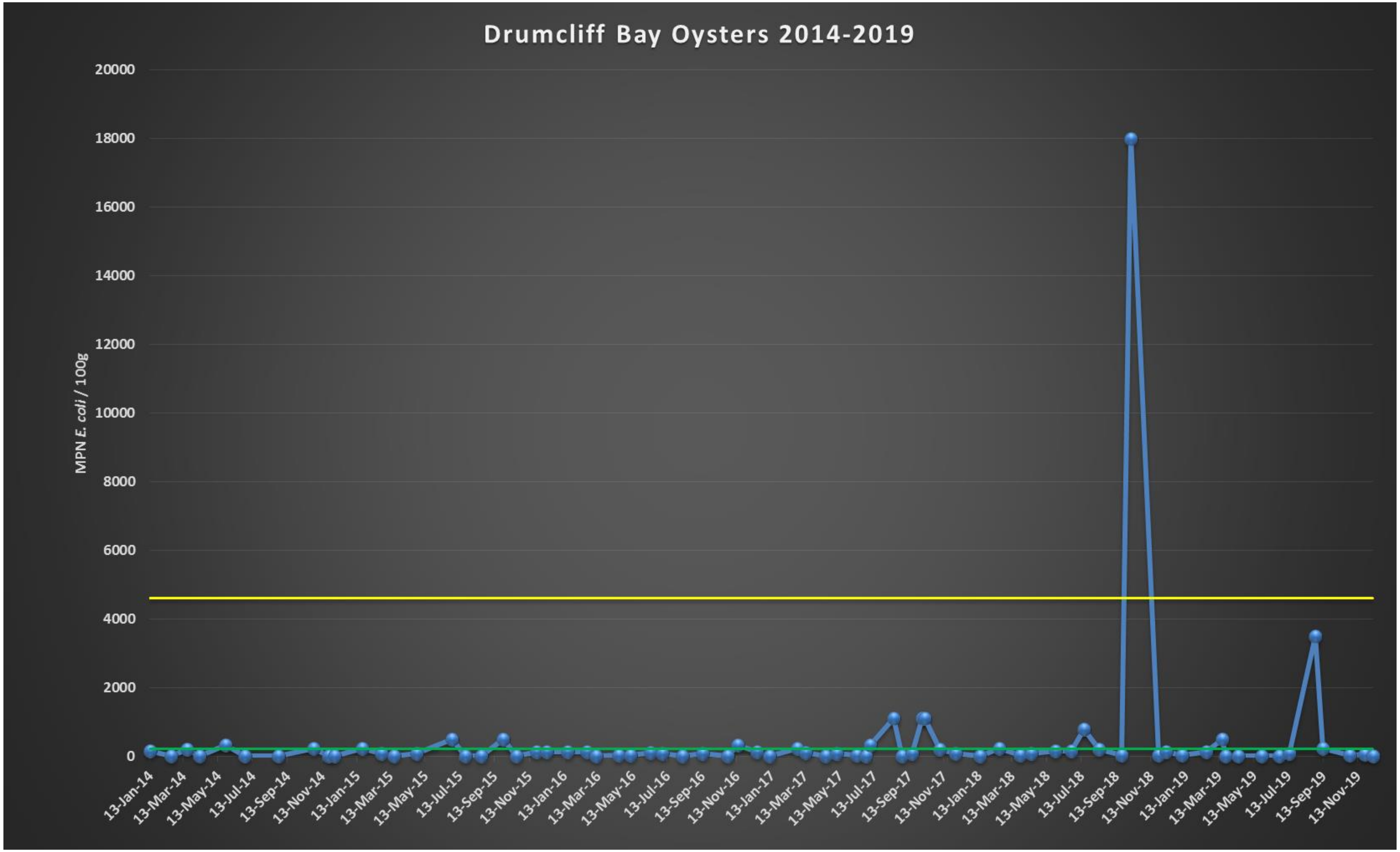


Figure 5.2: ***E. coli*** **levels from oysters at Drumcliff Bay from 2014 to 2019 (Source: SFPA).**

Table 5.6: *E. coli* results from Drumcliff Bay cockles from 2014 to 2019 (Source: SFPA).

Date	MPN *E. coli* /100g	Category	Date	MPN *E. coli* /100g	Category
13-Jan-14	20	A	4-Apr-17	20	A
20-Feb-14	130	A	8-May-17	18	A
20-Mar-14	20	A	12-Jun-17	790	B
29-Apr-14	790	B	6-Jul-17	130	A
27-May-14	490	B	16-Aug-17	2400	B
27-Aug-14	130	A	31-Aug-17	110	A
24-Nov-14	18	A	18-Sep-17	490	B
4-Dec-14	78	A	5-Oct-17	460	B
22-Jan-15	130	A	6-Nov-17	330	B
25-Feb-15	170	A	4-Dec-17	78	A
19-Mar-15	330	B	15-Jan-18	230	A
29-Apr-15	78	A	19-Feb-18	130	A
20-May-15	130	A	27-Mar-18	18	A
30-Jun-15	230	A	15-Apr-18	790	B
23-Jul-15	130	A	28-May-18	110	A
20-Aug-15	20	A	26-Jun-18	18	A
28-Sep-15	1400	B	18-Jul-18	220	A
26-Nov-15	18	A	14-Aug-18	20	A
14-Dec-15	110	A	23-Sep-18	110	A
20-Jan-16	78	A	8-Oct-18	78	A
23-Feb-16	230	A	26-Nov-18	110	A
10-Mar-16	68	A	10-Dec-18	230	A
18-Apr-16	20	A	7-Jan-19	18	A
9-May-16	230	A	18-Feb-19	230	A
14-Jun-16	270	B	19-Mar-19	230	A
26-Jul-16	130	A	23-Apr-19	230	A
9-Aug-16	20	A	14-May-19	68	A
13-Sep-16	230	A	27-Jun-19	78	A
17-Oct-16	490	B	15-Jul-19	45	A
6-Nov-16	790	B	29-Aug-19	1300	B
19-Dec-16	20	A	12-Sep-19	230	A
9-Jan-17	20	A	29-Oct-19	78	A
27-Feb-17	330	B	25-Nov-19	18	A
29-Mar-17	230	A	09-Dec-19	230	A

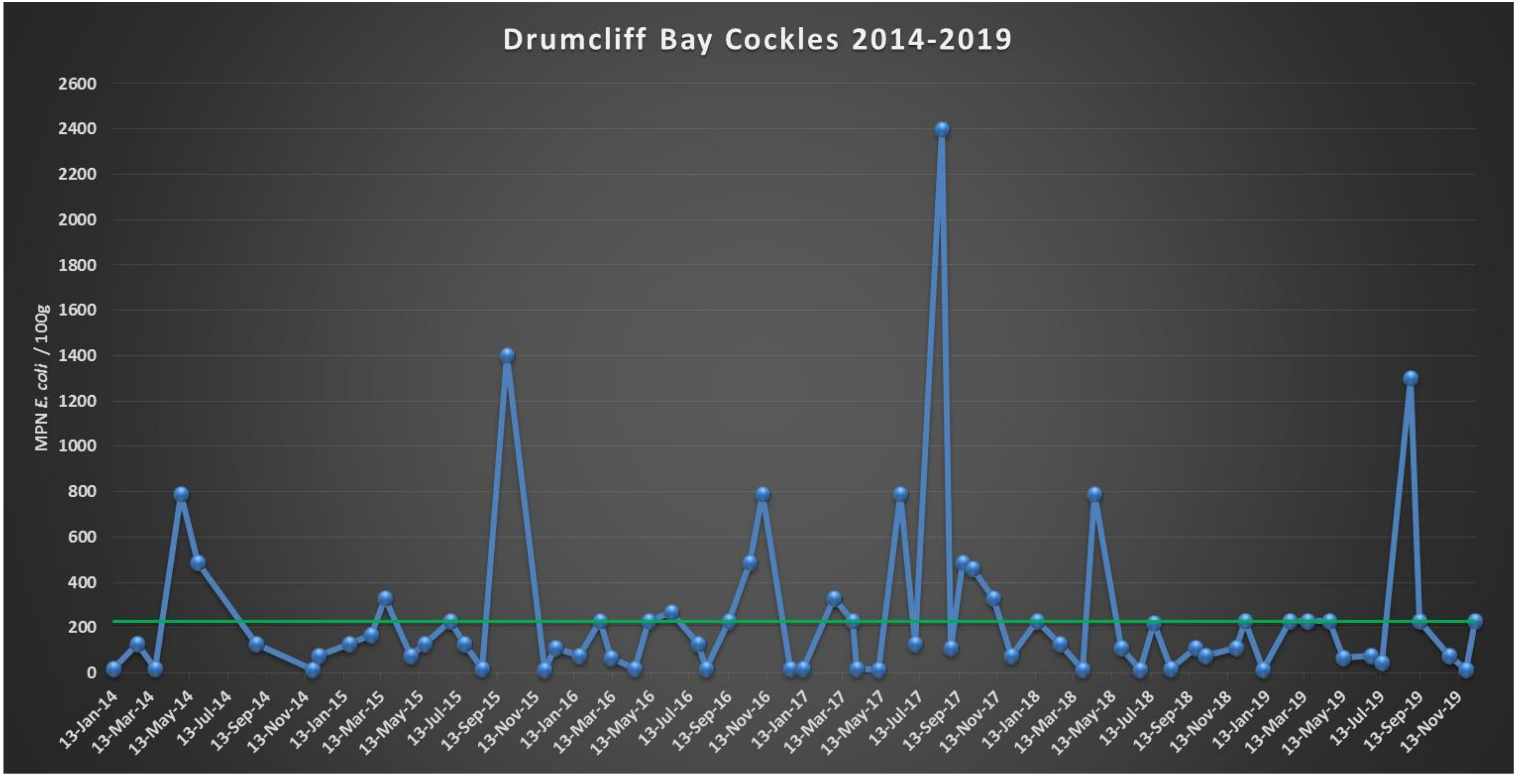


Figure 5.3: ***E. coli*** **levels from cockles at Drumcliff Bay from 2014 to 2019 (Source: SFPA).**

Table 5.7: *E. coli* results from Drumcliff Bay mussels from 2014 to 2019 (Source: SFPA).

Date	MPN *E. coli* /100g	Category	Date	MPN *E. coli* /100g	Category
13-Jan-14	110	A	14-Mar-17	78	A
20-Feb-14	130	A	4-Apr-17	45	A
20-Mar-14	490	B	8-May-17	18	A
10-Apr-14	330	B	12-Jun-17	490	B
27-May-14	1300	B	6-Jul-17	130	A
30-Jun-14	50	A	16-Aug-17	1100	B
27-Aug-14	18	A	31-Aug-17	78	A
29-Oct-14	18	A	18-Sep-17	330	B
24-Nov-14	170	A	5-Oct-17	5400	C
4-Dec-14	230	A	6-Nov-17	220	A
22-Jan-15	220	A	4-Dec-17	78	A
25-Feb-15	230	A	15-Jan-18	130	A
19-Mar-15	170	A	19-Feb-18	130	A
29-Apr-15	18	A	27-Mar-18	330	B
20-May-15	230	A	15-Apr-18	230	A
15-Jun-15	78	A	28-May-18	45	A
23-Jul-15	20	A	26-Jun-18	45	A
17-Aug-15	230	A	18-Jul-18	210	A
28-Sep-15	330	B	14-Aug-18	130	A
21-Oct-15	1700	B	23-Sep-18	110	A
26-Nov-15	220	A	8-Oct-18	2400	B
14-Dec-15	790	B	26-Nov-18	700	B
20-Jan-16	2400	B	10-Dec-18	68	A
23-Feb-16	490	B	7-Jan-19	78	A
10-Mar-16	68	A	18-Feb-19	110	A
18-Apr-16	45	A	19-Mar-19	170	A
9-May-16	330	B	23-Apr-19	78	A
14-Jun-16	78	A	14-May-19	45	A
4-Jul-16	170	A	27-Jun-19	20	A
9-Aug-16	45	A	15-Jul-19	790	B
13-Sep-16	68	A	29-Aug-19	3500	B
17-Oct-16	330	B	12-Sep-19	330	B
6-Nov-16	78	A	29-Oct-19	460	B
5-Dec-16	40	A	25-Nov-19	18	A
9-Jan-17	130	A	09-Dec-19	93	A
27-Feb-17	790	B			

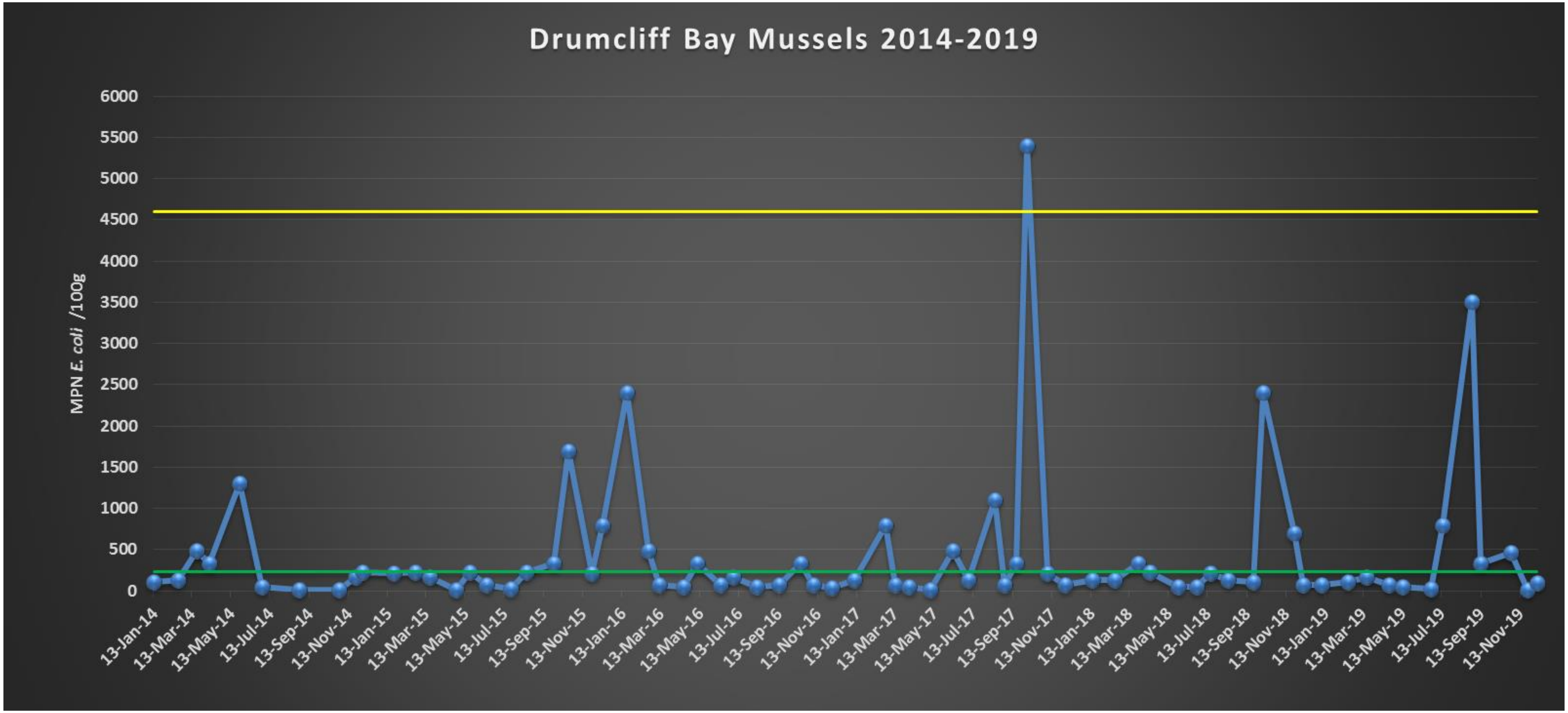


Figure 5.4: ***E. coli*** **levels from mussels at Drumcliff Bay from 2014 to 2019 (Source: SFPA).**

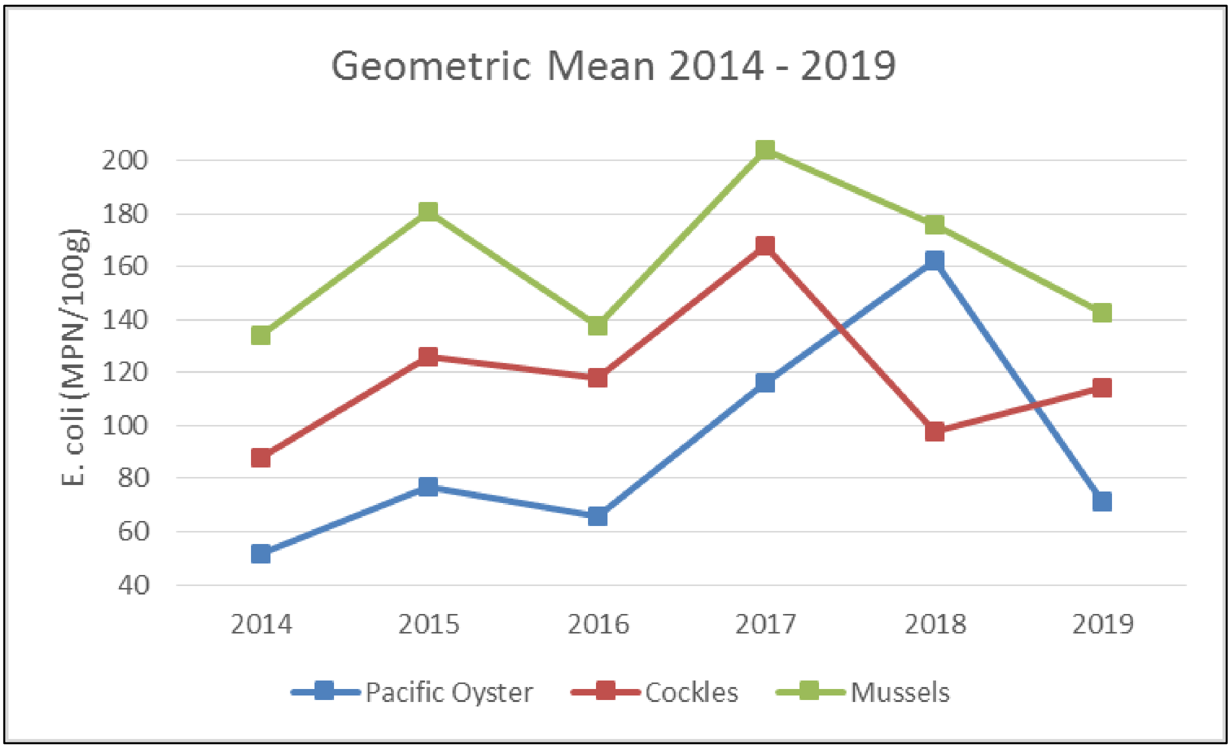


Figure 5.5: Trend in geometric mean of *E. coli* levels from 2014 to 2019 for all species in Drumcliff Bay.

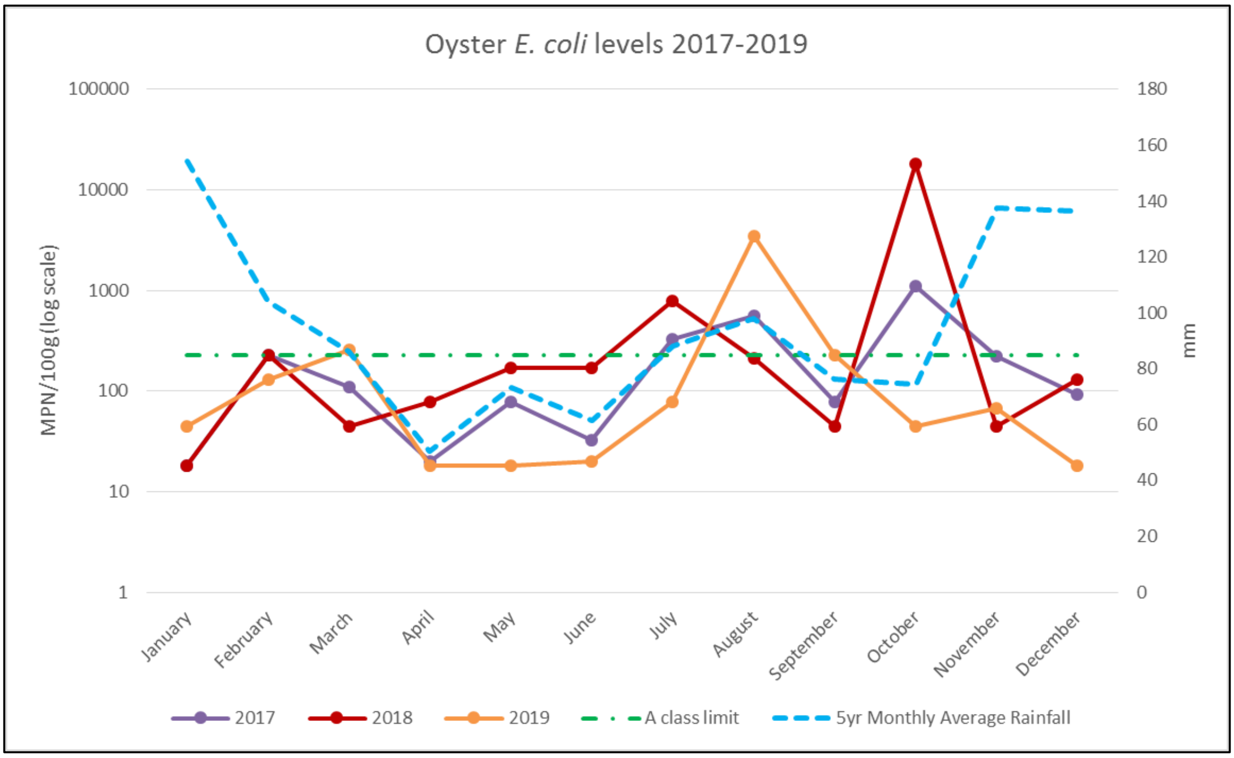


Figure 5.6: Oyster *E. coli* levels for 2017-2019 with 5yr monthly average rainfall.

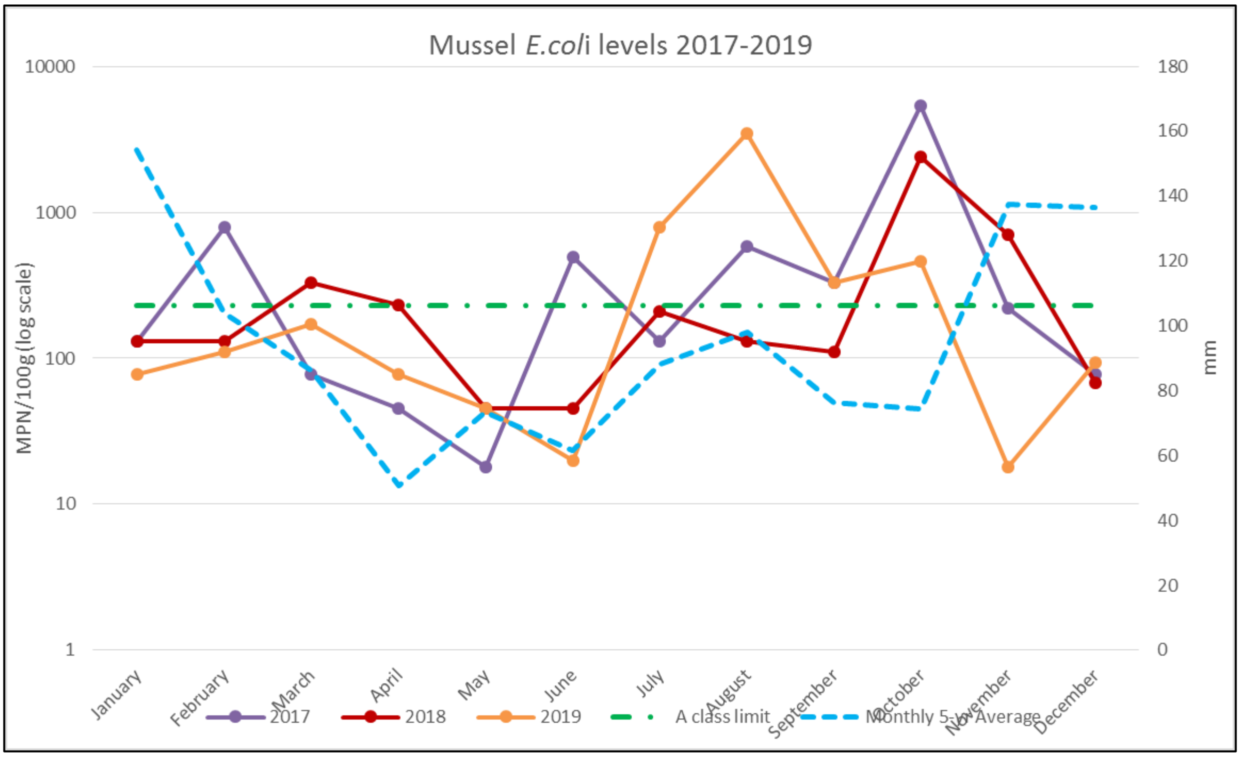


Figure 5.7: Mussel *E. coli* levels for 2017-2019 with 5yr monthly average rainfall.

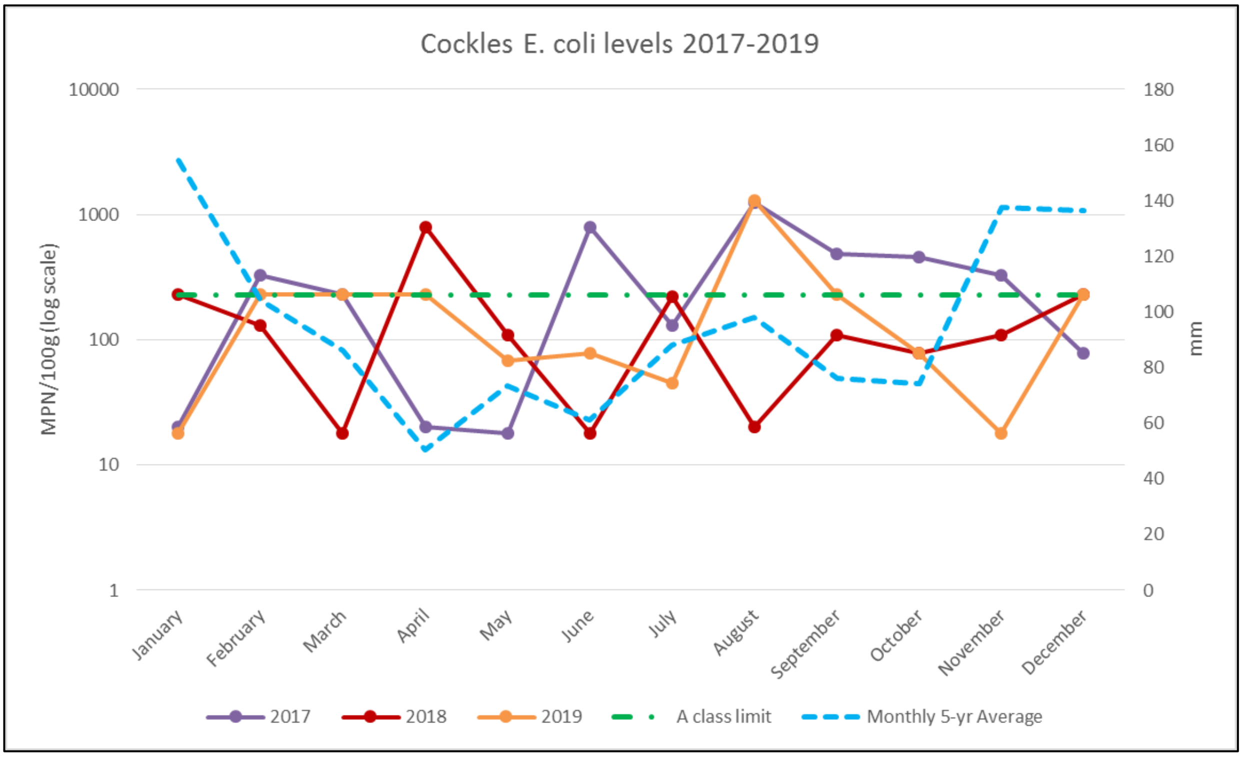


Figure 5.8: Cockle *E. coli* levels for 2017-2019 with 5yr monthly average rainfall.

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

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-DB-DB	Pacific Oyster	13/01/14	9/12/19	18	18000	78	86.4
SO-DB-DB	Cockles	13/01/14	9/12/19	18	2400	130	118.6
SO-DB-DB	Mussels	13/01/14	9/12/19	18	5400	130	162.2

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

Code	Species	2014	2015	2016	2017	2018	2019
SO-DB-DB	Pacific Oyster	52	77	66	116	162	72
SO-DB-DB	Cockles	88	126	118	168	98	114
SO-DB-DB	Mussels	134	181	138	204	176	143

Table 5.10: Elevated SFPA shellfish sample reports.

Date	Species	*E. coli* Level (MPN/100g)	Heavy Rain	Extreme Met Event	Industry Opinion	Additional Information
21/08/2017	Pacific Oysters	1100	Yes	Yes	Due to heavy rain	
09/10/2017	Pacific Oysters	1100	Yes	Yes	Due to heavy rain	
09/10/2017	Mussels	5400	Yes	Yes	Due to heavy rain	
13/10/2017	Pacific Oysters	1100	Yes	No	Due to heavy rain	
11/10/2018	Pacific Oysters	18,000	No	No	Unsure	Agricultural activity. Works ongoing at Carney WWTP
22/03/2019	Pacific Oysters	490	Yes	No	Due to heavy rain	No change in agricultural activity noted

Increased microbial loads are generally experienced after high rainfall events due to land run off containing animal faeces and increased flow to WWTW sometimes causing release of untreated waste through storm water overflows (see Table 5.10 for elevated results following heavy rain). As stated in section 4.6 above high rainfall events can occur at any time of the year. However, rainfall after extended dry periods can lead to higher influxes of waste from land which has been building up over this dryer period. This can be seen in figure 5.6 which shows the shellfish results for oysters from 2017 to 2019 with average monthly rainfall overlain. Although the highest rainfall occurs from November to January the highest *E. coli* levels were recorded between June and November after the driest months (April-June). The SFPA had identified in their three year data set that elevated *E. coli* levels tended to occur between June to November and in 2017 had allocated a seasonal A classification for pacific oysters based on this information. Since then the seasonal classification has been rescinded to an annual B classification for pacific oysters but as Table 5.10 shows there remains a trend towards more results above the A classification level of 230 *E.coli* mpn per 100g during the June to November period.

The trend for mussels was less strong, although the results in general were higher and mostly over the 230 limit for class A (Figure 5.7). While cockles showed no obvious trend (Figure 5.8).

In addition to the *E. coli* monitoring carried out by the 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 no biotoxin related closures for any location in Drumcliff Bay.

5.1.3. Norovirus (NoV)

Norovirus is the most common cause of viral gastroenteritis globally. Infections in Ireland and other countries demonstrate a strong seasonal distribution with illness peaking during the winter months. Transmission of norovirus is via the faecal-oral route either directly or via contaminated food or water.

The virus can be present then in water from municipal waste water treatment systems and smaller individual on site waste water systems. It can then enter shellfish production area waters through direct discharges such as treatment plant outflows and stormwater overflows. Bivalve shellfish in turn can accumulate human pathogenic viruses (including norovirus) when such viruses are present in the growing waters.

High risk factors for shellfish-related norovirus include cold weather with low water temperatures, high prevalence of norovirus gastroenteritis in the community, and high rainfall with its incumbent potential for high water sewage system overflows.

Monthly oyster samples collected during the EU baseline survey for norovirus demonstrated a high prevalence of norovirus in the production area with most months showing some levels. There was a noticeable trend towards higher results during the November to April period but it was also noticeable that prevalence of the virus was not limited to the colder months. This data would appear to indicate that the production area is at a generally high risk from faecal contamination from human sources (Table 5.11).

Table 5.11: Drumcliff Norovirus Sample Results 2016 – 2018.

Month-Year	Total norovirus conc. (copies/g)
November 2016	684
Decmeber 2016	1410
January 2017	1759
February 2017	955
March 2017	<LOQ
April 2017	<LOQ
May 2017	Not detected
June 2017	<LOQ
July 2017	Not detected
August 2017	Not detected
September 2017	<LOQ
October 2017	<LOQ
November 2017	<LOQ
December 2017	479
January 2018	3118
February 2018	2579
March 2018	<LOQ
April 2018	1164
May 2018	No Result

Month-Year	Total norovirus conc. (copies/g)
June 2018	<LOQ
July 2018	340
August 2018	103
September 2018	359
October 2018	<LOQ

5.2. Current Data

5.2.1. Sampling Sites & Methodology

Ten water sampling sites were sampled within the Drumcliff Bay BMCPA between September 2018 and October 2018. The locations of these sites can be seen in Figure 5.9 and Table 5.12 shows the station coordinates.

Station 1 was sampled on the 26th September 2018, there was 0.9mm of rain over the previous days. Station 2 was sampled on the 3rd October 2018. There was 7.8 mm of rain over the two previous days. Station 3 was sampled on the 4th October 2018. There was 4.8mm of rain over the two previous days. Station 4 was sampled on the 5th October 2018. There was 2.2mm of rain over the two previous days. Stations 1 to 4 were all sampled from rivers. Stations 5 to 10 were sampled on the 30th May 2019. There was 6.6mm of rain over the two previous days. Stations 5 to 10 were sea water samples from within the bay.

In addition, a bacteriological survey for shellfish flesh was carried out over a three month period (January-March 2020). *E. coli* levels were found to be higher in water samples in the inner part of the bay (Figure 5.8). Therefore, a trial was carried out to compare the original RMP locations for mussels and cockles with two new proposed location. The locations of these sites can be seen in Figure 5.10 and Table 5.13 shows the station coordinates.

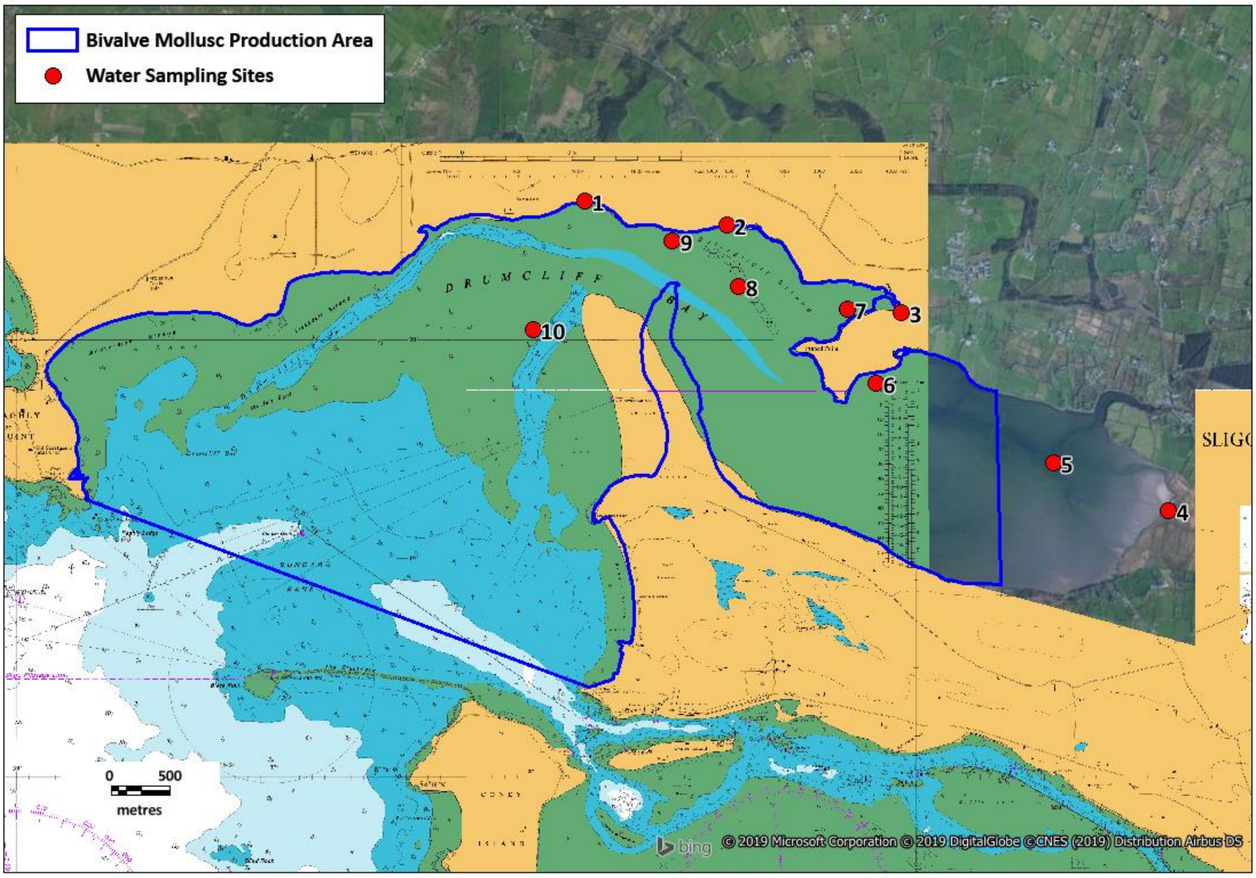


Figure 5.9: Water sampling sites.

Table 5.12: Water sample coordinates with date of sampling.

Station	Feature	Rainfall (mm) previous 48hrs	Latitude	Longitude	Easting	Northing	Sampling Date
1	Small river	0.9	54.34408	-8.57721	162515	344071	26/09/2018
2	Small river	7.8	54.34228	-8.55871	163716	343861	03/10/2018
3	Carney River	4.8	54.33559	-8.53602	165186	343105	04/10/2018
4	Small river	2.2	54.3205	-8.50135	167429	341409	05/10/2018
5	Sea water	6.6	54.32411	-8.51630	166459	341818	30/05/2019
6	Sea water	6.6	54.33016	-8.53936	164964	342502	30/05/2019
7	Sea water	6.6	54.33582	-8.54308	164727	343134	30/05/2019
8	Sea water	6.6	54.33753	-8.55726	163806	343331	30/05/2019
9	Sea water	6.6	54.34105	-8.56578	163255	343728	30/05/2019
10	Sea water	6.6	54.33424	-8.58388	162072	342979	30/05/2019

All water samples were collected in sterile plastic water bottles. These samples were stored in a cool box until delivery to the lab (within 24hrs of collection).

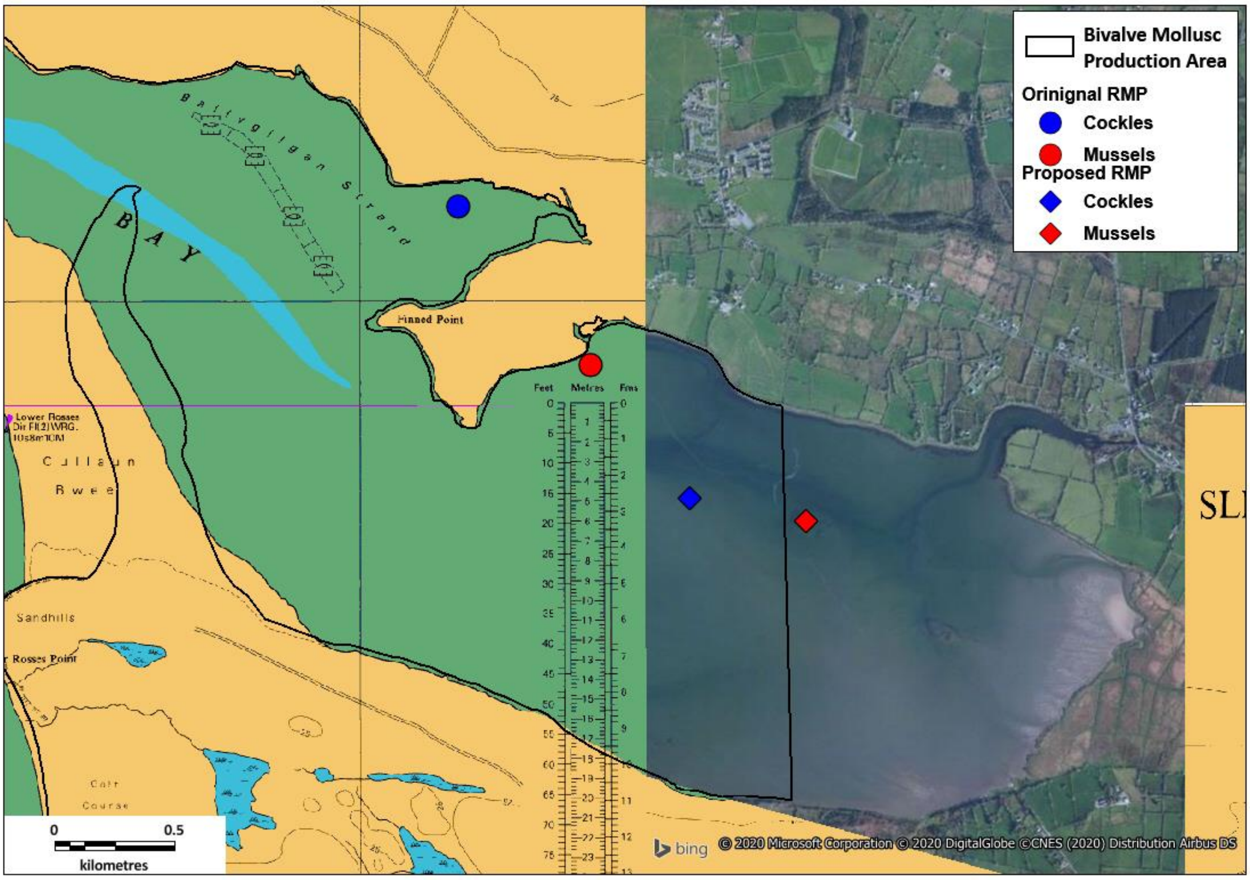


Figure 5.10: sampling points used in cockle and mussel RMP trial.

Table 5.13: Coordinates for sampling points used in cockle and mussel RMP trial.

Location	Longitude	Latitude	Easting	Northing
Original mussels RMP	-8.5361	54.3312	165,173.46	342,623.84
Original cockle RMP	-8.54462	54.3371	164,624.56	343,290.07
Proposed mussel RMP	-8.52225	54.3253	166,069.73	341,964.55
Proposed Cockle RMP	-8.52969	54.3261	165,586.34	342,061.56

5.2.2. Microbial Analysis Results

Table 5.14 shows the water sample analysis results and Figure 5.11 shows the location and magnitude of the results. Highest *E. coli* levels for the freshwater samples were recorded from the Carney River on the northern shore (Station 3; 220 cfu/100ml), followed by a small unnamed river on the eastern shore (Station 4; 140 cfu/100ml) and a small unnamed river on the northern shore (Station 1; 135 cfu/100ml). The lowest *E. coli* levels came from a small unnamed river (Station 2, 60 cfu/100ml) on the northern shore of the bay. The highest *E. coli* levels for the marine stations were recorded in the inner bay at stations 5 and 6 (Station 5, 485 cfu/100ml; Station 6, 445 cfu/100ml) followed by Station 8 (285 cfu/100ml) located in the main channel. The lowest *E. coli* levels were recorded at the mouth of the Carney River (Station 7, 0.0013 cfu/100ml) followed by stations 9 and 10 (10 cfu/100ml) located in the outer half of the bay (see Appendix 2 for *E. coli* lab results).

Table 5.15 shows the bacteriological results for the cockle and mussel RMP trial. For mussels *E. coli* ranged from 20 MPN/100g in March at the original RMP to 1700 MPN/100g in January also at the original RMP location. The original RMP for mussels recorded the highest individual *E.coli* level and a higher average *E. coli* level than the proposed RMP. The cockle *E. coli* levels ranged from <18 MPN/100g in January at the original RMP to 1100 MPN/100g in February at the proposed RMP. The proposed RMP for cockles recorded the highest individual *E.coli* level and a higher average *E. coli* level than the original RMP.

Table 5.14: Water *E. coli* results for Drumcliff Bay.

Station No.	*E. coli* (cfu/ 100ml)
1	135
2	60
3	220
4	140
5	485
6	445
7	0.0013
8	285
9	10
10	10

Table 5.15: Results for cockle and mussel RMP trial.

	Mussel (MPN/100g)		Cockle (MPN/100g)	
Date	**Original RMP**	**Proposed RMP**	**Original RMP**	**Proposed RMP**
27th January	1700	460	<18	20
24th February	78	68	230	1100
23rd March	20	78	130	20
Average	**599**	**202**	**126**	**380**

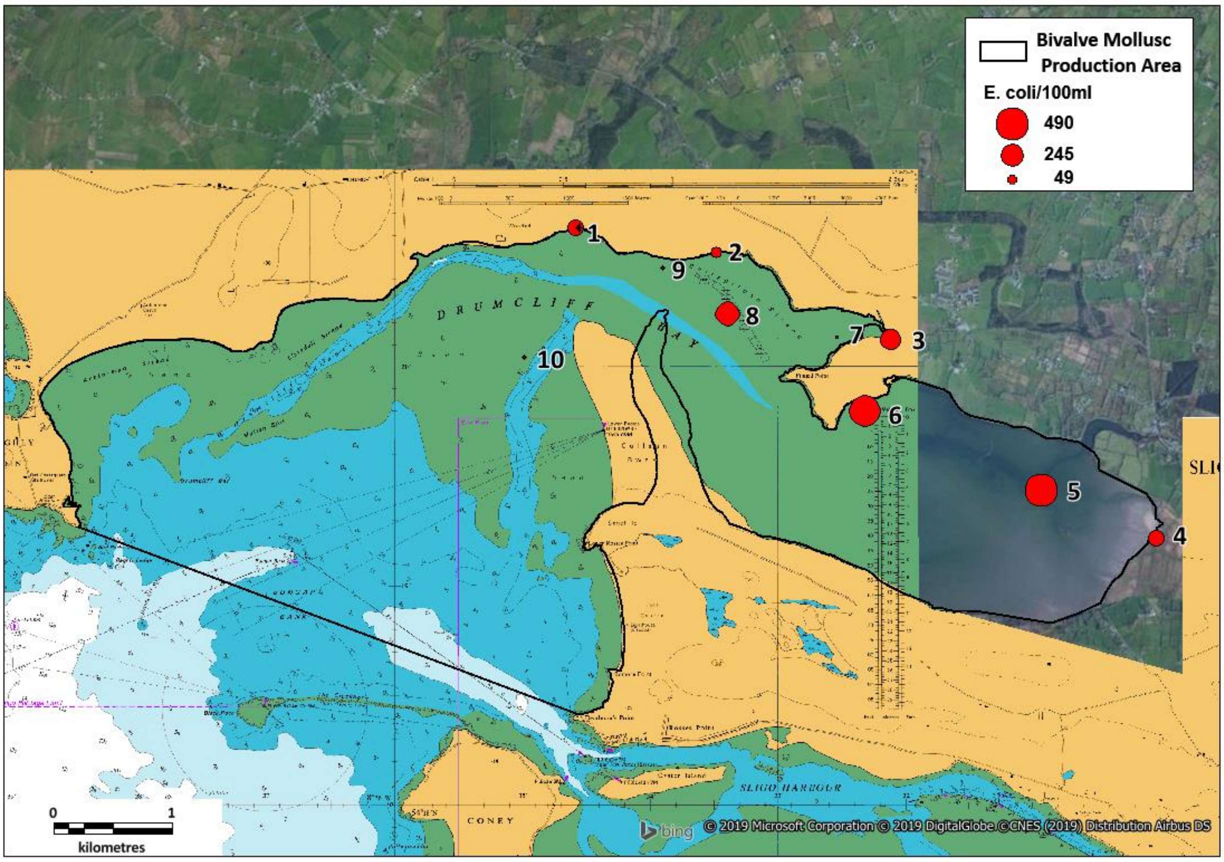


Figure 5.11: Location and magnitude of E. coli results from the shore survey.

6. Overall Assessment of the Effect of Contamination on Shellfish

6.1. Human sewage/Human population

The area around Drumcliff Bay has relatively low population concentrations with the small villages of Carney, Drumcliff and Rathcormac being the only conurbations of note. Other than these, the population is spread out within the catchment as one off houses. The total population of the entire catchment area of Drumcliff Bay is just over 3,700.

As noted in Section 4.1.3 above, there are two waste water or sewage treatment works within the Drumcliff Bay catchment and these discharge into Drumcliff Bay. The Carney treatment plant serves a population equivalent of 2000 and treats waste to the tertiary level before discharging o the Carney River above the tidal limit. This plant is currently under capacity at 387 PE. The second treatment works, that of Drumcliff and Environs, treats waste to a secondary level and is a smaller unit catering for 150 persons. It too is also under capacity with a current population equivalent of 93. It is expected that both plants will be impacting contamination levels with the production area.

Of note is that the Carney plant has a storm water overflow discharge facility whilst the Drumcliff plant does not. The Carney plant is currently under capacity but there is no event logger or flow measurement connected to the storm water capacity in order to record flows being directed to the discharge. It was notable that the Sea Fisheries Protection Authority elevated shellfish sampling report from October 2018 in response to an 18,000 ecoli per 100 grams result made reference to works having been undertaken at the Carney waste water plant around the same period.

A majority of households within the catchment though are not linked to either of these WwTP plants. It was recorded that there are 1,149 on-site wastewater treatment systems within the catchment in 2009 and that their density is much higher than the national average. The risk to surface and ground waters is high throughout the catchment because of inadequate percolation. It is difficult to accurately predict the impact of private treatment systems but it is expected that they are contributing to contamination levels within the harvesting area.

There are no industrial discharges within the catchment but there are two Section 4 trade discharges within the catchment. Only one of these though has a sewage related contingent and it discharges to the inner Drumcliff estuary/river upstream of the wild cockle and mussel beds.

Boating activity is very low within the harvesting area and the small pier at Raghly is only used by a small number of boats. Faecal contamination arising from activities here is expected to be virtually nil.

6.2. Agriculture

Land use in the Drumcliff catchment area is largely agricultural with pasture land overwhelmingly dominant. Cattle are grazed primarily in the west of the catchment in those electoral divisions surrounding Lissadell with sheep dominating the other parts of the area. Sheep numbers are particularly high in the Glencar valley area. The electoral divisions of Carney and the two Glencars support a population of 23,667 such animals in addition to 1239 cattle. Sheep were also noted feeding on an area of the foreshore close to Carney during the course of the shoreline survey.

It is likely that sheep in particular are adding to faecal contamination levels with the harvesting area through run-off during periods of high rainfall. Most of the land in the Glencar area and around the mountains is steep sided further aiding run off. The spreading of slurry and farmyard manure particularly in the lands in the west of the harvesting area may also be adding to background faecal contamination levels through run off via field drains.

Much of the diffuse agricultural contamination may enter the production area through the Drumcliff River, Carney River and those streams entering the area at Ballygilgan/Lissadell.

6.3. Rivers and Streams

The Drumcliff River drains a catchment of 61.6km2 and is the main freshwater input into Drumcliff Bay. Originating in Glencar Lough the river drains agricultural land along its whole length. The Drumcliff WwTP is located at the downstream end of the river and discharges to it at the tidal confluence. The river enters the harvesting area itself in the inner eastern section in close proximity to some of the cockle and mussel beds. It is expected that this river will be one of the primary drivers of faecal contamination within the harvesting area due to diffuse agricultural run-off, private septic tanks and the WwTP discharging to it. During the shoreline survey sea water sampled downstream of where it discharges to the harvesting area showed elevated levels of faecal contamination.

The Carney River is smaller and also drains a much smaller catchment than the Drumcliff River. It enters the harvesting area onto Ballygilgan Strand downstream of the village of Carney. Similarly to the Drumcliff it also has a WwTP discharging to it, this time it is the Carney WwTP. Where the river meets the sea it is carried across the inter-tidal sands by a small channel before it meets the main channel. During the shoreline survey relatively low levels of faecal contamination were evident in the Carney but with a stormwater overflow associated with the WwTP upstream it is expected that during episodic high rainfall events it may have a direct influence on contaminant levels in the nearby shellfish beds.

Two further small river/streams enter the harvesting area at Ballygilgan Strand, one in particular entering onto the strand in close proximity to the licensed oyster farm. Both when sampled during the shoreline survey showed evidence of faecal contamination but levels were low, the stream nearest the oyster farm showing 60 cfu/100 ml whilst that further west was slightly higher at 135 cfu/100 ml. Both drain very small catchments but drain through wooded areas populated by deer and through pasture land.

Another river enters the inner Drumcliff Bay area near Kintogher, this gave a reading of 140 cfu/100ml when sampled. This is a short stream that drains pasture land before running through the village of Rathcormac (150 persons population) and down through an area of saltmarsh before entering the sea. It is likely that water is a regular source of diffuse contamination to the harvesting area.

6.4. Wildlife

With regard to birds, it has been noted above (Section 4.1.6) that bird faeces are rich in faecal bacteria and have been shown to be a source of faecal contamination in the marine environment. Drumcliff is designated as an SPA (site code 004013) and supports a wide variety of species some of which occur in high numbers during the late Autumn through to the early Spring months.

Large numbers of barnacle geese (approx. 3000) use the Drumcliff area during the autumn and winter months and in particular large numbers frequent the fields adjacent Ballygilgan Strand at the nature reserve there. As the species prefers terrestrial habitat over that of inter-tidal they are not expected add massively to faecal contamination levels other than through diffuse run-off.

Seals frequent Drumcliff Bay and on the sand bar opposite Ballygilgan is an area where the animals regularly haul out, seals being noted here during the shoreline survey also. It is expected that due to low numbers there impact will be slight other than adding to background contamination levels.

A number of deer species inhabit the woodlands around Lissadell and may add to faecal contamination through diffuse run-off to the small streams that drain this part of the catchment. It is expected though that the impact will be minor in comparison to that of sheep and cattle throughout the rest of the catchment.

6.5. Seasonality

Of the overseas tourists in 2017, 173,000 visited Co. Sligo and of the domestic tourists, 247,000 visited Co. Sligo (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 and Glencar waterfall and Parke’s Castle in Co. Leitrim. 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 Sligo/Leitrim region. Whilst tourism infrastructure is quite limited within the catchment it could be extrapolated that there will be potential rise in contamination levels during the summer months.

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. In County Sligo the spreading of slurry or farmyard manure, which would be common place in the catchment, is limited by legislation with a closed period from the 1st of November to the 15th January. From mid January to the end of October there would be a potential risk of faecal contamination through diffuse run-off from this activity, if it coincides with a period of rainfall then that risk is raised further.

Bird numbers, particularly of geese and waders, will increase through the autumn/winter period and Drumcliff does support significant numbers of these bird species.

Analysis of the rainfall data for the thirty year period for the Drumcliff Bay region showed that the wettest months were from October to January so it could be anticipated that there will more high rainfall events during those months. The data though also showed that high daily totals could occur during any month of the year and it is therefore not just the winter months that are at risk of increased contamination from rainfall events.

Analysis of the historical Sea Fishery Protection Authority microbiological shellfish sampling showed a slight trend towards higher E.coli results during the June to November period. In addition the majority of E.coli results over the A classification limit of 230 per 100 g tended to occur during this period also. The source of this contamination is less obvious but may be due to increased tourist numbers in the area and/or an increase in the amount of sheep and cattle on the adjoining lands.

6.6. Movement of Contaminants

There is very little hydrological data available on Drumcliff Bay and no models were found to be in existence to demonstrate the movement of waters around the harvesting area. A simple approximation can be made of tidal movements based on the bathymetry of the bay.

A large percentage area of Drumcliff Bay is comprised of inter-tidal sand and mud flats which dry out completely at low water. The main channel arises from the Drumcliff River and runs north along the inner bay down to Finned Point before flowing in a north westerly direction towards Lissadell. At this point it swings south west towards the mouth of the bay and the open ocean. It is expected then as water tracks this channel that the ebb flows will be to the south west and those of the flood to the north east (Figure 6.1).

The northerly orientation of the channel in the inner and outer sections of Drumcliff coupled with the main fresh water inputs all entering the bay from the northern shore mean that whatever the level of faecal pollution is present in the inflowing freshwater, it is the marine waters along the northern sections of Drumcliff Bay that might experience the more negative impacts. This may be exacerbated by the prevailing wind direction in the bay which is from the south around to the west: these wind directions may force the freshwater onto parts of the northern shores of Drumcliff Bay.

It is likely that the main sources of faecal contamination to the harvesting area will originate from the Drumcliff and Carney rivers. From the former it is expected to track westwards on the ebb tide across the mussel and cockle beds that adjoin the main channel. Sea water sampling during the shoreline survey showed moderate levels of contamination originating in this channel with higher results in the inner bay before levels dissipated the further seaward towards the bay mouth the channel travelled.

Contamination originating from the Carney will likely track the small channel that runs from the river mouth on the ebb tide, meeting the main ebbing flow at Finned Point. Where the channel meets is also the location of one of the licensed oyster sites. On the flood tide these movements will be reversed in direction.

As mentioned above sea water sampling data suggest contamination levels decline the further seaward the channel flows. Salinity levels within the outer bay (WFD sampling site) and the middle parts close to the sand spit (SWD sampling station) were found to be quite high indicating that the freshwater influence of the Drumcliff and Carney rivers dissipates quite quickly.

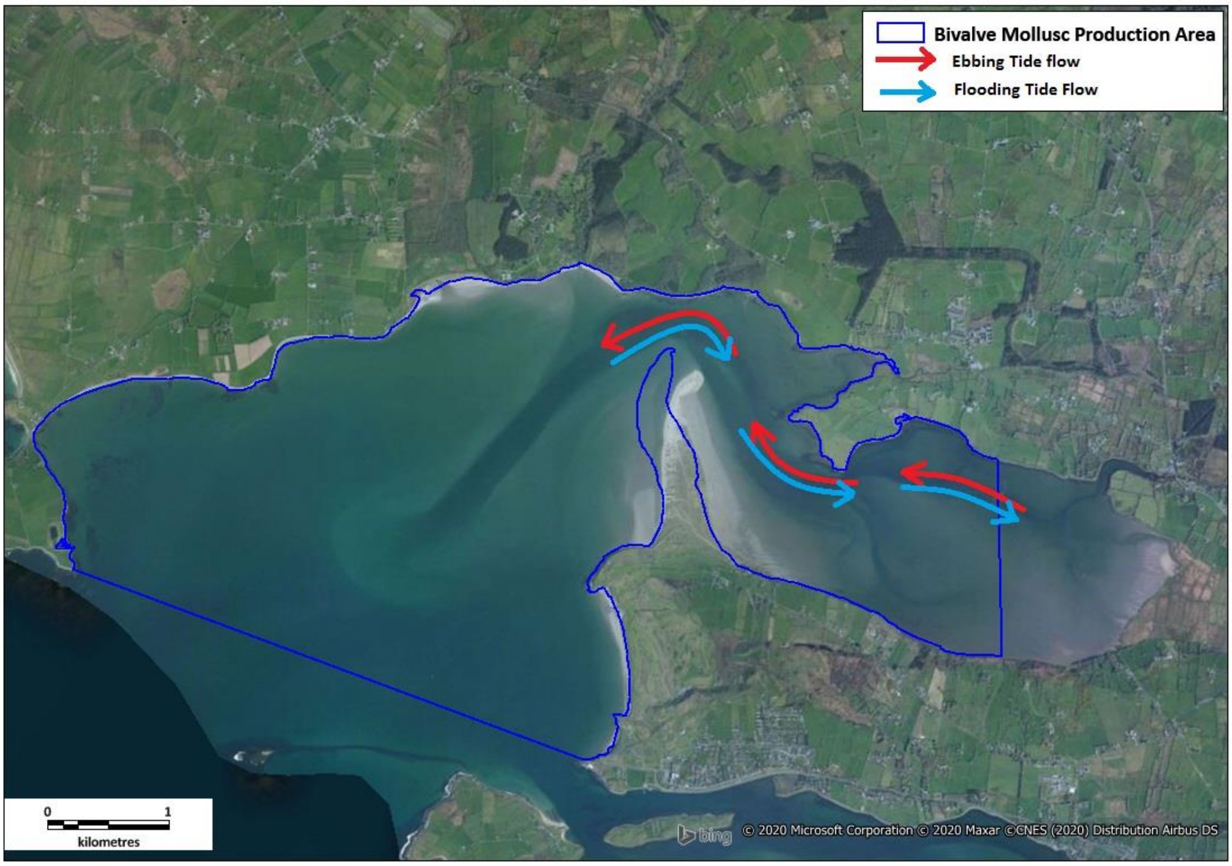


Figure 6.1: Tidal flows in Drumcliff Bay.

6.7. Shoreline Survey

The SFPA carried out a four day survey of the shoreline of Drumcliff Bay. In general numbers of potential contaminant sources identified during the shoreline survey were relatively low. The catchment is overwhelmingly rural with only fragments of urban infrastructure abutting it and this was reflected in the lack of discharges encountered.

In terms of physical infrastructure the two wastewater treatment plants at Carney and Drumcliff were noted with two discharges pipes from the later encountered entering the estuary immediately adjacent. The discharge point from the Carney plant was not visible during the survey but is believed to enter the river downstream of the plant. A man hole cover was also noted on the bank opposing the Drumcliff plant but no obvious discharge point was discovered and it is unclear if this is associated with the nearby Section 4 discharge licence or is part of the Drumcliff plant pipework.

A number of other pipes were encountered during the shoreline survey and these were identified as land drainage pipes, a cluster being noted draining pasture land at Ardtermon Strand.

Areas of pasture land were noted during the shoreline survey but numbers of agricultural animals encountered were low. Sheep though were noted feeding directly on the foreshore at the mouth of the Carney River. Cows (10 approx) were seen north of Raghly Point and another group (20 approx) were noted on ground near the shoreline at Kintogher.

In terms of wild animals large number (150 approx.) of mixed geese and wading birds was noted at the western end of Ardtermon Strand. A large number of barnacle geese (300 appox) were also encountered during the survey in the pasture ground at Ballygilgan Nature Reserve. A small seal haul out was also noted opposite the oyster farms at Ballygilgan, a group of seals (10 approx.) were seen there during the survey.

Of freshwater sources the Drumcliff and Carney Rivers were the most significant encountered. A low number of much smaller river/streams were also encountered during the survey, two at entering the bay in the Lissadell/Ballygilgan area, one entering the inner bay at Kintogher.

Water sampling for E.coli analysis was carried out during the shoreline survey at ten locations (see Figure 5.6 above) in the Drumcliff Bay area. Stations 1 – 4 were located at streams flowing into the bay while the remaining 6 were located in marine waters. The highest E. coli (see Table 5.10 above) levels for the marine stations were recorded in the inner bay at Stations 5 and 6 (Station 5, 485 cfu/100ml; Station 6, 445 cfu/100ml) followed by Station 8 (285 cfu/100ml) located in the main channel. These results are consistent with the predicted current flow patterns described above Section 3.5). The lowest E. coli levels were recorded at the mouth of the Carney River (Station 7, 0.0013 cfu/100ml) followed by stations 9 and 10 (10 cfu/100ml) located in the outer half of the bay.

The naturally occurring cockle beds were spread throughout the bay and constituted the largest m2 area of shellfish harvesting within the area. Four distinct beds were identified, those being the Inner Drumcliff Bed, the Rosses Point Bed, the Ballygilgan Strand Bed and the Ardtermon/Lissadell Bed. Cockles were noted in all beds during the shoreline survey.

Naturally occurring mussels were identified in smaller beds in specific areas, these were limited to areas of rocky or stony substrate. Two small beds were located in the inner bay area towards the Kintogher townland. The main bed occupies an inter-tidal area running from Coolbeg around Finned Point and intowards the mouth of the Carney River. Two further beds were located to the east and north west of Ballygilgan Strand, again in small areas of inter-tidal rocky substrate.

Active pacific oyster production was focused primarily on that area of Ballygiglan Strand running towards Finned Point where the channel from the Carney River enters the main bay channel. A second area of active production lays on the opposite side of the main channel as it enters the inner bay across from Finned. Oyster licences outside these two areas were not active during the shoreline survey.

Carpet shell clam production is limited to a small section of licensed areas at Ballygilgan Strand. Here small clams are currently held under netting but with as of yet no market size animals. No other clam licences were being actively used during the shoreline survey due to historical mortality issues.

7. Amendments to BMPA

The commercially harvested mussel and cockle beds in Drumcliff Bay extended outside of the existing BMPA area (Figure 7.1). The sand spit that divides the inner and outer bay has also moved since the BMPA boundary was originally drawn (See Figure 7.2). This has had the impact that one of the cockle areas is now outside the BMPA boundary. Therefore, the BMPA area was extended to include all beds and the new location of the sand spit (Figure 7.3). The BMPA area has increased from 19.36km2 to 20.32km2.

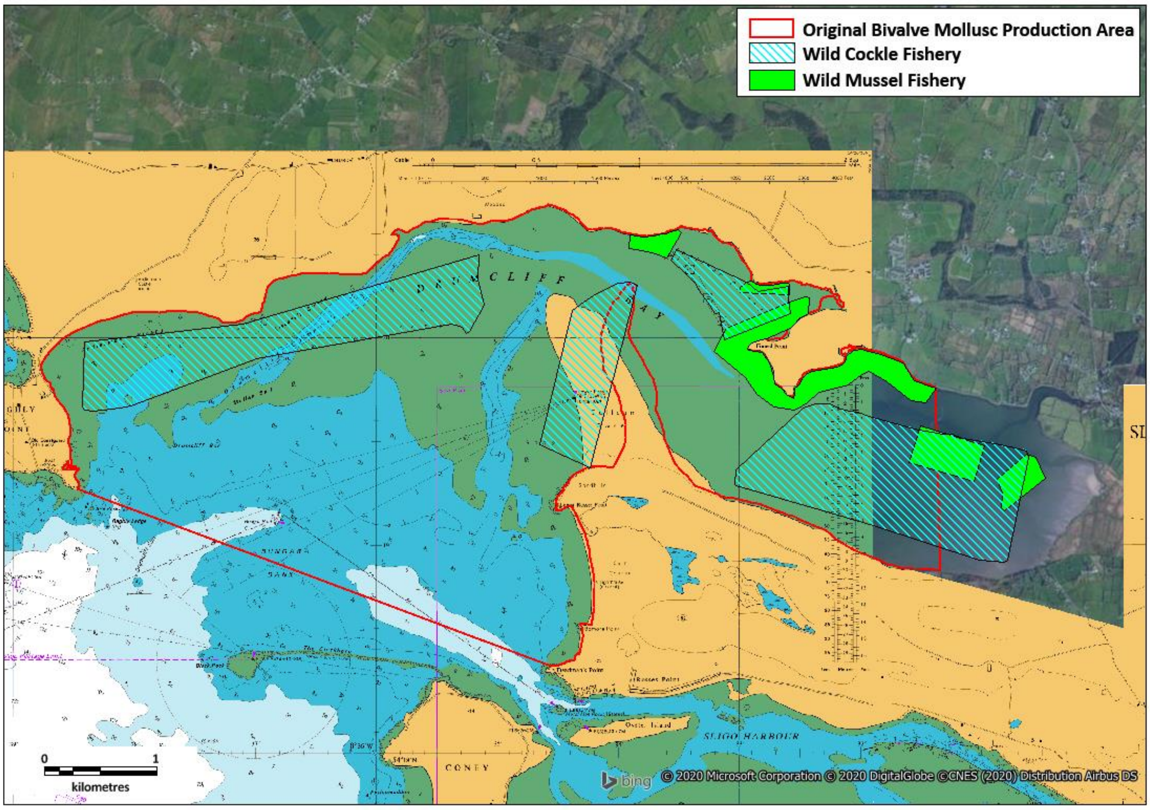


Figure 7.1: Original BMPA area.

Figure 7.2: Satellite imagery showing location of sand spit relative to the original BMPA boundary.

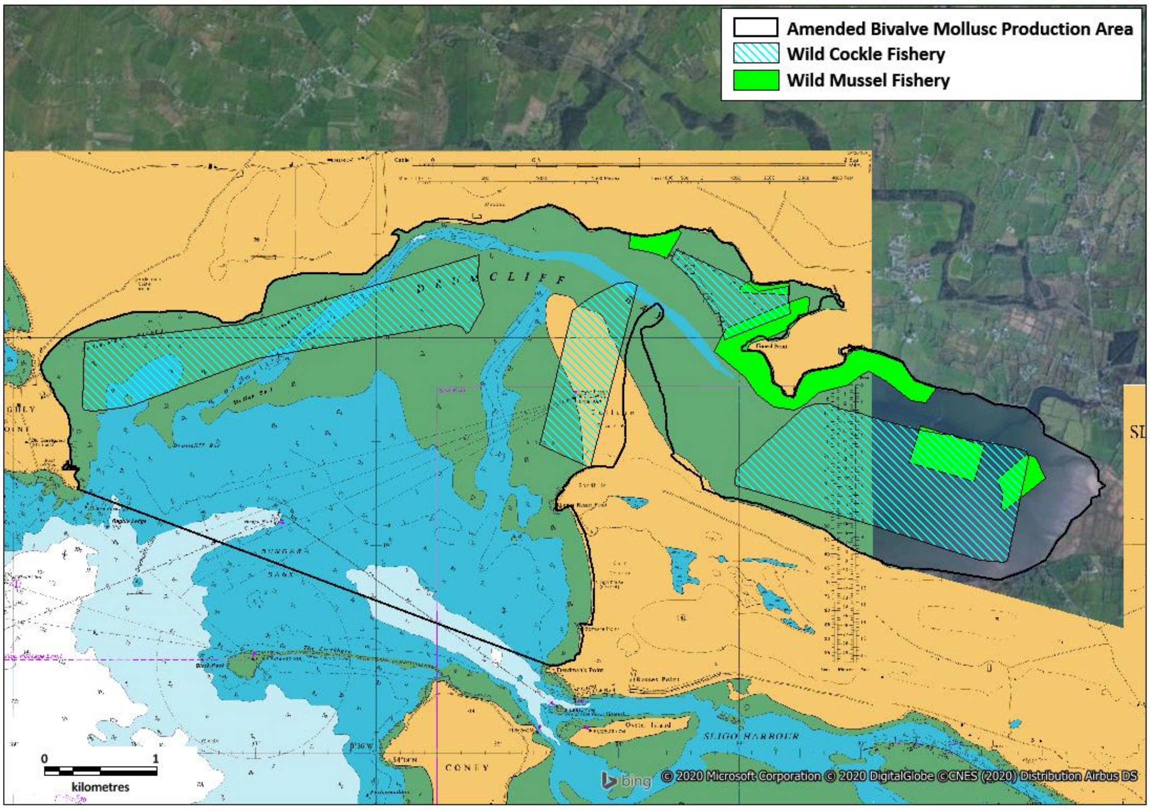


Figure 7.3: Amended BMPA area.

8. RMPS and Sampling Plans

In summary this sanitary survey recommends the adoption of a new RMP for both cockles and pacific oysters in Drumcliff Bay. It also proposes a new RMP for carpet shell clams in the event that commercial production commences.
It is recommended that the original mussel RMP remains in place and active. Figure 8.1 shows the locations of the new RMPs and Figure 8.2 shows the original locations of the RMPs.

8.1. Oysters

The location of RMP 1 for oysters is -8.55422 and 54.33645 (163,999.28E, 343,222.92N) and these are shown on Figure 8.3 below. RMP 1 is located on Ballygilgan strand west of Finned Point. This location is a short distance to the south east of the original RMP and is now closer to the mouth of the channel that runs from the Carney River and to those seawater sampling points that showed higher levels of *E. coli* contamination during the shoreline survey.

10 individuals of market size (minimum shell length 8 cms) should be collected for bacteriological analysis. As harvesting can take place throughout the year, sampling needs to be on a monthly basis.

8.2. Cockles

The location of the RMP 2 for Cockles is -8.529689 and 54.326127 (165,586.34E, 342,061.56N) and is shown on Figure 8.4 below. It is located in the eastern inner part of Drumcliff Bay. The RMP for the cockles is located on the northern end of the largest wild cockle bed in the fishery. The location selected is close to the sites where seawater sampling in the shoreline survey indicated high levels of *E. coli* contamination.

This new location when compared to the original RMP in the bacteriological survey also recorded the highest *E. coli* result at 1100 mpn. It is expected that this new RMP will better reflect contamination originating from the Drumcliff river and the smaller river at Kintogher.

In terms of numbers of cockles collected, this should be a minimum 30 individuals of market size (minimum length 3 cm) for bacteriological analysis. As harvesting can take place throughout the year, sampling needs to be on a monthly basis throughout the year.

8.3. Mussels

The location of the RMP 3 for mussels is -8.5361 and 54.33115 (165,173.46E, 342,623.84N) and is shown on Figure 8.5 below. It is located in the eastern inner part of Drumcliff Bay. The location of the RMP remains unchanged from the original mussel RMP location. Historical sampling data for all species within Drumcliff showed that samples from this location had the highest mean results and that the location has consistently captured evidence of *E.coli* contamination.

Results from the bacteriological survey in 2020 returned average higher results for this location as opposed to the proposed new location and also the highest individual result of the survey.

In terms of numbers of mussels collected, this should be between 15 of market size individuals (minimum length 4 cm) for bacteriological analysis. As harvesting can take place throughout the year, sampling needs to be on a monthly basis.

8.4. Clams

The location of the RMP 4 for Clams is -8.55673 and 54.33923 (163,838.46E, 343,533.66N) and is shown on Figure 8.6 below. Currently there is no active clam production in Drumcliff Bay. However, one producer has commenced on-growing of a small stock of clams. The RMP therefore has been located in this bed so as to allow monitoring once the stock reach market size and are ready for harvesting.

In terms of numbers of clams collected, this should be a minimum 30 individuals of market size (minimum length 4 cm) for bacteriological analysis. Sampling should be carried out on a monthly basis should production of clams recommence.

Table 8.1: Coordinates of the Production Area.

Corner	Longitude	Latitude	Easting	Northing
NE	-8.511428	54.327829	166,775.9	342,242.2
NE	-8.509544	54.327017	166,897.8	342,150.9
SW	-8.642029	54.321324	158272.2	341587.6
S	-8.576697	54.307046	162510.5	339961.6

Table 8.2: Coordinates of each RMP and its relevant species.

RMP	Site Code	Species	Longitude	Latitude	Easting	Northing
RMP 1	SO-DB-DB	Pacific Oyster	-8.55422	54.33645	163,999.28	343,222.92
RMP 2	SO-DB-DB	Cockles	-8.529689	54.326127	165,586.34	342,061.56
RMP 3	SO-DB-DB	Mussels	-8.5361	54.33115	165,173.46	342,623.84
RMP 4	SO-DB-DB	Clams	-8.55673	54.33923	163,838.46	343,533.66

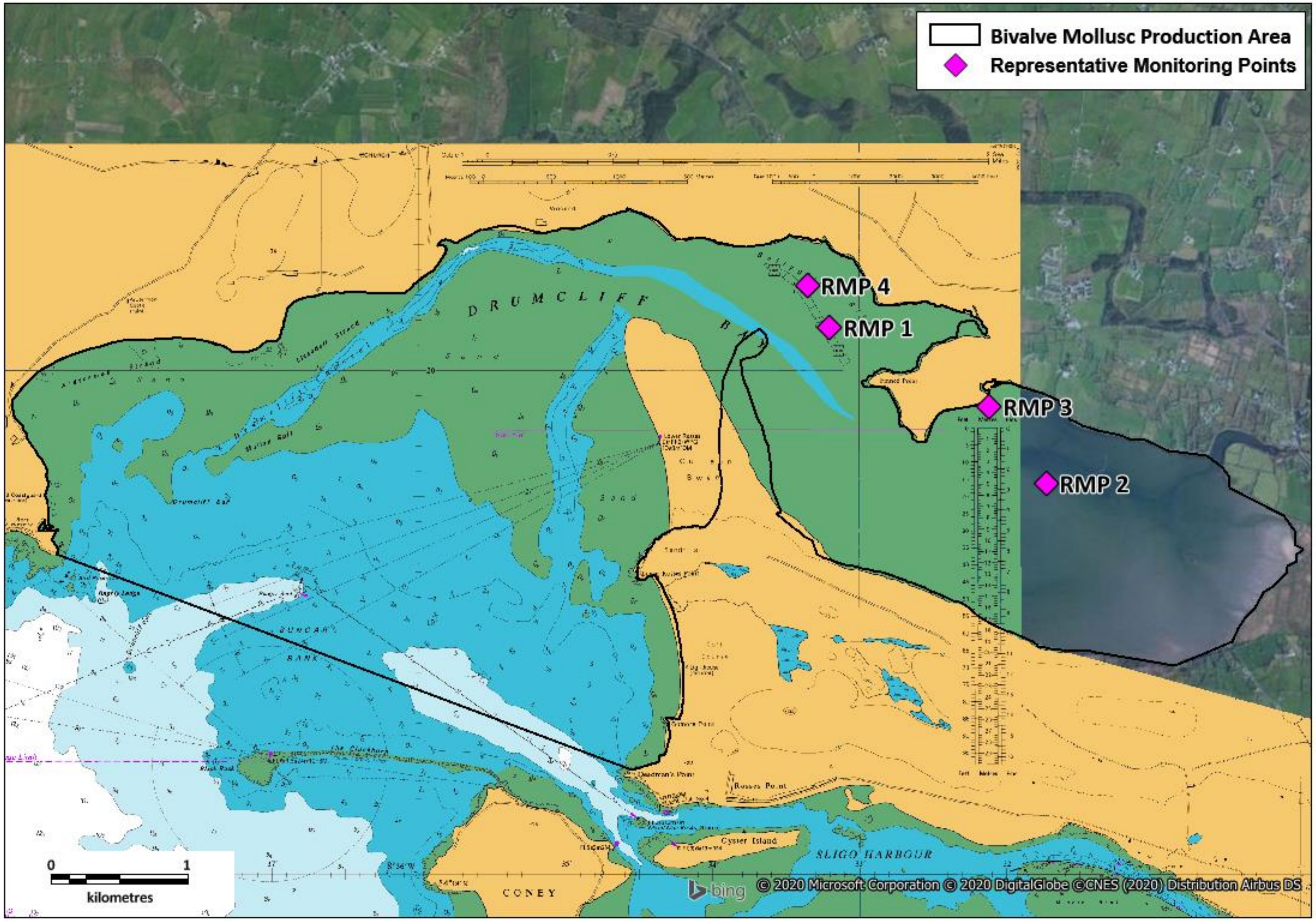


Figure 8.1: Bivalve Mollusc Classified Production Area within Drumcliff Bay with new RMP locations displayed.

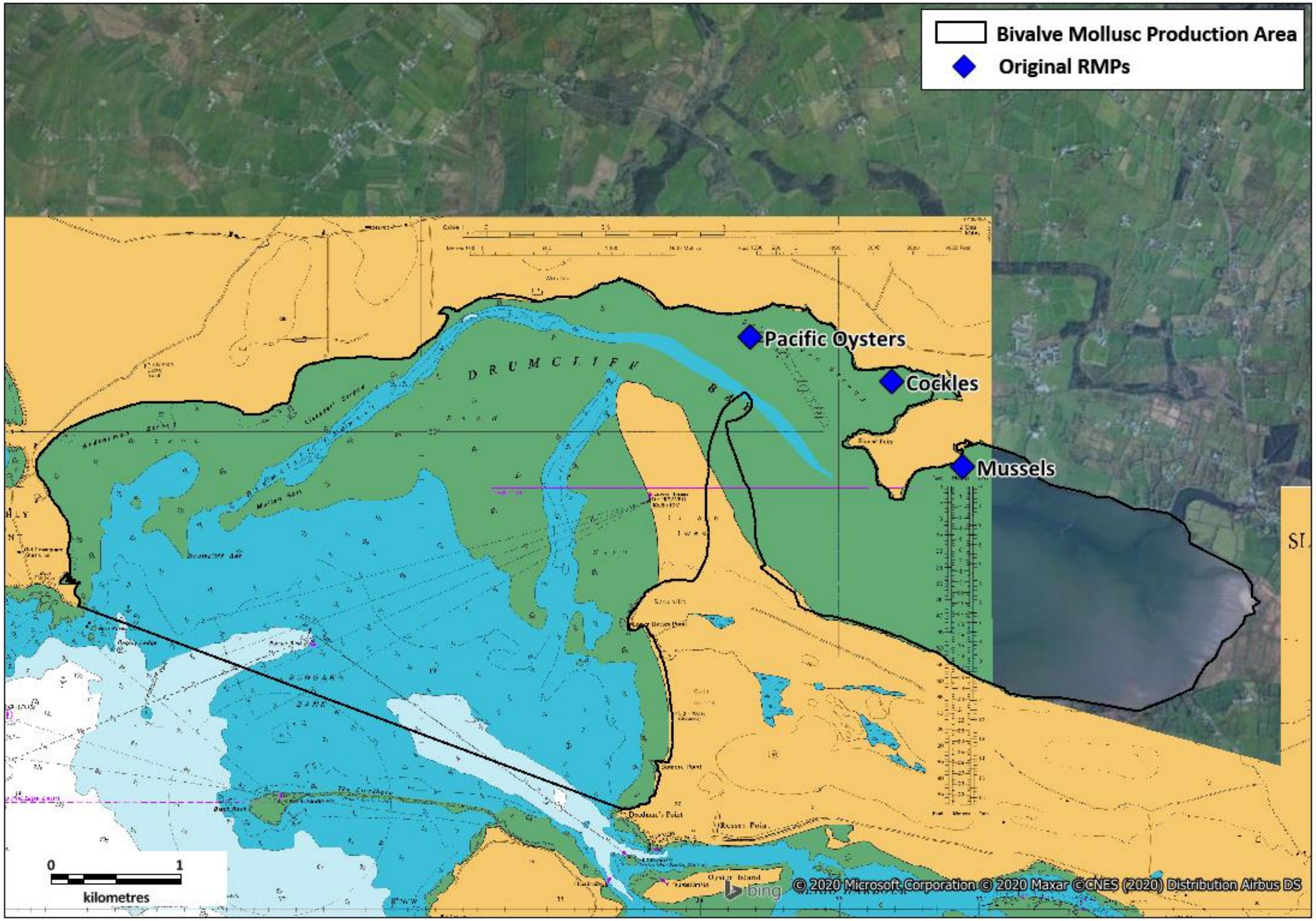


Figure 8.2: Bivalve Mollusc Classified Production Area within Drumcliff Bay with old RMP locations displayed.

8.5. *Species Specific RMP maps*

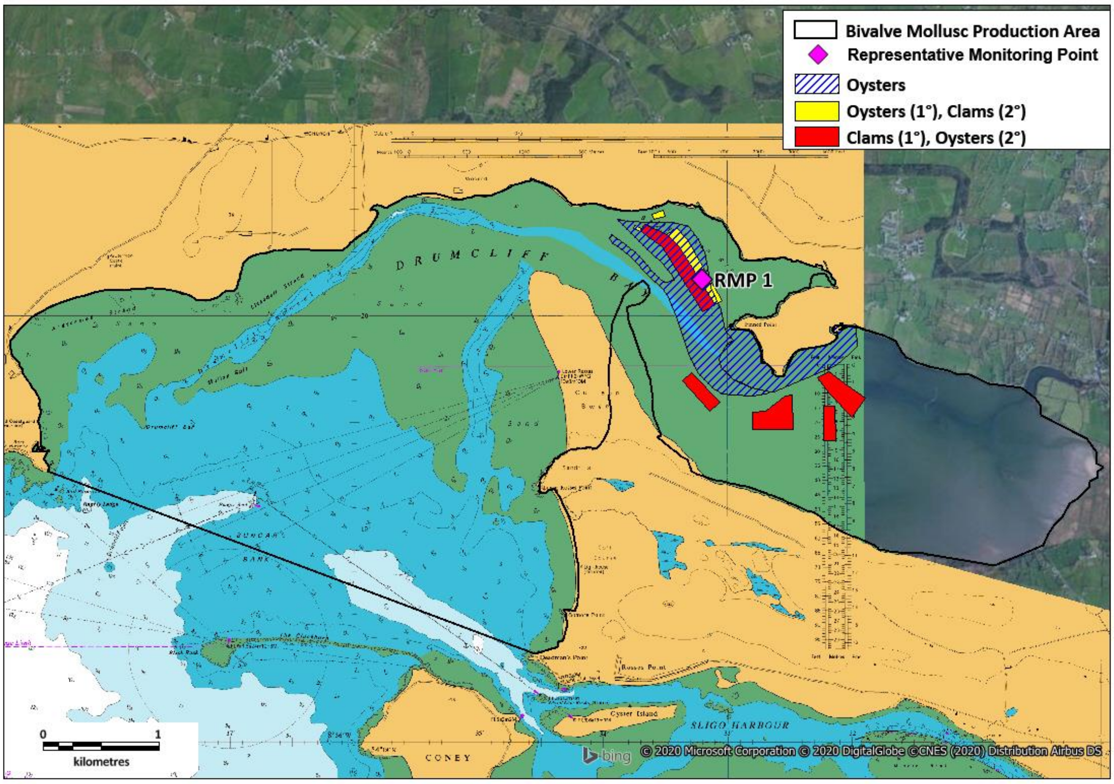


Figure 8.3 Representative Monitoring Points for oysters in Drumcliff Bay.

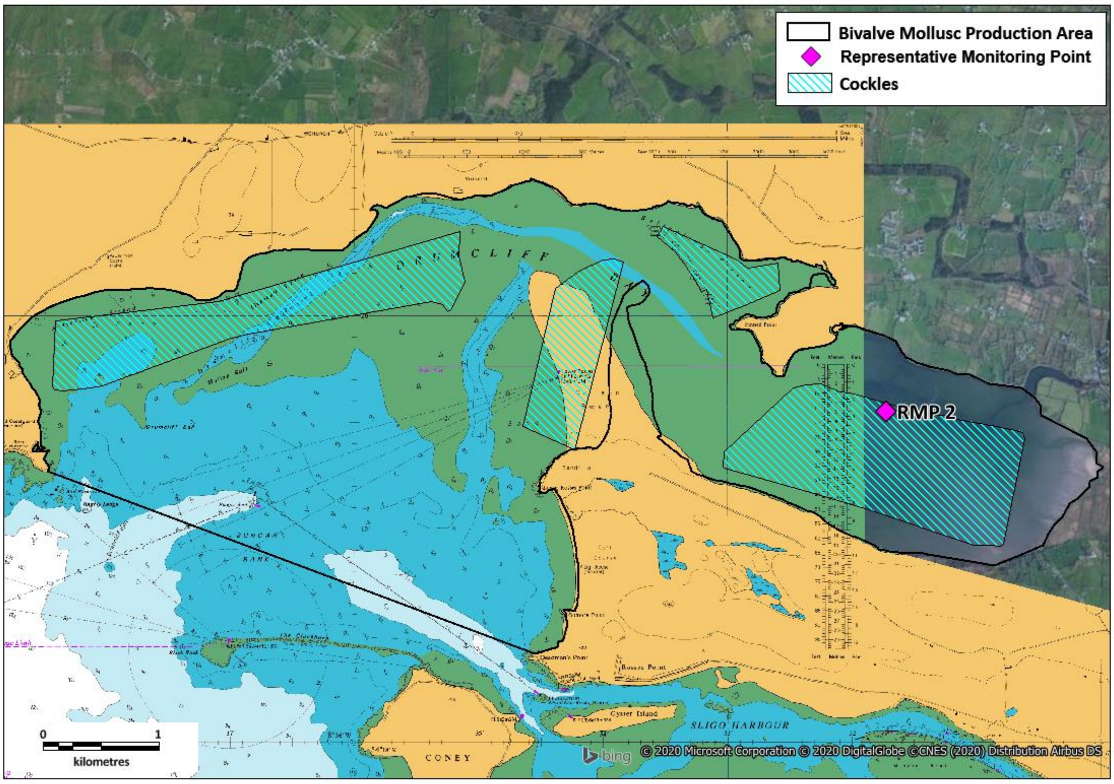


Figure 8.4 Representative Monitoring Points for cockles in Drumcliff Bay.

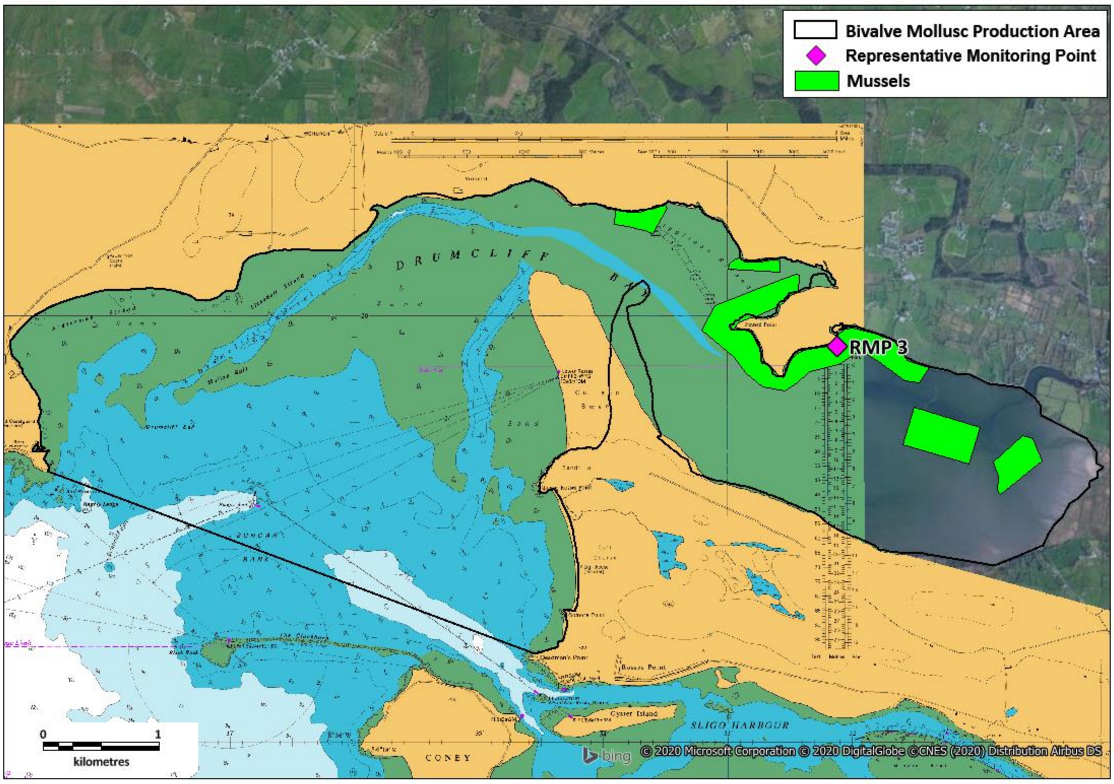


Figure 8.5: Representative Monitoring Points for mussels in Drumcliff Bay.

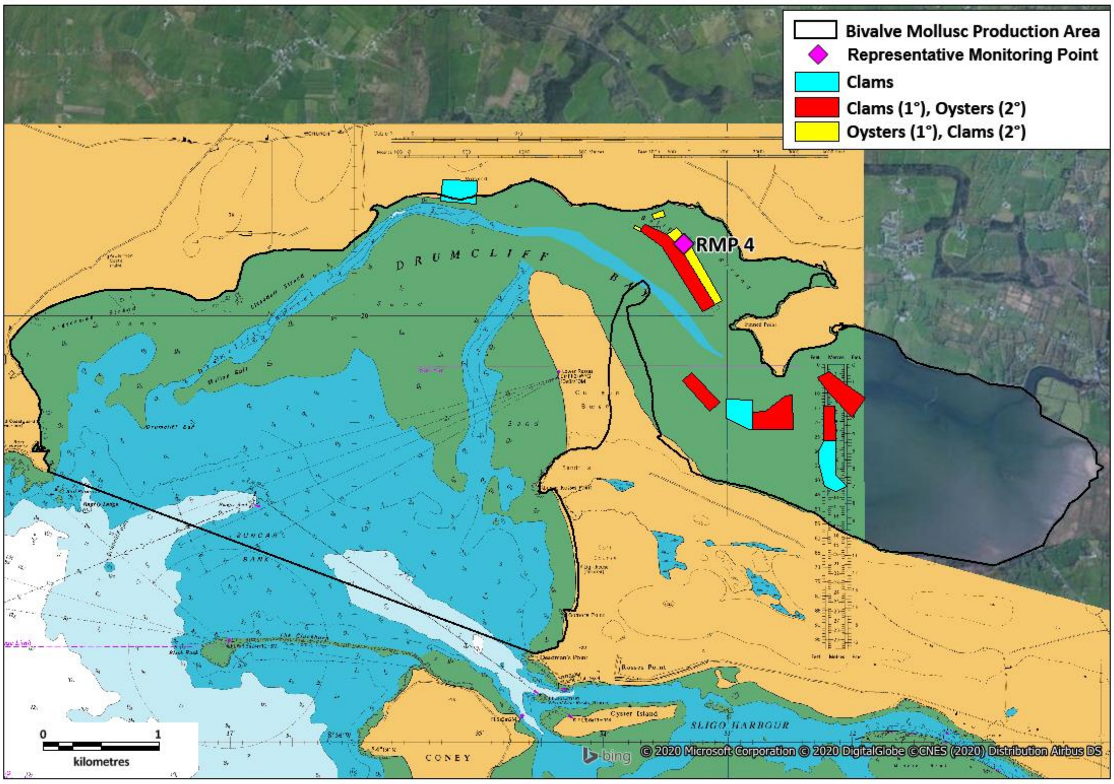


Figure 8.6: Representative Monitoring Points for clams in Drumcliff Bay.

8.6. General Sampling Method

All collection and transport of shellfish samples for E.coli testing under the Sampling Plan identified as part of the Drumcliff Bay 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.

9. References

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

BWI. 2019. Site Summary Table for 0C497 Drumcliff Bay Estuary . https://f1.caspio.com/dp/f4db3000060acbd80db9403f857c. Accessed April 2019.

CEFAS. 2013. Scottish Sanitary Survey Report. Brindister Vow SI 023. February 2013.

CEFAS. 2017. Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application. EU Working Group on the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas. Issue 6: January 2016.

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

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

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

EPA. 2019. WFD Status 2010 – 2015. https://gis.epa.ie/EPAMaps/ Accessed March 2019.

EPA. 2019a. WWTP locations https://gis.epa.ie/EPAMaps/SewageTreatment Accessed March 2019.

EPA. 2019c. EPA licenced facilities (IPC, IEL and Waste) http://gis.epa.ie/GetData/Download Accessed March 2019.

EPA. 2019d. WFD Section 4 Discharges http://gis.epa.ie/GetData/Download Accessed March 2019.

EPA. 2019e. Corine Land use http://gis.epa.ie/GetData/Download Accessed March 2019

Failte Ireland. 2018a. Tourism Facts 2017. Issued by Research Unit, Failte Ireland July 2018. http://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3_Research_Insights/5_International_Tourism_Trends/Tourism-Facts-2017_1.pdf?ext=.pdf

Failte Ireland. 2018b. 2017 Topline Performance by County. http://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3_Research_Insights/2_Regional_SurveysReports/2017-topline-regional-performance-(003).pdf?ext=.pdf

Fitzgerald D. L. 2007. Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin

IFI. 2019. Sea Fishing. Northwestern Regional Fisheries Board. http://fishinginireland.info/sea/northwest/sligo.htm

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

Jones, F. & R.W. White. 1984. Health and amenity aspects of surface waters. *Water Pollution Control* **Vol. 83:** 215-225.

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

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

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

Marine Institute. 2015a. Annex I Report supporting Appropriate Assessment of Aquaculture in Cummeen Strand/Drumcliff Bay (Sligo Bay) SAC (Site Code: 000627), April 2015

Marine Institute. 2015b. Marine Atlas: inshore fisheries. https://atlas.marine.ie/#?c=54.3307:-8.5868:12 Access May 2015.

Marine Institute. 2019. Water Framework Directive and Designated Shellfish Water monitoring results for water quality (AQUAFACT data request 2019)

Tyler-Walters, H., 2007. Cerastoderma edule Common cockle. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 10-10-2019]. Available from: https://www.marlin.ac.uk/species/detail/1384.

Met Eireann. 2019a. Historical Data Finner 2014-2018. https://www.met.ie/climate/available-data/historical-data Accessed April 2019.

Met Eireann. 2019b. The current rainfall Irish climatology and the long term average period 1981 to 2010. https://www.met.ie/climate/what-we-measure/rainfall Accessed February 2019.

Met Eireann. 2019c. Belmullet 1981-2010 averages. https://www.met.ie/climate-ireland/1981-2010/belmullet.html Accessed February 2019.

Met Eireann. 2019d. Historical Data Ardtarmon 2014-2018. https://www.met.ie/climate/available-data/historical-data Accessed April 2019.

Met Eireann. 2019e. return period rainfall depths for sliding durations (163301E; 342638N). www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

NPWS. 2014a. Drumcliff Bay SPA Site Synopsis (Site Code: 004013) https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004013.pdf https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004035.pdf

NPWS. 2014b. Cummeen Strand SPA Site Synopsis (Site Code: 004035) https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004035.pdf

NPWS. 2014c. Ballintemple and Ballygilgan SPA Site Synopsis (Site Code: 004234) https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004234.pdf

NPWS. 2016. Cummeen Strand/ Drumcliff Bay (Sligo Bay) SAC Site Synopsis (Site Code: 000627). https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY000627.pdf

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

PMFSC (Pacific States Marine Fisheries Commission). 1996. Pacific Oyster fact sheet. http://www.psmfc.org/habitat/edu_oyster_fact.html. Accessed February 2010.

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

UKHO. 2004. Admiralty Chart 2852. UK Hydrographic Office.

Appendix 1

Statistical Analysis

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

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Spring	18	36.7238	2.040211	0.315164
Summer	16	33.8087	2.113044	0.417681
Autumn	15	33.05969	2.203979	0.358066
Winter	18	35.90631	1.994795	0.174012

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.406922	3	0.135641	0.436119	0.727911	2.750541
Within Groups	19.59412	63	0.311018			
Total	20.00104	66				

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

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Spring	18	37.39982	2.077768	0.255002
Summer	17	36.0822	2.122483	0.41195
Autumn	17	41.19339	2.423141	0.436549
Winter	18	40.71919	2.262177	0.199941

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.259349	3	0.419783	1.300124	0.281815	2.743711
Within Groups	21.31003	66	0.322879			
Total	22.56938	69				

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

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Spring	18	31.59645	1.755358	0.216297
Summer	19	37.23507	1.959741	0.51102
Autumn	18	39.24077	2.180043	0.570943
Winter	18	33.99821	1.888789	0.175055

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.702667	3	0.567556	1.532291	0.213892	2.737492
Within Groups	25.55737	69	0.370397			
Total	27.26004	72				

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

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Cockles	68	141.5438	2.081527	0.298543
Mussels	71	157.2931	2.215396	0.323895
Oysters	73	142.0705	1.946171	0.378612

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.609162	2	1.304581	3.898724	0.021758	3.039085
Within Groups	69.93504	209	0.334617			
Total	72.54421	211				

t-Test: Two sample assuming equal variance: Log *E. coli* vs Species (Oysters v Cockles flesh results 2014-2019)

t-Test: Two-Sample Assuming Equal Variances

	Oysters	*Cockles*
Mean	1.946171	2.081527
Variance	0.378612	0.298543
Observations	73	68
Pooled Variance	0.340017	
Hypothesized Mean Difference	0	
df	139	
t Stat	-1.37731	
P(T<=t) one-tail	0.085315	
t Critical one-tail	1.65589	
P(T<=t) two-tail	0.17063	
t Critical two-tail	1.977178	

t-Test: Two sample assuming unequal variance: Log *E. coli* vs Species (Cockles v Mussels flesh results 2014-2019)

t-Test: Two-Sample Assuming Unequal Variances

	Cockles	*Mussels*
Mean	2.081527	2.215396
Variance	0.298543	0.323895
Observations	68	71
Hypothesized Mean Difference	0	
df	137	
t Stat	-1.41486	
P(T<=t) one-tail	0.079689	
t Critical one-tail	1.656052	
P(T<=t) two-tail	0.159377	
t Critical two-tail	1.977431	

t-Test: Two sample assuming equal variance: Log *E. coli* vs Species (Oysters v Mussels flesh results 2014-2019)

t-Test: Two-Sample Assuming Equal Variances

	Oysters	*Mussels*
Mean	1.946171	2.215396
Variance	0.378612	0.323895
Observations	73	71
Pooled Variance	0.351639	
Hypothesized Mean Difference	0	
df	142	
t Stat	-2.72381	
P(T<=t) one-tail	0.003632	
t Critical one-tail	1.655655	
P(T<=t) two-tail	0.007264	
t Critical two-tail	1.976811	

Appendix 2

Species Specific Representative Monitoring Points

Drumcliff Bay

Bivalve Mollusc Classified Production Area

Oyster Monitoring Information

Site Name: Drumcliff Bay

Site Identifier: SO-DB-DB

Monitoring Point Coordinates

Latitude: 54.33645 **Longitude:** -8.55422

Species: *Crassostrea gigas*

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

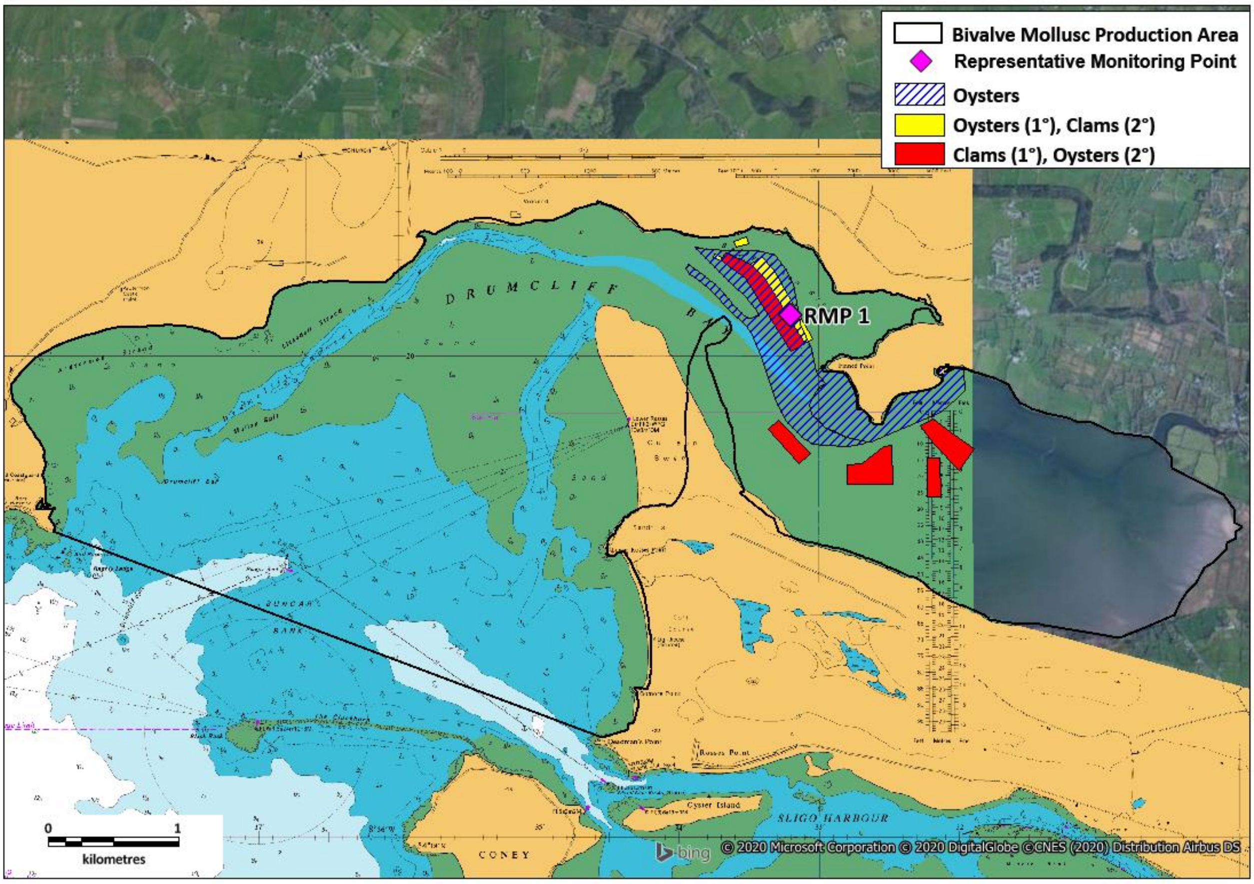
Responsible Authority: Sea Fisheries Protection Authority

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 animals

Sampling Method: Taken from trestles at point



Drumcliff Bay

Bivalve Mollusc Classified Production Area

Cockles Monitoring Information

Site Name: Drumcliff Bay

Site Identifier: SO-DB-DB

Monitoring Point Coordinates

Latitude: 54.326127 **Longitude:** -8.529689

Species: *Cerastoderma edule*

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

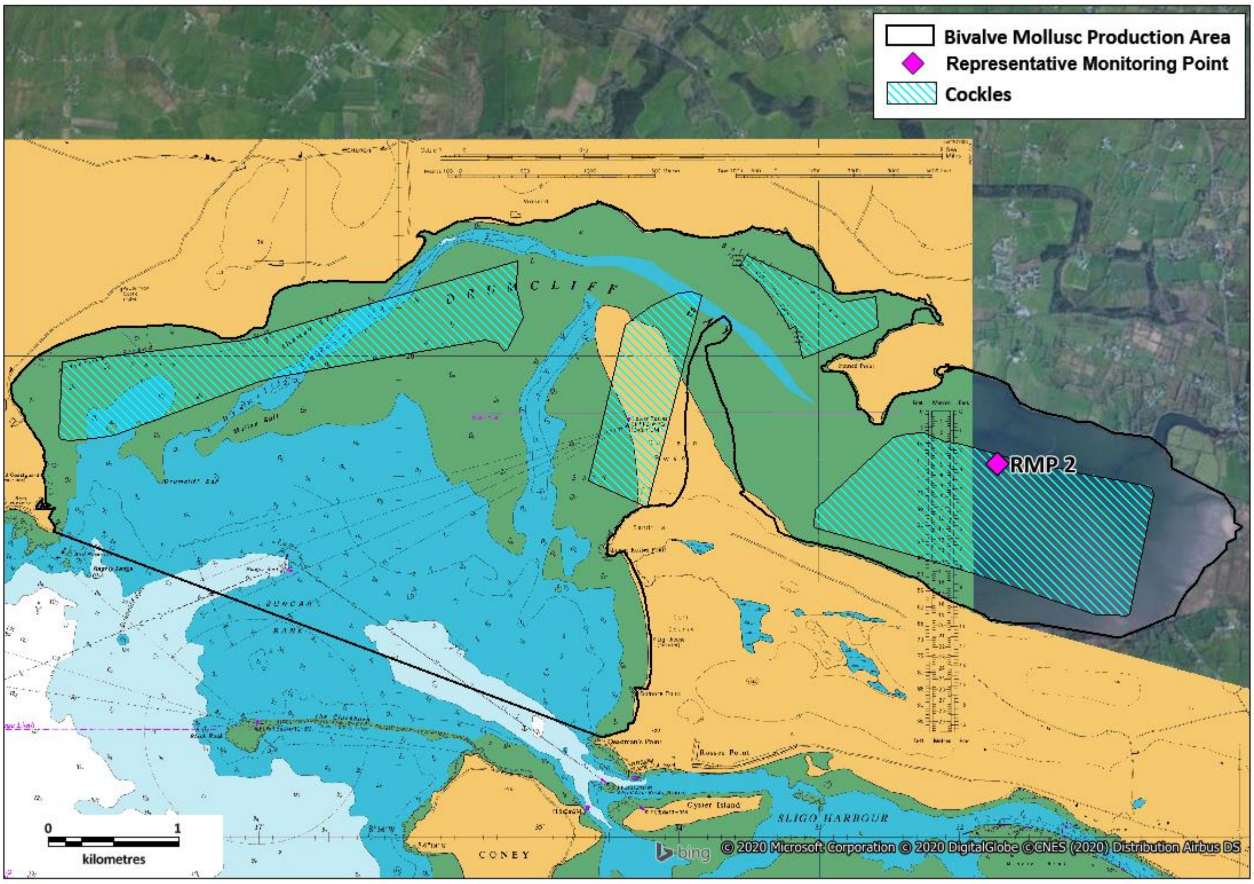
Responsible Authority: Sea Fisheries Protection Authority

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 30 market sized animals

Sampling Method: Taken from seabed at point



Drumcliff Bay

Bivalve Mollusc Classified Production Area

Mussels Monitoring Information

Site Name: Drumcliff Bay

Site Identifier: SO-DB-DB

Monitoring Point Coordinates

Latitude: 54.33115 **Longitude:** -8.5361

Species: *Mytilus edulis*

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

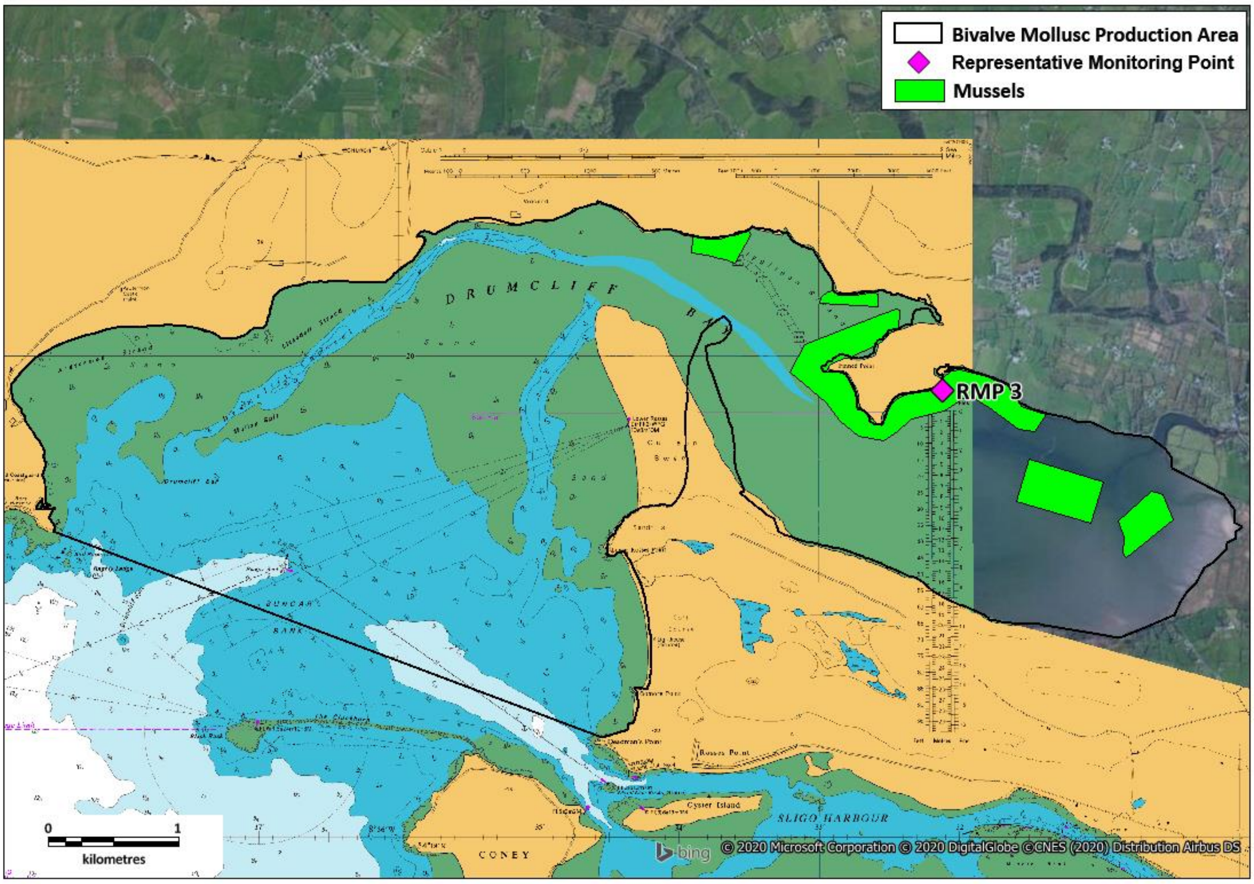
Responsible Authority: Sea Fisheries Protection Authority

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 15 market sized animals

Sampling Method: Taken at point



Drumcliff Bay

Bivalve Mollusc Classified Production Area

Clams Monitoring Information

Site Name: Drumcliff Bay

Site Identifier: SO-DB-DB

Monitoring Point Coordinates

Latitude: 54.33923 **Longitude:** -8.55673

Species: Clams

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 30 market sized animals

Sampling Method: Taken from seabed at point