Sanitary Survey Report
and
Sampling Plan
for Blacksod Bay

Produced by

AQUAFACT International Services Ltd

In conjunction with

The Sea Fisheries Protection Authority

April 2021

AQUAFACT INTERNATIONAL SERVICES Ltd.,

12 KILKERRIN PARK,

GALWAY.

www.aquafact.ie

info@aquafact.ie

tel +353 (0) 91 756812

Authors

AQUAFACT: Kevin Mc Caffrey, Dr. Brendan O'Connor

SFPA: Peter McGroary, Brian Nolan

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
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 (EU) 2017/625	of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products
RIB	Rigid Inflatable Boat
RMP	Representative Monitoring Point
RNA	Ribonucleic Acid
SAC	Special Area of Conservation
SFPA	Sea Fisheries Protection Authority
SMILE	Sustainable Mariculture in northern Irish Lough Ecosystems
SOA	Super Output Areas or ward
SPA	Special Protection Area
SPM	Suspended particulate Matter
SPS	Sewage Pumping Station

SS	Suspended Solids
STW	Sewage Treatment Works
Suspension feeders	Animals that feed on small particles suspended in water
TBTO	Tributyl Tin Oxide
Telemetry	The measurement and transmission of data from remote sources to receiving stations for recording and analysis
TPP	Total Physical Product
UKAS	United Kingdom Accreditation Service
UKHO	United Kingdom Hydrographic Office
Vector	A carrier, which transmits a disease from one party to another
WeBS	Wetland Bird Survey
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Works

1. Introduction

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

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

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

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

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

- An inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area;

- An examination of the quantities of organic pollutants released during the different periods of the year, according to the seasonal variations of human and animal populations in the catchment area, rainfall readings, waste-water treatment, *etc*.;

- Determination of the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area.

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

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

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

This report contains the documents relevant to the sanitary survey of the bivalve mollusc production area at Blacksod Bay, County Mayo. It identifies the representative monitoring points and supporting sampling plans for native oysters, pacific oysters, razor clams and surf clams in Blacksod 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

Blacksod Bay BMCPA is located along the western coast of Ireland. Blacksod Bay is a 91.62km^2 large shallow bay with large areas of mudflat and sandflats along the shore and particularly the inner bay inside of Cleggan Point. A deep channel runs from just south of Belmullet in a southwards direction before turning south-westerly as it meets two rock outcrops. As the channel passes the second rock outcrop it turns south and then south westerly as it passes Cleggan Point and finally south as it opens into the outer bay. Depths in the channel range from 5 to 11m. Depths in the outer part of the bay range from 5 to 17m with depths increasing from the shore and out towards the mouth of the bay. The area is approximately 12.2km E-W at its widest point and approximately 14.1km N-S. The catchment area of the BMCPA is 167.4km^2. The river network is made up of a series of small streams with no large rivers or lakes. The two largest streams are the Glencastle and Doolough, which flow into the north eastern end of the bay.

Blacksod Bay is designated as part of a Special Area of Conservation (SAC) which is the Mullet/Blacksod Bay Complex SAC (Site Code: IE000470) (Figure 2.1). The site is designated for the presence of a number of important habitats and species (NPWS, 2013).

Blacksod Bay/Broad Haven Bay SPA (Site Code: IE004037) and Mullet Peninsula SPA (Site Code: IE004227) are located within the catchment of Blacksod Bay BMPA. There are a number of other SPAs nearby including Duvillaun Islands SPA (Site Code: IE004111), Termoncarragh Lake and Annagh Machair SPA (Site Code: IE004093), Inishglora and Inishkeeragh SPA (Site Code: IE004084) and Inishkea Islands SPA (Site Code: IE004004). All SPAs in the area can be seen in Figure 2.1.

Blacksod Bay/Broad Haven Bay SPA is situated in the extreme north-west of Co. Mayo and comprises a number of bays and inlets including Sruwaddacon Bay, Moyrahan Bay, Traw-Kirtaun, Blind Harbour, Tullaghan Bay, and the various sheltered bays and inlets in Blacksod Bay, including Trawmore Bay, Feorinyeeo Bay, Saleen Harbour, Elly Bay and Elly Harbour. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Great Northern Diver (67), Light-bellied Brent Goose (279), Common Scoter (510), Red-breasted Merganser (83), Ringed Plover (590), Sanderling (171), breeding Dunlin (subsp. *schinzii*), Dunlin (1,255), Bar-tailed Godwit (664), Curlew (567) and Sandwich Tern (81 pairs in 1995). The E.U. Birds Directive pays particular attention to wetlands and, as these form part of this SPA, the site and its associated waterbirds are of special conservation interest for Wetland & Waterbirds. A number of wader species breed within the areas of machair in the SPA, including a nationally important population of Dunlin (subsp. *schinzii*) – 24 pairs (NPWS, 2013).

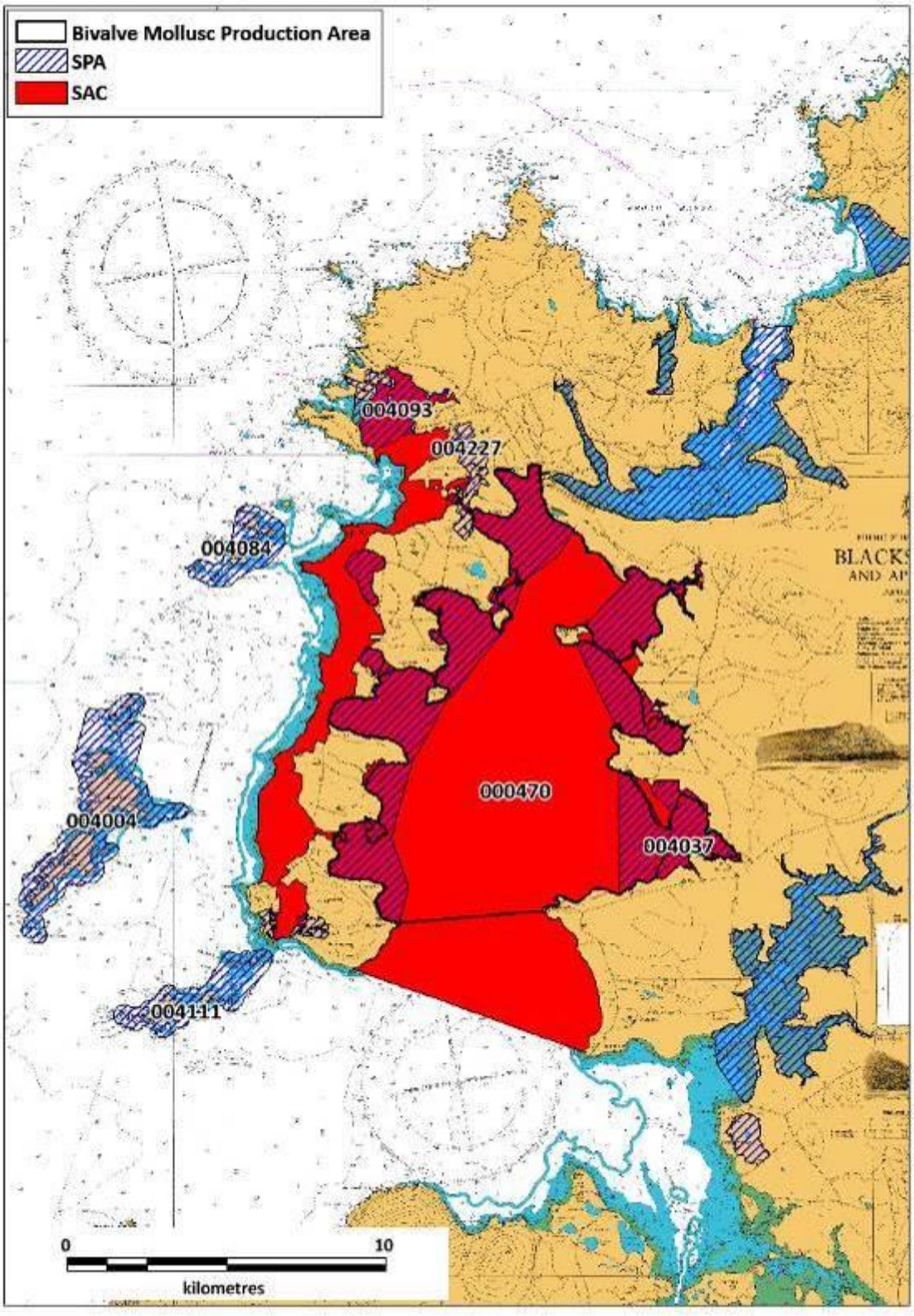


Figure 2.1: Location of Natura 2000 sites overlapping with the Blacksod Bay BMCPA.

The Blacksod Bay BMPA supports a diversity of fish species. Species present include mullet, dogfish, plaice, conger, Pollack, ray, bass, mackerel, sea trout and flounder (IFI, 2020). There are two main native oyster

dredge areas in the inner Blacksod Bay area with smaller, fragmented beds scattered throughout. The outer part of the Bay has in some years supported an intermittent dredge fishery for scallops. Figure 2.2 shows the fishing activity in the BMPA.

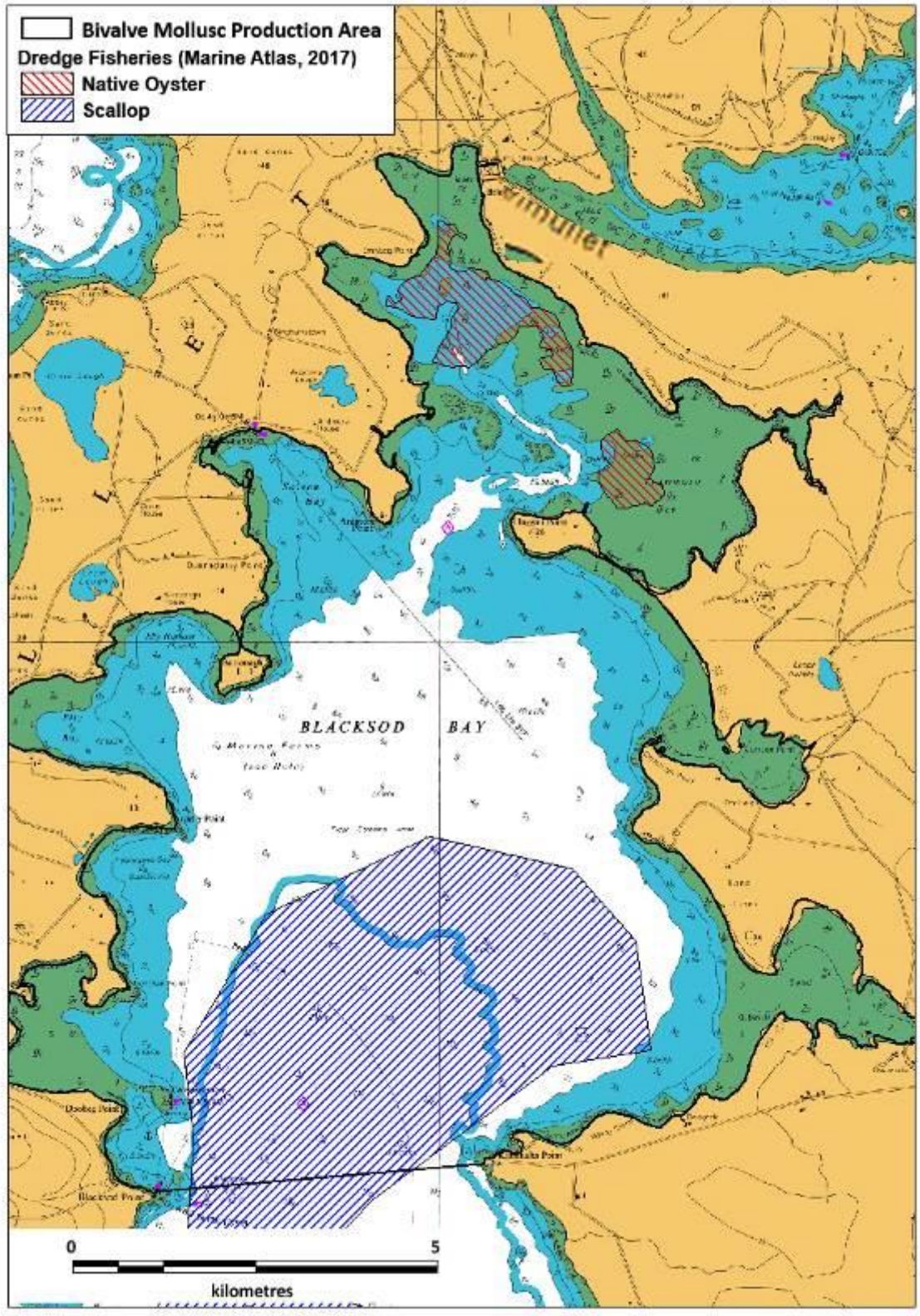


Figure 2.2: Fishing activity in the proposed BMCPA (Marine Institute, 2015).

Land cover within the Blacksod Bay catchment is a mixture of peat bogs, pastures, intertidal flats and Land principally occupied by agriculture, with significant areas of natural vegetation, beaches, dunes, sands and coniferous forest

The population of the catchment is approximately 3,490. The main towns/urban centres within the catchment are Belmullet and Dumha Thuama.

2.2. Blacksod Fishery

2.2.1. Location/Extent of Growing/Harvesting Area

The shellfish designated waters in Blacksod Bay cover an area of approximately 78.2km^2 and the Bivalve Mollusc Classified Production Area (BMCPA) covers *c*. 91.6km^2. Both can be seen in Figure 2.3.

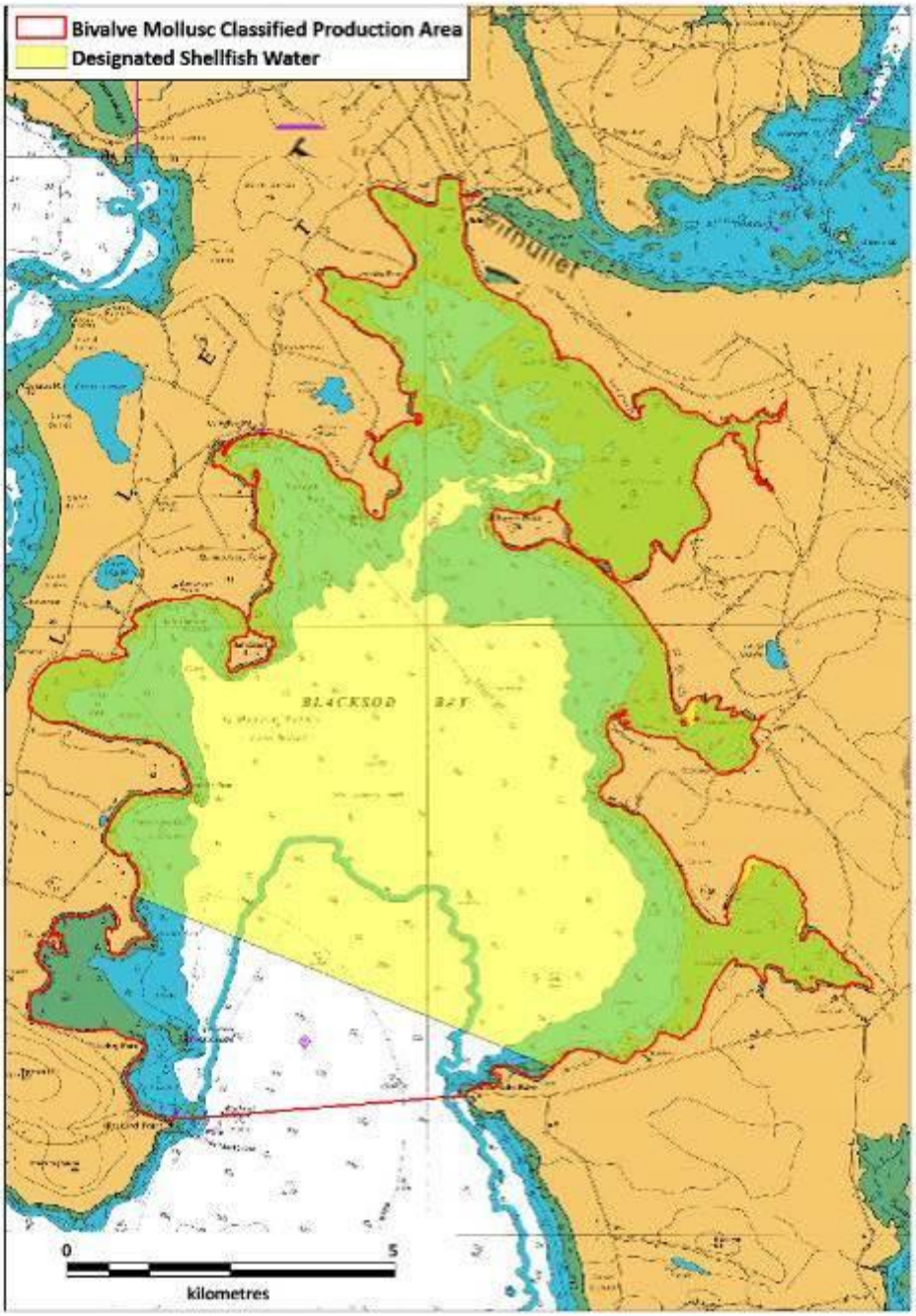


Figure 2.3: Bivalve Mollusc Classified Production Area and Designated Shellfish Waters within Blacksod Bay.

Figure 2.4 shows the current locations of licenced aquaculture sites within Blacksod Bay. There are two

large areas licensed for wild native oysters, one covers all of the bay inside of Cleggan Point except for Trawmore Bay and the other covers both Saleen Bay and Elly Harbour. These two zones are held by the one licensee and are currently under review by the licensing authority.

There is one other small licensed are for pacific oyster east of Doolough Point (Clams, mussels and winkles are listed as secondary species on the licence). Approximately 99.8% of the license area is for native oysters (17.2km^2), and 0.2% for pacific oysters (0.034km^2).

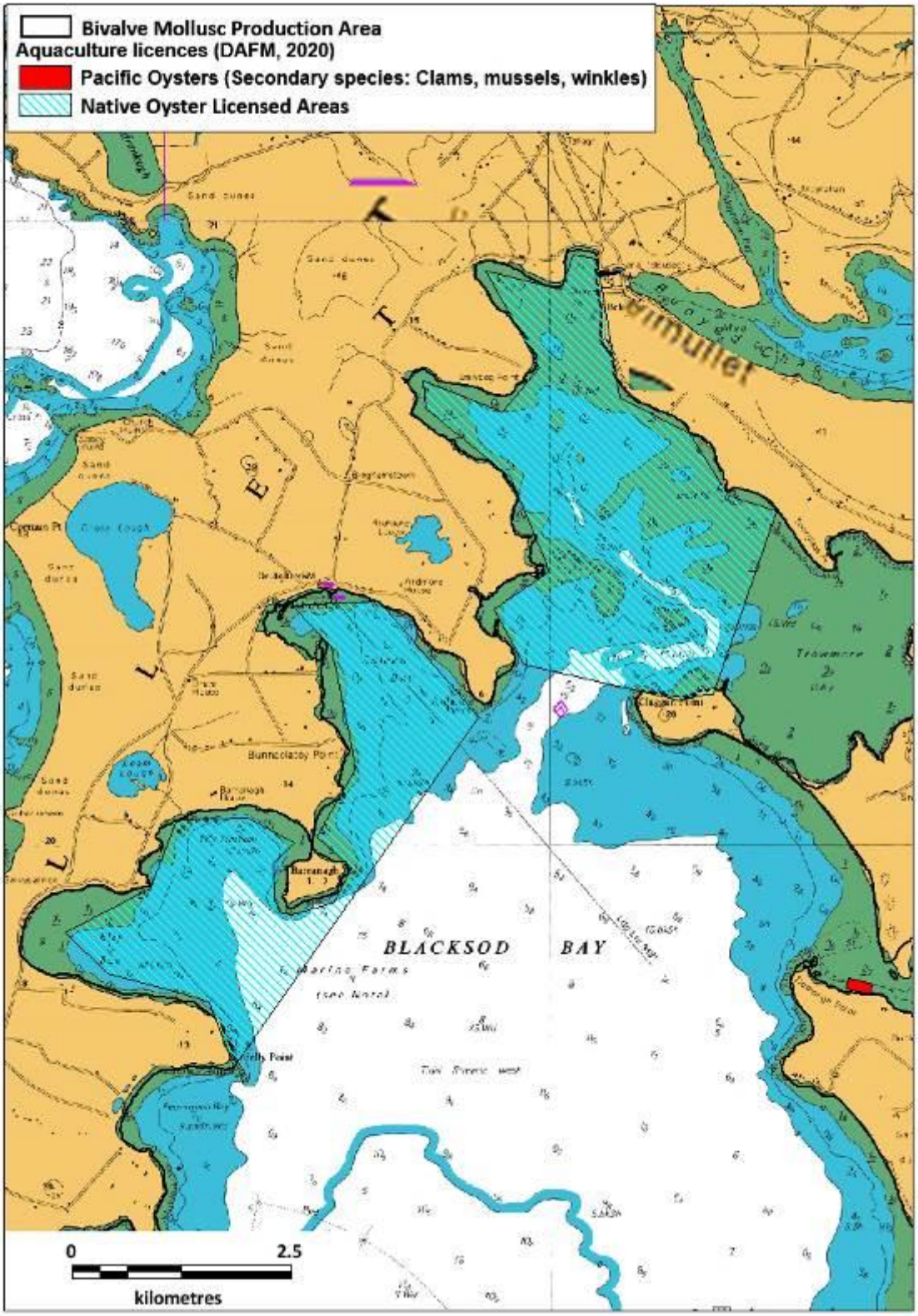


Figure 2.4: Licenced aquaculture sites within Blacksod Bay (Source: DAFM, 2020).

2.2.2. Description of Species

2.2.2.1. Native Oysters (Ostrea edulis)

Distribution

Figure 2.5 shows the locations of licensed native oyster sites in Blacksod Bay. These sites cover an area of 17.2km^2. The largest licensed area in Blacksod Bay is located in the inner bay inside of Cleggan Point and the other location is between Elly Harbour and Saleen Bay. Figure 2.6 show the location of native oyster beds within Blacksod Bay.

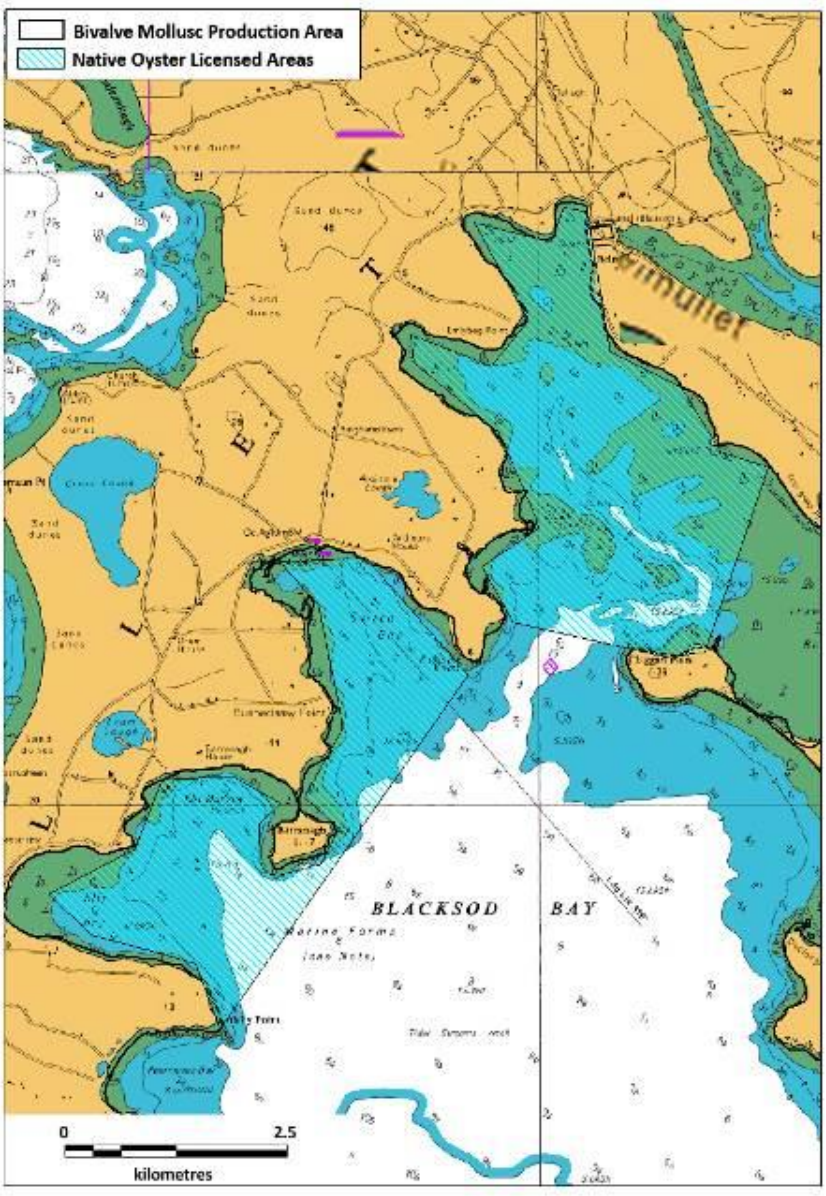


Figure 2.5: Licenced Native oyster harvesting sites in Blacksod Bay (Source: DAFM, 2020).

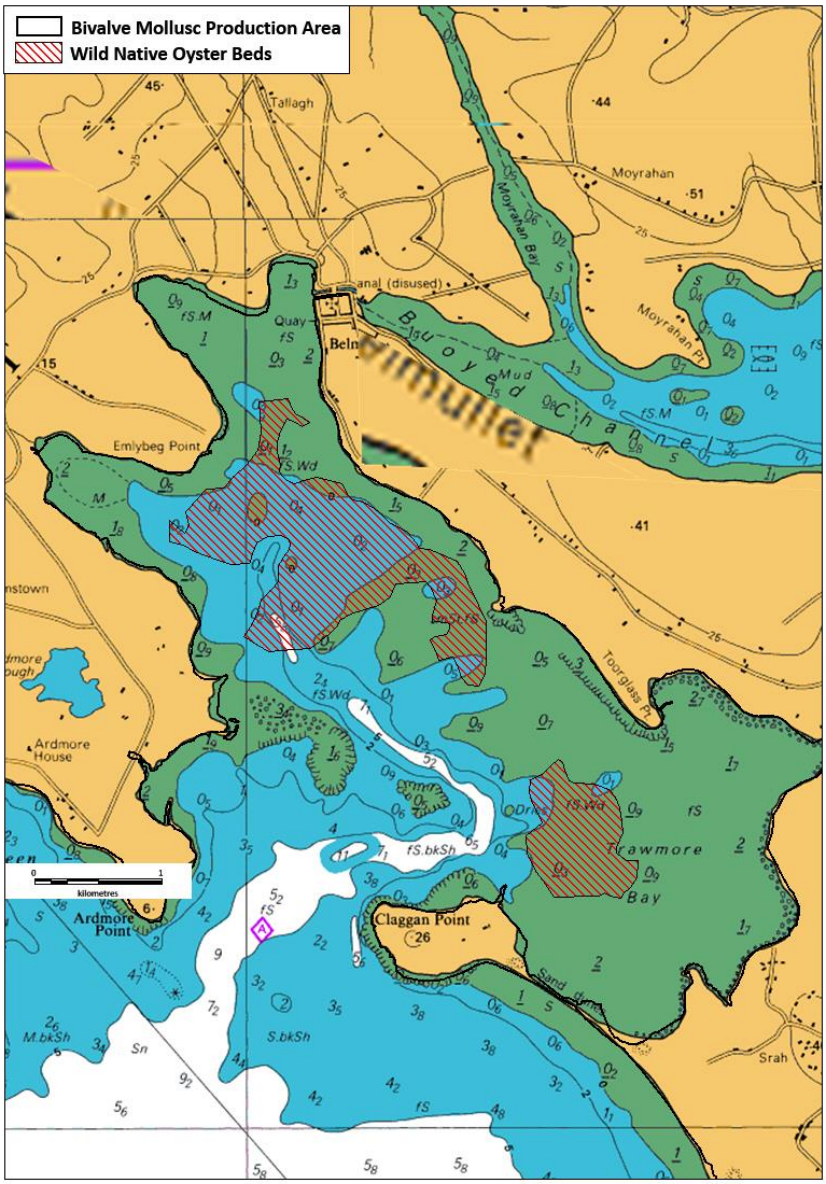


Figure 2.6: Wild native oyster beds in Blacksod Bay.

Fishery

Native oysters occur naturally in Blacksod Bay in what is regarded as nationally significant population and are exploited by fishing vessels using dredges of around 1.5 metre in width. The beds occur in a number of locations within the bay both within licensed aquaculture sites and outside them, the two largest being located within the inner part of the production area.

The licensed area is managed under the terms of a license issued by the Department of Agriculture, Food and the Marine. The licensees are the North Mayo Oyster Development Co-operative Society who manage the fishery within the license confines. Recruitment to the licensed areas is through natural spatfall which has been assisted by the Co-op in the past through the deposition of cultch and the employment of spat

collectors. The Co-op depending on stock levels opt to open and close the fishery as they see fit and often the fishery may only open for short, specific periods of time. In some years the fishery may not open.

Fishing vessels intending to exploit the fishery must also acquire a dredge fishing licence from Inland Fisheries Ireland (IFI).

*2.2.2.2. Pacific Oysters (*Crassostrea gigas*)*

Distribution

Figure 2.7 shows the location of the licensed intertidal farmed Pacific oyster site in Blacksod Bay. The site covers an area of 0.034km^2. The licensed area in Blacksod Bay is located on the intertidal sand and mudflats east of Doolough Point.

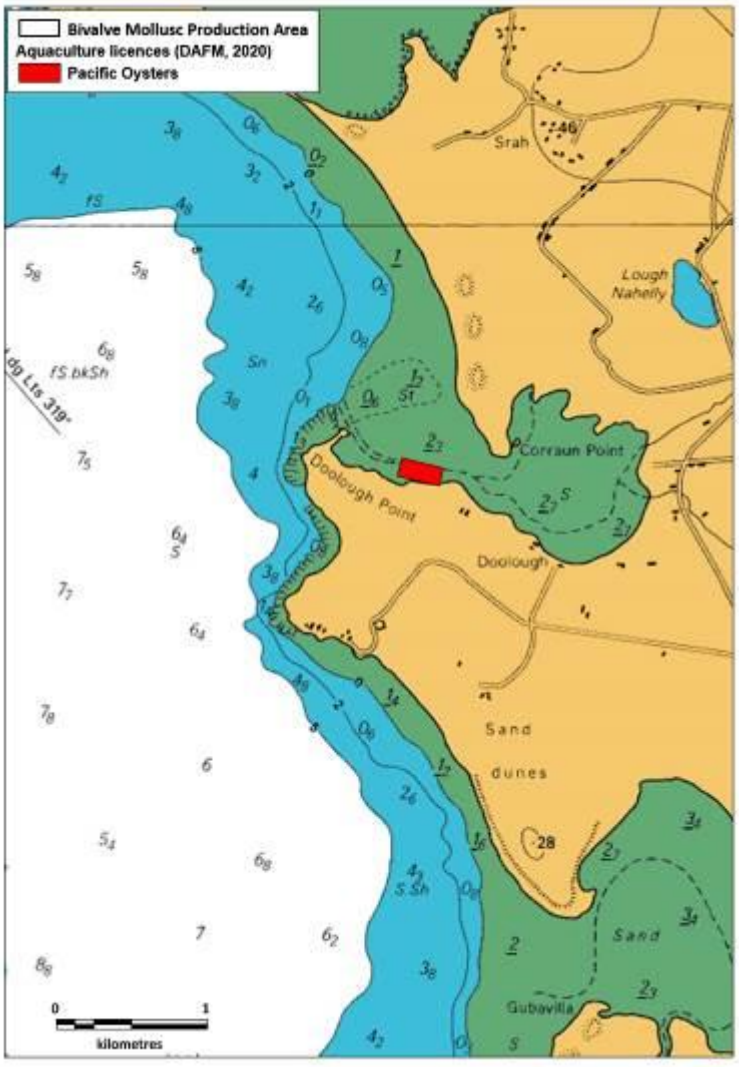


Figure 2.7: Licenced Pacific oyster harvesting sites in Blacksod Bay (Source: DAFM, 2019).

Fishery

There is currently no active production of pacific oysters in Blacksod Bay. In previous years low tonnages of farmed pacific oysters were produced in Trawmore Bay using the bag and trestle method. Similarly there is no clam or mussel production from this site either.

2.2.2.3. Surf Clams (Spisula solida)

Distribution

Figure 2.8 shows the distribution of surf clams in Blacksod Bay as surveyed by the Marine Institute in 2017.

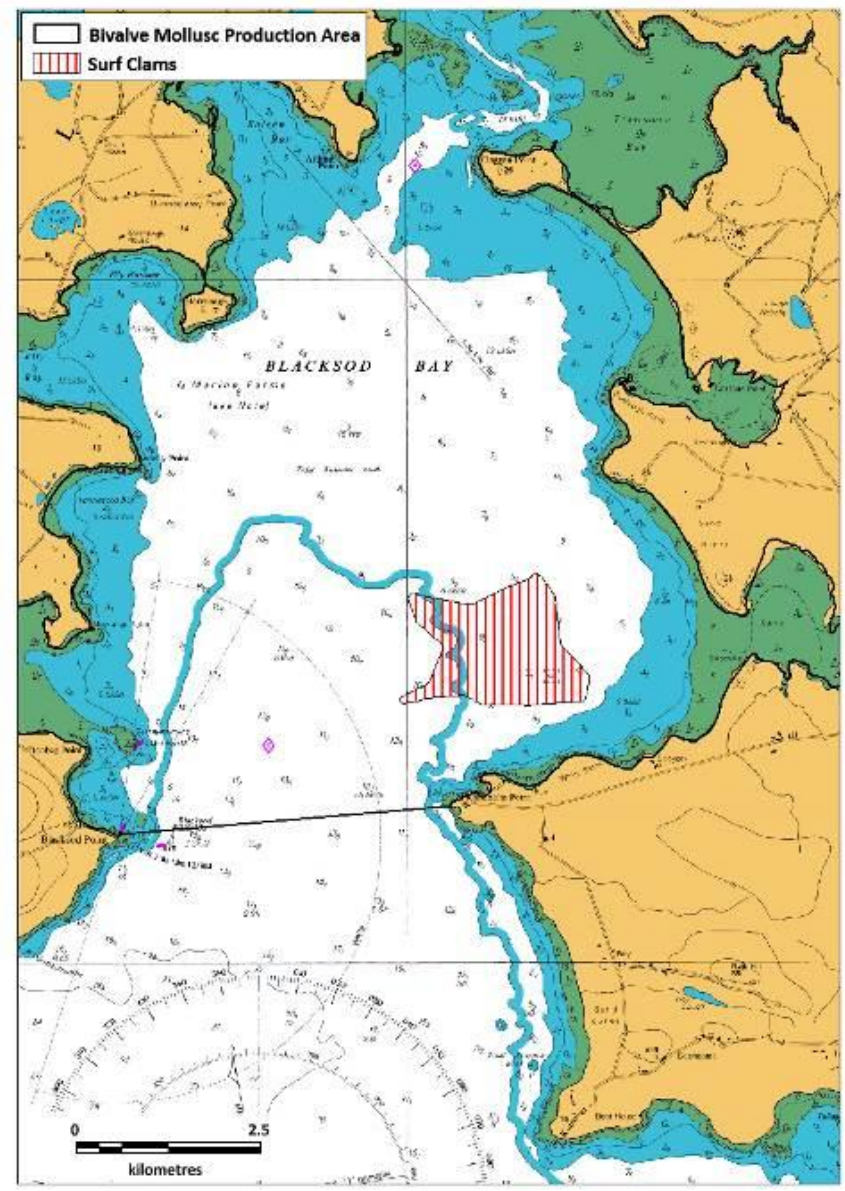


Figure 2.8: Surf clam distribution in Blacksod Bay (Marine Institute, 2017).

Fishery

There is currently no active surf clam fishing taking place within Blacksod Bay. A bed of surf clams though has been identified in recent Marine Institute surveys (2017) north of Kanfinalta Point.

2.2.2.4. Razor Clams (Ensis spp.)

Distribution

Figure 2.9 shows the distribution of Razor clams (*Ensis arcuatus, E. siliqua*) in Blacksod Bay as surveyed by the Marine Institute in 2017.

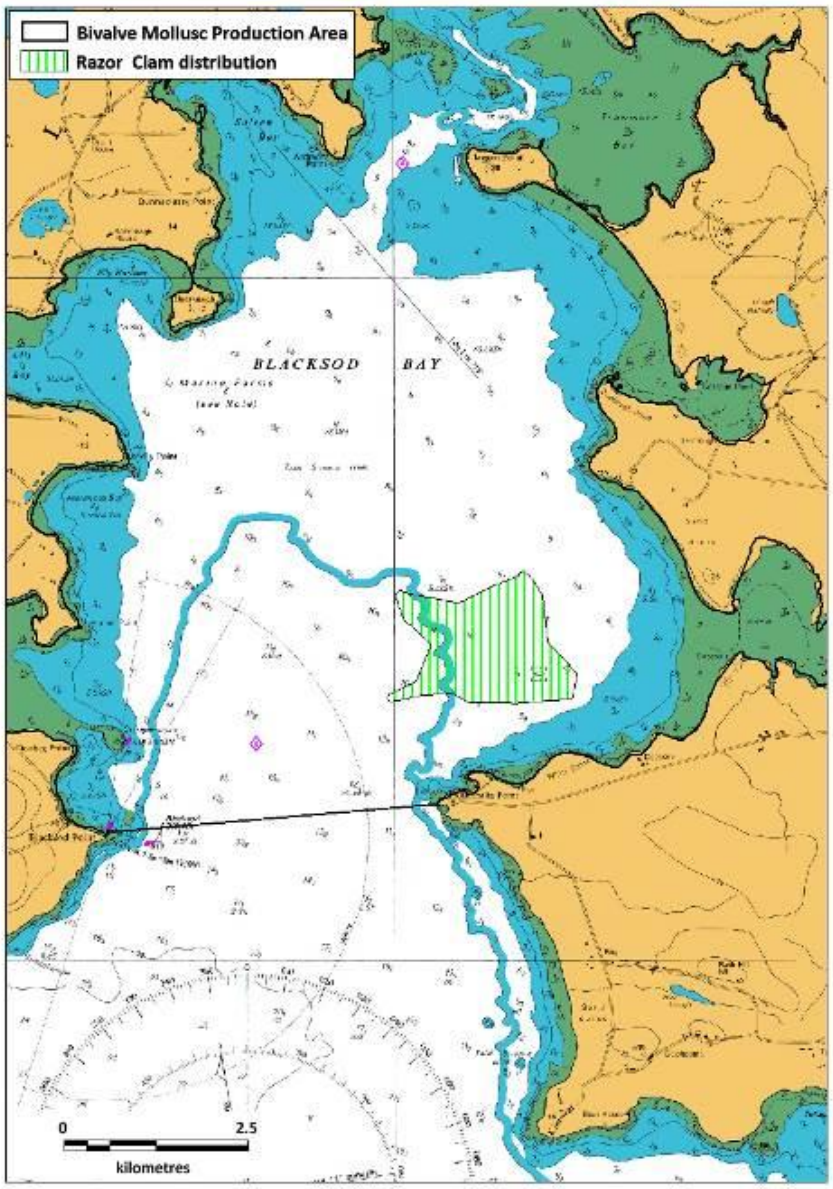


Figure 2.9: Razor clam distribution in Blacksod Bay (Marine Institute, 2017)

Fishery

There is currently no fishery of razor clams taking place within the Blacksod Bay classified production area. A bed of razor clams though has been identified in recent Marine Institute surveys (2017) north of Kanfinalta Point with both *Ensis arcuatus* and *Ensis siliqua* present.

2.2.2.5. King Scallops (Pecten maximus)

Distribution

Figure 2.10 shows the dredge fishery for King scallops in Blacksod Bay.

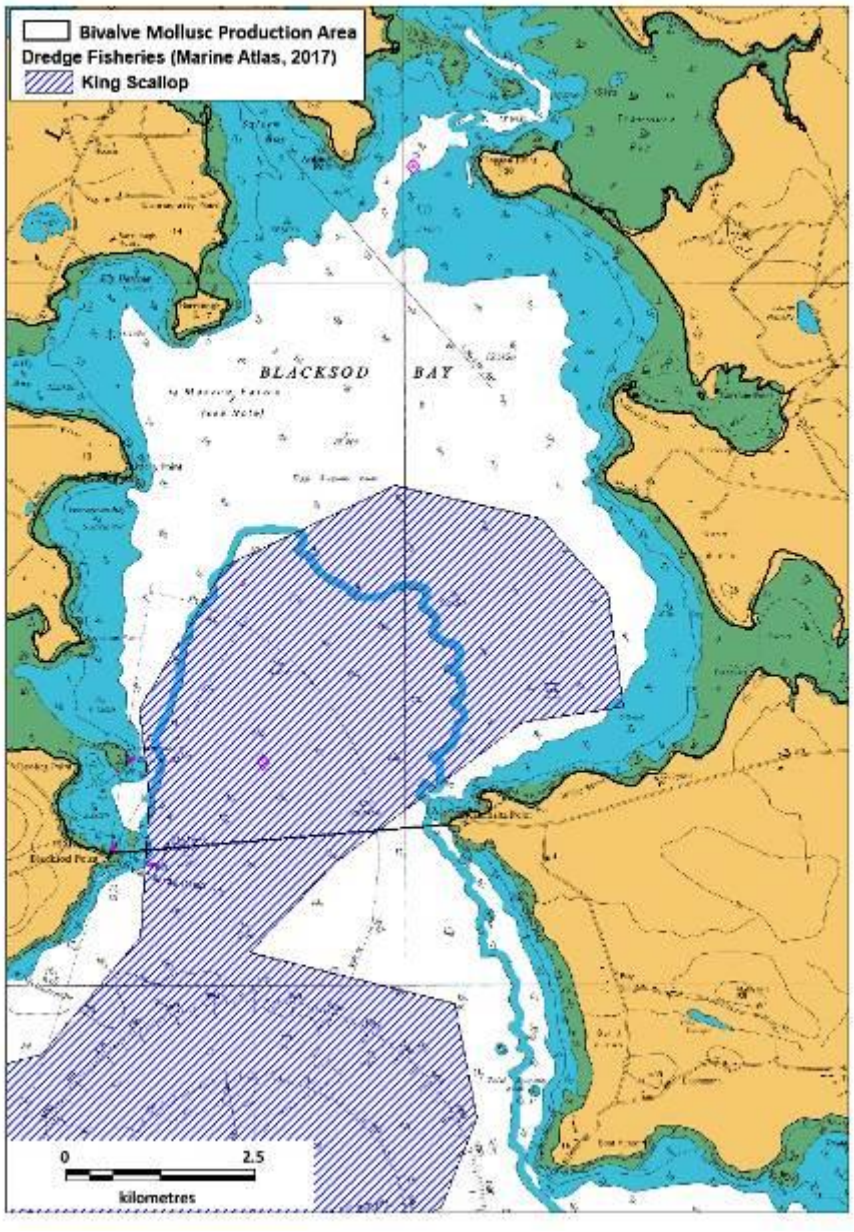


Figure 2.10: Blacksod Bay King scallop dredge fishery.

Fishery

King scallops naturally occur in Blacksod Bay particularly in the middle and outer reaches of the production area. The biomass of scallop is low and fishing using dredges is also intermittent with no fishing taking place in some years. Vessels fishing within Blacksod are also subject to specific legislation, 'Fisheries Natura Declaration No. 3 of 2018 – Blacksod Bay' which governs where boats can dredge or trawl and the conditions under which they can do so. This legislation limits the area within the bay which a vessel can fish scallops and also requires them to carry fully functioning GPS monitoring systems on board.

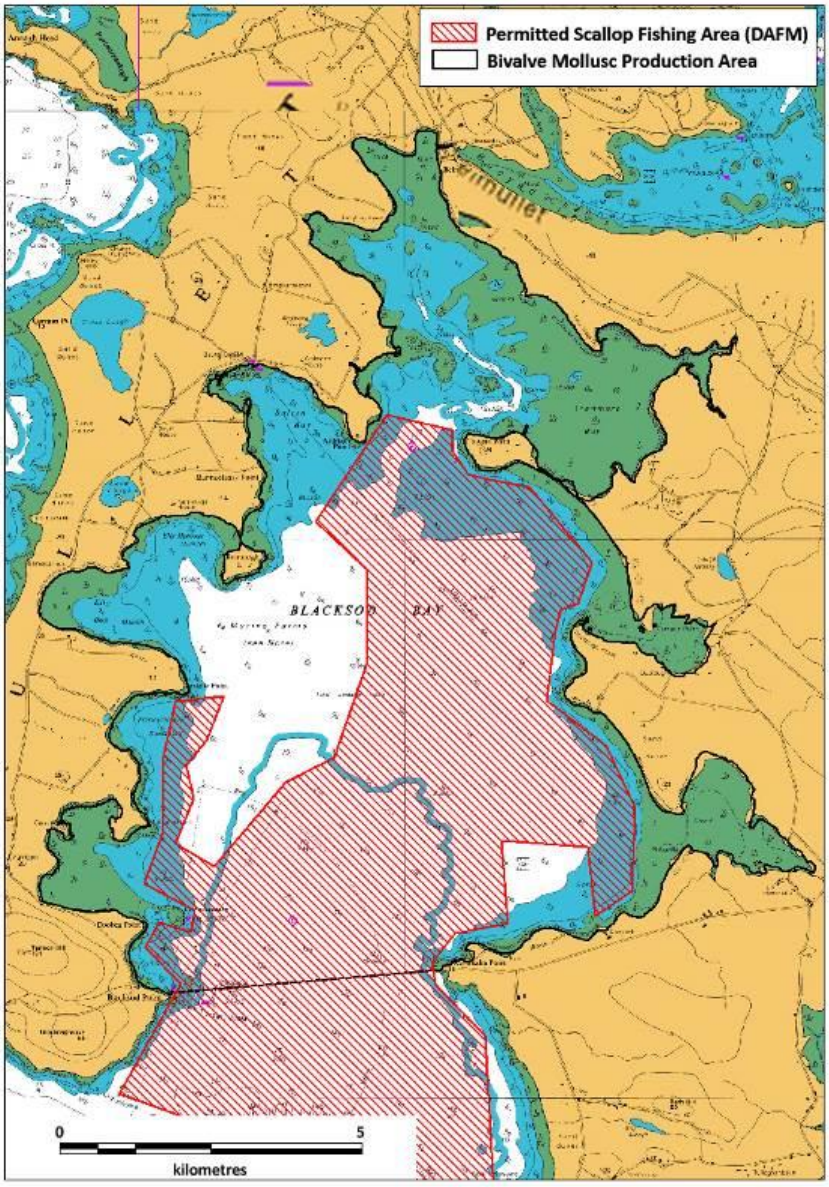


Figure 2.11: Permitted Scallop fishing area as set out in 'Fisheries Natura Declaration No. 3 of 2018 – Blacksod Bay' (Source: DAFM).

3. Overall Assessment of the Effect of Contamination on Shellfish

3.1. Human sewage/Human population

Blacksod Bay catchment has a population of 3,490 with over half of the population residing in the Belmullet electoral division (56%). There are only two urbans centres, the largest of which is Belmullet Town with a population of 1,019 and Dumha Thuama with a population of only 112. The population of the Blacksod catchment is below the average density for rural Ireland with 20.8 people per km^2 as opposed to 27 people per km^2 nationally in rural areas (CSO, 2016).

The 2016 census recorded 1,906 households in the catchment of which 19% are vacant and 2% are holiday homes. The sewage from half of these households is treated by means of septic tanks or other private treatment methods. Although there is a high percentage of households on private treatment systems, it is not considered a major concern due to the dispersed nature of households in the catchment.

The Belmullet WWTP treats waste to a tertiary level and has recently been upgraded to a design capacity of 4,005 PE and is operating at approximately half of its capacity with a loading of 2,049 PE. Similarly, the Gweesalia WWTP is operating significantly below its 700 PE design capacity at a loading of only 192 PE. Due to both of these treatment facilities working well below their designed capacity, there impact on shellfish quality will be reduced. In addition the Gweesala WWTP is located a considerable distance from any of the shellfish beds and this will further negate any potential effect on shellfish contamination levels.

The Belmullet plants discharge point though is immediately adjacent the native oyster fishery and is likely to be impacting contamination levels to some degree regardless of treatment levels.

Both WWTP's also have a number of associated storm water overflows, three from the Belmullet system are clustered around the Belmullet town area and discharge directly into the production area. These in particular may have a potential to affect contamination levels on the native oyster beds nearest them.

A number of locations in the inner bay were identified with signs of sewage contamination or at least high *E. coli* levels. Two culverts in the most northern end of Blacksod Bay (Figure 6.21, Map ID 62 and 69) were noted as having a sewage odour and a grey colouration. A culvert running adjacent to a Belmullet WWTP pumping station was noted at Map ID 72. The discharge rates from the storm water overflow associated with this pumping station are shown in Table 6.7. This discharge is of particular importance as although it is intermittent the effluent is untreated.

In addition water sampling from the shoreline survey identified two high *E. coli* results in a stream below the

secondary school in Belmullet Town and from a sluice next to a slip east of the town (Table 8.7, station 7 and 12). Whilst the source of this contamination is unclear it is quite likely human in origin.

Whilst a number of piers, slipways and boats themselves were noted during the desktop and shoreline surveys it is anticipated that due to the small size, lack of overnight staying vessels and the small relative numbers that any impacts will be virtually nil.

3.2. Agriculture

Agricultural land (pastures 38.7% and land principally occupied by agriculture, with significant areas of natural vegetation 4.5%) accounts for 43.2% of the Blacksod Bay catchment. Grasses and rough grazing account for almost all of the land used for farming in the catchment with only 10ha being used for to grow crops.

There are 10,759 cattle in the catchment with the highest no of cattle occurring in An Geata Mór Theas (3,094). The density of cattle in the catchment is relatively low at 0.68 cows/ha of farmland, which is less than half of the average national stocking density for cattle of 1.45 cows/ha of farmland. There are 28,732 sheep in the catchment with the highest no of sheep occurring in Knocknalower (7,654), Belmullet (7,239) and An Geata Mór Thuaidh (6,864). The stocking density for sheep in the catchment (1.79 sheep/ha of farmland) is almost double that of the national average of 1.04 sheep/ha. However, a significant proportion of the sheep (75.7%) is located in three Electoral Divisions to the north of Blacksod Bay. The majority of this farmland drains into Broad Haven Bay or to the open ocean (see Figure 5.15). Broad Haven and Blacksod are connected by a narrow channel in Belmullet Town. However, the water exchange is limited to short periods at high water, with the majority of water exchange for Broad Haven taking place with the open ocean to the north.

It would appear that at least some of the E.coli contamination originating in the small watercourses in the Elly Bay area could be associated with the higher density of cattle noted in the desktop study for this part of the catchment. Further suggestive evidence of this was noted at point 25 in the shoreline survey where approximately 45 cattle were noted in land adjoining the shore.

3.3. Rivers and Streams

Blacksod Bay drains a catchment of 167.4km^2. The catchment is made up of a series of small streams with

no large rivers or lakes. The two largest streams are the Glencastle and Doolough that flow into the north eastern end of the bay. The shoreline survey identified 24 streams/rivers and 90 discharges (Drains, pipes, culverts and a sluice) within the Bay. Many of these discharges show signs of enrichment or contamination, most of which drain agricultural land (See section 3.7 for more detail on these discharges). As the catchment consists of a series of small rivers and drains, run-off from the land will not be concentrated into one major source and instead will be distributed throughout the bay.

The current (2010-2015) WFD status of the Glencastle stream is of Good status and the Doolough Stream is of poor status. All other streams flowing into Blacksod have not been assigned a status and Blacksod itself has not been assigned a status either.

3.4. Movement of Contaminants

Inner Blacksod Bay is mostly intertidal with all but a deep channel drying out at low water. The outer bay is large and relatively deep with a 4.5km mouth providing a high level of connectivity with the open ocean. The bay has a relatively high tidal range (1.5m neaps -3.5 springs) allowing for a large water exchange with each tidal cycle. Contamination from land run-off is unlikely to impact of water quality in the bay due to the bay being over half the size of its catchment and so providing a high level of dilution of any contaminates. The fact that there are no major rivers, and that the small rivers that are present are spread out around the bay will further reduce contaminates concentrating in any one area from land run-off.

There is no tidal stream data available for Blacksod Bay. However, a hydrodynamic survey of inner Blacksod Bay (Aquafact, 2005) was carried out to assess the dispersion patterns from the new Belmullet WWTP discharge at the planning stage. The proposed upgrade of the treatment plant has since been completed. The survey found that the mean maximum neap tide velocity was 0.2m/s, whereas, the mean maximum spring tide velocity what 0.5m/s. Although spring tide velocities can reach 0.75m/s in certain locations. The dye and drogue study found that on an ebbing tide water movement was towards the deep channel in the inner bay which then dispersed out towards the outer bay. Although the Belmullet WWTP discharges directly to a section of the native oyster beds, contamination will be quickly dispersed out of the inner bay and away from the native oyster licensed area on the ebbing tide. The contamination from this discharge is also likely to be relatively low as it is a tertiary treatment facility and is operating well below capacity. Three drogues released on the spring ebbing tide are notable as they initially moved southwards to Cleggan Point before changing direction on the flooding tide turning to the north-east into Trawmore Bay. Although the majority of water from the inner bay empties to the outer bay at low tide, in certain tidal and wind conditions contaminates particularly in surface waters maybe transported to Trawmore Bay. Wild native

oyster beds are present in Trawmore Bay, however, the likelihood of contamination is low due to the high level of dispersion in the bay. The dye survey found that the dye released at the discharge location moved towards the deep channel where it quickly dispersed to untraceable levels.

The land surrounding the inner bay also has some of the highest agriculture intensity in the catchment, with the largest farmed area along with some of the highest stocking densities of both cattle and sheep. Contamination from these points will be dispersed on ebbing tide to the deep channel which it will follow out into the outer bay.

Broadhaven Bay is connected to Blacksod Bay via a narrow channel approximately 18m wide and 450m long. Contamination that enters Broadhaven Bay may enter Blacksod through this channel. However, the quantity of water exchange between the two bays is relatively low due partly to the narrowness of the channel. The quantity of water exchange is also restricted by the tide as water movement between the two bays will only occur around high tide. The majority of water exchange in Broadhaven will be with the open ocean, with only a small proportion entering Blacksod Bay.

The second and third highest water sampling results from the shoreline survey were both recorded in Elly harbour. Contamination of Elly Harbour from these two streams is expected to be minimal. Both streams have very small catchments and the small quantity of water discharged to the bay will be quickly diluted.

3.5. Wildlife

Blacksod Bay supports a number of bird species including but not limited to Great Northern Diver, Light-bellied Brent Goose, Common Scoter, Red-breasted Merganser, Ringed Plover, Sanderling, Dunlin, Bar-tailed Godwit, Curlew and Sandwich Terns. Another species of note that occurs in the bay in winter time is the Slavonian Grebe. Blacksod Bay is routinely monitored by Bird Watch Ireland with peak numbers from 2011 to 2016 ranging from 7,952 to 13,983.

Both common and grey seals are present within Blacksod Bay with haul out sites at Cleggan Point, Ardmore Point, Bunnaclassy Point and Doobeg Point. Grey seals have also been record at Kanfinalta Point. No abundance data are available for either species.

Due to the large size of Blacksod Bay and its high level of connectivity with the open ocean, waste from wildlife will quickly be diluted to very low levels.

3.6. Seasonality

In 2017, 324,000 overseas tourists visited Co. Mayo, and 503,000 domestic tourists visited Co. Mayo. The main tourist attractions in the catchment area Blacksod Point Lighthouse, Cross Loop and Erris Head Loop. As these tourist attractions do not appear in the top tourist attractions for mayo only a small proportion of these tourists are likely to visit the area. The number of holiday homes is also quite small at only 2% of the permanent households in the catchment. 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 West region. As tourism numbers in the area are relatively low it is unlikely that there will be a seasonal impact on the shellfish area from tourism.

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 Mayo 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.

There may be an increase in wading bird numbers during Autumn/winter due to migrating species.
Analysis of rainfall data for the area has shown that August to March are the months with higher rainfall. During this period faecal contamination may enter the bay in run-off from the land. The highest loading from the land would be expected in August and September as faecal load will have been accumulating over the dryer period of April to July.

Analysis of Sea Fishery Protection Authority *E. coli* results for the representative monitoring point found no significant variation between seasons.

3.7. Shoreline survey

In total 145 features were identified, of which 24 rivers/streams were identified, 54 drains, 1 WWTP, 1 location with sewage infrastructure, 32 pipes, 5 piers, 8 slipways, 9 locations with cattle, 3 culverts, 1 sluice, 1 sea channel, 1 pool and a seaweed farm.

Of the streams, rivers and drains 26 showed varying levels of enrichment. At two of these points (Features 62 & 69 in Figure 6.36 and Figure 6.37) in the very north of the bay to the west of Belmullet Town, sewage odour and grey colouration of the water were recorded. Point 69 was sampled and gave a reading of 2,900 cfu/100 ml E.coli indicating sewage related contamination.

The culvert identified at feature 72 (Figure 6.21) adjacent to pumping station for Belmullet WWTP has been identified as an unregistered storm water overflow for said station. This overflow intermittently discharging foul waste during high rainfall events. An incident report from Irish Water characterised the discharge as having little or no environmental impact as it was very dilute due to the heavy rainfall.

Numbers of cattle at the nine record locations varied from 10 to 45+ with more than 230 cattle recorded in total. At feature 130 (Figure 6.21) 30+ cattle were recorded in fields with direct access to the shore. This may result in direct release of faecal matter to the bay. There were six piers or quays that had boats present. The numbers of boats ranged from 4 to 20 boats most of which were small boats which would not have any toilet facilities on board.

Thirteen water sampling sites were sampled during the shoreline survey in June and July 2020 for bacteriological analysis. The highest E. coli result was record in the inner bay area close to the secondary school on the edge of Belmullet town. This stream also appeared to have broken pipework at the point where it meets the shore and judging by the 3,900 cfu/100 ml E.coli is carrying sewage related contamination. The second highest result also likely related to sewage contamination was recorded from a sluice beside a slip east of Belmullet town (2,900 cfu/100ml). Similarly the culvert linked to the shore road pumping station in the town also demonstrated likely sewage contamination although with a lower result of 650 E.coli cfu/100 ml.

4. Amendments

The Blacksod Bay BMPA boundary has be amended to exclude the area were the Gweesalia WWTP discharges (See Figure 4.1). The boundary has also been amended at Belmullet town and in the two small bays to the west to exclude a number of discharges that recorded high *E. coli* levels in the shoreline survey. The area of the production area is now 91.76km^2.

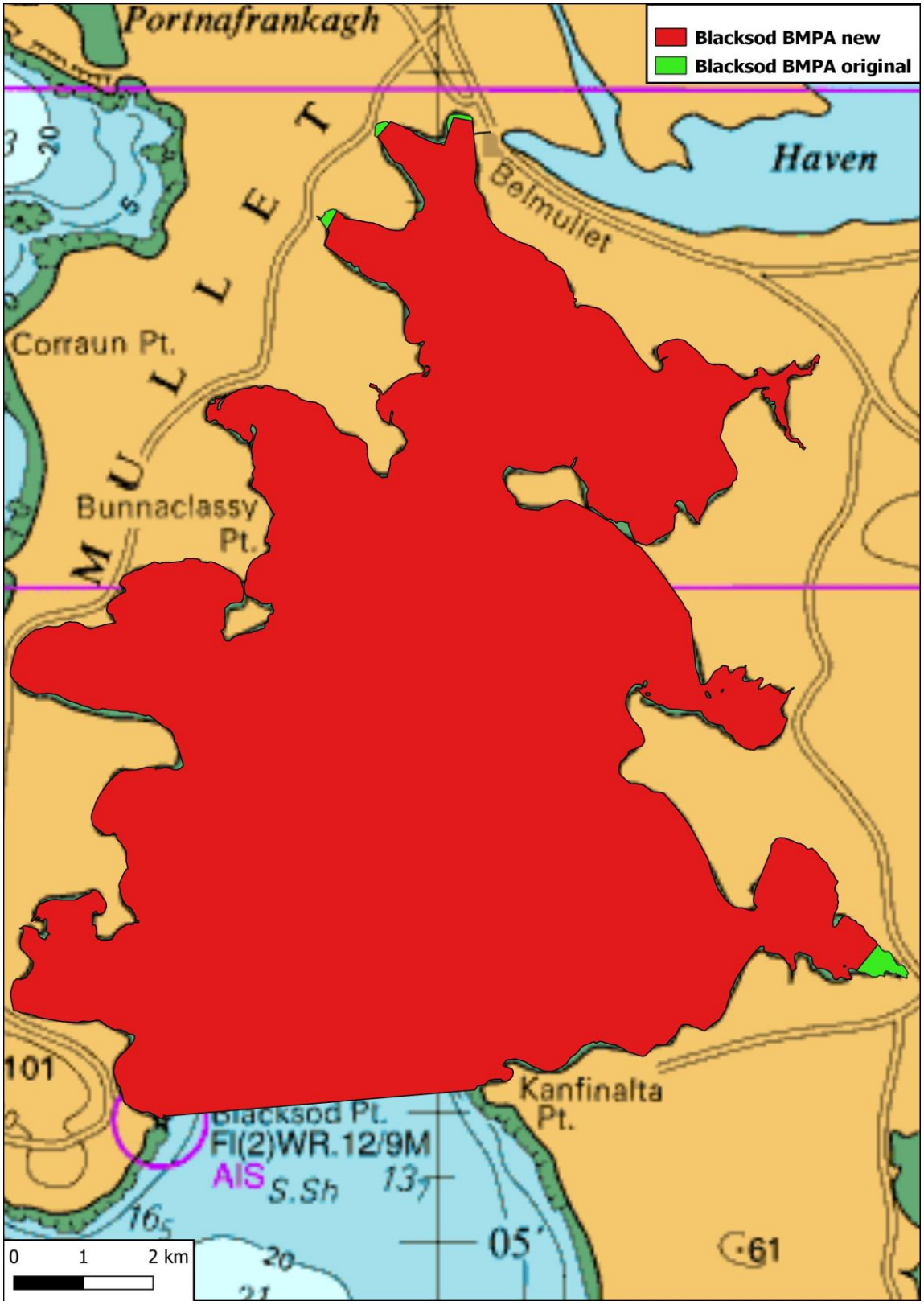


Figure 4.1: Blacksod Bay Amended BMPA boundary.

5. RMPS and Sampling Plan

5.1. Native Oysters (Ostrea edulis)

The location of RMP 1 for Native oysters is -10.0002 and 54.2062 (69,540.1E, 330,433.9N) and is shown on Figure 5.2 below. RMP 1 is located in the inner part of Blacksod Bay towards Emlybeg Point at the start of the deep channel in the middle of the inner bay. A number of locations in the inner bay were identified as likely to contain a high bacteriological load. These locations include a pumping station storm water overflow and rivers/streams/drains that recoded high *E. coli* levels in the shoreline survey. Based on the movement of water on the ebbing tide towards this deep channel, the majority of contamination from these sources will pass this point. Although the main discharge from Belmullet WWTP discharges directly to a native oyster bed this was not chosen as the RMP location as this effluent is treat to a high level. Also, once discharged the effluent will be dispersed away from the bed to the deep channel leading out to the outer bay. The discharges from Belmullet storm water overflows including the emergency discharge from the pumping station may release contaminated water during flood events. Therefore, the location of RMP 1 is best suited to identify high *E. coli* events.

10 individuals of market size (minimum shell length 8 cm) should be collected for bacteriological analysis. As opening of the fishery is intermittent the sampling frequency will be dependent on this.

5.2. Pacific Oysters (Crassostrea)

The location of RMP 2 for Pacific oysters is -9.94472and 54.15222 (72991.8E, 324322.2N), and is shown on

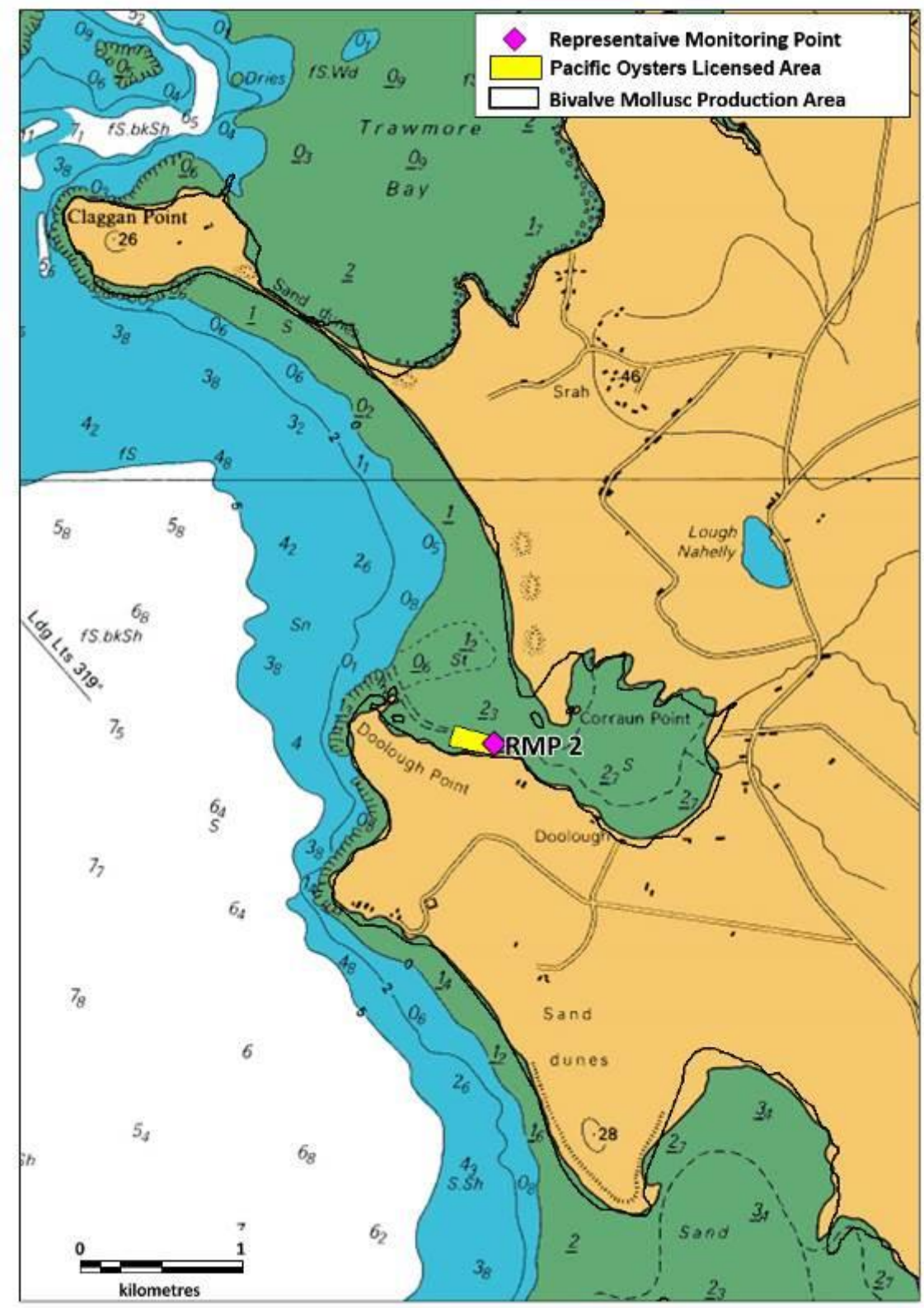


Figure 5.3 above. RMP 2 is located near Doolough point in the only licensed area for pacific oysters in the bay.

The sampling point is located at the eastern end of the site. Whatever contamination may enter this

enclosed part of the production area is likely to emanate from the small streams that enter the sea to the east of the farm. Water sampling did indicate some contamination, likely from diffuse agricultural sources, albeit it at very low levels. Any contamination from these streams will likely impact the eastern end of the licensed area on the ebbing tide as the water becomes concentrated into the ebbing channel.

Approximately 50 cows were also noted in the saltmarsh areas to the north of the farm and this land was drained by a large stream which may be a source of any associated diffuse contamination.

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

5.3. Surf Clams (Spisula solida)

In this instance it has been decided that an indicator species approach, as outlined in the 'Microbiological Monitoring of Bivalve Mollusc Harvesting Areas – Guide to Good Practice' will be taken with surf clam species. The indicator species in this instance will be the razor clam, both beds are located in the same open sea area a good distance from any identified contaminant sources. Thus the RMP and sampling plan as outlined for the razor clams will preclude the need for an RMP and separate sampling regime for the carpet shell clams.

5.4. Razor Clams (Ensis spp.)

The location of the RMP 3 for razor clams is -9.96485 and 54.11789 (71570.5E, 320537.6N), and is shown on **Error! Reference source not found.** below. Currently there is no active Razor clam production in Blacksod Bay. However, the Marine Institute identified a bed of Razor clams (*Ensis arcuatus, E. siliqua*) in a recent Marine Institute surveys (2017) north of Kanfinalta Point.

In the event that a fishery is to commence the RMP will be located in the eastern end of the bed nearest the entrance to Gweesala. Any contamination emanating from the WWTP in Gweesala, diffuse agricultural run-off or individual waste water treatment system run off would be moved west on the ebbing tide from this bay. Due to the open sea location of the razor clam beds and the small freshwater input emanating from Gweesala it is expected that contamination will be minimal.

In terms of numbers of razor clams collected, this should be a minimum 10 individuals of market size for bacteriological analysis. Sampling frequency will be determined on the basis of the seasonality of the fishery.

5.5. King Scallops (Pecten maximus)

Classification monitoring data obtained from the official monitoring of other bivalve molluscs within an existing classified production area are used to determine the classification of scallops fished from within an existing classified production area. Therefore, a specific scallop RMP and associated scallop monitoring is not required. All scallops harvested within classified production areas are classified as B unless harvested within classified production areas where all other mollusc shellfish are classified as being of class A, in such cases scallops may be classified as A.

Table 5.1: Coordinates of the Production Area.

Corner	Longitude	Latitude	Easting	Northing
NE	-9.988347	54.225745	70,372.05	332,584.02
NE	-9.988272	54.225602	70,376.50	332,567.97
SW	-10.060171	54.098932	65,276.81	318,605.27
SE	-9.991728	54.102623	69,765.26	318,887.77

Table 5.2: Coordinates of each RMP and its relevant species.

RMP	Site Code	Species	Longitude	Latitude	Easting	Northing
RMP 1	MO-BB-BT-NO	Native Oysters	-10.0002	54.2062	69540.1	330433.9
RMP 2	MO-BB-BT-PO	Pacific Oysters	-9.94472	54.15222	72991.8	324322.2
RMP 3	MO-BB-BT-RAZ	Razor Clams	-9.96485	54.11789	71570.5	320537.6

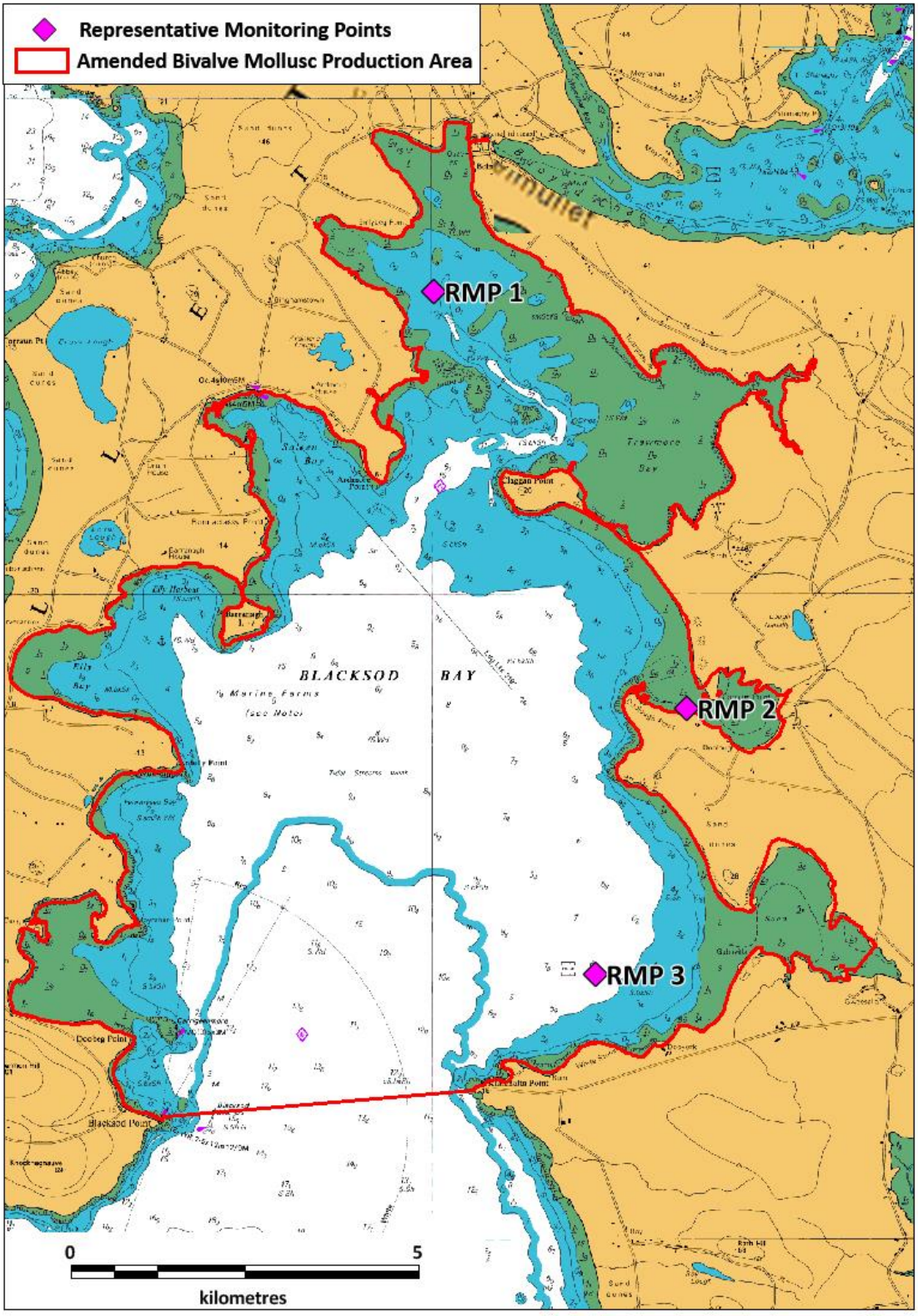


Figure 5.1: Bivalve Mollusc Classified Production Area with RMPs for Blacksod Bay.

5.6. Species Specific RMP maps.

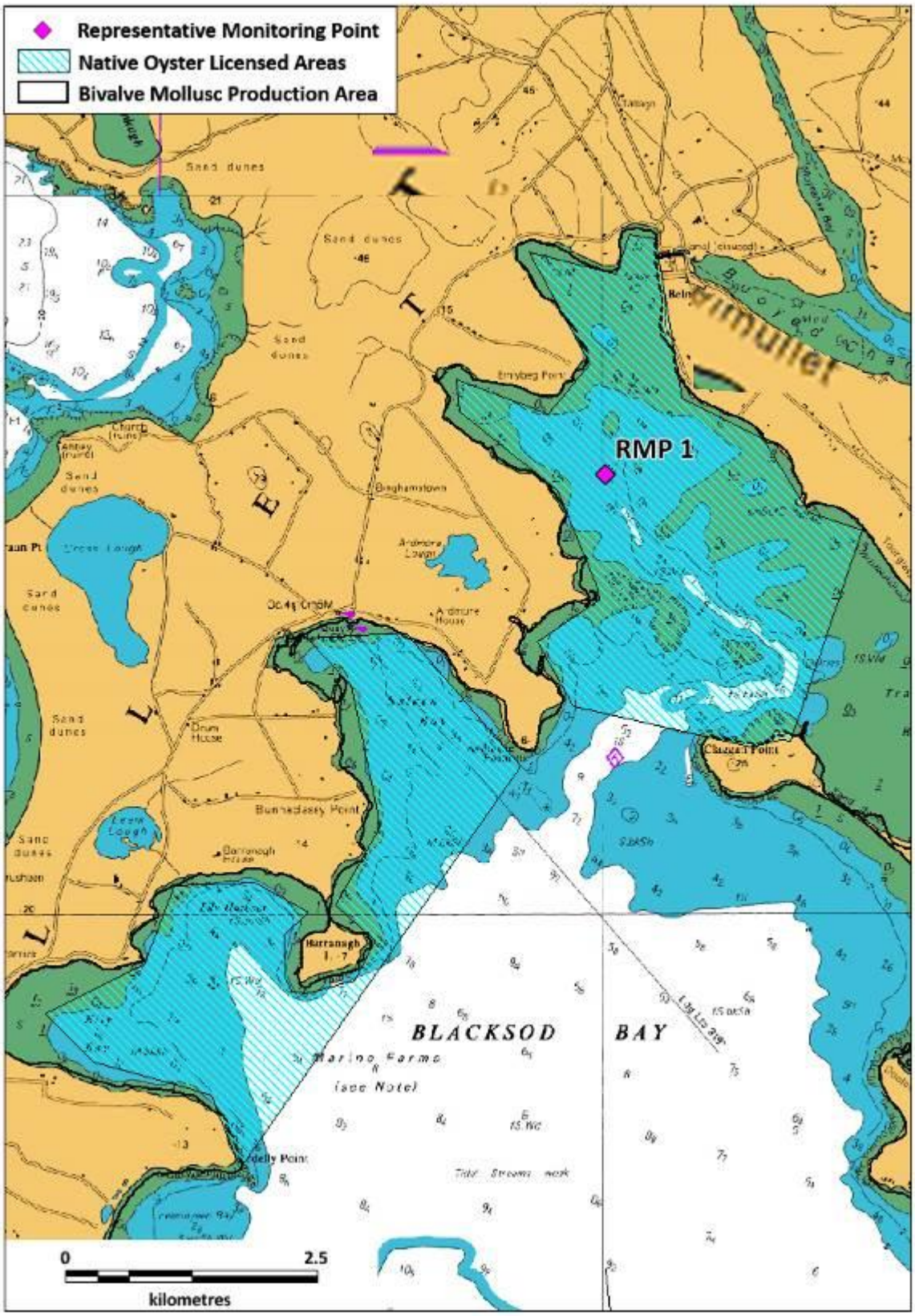


Figure 5.2: Location of the native oyster RMP within Blacksod Bay.

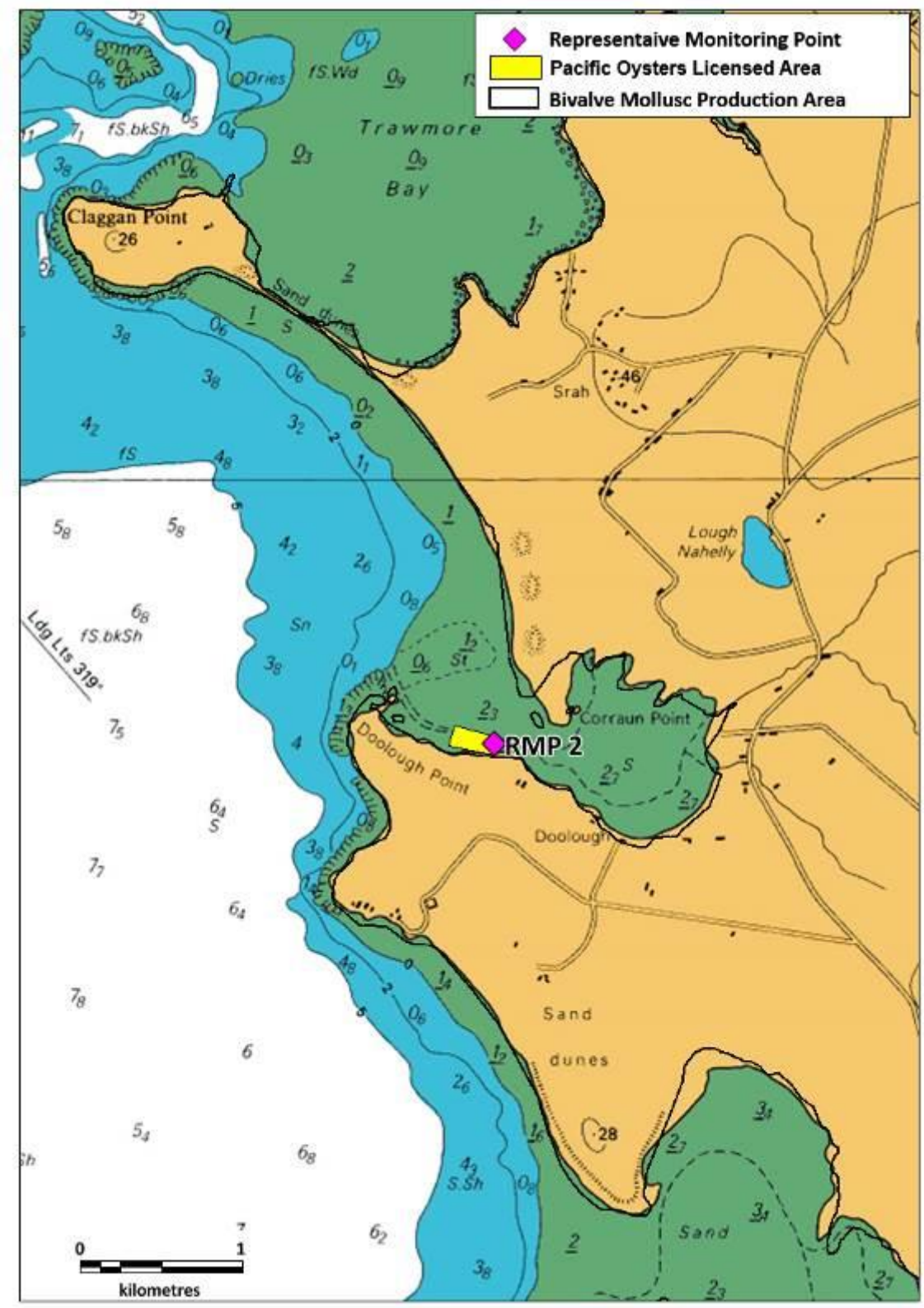


Figure 5.3: Location of the pacific oyster RMP within Blacksod Bay.

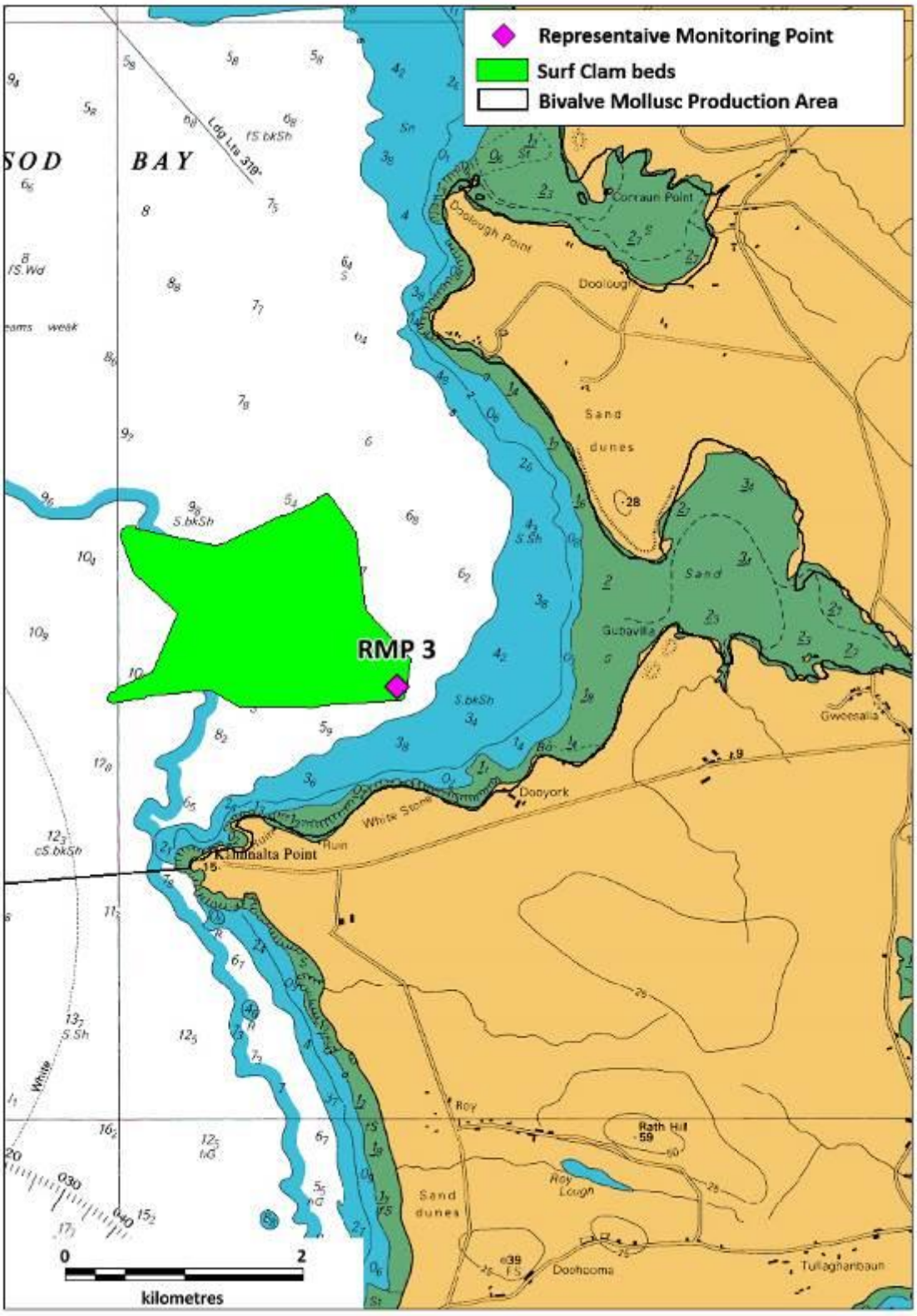


Figure 5.4: Location of the Razor clam RMP within Blacksod Bay.

5.7. General Sampling Method

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

6. Appendix 1: Identification of Pollution Sources

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

6.1. Desktop Survey

Pollution sources were considered within the catchment area of Blacksod Bay (see Figure 6.1). The catchment area covers an area of 167.4km^2, approximately 15km east west at its widest point and 23km north south at its longest point.

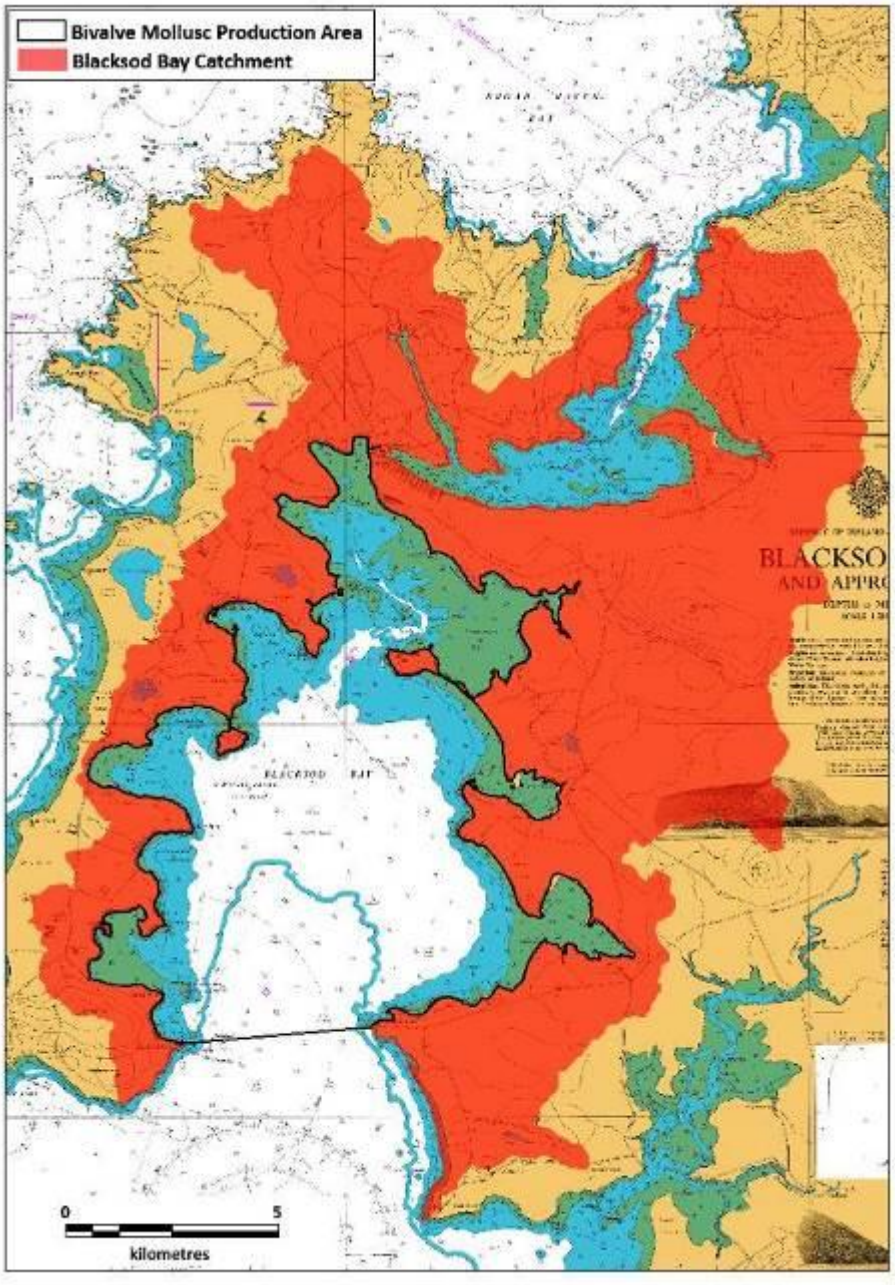


Figure 6.1: Blacksod Bay catchment area used for assessment of the pollution sources.

6.1.1. Human Population

Population census data used by the Central Statistics Office (CSO) is given in units of Electoral Divisions (ED). Figure 6.2 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. Town populations were also taken for the 2016 Census. Figure 6.3 shows the human population within Blacksod Bay catchment area and Table 6.1 shows these data in tabular form.

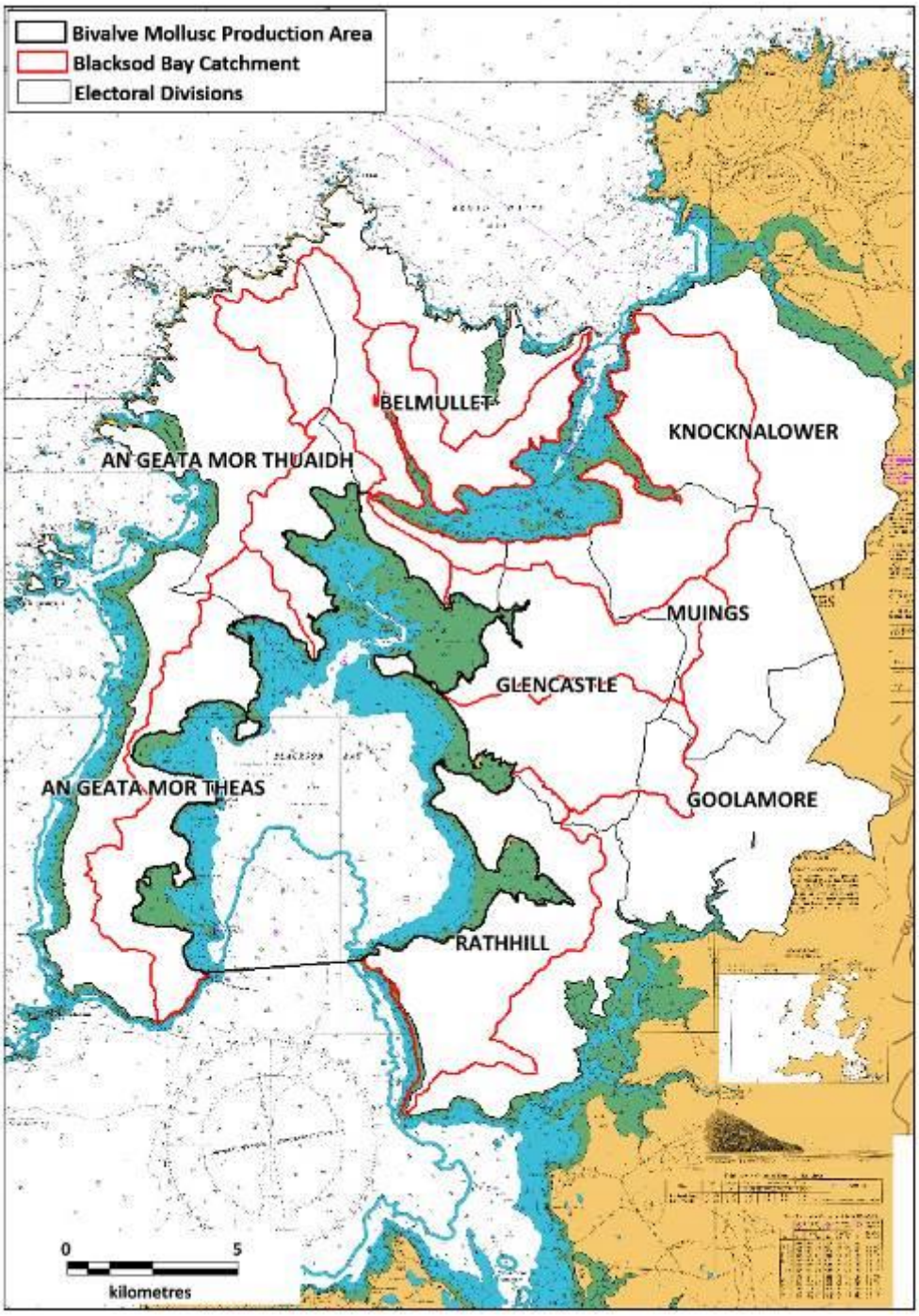


Figure 6.2: Electoral Divisions within the Blacksod Bay Catchment Area.

The Blacksod Bay Catchment Area overlaps 8 EDs (All partially). The EDs that are partially within the catchment are An Geata Mór Theas, An Geata Mór Thuaidh, Belmullet, Glencastle, Goolamore, Knocknalower, Muings and Rathhill. Belmullet contains the largest population (1,954) followed by An Geata Mór Theas (980) and An Geata Mór Thuaidh (939).

These 8 EDs accommodate a total population of 6,191. As all of these EDs 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 3,490 people. Table 6.1 shows this estimation.

There are two main towns/urban centres within the catchment area Belmullet and Dumha Thuama. Belmullet (1,019) has by far the largest population, while Dumha Thuama (112) has a relatively small population.

There are 3,386 households within the 8 EDs within the catchment area. Of this, 18% are vacant (626) and a further 2% are holiday homes (79). Of the 1,906 houses actually within the catchment (based on the % of the ED within the catchment), 19% are vacant and 2% are holiday homes. Table 6.2 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 Blacksod Bay system. Therefore, the highest levels of sewage and waste would be expected to enter from the Belmullet town area. As holiday homes only account for 2% of the dwellings in the catchment they are unlikely to cause a significant increase in the sewage and waste water levels relative to the permanent population.

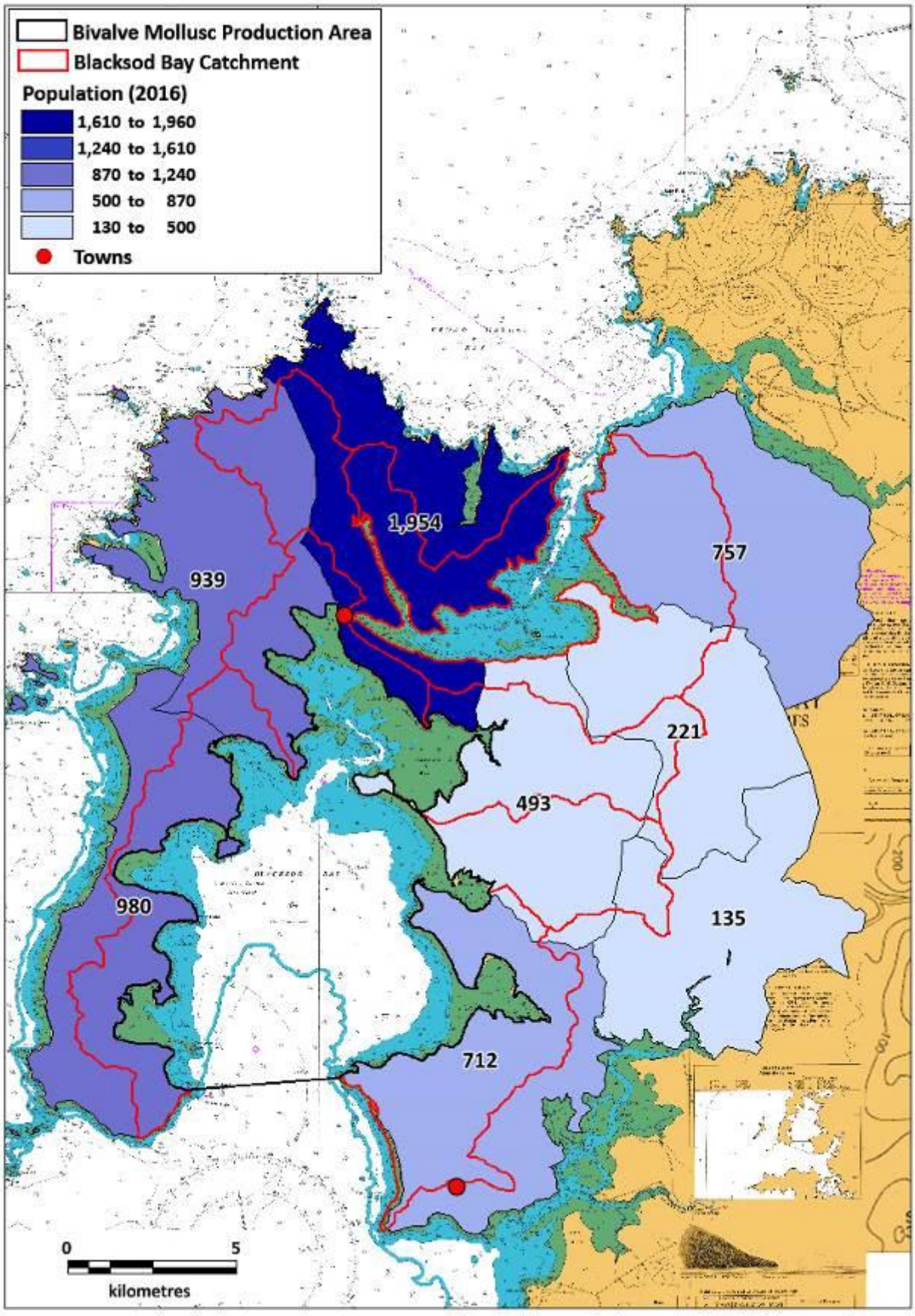


Figure 6.3: Human population within the Blacksod Bay Catchment Area (Source: CSO, 2019a).

Table 6.1: Human population within the Blacksod Bay Catchment Area (Source: CSO, 2019a).

Electoral Division	Population (2016)	% ED in Catchment	Estimated Population
An Geata Mor Theas	980	46.7	458
An Geata Mor Thuaidh	939	48.5	456
Belmullet	1954	64.2	1255
Glencastle	493	96.1	474
Goolamore	135	9.0	12
Knocknalower	757	36.1	273
Muings	221	46.8	103
Rathhill	712	64.4	458

Table 6.2: Households within the EDs in the Blacksod 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
An Geata Mor Theas	509	338	5	115	238	158	2	54
An Geata Mor Thuaidh	502	370	22	76	244	180	11	37
Belmullet	1026	739	6	223	659	475	4	143
Glencastle	251	188	7	39	241	181	7	37
Goolamore	86	55	5	14	8	5	0	1
Knocknalower	394	296	5	61	142	107	2	22
Muings	133	89	21	28	62	42	10	13
Rathhill	485	312	8	70	312	201	5	45

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

6.1.2. Tourism

In 2017, 3.6 million tourists visited the west Region of Ireland (Failte Ireland, 2018a). This figure was made up of 1,900,000 overseas tourists, 1,600,000 domestic tourists and 109,000 Northern Irish tourists. Of the overseas tourists, 324,000 visited Co. Mayo, and of the domestic tourists 503,000 visited Co. Mayo (Failte Ireland, 2018b). The main tourist attractions in the area are Blacksod Point Lighthouse, Cross Loop, Erris Head Loop, Carrowteige Loop, Ballycroy National Park and Inishkea Islands.

The attractions located inside the catchment area include Blacksod Point Lighthouse, Cross Loop and Erris Head Loop. 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 West region.

Several operators use the natural amenities in and adjacent to Blacksod Bay as a focal point for their aqua-tourism businesses. Two sea angling and charter vessels (Geraghty Charters and Dive West Ireland) operate out of Blacksod Bay. UISCE adventure centre offers a range of activities including sailing, surfing and windsurfing. Wave Sweeper Sea Adventures operate out of Belmullet and provide a range of activities.

In addition to the above there is also a number of beaches located along the shore of Blacksod Bay and a number of piers, quays and slips which provide sea access.

Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Blacksod Bay catchment area. In addition, Papadakis *et al.* (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria. In 2007, Elmir *et al.* (2007) showed the role of human skin as an intermediate mechanism of pathogen transmission to the water column. There are two monitored swimming areas within the production area, one at Mullaghroe Beach and the other at Elly beach, which are both Blue Flag beaches. In addition, waste can enter the area from recreational vessels.

6.1.3. Sewage Discharges

Sewage effluent can vary in nature depending on the degree to which the sewage has been treated. Discharges of sewage effluent can arise from a number of different sources and be continuous or intermittent in nature:

- treated effluent from urban sewage treatment plants (continuous);

- storm discharges from urban sewage treatment plants (intermittent);
- effluent from 'package' sewage treatment plants serving small populations (continuous);
- combined sewer and emergency overflows from sewerage systems (intermittent);
- septic tanks (intermittent);
- crude sewage discharges at some estuarine and coastal locations (continuous).

Treatment of sewage ranges from:

- none at all (crude sewage);
- preliminary (screening and/or maceration to remove/disguise solid matter);
- primary (settling to remove suspended solids as sewage sludge). Typically removes 40% of BOD (Biochemical Oxygen Demand), 60% of suspended solids; 17% of nitrogen and 20% of phosphorus from the untreated sewage;
- secondary (settling and biological treatment to reduce the organic matter content). Typically removes 95% of BOD, 95% of suspended solids, 29% of nitrogen and 35% of phosphorus from the untreated sewage. Nutrient removal steps can be incorporated into secondary treatment which can reduce ammonia - N down to 5 mg/l and phosphorus to 2mg/l.
- tertiary (settling, biological treatment and an effluent polishing step which may involve a reed bed (unlikely for a coastal works) or a treatment to reduce the load of micro-organisms in the effluent)., typically removes 100% of BOD, 100% of suspended solids, 33% of nitrogen and 38% of phosphorus from the untreated sewage.

6.1.3.1. Water Treatment Works

There are two waste water or sewage treatment works within the Blacksod Bay catchment, one in Belmullet Town and the other is in Gweesalia. Figure 6.4 shows both Treatment Works within the Blacksod Bay catchment area and Table 6.3 shows the coordinates and facility capacities of each works (EPA, 2019a).

6.1.3.2. Continuous Discharges

Belmullet WWTP is a Tertiary treatment facility with a design capacity of 4,005 PE (Population Equivalent) and is currently under capacity at 2,049 PE. The maximum discharge for this facility is 3,000 m^3/day. Gweesalia WWTP is a secondary treatment facility with a design capacity of 700 PE and is currently under capacity at 192 PE. The maximum discharge for this facility is 132.98 m^3/day. The locations of the discharges can be seen in Figure 6.5 and Table 6.4 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.

There is no geo-referenced database for septic tanks and on-site domestic waste water treatment systems. In order to estimate the numbers of these domestic sewage facilities within the catchment, information on the number of permanent private households and their sewage facilities was sourced from the 2016 census (CSO, 2019a). Of the 2,287 permanent private households in the 8 EDs, 18.2% (417) were connected to a public sewer/treatment system and 56.8% (1,300) had septic tanks or other individual treatment systems. The estimate for the total number of private permanent households actually within the catchment (based on % within the catchment) is 1,288 and of this 20.2% (260) are on the public system while 50.6% (652) households have their own septic tanks or other individual treatment systems. Table 6.5 shows this information at the ED level and an estimation (based on % within the catchment) of the numbers actually within the catchment.

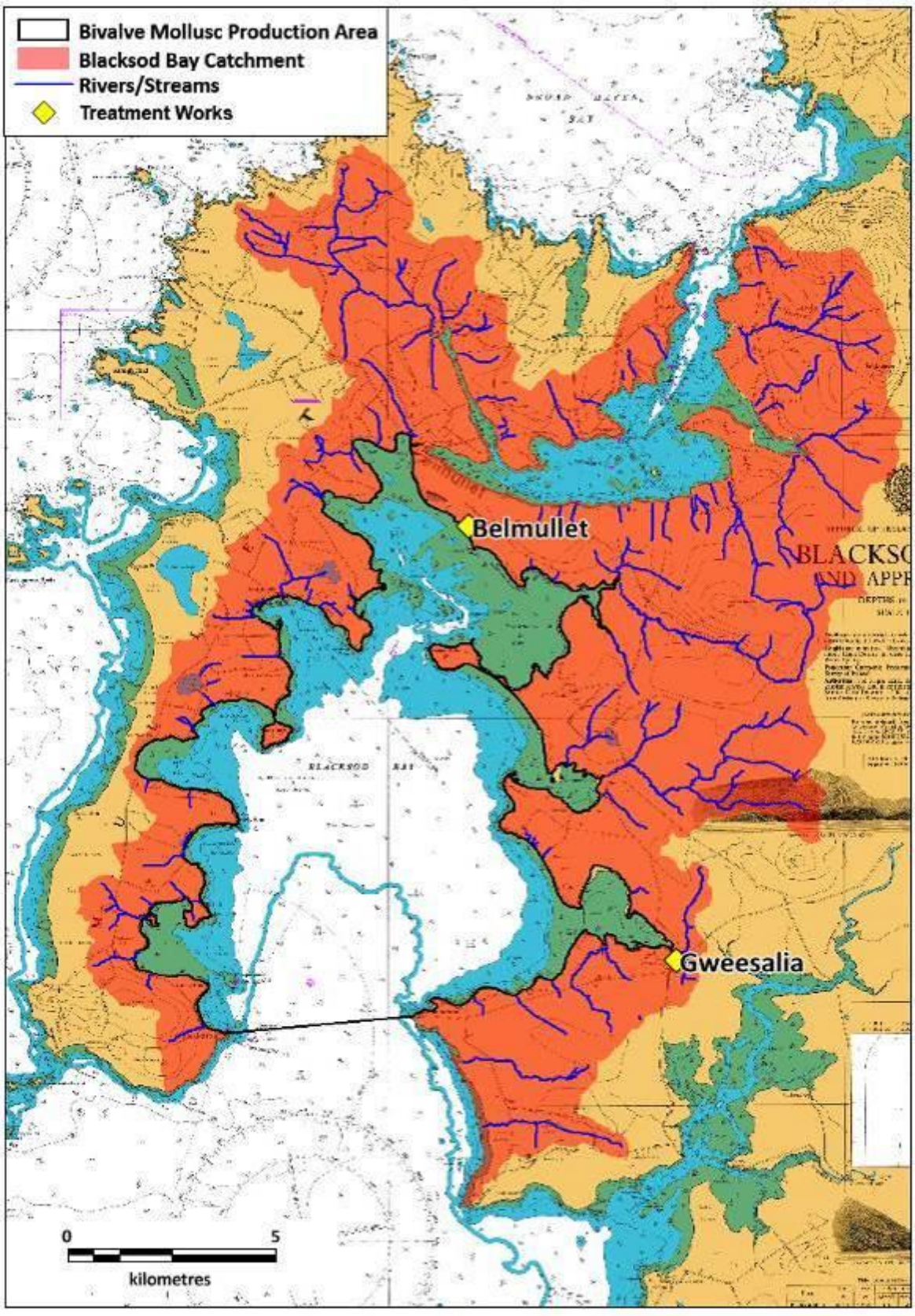


Figure 6.4: Sewage Treatment Works within the Blacksod Bay Catchment Area (Source: The EPA, 2019a).

Table 6.3: Sewage Treatment Works within the Blacksod Bay Catchment Area (Source: EPA, 2019a).

Name	Easting	Northing	Longitude	Latitude	p.e.	Designed p.e.
Belmullet	70964	330386	-9.978333	54.20616	2049	4005
Gweesalia	76064	320080	-9.895985	54.114882	192	700

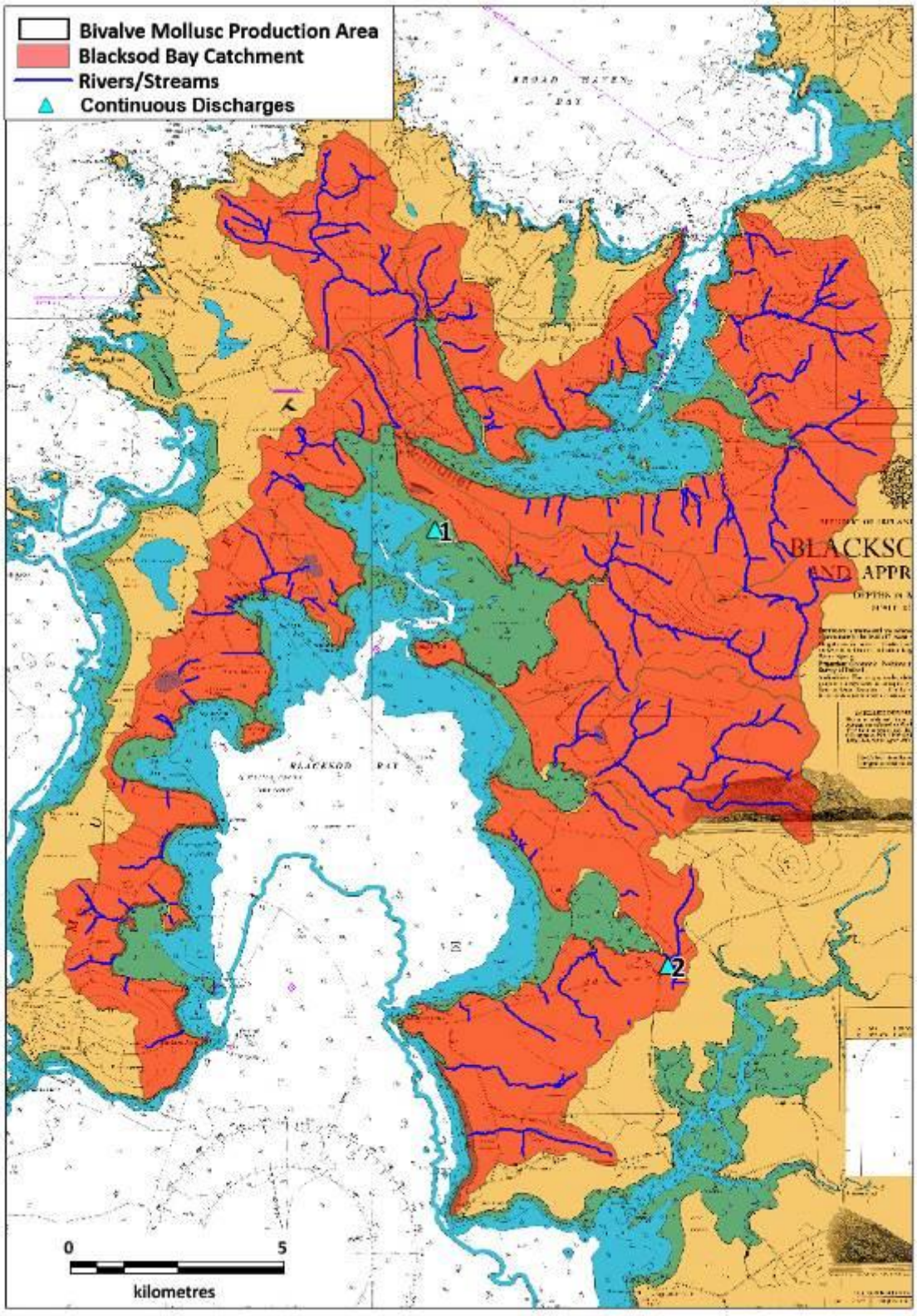


Figure 6.5: Continuous Discharges associated with the Sewage Treatment Works within the Blacksod Bay Catchment Area (Source: The EPA, 2019a).

Table 6.4: Continuous Discharges within the Blacksod Bay Catchment area (Source: EPA, 2019a). Map Codes refer to Figure 5.5.

Map Code	Name	Treatment	Easting	Northing	Longitude	Latitude	Receiving Body	Max Discharge/ day (m^3)	DWF/ day (m^3)
1	Belmullet	Tertiary Treatment	71,439	330,628	-9.971162	54.208452	Blacksod Bay	3,000	1036.8
2	Gweesalia	Secondary Treatment	76,064	320,080	-9.895985	54.114882	Blacksod Bay	132.98	43.2

Table 6.5: Sewage facilities at permanent households in the catchment area (CSO, 2019a).

Electoral Division	Entire ED						Catchment %					
	Permanent Private Household	Public Sewage Scheme	Individual Septic Tank	Other individual treatment	Other /Not Stated	No sewage facility	Permanent Private Households	Public Sewage Scheme	Individual Septic Tank	Other individual treatment	Other /Not Stated	No sewage facility
An Geata Mor Theas	330	7	74	4	3	0	154	3	35	2	1	0
An Geata Mor Thuaidh	358	19	66	4	6	1	174	9	32	2	3	0
Belmullet	701	320	105	18	7	0	450	206	67	12	4	0
Glencastle	180	0	119	16	5	0	173	0	114	15	5	0
Goolamore	52	1	132	16	6	0	5	0	12	1	1	0
Knocknalower	288	10	66	2	2	2	104	4	24	1	1	1
Muings	87	3	526	49	23	0	41	1	246	23	11	0
Rathhill	291	57	98	5	5	1	187	37	63	3	3	1

6.1.3.3. Rainfall Dependent / Emergency Sewage Discharges

In addition to WWTPs having a continuous discharge pipe, they also have intermittent or rainfall dependent discharge pipes in the form of storm water overflows. During storm flows in excess of a predetermined flow rate, the excess will bypass the works and flow directly to the outfall via the storm overflow discharge pipes. The details for the intermittent discharges can be seen in Table 6.6 and their locations can be seen in Figure 6.6.

As the discharge from storm water overflows are dependent on the amount of rainfall the volume of water discharged can vary greatly. Table 5.7 shows the discharge rate for SW3 for February 2020.

Table 6.6: Rainfall dependent discharges (storm water overflows) within the Blacksod Bay Catchment area (Source: EPA, 2019a). Map Codes refer to Figure 5.6.

Map Code	Name	Discharge Point Code	Easting	Northing	Longitude	Latitude	Receiving Body
1	Belmullet	SW3	70,134	332,282	-9.991864	54.222973	Blacksod Bay
2	Belmullet	SW2	70,144	331,988	-9.991584	54.220336	Blacksod Bay
3	Belmullet	SW4	70,599	332,395	-9.984788	54.224105	Broadhaven Bay
4	Gweesalia	SW2	75,628	320,255	-9.90272	54.116349	Blacksod Bay
5	Gweesalia	SW3	76,098	320,044	-9.89545	54.114567	Blacksod Bay
6	Belmullet	N/A	70,109	332,788	-9.99246	54.22751	Blacksod Bay

Table 6.7: Storm water overflows February and August 2020 for the Shore Road pumping station at Belmullet (Irish Water)

Storm Water Overflow (SW3)	
Date	**Volume**
6th February	1m3/day
7th February	864m3/day
8th February	3720m3/day
9th February	3147m3/day
10th February	853m3/day
11th February	1074m3/day
12th February	1780m3/day
13th February	1005m3/day
14th February	250m3/day
15th February	4017m3/day
16th February	1342m3/day
17th February	612m3/day
18th February	1153m3/day
19th February	3882m3/day
20th February	1975m3/day
21st February	3294m3/day
22nd February	1434m3/day
23rd February	2225m3/day
24th February	3116m3/day
25th February	2242m3/day
26th February	1257m3/day
27th February	373m3/day
28th February	2995m3/day
29th February	2503m3/day
01st August	146m3/day
04th August	1463m3/day
05th August	189m3/day
17th August	46m3/day
18th August	14m3/day
20th August	832m3/day
21st August	63m3/day
22nd August	73m3/day
25th August	5,697m3/day
26th August	386m3/day
27th August	162m3/day
28th August	744m3/day
29th August	60m3/day

This table demonstates the spill frequency of the storm water overflow associated with shore road pumping

station at Belmullet for the months of February and August. Spill frequency was higher during the wetter month of February but the highest daily volume flow was noted on the 25th of August at 5,597 m3/day

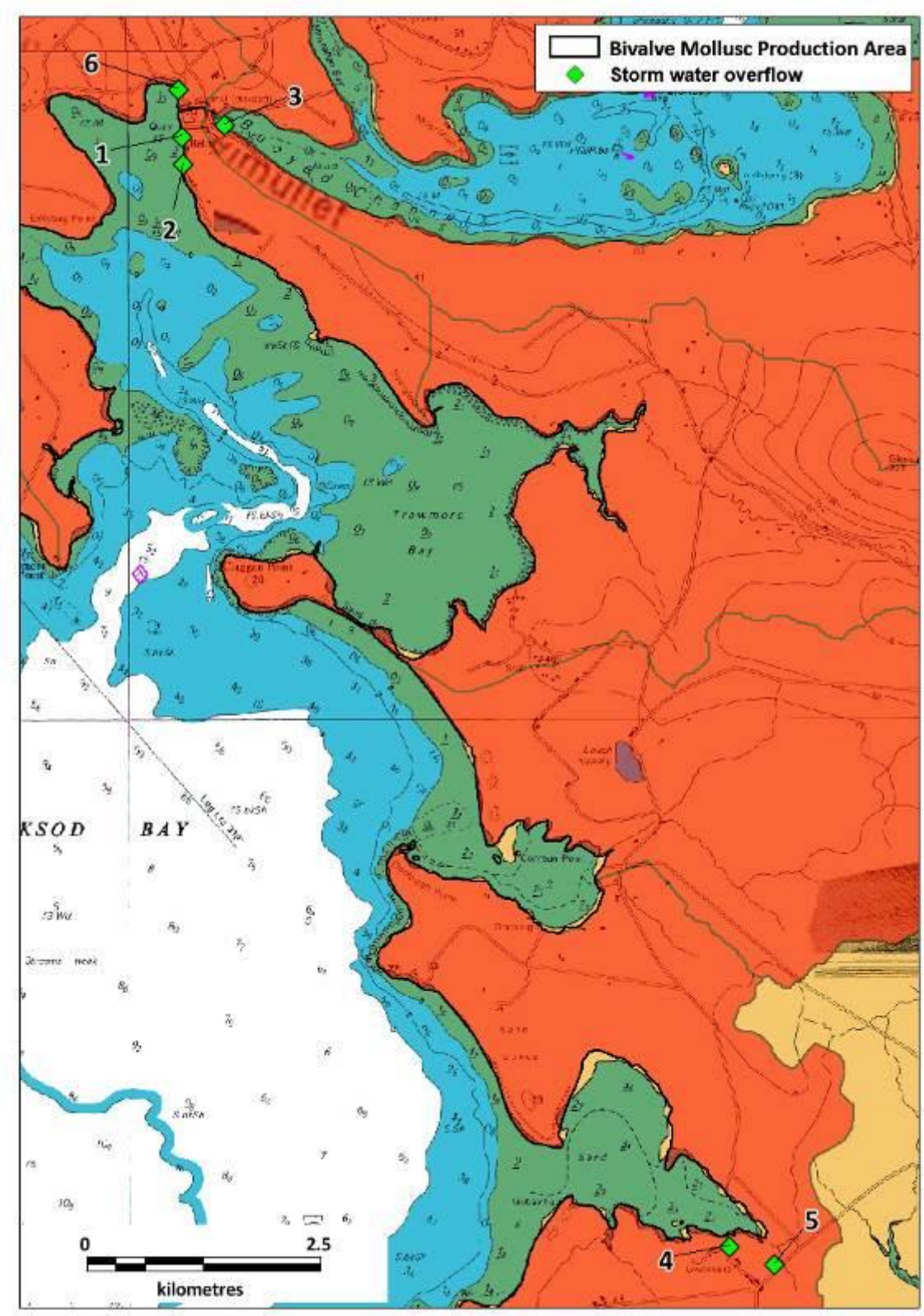


Figure 6.6: Rainfall Dependent Discharges associated with the Sewage Treatment Works within the Blacksod Bay Catchment Area (Source: The EPA, 2019a).

6.1.4. Industrial Discharges

At the time of writing there were no facilities with industrial discharges or section 4 discharges within the Blacksod Bay catchment (EPA, 2019b; EPA, 2019c).

6.1.5. Landuse Discharges

Figure 6.7 shows the Corine landuse (EPA, 2019d) within the Blacksod Bay catchment area. Figure 7.5 shows all rivers/streams within the catchment area. Within the catchment area, land use is dominated by peat bogs (78.6km^2, 45%), pastures (67.7km^2; 38.7%), intertidal flats (9.4km^2, 5.4%) and Land principally occupied by agriculture, with significant areas of natural vegetation (7.9km^2; 4.5%), followed by, beaches, dunes, sands (3.1km^2; 1.8%) and coniferous forest (2.2km^2; 1.2%) (see Figure 6.8).

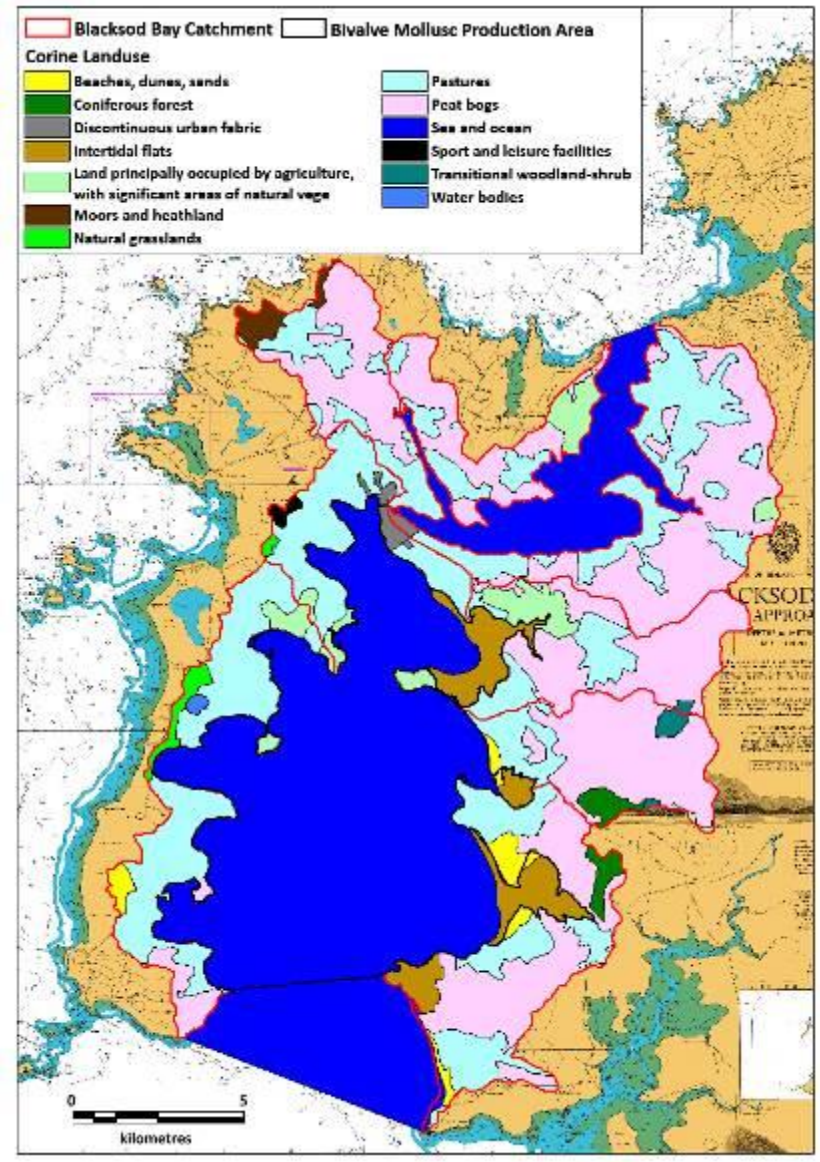


Figure 6.7: Landuse within the Blacksod Bay Catchment Area (Source: EPA, 2019e).

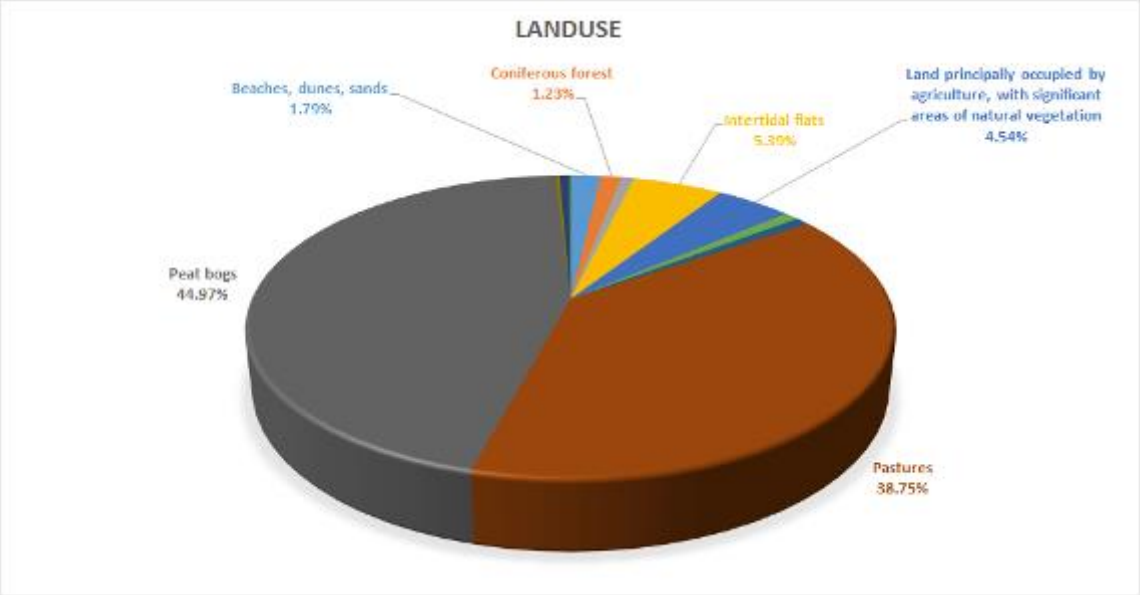


Figure 6.8: Breakdown of landuse within the Blacksod Bay Catchment Area (only landuse ≥1% is labelled).

Data from the Census of Agriculture 2010 (CSO, 2019b) can be seen in Table 6.8 below. Figure 6.9 to Figure 6.16 show thematic maps for each category in Table 6.8.

Numbers of farms within the catchment range from 47 in Goolamore to 169 in An Geata Mór Theas. The total area farmed within the catchment varies from 1210 ha in Muings to 2,930 ha in An Geata Mór Thuaidh. The average farm size ranges from 13.1 ha in Rathhill to 29.9 ha in Goolamore.

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 1210 ha in Muings to 2,929 ha in An Geata Mór Thuaidh. Total crops range from 0 ha in all areas with the exception of 1 ha in Belmullet and Glencastle, 2 ha An Geata Mór Thuaidh and 6 ha in Rathhill.

The total number of cattle within the catchment range from 421 in Muings to 3,094 in An Geata Mór Theas. The total number of sheep within the catchment range from 335 in An Geata Mór Theas to 7,654 in Knocknalower. The total number of horses within the catchment range from 7 at Muings to 60 in An Geata Mór Theas.

The total area farmed in the entire ED's shown in Figure 6.9 to Figure 6.16 amounts to 15,995 ha. However, as most of these ED's only partially overlap the catchment area, an attempt was made to estimate the actual area farmed within the catchment. The percentage of the ED lying within the catchment was

calculated in GIS and from this value the area farmed was calculated *e.g.* if 50% of ED lies within catchment area then 50% of the area farmed was taken to be the area farmed within the catchment. Using this method, the area farmed within the catchment is estimated at 8,157 ha. This represents 51% of the area.

Table 6.8: Farm census data for all EDs within the Blacksod 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
An Geata Mór Theas	Mayo	169	2844	16.8	0	2844	3094	335	60
An Geata Mór Thuaidh	Mayo	159	2930	18.4	2	2929	2437	6864	39
Belmullet	Mayo	148	2202	14.9	1	2201	1487	7239	27
Glencastle	Mayo	90	1377	15.3	1	1376	783	1718	28
Goolamore	Mayo	47	1404	29.9	0	1404	632	1521	11
Knocknalower	Mayo	162	2183	13.5	0	2183	749	7654	31
Muings	Mayo	67	1210	18.1	0	1210	421	3063	7
Rathhill	Mayo	141	1845	13.1	6	1838	1156	338	27

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

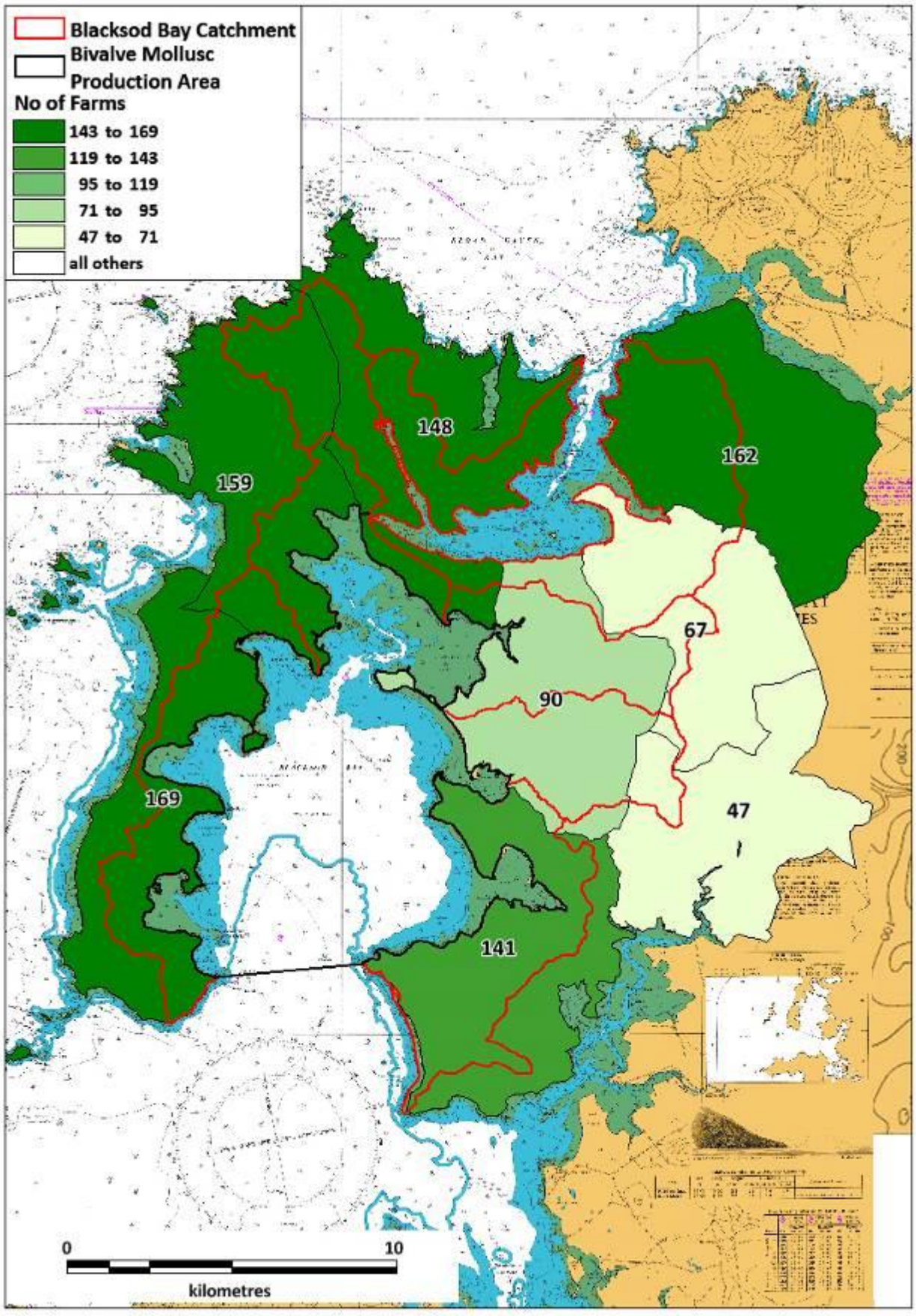


Figure 6.9: Number of farms within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

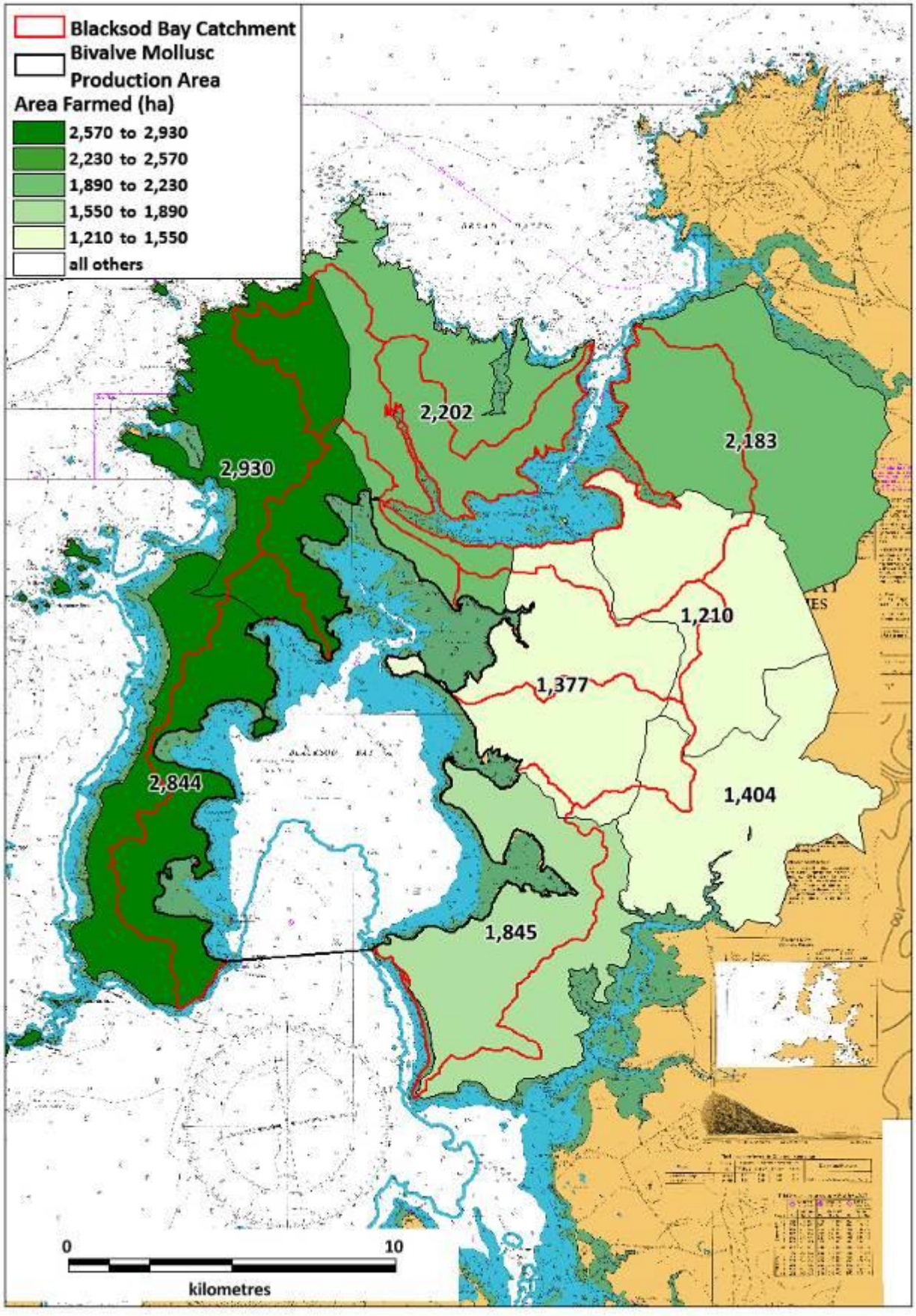


Figure 6.10: Area farmed (ha) within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

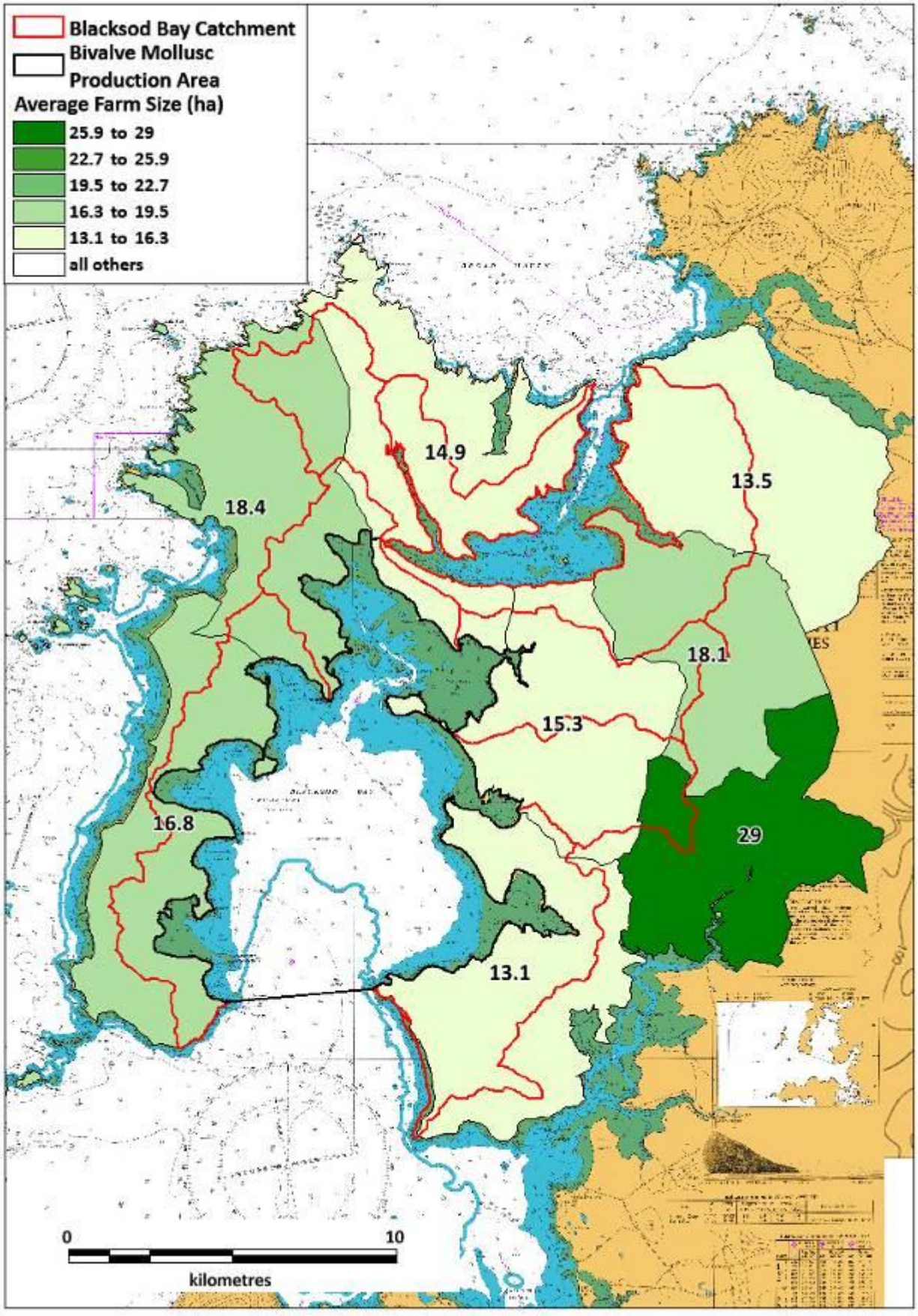


Figure 6.11: Average farm size (ha) within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

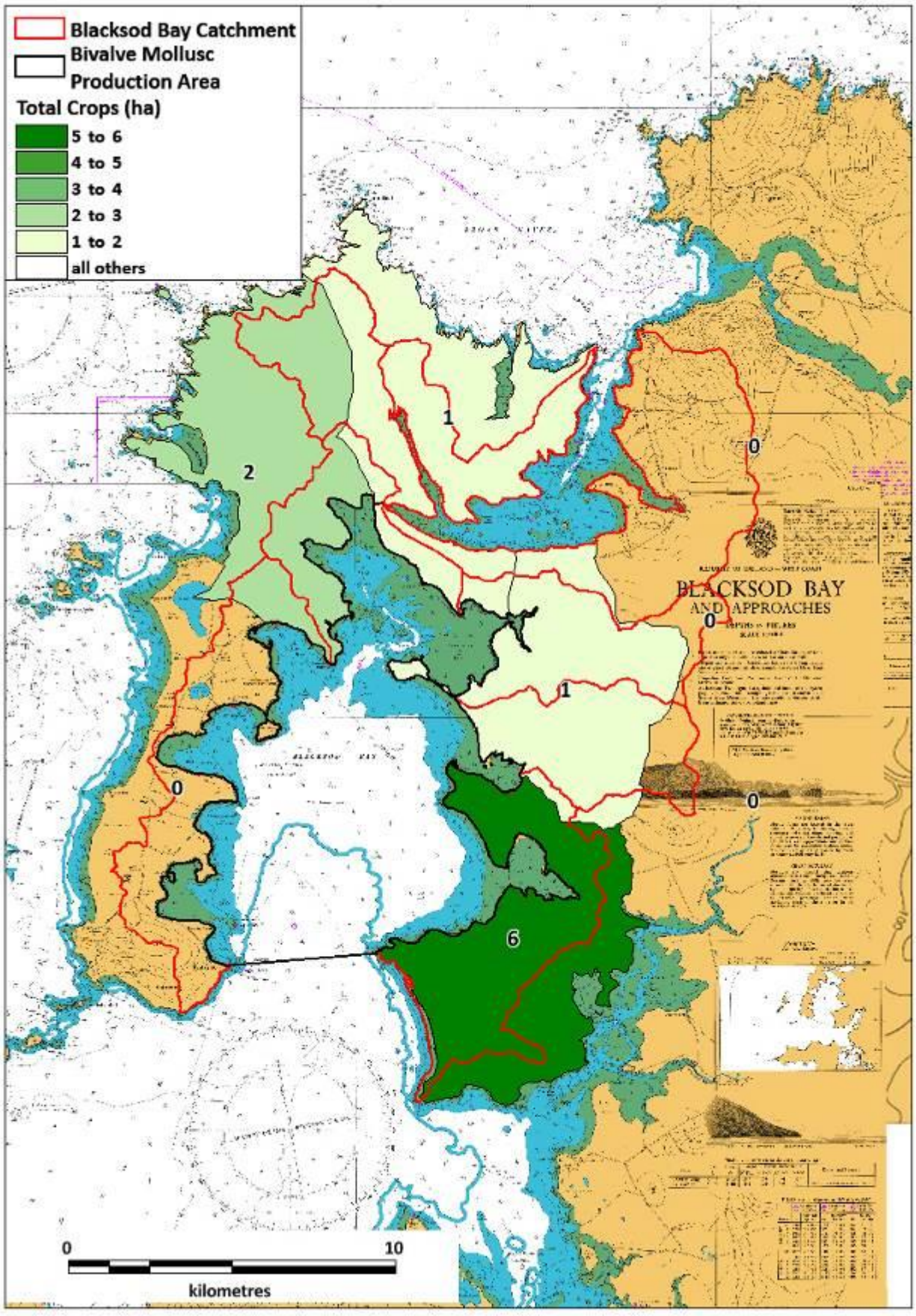


Figure 6.12: Total crops within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

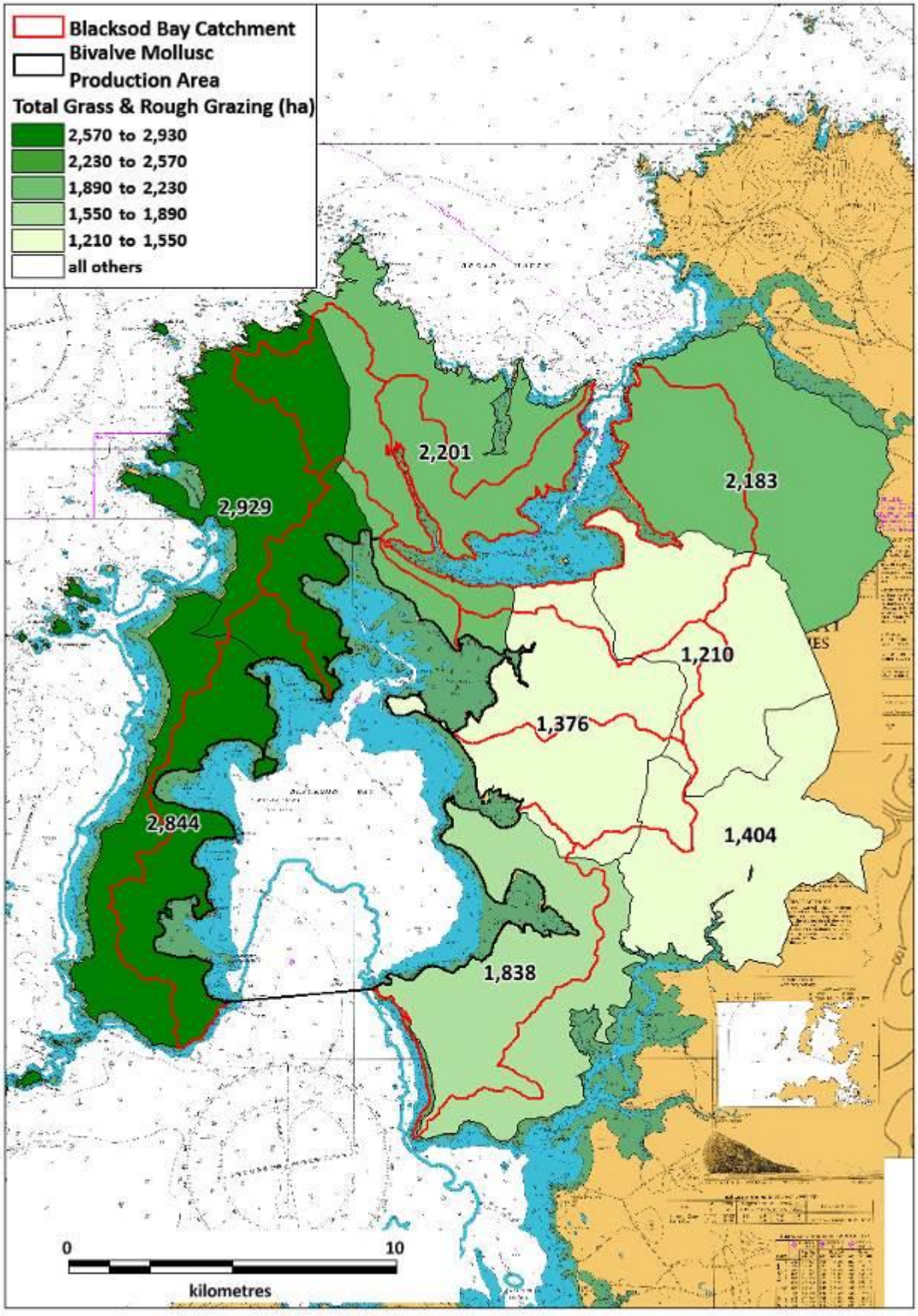


Figure 6.13: Total grass and rough grazing within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

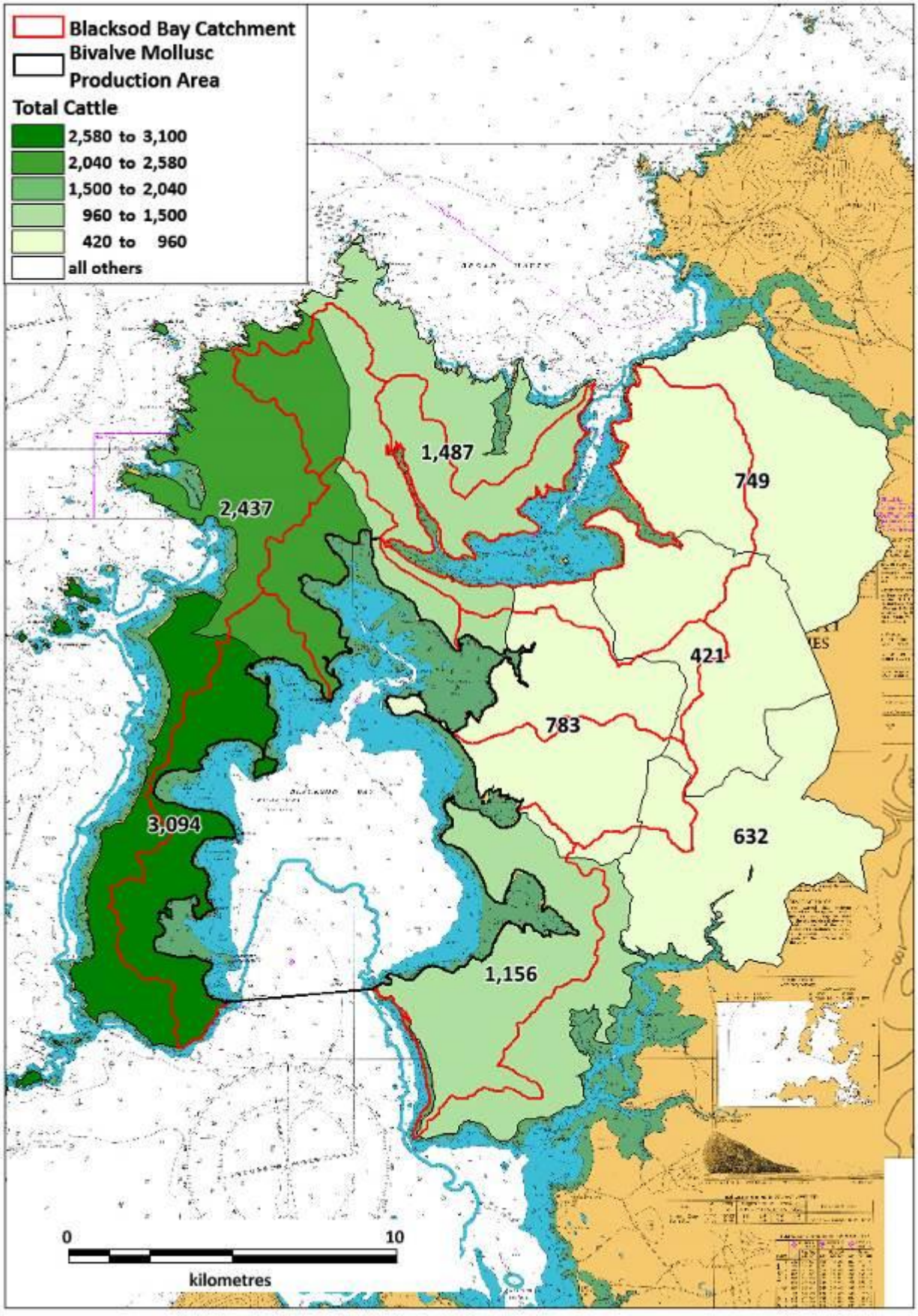


Figure 6.14: Cattle within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

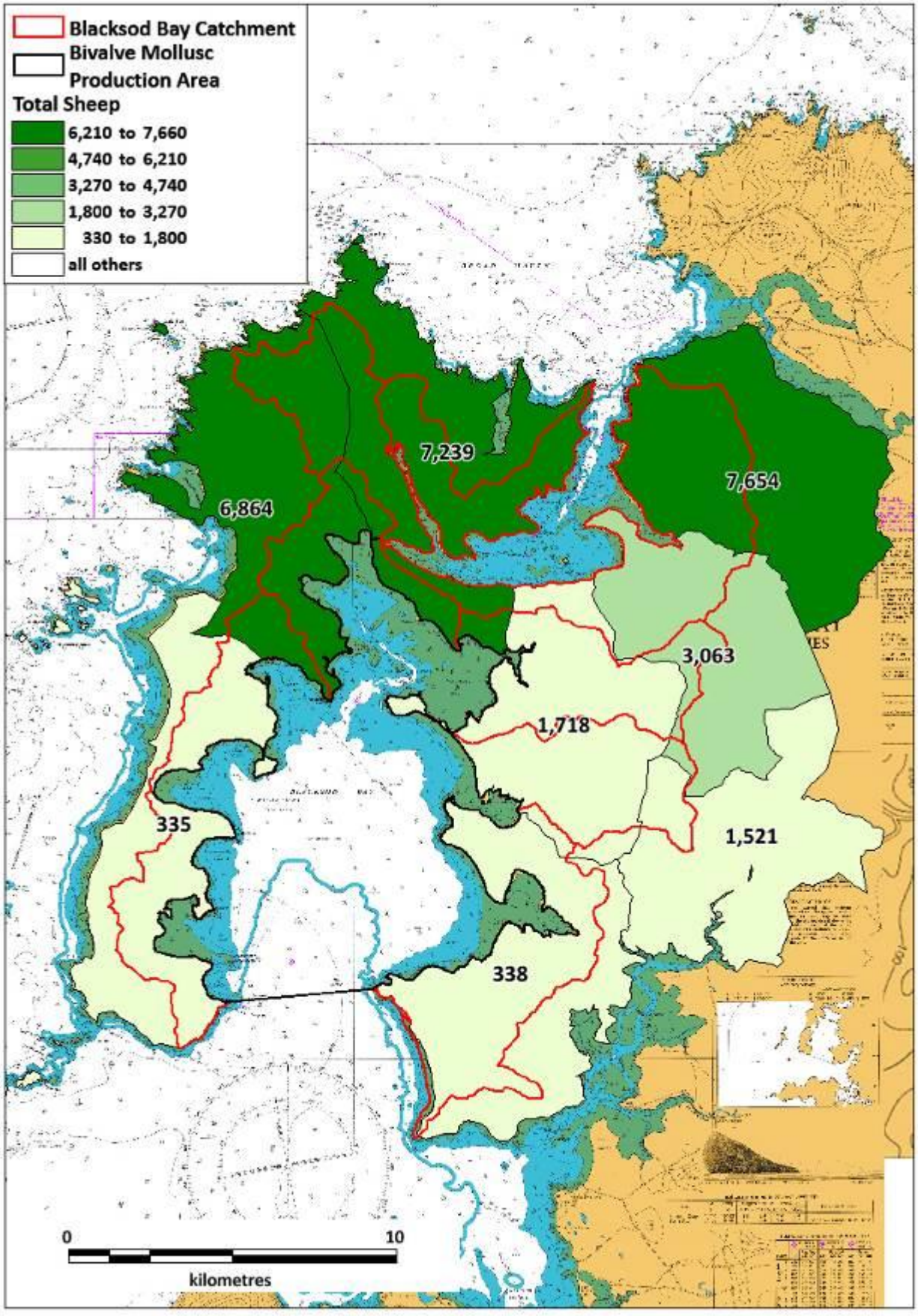


Figure 6.15: Sheep within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

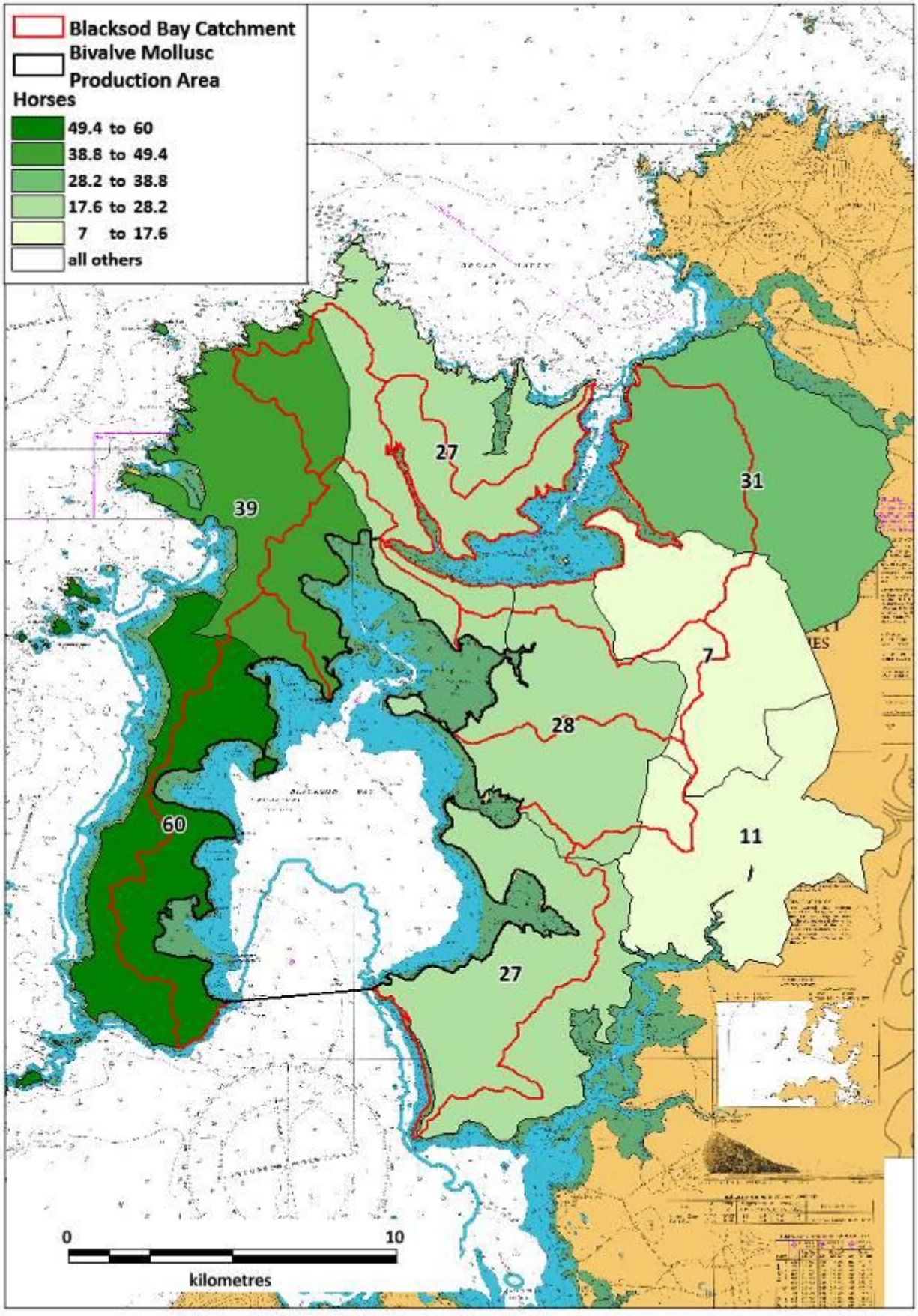


Figure 6.16: Horses within the Blacksod Bay Catchment Area (Source: CSO, 2019b).

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 6.9 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 6.9: 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 largest majority of livestock in the area are sheep (28,732). Cattle are also present but in lower numbers (10,759). The majority of agricultural land use in the area is total grass and rough grazing. Sheep are present in relatively large numbers throughout with the highest numbers in the northern half of the catchment while the highest numbers of cattle are present in the south and western areas. Sheep numbers would be expected to increase in spring following the birth of lambs and decrease in the autumn as they are sent to market. Therefore, larger quantities of livestock droppings will be deposited during this period, though it may not impact the fishery until washed into the sea during and/or after periods of rainfall unless deposited directly on the shoreline.

6.1.6. Other Pollution Sources

6.1.6.1. Shipping

Operational waste from vessels, if not properly managed, can end up in the sea where the potential for contamination or pollution occurs. Wastes generated or landed in ports and harbours can be broadly divided into a) operational and domestic waste from ships and boats, b) waste from commercial cargo activities and c) wastes generated from maintenance activities and associated maritime industry activities.

Marpol Annex IV defines sewage as “drainage from medical premises, toilets, urinals, spaces containing live animals and other waste waters when mixed with sewage waste streams”. Although adopted in 1973, the Annex did not come into effect until September 2003, with subsequent amendments entered into force in

August 2005. Annex IV requires ships to be equipped with either a sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank. Within 3 miles of shore, Annex IV requires that sewage discharges be treated by a certified Marine Sanitation Device (MSD) prior to discharge into the ocean. Sewage discharges made between 3 and 12 miles of shore must be treated by no less than maceration and chlorination and sewage discharged greater than 12 miles from shore are unrestricted. Annex IV also established certain sewage reception facility standards and responsibilities for ports and contracting parties.

Ship sewage originates from water-borne human waste, wastewaters generated in preparing food, washing dishes, laundries, showers, toilets and medical facilities. However, as waste enters the marine environment from many sources, it makes the identification of specific impacts from ship/boat waste very difficult. It is widely recognised that the majority of pollution entering the marine environment comes from land based sources and atmospheric inputs from land based industrial activities, with only an estimated 12% originating from shipping activities (GESAMP [Joint Group of Experts on the Scientific Aspects of Marine environmental Pollution], 1990).

Figure 6.17 shows all boat facilities and activities in Blacksod Bay. Table 3.9 details these facilities. There are no commercial ports in Blacksod Bay. There are no ferries operating in Blacksod Bay. There are several piers and slipways located along the shorelines of Blacksod Bay. The pier at Blacksod Point is frequently used by the fishing fleet in this area with smaller vessels landing their catches here. Approximately 20 to 30 fishing boats would use the pier and adjoining moorings here but the majority of these vessels would be less than 15 metres in length. To a lesser degree the pier at Curraghboy is also used by the fishing industry.

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.

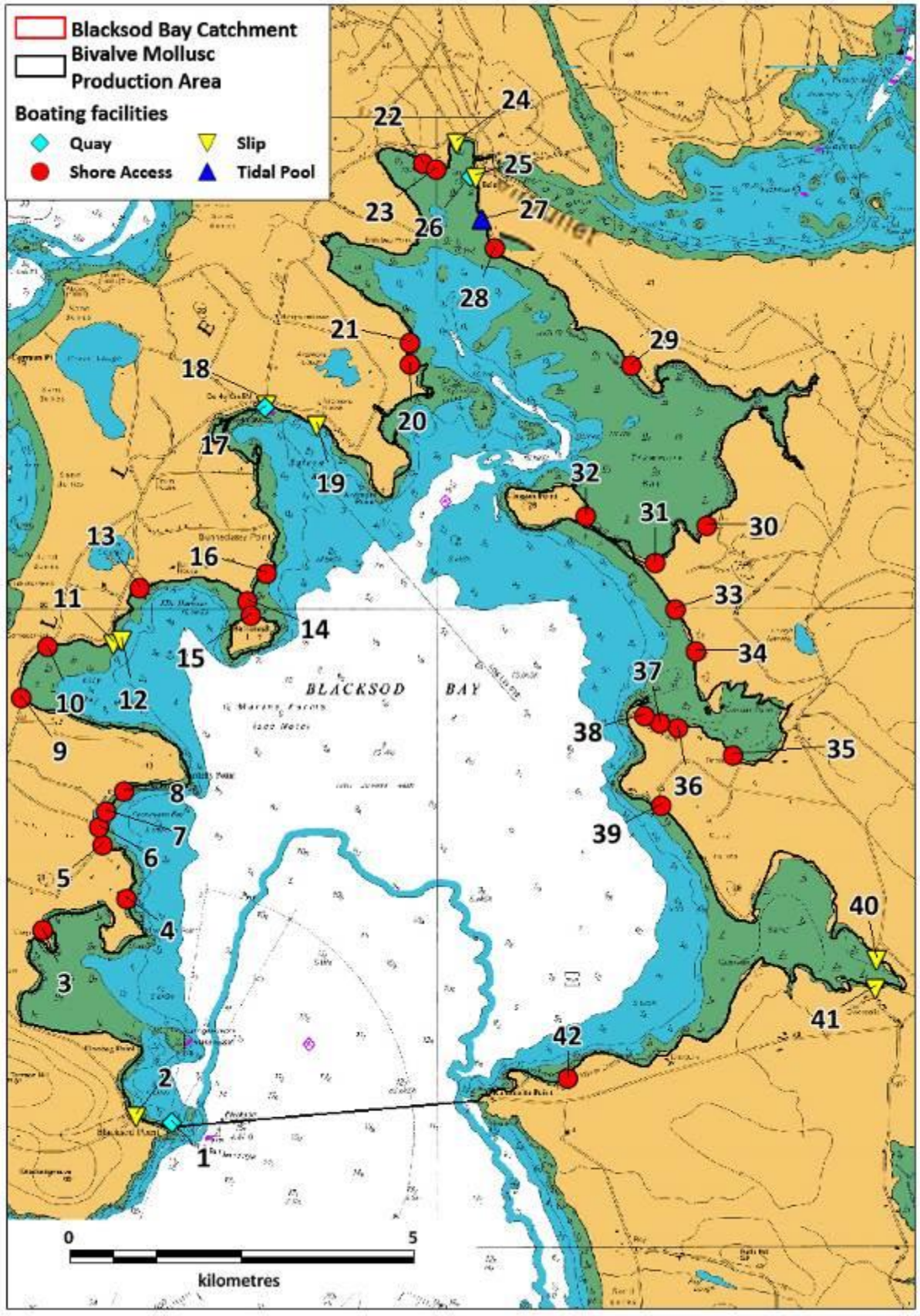


Figure 6.17: Location of all boating facilities and activities in Blacksod Bay.

Table 6.10: Boating facilities in the Blacksod Bay. Map Code refers to Figure 5.17.

Map Code	Feature	Use (if known)
1	Quay	Blacksod Pier
2	Slip	
3	Shore Access	
4	Shore Access	
5	Shore Access	
6	Shore Access	
7	Shore Access	
8	Shore Access	
9	Shore Access	
10	Shore Access	
11	Slip	Uisce Gaeltacht
12	Slip	Uisce Gaeltacht
13	Shore Access	
14	Shore Access	Access to Barranagh Island
15	Shore Access	Access to Barranagh Island
16	Shore Access	
17	Quay	
18	Slip	
19	Slip	
20	Shore Access	
21	Shore Access	
22	Shore Access	Private Access
23	Shore Access	Private Access
24	Slip	
25	Slip	
26	Quay	
27	Tidal Pool	Public tidal swimming pool
28	Shore Access	
29	Shore Access	
30	Shore Access	
31	Shore Access	Access to Cleggan Point
32	Shore Access	Access to Cleggan Point
33	Shore Access	
34	Shore Access	
35	Shore Access	
36	Shore Access	
37	Shore Access	Private access
38	Shore Access	
39	Shore Access	
40	Slip	
41	Slip	
42	Shore Access	

6.1.6.2. Wildlife

Birds

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

Blacksod Bay/Broad Haven Bay SPA (Site Code: IE004037) and Mullet Peninsula SPA (Site Code: IE004227) are located within the catchment of Blacksod Bay BMPA. There are a number of other SPAs nearby including Duvillaun Islands SPA (Site Code: IE004111), Termoncarragh Lake and Annagh Machair SPA (Site Code: IE004093), Inishglora and Inishkeeragh SPA (Site Code: IE004084) and Inishkea Islands SPA (Site Code: IE004004). All SPAs in the area can be seen in Figure 2.3.

Blacksod Bay/Broad Haven Bay SPA Situated in the extreme north-west of Co. Mayo, this site comprises a number of bays and inlets including Sruwaddacon Bay, Moyrahan Bay, Traw-Kirtaun, Blind Harbour, Tullaghan Bay, and the various sheltered bays and inlets in Blacksod Bay, including Trawmore Bay, Feorinyeeo Bay, Saleen Harbour, Elly Bay and Elly Harbour. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Great Northern Diver (67), Light-bellied Brent Goose (279), Common Scoter (510), Red-breasted Merganser (83), Ringed Plover (590), Sanderling (171), breeding Dunlin (subsp. *schinzii*), Dunlin (1,255), Bar-tailed Godwit (664), Curlew (567) and Sandwich Tern (81 pairs in 1995). Slavonian Grebes are known to occur in Blacksod Bay in Winter months. The E.U. Birds Directive pays particular attention to wetlands and, as these form part of this SPA, the site and its associated waterbirds are of special conservation interest for Wetland & Waterbirds. A number of wader species breed within the areas of machair in the SPA, including a nationally important population of Dunlin (subsp. *schinzii*) – 24 pairs (NPWS, 2013).

Mullet Peninsula SPA comprises three separate areas situated on the Mullet peninsula in Co. Mayo. The site is selected as a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Corncrake (NPWS, 2014).

Duvillaun Islands SPA comprises a group of marine islands, rocks and reefs, located between 1 and 5 km off the southern tip of the Mullet Peninsula in Co. Mayo. The site is a Special Protection Area (SPA) under the

E.U. Birds Directive, of special conservation interest for the following species: Fulmar, Storm Petrel and Barnacle Goose (NPWS, 2014).

Termoncarragh Lake is a shallow, coastal lake situated on the north-west side of the Mullet peninsula, Co. Mayo. The site was designated as a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Barnacle Goose, Whooper Swan, Greenland White-fronted Goose, Corncrake, Chough, Lapwing and Dunlin (NPWS, 2015).

The Inishglora and Inishkeeragh SPA comprises the two islands, Inishglora and Inishkeeragh, as well as a number of smaller islets and rocks situated c. 1.5-3 km west of the Mullet Peninsula, Co. Mayo. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Storm Petrel, Cormorant, Shag, Barnacle Goose, Lesser Black-backed Gull, Herring Gull and Arctic Tern (NPWS, 2014).

Inishkea Islands SPA are the two largest islands off the west coast of the Mullet Peninsula in north-west County Mayo. As well as Inishkea North and Inishkea South, this site includes Carrickawilt, Carrigee, Carrickmoylenacurhoga, Pluddany Rocks, Carrickfad, Carrickgormal, Carricklaur, Carrickalaveen and several smaller rocks and reefs. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Barnacle Goose, Shag, Ringed Plover, Sanderling, Purple Sandpiper, Dunlin, Turnstone, Common Gull, Herring Gull, Arctic Tern and Little Tern (NPWS, 2015).

Blacksod 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 6.11.

Table 6.11: Total number of waterbirds in Blacksod and Tullaghan Bays between 20011/12 and 2015/16 seasons (Source: BWI, 2019).

Site Name	2011/12	2012/13	2013/14	2014/15	2015/16	Mean
Blacksod and Tullaghan Bays	10336	11356	13983	9525	7952	10630

Population levels of birds over the five years are fairly stable, with a low in the 2015/2016 season and a high in the following year 2013/2014. 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.

Aquatic mammals

There are a number of Haul-out sites for both Common (*Phoca vitulina)* and Grey seals (*Haliochoerus grypus*) within Blacksod Bay (See Figure 6.18 and Figure 6.19). Other aquatic mammals that may occur in Blacksod Bay include Otter (*Lutra lutra),* Bottlenosed Dolphin (*Tursiops truncatus)* and Harbour Porpoise (*Phocoena phocoena*).

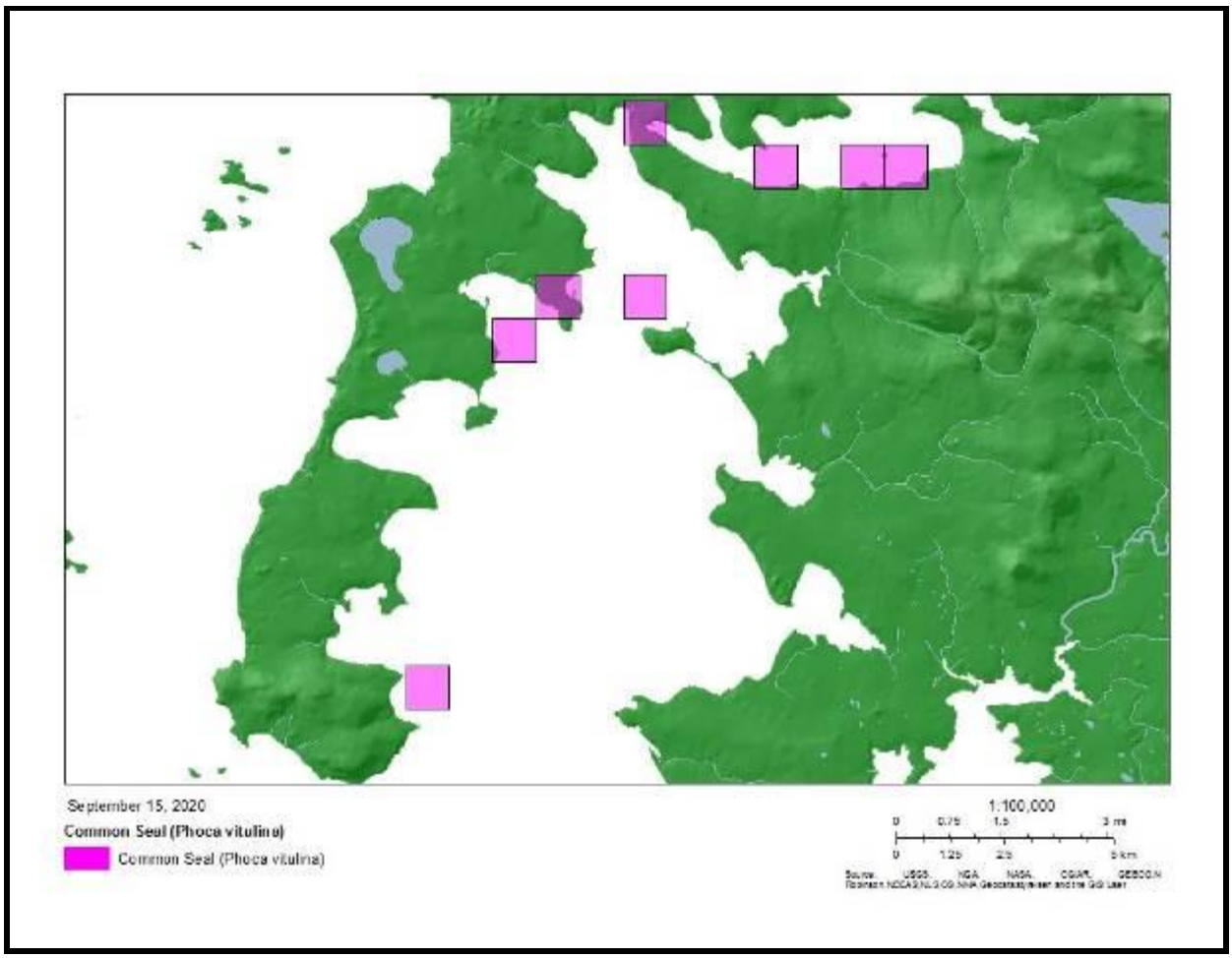


Figure 6.18: Common Seal locations in Blacksod Bay (Biodiversity Ireland).

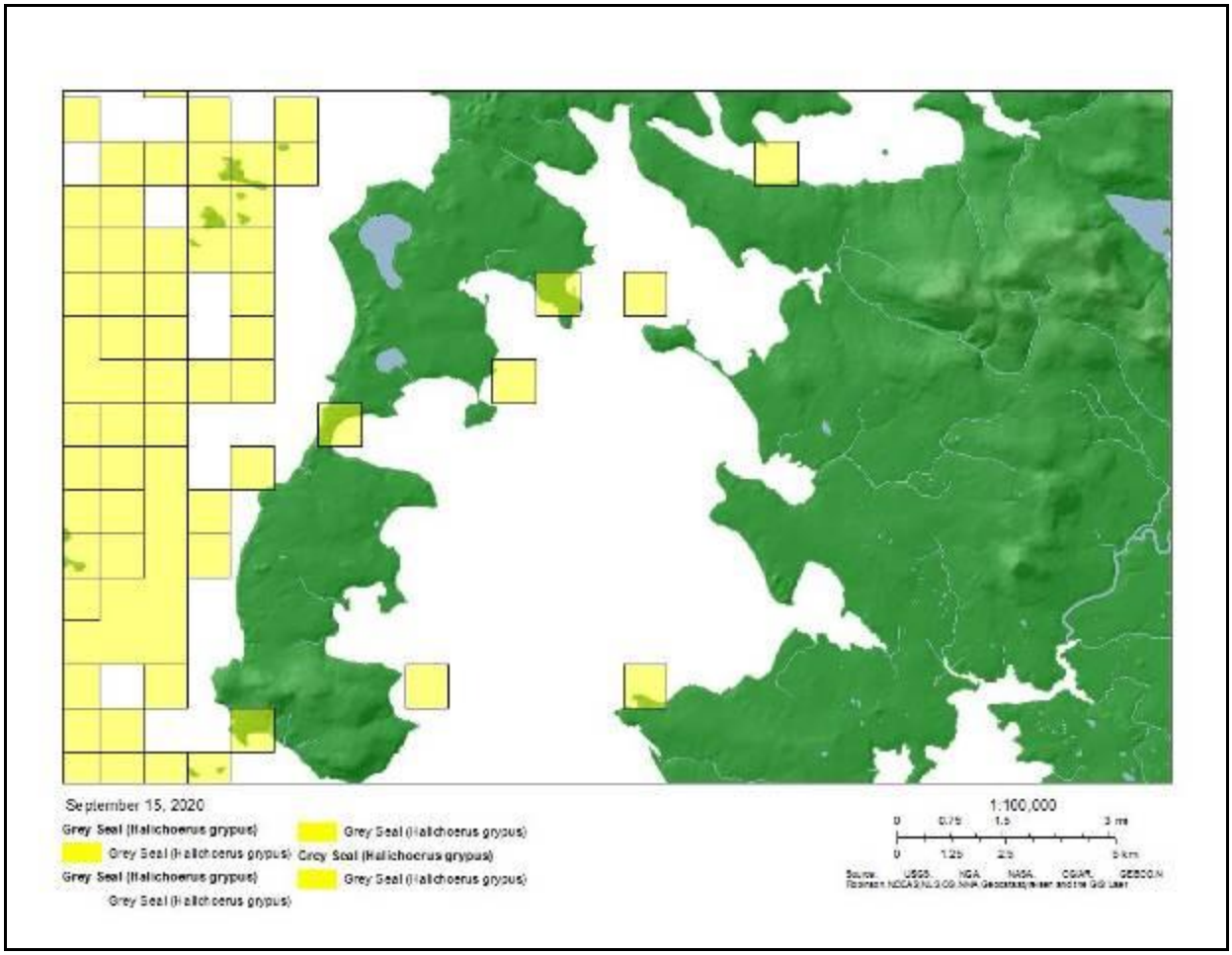


Figure 6.19: Grey Seal Locations in the Blacksod Bay area (Biodiversity Ireland).

No estimates of the volumes of seal faeces are available although it is reasonable to assume that what is ingested and not assimilated in the gut must pass. Assuming 6% of a median body weight for grey seals of 185kg, that would equate to 11.1kg consumed per day and probably very nearly that defecated. The concentration of *E. coli* and other faecal indicator bacteria contained in seal faeces has been reported as being similar to that found in raw sewage, with counts showing up to 1.21 x 104 CFU *E. coli* per gram dry weight of faeces (Lisle *et al.,* 2004). *Salmonella* and *Campylobacter* spp. have also been found in wild seals (Stoddard *et al.,* 2005).

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

6.2. Shoreline Survey

6.2.1. Shoreline Survey Report

A shoreline survey was carried out by the Sea Fisheries Protection Authority. Figure 6.20 shows the GPS (Global Positioning System) and photography sites accounted for during the 7 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.

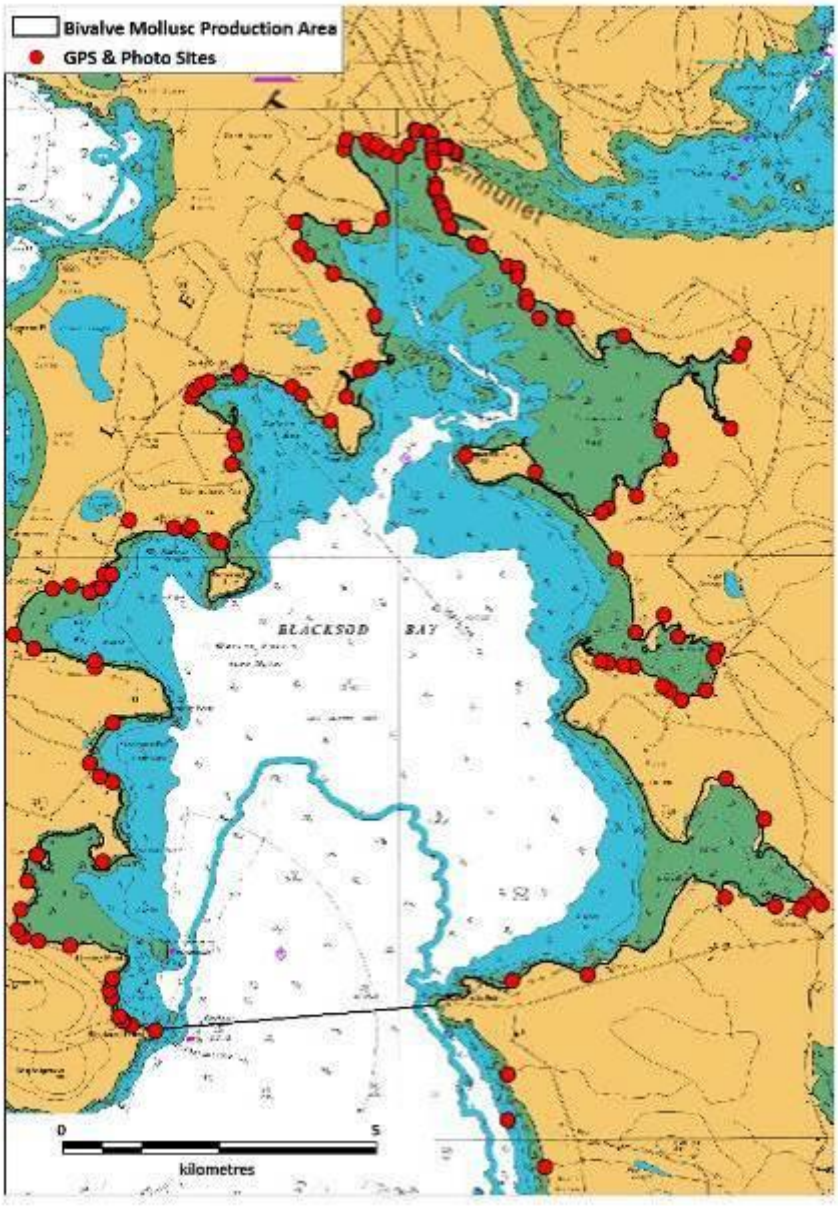


Figure 6.20: Locations of GPS and Photograph Sites.

Figure 6.20 shows the locations of all features observed during the shoreline survey. In total 145 features were identified, of which 24 rivers/streams were identified, 54 drains, 1 WWTP, 1 location with sewage infrastructure, 32 pipes, 5 piers, 8 slipways, 9 locations with cattle, 3 culverts, 1 sluice, 1 sea channel, 1 pool and a seaweed farm. Figure 6.21 to Figure 6.55 show aerial imagery of the location of the features and Appendix 6 shows images of most of these features. Table 6.12 details all features identified and the numbering used is cross-referenced to Figure 6.21 to Figure 6.55.

Table 6.12: Features identified during the shoreline survey. Refer to Figures 5.19 – 5.52 for locations and Appendix 6 for photographs.

Map ID	Observation	Comments	Latitude	Longitude	Easting	Northing
1	Pier	Blacksod Pier, 20 boats.	54.09933	-10.06005	65286.0	318649.4
2	Pipe	Blue road pipe, drainage. No flow.	54.09999	-10.06590	64905.5	318734.0
3	Stream/drain	Good flow, enrichment. Brown algae.	54.10069	-10.06798	64771.8	318815.8
4	Slipway	Slipway, boats on moorings in bay. Approx 8 boats.	54.10073	-10.06803	64768.6	318820.4
5	Stream	Stream, brown algae evident.	54.10122	-10.06901	64706.1	318876.8
6	Stone drain	Old culvert, no flow.	54.10401	-10.07081	64597.5	319190.7
7	Drain	Field drain	54.10506	-10.07127	64570.8	319308.5
8	Drain	Field drain	54.10634	-10.07081	64605.1	319450.0
9	Drain	Field drain	54.10674	-10.07043	64631.2	319493.8
10	Drain	Field drain	54.11138	-10.08079	63968.9	320030.1
11	Piped drain	Enrichment obvious	54.11210	-10.08862	63459.3	320125.3
12	Piped drain	Good flow	54.11275	-10.09223	63225.4	320204.6
13	Cattle	Beef cattle, 20 +.	54.11365	-10.09371	63131.5	320307.7
14	Stream	Steady flow.	54.11659	-10.09285	63197.5	320633.2
15	Drain	Field drain, flowing. Enrichment evident.	54.12073	-10.09130	63312.4	321090.9
16	Saltmarsh stream/drain	Flowing.	54.12437	-10.08895	63478.0	321491.5
17	Natural drain	Saltmarsh drainage channel.	54.12354	-10.07278	64532.4	321368.0
18	Concrete pipe	Likely agricultural field drainage pipe	54.13482	-10.07041	64724.1	322618.8
19	Grey pipe	Likely agricultural field drainage pipe	54.13569	-10.07359	64519.1	322721.7
20	Concrete sluice	Good flow, draining small lake behind dunes. No smell or signs of pollution.	54.13755	-10.07603	64365.7	322933.4
21	Drain	Stone drain with natural drain flowing alongside.	54.14324	-10.07052	64744.3	323556.1
22	Drain	Low flow, enrichment evident.	54.15122	-10.07468	64498.6	324452.1
23	Boats	Boats berths by 4. Two boats.	54.15215	-10.07464	64504.2	324555.5
24	Drain	Field drain. Enrichment evident, steady flow.	54.15384	-10.08959	63533.2	324772.4

Map ID	Observation	Comments	Latitude	Longitude	Easting	Northing
25	Cows	45+ beef cattle on adjoining land.	54.15602	-10.09439	63226.8	325024.3
26	Drain	Stone drain in wall, flowing from under road. Drainage.	54.16248	-10.08507	63856.8	325725.2
27	Drain	Old stone drain from under road. Enrichment evident.	54.16303	-10.08054	64154.5	325777.7
28	Pipe	Large concrete pipe. Flowing, some enrichment. Likely drainage.	54.16203	-10.07607	64443.1	325657.8
29	Pipes	Two grey pipes, no flow. Located to the rear of two houses.	54.16247	-10.07454	64544.5	325703.9
30	Pipes	Number of drainage pipes linked to adventure college. Mostly non-flowing.	54.16272	-10.07308	64640.7	325728.9
31	Stone pipe	Sluice, stone structure with flap. Flowing. Some enrichment but no smell.	54.16458	-10.07258	64679.4	325934.9
32	Slipway	Slipway associated with adventure college	54.16458	-10.07082	64794.3	325931.6
33	Lagoon discharge	Lagoon discharge	54.17238	-10.06646	65104.5	326791.3
34	Drain	Field drain from agricultural land. Flowing.	54.17119	-10.05548	65817.5	326637.9
35	Pipe	Pipe drain	54.17099	-10.05211	66036.9	326609.3
36	Cattle	10 to 15 beef cattle	54.17132	-10.05116	66100.0	326644.2
37	Drain	Field drain. Some enrichment, stone surround.	54.16951	-10.04540	66470.3	326431.9
38	Drain	Piped field drain.	54.16907	-10.04419	66547.9	326380.6
39	Saltmarsh stream/drain	Drain	54.18028	-10.04129	66773.3	327622.7
40	Drain	Field drain	54.18304	-10.04034	66844.2	327928.1
41	Drain	Field drain	54.18433	-10.04074	66822.3	328072.4
42	Drain	Field drain	54.18992	-10.05114	66161.5	328714.2
43	Drain	Field drain	54.19090	-10.05051	66205.8	328822.0
44	Drain	Field drain	54.19168	-10.04882	66318.6	328905.6
45	Drain	Field drain	54.19215	-10.04688	66446.7	328954.3
46	Pier	6 boats	54.19313	-10.03957	66926.9	329049.6
47	Pier	Curraghboy Pier, four boats.	54.19355	-10.03917	66954.4	329095.6
48	Drain	Field drain	54.19129	-10.02673	67759.0	328820.6
49	Drain	Field drain	54.19022	-10.02444	67905.0	328697.3

Map ID	Observation	Comments	Latitude	Longitude	Easting	Northing
50	Stone drain	Drain	54.18656	-10.01730	68359.4	328276.6
51	Saltmarsh stream/drain	Drain	54.19000	-10.01343	68622.9	328652.2
52	Drain	Field drain.	54.19361	-10.00986	68867.4	329047.4
53	Drain	Drain through area of saltmarsh	54.19418	-10.00785	69000.3	329107.1
54	Drain	Field drain.	54.20168	-10.00658	69106.9	329939.4
55	Drain	Field drain.	54.20757	-10.01669	68466.0	330613.7
56	Drain	Field drain.	54.21025	-10.02265	68085.7	330923.1
57	Drain	Field drain.	54.21127	-10.02463	67959.8	331040.3
58	Stream	Low flow.	54.21486	-10.02597	67883.9	331442.4
59	Drain	Field drain.	54.21418	-10.01381	68674.9	331344.0
60	Drain	Field drain.	54.21537	-10.00462	69278.1	331459.4
61	Stream/drain	Some green algae evident.	54.22536	-10.01374	68714.9	332588.1
62	Culvert	Steady flow, sewage odour. Enrichment evident. Grey colouration of water.	54.22670	-10.01336	68744.0	332736.5
63	Slipway	No boats in place or being used at time.	54.22655	-10.00820	69080.0	332710.3
64	Pipe	Trickle flow, drainage pipe. No odour or colouration.	54.22567	-10.00752	69121.5	332611.1
65	Stream	Steady flow, some green algae evident.	54.22593	-10.00579	69235.2	332636.8
66	Slipway	No boats in place or being used at time. Private slipway.	54.22497	-10.00366	69371.0	332526.0
67	Slipway	No boats in place or being used at time. Private slipway.	54.22441	-10.00084	69553.2	332458.5
68	Drain	Field drain.	54.22577	-9.99808	69737.4	332604.7
69	Culvert	Steady flow, sewage odour. Enrichment evident. Grey colouration of water.	54.22810	-9.99642	69853.0	332861.0
70	Slipway	No boats in place or being used at time.	54.22806	-9.99635	69857.5	332856.4
71	Pipe	Orange small bore pipe coming of adjacent road. Surface water drain.	54.22790	-9.99335	70052.6	332833.1
72	Culvert	Steady flow. Adjacent wwtp pump station.	54.22751	-9.99246	70109.4	332788.0
73	Pipe	Two orange pipes, no flow. Possibly drainage from footpaths.	54.22590	-9.99231	70114.1	332608.6

Map ID	Observation	Comments	Latitude	Longitude	Easting	Northing
74	Sea channel	Sea channel, flowing from Broadhaven to Blacksod	54.22559	-9.99021	70250.1	332570.2
75	Pipe	Orange drainage pipe, no flow evident	54.22566	-9.98984	70274.4	332577.3
76	Pipe	Two concrete pipes, closed with flaps. Possibly storm water.	54.22575	-9.98880	70342.5	332585.4
77	Pier	Pier, 8 to 10 boats. Small half decker style boats.	54.22479	-9.98642	70494.7	332474.2
78	Pipe	Trickle flow, some enrichment. Likely drainage pipe.	54.22504	-9.98688	70465.5	332502.9
79	Pipe	Three pipes, flow from large bore concrete pipe. Green algal enrichment	54.22553	-9.98879	70342.5	332560.9
80	Pipe	Small bore white pipe, possibly septic tank related	54.22550	-9.98933	70307.2	332558.6
81	Pipe	Small flow, some grey colour	54.22515	-9.99256	70095.4	332525.6
82	Pipe	Orange medium bore pipe. No odour. Some enrichment, some grey colour.	54.22415	-9.99231	70108.6	332413.8
83	Pier	Old pier, no boats. Dries at low water.	54.22346	-9.99207	70122.1	332336.6
84	Pipe	Some enrichment, likely drainage.	54.22030	-9.99159	70143.5	331984.0
85	Pipe	Large bore stone pipe, small flow.	54.21979	-9.99158	70142.5	331927.2
86	Drains	Old stone drains, x 8. Water drainage.	54.21946	-9.99172	70132.4	331890.8
87	Pipe	Modern drainage pipe	54.21789	-9.99056	70203.1	331713.9
88	Pool	Outdoor swimming pool	54.21737	-9.98999	70238.6	331655.0
89	Pipe	Plastic pipe. Enrichment. Likely drainage. No colour or odour.	54.21671	-9.98966	70258.1	331580.9
90	Pipe	Plastic pipe. Enrichment. Likely drainage. No colour or odour.	54.21580	-9.98920	70285.2	331478.8
91	Drain	Constant flow. Likely water drainage.	54.21431	-9.98799	70359.5	331310.7
92	Slipway	Slipway, no boats evident.	54.21409	-9.98781	70370.5	331285.9
93	Pipe	Heavy black pipe. Steady flow. Enrichment. Unsure of origin.	54.21189	-9.98217	70731.6	331030.7
94	Pipe	Old pipe structure with manhole. Drain also. Strong flow. Near school.	54.21176	-9.98184	70752.7	331015.7
95	Drain	Field drain, flowing. Enrichment.	54.21146	-9.98060	70832.6	330980.0
96	Stream	Good flow, enrichment evident.	54.20865	-9.97404	71251.8	330655.3
97	WWTP	Belmullet waste water treatment plant. Yellow marker buoy out to sea.	54.20831	-9.97161	71409.3	330613.0
98	Pipe	Black field drainage pipe, flowing.	54.20710	-9.97169	71400.3	330478.5

Map ID	Observation	Comments	Latitude	Longitude	Easting	Northing
99	Pipe	Black field drainage pipe, flowing.	54.20421	-9.96938	71542.1	330152.7
100	Cows	Beef cows, 25 +. On shore also.	54.20330	-9.96914	71554.9	330050.9
101	Pipe	Old stone pipe, draining fields. Flowing.	54.20114	-9.96636	71729.6	329805.5
102	Pipe	Black field drainage pipe, flowing.	54.20133	-9.96045	72115.8	329815.9
103	Drain	Drain, flowing	54.20106	-9.95966	72166.5	329784.4
104	Drain	Field drain, flowing.	54.19863	-9.94575	73066.7	329488.9
105	Stream	Stream, flowing through saltmarsh.	54.19727	-9.91645	74974.5	329285.2
106	River	Small river inflow. Good flow. Through agricultural grazing land.	54.19568	-9.91756	74897.3	329110.3
107	Stream	Stream, flowing through moor and rough pasture.	54.18526	-9.91986	74715.7	327954.7
108	Drain	Field drain, flowing.	54.18502	-9.93644	73632.7	327957.5
109	Stream	Flowing, enrichment evident.	54.18095	-9.93443	73751.5	327500.9
110	Drain	Field drain, flowing.	54.17565	-9.94259	73202.5	326925.7
111	Drain	Field drain, low flow.	54.17387	-9.94971	72732.2	326740.4
112	Drain	Field drain, low flow.	54.17338	-9.95131	72626.2	326688.8
113	Drain	Culvert drain of pasture land. No flow or smells.	54.17917	-9.96753	71585.1	327362.5
114	Cattle	Beef cows on pasture, 40 +	54.18153	-9.98452	70483.3	327656.2
115	Drain	Two field drains, both flowing	54.16659	-9.94782	72833.3	325926.8
116	Cows	Beef cattle, 25 +	54.15612	-9.94302	73114.7	324752.9
117	Stream	Large stream, flowing through saltmarsh	54.15863	-9.93606	73577.0	325019.8
118	Cows	Beef cattle, 25 +	54.15546	-9.93262	73792.0	324660.8
119	River	Good flow.	54.15356	-9.92305	74411.4	324432.3
120	Drain	Field drain, flowing.	54.15242	-9.92389	74353.1	324306.9
121	Stream	Good flow.	54.14774	-9.92611	74193.8	323790.0
122	Drain	Field drain, flowing.	54.14774	-9.92611	74193.8	323790.0
123	Pipe	Piped field drain. Strong flow.	54.14646	-9.93196	73807.8	323658.0

Map ID	Observation	Comments	Latitude	Longitude	Easting	Northing
124	Drain	Field drain, flowing.	54.14768	-9.93461	73638.3	323798.5
125	Drain	Field drain, flowing.	54.14843	-9.93631	73529.5	323885.0
126	Drain	Field drain, low flow.	54.15134	-9.94352	73067.4	324221.8
127	Drain	Field drain, good flow.	54.15144	-9.94600	72905.7	324237.4
128	Drain	Field drain, low flow.	54.15173	-9.94979	72659.0	324276.5
129	Slipway	Private slipway, no vessels evident.	54.15211	-9.95149	72549.1	324321.9
130	Cows	Beef cattle upon fields adjoining shore, 30 + in number	54.13512	-9.92114	74480.4	322376.7
131	Stream	Stream flowing through heath/blogland. Flowing, 0.5 metre width	54.12943	-9.91184	75071.1	321726.9
132	Stream	Outflow through area of saltmarsh	54.11827	-9.89955	75841.0	320463.3
133	Cows	Beef cattle, 5 + in number	54.11710	-9.89811	75931.6	320330.5
134	Drain	Flowing downstream of pumping station and small housing estate	54.11724	-9.90214	75668.6	320353.2
135	Sewage infrastructure	Gweesalia Pumping Station	54.11635	-9.90317	75598.6	320255.9
136	Drain	Drain/tiny stream. Flowing.	54.11681	-9.90930	75199.1	320317.9
137	Stream	Combined stream inflows. Strong flow of water.	54.11814	-9.92140	74412.0	320487.4
138	Stream	Stream, good flow. Signs of enrichment on surrounding shore.	54.10711	-9.95499	72181.9	319320.1
139	Seaweed farm	Series of buoys marking location	54.10642	-9.97328	70983.6	319276.5
140	Stream	Stream, good flow of water. Draining area of moor/bog.	54.09297	-9.97439	70869.3	317781.7
141	Drain	Piped drain, good flow. Draining rough grazing area.	54.08633	-9.97439	70848.6	317042.7
142	Stream	Good flow.	54.07969	-9.96530	71422.8	316287.2
143	Stream	Discharge from waste water treatment plant to stream/drain. Flowing, sewage odour.	54.116336	-9.902733	75,627.1	320,251.1
144	Pipes	two pipes which appear to be the storm water overflow associated with the pumping station on the shore road	54.227724	-9.992066	70,135.8	332,810.7
145	Drain	Drain with large flap and a strong flow.	54.192870	-10.038912	66,986	329,008

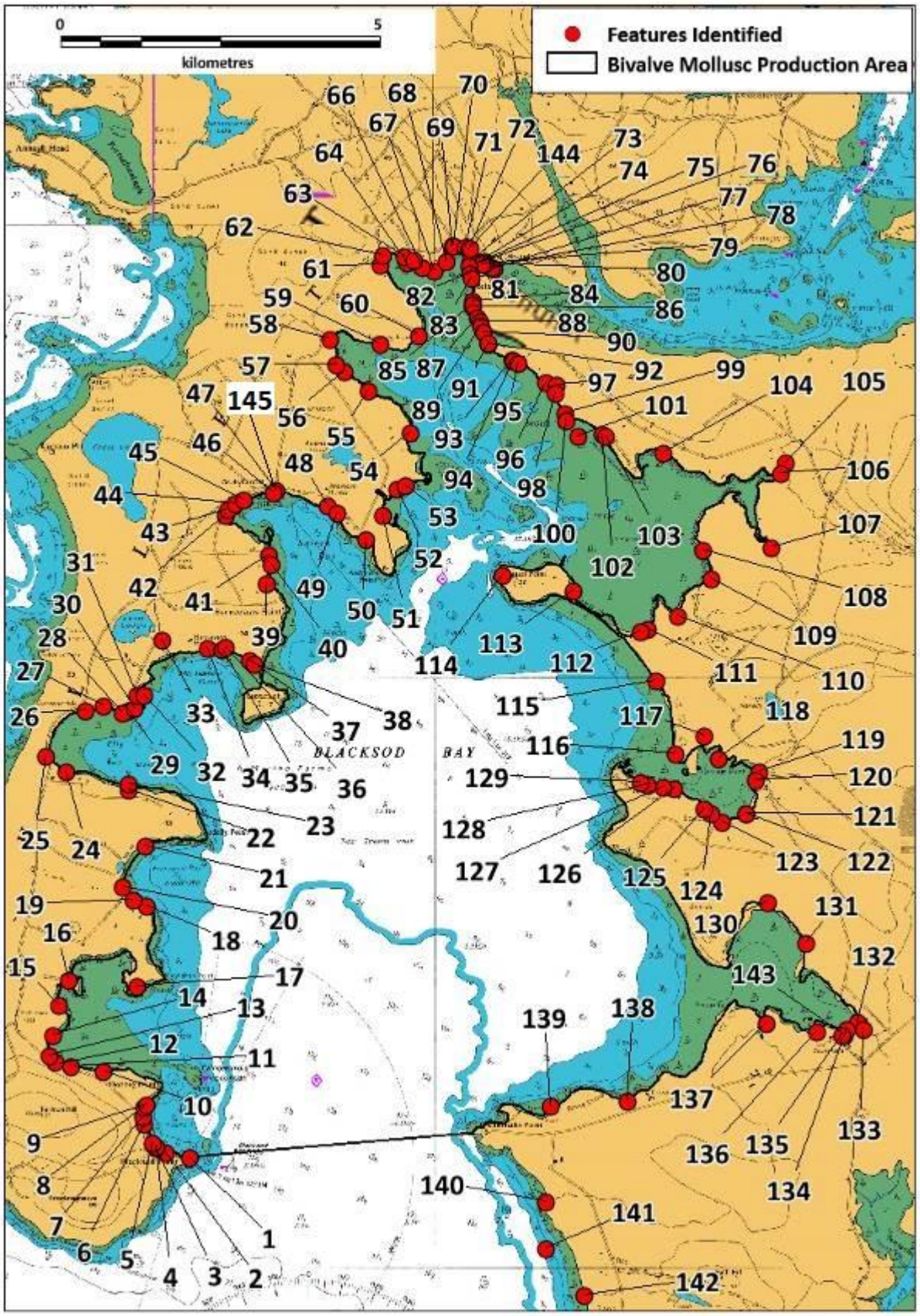


Figure 6.21: All features (numbering cross-reference to Table 6.12) identified during the shoreline survey.

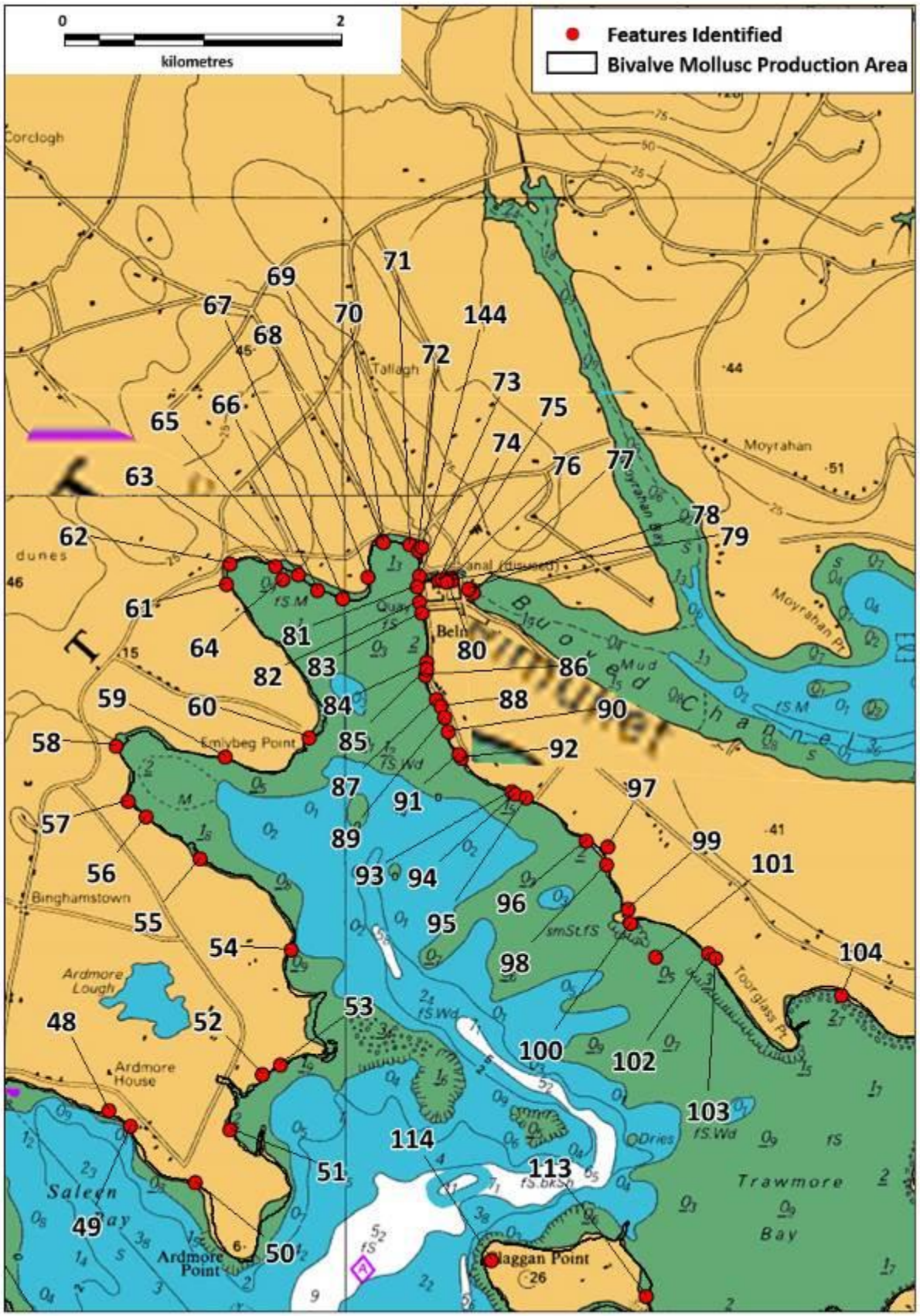


Figure 6.22: All features Belmullet Town (numbering cross-reference to Table 6.12) identified during the shoreline survey.

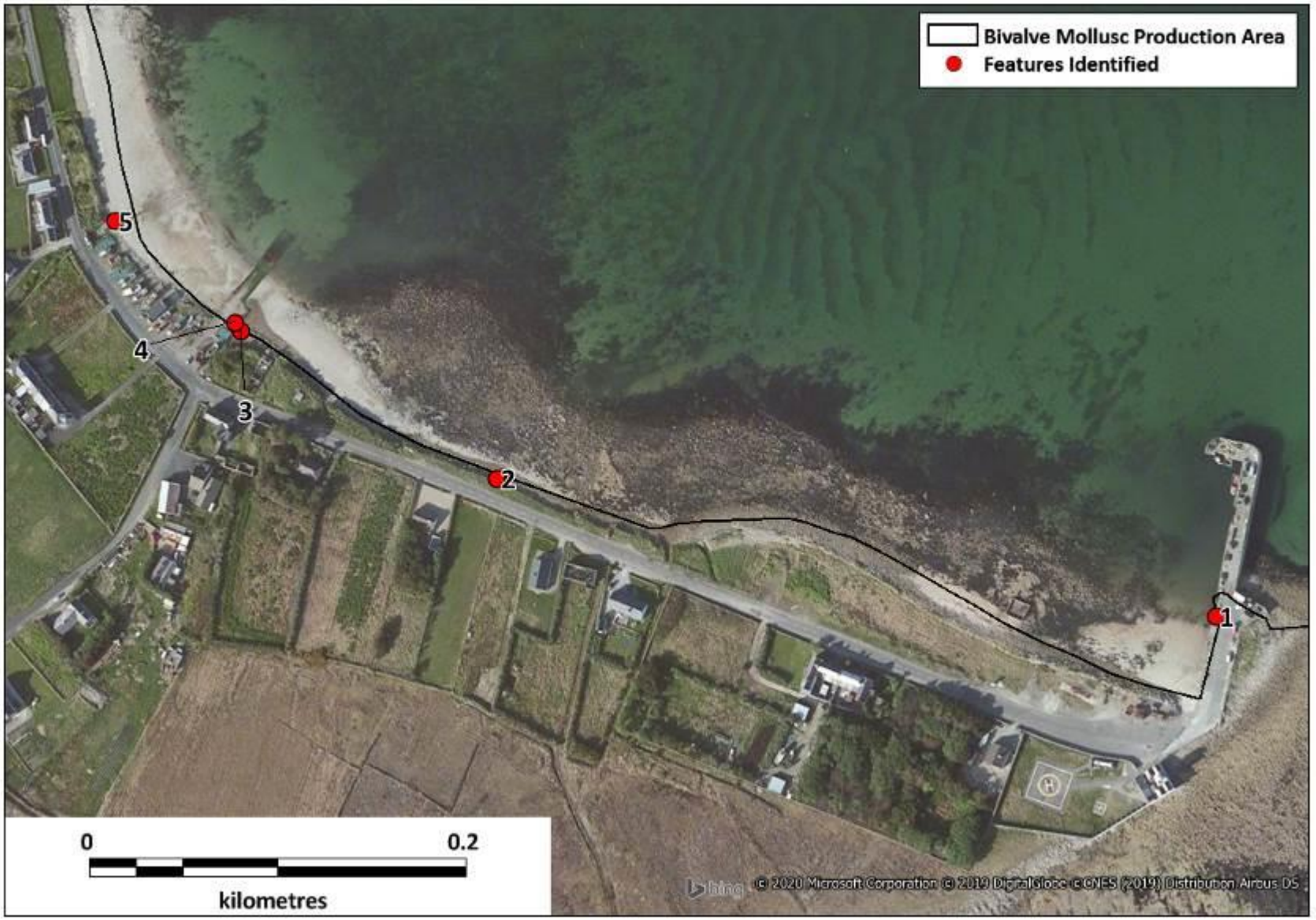


Figure 6.23: Features 1-5 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.24: Features 6-9 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.25: Features 10-13 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.26: Features 14-17 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.27: Features 18-21 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.28: Features 22-25 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.29: Features 26-32 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.30: Features 33-38 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.31: Features 39-41 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.32: Features 42-47 & 145 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.33: Features 48-41 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.34: Features 52-54 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.35: Features 55-60 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.36: Features 61-67 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.37: Features 68-73 & 144(numbering cross-reference to Table 6.12) identified during the shoreline survey.

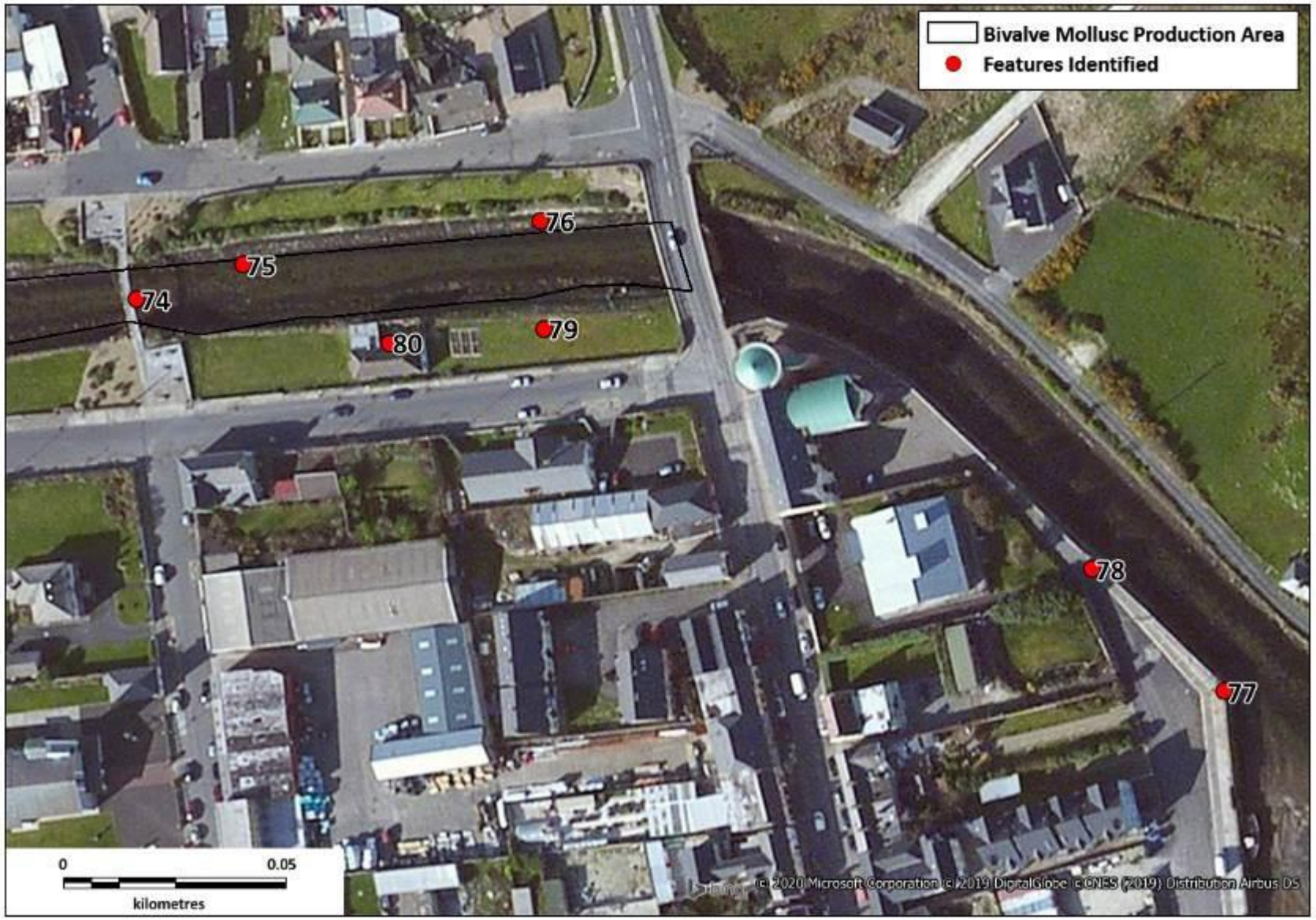


Figure 6.38: Features 74-80 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.39: Features 81-83 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.40: Features 84-86 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.41: Features 87-92 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.42: Features 93-95 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.43: Features 96-98 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.44: Features 99-103 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

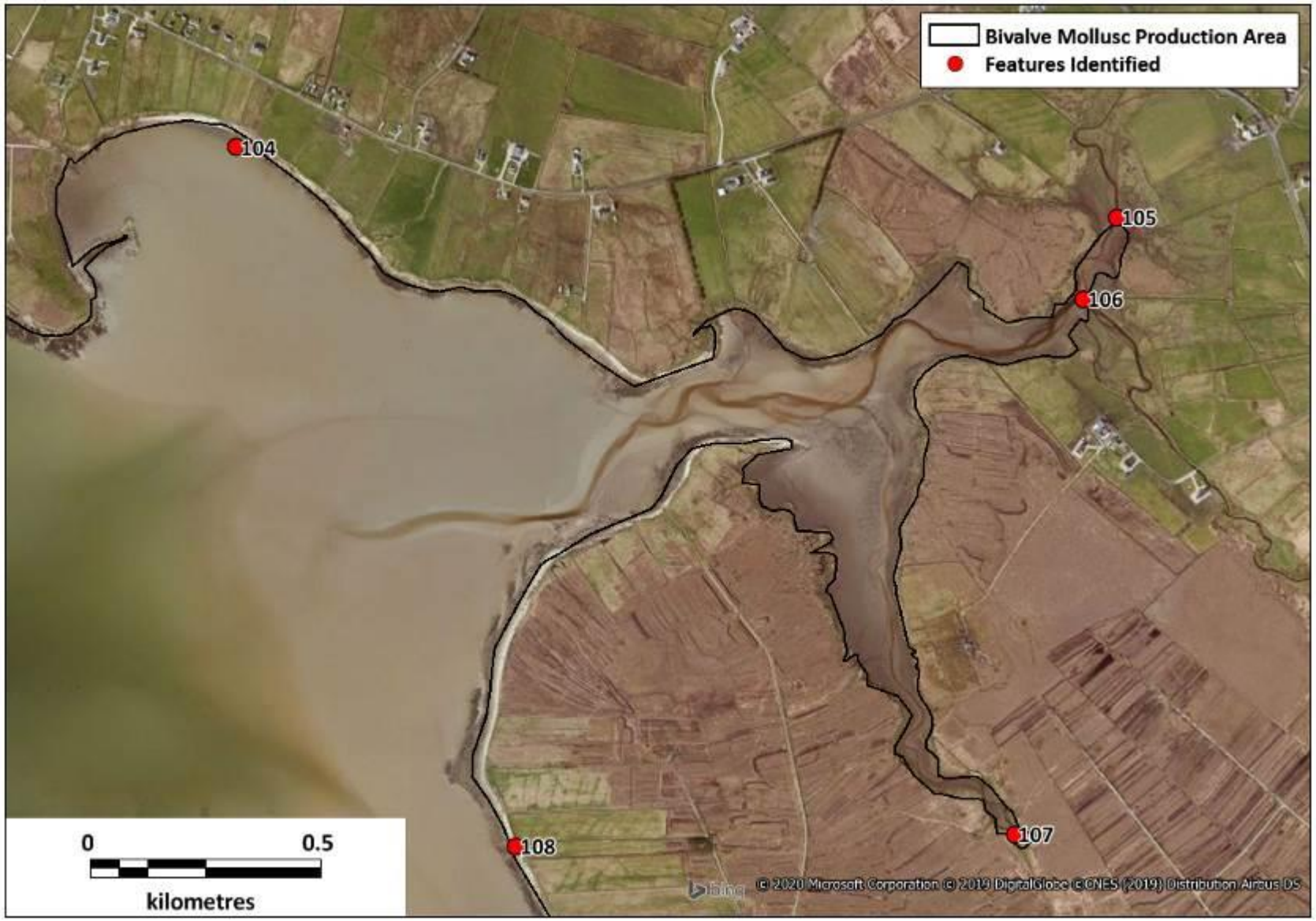


Figure 6.45: Features 104-108 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.46: Features 109-112 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.47: Features 113-114 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

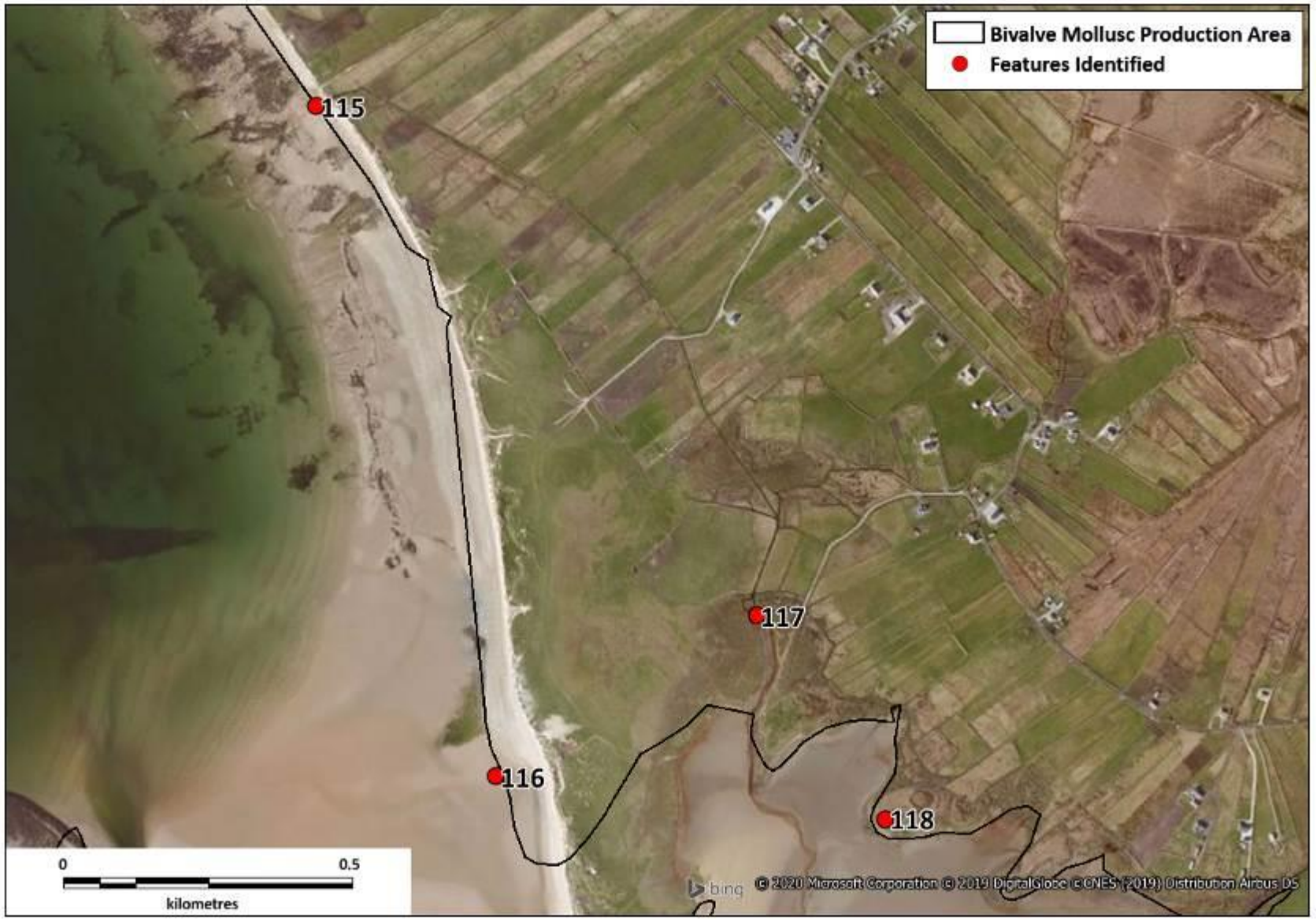


Figure 6.48: Features 115-118 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

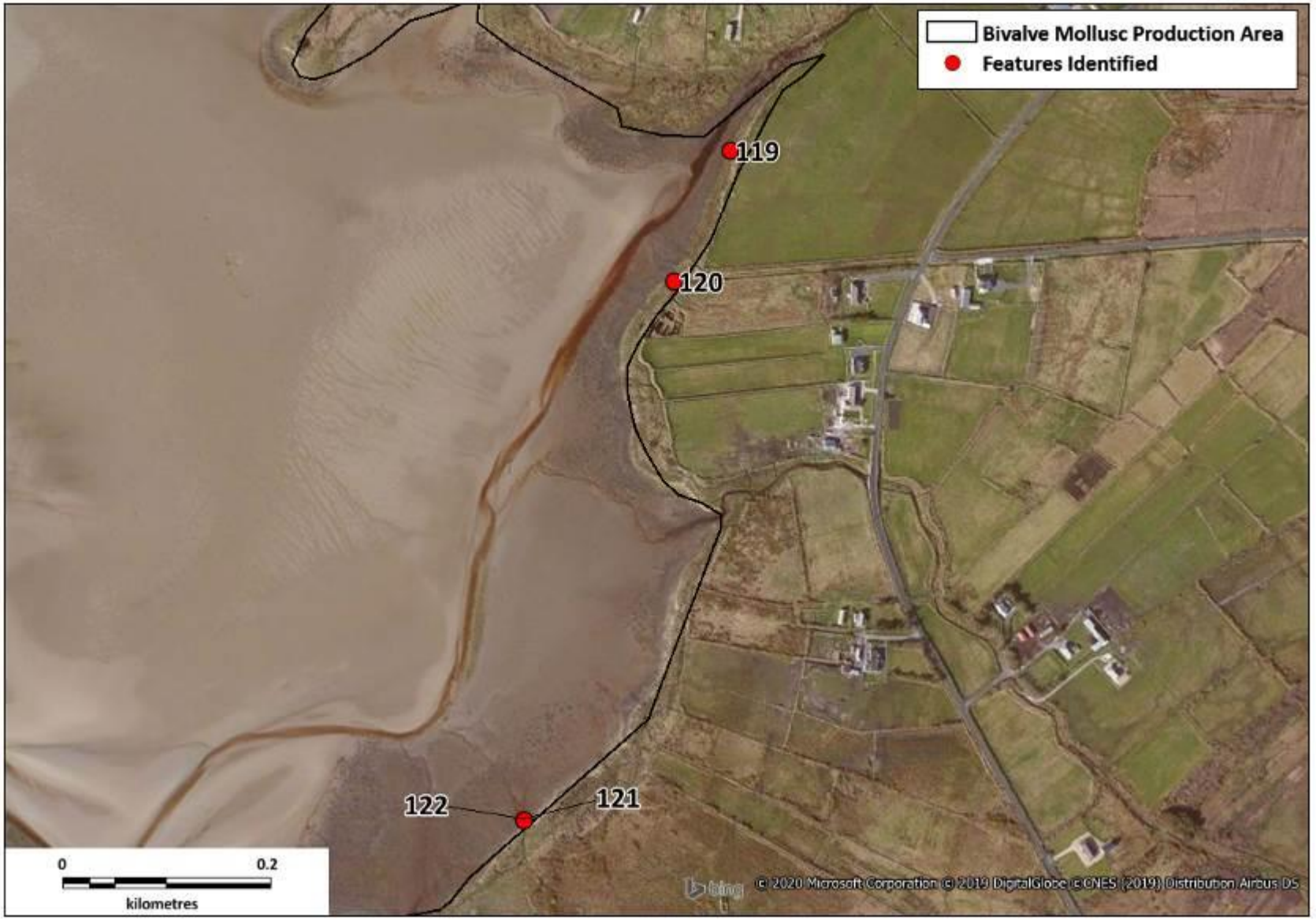


Figure 6.49: Features 119-122 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.50: Features 123-125 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.51: Features 126-129 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

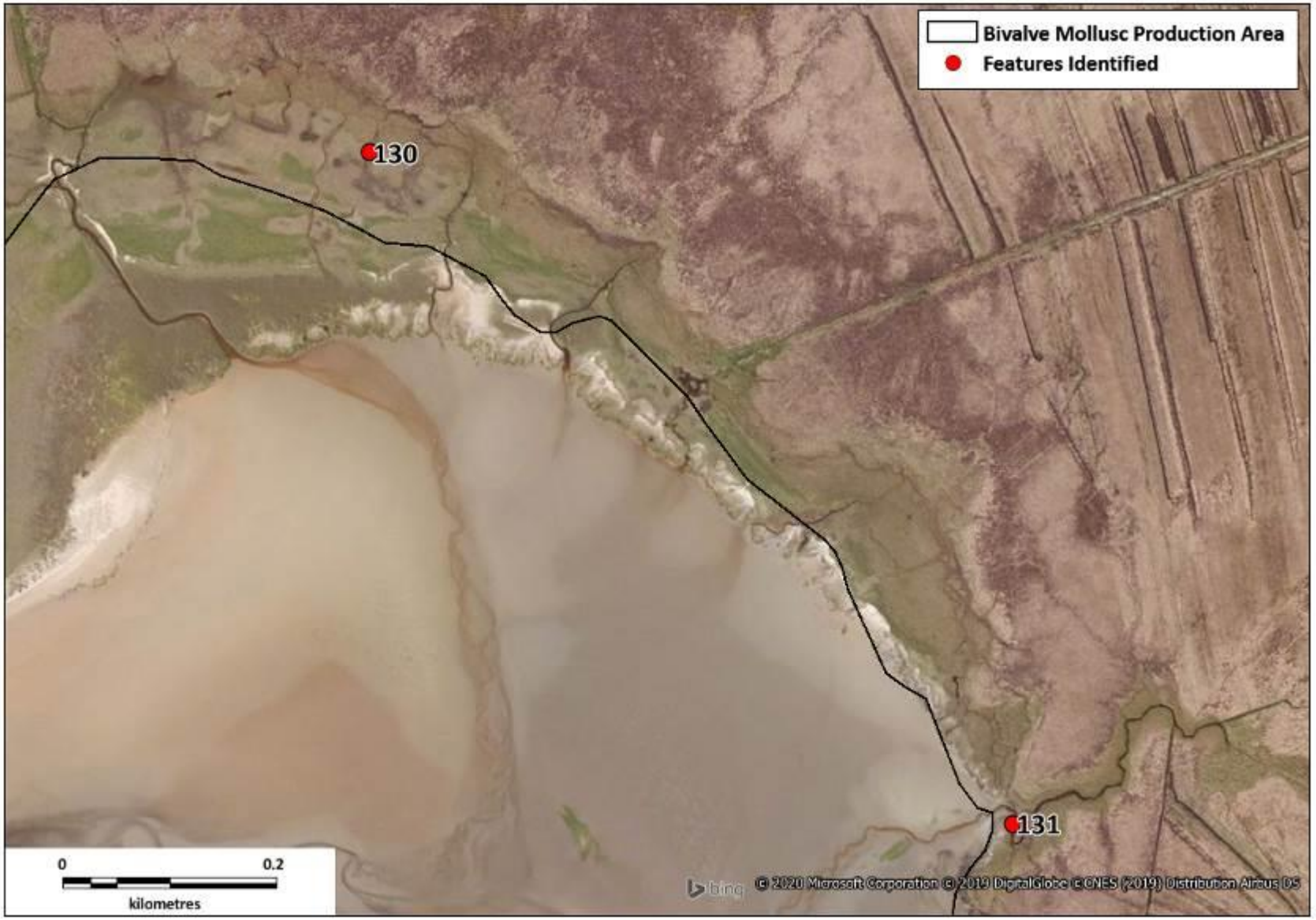


Figure 6.52: Features 130-131 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

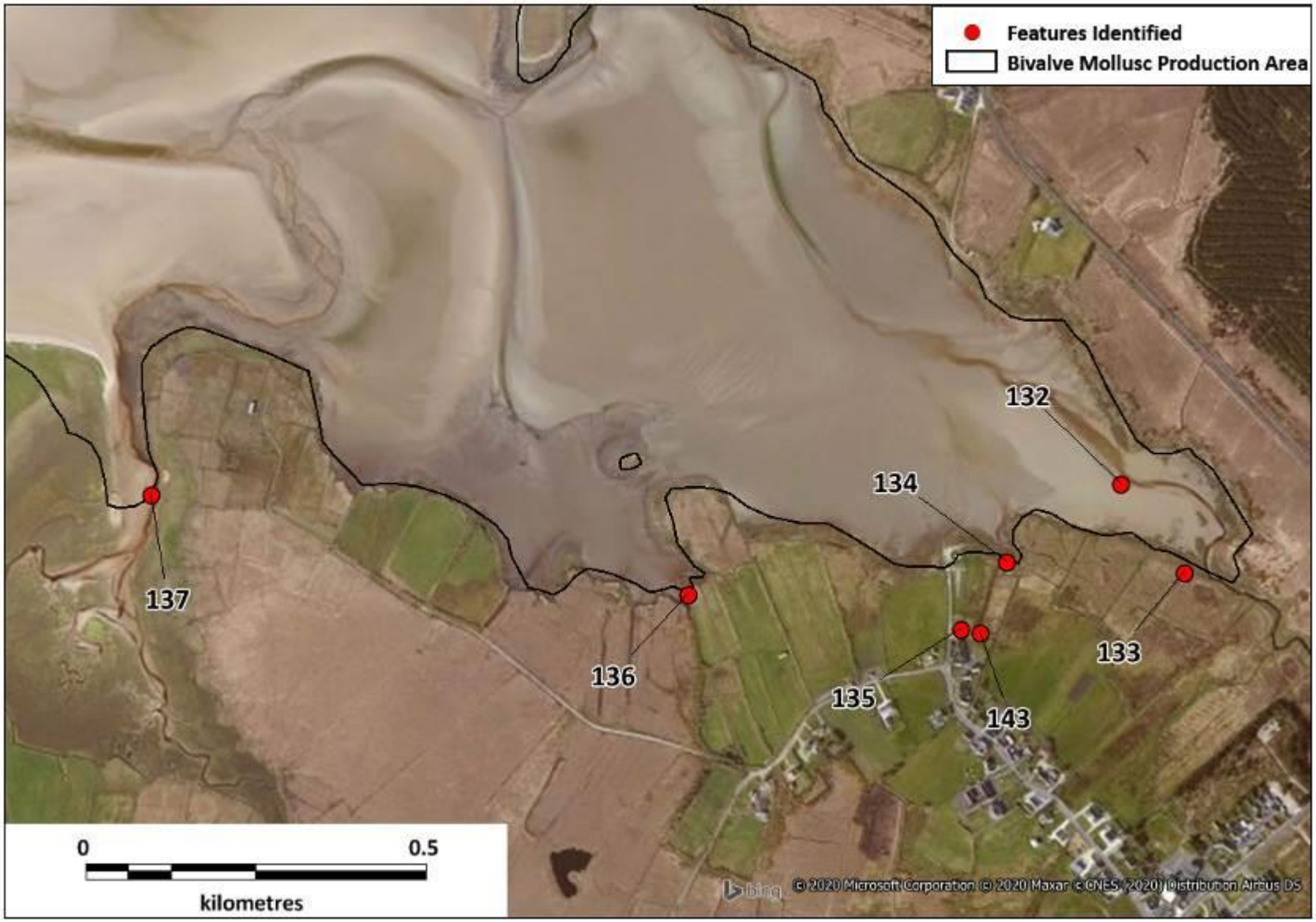


Figure 6.53: Features 132-137 & 143 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.54: Features 138-139 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

Figure 6.55: Features 140-142 (numbering cross-reference to Table 6.12) identified during the shoreline survey.

6.2.2. Locations of Sources

Figure 6.56 shows all watercourses discharging into Blacksod Bay and Table 6.13 provides cross-referenced details for this map. Figure 6.57 shows all discharges in the Blacksod Bay catchment area and Table 6.14 provides cross-referenced details for the WWTP, drain and pipe discharges.

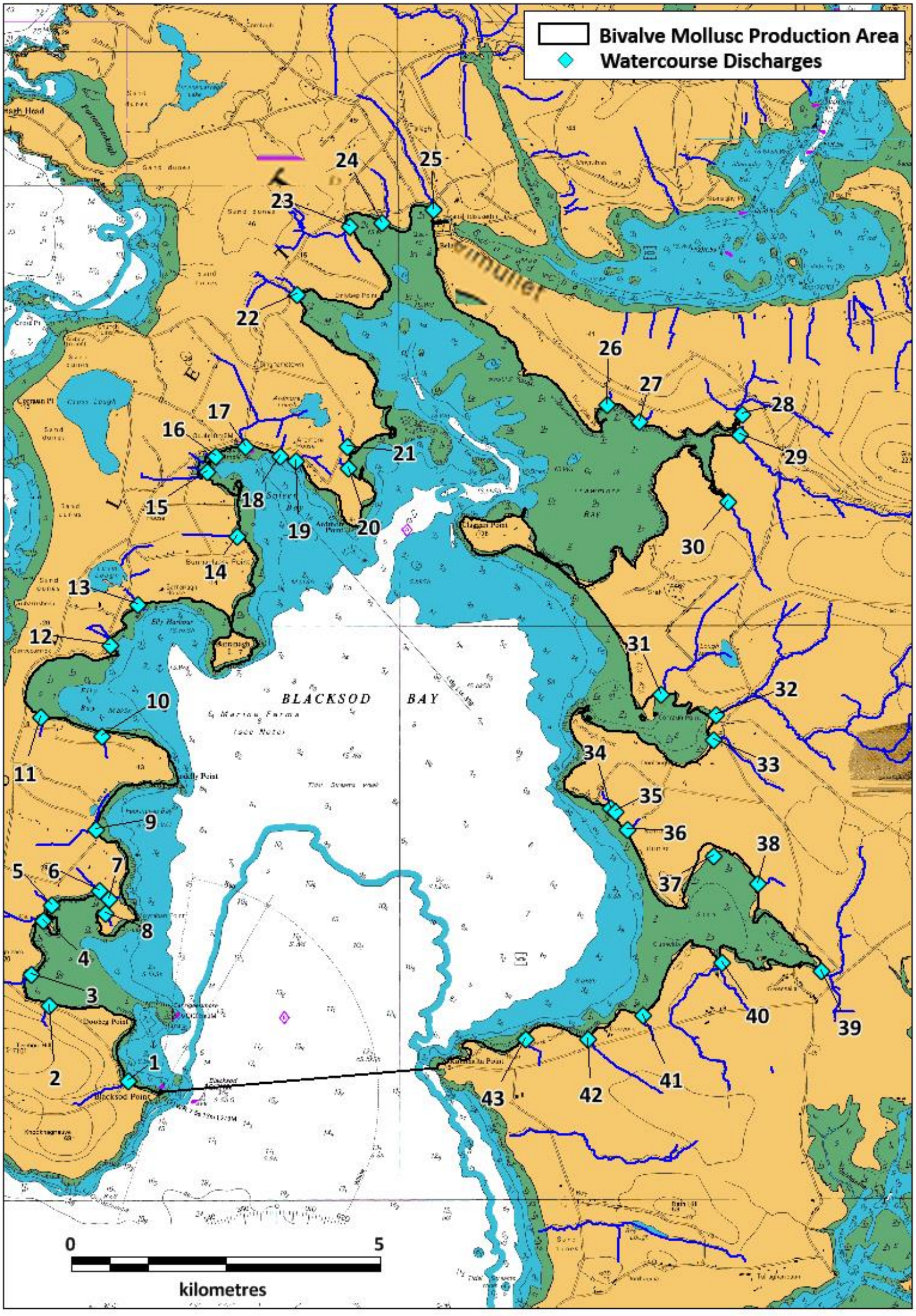


Figure 6.56: Location of all watercourses discharging into Blacksod Bay.

Table 6.13: Cross-referenced table for Figure 5.55 Watercourses.

Map ID	Watercourse
1	Unnamed River
2	Unnamed River
3	Unnamed River
4	Unnamed River
5	Unnamed River
6	Unnamed River
7	Unnamed River
8	Unnamed River
9	Unnamed River
10	Unnamed River
11	Unnamed River
12	Unnamed River
13	Unnamed River
14	Unnamed River
15	Unnamed River
16	Unnamed River
17	Unnamed River
18	Unnamed River
19	Unnamed River
20	Unnamed River
21	Unnamed River
22	Unnamed River
23	Unnamed River
24	Unnamed River
25	Unnamed River
26	Unnamed River
27	Unnamed River
28	Unnamed River
29	Glencastle River
30	Unnamed River
31	Unnamed River

32	Doolough River
33	Unnamed River
34	Unnamed River
35	Unnamed River
36	Unnamed River
37	Unnamed River
38	Unnamed River
39	Unnamed River
40	Unnamed River
41	Unnamed River
42	Unnamed River
43	Unnamed River

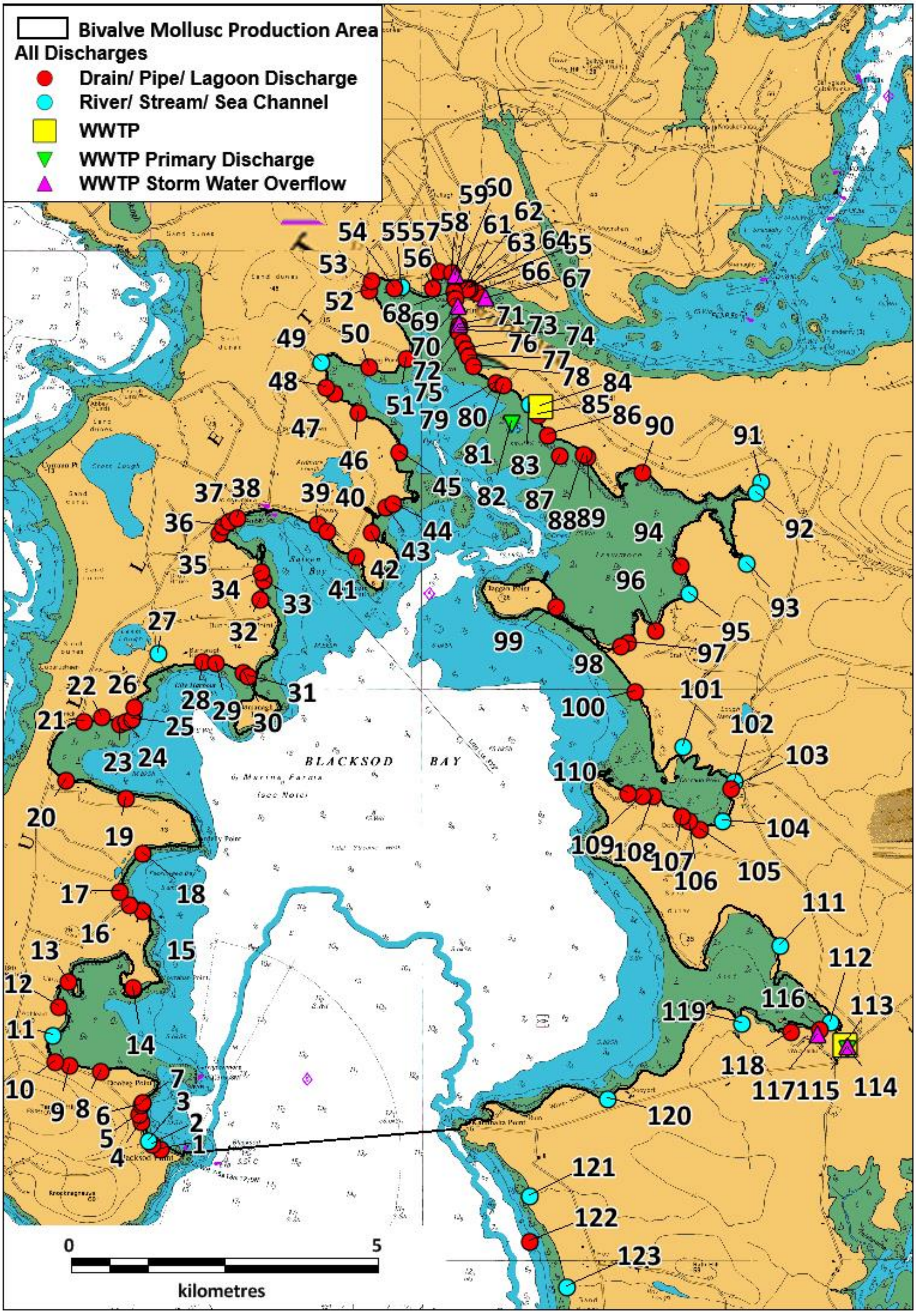


Figure 6.57: Locations of all discharges within Blacksod Bay Catchment Area.

Table 6.14: Cross-referenced table for Figures 5.56 Discharges.

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
1	Pipe	Blue road pipe, drainage. No flow.	54.09999	-10.0659	64905.5	318734.0
2	Stream/drain	Good flow, enrichment. Brown algae.	54.10069	-10.06798	64771.8	318815.8
3	Stream	Stream, brown algae evident.	54.10122	-10.06901	64706.1	318876.8
4	Stone drain	Old culvert, no flow.	54.10401	-10.07081	64597.5	319190.7
5	Drain	Field drain	54.10506	-10.07127	64570.8	319308.5
6	Drain	Field drain	54.10634	-10.07081	64605.1	319450.0
7	Drain	Field drain	54.10674	-10.07043	64631.2	319493.8
8	Drain	Field drain	54.11138	-10.08079	63968.9	320030.1
9	Piped drain	Enrichment obvious	54.1121	-10.08862	63459.3	320125.3
10	Piped drain	Good flow	54.11275	-10.09223	63225.4	320204.6
11	Stream	Steady flow.	54.11659	-10.09285	63197.5	320633.2
12	Drain	Field drain, flowing. Enrichment evident.	54.12073	-10.0913	63312.4	321090.9
13	Saltmarsh stream/drain.	Flowing.	54.12437	-10.08895	63478.0	321491.5
14	Natural drain	Saltmarsh drainage channel.	54.12354	-10.07278	64532.4	321368.0
15	Concrete pipe	Likely agricultural field drainage pipe	54.13482	-10.07041	64724.1	322618.8
16	Grey pipe	Likely agricultural field drainage pipe	54.13569	-10.07359	64519.1	322721.7
17	Concrete sluice	Good flow, draining small lake behind dunes. No smell or signs of pollution.	54.13755	-10.07603	64365.7	322933.4
18	Drain	Stone drain with natural drain flowing alongside.	54.14324	-10.07052	64744.3	323556.1
19	Drain	Low flow, enrichment evident.	54.15122	-10.07468	64498.6	324452.1
20	Drain	Field drain. Enrichment evident, steady flow.	54.15384	-10.08959	63533.2	324772.4
21	Drain	Stone drain in wall, flowing from under road. Drainage.	54.16248	-10.08507	63856.8	325725.2
22	Drain	Old stone drain from under road. Enrichment evident.	54.16303	-10.08054	64154.5	325777.7
23	Pipe	Large concrete pipe. Flowing, some enrichment. Likely drainage.	54.16203	-10.07607	64443.1	325657.8
24	Pipes	Two grey pipes, no flow. Located to the rear of two houses.	54.16247	-10.07454	64544.5	325703.9

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
25	Pipes	Number of drainage pipes linked to adventure college. Mostly non-flowing.	54.16272	-10.07308	64640.7	325728.9
26	Stone pipe	Sluice, stone structure with flap. Flowing. Some enrichment but no smell.	54.16458	-10.07258	64679.4	325934.9
27	Lagoon discharge	Lagoon discharge	54.17238	-10.06646	65104.5	326791.3
28	Drain	Field drain from agricultural land. Flowing.	54.17119	-10.05548	65817.5	326637.9
29	Pipe	Pipe drain	54.17099	-10.05211	66036.9	326609.3
30	Drain	Field drain. Some enrichment, stone surround.	54.16951	-10.0454	66470.3	326431.9
31	Drain	Piped field drain.	54.16907	-10.04419	66547.9	326380.6
32	Saltmarsh stream/drain	Drain	54.18028	-10.04129	66773.3	327622.7
33	Drain	Field drain	54.18304	-10.04034	66844.2	327928.1
34	Drain	Field drain	54.18433	-10.04074	66822.3	328072.4
35	Drain	Field drain	54.18992	-10.05114	66161.5	328714.2
36	Drain	Field drain	54.1909	-10.05051	66205.8	328822.0
37	Drain	Field drain	54.19168	-10.04882	66318.6	328905.6
38	Drain	Field drain	54.19215	-10.04688	66446.7	328954.3
39	Drain	Field drain	54.19129	-10.02673	67759.0	328820.6
40	Drain	Field drain	54.19022	-10.02444	67905.0	328697.3
41	Stone drain	Drain	54.18656	-10.0173	68359.4	328276.6
42	Saltmarsh stream/drain	Drain	54.19	-10.01343	68622.9	328652.2
43	Drain	Field drain.	54.19361	-10.00986	68867.4	329047.4
44	Drain	Drain through area of saltmarsh	54.19418	-10.00785	69000.3	329107.1
45	Drain	Field drain.	54.20168	-10.00658	69106.9	329939.4
46	Drain	Field drain.	54.20757	-10.01669	68466.0	330613.7
47	Drain	Field drain.	54.21025	-10.02265	68085.7	330923.1
48	Drain	Field drain.	54.21127	-10.02463	67959.8	331040.3
49	Stream	Low flow.	54.21486	-10.02597	67883.9	331442.4
50	Drain	Field drain.	54.21418	-10.01381	68674.9	331344.0

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
51	Drain	Field drain.	54.21537	-10.00462	69278.1	331459.4
52	Stream/drain	Some green algae evident.	54.22536	-10.01374	68714.9	332588.1
53	Culvert	Steady flow, sewage odour. Enrichment evident. Grey colouration of water.	54.2267	-10.01336	68744.0	332736.5
54	Pipe	Trickle flow, drainage pipe. No odour or colouration.	54.22567	-10.00752	69121.5	332611.1
55	Stream	Steady flow, some green algae evident.	54.22593	-10.00579	69235.2	332636.8
56	Drain	Field drain.	54.22577	-9.99808	69737.4	332604.7
57	Culvert	Steady flow, sewage odour. Enrichment evident. Grey colouration of water.	54.2281	-9.99642	69853.0	332861.0
58	Pipe	Orange small bore pipe coming of adjacent road. Surface water drain.	54.2279	-9.99335	70052.6	332833.1
59	WWTP Storm Water Overflow		54.22751	-9.99246	70109.4	332788.0
60	Pipe	Two orange pipes, no flow. Possibly drainage from footpaths.	54.2259	-9.99231	70114.1	332608.6
61	Sea channel	Sea channel, flowing from Broadhaven to Blacksod	54.22559	-9.99021	70250.1	332570.2
62	Pipe	Orange drainage pipe, no flow evident	54.22566	-9.98984	70274.4	332577.3
63	Pipe	Small bore white pipe, possibly septic tank related	54.2255	-9.98933	70307.2	332558.6
64	Pipe	Three pipes, flow from large bore concrete pipe. Green algal enrichment	54.22553	-9.98879	70342.5	332560.9
65	Pipe	Two concrete pipes, closed with flaps. Possibly storm water.	54.22575	-9.9888	70342.5	332585.4
66	Pipe	Trickle flow, some enrichment. Likely drainage pipe.	54.22504	-9.98688	70465.5	332502.9
67	WWTP Storm Water Overflow		54.224105	-9.984788	70599.0	332395.0
68	Pipe	Small flow, some grey colour	54.22515	-9.99256	70095.4	332525.6
69	Pipe	Orange medium bore pipe. No odour. Some enrichment, some grey colour.	54.22415	-9.99231	70108.6	332413.8
70	WWTP Storm Water Overflow		54.222973	-9.991864	70134.0	332282.0
71	WWTP Storm Water Overflow		54.220336	-9.991584	70144.0	331988.0
72	Pipe	Some enrichment, likely drainage.	54.2203	-9.99159	70143.5	331984.0
73	Pipe	Large bore stone pipe, small flow.	54.21979	-9.99158	70142.5	331927.2
74	Drains	Old stone drains, x 8. Water drainage.	54.21946	-9.99172	70132.4	331890.8
75	Pipe	Modern drainage pipe	54.21789	-9.99056	70203.1	331713.9
76	Pipe	Plastic pipe. Enrichment. Likely drainage. No colour or odour.	54.21671	-9.98966	70258.1	331580.9

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
77	Pipe	Plastic pipe. Enrichment. Likely drainage. No colour or odour.	54.2158	-9.9892	70285.2	331478.8
78	Drain	Constant flow. Likely water drainage.	54.21431	-9.98799	70359.5	331310.7
79	Pipe	Heavy black pipe. Steady flow. Enrichment. Unsure of origin.	54.21189	-9.98217	70731.6	331030.7
80	Pipe	Old pipe structure with manhole. Drain also. Strong flow. Near school.	54.21176	-9.98184	70752.7	331015.7
81	Drain	Field drain, flowing. Enrichment.	54.21146	-9.9806	70832.6	330980.0
82	WWTP Primary Discharge		54.20616	-9.978333	70964.0	330386.0
83	Stream	Good flow, enrichment evident.	54.20865	-9.97404	71251.8	330655.3
84	WWTP		54.208351	-9.971295	71430.0	330617.0
85	Pipe	Black field drainage pipe, flowing.	54.2071	-9.97169	71400.3	330478.5
86	Pipe	Black field drainage pipe, flowing.	54.20421	-9.96938	71542.1	330152.7
87	Pipe	Old stone pipe, draining fields. Flowing.	54.20114	-9.96636	71729.6	329805.5
88	Pipe	Black field drainage pipe, flowing.	54.20133	-9.96045	72115.8	329815.9
89	Drain	Drain, flowing	54.20106	-9.95966	72166.5	329784.4
90	Drain	Field drain, flowing.	54.19863	-9.94575	73066.7	329488.9
91	Stream	Stream, flowing through saltmarsh.	54.19727	-9.91645	74974.5	329285.2
92	River	Small river inflow. Good flow. Through agricultural grazing land.	54.19568	-9.91756	74897.3	329110.3
93	Stream	Stream, flowing through moor and rough pasture.	54.18526	-9.91986	74715.7	327954.7
94	Drain	Field drain, flowing.	54.18502	-9.93644	73632.7	327957.5
95	Stream	Flowing, enrichment evident.	54.18095	-9.93443	73751.5	327500.9
96	Drain	Field drain, flowing.	54.17565	-9.94259	73202.5	326925.7
97	Drain	Field drain, low flow.	54.17387	-9.94971	72732.2	326740.4
98	Drain	Field drain, low flow.	54.17338	-9.95131	72626.2	326688.8
99	Drain	Culvert drain of pasture land. No flow or smells.	54.17917	-9.96753	71585.1	327362.5
100	Drain	Two field drains, both flowing	54.16659	-9.94782	72833.3	325926.8
101	Stream	Large stream, flowing through saltmarsh	54.15863	-9.93606	73577.0	325019.8
102	River	Good flow.	54.15356	-9.92305	74411.4	324432.3

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
103	Drain	Field drain, flowing.	54.15242	-9.92389	74353.1	324306.9
104	Stream	Good flow.	54.14774	-9.92611	74193.8	323790.0
105	Pipe	Piped field drain. Strong flow.	54.14646	-9.93196	73807.8	323658.0
106	Drain	Field drain, flowing.	54.14768	-9.93461	73638.3	323798.5
107	Drain	Field drain, flowing.	54.14843	-9.93631	73529.5	323885.0
108	Drain	Field drain, low flow.	54.15134	-9.94352	73067.4	324221.8
109	Drain	Field drain, good flow.	54.15144	-9.946	72905.7	324237.4
110	Drain	Field drain, low flow.	54.15173	-9.94979	72659.0	324276.5
111	Stream	Stream flowing through heath/bog land. Flowing, 0.5 metre width	54.12943	-9.91184	75071.1	321726.9
112	Stream	Outflow through area of saltmarsh	54.11827	-9.89955	75841.0	320463.3
113	WWTP		54.114882	-9.895985	76064.0	320079.9
114	WWTP Primary Discharge		54.114567	-9.89545	76098.0	320043.9
115	WWTP Storm Water Overflow		54.114567	-9.89545	76098.0	320043.9
116	Drain	Flowing downstream of pumping station and small housing estate	54.11724	-9.90214	75668.6	320353.2
117	WWTP Storm Water Overflow		54.116349	-9.90272	75628.0	320255.0
118	Drain	Drain/tiny stream. Flowing.	54.11681	-9.9093	75199.1	320317.9
119	Stream	Combined stream inflows. Strong flow of water.	54.11814	-9.9214	74412.0	320487.4
120	Stream	Stream, good flow. Signs of enrichment on surrounding shore.	54.10711	-9.95499	72181.9	319320.1
121	Stream	Stream, good flow of water. Draining area of moor/bog.	54.09297	-9.97439	70869.3	317781.7
122	Drain	Piped drain, good flow. Draining rough grazing area.	54.08633	-9.97439	70848.6	317042.7
123	Stream	Good flow.	54.07969	-9.9653	71422.8	316287.2

7. Appendix 2: Hydrography/Hydrodynamics

7.1. Simple/Complex Models

A hydrodynamic model of inner Blacksod Bay was developed by AQUAFACT on behalf of Mayo County Council to assess the assimilative and dispersion ability of the bay in relation to a proposed treatment plant (Aquafact, 2005). The results of this model have been used to describe the hydrodynamics of Blacksod Bay below.

7.2. Depth

Blacksod Bay is a large shallow bay with large areas of mudflat and sandflats along the shore and particularly the inner bay inside of Cleggan Point. The inner bay inside of Ardmore point and Cleggan Point is mostly intertidal. A deep channel runs from just south of Belmullet in a southwards direction before turning south-westerly as it meets two rock outcrops. As the channel passes the second rock outcrop it turns south and then south westerly as it passes Cleggan point and finally south as it opens into the outer bay. Depths in the channel range from 5 to 11m. Depths in the outer part of the bay range from 5 to 17m with depths increasing from the shore and out towards the mouth of the bay (Admiralty Chart 2704). Figure 7.1 shows water depth in the area.

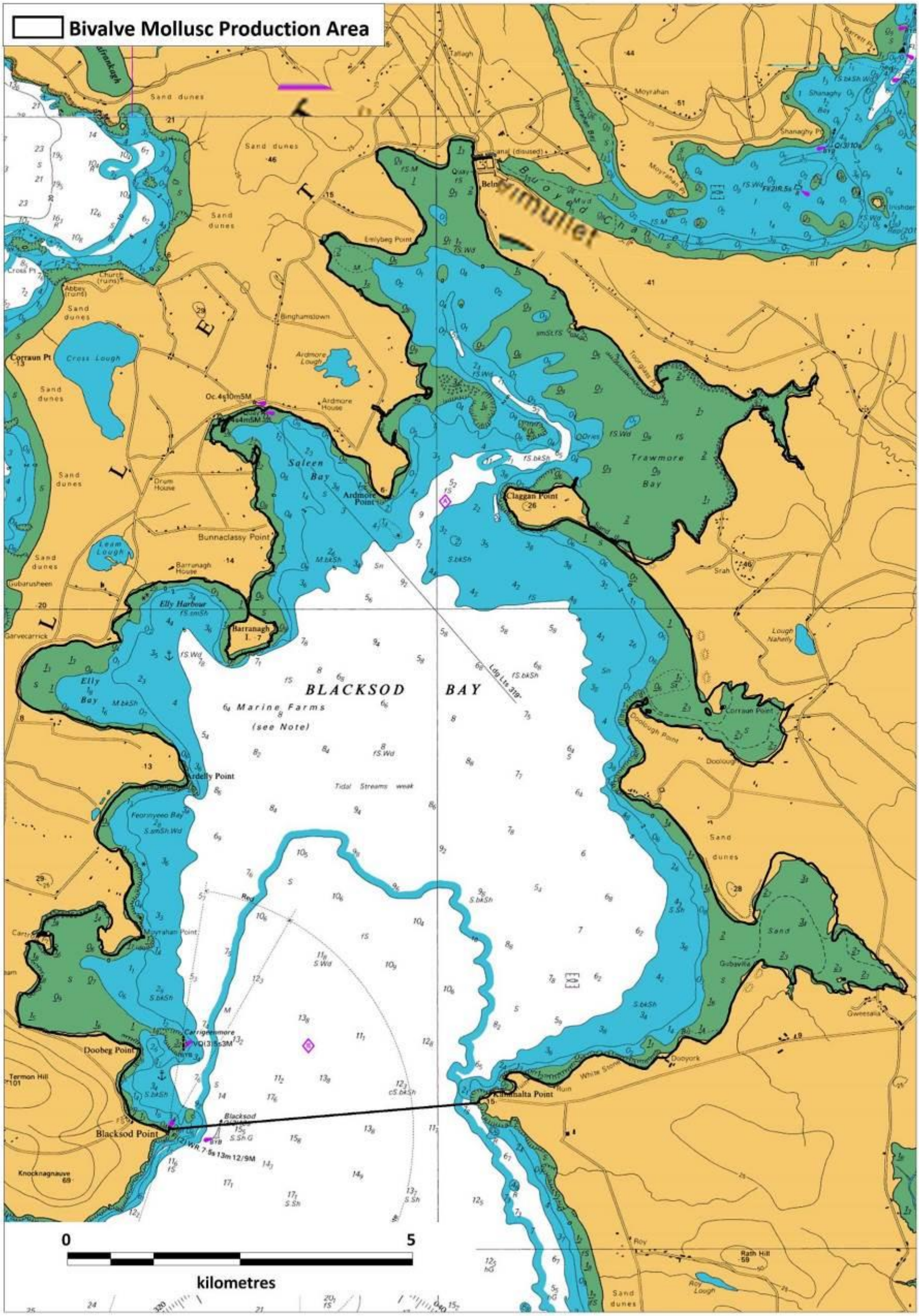


Figure 7.1: Depths in Blacksod Bay (Source: Admiralty Chart 2704).

7.3. Tides & Currents

Predicted spring and neap tidal ranges in Blacksod Bay are in the region of 3.5 and 1.5m respectively (Admiralty Chart 2704). AQUAFACT (2005) found that the mean maximum neap tide velocity was 0.2m/s, whereas, the mean maximum spring tide velocity what 0.5m/s. Although spring tide velocities can reach 0.75m/s in certain locations (See Figure 7.2 and Figure 7.3). AQUAFACT also carried out a drogue and dye study as part of the hydrographic survey. Dye was release at two proposed locations for the WWTP discharge. On the spring tide it was found that the dye patch from both locations moved towards the relatively deep channel where it dispersed to undetectable levels. On the neap tide the proposed discharge location further out into the bay behaved the same as the spring tide release. However, the proposed discharge release location nearer the shore did not disperse towards the channel and instead dispersed horizontally and vertically around the release point. The reason given for the lack of dispersion was a combination of the weaker neap tide currents and relatively strong south-easterly winds. It was found that drogues generally move north to northwest on the flooding tide and south on the ebbing tide on both neap and spring tides. Three drogues released on the spring ebbing tide are notable as they initially moved southwards to Cleggan Point before changing direction on the turning tide to eastwards into Trawmore Bay.

Table 7.1: Blacksod Bay tidal characteristics (Source: Admiralty Chart No. 2704).

Admiralty Chart 2704 Levels (m CD)	MHWS	MHWN	MLWN	MLWS
Blacksod Quay	3.9	2.9	1.4	0.4

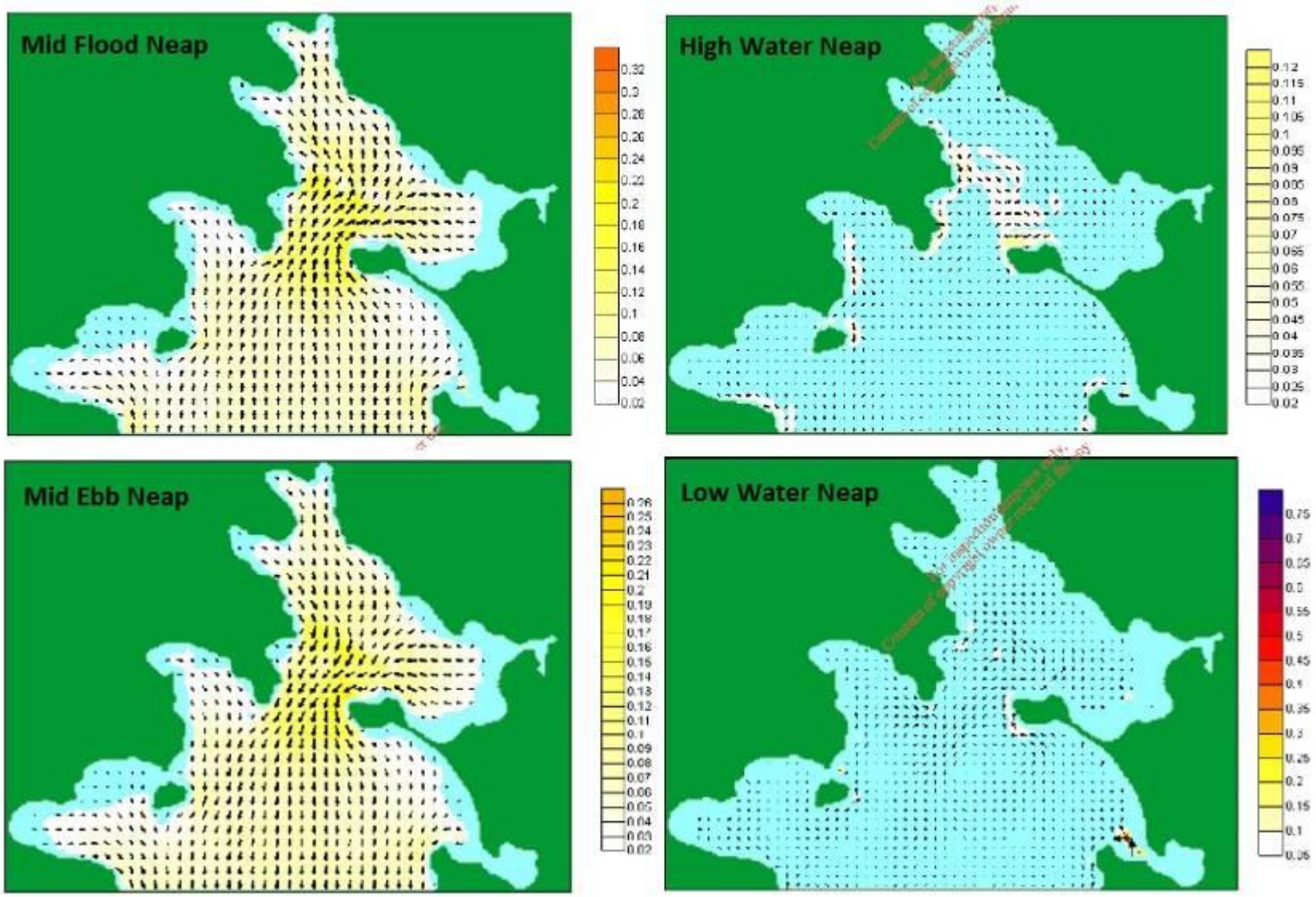


Figure 7.2: Predicted Inner Blacksod Bay currents during a neap tide (AQUAFACT, 2005).

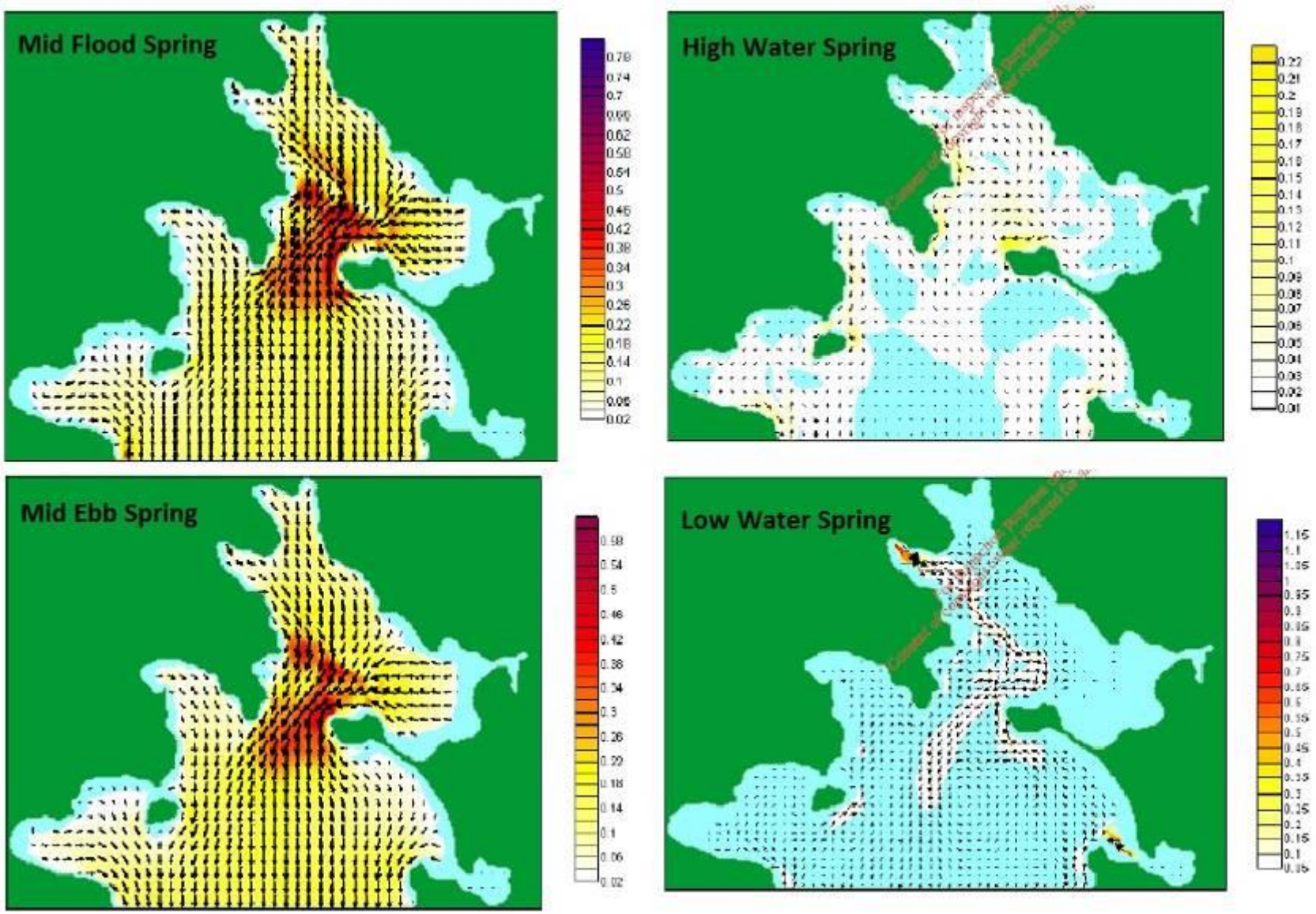


Figure 7.3: Predicted Inner Blacksod Bay currents during a Spring tide (AQUFACT, 2005).

7.4. Wind and Waves

Wind data from 2014 to 2018 from the Belmullet station (Met Eireann, 2019a) are displayed in Table 7.2 below and wind roses for each year can be seen in Figure 7.4.

In 2014, 19.9% of the wind came from the west, while 19.5% came from the southwest and 18% from the south. The strongest winds came from the south (44kn). In 2015, 21.5% of the wind came from the south, 21% from the southwest and 19.5% from the west. The strongest winds (47kn) came from the south. In 2016, 19.9% of the wind came from the south, 17.7% came from the southwest and 17% came from the west. The strongest winds (43kn) came from the south. In 2017, 22.7% of the winds came from the southwest, with 19.5% coming from the west and 18.6% coming from the south. The strongest winds (36kn) came from the northwest. In 2018, 21.4% of the wind came from the southwest, 18.5% came from the south and 18% came from the west. The strongest winds (45kn) came from the south. It can be seen from the 2014-2018 wind rose diagram that the prevailing wind direction is southwest.

Table 7.3 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 (13.8kn), followed by spring (12.2kn) and autumn (11.4kn), with 10.8kn in summer.

Table 7.2: Wind speed and direction data for Belmullet 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	13.9	198.7	17.8	224.5	13.7	187.4	12.7	183.5	14.7	216.1
February	15.3	194.3	12.7	202.9	13.3	180.0	13.4	180.7	13.0	174.3
March	12.5	197.1	14.7	207.4	12.0	185.2	12.3	163.5	10.4	159.4
April	10.3	161.0	10.0	165.7	11.1	118.3	10.4	222.3	12.3	152.0
May	12.0	138.7	12.8	205.5	10.5	110.0	10.2	172.3	12.9	142.9
June	8.3	144.3	12.1	171.0	9.7	176.0	13.1	181.0	8.9	133.0
July	9.1	206.5	11.2	211.9	10.4	212.9	10.2	178.4	9.9	167.1
August	9.1	211.3	12.1	205.8	12.2	198.4	10.6	229.4	10.6	211.6
September	7.6	164.7	9.6	229.0	14.2	180.3	12.2	211.0	12.4	205.7
October	14.1	186.1	9.5	166.1	9.2	146.8	14.0	221.3	13.7	217.7
November	9.6	175.3	15.5	225.7	10.2	179.0	11.6	224.0	13.7	163.7
December	14.6	227.7	17.8	167.7	15.2	184.2	12.7	211.3	13.0	192.3

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 7.3: Seasonal averages (knots) for Belmullet wind data (Source: Met Eireann, 2019a).

Season	2014	2015	2016	2017	2018	5 Year Average
Winter	12.7	17.1	13.0	12.3	13.8	13.8
Spring	12.7	12.5	12.1	12.0	11.9	12.2
Summer	9.8	12.0	10.2	11.2	10.6	10.8
Autumn	10.3	10.4	11.9	12.3	12.2	11.4

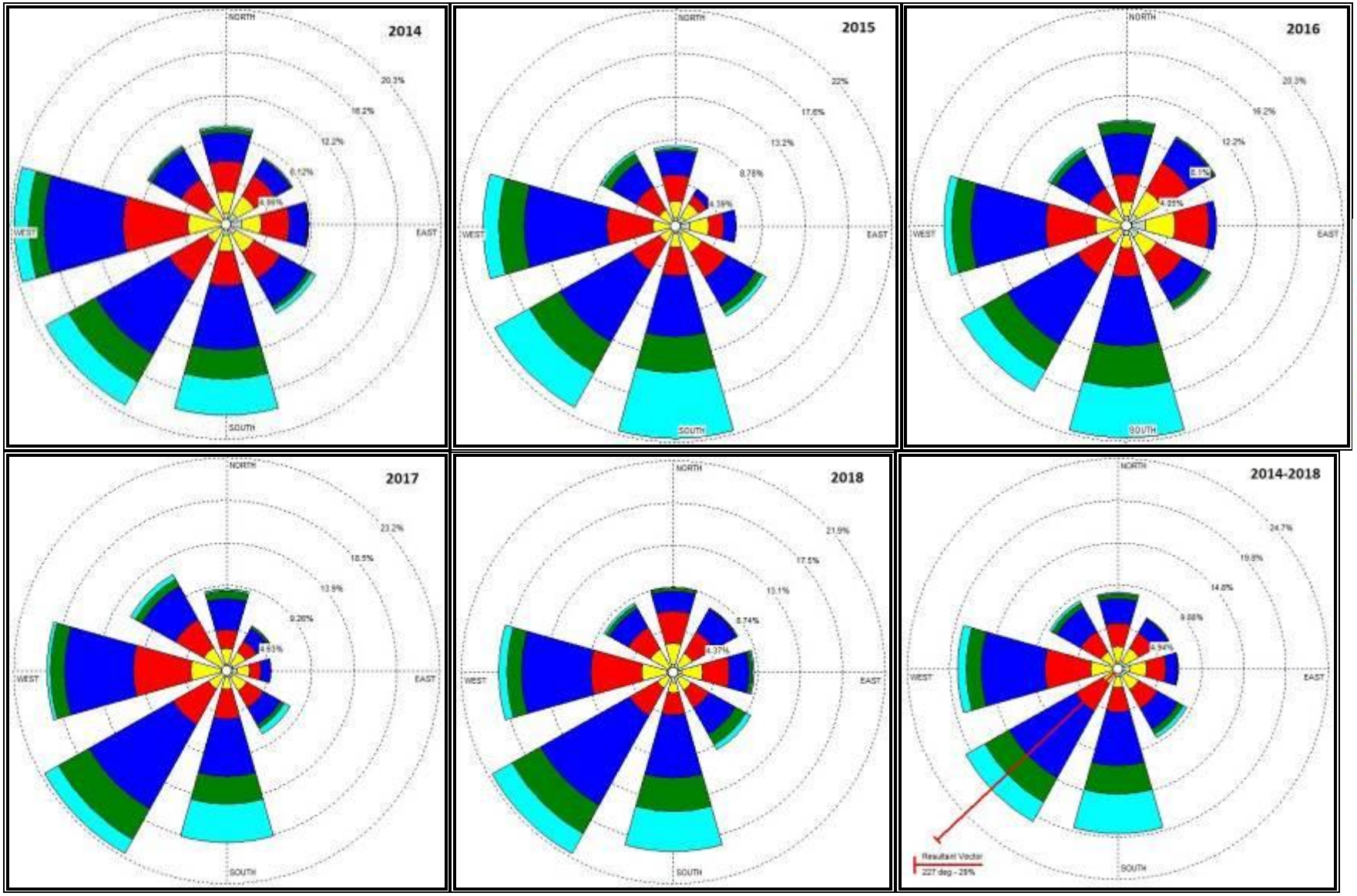


Figure 7.4: Wind roses for Belmullet from 2014 to 2018 (Source: Met Eireann, 2019a).

Wind conditions affect the hydrodynamic conditions in Blacksod 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.

7.5. River Discharges

Blacksod Bay drains a catchment of 167.4km^2, the catchment is made up of a series of small streams with no large rivers or lakes (Figure 7.5). The two largest streams are the Glencastle and Doolough that flow into the north eastern end of the bay.

The current (2010-2015) WFD status of Blacksod Bay and its associated freshwater sources can be seen in Figure 7.6. Of the river systems flowing directly into the Blacksod Bay BMPA, the Glencastle stream is of Good status and the Doolough stream is of poor status. All other streams flowing directly into the bay are unassigned. Blacksod Bay coastal waterbody (CWB) is unassigned a status and Belmullet Bay CWB is also unassigned, while Broadhaven Bay is of Good Status.

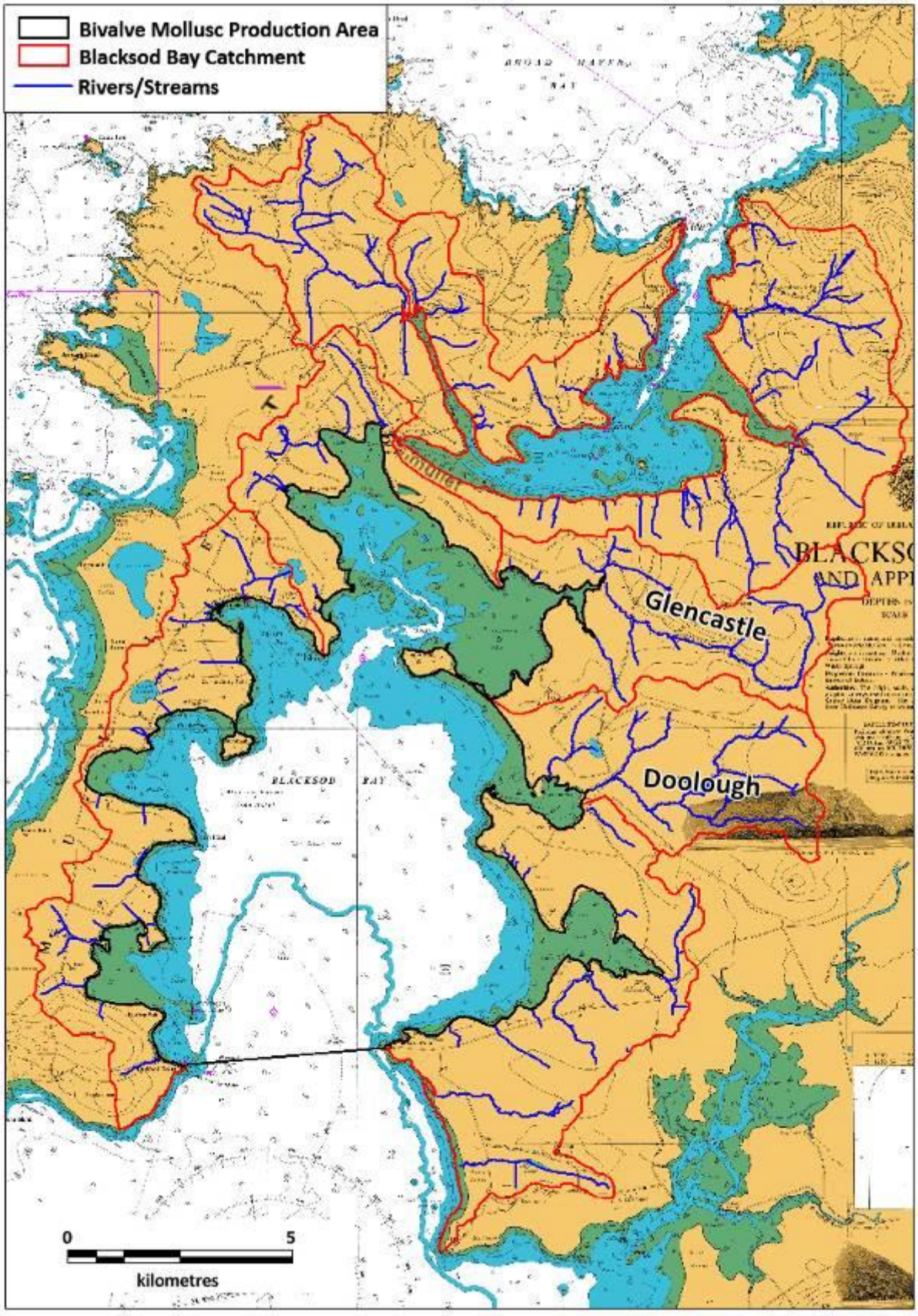


Figure 7.5: Rivers in the Blacksod Bay catchment area (Source: EPA, 2019).

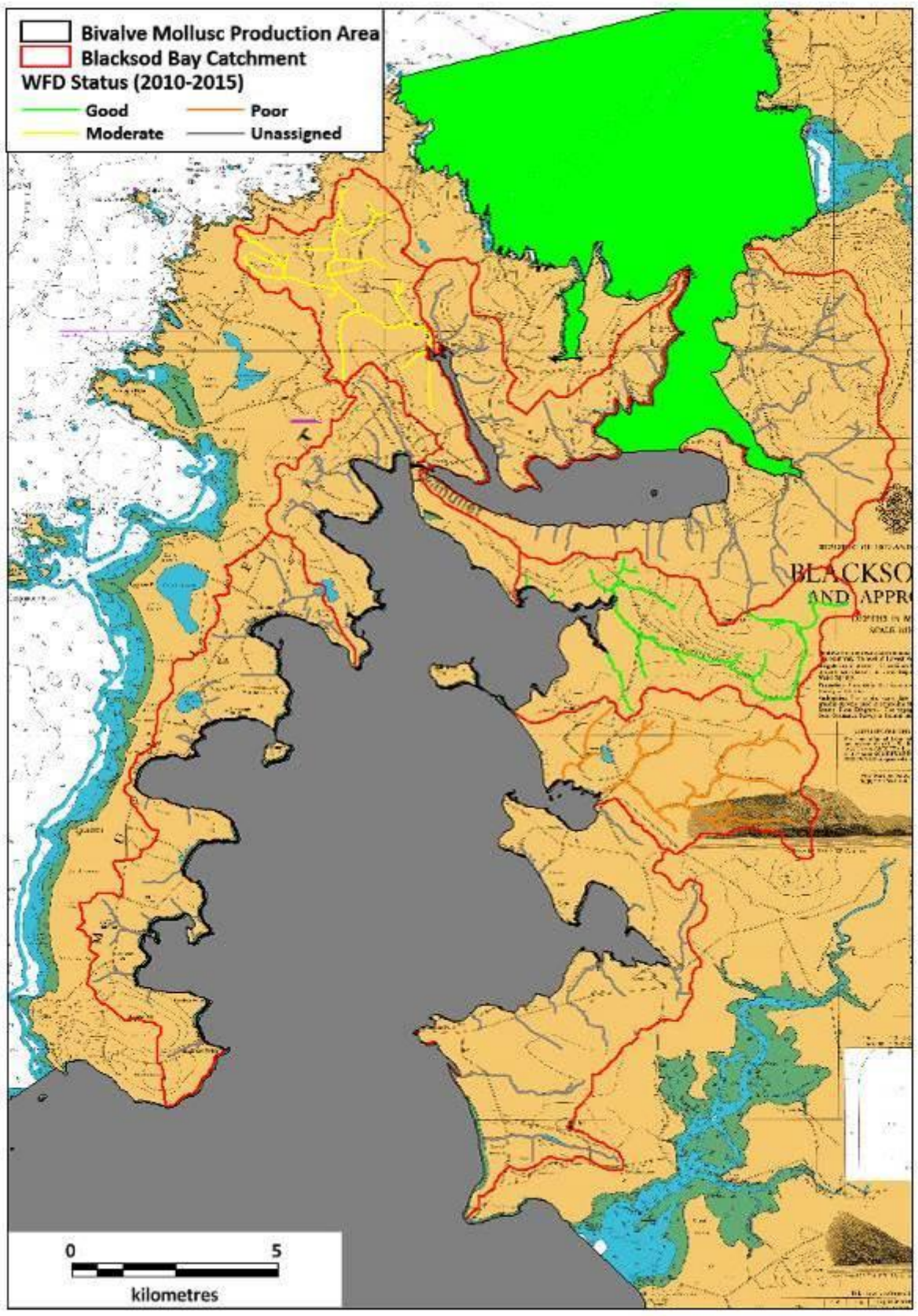


Figure 7.6: WFD Status of the coastal and river waterbodies in the catchment area (Source EPA, 2019).

7.6. Rainfall Data

7.6.1. Amount & Time of Year

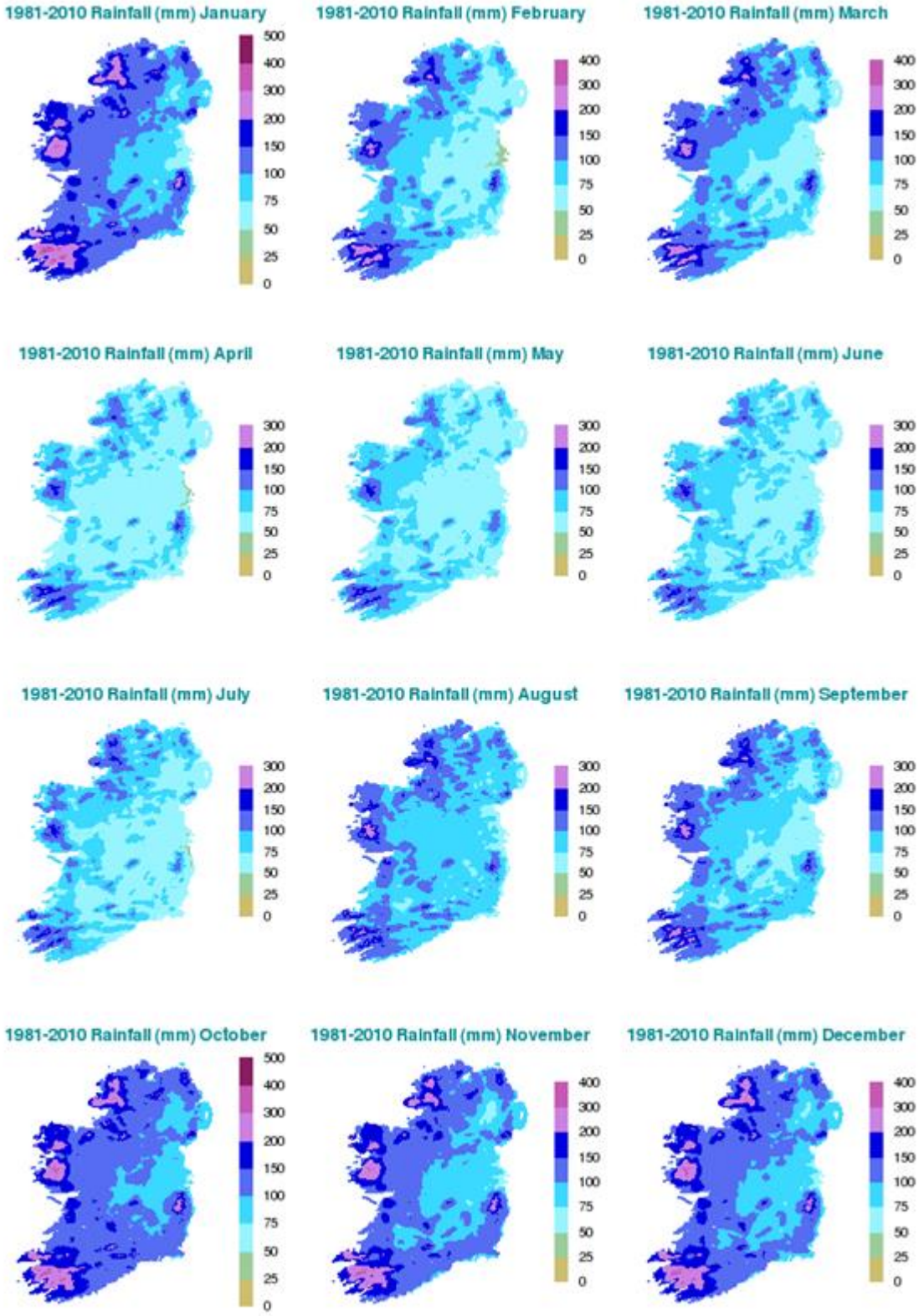
Figure 7.7 shows the average monthly rainfall data for Ireland (Met Eireann, 2019b) from 1981 to 2010. The wettest months in the Blacksod Bay region over this 30-year period were October to January with the driest months from April to July. Table 7.4 shows the 30-year average monthly rainfall at the Belmullet station which is located at the northern end of the Blacksod Bay production area (Figure 7.8 shows the location of the Belmullet station). During the period 1981 to 2010, average rainfall at Belmullet was lowest in May (70.4mm) and highest in October (145.9mm). The greatest daily total ranged from a low of 25.6 in March to a high of 79.6mm in October. Table 7.5 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 7.4: 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 7.5: 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


1981-2010 Rainfall (mm) January
500 400 300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) February
400 300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) March
400 300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) April
300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) May
300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) June
300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) July
300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) August
300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) September
300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) October
500 400 300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) November
400 300 200 150 100 75 50 25 0
1981-2010 Rainfall (mm) December
400 300 200 150 100 75 50 25 0

9b).

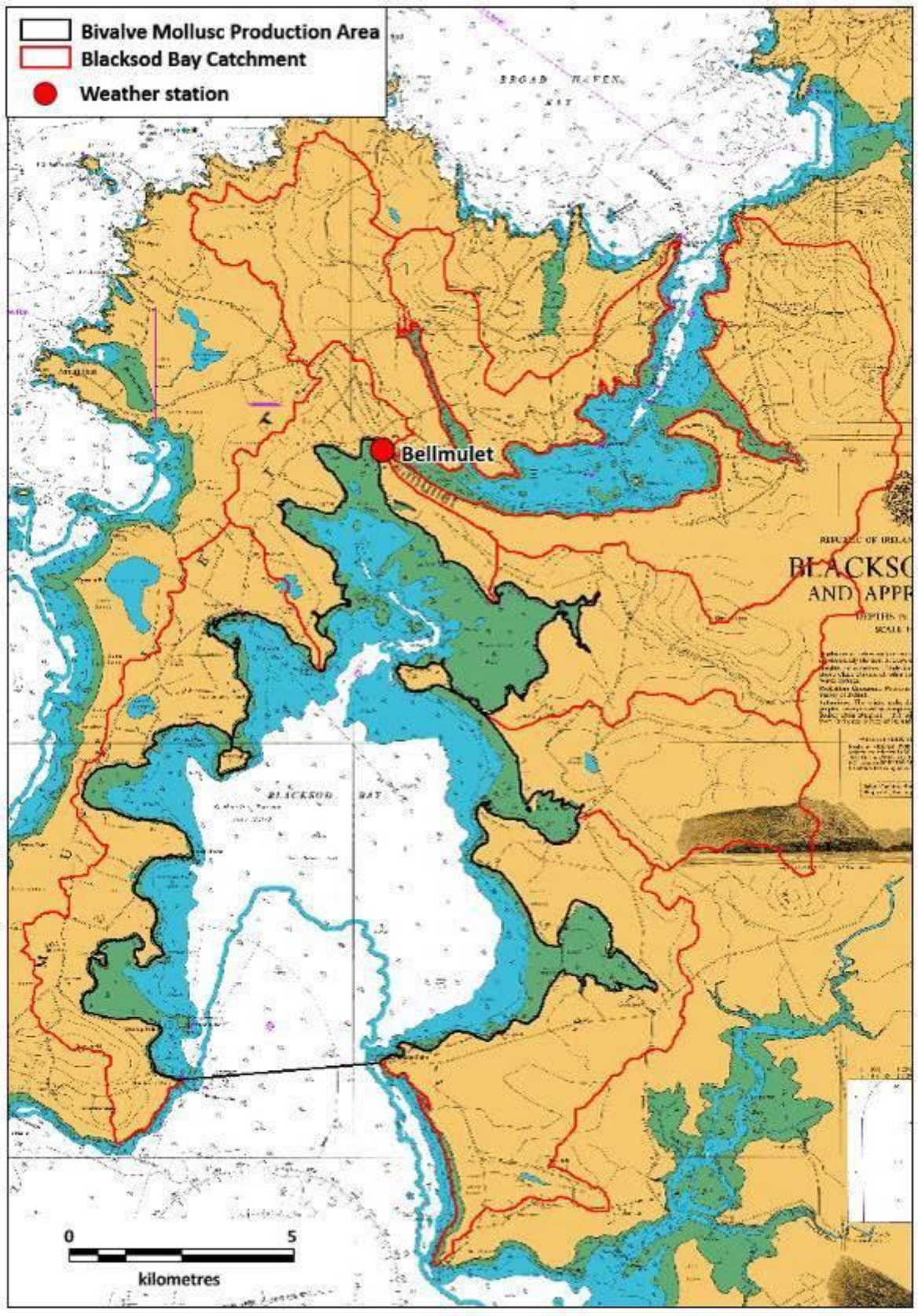


Figure 7.8: Location of Met Eireann weather stations in relation to the Blacksod Bay production area.

Table 7.6 shows total monthly rainfall at the Belmullet Met Eireann station (see Figure 7.8), located at the northern end of Blacksod Bay production area from 2014 to 2018 (Met Eireann, 2019d).

Belmullet weather station is located in Belmullet town at the northern end of Blacksod Bay. Maximum monthly rainfall was in December 2015 (255.7mm) and the lowest monthly rainfall was April 2017 (25.2mm). The 5-year average monthly rainfall ranged from a low of 56.14mm in April to a high of 173.2mm in January. Annual averages ranged from 99.0mm in 2016 to 120.9mm in 2015.

Table 7.7 shows the total seasonal rainfall at Belmullet from 2014-2018 (Met Eireann, 2019d). The following seasonal fluctuations were observed from 2014-2017: In 2014, summer was the driest season and winter was the wettest, in 2015 spring was the driest and winter was the wettest. In 2016, summer was the driest and winter was the wettest. In 2017, spring was the driest and autumn was the wettest and in 2018 summer was the driest and winter was the wettest. Over the five years summer 2018 was the driest season and winter 2015 was the wettest season.

Table 7.6: Total monthly rainfall (mm) data at Belmullet, Co. Mayo, from 2014 to 2018 (Source: Met Eireann, 2019d).

Year	2014	2015	2016	2017	2018	Monthly 5-yr Average
Jan	210.5	178.1	189.1	60	228.3	173.2
Feb	198	70.8	171.6	110.6	123.6	134.92
Mar	87	107.9	98.4	108.8	87.4	97.9
Apr	53.5	62.8	57.8	25.2	81.4	56.14
May	103.6	102.3	49.3	49.6	67.4	74.44
Jun	46	59.9	100	97.6	40.1	68.72
Jul	59.8	131.3	99.3	98.7	64.6	90.74
Aug	91.6	96.3	56.2	134.3	135.2	102.72
Sep	25.4	118.1	145.8	139.6	93.9	104.56
Oct	176	76.3	47.8	131.6	135.1	113.36
Nov	83.5	191.8	89.2	143.6	147.5	131.12
Dec	140.3	255.7	83.8	143.5	152.3	155.12
Annual Average	106.3	120.9	99.0	103.6	113.1	-

Table 7.7: Total seasonal rainfall (mm) at Belmullet from 2014-2018 (Source: Met Eireann, 2019d).

Station	Season/Year	2014	2015	2016	2017	2018
Belmullet	Spring	338.5	241.5	327.8	244.6	292.4
	Summer	209.4	293.5	248.6	245.9	172.1
	Autumn	293	290.7	249.8	405.5	364.2
	Winter	434.3	625.6	362.1	347.1	528.1

7.6.2. Frequency of Significant Rainfalls

Figure 7.9 shows the average monthly rainfall at Belmullet from 1981-2010 and Figure 7.10 shows the 5 year monthly average rainfall at Belmullet weather station from 2014-2018. 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 Belmullet, January has been the wettest month followed by December, February and November. April was the driest month followed by June and May.

For the 5-year 2014-2018 period, average greatest daily rainfall at Belmullet was 18.9mm, with a maximum of 42.5mm. Over the same period, the number of wet days (rainfall >1mm) a month averaged at 17with the maximum number of 28 days/month.

Met Eireann has developed a depth duration frequency model for the estimation of point rainfall frequencies (Fitzgerald, 2007; Met Eireann, 2019d). For a 1 in 100 year return period, 25.3mm of rain would be expected over 1 hour and 80.7mm over 24 hours. Whiles these would be extreme uncommon events, the model predicts that once a year 9.7mm would fall in 1 hour and 32.2mm 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 rainfall data in this section , heavy 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.

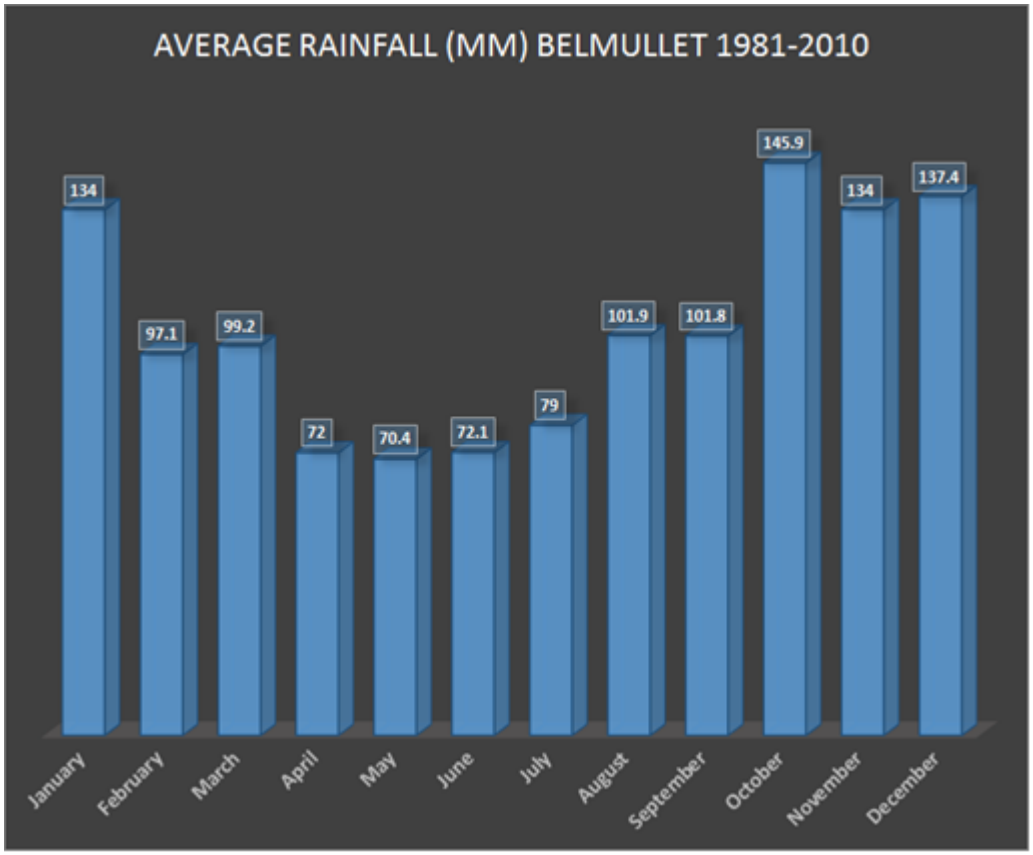


Figure 7.9: Average monthly rainfall (mm) at Belmullet from 1981-2010 (Source: Met Eireann, 2019c).

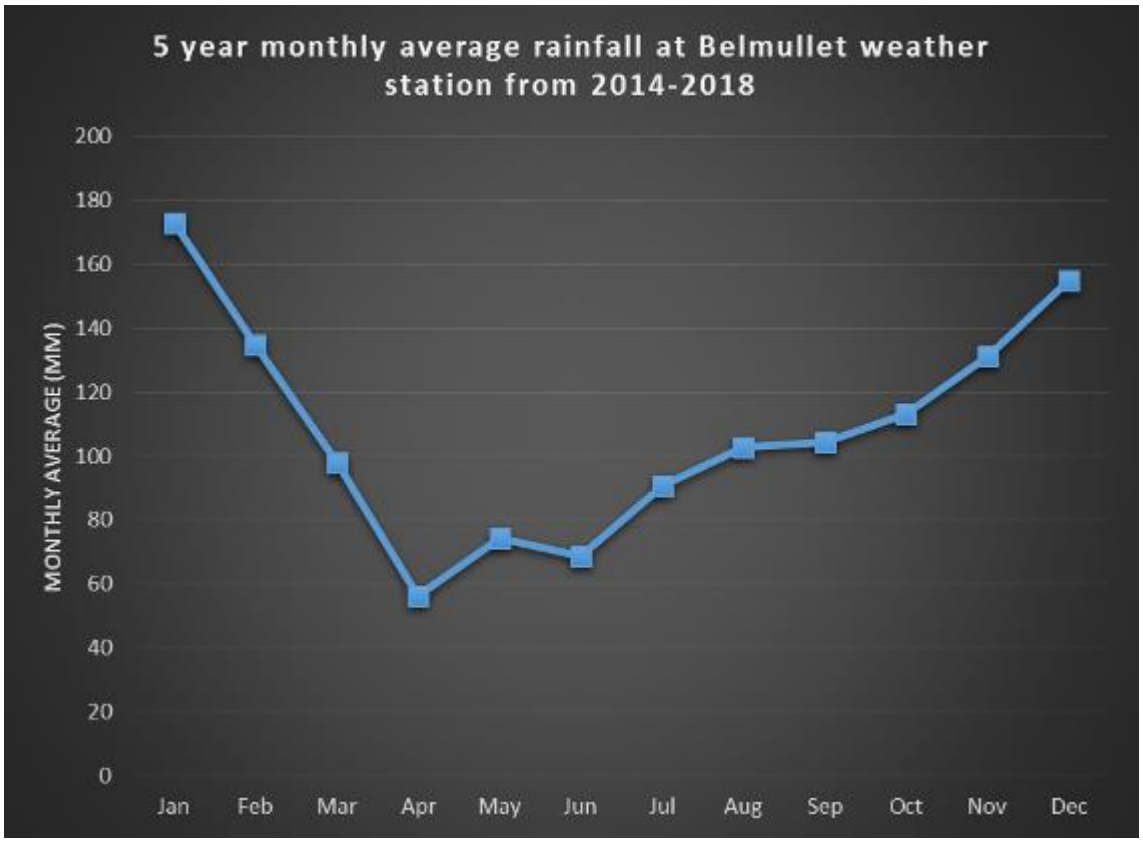


Figure 7.10: 5 year monthly average rainfall (mm) at Belmullet weather station from 2014-2018 (Source: Met Eireann, 2019d).

7.7. Salinity

The Blacksod Bay production area has a stable salinity due to its open connection to the open Ooean and low level of freshwater influence. The salinity is effected by the stage of the tide and the level of freshwater influence from the catchment. The salinity in the inner bay in Trawmore Bay can vary from 32 to 35 PSU, while in the outer bay near Blacksod Point salinity can range from 33 to 34 PSU (Marine, 2020).

7.8. Turbidity

The turbidity of Blacksod Bay can vary significantly depending on the tide, levels of freshwater input and weather conditions. Turbidity at Trawmore Bay can range from 0 to 110.7 NTU, with an average turbidity of 14.35NTU. (Marine, 2020).

7.9. Residence Time

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 currents within the bay are dominated by the shallow bathymetry and generally flow parallel to the channel.

At the time of writing there were no data available on the residence time of Blacksod Bay. However, as the bay has a relatively high tidal range (1.5m neaps -3.5 springs) and a large connection with the Open Ocean (4.5km), the residence time is considered to be relatively short.

7.10. Discussion

Blacksod Bay is a large shallow bay with large areas of mudflat and sandflats along the shore and particularly the inner bay inside of Cleggan Point. Depths in the bay range from 0 to 17m with depths increasing from the shore and out towards the mouth of the bay. The main direction of water flow is to the south during the mid-ebb period. Current flows during a flooding tide are mainly northerly in direction. There are relatively low Freshwater inputs to the bay due to the small catchment size relative to the size of the bay. The salinity in the inner bay can vary from 32 to 35 PSU, while in the outer bay near Blacksod Point salinity can range from 33 to 34 PSU.

8. Appendix 3: Shellfish and Water Sampling

8.1. Historical Data

8.1.1. Shellfish Water Quality

The Marine Institute carries out quarterly water quality monitoring as part of the Shellfish Waters Directive in Blacksod Bay. 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.

8.1.2. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and the subsequent implementing regulation (EU) 2017/627 the Sea Fishery Protection Authority is required to classify bivalve mollusc production areas and to fix the boundaries thereof. The process involves regular sampling of shellfish from each area to be classified in order to establish levels of microbiological contamination which subsequently determines which classification should be awarded for that particular area. The SFPA currently sample shellfish flesh at one location in the Blacksod Bay production area for classification purposes. Figure 8.1 shows this location of this sampling site Table 8.1 shows the coordinates.

Table 8.1: Coordinates of sampling sites within the Blacksod Bay Production Area.

Sample Code	Species	Latitude	Longitude
MO-BB-EB	Native Oysters	54.154777	-10.06153

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

An A classification allows for the product to be placed directly on the market, whereas a B or C classification requires the product to go through a process of depuration, heat treatment or relaying before it can be placed on the market. Table 8.2 summarises this system. Table 8.3 shows the current and historical (back to 2014) classifications within Blacksod Bay. For the 2018-2019 period, Blacksod Bay is classified as A for Oysters.

Table 8.2: Classification system for shellfish harvesting areas.

Classification			Permitted Levels	Outcome
	A	<230	Not exceeding 230 *E. coli* 100g flesh/liquid in 80% of samples. Not exceeding 700 *E.coli* 100 g in remaining 20% of samples	May go direct for human consumption if end product standard met.
	B	<4600	Not exceeding 4,600 *E. coli* 100g flesh/liquid in 90% of samples. Not exceeding 46,000 *E.coli* 100 in remaining 10% of samples	Must be subject to purification, relaying in Class A area (to meet Category A requirements) or cooked by an approved method.
	C	<46000	Not exceeding 46,000 *E.coli* 100g flesh in all samples	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

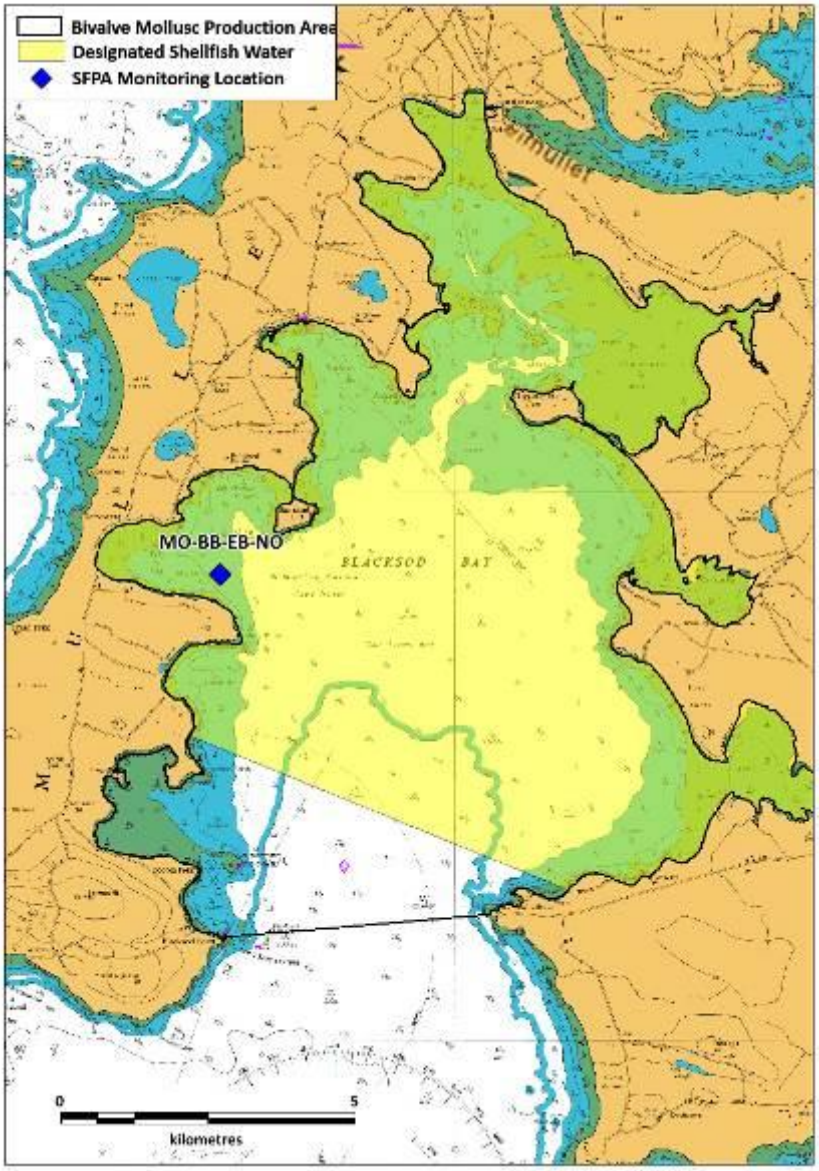


Figure 8.1: Locations of SFPA shellfish monitoring points for classification purposes.

Table 8.3: Current and historical classification of shellfish beds in Blacksod Bay (2014 – 2020).

Boundaries	Bed Name	Species	Classification					
			2014	2015	2016	2017	2018	2019
Blacksod Point to Kanfinalta Point	All Beds	Oysters	A*	A**	A**	A**	A#	A

*Seasonal Classification 01 Jan – 01 Oct reverts to Class B at other times.

**Seasonal Classification 01 Jan – 01 Sept reverts to Class B at other times.

#Seasonal Classification 01 Dec – 01 Sept reverts to Class B at other times.

Table 8.4 list the *E. coli* results for native oysters in Blacksod Bay from January 2017 to December 2019. Figure 8.2 shows these data in graphical form.

As shown in Table 8.3 above, Blacksod Bay has had an **A** classification for Native oysters from 2014 to 2019, with seasonal classifications being in place from 2014 to 2018. The monthly classification trends for native oysters can be seen in Table 8.4 and Figure 8.2.

Table 8.5 shows the summary statistics for the *E. coli* historical data from the native oyster monitoring site from 2017 to 2019. Table 8.6 shows the variations of the annual geometric means of *E. coli* for the native oyster beds from the year 2017 to 2019. Figure 8.3 shows the trend in geometric mean from 2017 to 2019 for native oysters in Blacksod Bay. The geometric mean ranged from 20.2 MPN/100ml in 2017 to 31.2 MPN/100ml in 2018.

There were no statistical differences between the oyster *E. coli* results between season (one-way ANOVA, p = 0.5846, Appendix 4).

Table 8.4: *E. coli* results from Blacksod Bay Native Oysters from January 2017 to December 2020 (Source: SFPA).

Date	MPN *E. coli* /100g	Category
11-Jan-17	18	A
14-Feb-17	18	A
27-Mar-17	18	A
24-Apr-17	18	A
23-May-17	20	A
19-Jun-17	18	A
30-Jul-17	18	A
8-Nov-17	18	A
7-Dec-17	45	A
16-Jan-18	230	A
21-Feb-18	18	A
22-Mar-18	78	A
25-Apr-18	18	A
23-May-18	20	A
21-Jun-18	78	A
12-Jul-18	18	A
28-Aug-18	18	A
27-Sep-18	18	A
24-Oct-18	20	A
28-Nov-18	45	A
10-Dec-18	18	A

Date	MPN *E. coli* /100g	Category
10-Jan-19	110	A
25-Feb-19	18	A
25-Mar-19	18	A
20-May-19	18	A
10-Jun-19	18	A
1-Jul-19	20	A
20-Aug-19	18	A
24-Sep-19	18	A
31-Oct-19	20	A
19-Nov-19	45	A
16-Dec-19	18	A

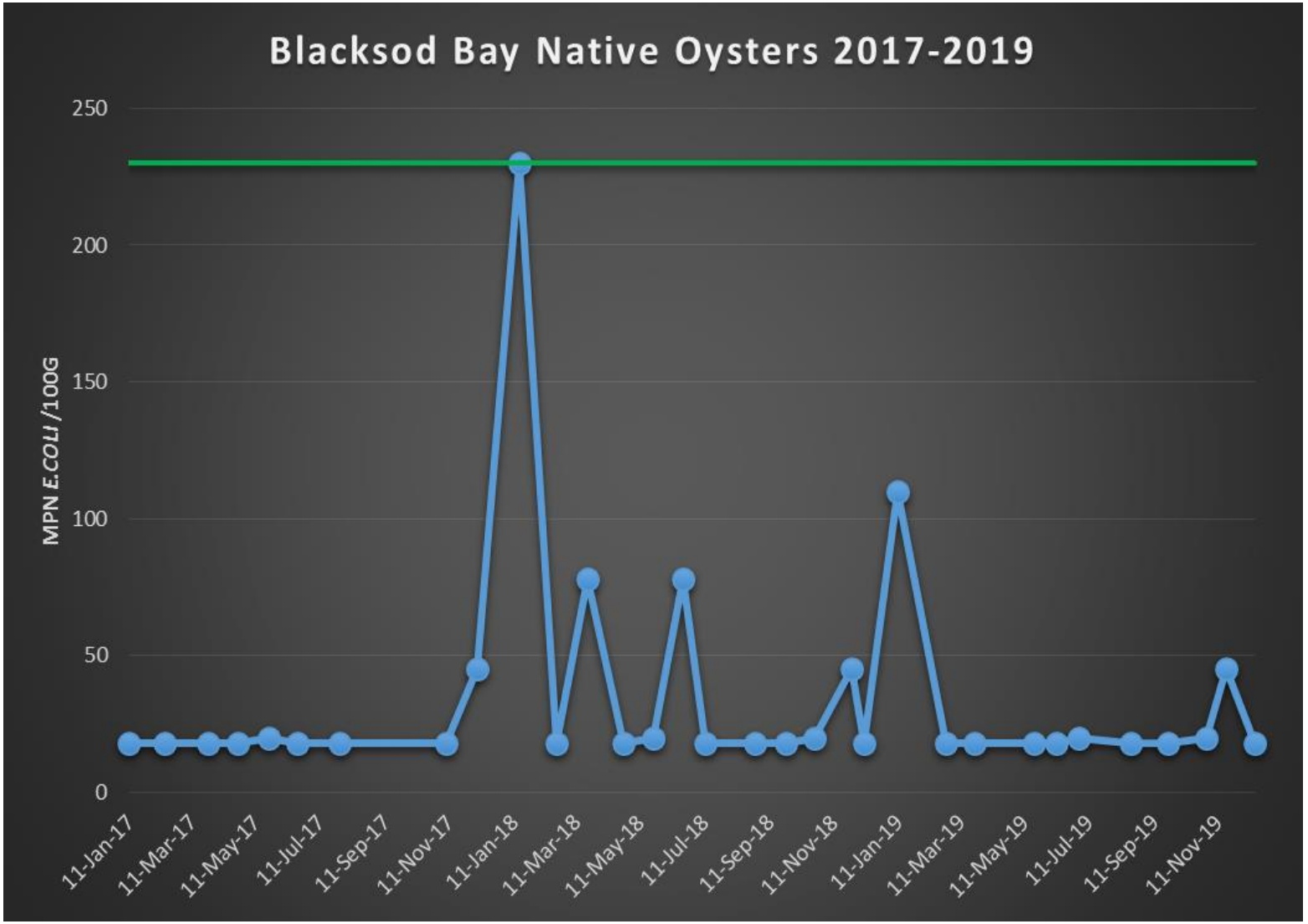


Figure 8.2: *E*. coli results from Native Oysters at Blacksod Bay from January 2017 to December 2019 (Source: SFPA).

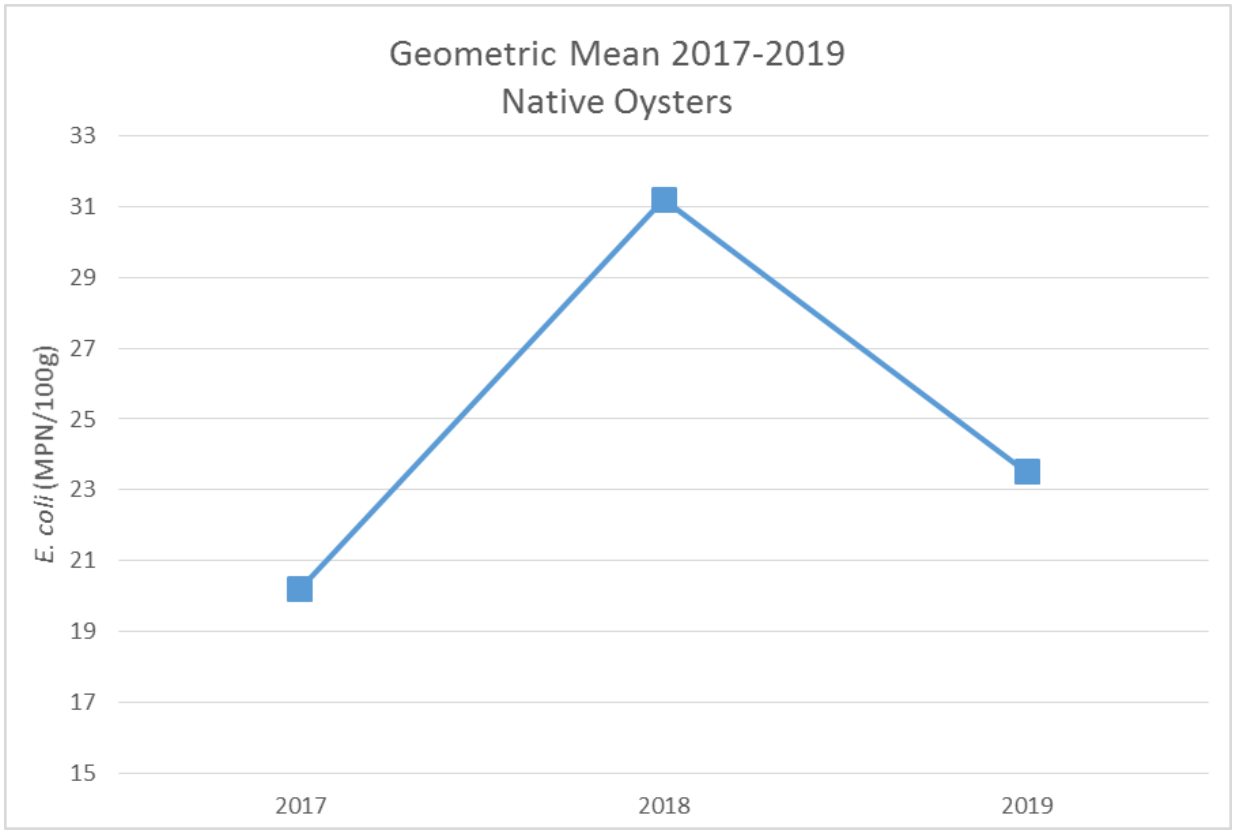


Figure 8.3: Trend in geometric mean of *E. coli* levels from 2017 to 2019 for Native Oysters in Blacksod Bay.

Table 8.5: Summary statistics of historical *E. coli* data monitored from shellfish beds in Blacksod 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)
MO-BB-EB	Native Oyster	11/01/2017	16/12/2019	18	230	18	25

Table 8.6: Variation of annual geometric means of *E. coli* (MPN/100g) from shellfish beds monitored in Blacksod Bay.

Code	Species	2017	2018	2019
MO-BB-EB	Native Oyster	20.2	31.2	23.5

In addition to *E. coli* monitoring carried out by SFPA, the Marine Institute (MI) conducts monthly monitoring for the presence of toxin producing phytoplankton in shellfish waters, including *Alexandrium* spp and *Dinophysis* spp and for marine biotoxins (including DSP, PSP and ASP) in shellfish flesh. The MI also monitors shellfish flesh for chemical contaminants *e.g.* heavy metals, organochlorides, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), pentachlorophenol (PCP) and Tributyl Tin Oxide (TBTO).

Over the period 2014 to 2018, there have been 19 biotoxin related closures.

8.1.3. Norovirus (NoV)

Currently there are no available data to indicate the presence or levels of norovirus contamination of shellfish in the Blacksod Bay classified production area. From evidence of other production areas in Ireland and due to the presence of waste water outflows and storm water discharges entering the area it can be reasonably expected that norovirus will be present in shellfish in Blacksod Bay.

8.2. Current Data

8.2.1. Sampling Sites & Methodology

Thirteen water sampling sites were sampled within the Blacksod Bay BMCPA between June and July 2020. The locations of these sites can be seen in Figure 8.4**Error! Reference source not found.** and Table 8.7 shows the station coordinates.

Seven stations were sampled on the 30th June 2020 (Stations 1 -7), there was 22.4 mm of rain over the previous 48 hours. Six stations were sampled on the 8th July 2020 (Stations 8-13), there was 2.9 mm of rain over the previous 48 hours.

Table 8.7: Water sample coordinates with date of sampling.

Station	Feature	Latitude	Longitude	Easting	Northing	Sampling Date
1	Concrete drainage pipe	54.1645	-10.07257	64679.79	325926.01	30/06/2020
2	Outflow of lagoon	54.16951	-10.0649	65196.99	326468.90	30/06/2020
3	An Geata Mor - stream	54.21441	-10.02529	67926.79	331391.01	30/06/2020
4	Culvert	54.22666	-10.01362	68726.88	332732.57	30/06/2020
5	Pump Station Stream	54.2274	-9.99284	70084.26	332776.47	30/06/2020
6	Channel in Belmullet	54.22544	-9.99228	70114.62	332557.31	30/06/2020
7	Stream below school	54.21211	-9.98352	70644.19	331057.69	30/06/2020
8	Drain	54.20294	-9.96356	71917.85	330000.74	08/07/2020
9	Concrete drainage pipe	54.20029	-9.95984	72152.38	329699.06	08/07/2020
10	Saltwater channel	54.19344	-9.93174	73,965.18	328,886.62	08/07/2020
11	Belmullet Channel on ebb tide	54.22549	-9.991749			08/07/2020
12	Stone sluice at slipway	54.22811	-9.996425			08/07/2020
13	River running into bay	54.15473	-9.921264			08/07/2020

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

8.2.2. Microbial Analysis Results

Table 8.8 shows the water sample analysis results and Figure 7.4 shows the magnitude of the *E. coli* results. The two highest *E. coli* result was record in the inner bay one in a stream below a school in Belmullet Town and the other from a sluice at a slip just west of the town. However, the two lowest results were recorded less than 2km to the east. The next two highest results were both recorded in Elly harbour.

Table 8.8: Water *E. coli* results for Blacksod Bay.

Station No.	*E. coli* (cfu/ 100ml)
1	2400
2	1500
3	445
4	400
5	650
6	220
7	3900
8	80
9	170
10	480
11	25
12	2900
13	10

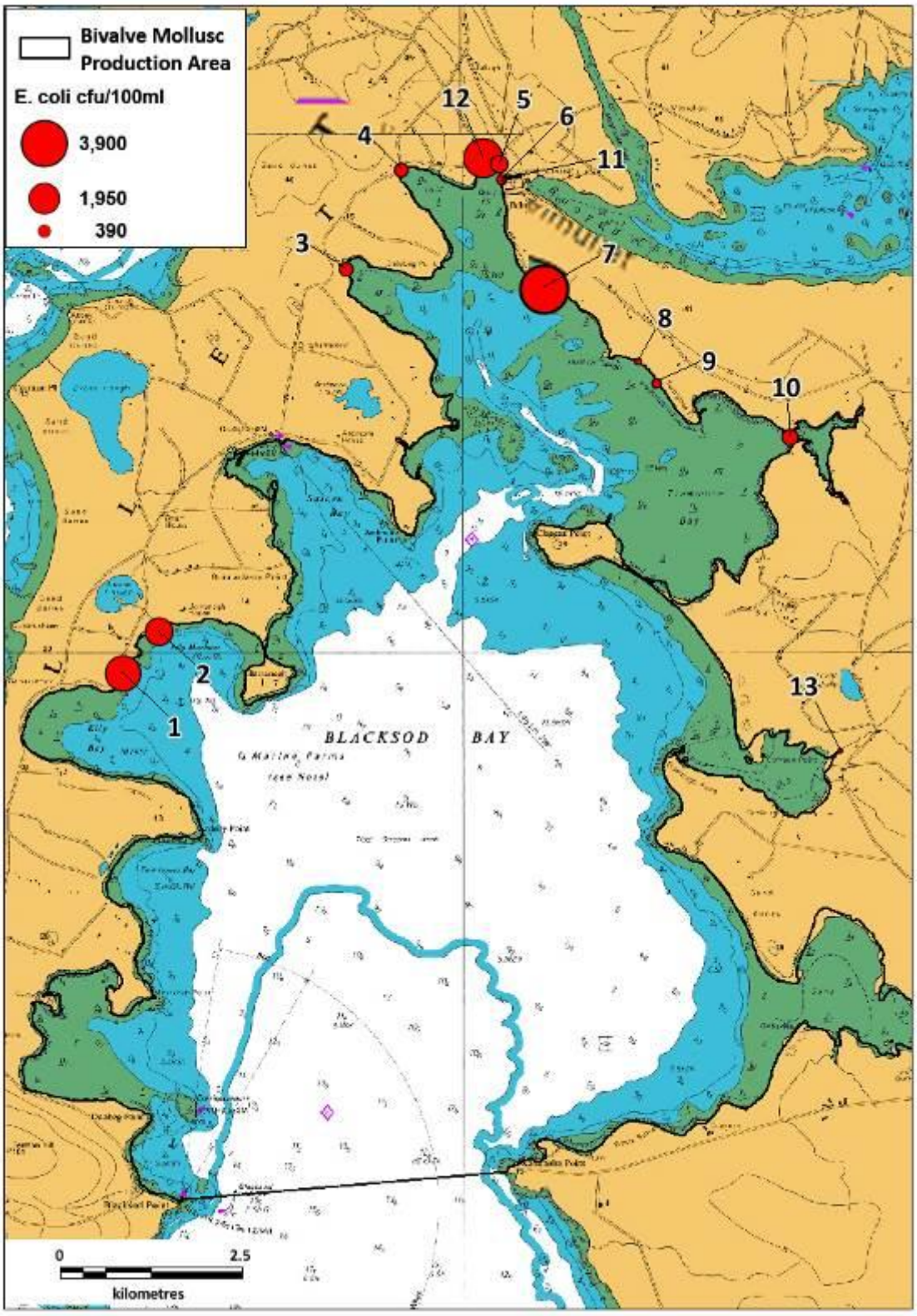


Figure 8.4: Location and magnitude of *E. coli* results from the shore survey.

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.

AQUAFACT. 2005. Environmental and Hydrographic Survey of the Marine Environment, Belmullet, Co. Mayo. January 2005.

BWI. 2019. Site Summary Table for 0C492 Inishbofin. https://f1.caspio.com/dp/f4db3000060acbd80db9403f857c Accessed December 2019.

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.

DAFM. 2019. Licenced Aquaculture Sites. March 2019.

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

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

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

EPA. 2019d. 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

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

IFI. 2020. Sea Fishing. Northwestern Regional Fisheries Board.
https://fishinginireland.info/sea/northwest/belmullet/

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.

Lisle, J.T., Smith, J.J., Edwards, D.D. & G.A. McFeters. 2004. Occurrence of Microbial Indicator and *Clostridium perfringens* in Wastewater, Water Column Samples, Sediments, Drinking Water, and Weddell Seal Feces Collected at McMurdo Station, Antarctica. *Appl. Environ. Microbiol.* **70(12):** 7269–7276.

Marine Institute. 2015. Article 6.2 (Habitats Directive) Risk Assessment. The effects of fisheries on Qualifying Interests in Special Areas of Conservation in Irish coastal waters. Marine Institute, July 2015.

Met Eireann. 2019a. Historical Data Belmullet 2014-2018. https://www.met.ie/climate/available-data/historical-data Accessed October 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. return period rainfall depths for sliding durations (066670E; 325851N). https://www.met.ie/cms/assets/uploads/2020/01/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf.

NPWS. 2013. Mullet/Blacksod Bay Complex SAC (Site Code: IE000470) Site Synopsis https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY000470.pdf

NPWS. 2013. Blacksod Bay/Broad Haven Bay SPA (Site Code: IE004037) Site Synopsis. https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004037.pdf

NPWS. 2014. Mullet Peninsula SPA (Site Code: IE004227) Site Synopsis. https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004227.pdf

NPWS. 2014. Duvillaun Islands SPA (Site Code: IE004111) Site Synopsis. https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004111.pdf

NPWS. 2015. Termoncarragh Lake and Annagh Machair SPA (Site Code: IE004093) Site Synopsis. https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004093.pdf

NPWS. 2014. Inishglora and Inishkeeragh SPA (Site Code: IE004084) Site Synopsis. https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004084.pdf

NPWS. 2015. Inishkea Islands SPA (Site Code: IE004004) Site Synopsis. https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004004.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.

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

Perry, F., Jackson, A. & Garrard, S. L. 2017. Ostrea edulis Native oyster. 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 03-02-2020]. Available from: https://www.marlin.ac.uk/species/detail/1146

SFPA. 2017. Code of Practice for the Microbiological Monitoring of Bivalve Mollusc Production Areas. Version 6 May 2017. pp. 42.

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.

Appendix 4

Statistical Analysis

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Spring	8	10.93583	1.366979	0.046359
Summer	8	10.89237	1.361546	0.047151
Autumn	7	9.806215	1.400888	0.03238
Winter	9	13.74421	1.527135	0.169596

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.155565	3	0.051855	0.658292	0.584589	2.946685
Within Groups	2.205615	28	0.078772			
Total	2.36118	31				

Appendix 5

Shoreline Survey Images


1


2


3


4


5


6


7


8


9


10


11


12


13


14


15


16


17


18


19


20


21


22


23


24


25


26


27


28


29


31


32


33


34


35


36


37


38

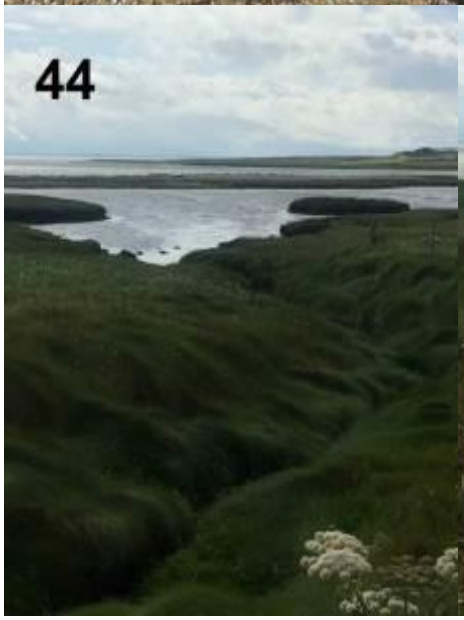

39


40


41


42


43


44

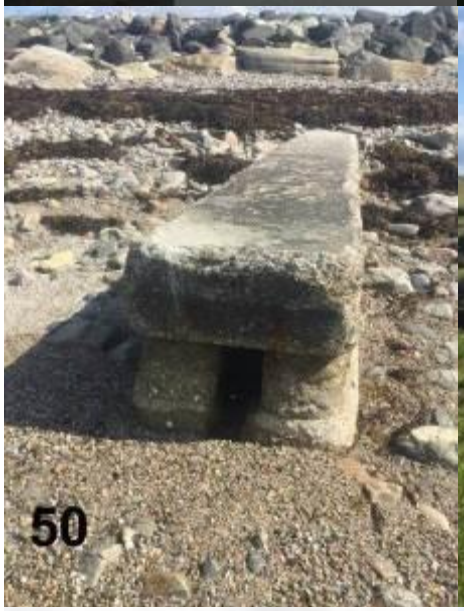

45


46


47


48


49


50


51


52


53


54


55


56


57


58


59


60


61


62


63


64


65


66


67


68


69


70


71


72


73


74


75


76


77


78

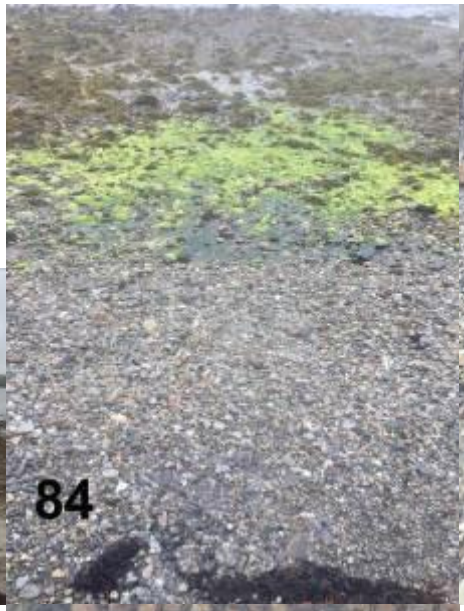

79


80


81


82

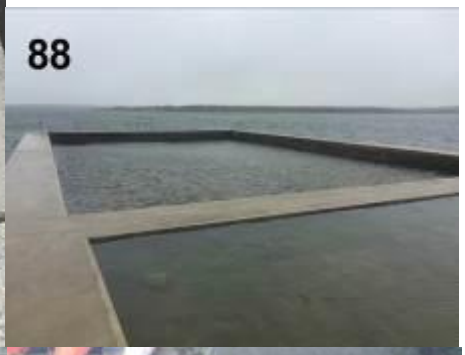

83


84


85


87


86


88


89


90


91


92


93


94


95


96


97


98


99


101


102


103


104


105


106


108


109


110


111


112


113


114


115


116


117


118


119


120


121


122


123


124


125


126


127


128


129


130

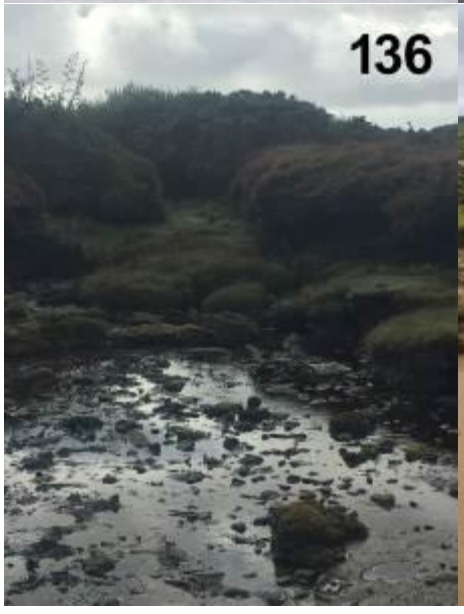

131


132


134


133


135


136


137


138


139


140


141


142


143


144


145

Appendix 6

Species Specifc RMPs

Blacksod Bay

Bivalve Mollusc Classified Production Area

Native Oyster Monitoring Information

Site Name: Blacksod Bay

Site Identifier: MO-BB-BT-NO

Monitoring Point Coordinates

Latitude: 54.2062 **Longitude:** -10.0002

Species: *Ostrea edulis*

Sample Depth: Sea bed **Sample Frequency:** Frequency dependant on fishery opening

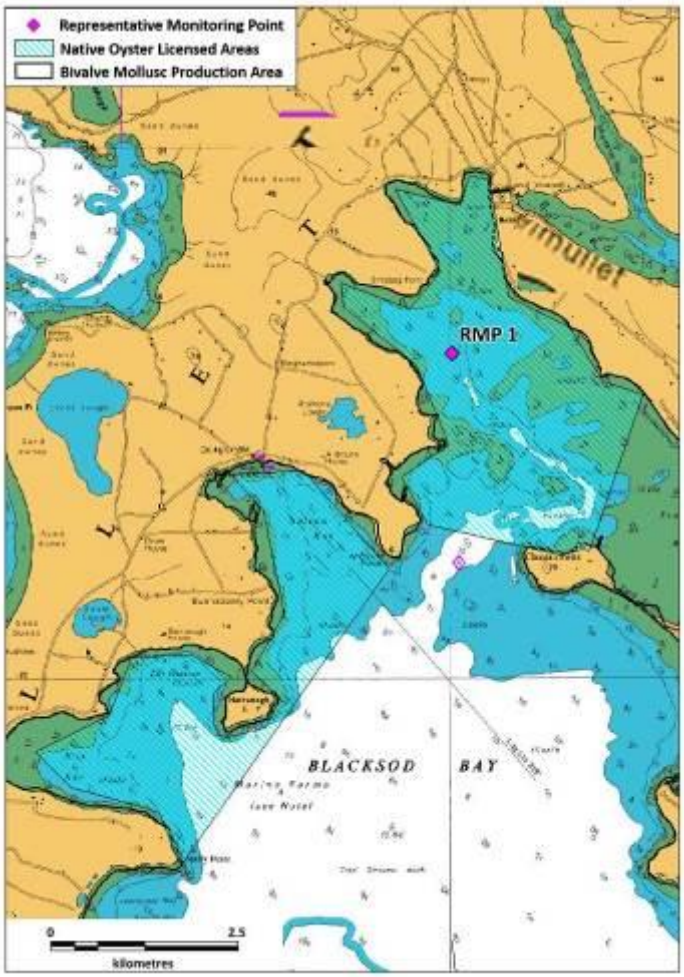
Responsible Authority: Sea Fisheries Protection Authority

Authorised Samplers: SFPA Port Office Killybegs

Maximum Allowed Distance from Sampling Point: The sample must be taken from within 250m of the sampling point.

Sampling Size: Minimum 10 market sized animals

Sampling Method: Taken from oyster dredge



Blacksod Bay

Bivalve Mollusc Classified Production Area

Pacific Oyster Monitoring Information

Site Name: Blacksod Bay

Site Identifier: MO-BB-BT-PO

Monitoring Point Coordinates

Latitude: 54.1522 **Longitude:** -9.9465

Species: *Crassostrea gigas*

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

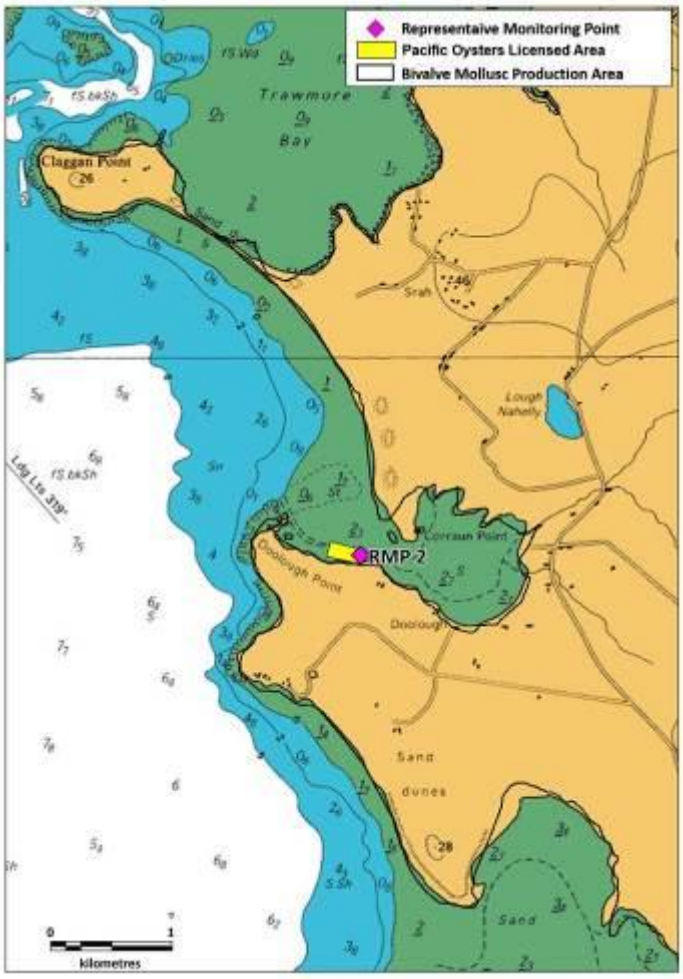
Responsible Authority: Sea Fisheries Protection Authority

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



Blacksod Bay

Bivalve Mollusc Classified Production Area

Razor Clams Monitoring Information

Site Name: Blacksod Bay

Site Identifier: MO-BB-BT-RAZ

Monitoring Point Coordinates

Latitude: 54.1214 **Longitude:** -9.9792

Species: *Ensis arcuatus, E. siliqua*

Sample Depth: Sea bed **Sample Frequency:** Frequency dependant on fishery opening

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 250m of the sampling point.

Sampling Size: Minimum 10 market sized animals

Sampling Method: Taken from dredge at point