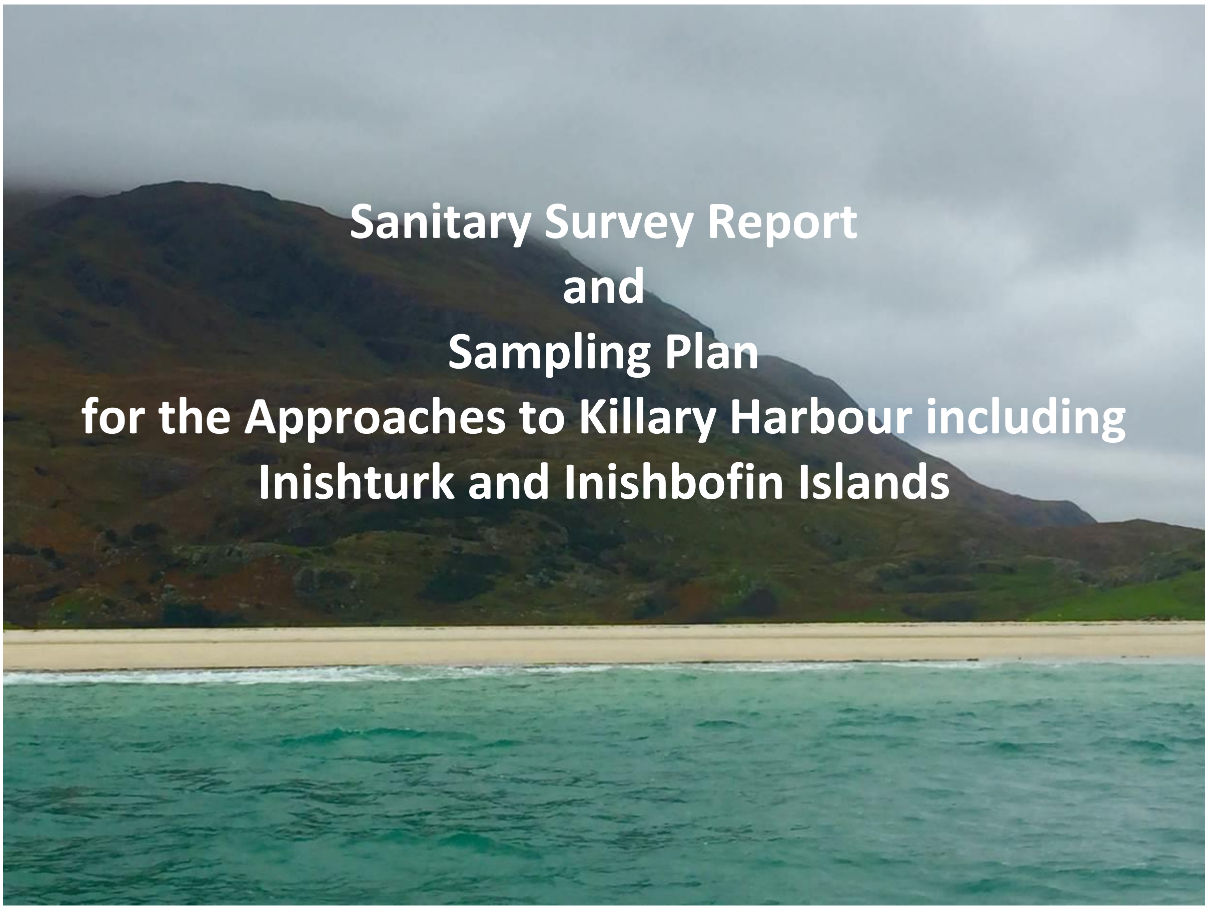


Sanitary Survey Report
and
Sampling Plan
for the Approaches to Killary Harbour including Inishturk and Inishbofin Islands

Produced by

AQUAFACT International Services Ltd

On behalf of

The Sea Fisheries Protection Authority
May 2019

AQUAFACT INTERNATIONAL SERVICES Ltd
12 KILKERRIN PARK, LIOSBAUN,
TUAM RD, GALWAY CITY
H91 FW7V
www.aquafact.ie
info@aquafact.ie
tel +353 (0) 91 756812
fax +353 (0) 91 756888

Report Approval Sheet

Client	Sea Fisheries Protection Authority
Report Title	Sanitary Survey Report and Sampling Plan for the Approaches to Killary Harbour including Inishturk and Inishbofin Islands
Job Number	JN1520
Report Status	Final
Issue Date	22.05.2019

Rev	Status	Issue Date	Document File Name	Author (s)	Approved by:
1	Draft	10.04.19	JN1520 Killary Sanitary Survey Final Report DRAFT	C. Roche	Brendan O'Connor
2	Final	20.5.19	JN1520 Killary Sanitary Survey Final Report	C. Roche	Brendan O'Connor
3	Final Rev1	22.5.19	JN1520 Killary Sanitary Survey Final Report	C. Roche	Brendan O'Connor

AQUAFACT

Table of Contents

List of Figures

List of Tables

List of Appendices

Glossary

BMPA	Bivalve Mollusc Production Area
BOD	Biochemical Oxygen Demand
CD	Chart Datum
CFU	Colony Forming Unit
CSO	Central Statistics Office
ED	Electoral Divisions
Depuration	The process of purification or removal of impurities
DWF	Dry Weather Flow
EC	European Communities
E. coli	*Escherichia coli*
Fetch	The distance a wave can travel towards land without being blocked
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
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
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.
MPN	Most Probable Number
MSD	Marine Sanitation Device
NAP	Nitrates Action Programme
NoV	Norovirus
NRL	National Reference Laboratory

OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
Pathogenic	Capable of causing disease
p.e.	Population Equivalent
Plankton/Planktonic	Pertaining to small, free-floating organisms of aquatic systems
PSU	Practical Salinity Units
Regulation (EC) 854/2004	REGULATION (EC) No 854/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SFPA	Sea Fisheries Protection Authority
SPA	Special Protection Area
SS	Suspended Solids
STW	Sewage Treatment Works
Suspension feeders	Animals that feed on small particles suspended in water
UKAS	United Kingdom Accreditation Service
UKHO	United Kingdom Hydrographic Office
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant
WWTW	Waste Water Treatment Works

1. Executive Summary

Under Regulation (EC) 854/2004, there is a requirement for competent authorities intending to classify bivalve production and relaying areas to undertake a sanitary survey. The purpose of this is to inform the sampling plan for the Official Control Microbiological Monitoring Programme, the results of which determine the annual classification for bivalve mollusc production areas. Other wider benefits of sanitary surveys include the potential to improve the identification of pollution events and the sources of those events so that in the future remedial action can be taken to the benefit of the fisheries in the area.

Killary Approaches proposed Bivalve Mollusc Production Area (BMPA) is located outside Killary Harbour, along the western coast of Ireland between Co. Galway and Co. Mayo. The 251.6km^2 open expanse of water meets the coastline of Co. Mayo and Co. Galway to the east and encompasses the islands of Inishturk, Inishbofin and Inishshark to the west. Water depths range from <1m in the shallow subtidal coastal areas to a maximum of *c.* 62m towards the western edge. The sediment type varies from hard rocky ground to coarse sand and sandy mud/muddy sand areas which form deep mounds and furrows in the more exposed areas. The site supports breeding seabird and grey seal populations and the site has been proposed as a BMPA due to its populations of razor clams (*Ensis* spp.).

This report attempts to document and quantify all known sources of pollution to the waterbody. It was concluded that the main sources of pollution in Killary Approaches BMPA comes from direct sewage discharges from one off domestic housing and from livestock. There are also some seasonal contributions from wildfowl, grey seals, boats (shipping and recreational activity) and tourism.

Due to oceanographic conditions that operate in this shellfish production area and largest volumes of freshwater entering it, the most likely location where water quality might be compromised is to the northwest of the mouth of Killary Harbour. For this reason, it is entirely appropriate that the RMP is located in that area. The razors sampled at this location will be representative of the razors further west towards Inishturk and Inishbofin. It is also entirely appropriate that the full area be treated as one Production Area.

2. Overview of the Fishery/Production Area

2.1. *Location/Extent of Growing/Harvesting Area*

The proposed Bivalve Mollusc Production Area (BMPA) for Killary Harbour Approaches including Inishturk and Inishbofin Islands cover an area of approximately 252km^2 and can be seen in Figure 2.1. Razor clam beds are present within the waterbody but at present the site is not designated as a bivalve mollusc production area, it is not classified and no shellfish aquaculture licences have been issued for the site.

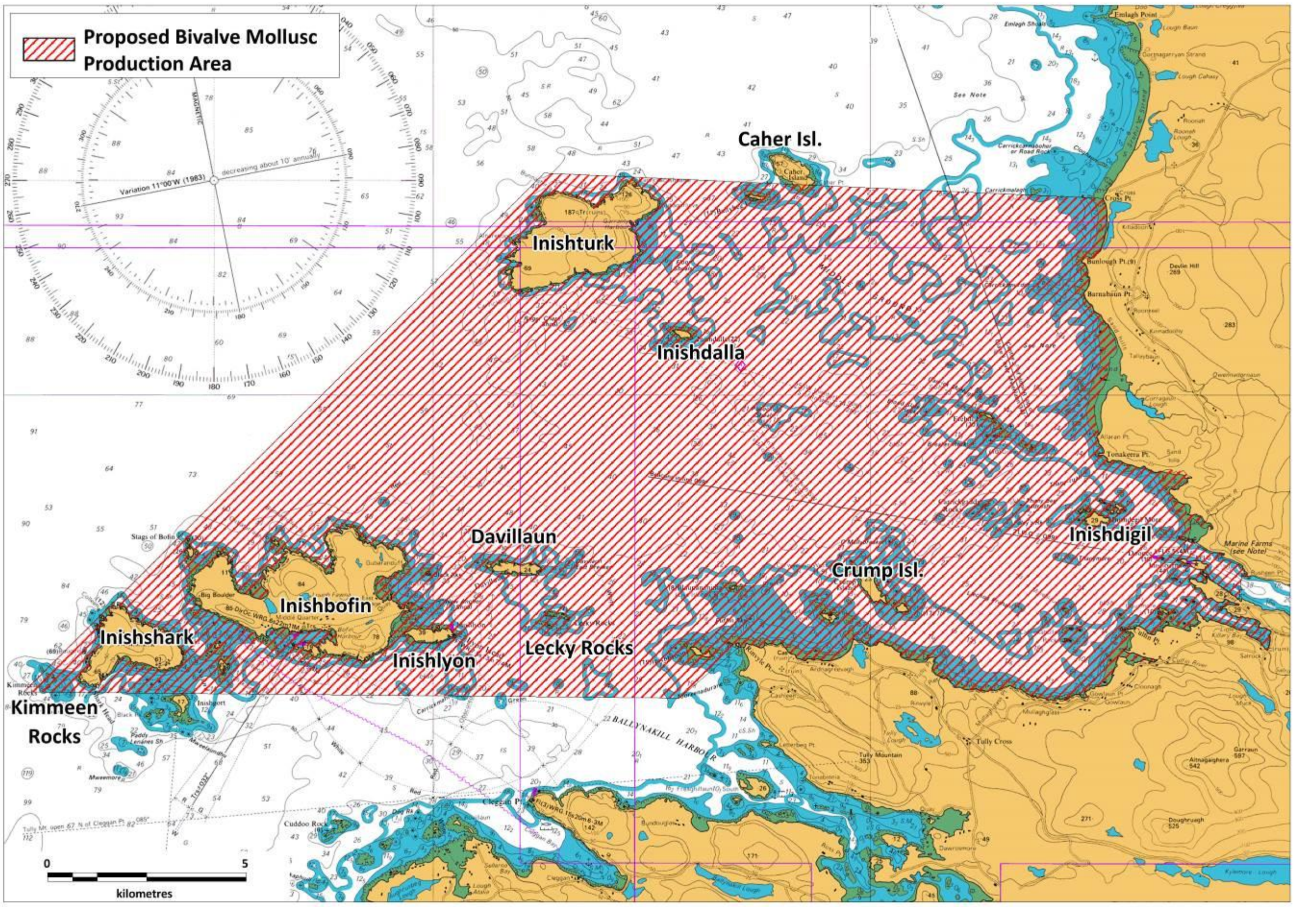


Figure 2.1: Extent of the proposed Killary Harbour Approaches bivalve mollusc production area.

2.2. *Description of the Area*

Killary Approaches proposed Bivalve Mollusc Production Area (BMPA) is located outside Killary Harbour, along the western coast of Ireland between Co. Galway and Co. Mayo. The 252km^2 open expanse of water meets the coastline of Co. Mayo and Co. Galway to the east and encompasses the islands of Inishturk, Inishbofin and

Inishshark to the west.

The area is approximately 30km E-W at its widest point and approximately 13km N-S. The catchment area of the proposed BMPA is 106.2km^2 and the main freshwater source from this catchment is the Culfin River on the south coast. Killary Harbour is located immediately to the southeast of the proposed BMPA and there is an exchange of water between the two. The Killary Harbour catchment area covers 261km^2 and the main freshwater sources into Killary Harbour are the Erriff and Bundorragha from Mayo on the north shore, and the Bunowen from Galway on the south shore.

Water depths in the proposed BMPA range from <1m in the shallow subtidal coastal areas to a maximum of *c.* 62m towards the western edge. The sediment type in the proposed BMPA varies from hard rocky ground to coarse sand and sandy mud/muddy sand areas. The sandy seabed in the more exposed areas form deep mounds and furrows and the rocky reef habitat was characterised by the spiny starfish *Marthasterias glacilis*, the common sea urchin *Echinus esculentus*, the cotton spinner sea cucumber *Holothuria forskali* and the sponge *Cliona celata* (AQUAFACT, 1999).

The islands of Inishbofin, Inishshark, Inishlyon, Davillaun, Kimmeen Rocks and Lecky Rocks are designated as a Special Area of Conservation (SAC); Inishbofin and Inishshark SAC (Site Code: IE000278) (see Figure 2.2). In addition to being designated for heath and freshwater habitats, the site is protected for coastal lagoon (Lough Bofin on Inishbofin) and sea cliff habitat (NPWS, 2013). The site is not designated for any marine habitat but it is designated for grey seals. Grey seals breed on Inishshark, Davillaun, Inishskinnybeg and Inishskinnymore, they moult on Inishshark and Lecky Rocks and they rest on Inishshark, Lecky Rocks, Kimmeen Rocks and Inishskinnymore.

A large portion of the proposed BMPA is designated as a SAC; the West Connacht Coast SAC (Site Code: 002998). This SAC is designated for the protection of bottle nose dolphins *Tursiops truncatus* and the site consists of a substantial area of marine waters from Erris Head, Co. Mayo to Knock Point, Co. Galway (see Figure 2.2). In the proposed BMPA the SAC is mostly inshore of the main islands of Inishturk, Inishbofin and Inishshark. The site encompasses a diverse range of shallow marine habitats occurring in waters < 100 m deep e.g. reefs, islets and sedimentary basins (NPWS, 2014a). The site contains physical and hydrographic features which include shallow coastal bays, areas of steep seafloor topography and complex areas of strong current flow adjacent to estuaries, coastal headlands and islands, sandbanks, shoals and reefs all of which are believed to be important for bottle nosed dolphins. The species are present throughout the year and the sighting records of bottle nose dolphins in the SAC are significant for the west coast of Ireland and indicate widespread use of the area by individual groups of dolphins. Groups are known to alter their composition or to aggregate together within the site and comparatively high group sizes of up to 50-65 individual dolphins or more have been recorded in the site’s northern and southern components. Adults closely accompanying calves are commonly observed in summer and autumn months at a number of locations within the site, and group foraging, resting or social behaviour are also regularly recorded. Individual dolphins are also known to recur within and between years at key locations within the site (e.g., outer Killary Harbour, off the Mullet Peninsula), indicating a degree of site fidelity to its coastal waters.

The proposed BMPA also overlaps a Special Protection Area (SPA): High Island, Inishshark and Davillaun SPA (IE004144) which covers Inishshark, Kimmeen Rocks, Davillaun and Lecky Rocks (see Figure 2.2). The site supports breeding Manx Shearwater (200-300 pairs) and wintering Barnacle Goose (up to 640 individuals), the latter a species that is listed on Annex I of the E.U. Birds Directive (NPWS, 2013). Nationally important numbers of Fulmar (824 pairs) and smaller numbers of other breeding birds including Kittiwake (230 pairs), Shag (30 pairs), Herring Gull (18 pairs), Common Gull (13 pairs) and Storm Petrel (> 30 pairs) (NPWS, 2010; 2013). A pair of Peregrine has nested for many years, while small numbers of Chough breed and forage on the main islands. Corncrake was once abundant on the islands but declined in the 1960s until the early 1990s when none was recorded. More recently, however, the species has been recorded from the site – 1996, 1997 (two singing males) and 2003. In 1995, a survey recorded nationally important numbers of Arctic Tern (64 pairs). Other breeding birds recorded from the site include Black Guillemot.

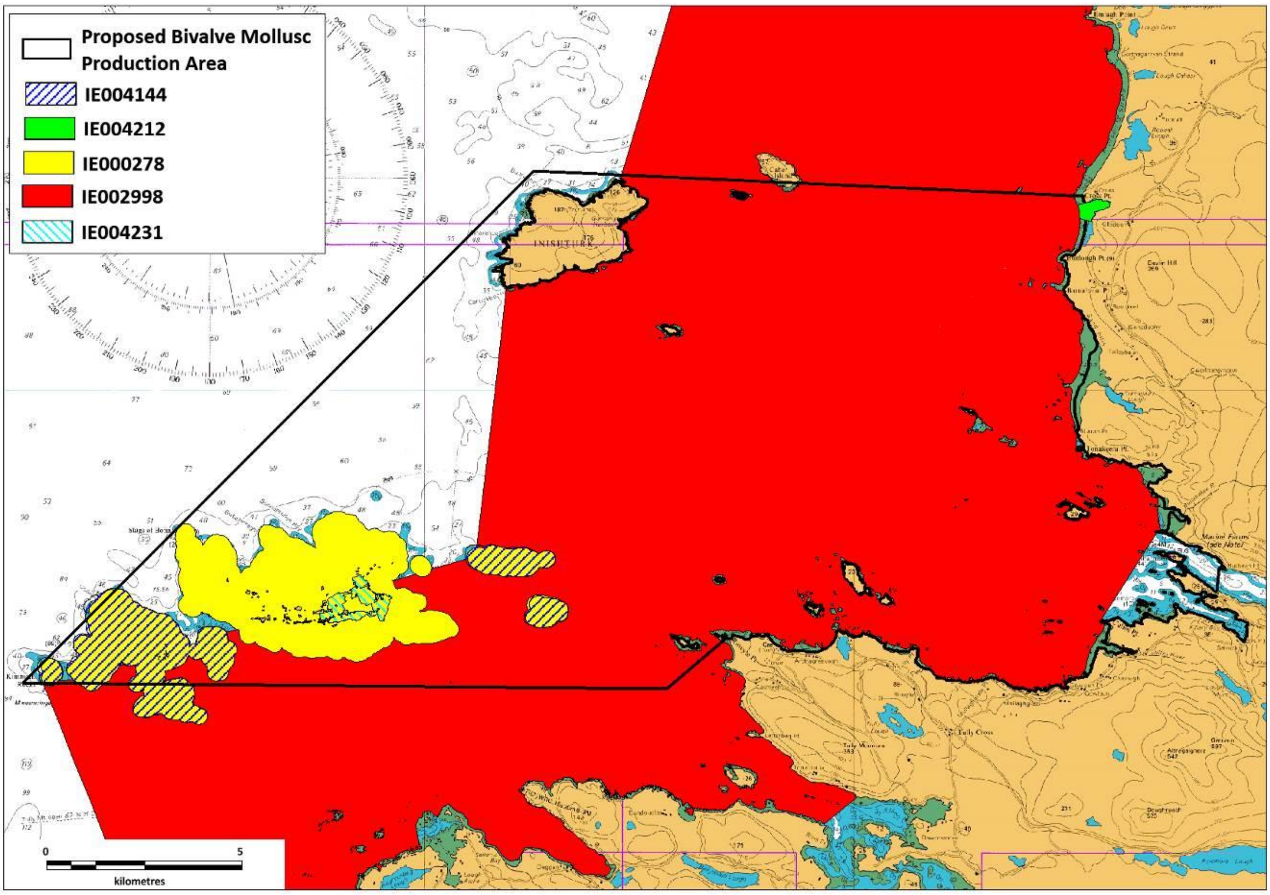


Figure 2.2: Location of Natura 2000 sites overlapping with the proposed BMPA.

The proposed Killary Approaches BMPA supports a wide diversity of fish species. Species present include pollack, mackerel, wrasse, conger, plaice, ray, dog fish, spurdog, ling, gurnet, brill, turbot, mullet, dab, megrim, black sole, lemon sole, sand sole, monkfish, whiting, and cod (IFI, 2019). Six vessels operate in the area for brown crab (Marine Institute, 2015). Two vessels operate during the summer months in the proposed BMPA area using bottom trawls for mixed demersal species and 1 vessel operates in Killary Harbour. There is also a tangle net fishery for crayfish around Inishbofin and Inishturk between April and September. The number of vessels involved in this is unknown. While the Marine Institute (2015) show a dredge fishery for razors clams and scallops in the area, this fishery is not active. There is periwinkle harvesting at 3 coastal locations. There is also a salmon farm located within the proposed BMPA (DAFM, 2019). The smolts are put to sea in cages east of Inishdigil from April to December after which they are moved to the Rosroe site in outer Killary Harbour for on-growing. Figure 2.3 shows the fishing and aquaculture activity in the proposed BMPA.

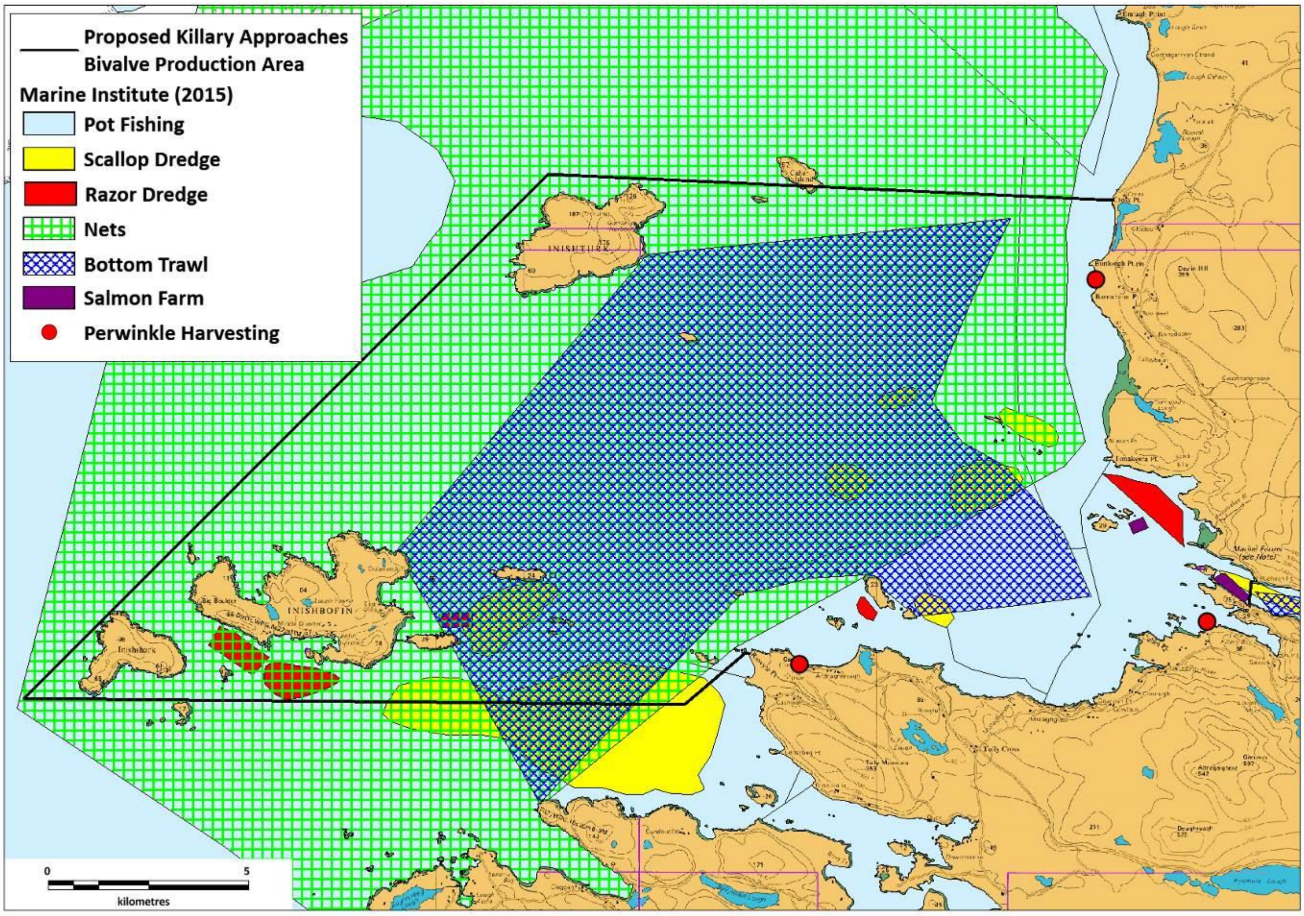


Figure 2.3: Fishing activity in the proposed BMPA (Marine Institute, 2015)

Land cover within the Killary Approaches and Killary Harbour catchment is a mixture of peat bogs, land principally occupied by agriculture but with significant areas of natural vegetation, natural grassland, sparsely vegetated areas, traditional woodland scrub, inland marshes, moors and heathland, coniferous, broad-leafed and mixed forestry and discontinuous urban fabric.

The population of the catchment is approximately 2,158[1]. There main villages/urban centres within the catchment are Killadoon, Tully, Inishbofin, Inishturk, Drummin and Leenane. The population increases in the spring and summer months due to tourists. Almost a quarter of the homes in the area are holiday homes.

[1] Calculation explained in Section 4.1.1

2.3. *Description of Species*

2.3.1. Razor Clam (*Ensis* spp.)

2.3.1.1. General Biology

Razor clams live in soft sand and mud around the low tide mark. They bury themselves in the sediment using their powerful muscular foot with only a siphon protruding from their vertical burrow. They are filter/suspension feeders and use their siphon to filter plankton out of the water column.

2.3.1.2. Distribution

Marine Institute (2015) identified five razor clam dredge fishery areas, based on 2013 data (see Figure 2.4 below).

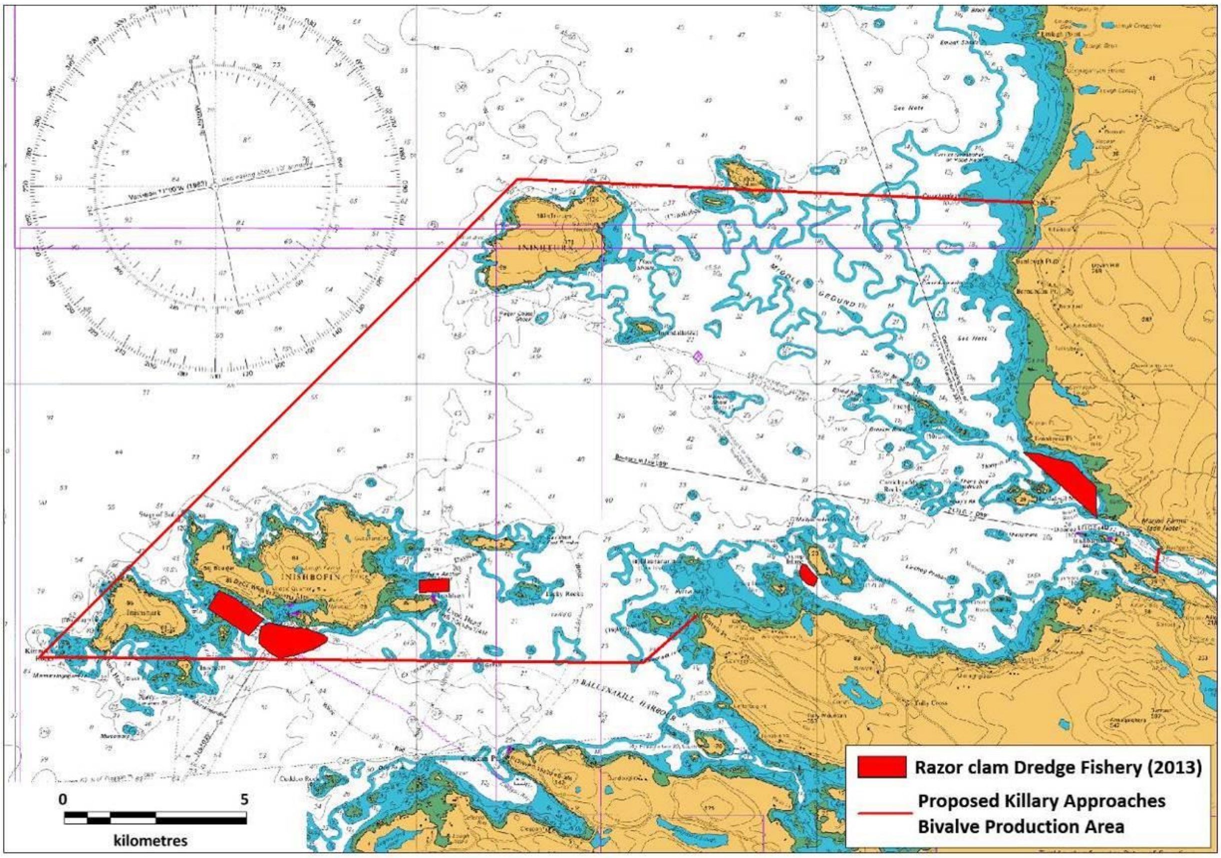


Figure 2.4: Locations of razor clam beds in the proposed Killary Approaches Bivalve Production Area.

The Inshore Fisheries Team of the Marine Institute's Fisheries Ecosystems Advisory Services surveyed the razor clam beds in the area in 2016 (FEAS, 2016). The razor clam distribution at Inishturk can be seen in Figure 2.5 below. This bed was surveyed on November 7th 2016 aboard MFV Rosanne. The bed is at least

0.335km^2 in area and the data recorded suggests a biomass of 15 tonnes.

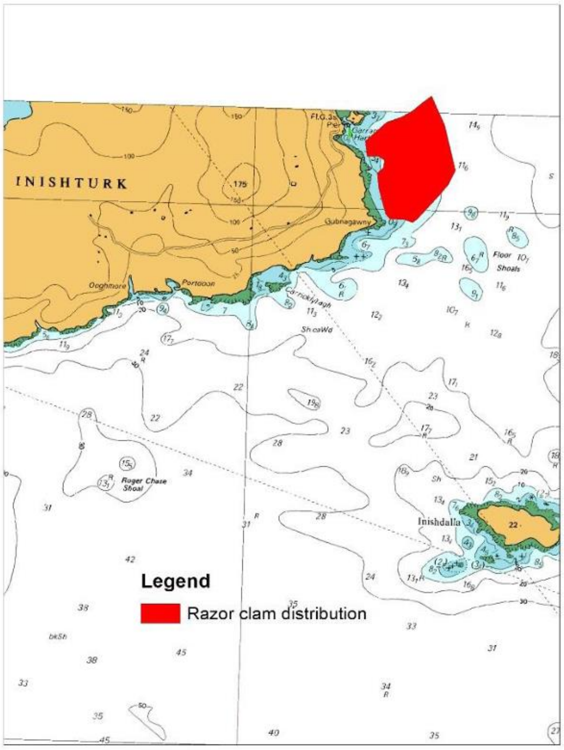


Figure 2.5: Razor clam distribution at Inishturk (FEAS, 2016).

The razor clam bed at Inishbofin can be seen in Figure 2.6. This bed was surveyed on September 15th 2016 aboard MFV Rosanne using a hydraulic dredge. Average length of *Ensis magnus* was 131±25mm and average length of *E. siliqua* was 198±13mm. The biomass of *E. magnus* was estimated to be 72±39t in the surveyed area (0.258km^2) and 126±69t in the extended survey area (0.459km^2, potential distribution). The biomass of *E. siliqua* was estimated to be 0.33±0.28t in the surveyed area (0.258km^2) and 0.8±0.45t in the extended survey area (0.459km^2). Figures 2.7 and 2.8 show the biomass densities of *E. magnus* and *E. siliqua* over the surveyed zone and extended zone at Inishbofin. Some tows were taken in a separate area east of the Island and although razor clams were present the ground is considered too stony to fish.

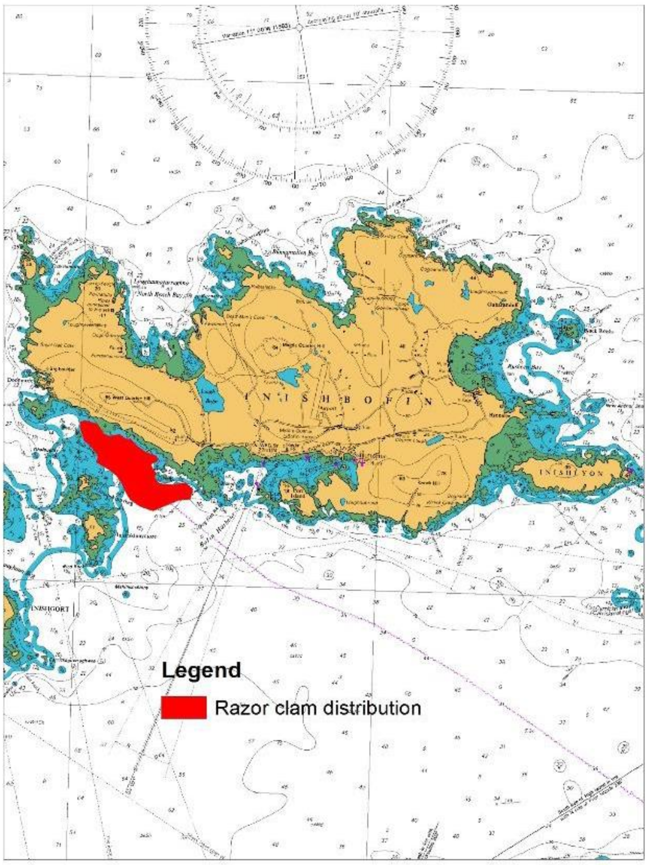
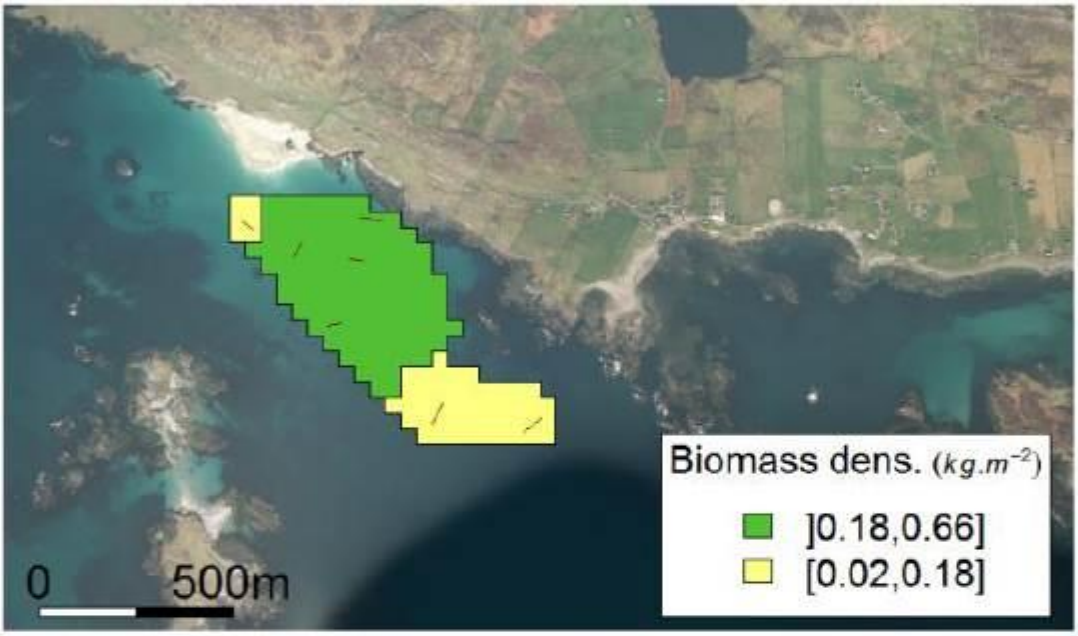


Figure 2.6: Razor clam distribution at Inishbofin (FEAS, 2016).



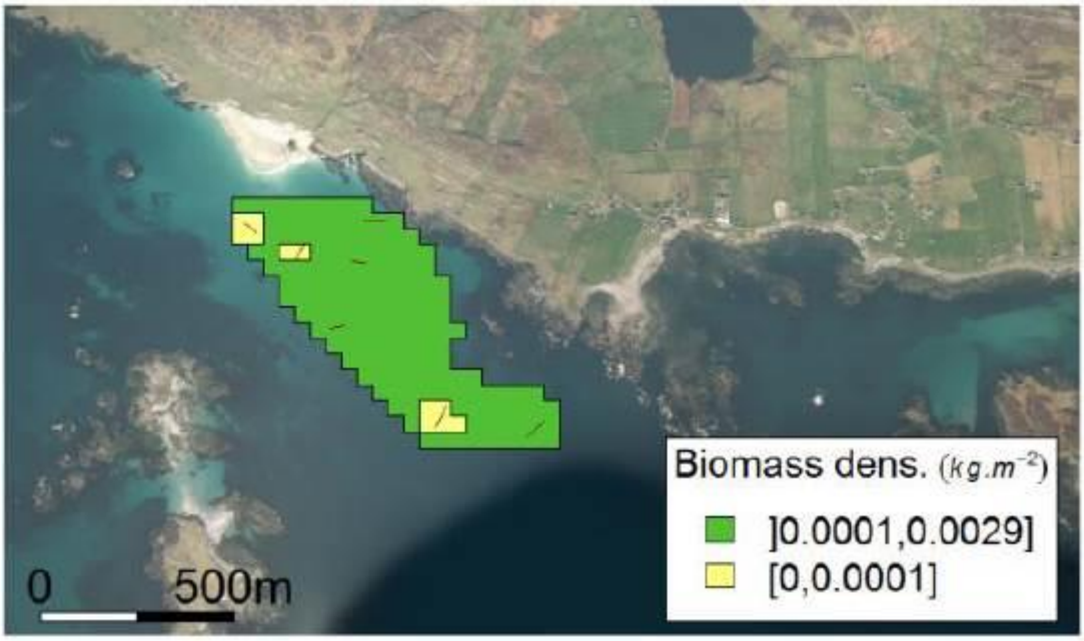
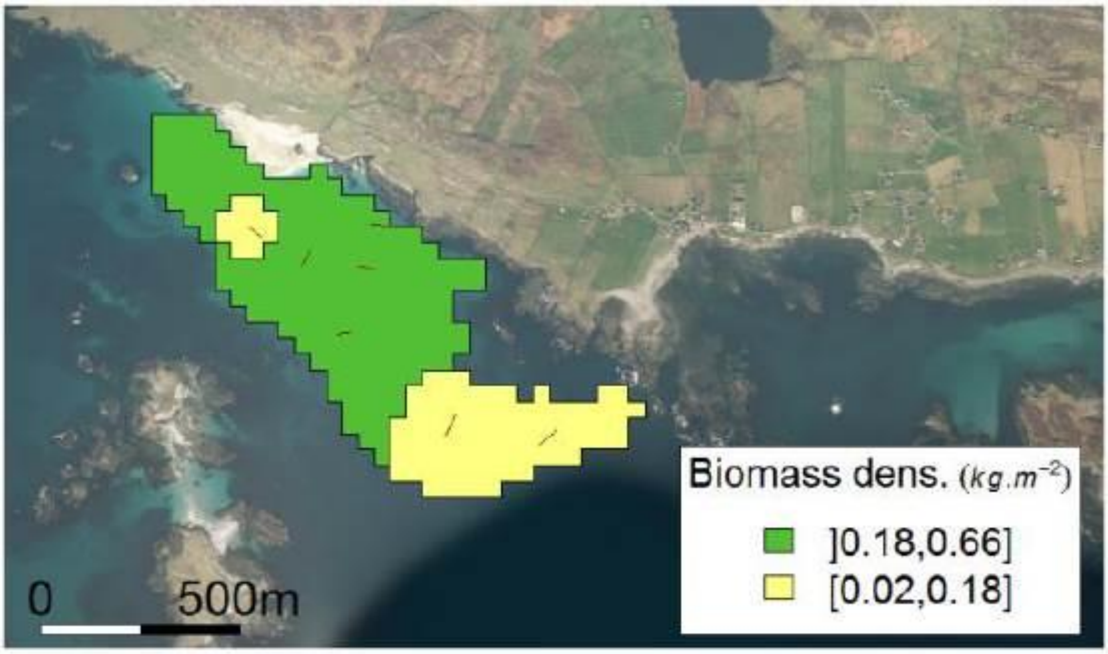


Figure 2.7: Biomass density of *E. magnus* (top) and *E. siliqua* (bottom) over the surveyed zone (0.258km^2) at Inishbofin.



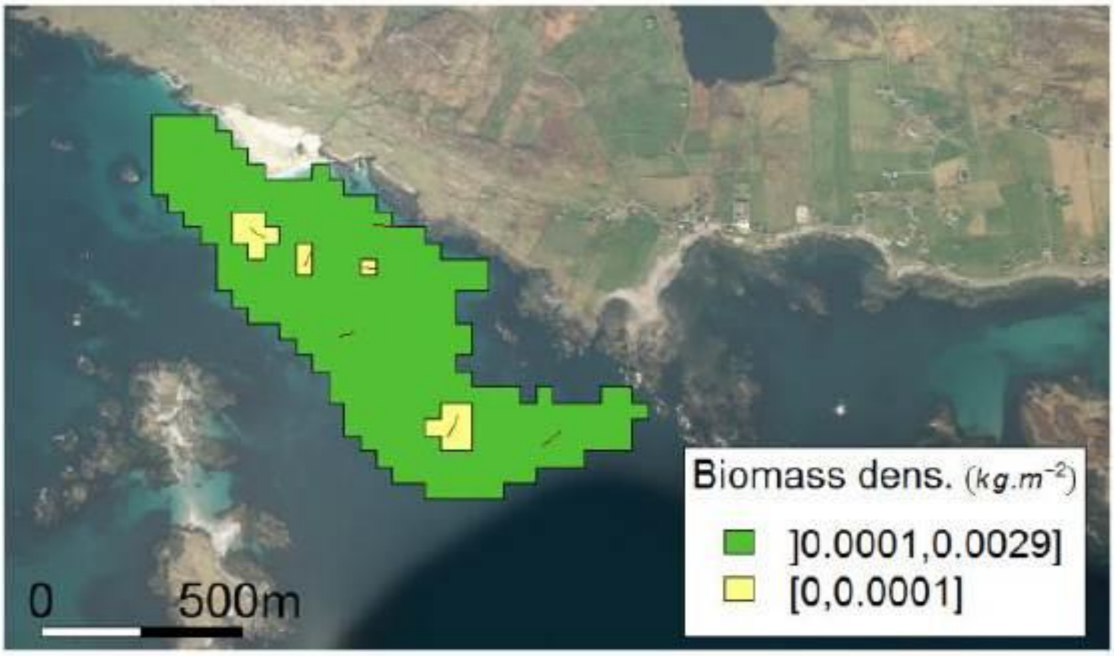


Figure 2.8: Biomass density of *E. magnus* (top) and *E. siliqua* (bottom) over the extended zone (0.459km^2) at Inishbofin.

The razor clam bed in the Killary Approaches can be seen in Figure 2.9. Razor clams occur in a number of areas in the approaches to Killary Harbour. Some patches are quite small. The beds were surveyed on the 2nd November 2016 aboard MFV Rosanne. No catch weight by tow was available for this survey. Biomass was consequently assessed on the basis of density (individuals/m^2) and mean weight calculated from the size distribution and a weight-length relationship. Average size of *E. magnus* was 130±25mm and average size of

E. siliqua was 162±36mm. Biomass of *E. magnus* was estimated at 46±17t in the surveyed area (0.864km^2) and 96±33t in the extended survey area (1.346km^2). Biomass of *E. siliqua* was 60±13t in the survey area (0.864km^2) and 95±23t in the extended survey area (1.346km^2). Figures 2.10 and 2.11 show the biomass densities of *E. magnus* and *E. siliqua* over the surveyed zone and extended zone in Killary Approaches in 2016.

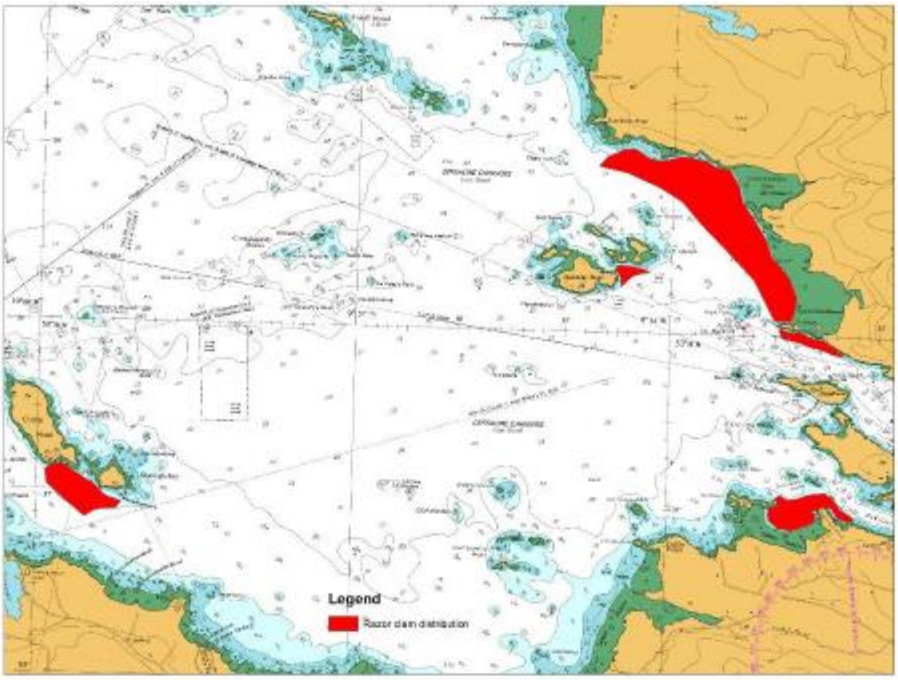
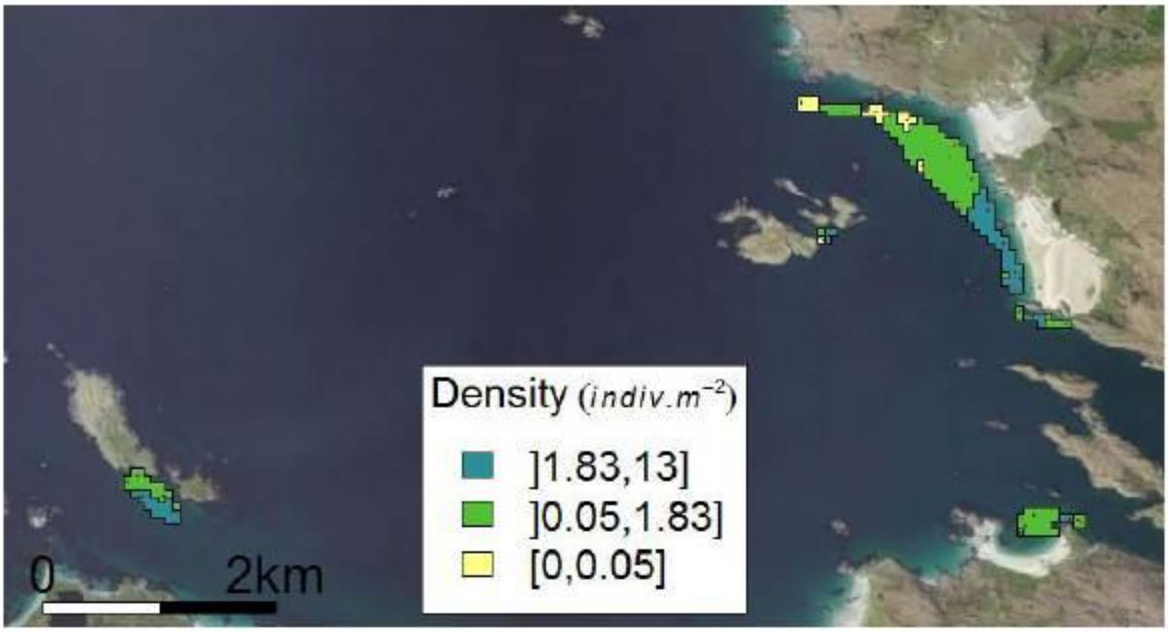


Figure 2.9: Razor clam distribution in Killary Approaches (FEAS, 2016).

This area was also surveyed more recently in August 2018 (FEAS, 2019). Fifteen stations were sampled in shallow water. Deeper areas could not be accessed during the survey so 2018 and 2016 data were combined to provide a biomass estimate for the stock area. No recent fishery had occurred in the area prior to the survey. The stock is distributed over an area of 0.97km^2 although density is much lower in the deeper part of the area.

E. siliqua and *E. magnus* occur in the area in commercial quantities (Figures 2.12 and 2.13). *E. ensis* was recorded in low numbers. Estimated biomass of *E. magnus* and *E. siliqua* was 24 tonnes and 71 tonnes respectively. No confidence intervals are available due to difficulty in estimation caused by poor survey coverage in deep water. Almost all of this biomass was over the minimum landing size. Table 2.1 shows the biomass estimates for Killary Approaches.

No fishery occurred in 2018 and no catch advice or management plan was developed.



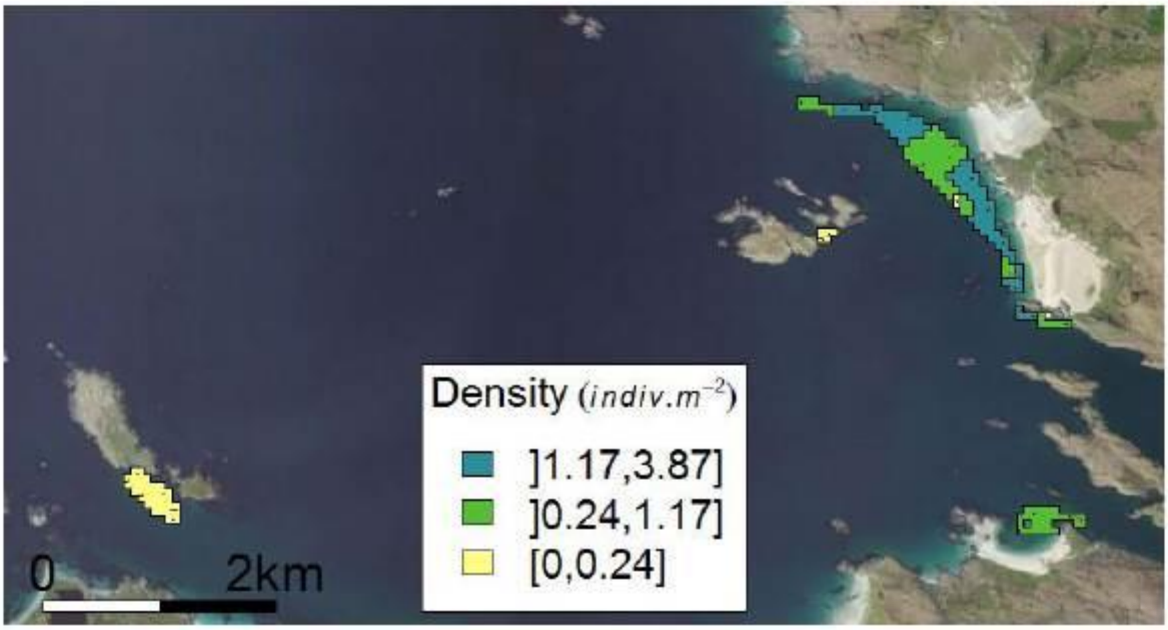
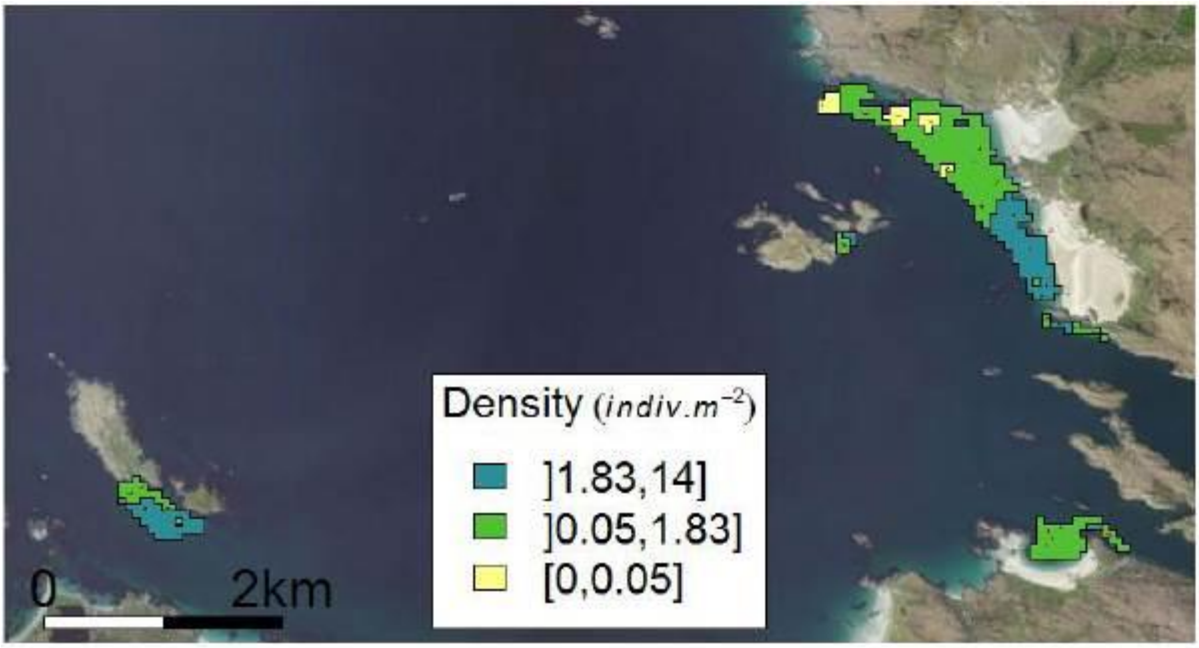


Figure 2.10: Biomass density of *E. magnus* (top) and *E. siliqua* (bottom) over the surveyed zone (0.864km²) in Killary Approaches.



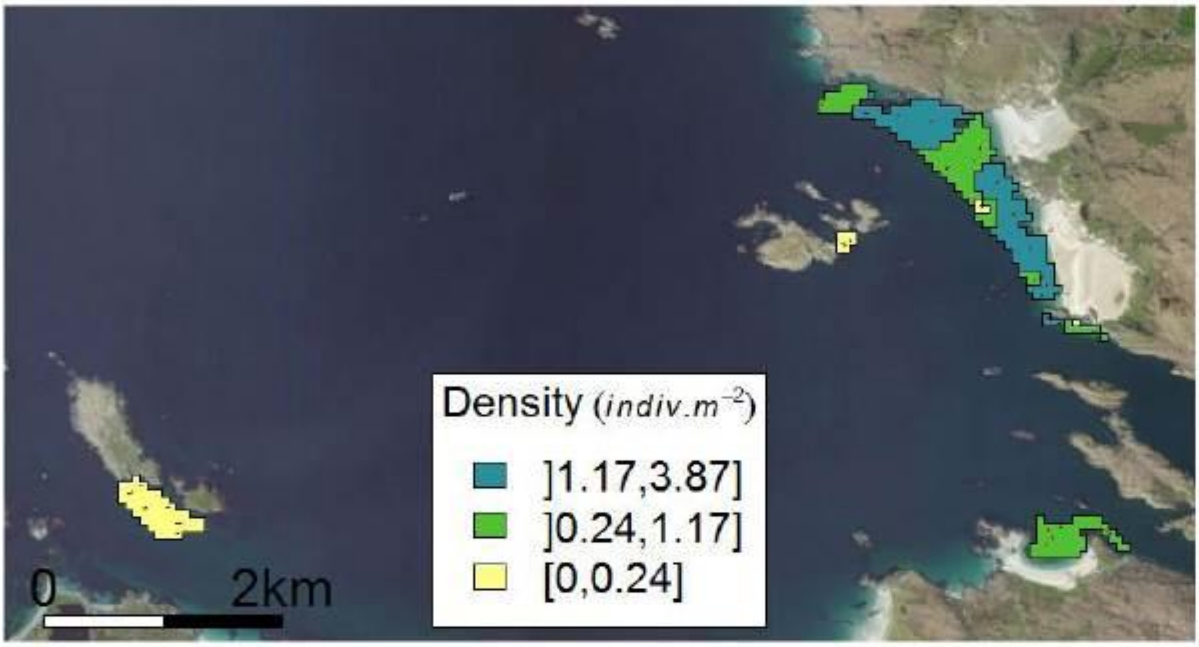


Figure 2.11: Biomass density of *E. magnus* (top) and *E. siliqua* (bottom) over the extended surveyed zone (1.346km^2) in Killary Approaches.

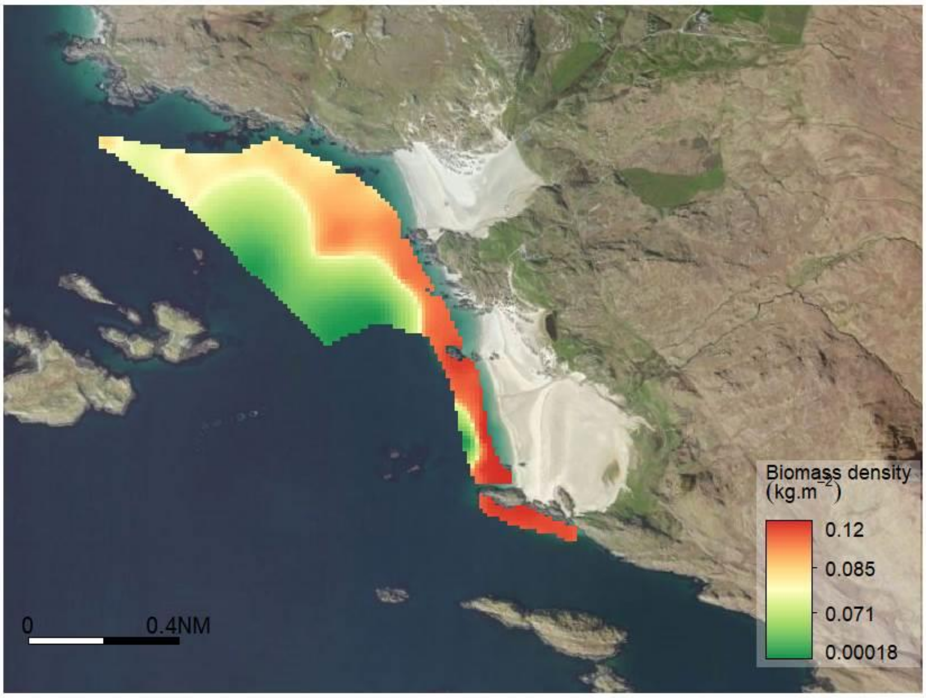


Figure 2.12. Distribution of razor clams (*Ensis siliqua*) at the approaches to Killary Harbour in August 2018.

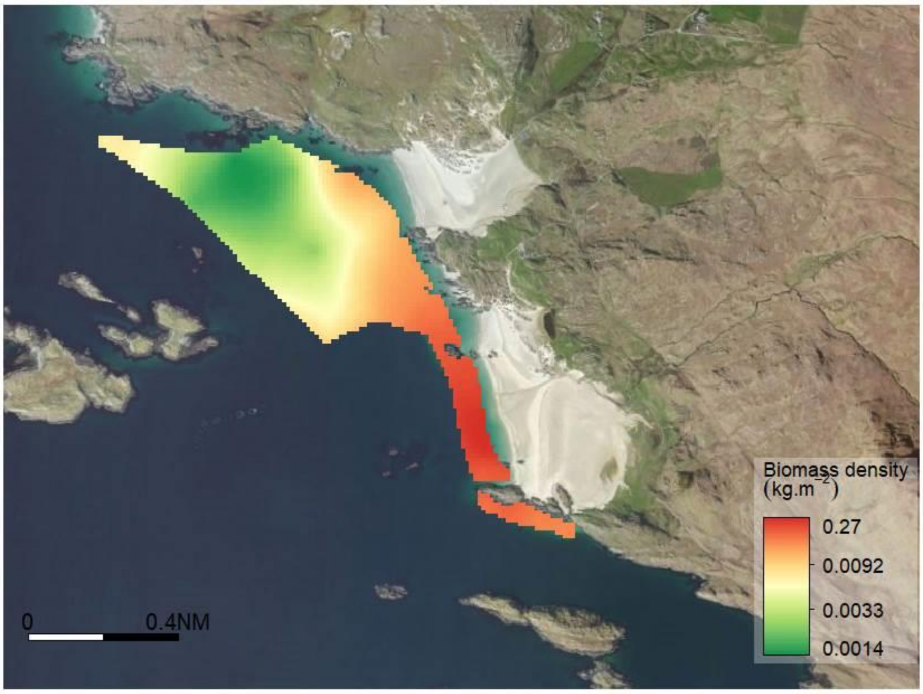


Figure 2.13. Distribution of razor clams (*Ensis magnus*) at the approaches to Killary Harbour in August 2018.

Table 2.1: Estimates of biomass of razor clams at the Killary Approaches (2016-2018)

Species	Biomass (tonnes)
Ensis magnus	24.1
Ensis siliqua	70.9
Ensis magnus >100mm	23.9
Ensis siliqua >130mm	66.9

2.3.1.3. Fishery

There is no razor clam fishery in Killary Approaches at present. The intention for the fishery when licensed and classified is that there will be no more than 3 or 4 local vessels operating the fishery with an expectation of visiting boats from elsewhere in the country. The fishery will generally be located between the low spring tide mark seaward to approximately 15m depth in areas of fine sediment. The razors will be collected by hydraulic dredge. It is expected a management plan will be drawn up to regulate tonnages in light of the results of the most recent stock assessment.

3. Hydrography/Hydrodynamics

3.1. Simple/Complex Models

Unfortunately no models exist for Killary Approaches. However, the information that follows will allow for an understanding of the hydrographic conditions in the area.

3.2. Depth

The 50m depth contour line is located towards the western edge of the proposed Killary Harbour Approaches BMPA, running west of Inishturk and north and west of Inishbofin. Maximum depths west of the line reach 60m. The central region of the proposed water body between Crump Island, Inishbofin and Inishturk ranges in depth from 30 to 50m. The coastal waters inshore of this are <30m with the exception of the main entrance channel to Killary Harbour where depths reach approximately 45m. Water depths around Inishbofin reach 30m depth within 200m of the north of the island and within 450m of the south of the Island. East of the island depths reach 20m within 2.4km of the coast. Water depths around Inishturk reach 30m within 200m of the northwestern part of the island with a much more gradual decline southeast of the island, reaching 20m in *c.* 2.75km. Figure 3.1 shows water depth in the area.

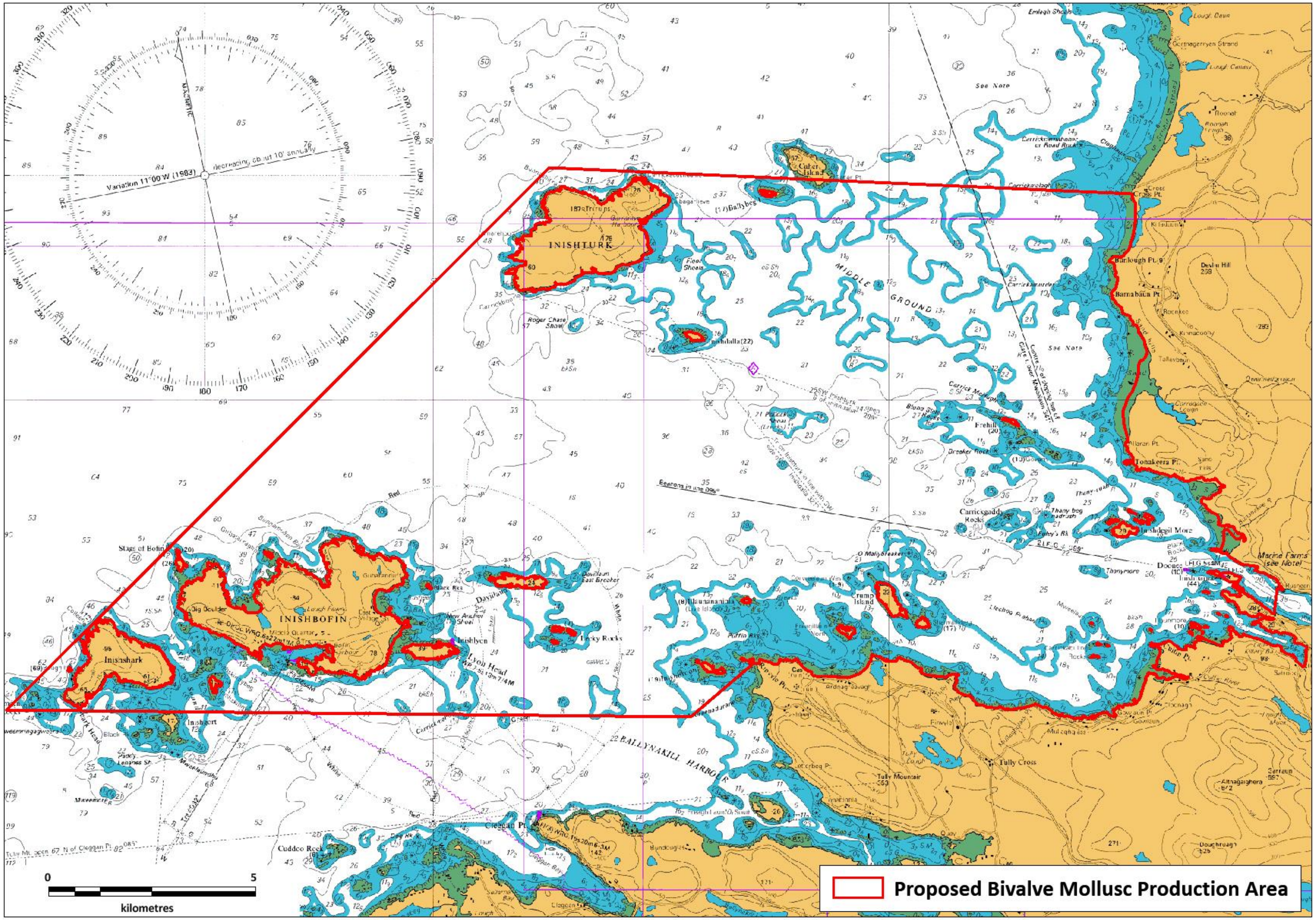


Figure 3.1: Depths in the proposed Killary Harbour Approaches area.

3.3. Tides & Currents

The tidal cycle at Inishbofin and at the entrance to Killary Harbour ranges from a mean high water of 4.1m to a mean low water of 0.5m during spring tides (UKHO, 2004). The characteristic tidal levels for Killary Harbour and Inishbofin can be seen in Table 3.1. These are taken from the Admiralty Chart 1820. Levels are presented in metres Chart Datum, which is approximately equal to Lowest Astronomical Tide (LAT).

Table 3.1: Killary Harbour Approaches tidal characteristics.

Admiralty Chart 1820 Levels (m CD)	MHWS	MHWN	MLWN	MLWS
Killary Harbour	4.1	3.1	1.6	0.5
Inishbofin	4.1	3.1	1.6	0.5

Figure 3.2 shows tidal stream information for the area and was sourced from admiralty chart 2706.

On a flooding tide water enters the site from the south between Inishbofin and Rinvyle Point and moves in a northerly direction at a rate of 1.5kn on a spring tide with high-water on Inishbofin approximately 6-8 minutes earlier than at Killary Harbour. On an ebbing tide, water enters the site from the southeast as it leaves Killary Harbour at a rate of 0.5 to 1kn on a spring tide with low-water on Inishbofin approximately 12-14 minutes earlier than at Killary Harbour. The tidal streams in the center of the site (*c.* 1.4km southeast of Inishdalla; see Figure 3.2) have a mean rate of between 0.2 to 0.3kn on a flooding spring tide and a rate of 0.3 and 0.4 on an ebbing spring tide. On a neap tide, the mean rate on a flooding tide is 0.1kn and on an ebbing tide is 0.1-0.2kn. At high water on a spring, the mean rate is 0.4kn and on a neap tide is 0.2kn. Table 3.2 shows the tidal stream data for this site. Tidal movements in the general area are relatively simple entering in the south on a flooding tide and moving easterly along the coast and into Killary Harbour and continuing in a northeasterly direction up the coast. On an ebbing tide, water enters the site from the southeast as it leaves Killary Harbour and flows in a north/northeast direction initially moving around to a southwest direction as low water approaches.

Table 3.2: Killary Harbour Approaches tidal streams.

Hours		Direction	Rate (kn)	
			Sp	Np
Before HW	6	211 (SSW/SW)	0.3	0.1
	5	183 (S)	0.2	0.1
	4	152 (SSE)	0.2	0.1
	3	122 (ESE/SE)	0.2	0.1
	2	105 (E/ESE)	0.3	0.1
	1	077 (ENE)	0.3	0.1
HW		042 (NE)	0.4	0.2
After HW	1	010 (N/NNE)	0.4	0.2
	2	331 (NNW)	0.3	0.2
	3	296 (WNW)	0.3	0.1
	4	262 (WSW/W)	0.3	0.1
	5	235 (SW/WSW)	0.3	0.1
	6	217 (SSW/SW)	0.3	0.2

AQUAFACT carried out a localised hydrographic survey east of Inishturk in 2001 where three current meters were deployed (AQUAFACT, 2001). Recorded current velocities were relatively low, with a maximum current (at mid-ebb) of 0.367kn recorded sub-surface, 0.315kn recorded mid-water and 0.352kn recorded off bottom. On the eastern side of Inishturk current directions were generally in a northeast direction during an ebb tide and west-northwest during a flood tide.

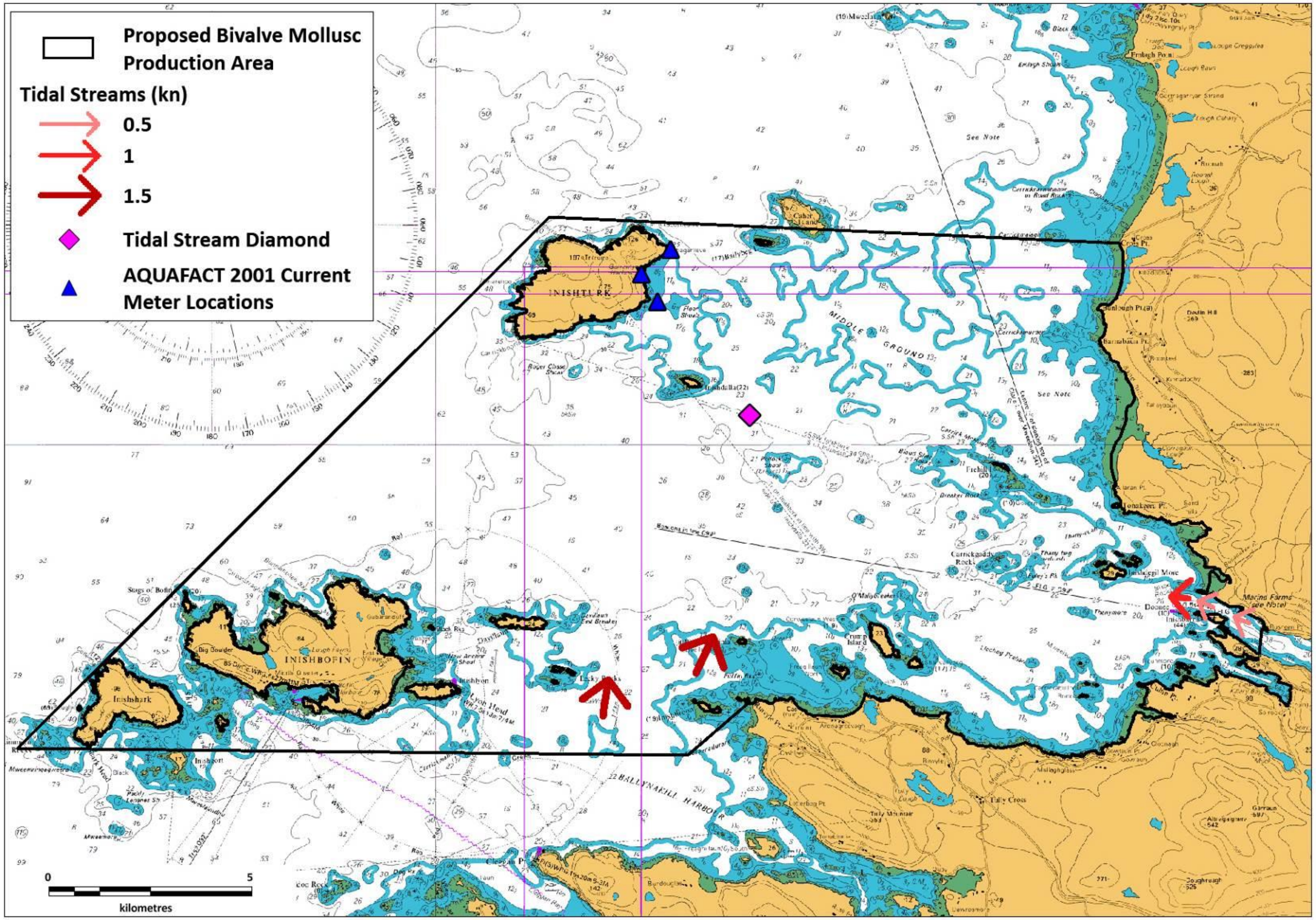


Figure 3.2: Tidal streams within Killary Harbour Approaches.

3.4. Wind and Waves

Wind data from 2014 to 2018 from the Mace Head station (Co. Galway, located approximately 32km south of Killary Harbour Approaches) are displayed in Table 3.3 below and wind roses for each year can be seen in Figure 3.4 below. In 2014, 31% of the wind came from the southwest, while 23% can from the west and 15% from the east. The strongest winds came from the west (19.7kn). In 2015, 38.5% of the wind came from the west, 23% from the west-southwest and 15% from the west-northwest. The strongest winds (21.9kn) came from the west-southwest. In 2016, 38.5% of the wind came from the southwest and 15% came from each of the following directions: the west-southwest, south-southwest and south. The strongest winds (18.1kn) came from the south-southwest. In 2017, 31% of the winds came from the southwest, with 23% coming from the south-southwest and 15% coming from the west and the south. The strongest winds (17.3kn) came from the southwest. In 2018, 38.5% of the wind came from the southwest and 15% came from each of the following directions: the west-southwest, south-southwest and south-southeast. The strongest winds (20.3kn) came from the southwest. It can be seen from these data that the prevailing wind direction is southwest.

Table 3.4 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 (18.1kn), followed very closely by autumn (15.0kn), decreasing to 13.5kn in spring and 12.7kn in summer.

Table 3.3: Wind speed and direction data for Mace Head from 2014-2018 (Source: Met Eireann, 2019a; 2019b).

	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	18.8	216	21.9	240	17.3	227	14.3	184	20.3	220
February	21	280	15	270	18.1	206	17.1	194	16.5	227
March	14.5	214	17	260	14.8	215	14.5	211	13.3	167
April	12.3	80	11.9	270	13.6	216	11.7	265	13.4	178
May	13.2	270	16.2	290	11.3	173	12.2	186	11.9	202
June	9.4	90	12.8	200	11.3	248	15	211	10	230
July	10.7	200	14.7	250	12.7	253	12.8	234	10.3	248
August	14.1	220	13.9	180	15.3	217	13.9	230	14.2	231
September	9.1	220	12.5	290	16.1	217	15.7	222	15.3	243
October	17.1	290	12.4	240	12.3	148	17.3	226	16.2	228
November	13.9	180	20.9	280	12.9	211	15	263	17.6	163
December	19.7	270	21.8	260	16.8	185	16	240	16.3	192

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 3.4: Seasonal averages (knots) for Mace Head wind data (Source: Met Eireann, 2019a; 2019b).

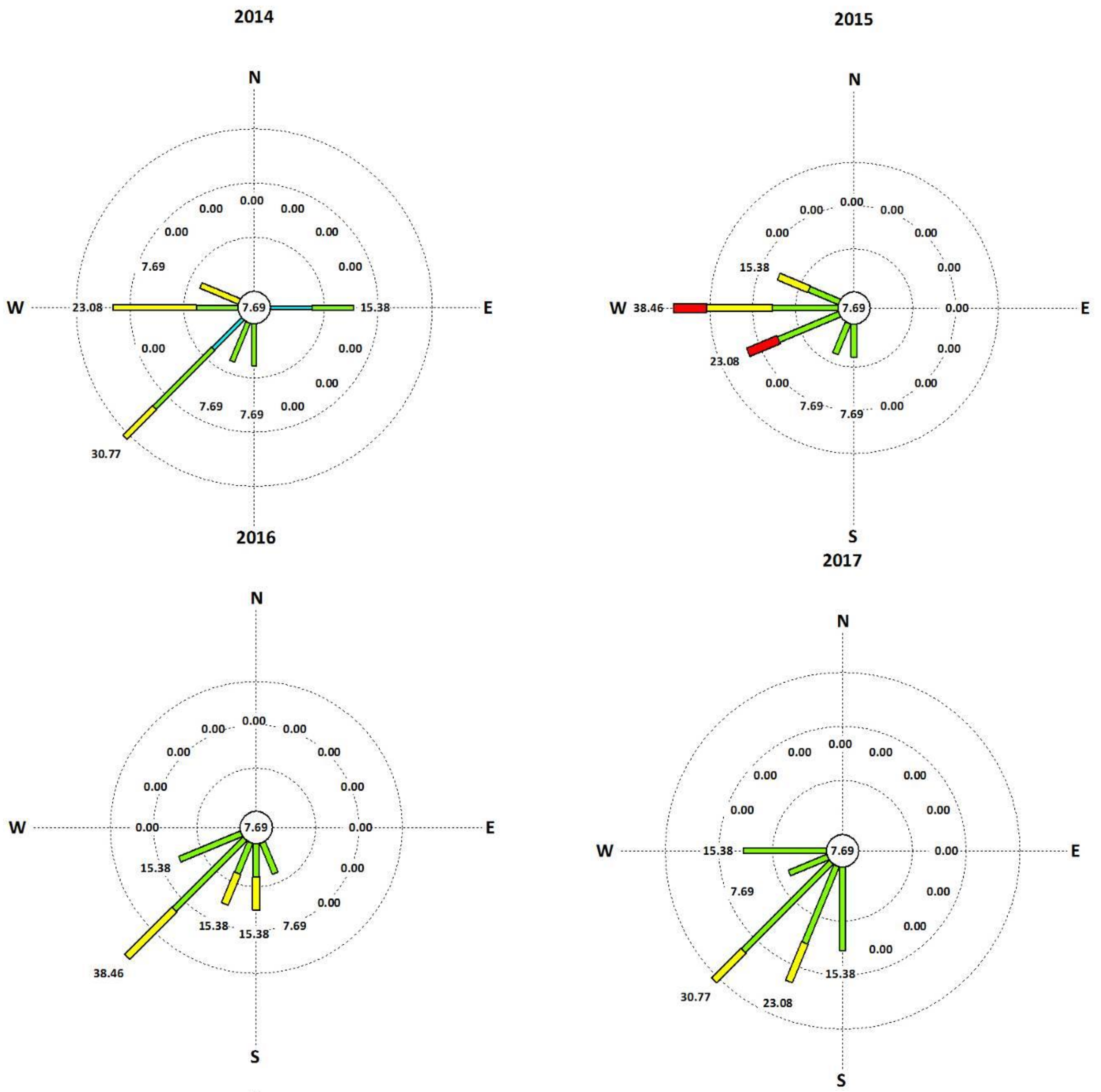
Season	2014	2015	2016	2017	2018	5-year Average
Winter	19.8	19.6	17.4	15.8	17.7	18.1
Spring	13.3	15.0	13.2	12.8	12.9	13.5
Summer	11.4	13.8	13.1	13.9	11.5	12.7
Autumn	13.4	15.3	13.8	16.0	16.4	15.0

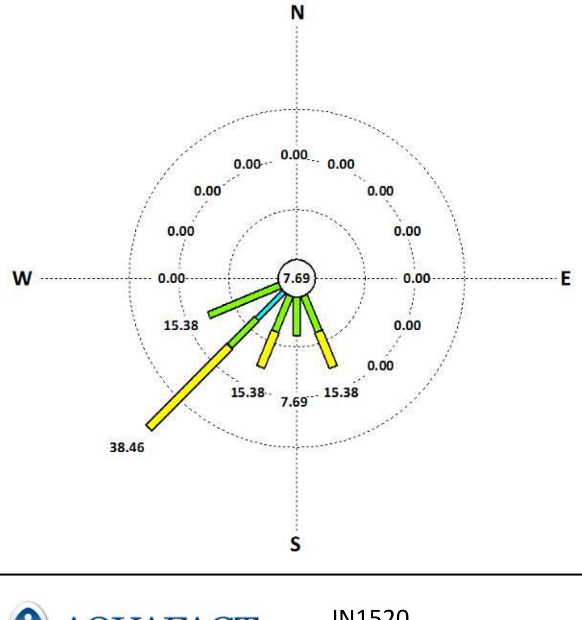
Wind conditions affect the hydrodynamic conditions in an area by generating wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Wind waves are produced by the local prevailing wind. They travel in the direction 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.

Predicted wave heights of locally generated waves east of Inishturk and Inishdalla range from 2.9 to 3.2m due to a 1 in 50 year return storm and from 2.4 to 2.6m due to a 1 in 1 year return storm (AQUAFACT, 1999). The direction of these locally generated waves are from the west-southwest. Of the deep water waves that penetrate into the area, the largest wave likely to occur would be from the west due to a 1 in 50 year return storm. This wave would have a significant height of *c.* 6m east of Inishdalla. The largest wave east of Inishturk would be from the west-northwest due to a 1 in 50 year return storm. This wave would have a significant height of *c.* 4.4m. The largest wave east of Crump Island would be from the west-southwest due to a 1 in 50 year return storm. This wave would have a significant height of *c.* 5m. Predicted significant wave heights for these 1 in 50 year return storms range from 16 to 18m.

The largest deep water wave due to a 1 in 1 year return storm would be 3m at all three locations. The predicted significant wave height for this scenario would be 15m. The seabed in the area shows evidence of wave action from the mounding and furrowing of sand on the bottom to scoured rocky reefs (AQUAFACT, 1999).





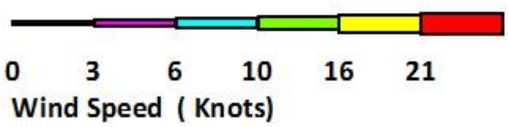


Figure 3.3: Wind roses for Mace Head from 2014 to 2018 (Source: Met Eireann, 2019a; 2019b).

3.5. River Discharges

Given the connectivity between the proposed Killary Harbour Approaches BMPA and Killary Harbour it is not possible to fully separate the two catchments as one flows directly into the other. Figure 3.5 shows the Killary Harbour Approaches catchment (106.2km^2), the Killary Harbour catchment (261km^2) and the rivers and lakes within each catchment.

Freshwater flow into the proposed Killary Approaches BMPA is low. Along the north shore, north of Killary Harbour, there are three main inflows: the Bunanakee River located just north of Killary Harbour enters the sea at Uggool beach, the Owennadornaun River located *c.* 4km further north and enters the sea at Whitestrand beach along with a discharge from the Corragaun Lough lagoon and a discharge from Cross Lough a further 2.8km north.

Along the southern shore of the proposed BMPA, the main freshwater discharge is from the Culfin River which enters the area at Lettergesh beach. The Culfin River is fed by Lough Muck, which is fed by the Owengar River from Lough Fee. There is a hydrometric gauge in Lough Fee and Table 3.5 shows the seasonal mean, minimum and maximum flows from February 2018 to February 2019 (EPA, 2019). Maximum flows of 6.82m^3/s were recorded in Autumn and minimum flows of 0.009m^3/s in Summer. Mean flows ranged from 0.59m^3/s in Summer to 1.76m^3/s in Winter. There are a number of smaller outflows along the south shore' the Owennacloonagh, Sruffaunathybona, Keeraun River, Fiddaunbaun, Mullaghglass stream and the outflows from Tully Lough and Rusheenduff Lough.

Three main rivers feed into Killary Harbour, the Erriff and Bundorragha from Mayo on the north shore, and the Bunowen from Galway on the south shore. In addition numerous streams also discharge into Killary Harbour and contribute approximately 10% of the total annual freshwater input (CLAMS, 2002). There is a hydrometric gauge on the Bundorragha River which measures flow. There is also a gauge on the Erriff River however flow data is not recorded. Table 3.6 shows the seasonal mean, minimum and maximum flows on the Bundorragha River from February 2018 to February 2019 (EPA, 2019). Maximum flows of 34.2m^3/s were recorded in Autumn and minimum flows of 0.73m^3/s in Spring. Mean flows ranged from 2.56m^3/s in Summer to 6.2m^3/s in Autumn and Winter.

Table 3.5: Hydrometric flow data from Lough Fee (February 2018 to February 2019) (Source: EPA, 2019).

Season	Mean m^3/s	Min m^3/s	Max m^3/s
Spring	0.86	0.081	4.14
Summer	0.59	0.009	3.9
Autumn	1.74	0.149	6.82
Winter	1.76	0.092	6.34

Table 3.6: Hydrometric flow data from Bundorragha River (February 2018 to February 2019) (Source: EPA, 2019).

Season	Mean m^3/s	Min m^3/s	Max m^3/s
Spring	2.92	0.73	13.4
Summer	2.56	0.313	11.8
Autumn	6.21	1.09	34.2
Winter	6.2	0.9	27.4

The current (2010-2015) WFD status of Killary Approaches, Killary Harbour and their associated freshwater sources can be seen in Figure 3.6. Of the river and lake systems flowing directly into the proposed Killary Approaches BMPA, the vast majority are unassigned. Of the ones that are assigned, the ones on the north shore have a Moderate status (Owennadornaun) and the one on the south shore has a Good status (Culfin – the upper reaches of which have a Moderate status). The remaining river and lake systems flow into Killary Harbour. These range in status from High (Glenummera, Glenaur, Erriff and Glencullin Lake) to Good (Bundorragha, Erriff, Derrycraff, Owenduff and Doo Lough). The majority of rivers flowing directly into Killary Harbour are unassigned. The Erriff transitional waterbody located where the Erriff River enters Killary Harbour has a High Status and the Killary Harbour Coastal waterbody has a Good status. The coastal waterbody encompassing the proposed Killary Approaches BMPA (Western Atlantic Seaboard Has 32, 33, 34) is unassigned as is the Ballynakill Bay coastal waterbody, a small section of which overlaps the Killary Approaches BMPA. Both of these waterbodies while currently unassigned are not at risk of meeting their WFD objectives.

As the status of the Killary Harbour coastal waterbody and Erriff transitional waterbody are indicative of good water quality, no risk is perceived to the water quality of the Killary Approaches BMPA from these sources.

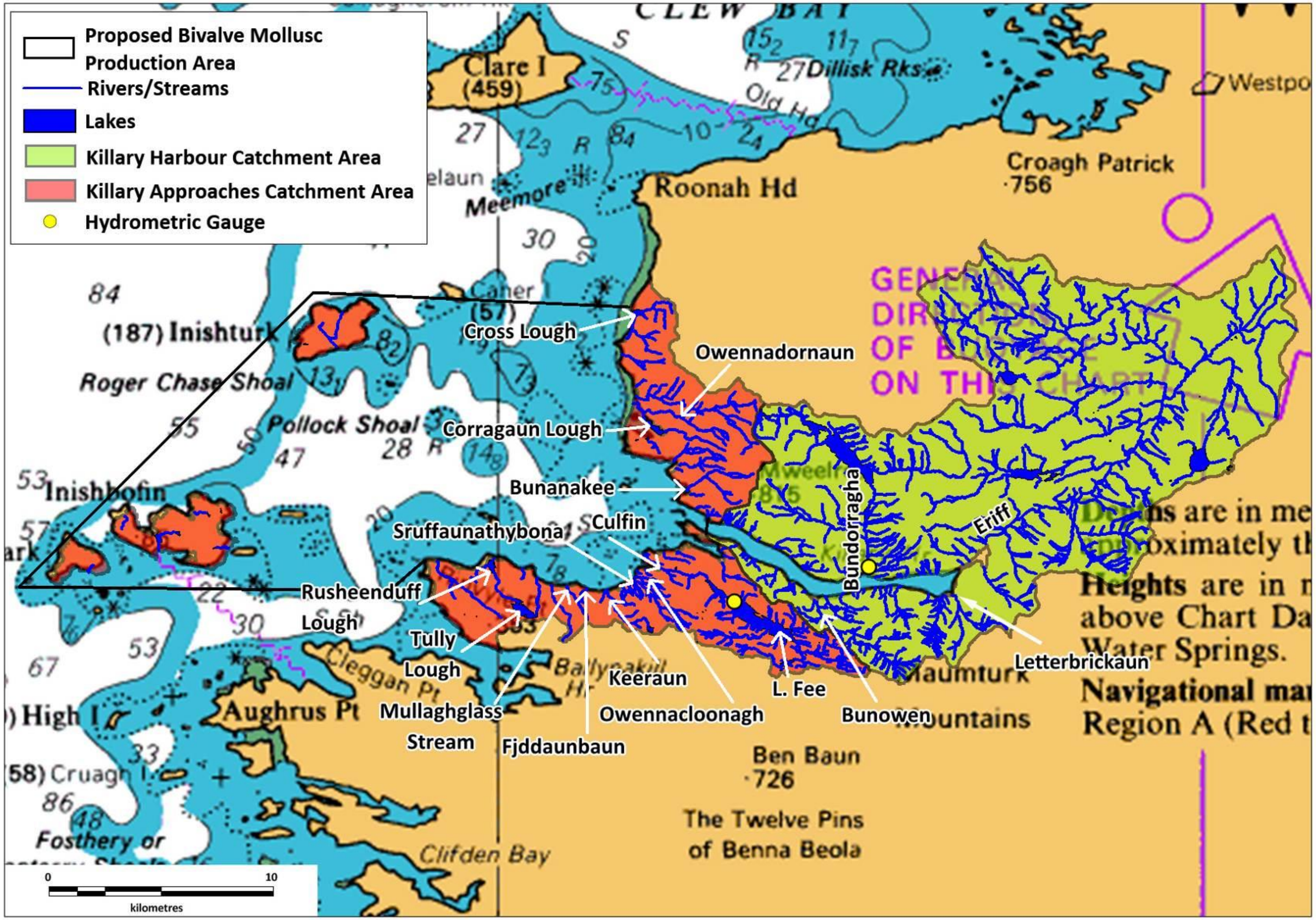


Figure 3.4: Rivers, streams and lakes in the catchment areas including hydrometric station locations (Source: EPA, 2019).

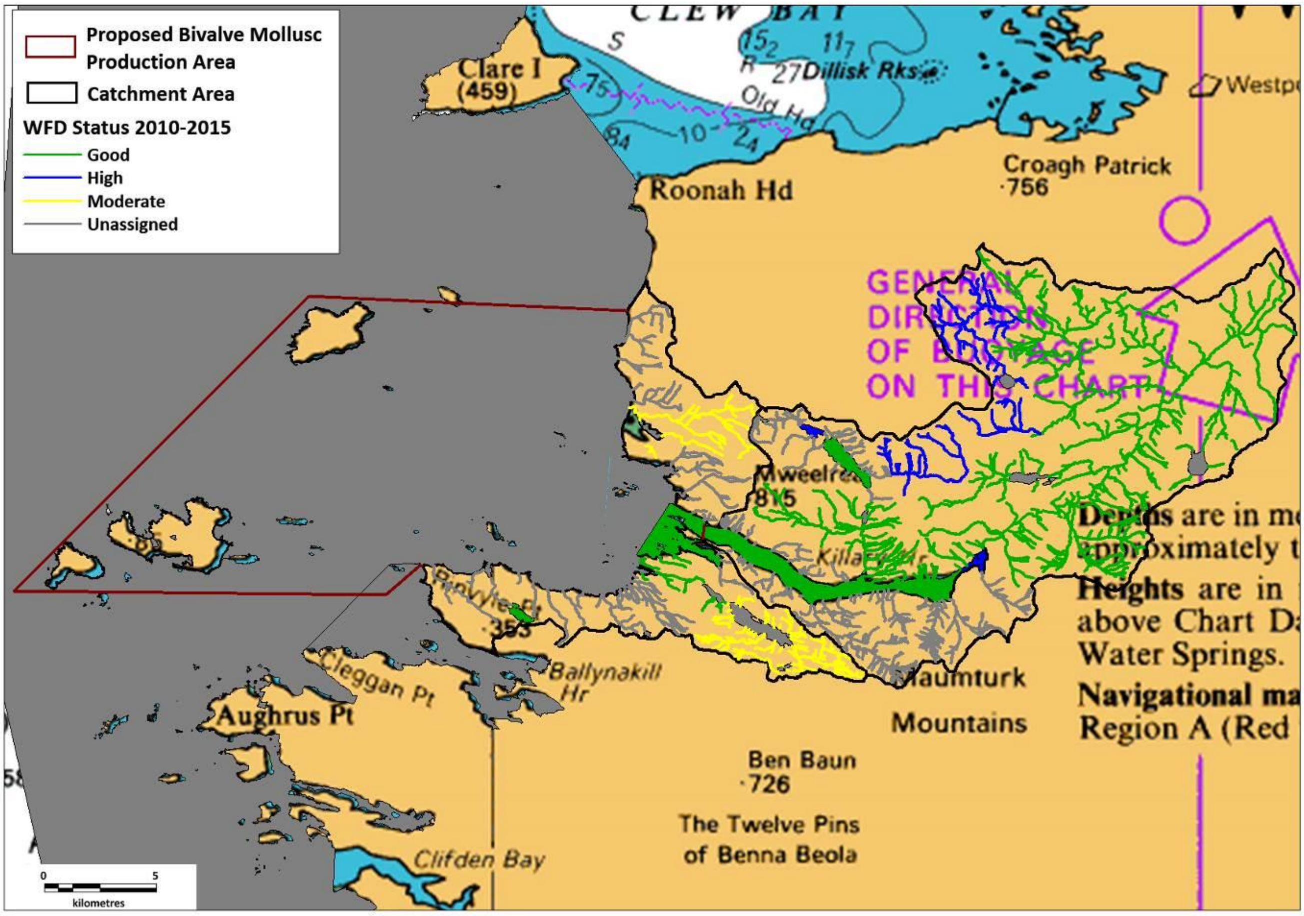


Figure 3.5: WFD Status of the coastal, transitional, lake and river waterbodies in the catchment area (Source EPA, 2019).

3.6. Rainfall Data

3.6.1. Amount & Time of Year

Figure 3.7 shows the average monthly rainfall data for Ireland (Met Eireann, 2019c) from 1981 to 2010. The wettest months in the Killary Harbour region over this 30-year period were October to January with the driest months from April to July. Table 3.7 shows the 30-year average monthly rainfall at the Belmullet station which is located *c.* 56km north of the proposed BMPA (Figure 3.8 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 3.8 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 3.7: Monthly average rainfall at Belmullet from 1981 to 2010 (Source: Met Eireann, 2019d).

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

Table 3.8: Average seasonal rainfall values (mm) from 1981-2010 at Belmullet (Source: Met Eireann, 2019d).

Season	Average
Spring	80.5
Summer	84.3
Autumn	127.2
Winter	122.8

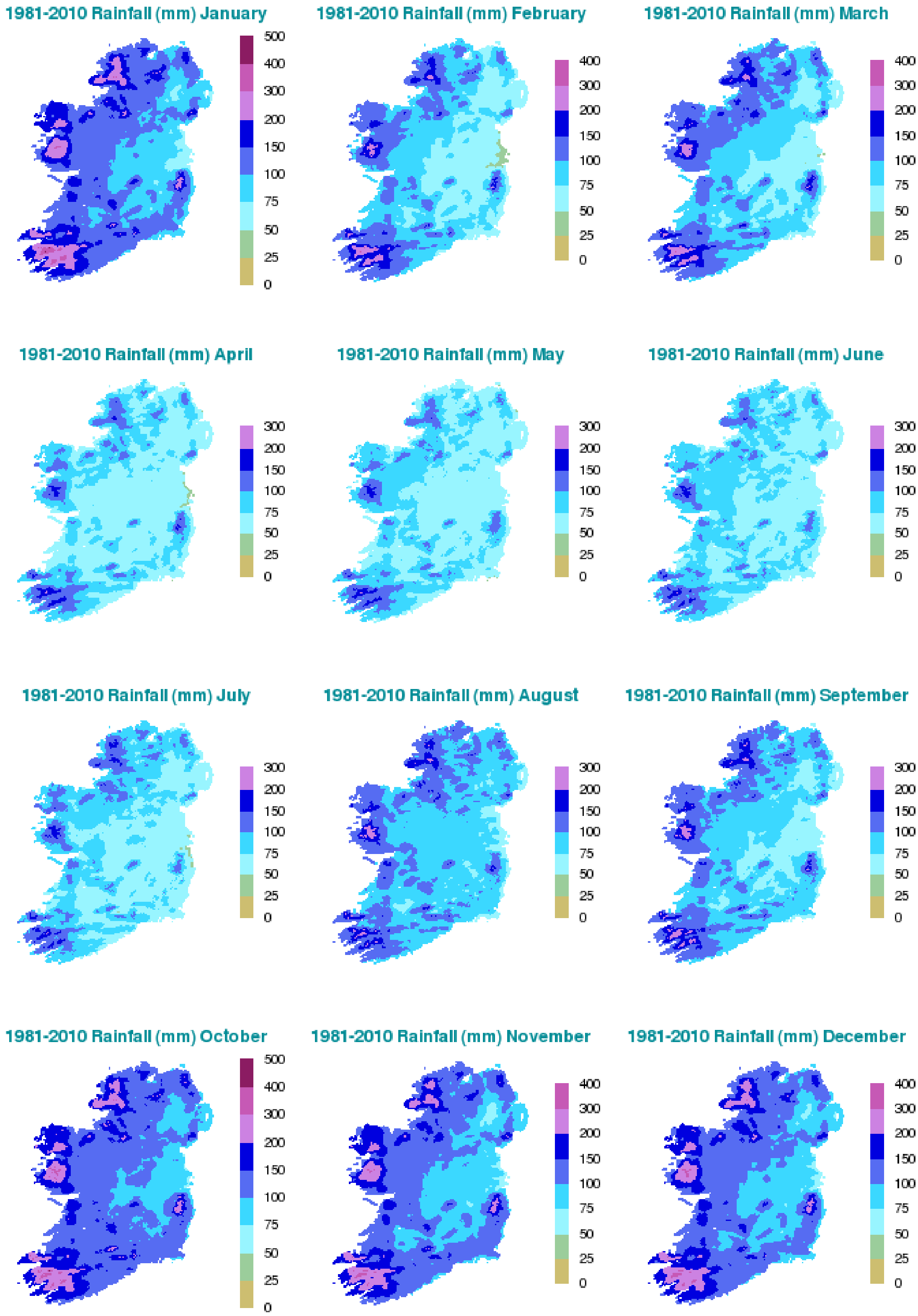


Figure 3.6: Average monthly rainfall (mm) data from 1981 to 2010 for Ireland (Source: Met Eireann, 2019c).

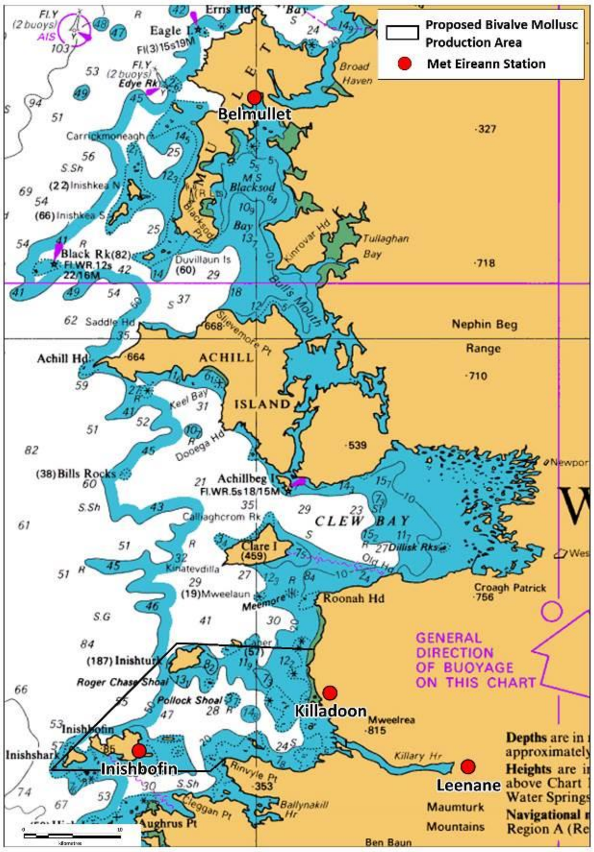


Figure 3.7: Location of Met Eireann weather stations in relation to the proposed BMPA.

Tables 3.9, 3.10 and 3.11 show total monthly rainfall at three Met Eireann stations (Inishbofin, Killadoon and Leenane; see Figure 3.8) located around the proposed BMPA from 2014 to 2018 (Met Eireann, 2019e; 2019f; 2019g).

The Inishbofin station is located on the eastern side of Inishbofin within the proposed BMPA. Maximum monthly rainfall was in September 2015 (169.2mm) and the lowest monthly rainfall was September 2014 (8.7mm). The 5-year average monthly rainfall ranged from a low of 37mm in April to a high of 105.3mm in December. Annual averages ranged from 66.8mm in 2014 to 85mm in 2015.

The Killadoon station is located north of Killary Harbour within 1.5km of proposed BMPA. Maximum monthly rainfall was in December 2015 (249.3mm) and the lowest monthly rainfall was September 2014 (21.1mm). The 5-year average monthly rainfall ranged from a low of 53.8mm in April to a high of 161.1mm in January. Annual averages ranged from 102mm in 2017 to 122mm in 2015.

The Leenane station is located 1.8km northeast of Leenane in the inner reaches of Killary Harbour. Maximum monthly rainfall was in December 2015 (732.8mm) and the lowest monthly rainfall was September 2014

(27.9mm). The 5-year average monthly rainfall ranged from a low of 137.8mm in June to a high of 435mm in December. Annual averages ranged from 222.9mm in 2016 to 280.1mm in 2015.

Over the 5-year period, Leenane was the wettest location (total rainfall of 14,650mm) which was over double the total rainfall at Killadoon (6,280mm) and over three times the total rainfall at Inishbofin (4,446mm).

Table 3.12 shows the total seasonal rainfall at Inishbofin, Killadoon and Leenane from 2014-2018 (Met Eireann, 2019e; 2019f; 2019g). The following seasonal fluctuations were observed from 2014-2017 (as a complete data set was not available for 2018, this year was excluded from the summary): In 2014, at all 3 locations, summer was the driest season and winter was the wettest, in 2015 summer was the driest and winter was the wettest at Inishbofin and Leenane whereas spring was the driest and winter the wettest at Killadoon. In 2016, at all 3 locations, spring was the driest and winter was the wettest and in 2017 spring was the driest at all 3 stations, with autumn being the wettest at Inishbofin and Leenane and summer the wettest at Killadoon. On average over the 3 stations, summer was the driest season in 2014, with spring being the driest from 2015 to 2017 and winter was the wettest season from 2014 to 2016 with autumn being the wettest in 2017.

Table 3.9: Total monthly rainfall (mm) data at Inishbofin Co. Galway, from 2014 to 2018 (Source: Met Eireann, 2019e).

Year	2014	2015	2016	2017	2018	Monthly 5-yr Average
Jan	132.1	107.8	105.8	40.6	137.3	104.7
Feb	137.3	69.0	115.6	73.4	69.2	92.9
Mar	54.1	60.5	58.3	110.4	52.5	67.2
Apr	29.7	45.3	41.5	11.8	56.7	37.0
May	71.2	68.6	40.0	38.6	39.2	51.5
Jun	18.8	39.2	76.7	49.9	27.3	42.4
Jul	40.6	61.5	55.1	100.8	44.1	60.4
Aug	49.9	66.2	78.7	126.6	80.4	80.4
Sep	8.7	169.2	140.0	112.9	88.7	103.9
Oct	123.9	46.0	39.8	66.3	112.9	77.8
Nov	50.6	131.3	67.1	103.3	82.3	86.9
Dec	85.2	155.8	59.8	120.5	n/a	105.3
Annual Average	66.8	85.0	73.2	79.6	71.9	-

Table 3.10: Total monthly rainfall (mm) data at Killadoon Co. Mayo, from 2014 to 2018 (Source: Met Eireann, 2019f).

Year	2014	2015	2016	2017	2018	Monthly 5-yr Average
Jan	247.1	162.4	181.0	60.3	154.5	161.1
Feb	200.1	86.8	146.0	100.8	99.1	126.6
Mar	98.0	83.5	90.2	125.2	61.4	91.7
Apr	71.6	57.7	62.5	23.2	n/a	53.8
May	112.1	96.8	76.2	51.2	66.4	80.5
Jun	32.9	61.4	91.7	89.6	54.6	66.0
Jul	95.6	123.2	84.2	149.1	77.5	105.9
Aug	80.7	106.6	127.5	162.4	127.0	120.8
Sep	21.1	180.8	171.4	97.5	133.9	120.9
Oct	145.5	77.5	44.0	97.1	128.3	98.5
Nov	88.4	178.3	74.8	131.5	144.2	123.4
Dec	126.7	249.3	76.8	135.6	n/a	147.1
Annual Average	110.0	122.0	102.2	102.0	104.7	-

Table 3.11: Total monthly rainfall (mm) data at Leenane Co. Galway, from 2014 to 2018 (Source: Met Eireann, 2019g).

Year	2014	2015	2016	2017	2018	Monthly 5-yr Average
Jan	541.7	408.2	442.4	197.4	411.3	400.2
Feb	484.8	223.9	359.8	295.0	201.0	312.9
Mar	202.8	224.4	203.1	305.6	176.2	222.4
Apr	124.3	142.4	133.4	68.7	263.8	146.5
May	249.2	233.7	102.1	152.5	111.3	169.8
Jun	77.1	131.9	129.7	201.1	149.3	137.8
Jul	120.1	239.0	160.8	188.7	117.8	165.3
Aug	260.4	211.4	259.3	280.4	196.9	241.7
Sep	27.9	226.5	361.5	265.4	244.1	225.1
Oct	376.2	116.9	113.0	279.9	301.4	237.5
Nov	225.6	470.4	156.4	273.7	487.5	322.7
Dec	412.3	732.8	253.5	341.5	n/a	435.0
Annual Average	258.5	280.1	222.9	237.5	241.9	-

Table 3.12: Total seasonal rainfall (mm) at Inishbofin, Killadoon and Leenane from 2014-2018 (Source: Met Eireann, 2019e; 2019f; 2019g).

Station	Season/Year	2014	2015	2016	2017	2018
Inishbofin	Spring	155	174.4	139.8	160.8	148.4
	Summer	109.3	166.9	210.5	277.3	151.8
	Autumn	183.2	346.5	246.9	282.5	283.9
	Winter	354.6	332.6	281.2	234.5	206.5*
Killadoon	Spring	281.7	238	228.9	199.6	127.8#
	Summer	209.2	291.2	303.4	401.1	259.1
	Autumn	255	436.6	290.2	326.1	406.4
	Winter	573.9	498.5	403.8	296.7	253.6*
Leenane	Spring	576.3	600.5	438.6	526.8	551.3
	Summer	457.6	582.3	549.8	670.2	464.0
	Autumn	629.7	813.8	630.9	819.0	1033.0
	Winter	1438.8	1364.9	1055.7	833.9	612.3*
Average	Spring	337.7	337.6	269.1	295.7	275.8
	Summer	258.7	346.8	354.6	449.5	291.6
	Autumn	356.0	532.3	389.3	475.9	574.4
	Winter	789.1	732.0	580.2	455.0	357.5

* No data for December
# No data for April

3.6.2. Frequency of Significant Rainfalls

Figure 3.9 shows the average monthly rainfall at Belmullet from 1981-2010 and Figure 3.10 shows the 5-year average and total monthly rainfall at Inishbofin, Killadoon and Leenane. 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, January has been the wettest month at all 3 stations around the proposed BMPA. This was followed by September and February at Inishbofin, February and November at Killadoon and December (despite there being no 2018 data) and November at Leenane. Figure 3.10 also shows the monthly average rainfall averaged across the three locations (Inishbofin, Killadoon and Leenane). Overall November, December, January and February were the wettest months followed by August and September.

For the 5-year 2014-2018 period, average greatest daily rainfall at Leenane was 45.9mm, with a maximum of 140.2mm; average greatest daily rainfall at Killadoon was 20.7mm, with a maximum of 83.5mm and average greatest daily rainfall at Inishbofin was 15.9mm, with a maximum of 76.6mm. Across the 3 sites, average greatest daily rainfall was 27.5mm, with an average maximum of 100.1mm. Over the same period, the number of wet days (rainfall >1mm) a month averaged at 18 with the maximum number averaging at 29 days/month.

Met Eireann have developed a depth duration frequency model for the estimation of point rainfall frequencies (Fitzgerald, 2007; Met Eireann, 2019h). For a 1 in 100 year return period, 33.7mm of rain would be expected over 1 hour and 136mm over 24 hours. Whiles these would be extreme uncommon events, the model predicts that once a year 13.2mm would fall in 1 hour and 53.3mm over a 24 hour period.

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

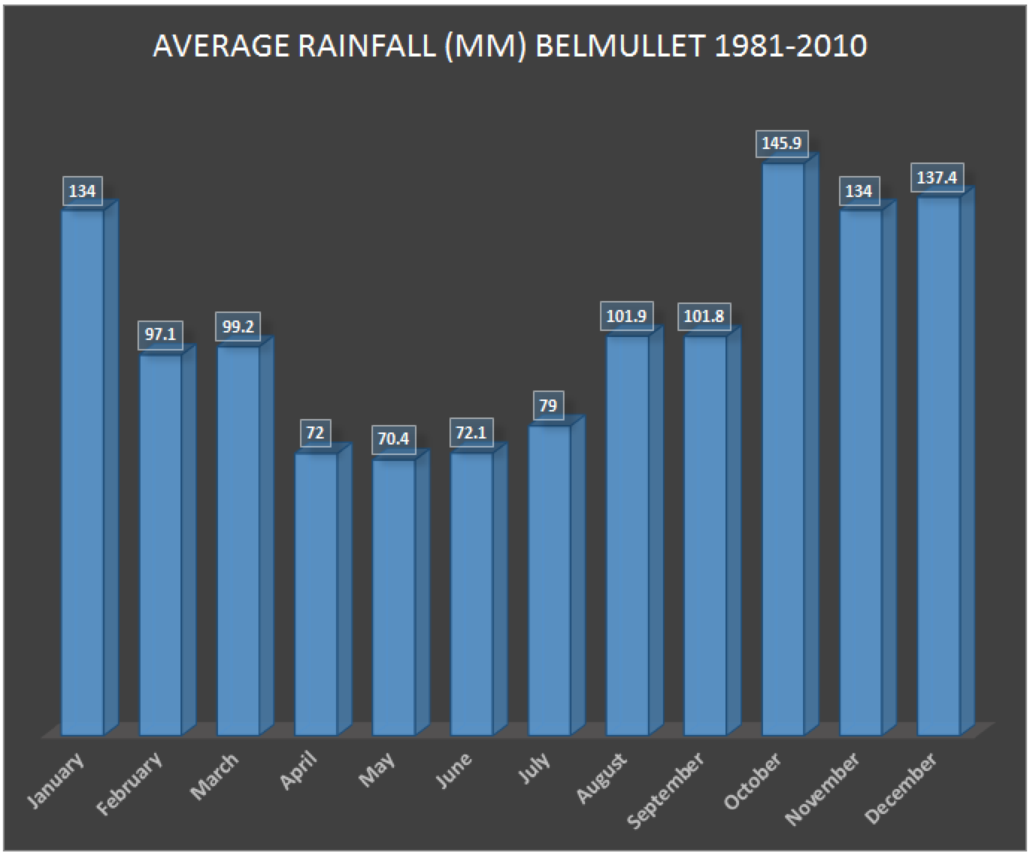


Figure 3.8: Average monthly rainfall (mm) at Belmullet from 1981-2010 (Source: Met Eireann, 2019d).

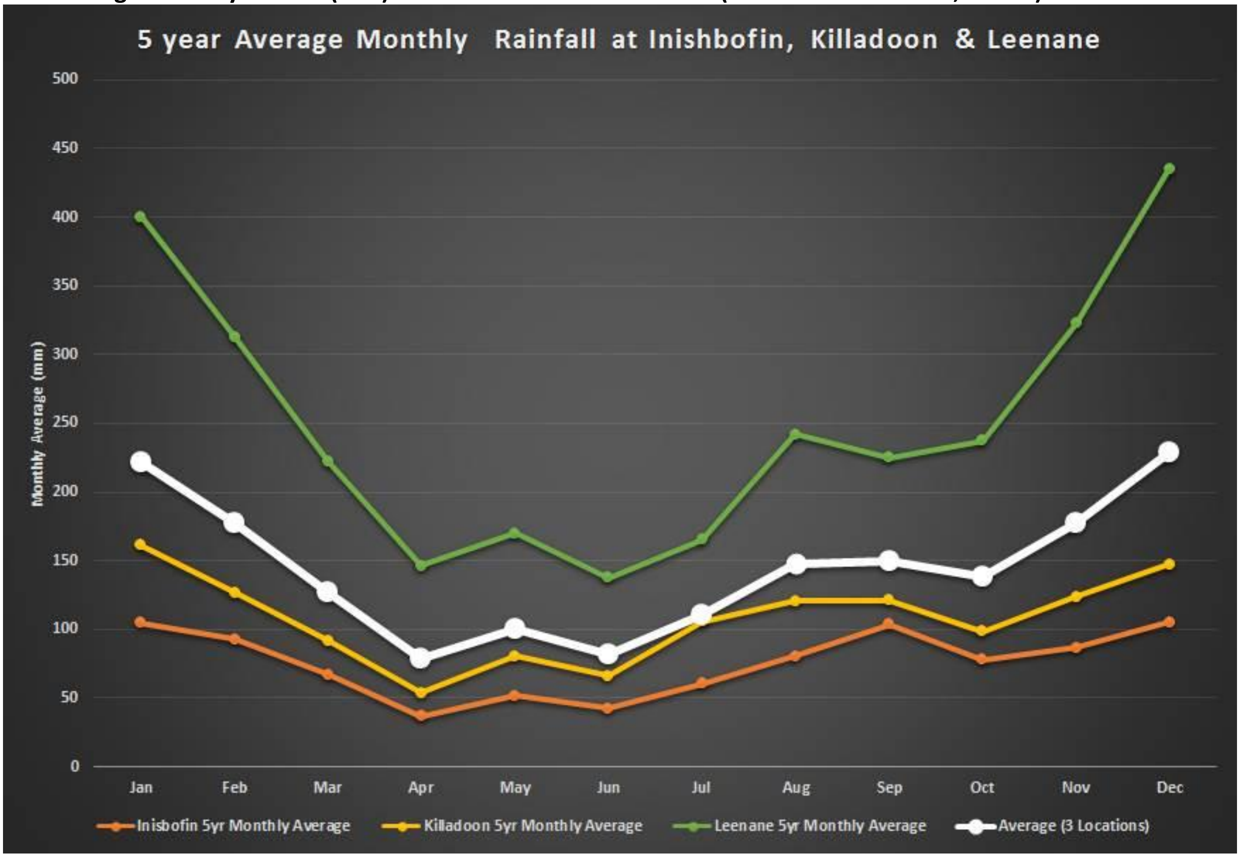


Figure 3.9: 5-year average monthly rainfall (mm) at Inishbofin, Killadoon and Leenane (and average across 3 locations) from 2014-2018 (Source: Met Eireann, 2010e, 2010f; 2010g).

3.7. Salinity

The proposed BMPA is fully marine with salinities ranging from 33.5 PSU in spring to 34.5 PSU in winter in the inner part of the proposed BMPA and from 34.5 PSU in spring to 35.1 PSU in winter towards Inishbofin and Inishturk. The influence of freshwater input on salinity levels is insignificant.

3.8. Turbidity

While no data is available, turbidity levels due to suspended sediments will be close to zero.

3.9. Residence Times

Residence time can be defined as the average amount of time that a molecule of water of a particle spends in a particular system. Residence times are important because of the way they govern productivity rates as well as the vulnerability to water quality degradation. Given the open exposed nature of the proposed BMPA, water flow has a clear path through and it does not reside in the area as it would in an enclosed bay or harbour.

3.10. Discussion

The deep, open exposed waters of the proposed Killary Approaches BMPA are fast moving and well flushed. Any contamination entering the area will be diluted and dispersed rapidly and the area will not act as a sink for any contaminants. In addition, the prevailing wind direction has the effect of pushing water towards the north. Freshwater input is relatively low and has little influence on salinity levels in the water body.

4. Identification of Pollution Sources

The main sources of *E. coli* are municipal sewage discharges or runoff from failing septic systems, animal feed operations, farms and faeces deposited in woodlands from warm blooded animals. In urban areas, the *E. coli* from the excrement of warm blooded animals (such as pets in a park or on the street) may be washed into creeks, rivers, streams, lakes, or groundwater during rainfalls or snow melts. The contamination in water is often highest immediately following a storm, because of the runoff. Increases can also be evident during the summer months due to higher populations (tourists) in coastal areas. In addition, infected bathers can unknowingly contaminate water, or contamination can occur from boaters discharging wastes directly into the water. This section attempts to document all pollution sources within the Killary Approaches and Killary Harbour catchment area.

4.1. Desktop Survey

Pollution sources were considered within the catchment area of Killary Approaches and Killary Harbour as the latter flows directly into the former (see Figure 4.1). The Killary Approaches catchment area covers 106.2km^2 and the Killary Harbour catchment area covers 261km^2. The catchment extends *c.* 25.5km inland.

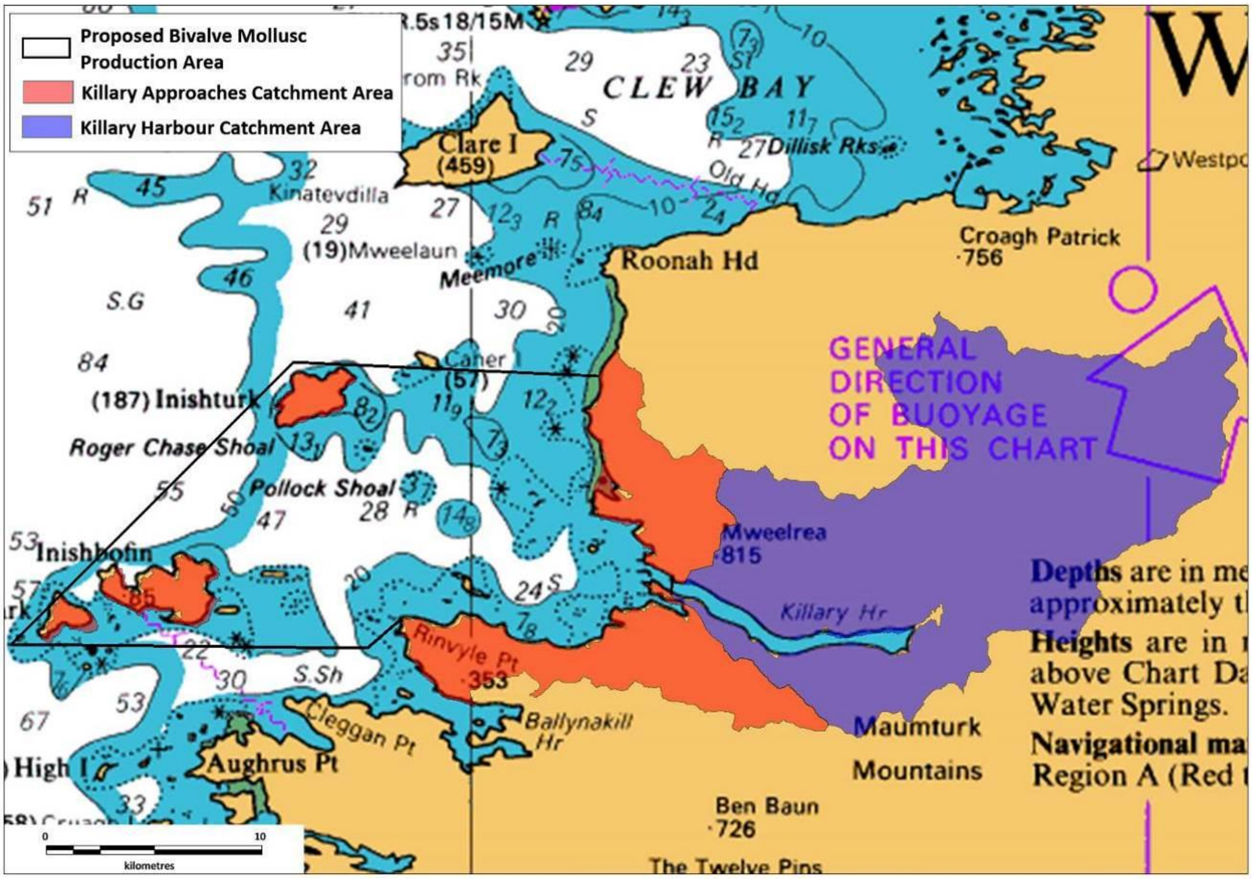


Figure 4.1: Killough Approaches and Killary Harbour catchment areas used for assessment of the pollution sources.

4.1.1. Human Population

Figure 4.2 shows the counties which fall within the Killary Approaches and Killary Harbour catchment areas; Co. Mayo lies to the north of Killary Harbour and Co. Galway to the south. Inishturk is in Co. Mayo and Inishbofin is in Co. Galway. Population census data used by the Central Statistics Office (CSO) is given in units of Electoral Divisions (ED). Figure 4.3 shows the EDs within the catchment areas. The population data were obtained through the Central Statistics Office (CSO) online Small Area Population Statistics (SAPS) (CSO, 2019a) for the year 2016. Figure 4.4 shows the human population within Killary Approaches and Killary Harbour catchment area and Table 4.1 shows these data in tabular form.

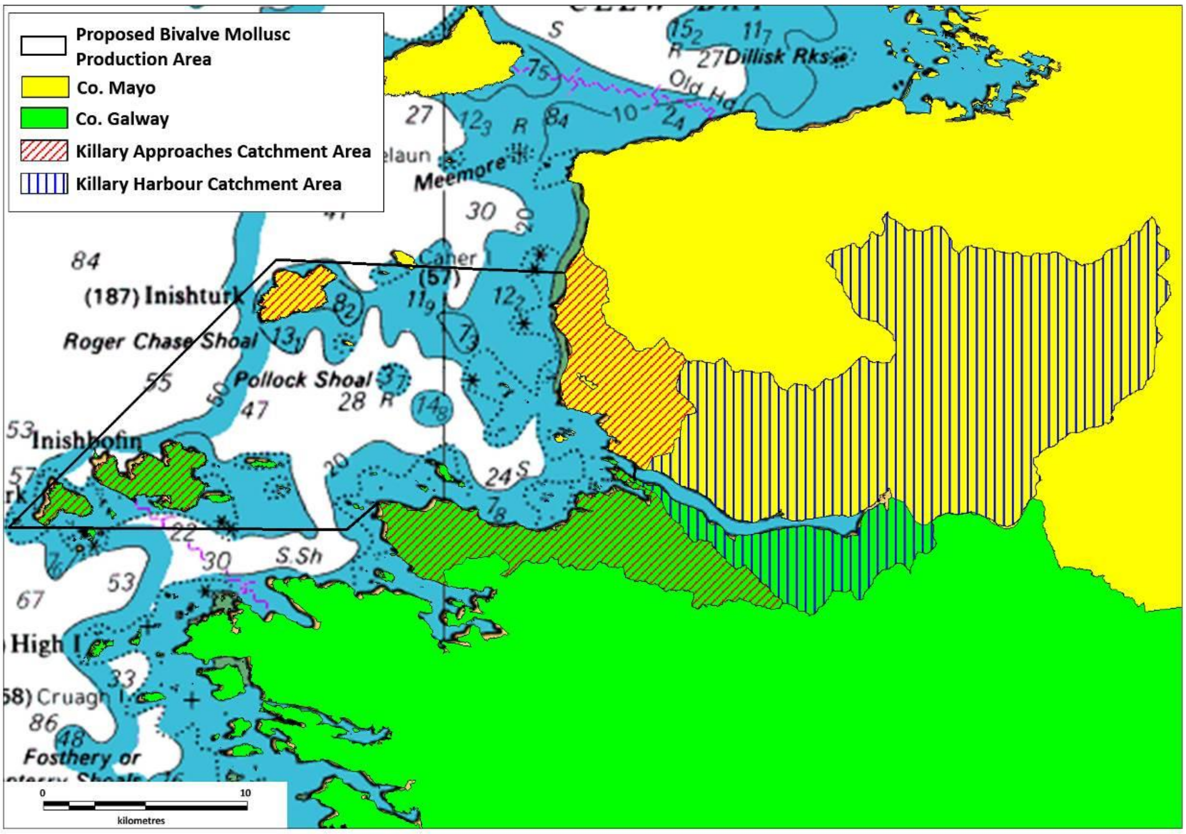


Figure 4.2: Counties within the Killary Approaches and Killary Harbour Catchment Areas.

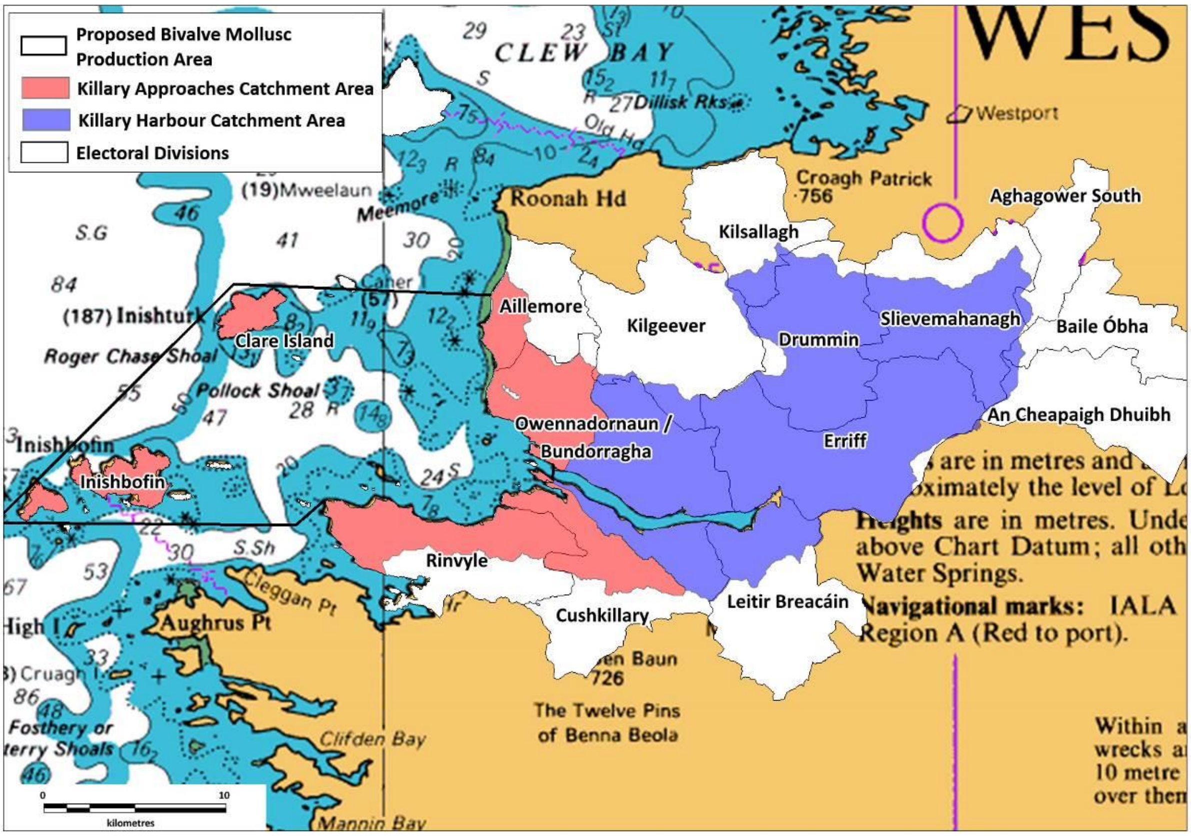


Figure 4.3: Electoral Divisions within the Killary Harbour and Killary Approaches Catchment Area.

The Killary Approaches Catchment Area overlaps six ED's (one in its entirety and 5 partially): Aillemore (partial), Owennadornaun/Bundorragha (partial), Cushkillary (partial), Rinville (partial), Inishbofin (complete) and Clare Island (partial). Rinville contains by far the largest population (1,226) followed by Aillemore (355) and Cushkillary (318).

The Killary Harbour Catchment Area overlaps 11 ED's (all partially): Owennadornaun/Bundorragha, Kilgeever, Erriff, Drummin, Kilsallagh, Slievemahanagh, Aghagower South, Baile Óbha, An Cheapaigh Dhuibh, Leitir Breacáin and Cushkillary. Kilsallagh contains by far the largest population (531) followed by Slievemahanagh (454) and An Cheapaigh Dhuibh (372).

These 15 ED's accommodate a total population of 4,766. As most of these ED's only partially overlap the catchment area, an attempt was made to estimate the actual population within the catchment. The percentage of the ED lying within the catchment was calculated in GIS and from this value the population size was calculated e.g. if 50% of ED lies within catchment area then 50% of the total population was taken to be the population size of the area within the catchment. Using this method, the population of the catchment areas is estimated at 2,158 people. Table 4.1 shows this estimation.

There are six main villages/urban centres within the catchment areas. Four (Killadoon, Tully, Inishbofin and Inishturk) are located within the Killary Approaches catchment area and two (Drummin and Leenane) are located within the Killary Harbour catchment area. Populations for these villages are not available.

There are 2,728 households within the 15 ED's within the catchment areas. Of this, 13% are vacant (356) and a further 21.9% are holiday homes (597). Of the 1,200 houses actually within the catchment (based on the % of the ED within the catchment), 12.7% are vacant and 23.5% are holiday homes. Table 4.2 shows the number of households in each ED and the proportion actually within the catchment areas.

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 Killary Approaches system. Therefore, the highest levels of sewage and waste would be expected to enter from the southern shoreline in the ED of Rinvyle. Given the number of holiday homes in the catchment, it is also reasonable therefore to expect the population in the area to increase by almost a quarter during the summer holiday period.

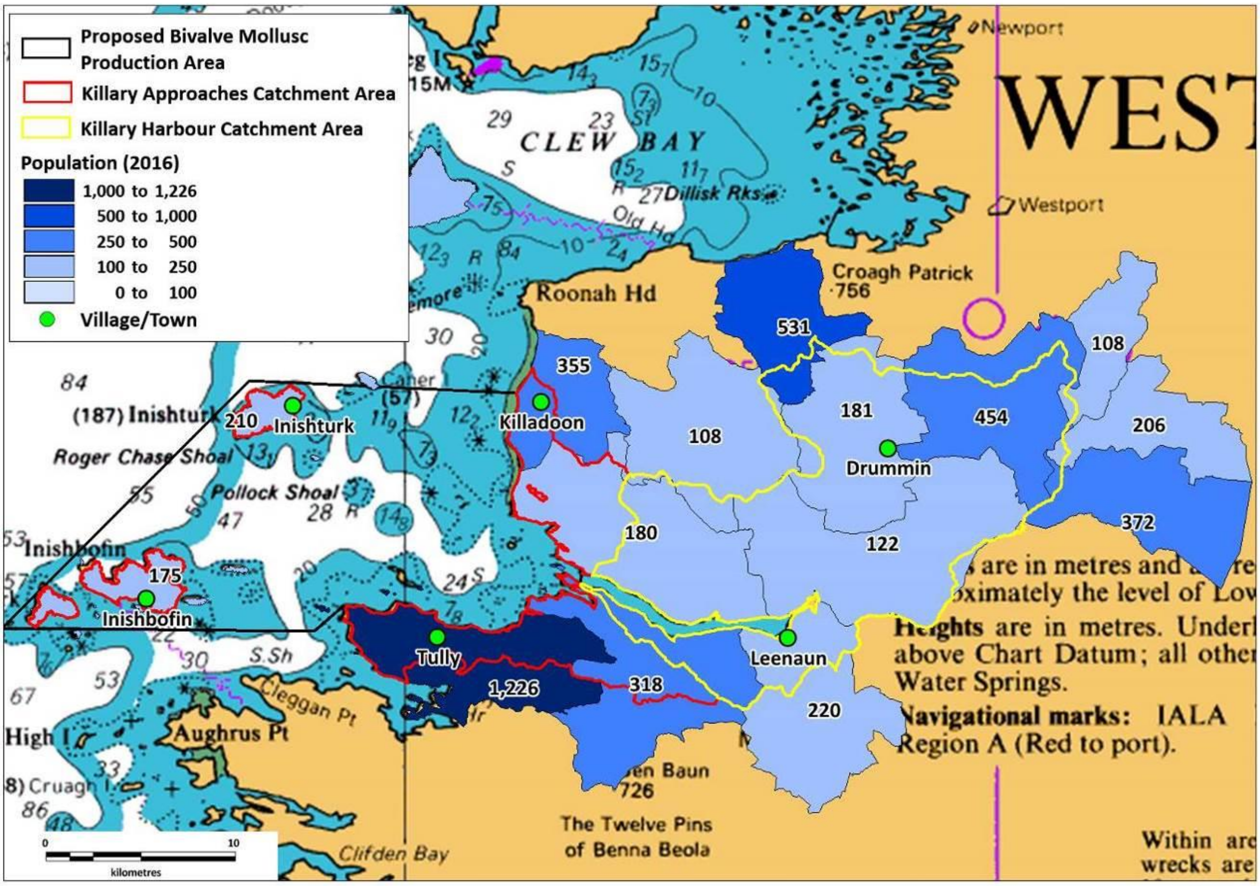


Figure 4.4: Human population within the Killary Approaches and Killary Harbour Catchment Areas (Source: CSO, 2019a).

Table 4.1: Human population within the Killary Approaches and Killary Harbour Catchment Areas (Source: CSO, 2019a).

Electoral Division	Population (2016)	% ED in Catchment	Estimated Population
Owennadornaun/Bundorragha	180	96.52	174
Cushkillary	318	58.71	187
Inishbofin	175	100.00	175
Rinvyle	1226	57.10	700
Baile Óbha	206	2.93	6
An Cheapaigh Dhuibh	372	2.71	10
Aghagower South	108	4.40	5
Aillemore	355	28.93	103
Clare Island	210	25.57	54
Drummin	181	90.22	163
Erriff	122	97.74	119
Kilgeever	108	10.48	11
Kilsallagh	531	13.30	71
Slievemahanagh	454	70.12	318
Leitir Breacáin	220	28.32	62

Table 4.2: Households within the EDs in the Killary Approaches and Killary Harbour Catchment Areas (Source: CSO, 2019a).

Electoral Division	Total Households	No. Occupied*	Unoccupied holiday homes	Vacant houses	Total Households in Catchment	No. Occupied in Catchment	Unoccupied holiday homes in Catchment	Vacant houses in Catchment
Owennadornaun /Bundorragha	69	50	9	10	67	48	9	10
Cushkillary	106	74	22	10	62	43	13	6
Inishbofin	157	76	65	16	157	76	65	16
Rinvyle	718	453	192	73	410	259	110	42
Baile Óbha	122	83	13	26	4	2	0	1
An Cheapaigh Dhuibh	189	145	6	19	5	4	0	1
Aghagower South	57	46	2	9	3	2	0	0
Aillemore	251	141	69	41	73	41	20	12
Clare Island	139	80	30	29	36	20	8	7
Drummin	98	75	6	17	88	68	5	15
Erriff	67	39	13	15	65	38	13	15
Kilgeever	58	45	3	10	6	5	0	1
Kilsallagh	345	205	102	38	46	27	14	5
Slievemahanagh	189	149	17	23	133	104	12	16
Leitir Breacáin	163	95	48	20	46	27	14	6
Total	2728	1756	597	356	1200	765	282	152

* This figure includes those houses temporarily unoccupied on census night

4.1.2. Tourism

In 2017, 3.6 million tourists visited the West Region of Ireland (Failte Ireland, 2018a). This figure was made up of 1,911,000 overseas tourists, 1,622,000 domestic tourists and 109,000 Northern Irish tourists. Of the overseas tourists, 1,673,000 visited Co. Galway and 324,000 visited Co. Mayo (Fáilte Ireland, 2018b). Kylemore Abbey is located *c.* 2km south of the Killary Approaches catchment area and this is the top fee-paying tourist attraction in the area (and 8th overall in the country). 558,000 tourists visited this centre in 2017 (Fáilte Ireland, 2018a). Connemara National Park is the top non-fee paying attraction in the area (and 16th overall in the country), attracting 221,713 visitors in 2017. This attraction is located *c.* 3km south of the Killary Approaches catchment area. Other tourist attractions in the area include Croagh Patrick (*c.* 2.5km north of the Killary Harbour catchment area) and the islands of Inishbofin and Inishturk themselves.

While most of these attractions are located outside the catchment areas, the tourists may also visit Killary Harbour, Inishbofin and Inishturk while in the area. 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.

Several operators use the natural amenities in and adjacent to Killary Harbour as a focal point for their aqua-tourism businesses (CLAMS, 2002). The two adventures centres (Delphi Lodge and Killary Adventure Centres) are located close to the shoreline of the Harbour and offer both land and sea based activities all year round. Scubadive West, based at Lettergesh close to Killary Harbour, offers diving in and around the mouth of the Harbour while Killary Fjord Boat Tours offer 90 minute boat tours around the harbour up to four times a day from April to October. The Leenane Culture Centre, located in the village of Leenane, provides an in-depth interpretation on sheep farming and the wool trade which the village was once noted for.

There are approximately 4 sea angling charter vessels operating in the area from Cleggan, Derryinver and Clifden. These vessels fish the area within the proposed BMPA but also further afield. In addition, Inishbofin and Inishturk attract anglers throughout the year.

Two ferries operate locally, one from Cleggan to Inishbofin (sailing twice daily and up to 3 times in the summer) and one from Roonagh Pier to Inishturk (sailing twice daily throughout the year). In addition to the above there is also a number of beaches and caravan/camping sites located along the shore of Killary Approaches, an airstrip on Inishbofin and a number of piers, quays and slips which provide sea access. Figure

4.5 shows all tourism related activity sites within the Killary Approaches and Killary Harbour catchment areas. Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Killary Approaches and Killary Harbour catchment areas. In addition, Papadakis *et al.* (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria. In 2007, Elmir *et al.* (2007) showed the role of human skin as an intermediate mechanism of pathogen transmission to the water column. The main swimming areas in the proposed BMPA are on the southern shore at Glassillaun and Renvyle beaches, on the eastern shore at Silver Strand and the two beaches at the east end of Inishbofin. All five of these beaches are monitoring by local authorities because swimming or recreational activities are known to take place there (although they have not been formally identified to the EU as bathing waters). Examination of water quality results for these beaches for the period 2014-2017 show that an Excellent water quality is likely to be achieved at these waters (Webster, 2018; 2017; Webster & Lehane, 2016; 2015). In addition, waste can enter the area from recreational vessels.

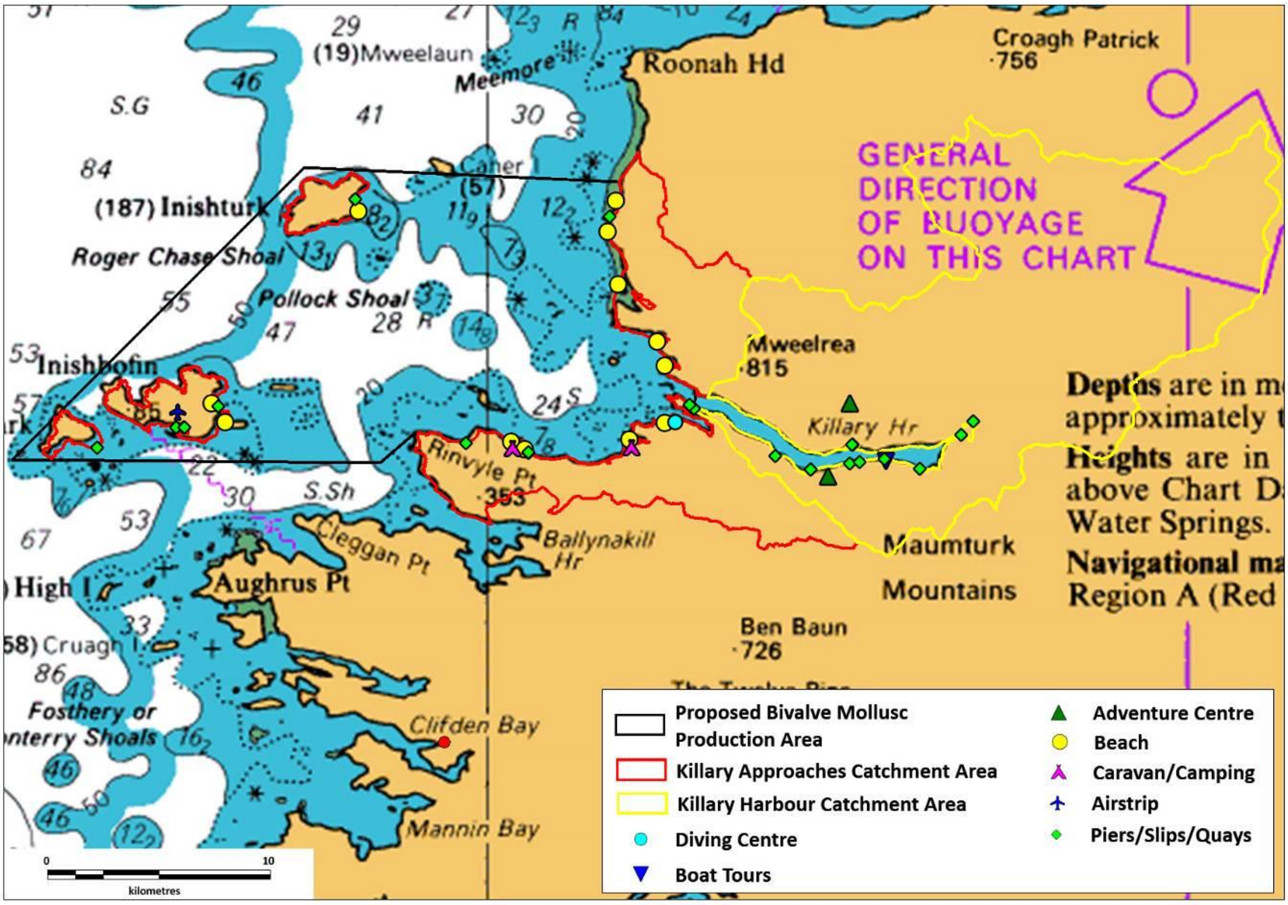


Figure 4.5: Tourist facilities within the Killary Approaches and Killary Harbour Catchment Areas.

4.1.3. Sewage Discharges

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

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

Treatment of sewage ranges from:

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

4.1.3.1. Waste Water Treatment Works

There are no waste water or sewage treatment works within the Killary Approaches catchment. Leenane WWTP (Waste Water Treatment Plant) is the only one within the Killary Harbour catchment. The location of these works can be seen in Figure 4.6 and Table 4.3 provides details of the works. The plant is designed for a PE (Population Equivalent) of 550 and the current PE loading is 415. Flows from Leenane village are received into the Leenane pumping station as part of the foul sewer network. The pump sump has been designed to cater for flows up to 25.2m^3/hr (6DWF). Installed at the Leenane WWTP are 2 foul pumps (25.2m^3/hr each) within the sump, operating in duty/standby operation. The pumping station pumps are set to pump at

13.1m^3/hr.

The plant provides secondary treatment. The plant consists of a conventional aeration treatment plant, inlet screenings followed by an aeration treatment tank, a secondary treatment settlement tank and sludge holding tank.

4.1.3.2. Continuous Discharges

There is a continuous discharge associated with the Leenane WWTP. Final effluent discharge flows into the Letterbrickaun River which flows into Killary Harbour via a 150mm pipe. The location of the discharge can also be seen in Figure 4.6 and Table 4.4 provides details of the discharge. Strict emissions limits are set for the discharge in terms of BOD (Biological Oxygen Demand), Ortho-Phosphate, Suspended Solids, Nitrogen and Ammonia and these can be seen in Appendix 1. 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 1,652 permanent private households in the 15 EDs, 4.9% (81) were connected to a public sewer/treatment system and 90.4% (1,493) 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 716 and of this 2.9% (21) are on the public system while 91.9% (658) households have their own septic tanks or other individual treatment systems. Table 4.5 shows this information at the ED level and an estimation (based on % within the catchment) of the numbers actually within the catchment.

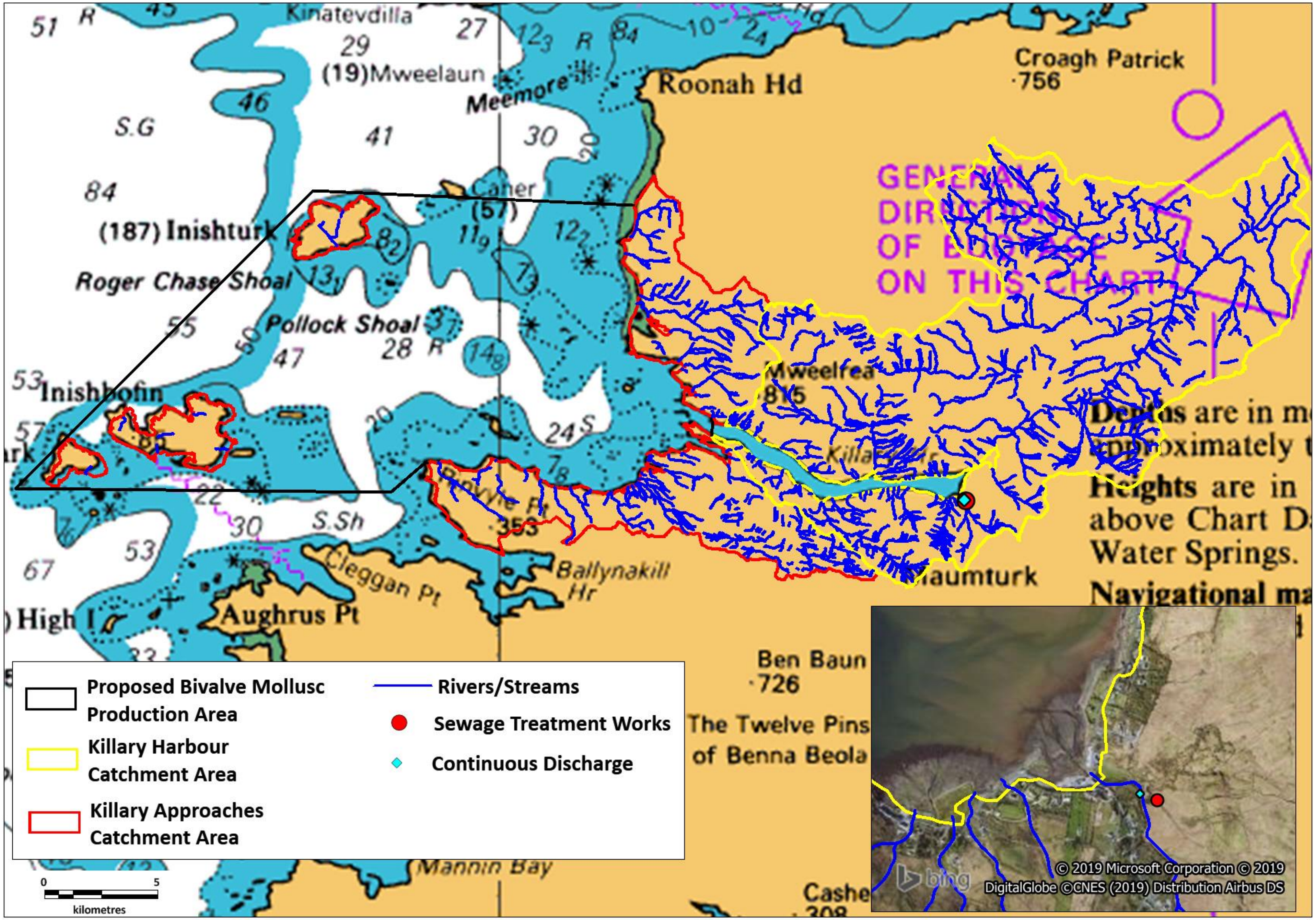


Figure 4.6: Sewage Treatment Works and Continuous Discharges within the Killary Approaches and Killary Harbour Catchment Areas (Source: The EPA, 2019a).

Table 4.3: Sewage Treatment Works within the Killary Approaches and Killary Harbour Catchment Areas (Source: EPA, 2019a).

Map Code	Name	Easting	Northing	Longitude	Latitude	p.e.
1	Leenane Sewage Treatment Works	88,128.5	261,916.5	-9.69040	53.59533	550

Table 4.4: Continuous Discharges within the Killary Approaches and Killary Harbour Catchment Areas (Source: EPA, 2019a).

Name	Treatment	Easting	Northing	Longitude	Latitude	Receiving Body	Max Discharge/ day (m^3)	DWF/ day (m^3)
Leenane WWTP	Secondary Treatment	88,067	261,912	-9.69133	53.59527	Letterbrickaun River	308	$70m^3$/day*

* $70m^3$/day is the existing DWF at a PE of 415. The design DWF is $314m^3$/day at a PE of 550.

Table 4.5: 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
Owennadornaun /Bundorragha	47	0	40	6	1	0	45	0	39	6	1	0
Cushkillary	66	0	50	10	5	1	39	0	29	6	3	1
Inishbofin	70	1	56	7	6	0	70	1	56	7	6	0
Rinvyle	415	8	344	39	24	0	237	5	196	22	14	0
Baile Óbha	81	0	69	8	4	0	2	0	2	0	0	0
An Cheapaigh Dhuibh	136	27	95	10	4	0	4	1	3	0	0	0
Aghagower South	46	0	41	4	1	0	2	0	2	0	0	0
Aillemore	132	1	114	13	4	0	38	0	33	4	1	0
Clare Island	76	3	64	5	4	0	19	1	16	1	1	0
Drummin	71	0	65	3	3	0	64	0	59	3	3	0
Erriff	38	0	33	3	2	0	37	0	32	3	2	0
Kilgeever	45	1	43	0	1	0	5	0	5	0	0	0
Kilsallagh	196	2	166	19	8	1	26	0	22	3	1	0

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
Slievemahanagh	147	5	116	18	8	0	103	4	81	13	6	0
Leitir Breacáin	86	33	48	4	1	0	24	9	14	1	0	0
Total	1652	81	1344	149	76	2	716	21	589	69	38	1

4.1.3.3. Rainfall Dependent / Emergency Sewage Discharges

Provision has been made for a storm overflow associated with the Leenane WWTP. Flow in excess of $13.1m^3/hr$ is considered storm flow and as such will bypass the works and flow directly to the outfall via the storm overflow pipe (see Figure 4.6 above for location). This storm flow is measured via flow-meter. There are no storm overflows in the upstream foul sewer collection network.

4.1.4. Industrial Discharges

There are no licenced waste facilities or IE (Industrial Emissions) / IPC[2] (Integrated Pollution Control) facilities in the Killary Approaches or Killary Harbour catchment areas. There are a number of Section 4 licences (see Figure 4.7) for the discharge of trade effluent, 8 in the Killary Approaches catchment and 5 in the Killary Harbour catchment. Table 4.10 shows details of these Section 4 licences. Where available details on the discharges can be seen in Table 4.10.

[2] The categories of industry coming within the scope of IPC licensing are Minerals and Other Materials, Metals, Mineral Fibres and Glass, Chemicals, Food and Drink, Textiles and Leather, Fossil Fuels, Cement, Waste (class 11.1), Surface Coatings, Other Activities (includes testing of engines, manufacture of integrated circuits and printed circuit boards, production of lime and manufacture of ceramics)

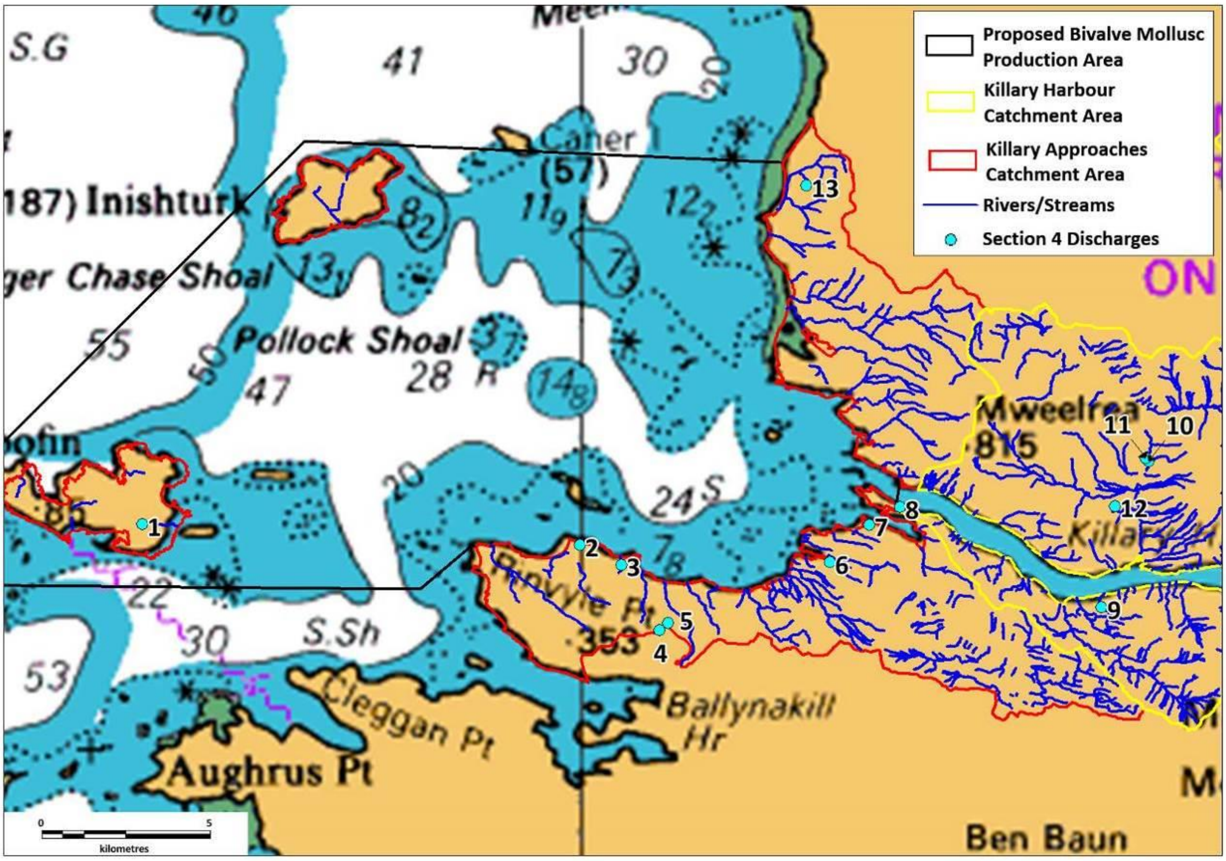


Figure 4.7: All industrial discharges within the Killary Approaches and Harbour Catchment Areas (Source: EPA, 2019c).

Table 4.6: Details on Section 4 discharges with the Killary Approaches and Killary Harbour Catchment Areas (Source: EPA, 2019c).

Map ID	File Reference	Licence holder	Facility Type	Nature of Discharge	Longitude	Latitude	Easting	Northing
1	W403/06	Pat and Mary Coyne	N/A	N/A	-10.1977	53.61531	54611.17	265057.6
7	W270/92	Scubadive Limited	Recreational/ Commercial	N/A	-9.87243	53.61528	76136.34	264438.5
12	WP(W)99	Seedlings Investment Ltd, Delphi Mountain Resort & Spa	Recreational / Commercial	Primary, secondary and tertiary treated wastewater effluent to Groundwater	-9.7624	53.62017	83430.42	264796.6
13	WP(W)71	Paraic O'Malley	N/A	N/A	-9.90074	53.70542	74531.34	274519.6
10	WP(W)97	Delphi Fishery Ltd.	Delphi Lodge & Cottages	Treated effluent (including domestic) to Groundwater	-9.7473	53.63216	84462.42	266106.6
6	W476/14	Laffey Caravan Park	N/A	N/A	-9.89004	53.60524	74941.34	263352.5
8	W452/09	Purple Spade Ltd.	Shellfish	N/A	-9.85862	53.61994	77063.36	264933.6
3	W455/09	Pauline Mortimer	N/A	N/A	-9.98322	53.60462	68772.29	263450.5
11	WP(W)98	Delphi Fishery Ltd.*	Salmon hatchery	Treated effluent from hatchery to Owengarr River	-9.74871	53.6329	84371.42	266191.6
9	W338/00	Little Killary Adventure Centre Ltd.	Recreational/ Commercial	N/A	-9.76835	53.59324	82962.41	261809.5

Map ID	File Reference	Licence holder	Facility Type	Nature of Discharge	Longitude	Latitude	Easting	Northing
5	W111/78	Connemara West Ltd.	N/A	N/A	-9.96243	53.5891	70100.3	261685.5
2	W304/95	Vincent Flannery (Renvyle House Hotel)	Commercial	N/A	-10.002	53.60982	67544.28	264064.5
4	W351/02	Maol Reidh Lodge	Commercial	N/A	-9.9663	53.58722	69838.3	261483.5

*The Delphi Salmon Hatchery also abstracts water for use in the hatchery, the quantity of which shall not exceed 4.3 million litres per day or 179,200 litres per hour with an average water usage of 2 million litres per day and shall not exceed 50% of the flow at the abstraction points at any time.

4.1.5. Landuse Discharges

Figure 4.8 shows the Corine land use within the Killary Approaches and Killary Harbour catchment areas. Figure 3.5 (page 29) shows all rivers/streams within the catchment areas. Within the catchment area, landuse is dominated by peat bogs (224km^2; 59.6%), followed by land principally occupied by agriculture but with significant areas of natural vegetation (25.34km^2; 6.7%), natural grassland (25.32km^2; 6.7%) and sparsely vegetated areas (25.06km^2; 6.7%) (see Figure 4.9). Forestry (coniferous, broad-leafed and mixed) makes up 3.9% of the land use in the area (14.7km^2).

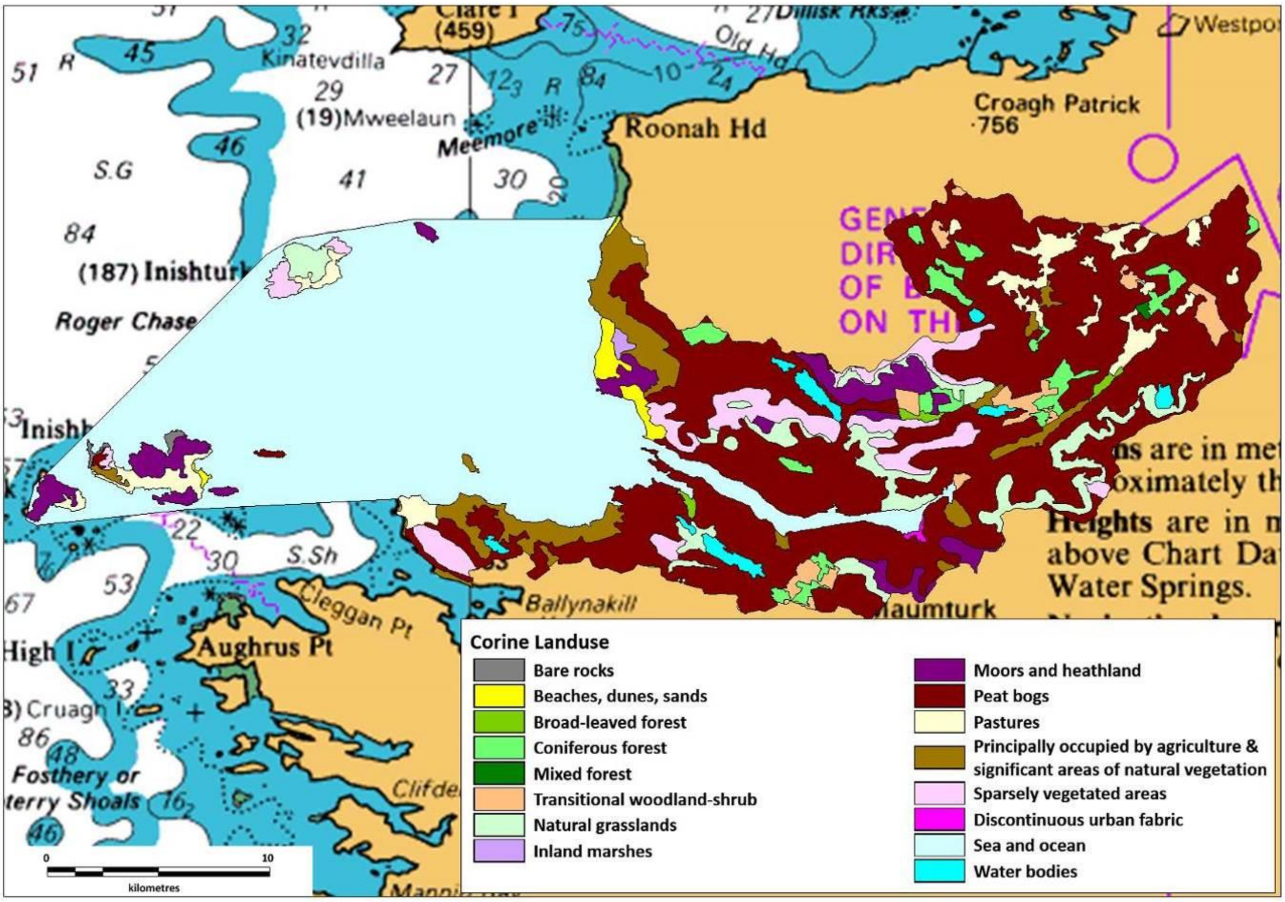


Figure 4.8: Land use within the Killary Approaches and Killary Harbour Catchment Areas (Source: EPA).

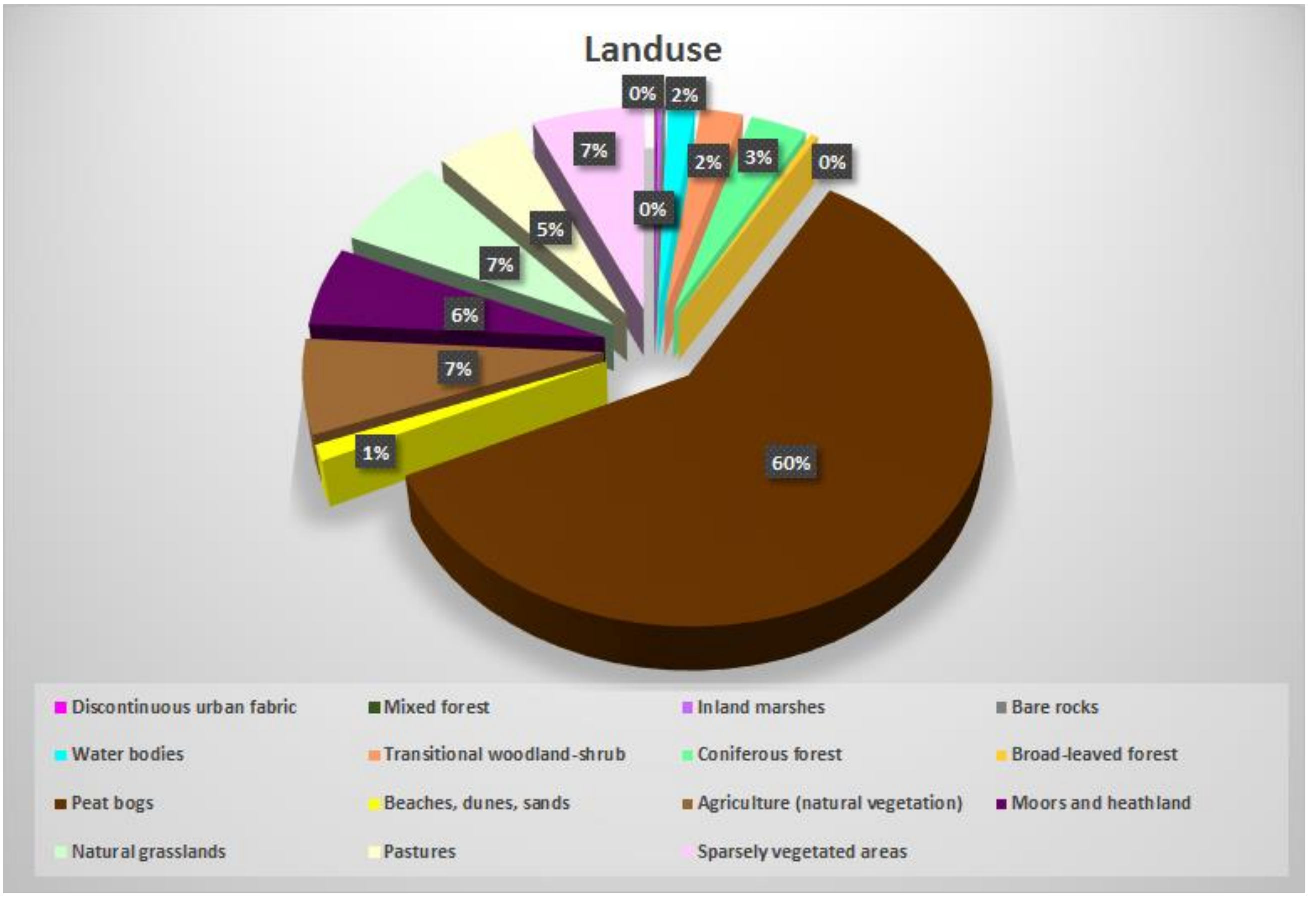


Figure 4.9: Breakdown of landuse within the Killary Harbour and Killary Approaches Catchment Areas.

Data from the Census of Agriculture 2010 (CSO, 2019b) can be seen in Table 4.11 below. Figures 4.10 to 4.17 show thematic maps for each category in Table 4.11. There are no farms or agricultural activity in the Owennadornaun / Bundorragha which boarders much of the northern shore of Killary Harbour.

Numbers of farms within the catchment range from 32 in Leitir Breacain, Co. Galway to 115 in Rinville, Co. Galway. The total area farmed within the catchment varies from 304 ha on Inishbofin (Co. Galway) to 4,772 ha in Leitir Breacain, Co. Galway. The average farm size ranges from 9.2 ha on Inishbofin, Co. Galway to 149.1 ha in Leitir Breacain, Co. Galway.

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 3.3 ha on Inishbofin, o. Galway to 4,772 ha in Leitir Breacain, Co. Galway. Total crops range from 0 ha in all areas with the exception of 1ha in An Cheapaigh Dhuibh, Co. Mayo and Slievemahanagh, Co. Mayo and 2 ha in Aghagower South, Co. Mayo.

The total number of cattle within the catchment range from 72 in Leitir Breacain, Co. Galway to 854 in

Aillemore, Co. Mayo. The total number of sheep within the catchment range from 2,273 on Inishbofin, Co. Galway to 14,541 in Slievemahanagh, Co. Mayo. The total number of horses within the catchment range from 0 at Kilgeever, Co. Mayo to 73 in An Cheapaigh Dhuibh, Co. Mayo.

The total area farmed in the entire ED's shown in Figures 4.10 to 4.17 amounts to 28,208 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 13,255 ha. This represents 36% of the area.

Table 4.7: Farm census data for all EDs within the Killary Approaches and Killary Harbour Catchment Areas (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
Owennadornaun / Bundorragha	Mayo	0	0	0	0	0	0	0	0
Rinvyle	Galway	115	1822	15.8	0	1821	776	5757	62
Aillemore	Mayo	76	1678	22.1	0	1677	854	10907	23
Cushkillary	Galway	44	3000	68.2	0	3001	98	9829	26
Inishbofin	Galway	33	304	9.2	0	303	82	2273	3
Clare Island	Mayo	53	832	15.7	0	832	86	6463	19
Drummin	Mayo	60	3021	50.4	0	3021	230	11969	1
An Cheapaigh Dhuibh	Mayo	46	1127	24.5	1	1127	410	6415	73
Kilgeever	Mayo	44	1166	26.5	0	1166	164	4974	0
Leitir Breacain	Galway	32	4772	149.1	0	4772	72	10475	1
Aghagower South	Mayo	33	1306	39.6	2	1304	386	5839	5
Erriff	Mayo	41	2456	59.9	0	2456	106	12853	4
Baile Obha	Mayo	54	1590	29.4	0	1589	458	9945	11
Slievemahanagh	Mayo	79	3580	45.3	1	3579	562	14541	11
Kilsallagh	Mayo	86	1554	18.1	0	1552	568	6848	37

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

Figure 4.10: Number of farms within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

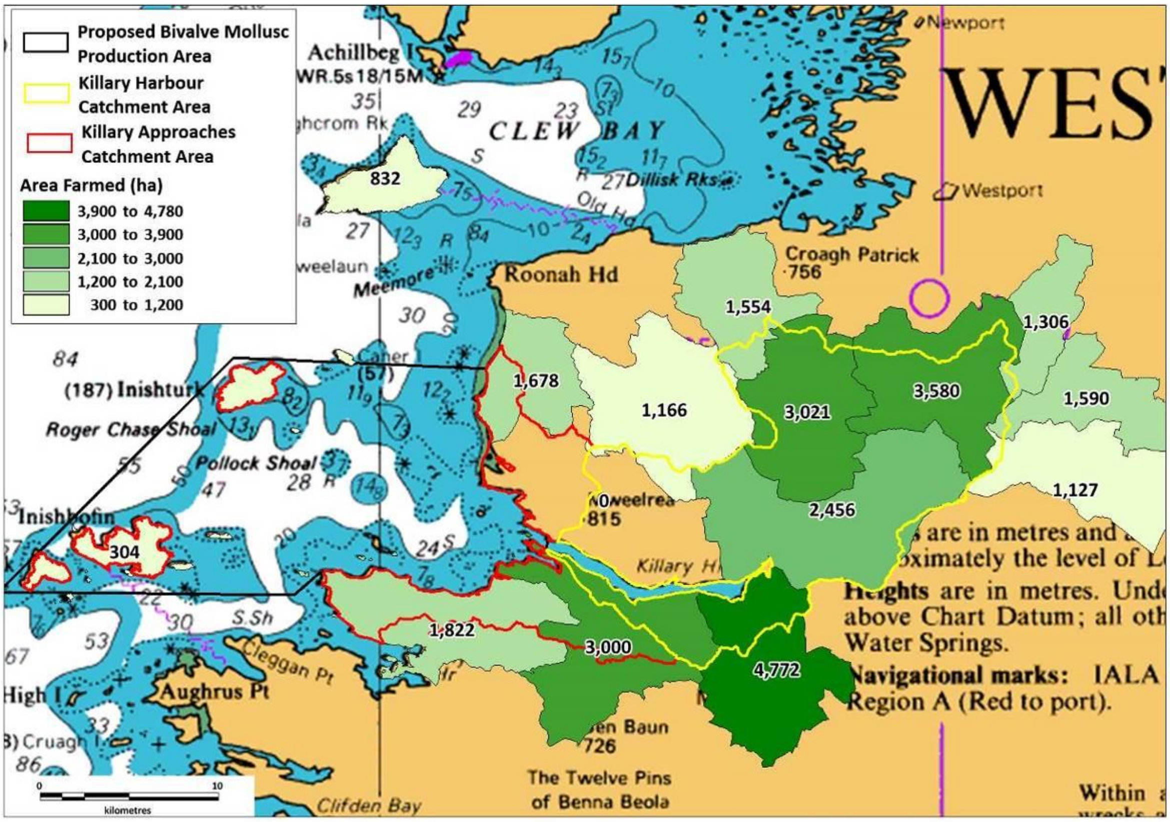


Figure 4.11: Area farmed (ha) within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

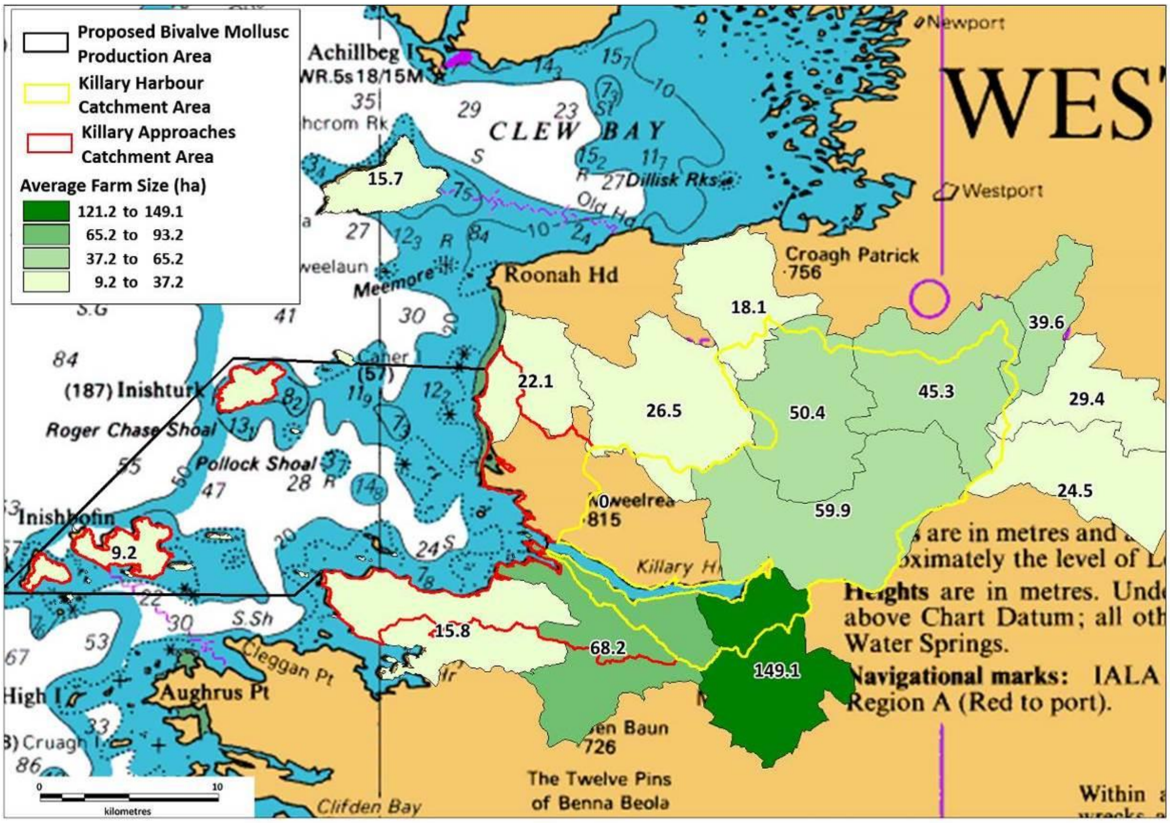


Figure 4.12: Average farm size (ha) within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

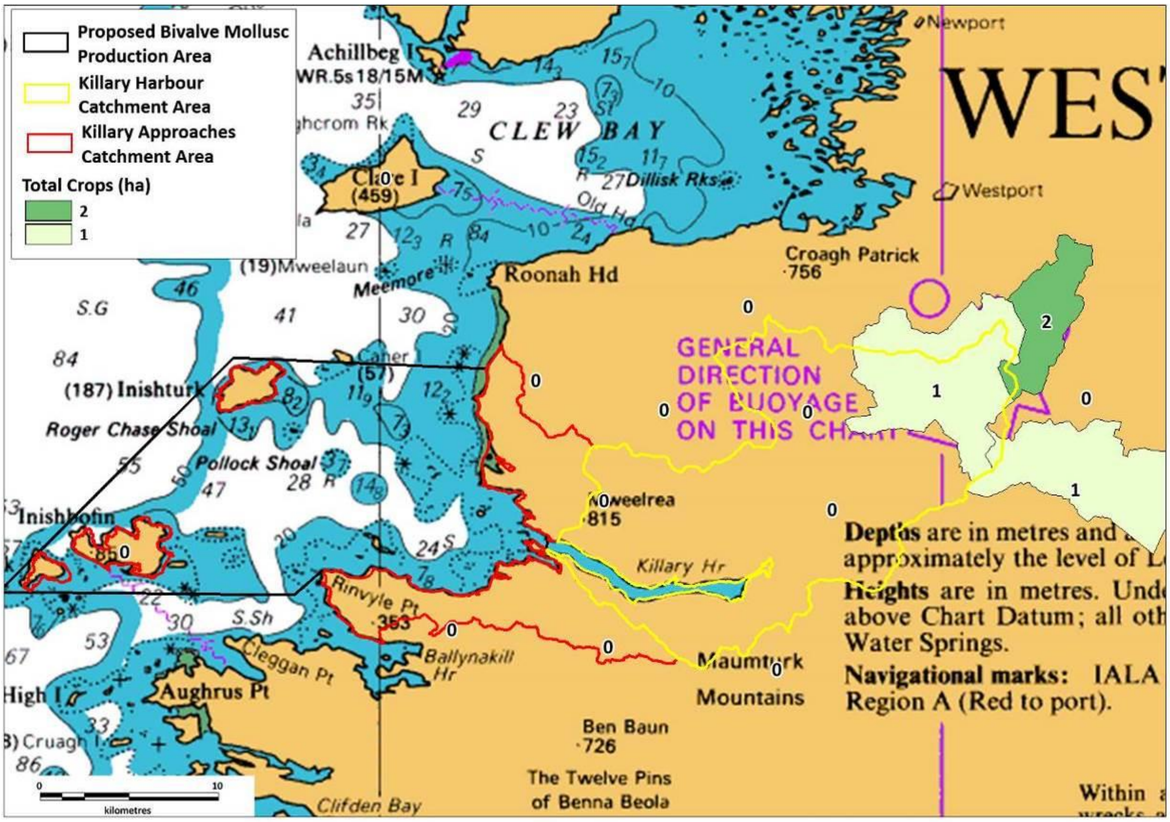


Figure 4.13: Total crops within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

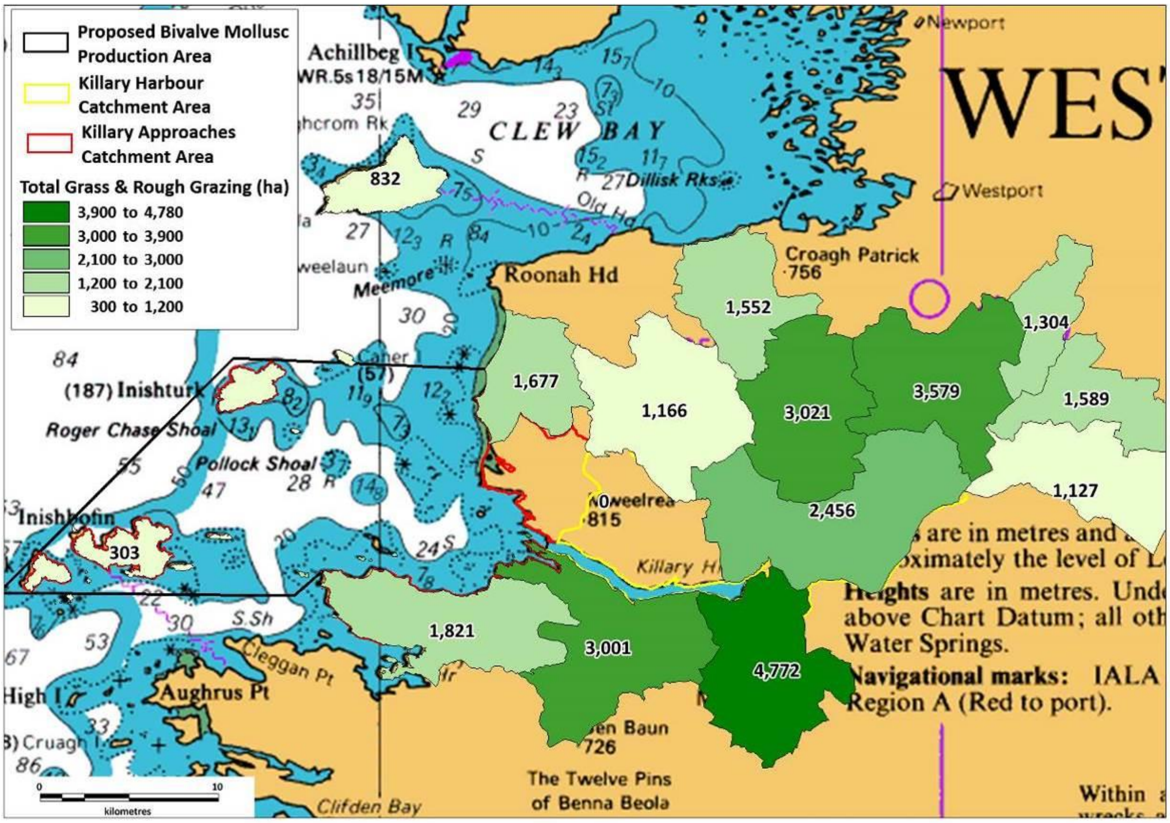


Figure 4.14: Total grass and rough grazing within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

Figure 4.15: Cattle within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

Figure 4.16: Sheep within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

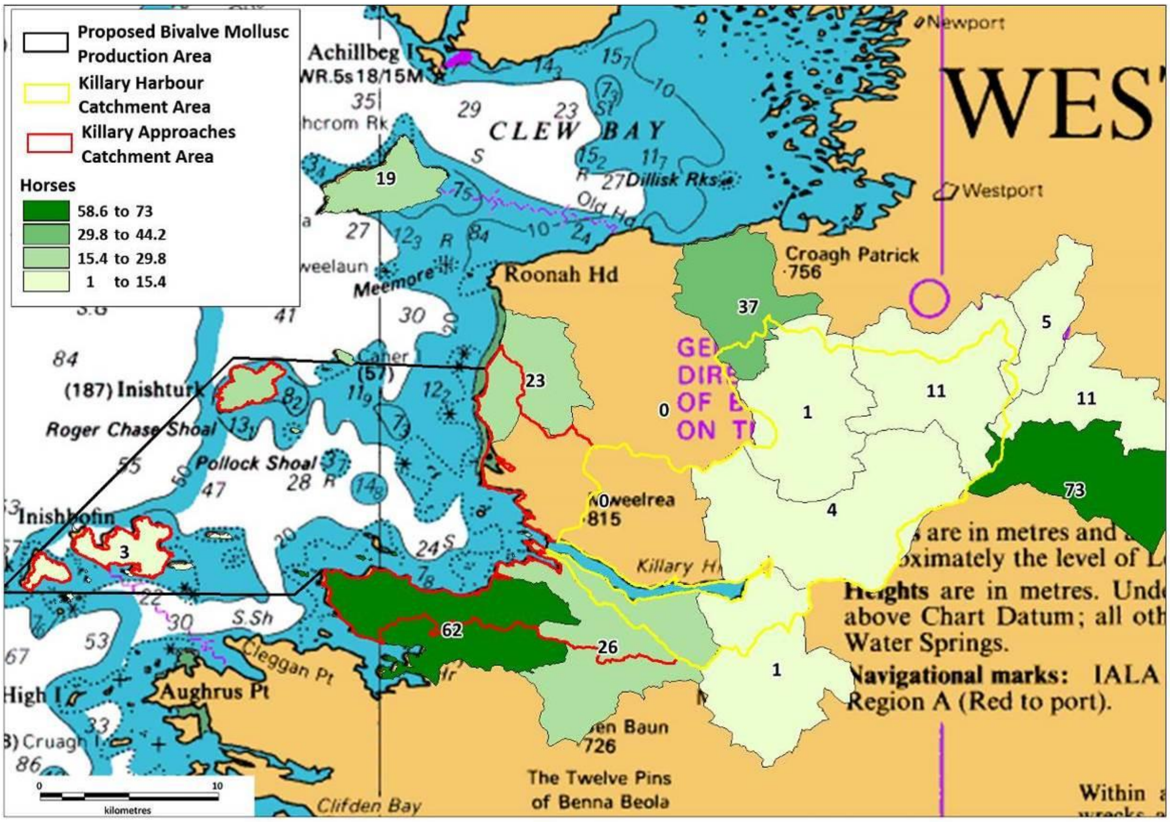


Figure 4.17: Horses within the Killary Harbour and Killary Approaches Catchment Areas (Source: CSO, 2019b).

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). Studies have shown that *E. coli* can survive in faeces for extended periods of 70–100 days at temperatures in the region of 10°C (Wang *et al.*, 1996; Kudva *et al,* 1998; Bolton *et al.,* 1999). Table 4.12 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 4.8: Potential daily loading of *E. coli* (Jones & White, 1984).

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

The large majority of livestock in the area are sheep. Cattle are also present but in lower numbers. The majority of agricultural land use in the area is total grass and rough grazing. Sheep are present in relatively large numbers throughout including on Inishturk and Inishbofin while highest numbers of cattle are present in the coastal regions along the south and east of the proposed BMPA. 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.

In addition to the deposition of faeces from livestock, slurry is also spread on agricultural lands which not only adds to *E. coli* loadings, but also increases nitrogen and phosphorus run-off to waterbodies. The Nitrates Directive for the purposes of agriculture is implemented through the Nitrates Action Programme (NAP) which is contained in the Good Agricultural Practice for Protection of Waters Regulations 2017. These regulation set out the maximum nitrate and phosphorus levels which can be applied to land through a combination of manure deposited directly by livestock and spreading of organic and chemical fertilizer. The total quantity of livestock manure per calendar year is not to exceed 170 kg of nitrogen per hectare (or must not exceed 250 kg in derogation). The total quantity of organic and chemical fertilizer must not exceed what is needed by the crops grown. The spreading of fertilizer is prohibited within the wetter months of the year, the exact period varies by location as the country has been divided into three zones. Fertilizer is not to be spread if the land is waterlogged, frozen, covered with snow, heavy rain forecast within 48 hours or land is unsuitable due to a slope greater than 10%. Further restrictions provide buffers around water bodies, which range from 5 – 250 metres depending on the water body or usage (e.g. water abstraction for human consumption).

4.1.6. Other Pollution Sources

4.1.6.1. Shipping

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

Marpol Annex IV defines sewage as “drainage from medical premises, toilets, urinals, spaces containing live animals and other waste waters when mixed with sewage waste streams”. Although adopted in 1973, the Annex did not come into effect until September 2003, with subsequent amendments entered into force in August 2005. Annex IV requires ships to be equipped with either a sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank. Within 3 miles of shore, Annex IV requires that sewage discharges be treated by a certified Marine Sanitation Device (MSD) prior to discharge into the ocean. Sewage discharges made between 3 and 12 miles off 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 4.18 shows all shipping and boating facilities and activities in the proposed Killary Approaches BMPA and in Killary Harbour. Table 4.13 details these facilities.

There are no commercial or fishing ports in the area.

There are 2 local ferry piers, one on Inishbofin and 1 on Inishturk. A ferry runs once from Cleggan to Inishbofin (sailing twice daily and up to 3 times in the summer) and one from Roonagh Pier to Inishturk (sailing twice daily throughout the year). There are also 2 other piers on Inishbofin and 1 on Inishshark. The only other piers in the proposed Killary Approaches are on the southern coastline, Gurteen Pier and at the boundary of the proposed BMPA; Rosroe Pier and the Killary Salmon Farm Pier.

There are several piers and slipways located along the shorelines of Killary Harbour with the majority sited along the Galway side *e.g.* Rosroe, King's, Leenane and Ashleigh piers while Bundorragha pier is located on the Mayo side. Also situated on the Galway side are two slipways at Derrynacleigh and Nancy's Point, which are operated by the Killary Mussel Co-op and Killary Fjord Boat Tours Ltd. respectively. Killary Fjord Boat Tours offer 90 minute boat tours around the harbour up to four times a day from April to October.

Six vessels operate in the area between February and December for brown crab (Marine Institute, 2015). Two vessels operating during the summer months in the proposed BMPA area using bottom trawls for mixed demersal species and 1 vessel operates in Killary Harbour. There is also a tangle net fishery for crayfish around Inishbofin and Inishturk between April and September. The number of vessels involved in this is unknown.

All the piers are used frequently by a wide number of groups most notably the wild fisheries, aquaculture and aqua-tourism sectors.

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.

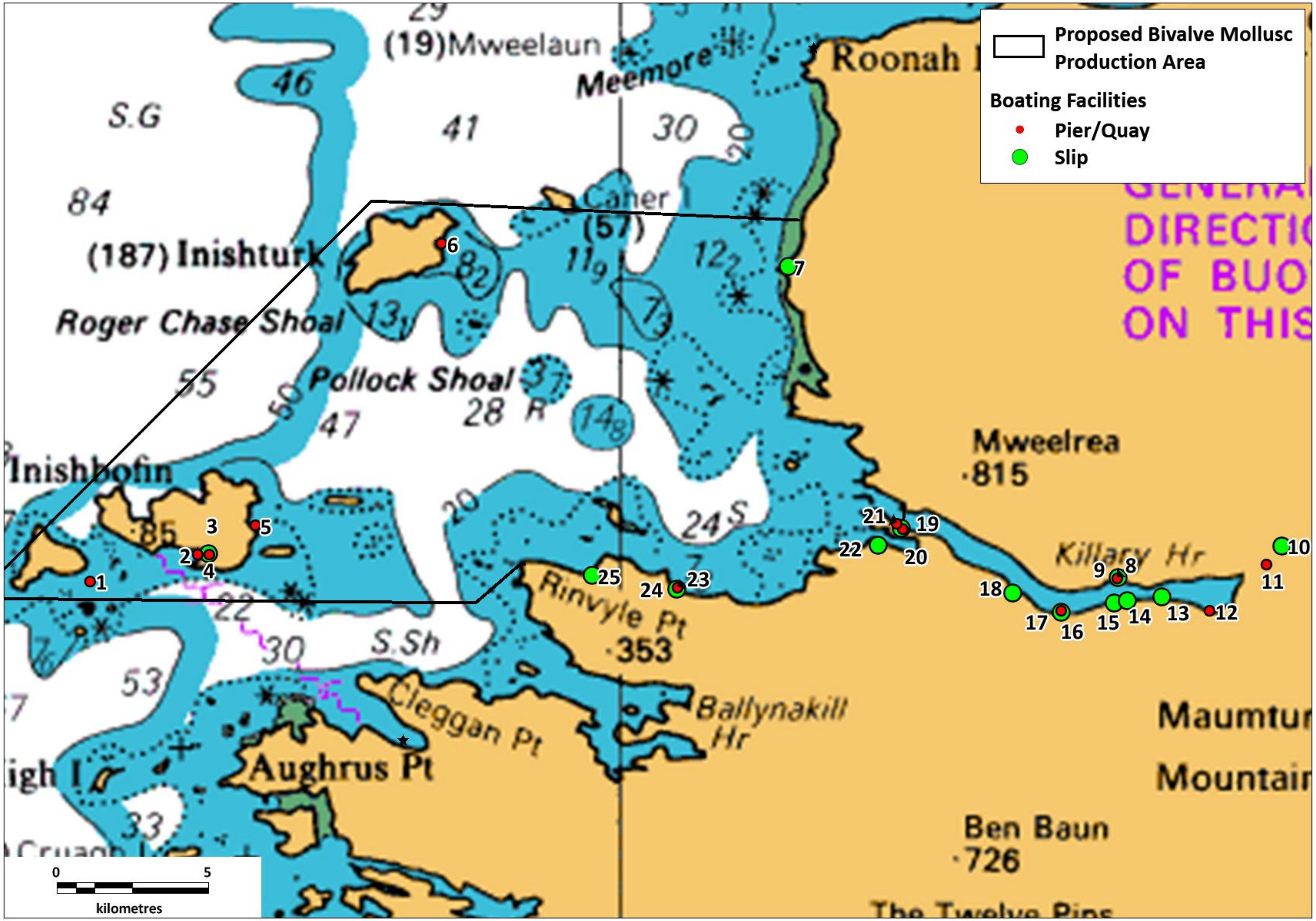


Figure 4.18: Location of all shipping/boating facilities and activities in Killary Approaches and Killary Harbour.

Table 4.9: Boating facilities in the proposed Killary Approaches BNPA and Killary Harbour.

Map ID	Name	Use (if known)
1	Inishshark Quay	
2	Inishbofin Pier	
3	Slipway	
4	Inishbofin Quay	
5	Glassillan Pier	
6	Inishturk Pier	
7	Bunlough Point Slipway	
8	Bundorragha Pier	Aquaculture, Fishing, Aqua-Tourism
9	Bundorragha Slipway	
10	Slipway	
11	Gimlock (Ashleigh) Pier	No Boats
12	Leenane Pier	Aquaculture, Fishing, Pleasure craft
13	Nancy's Point Slipway	Killary Fjord Boat Tours (Aqua-Tourism)
14	Derrynacleigh Slipway	Killary Mussels Co-op (Aquaculture Only)
15	Kings Pier	Aquaculture, Fishing
16	Slipway	
17	Pier	
18	Slipway	
19	Rosroe Pier	Aquaculture, Fishing, Aqua-Tourism
20	Rosroe Slipway	
21	Killary Salmon Farm	Aquaculture
22	Little Killary Slipway	
23	Gorteen Pier	
24	Gorteen Slipway	
25	Slipway	

4.1.6.2. Birds

It is important to document the bird populations in the proposed Killary Approaches BMPA area as bird faeces are rich in faecal bacteria (Oshira & Fujioka, 1995) and have been shown to be a source of faecal contamination in the marine environment (Jones *et al.* 1978; Standridge *et al.* 1979; Levesque *et al.* 1993, Alderisio & DeLuca 1999, Levesque *et al.* 2000, Ishii *et al.* 2007).

Figure 4.19 shows the locations of the Special Protection Areas (SPA) within the proposed BMPA. The High Island, Inishshark and Davillaun SPA (IE004144) covers Inishshark, Kimmeen Rocks, Davillaun and Lecky Rocks all of which are located within the proposed BMPA. The site supports breeding Manx Shearwater (200-300 pairs) and wintering Barnacle Goose (up to 640 individuals), the latter a species that is listed on Annex I of the E.U. Birds Directive (NPWS, 2013). Nationally important numbers of Fulmar (824 pairs) and smaller numbers of other breeding birds including Kittiwake (230 pairs), Shag (30 pairs), Herring Gull (18 pairs), Common Gull (13 pairs) and Storm Petrel (> 30 pairs) (NPWS, 2010; 2013). A pair of Peregrine has nested for many years, while small numbers of Chough breed and forage on the main islands. Corncrake was once abundant on the islands but declined in the 1960s until the early 1990s when none was recorded. More recently, however, the species has been recorded from the site – 1996, 1997 (two singing males) and 2003. In 1995, a survey recorded nationally important numbers of Arctic Tern (64 pairs). Other breeding birds recorded from the site include Black Guillemot.

The Inishbofin, Omey Island and Turbot Island SPA (IE004231) covers one fifth of Inishbofin and mostly comprises agricultural grassland used for cattle and/or sheep pasture and fodder (NPWS, 2014b). This site is protected for corncrake. They are summer visitors to Ireland, arriving from early April and departing again in August and September.

The Cross Lough (Killadoon) SPA (IE004212) is located to the northeastern corner of the proposed BMPA. This site is designated for sandwich terns although in recent years terns have not used the site but terns are known to abandon breeding sites for several years and then return to the site again if conditions are favourable (NPWS, 2015a). Black-headed Gull also breed here (70 pairs in 1995) and there are small numbers of breeding Common Gull (*c*.10 pairs).

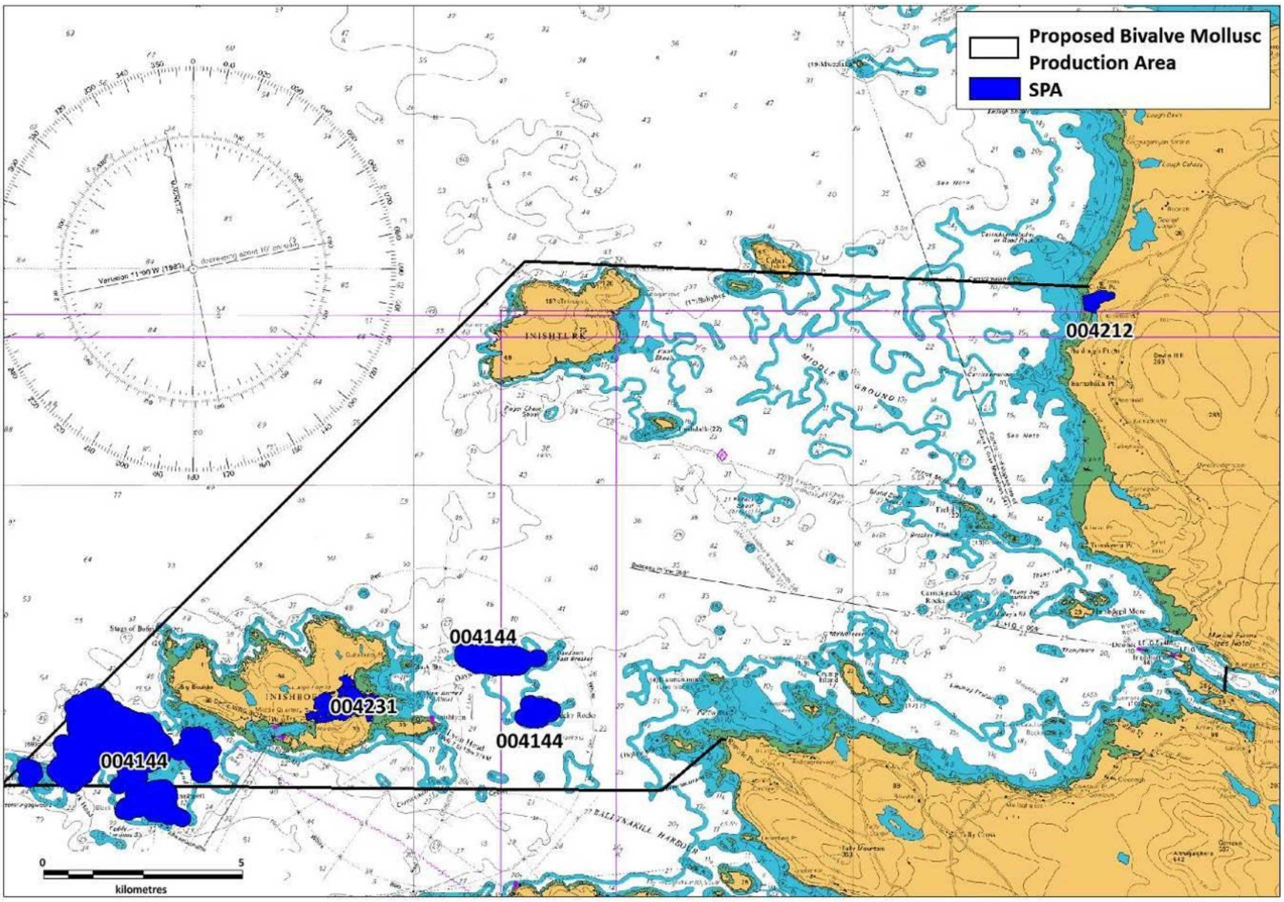


Figure 4.19: SPAs within in the proposed Killary Approaches BMPA.

There is an I-WeBS (Irish Wetland Bird Survey) survey site on Inishbofin, which was routinely surveyed by Birdwatch Ireland from 2007 to 2012. The total peak counts for each season can be seen in Table 4.14.

Table 4.10: Total peak counts of waterbirds at the Inishbofin I-WeBS survey site between 2007/08 and 2011/12 (Source: BWI, 2019).

Site Name	2007/08	2008/09	2009/10	2010/11	2011/12	Mean*
Inishbofin	516	416	308	354	187	187

* Based only on the most recent 5-season period.

Population levels of birds throughout the site is fairly stable throughout the year, with slight increases in winter when the barnacle geese arrive and in summer when the terns arrive. However, it is highly likely that these levels are low when compared with land-based discharges.

4.1.6.3. Seals

The islands of Inishbofin, Inishshark, Inishlyon, Davillaun, Kimmeen Rocks and Lecky Rocks are designated for the protection of grey seals (*Haliocherous grypus*) (Inishbofin and Inishshark SAC Site Code: IE000278).

Grey seals breed on Inishshark, Davillaun, Inishskinnybeg and Inishskinnymore, they moult on Inishshark and Lecky Rocks and they rest on Inishshark, Lecky Rocks, Kimmeen Rocks and Inishskinnymore (Figure 4.20). The population in the area is estimated at between 1,456 and 1,872 individuals (O'Cadhla *et al.,* 2013). Grey seals breed in late August to December and moult from November to April and during these periods they are hauled out along the coastline.

Adult grey seals can weight 150-220kg and they are estimated to consume between 4 and 8% of their body weight in fish, squid, molluscs and crustaceans (CEFAS, 2013). 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). Seals present in the proposed BMPA are likely to contribute to background levels of faecal contamination within the area particularly during the haul-out periods.

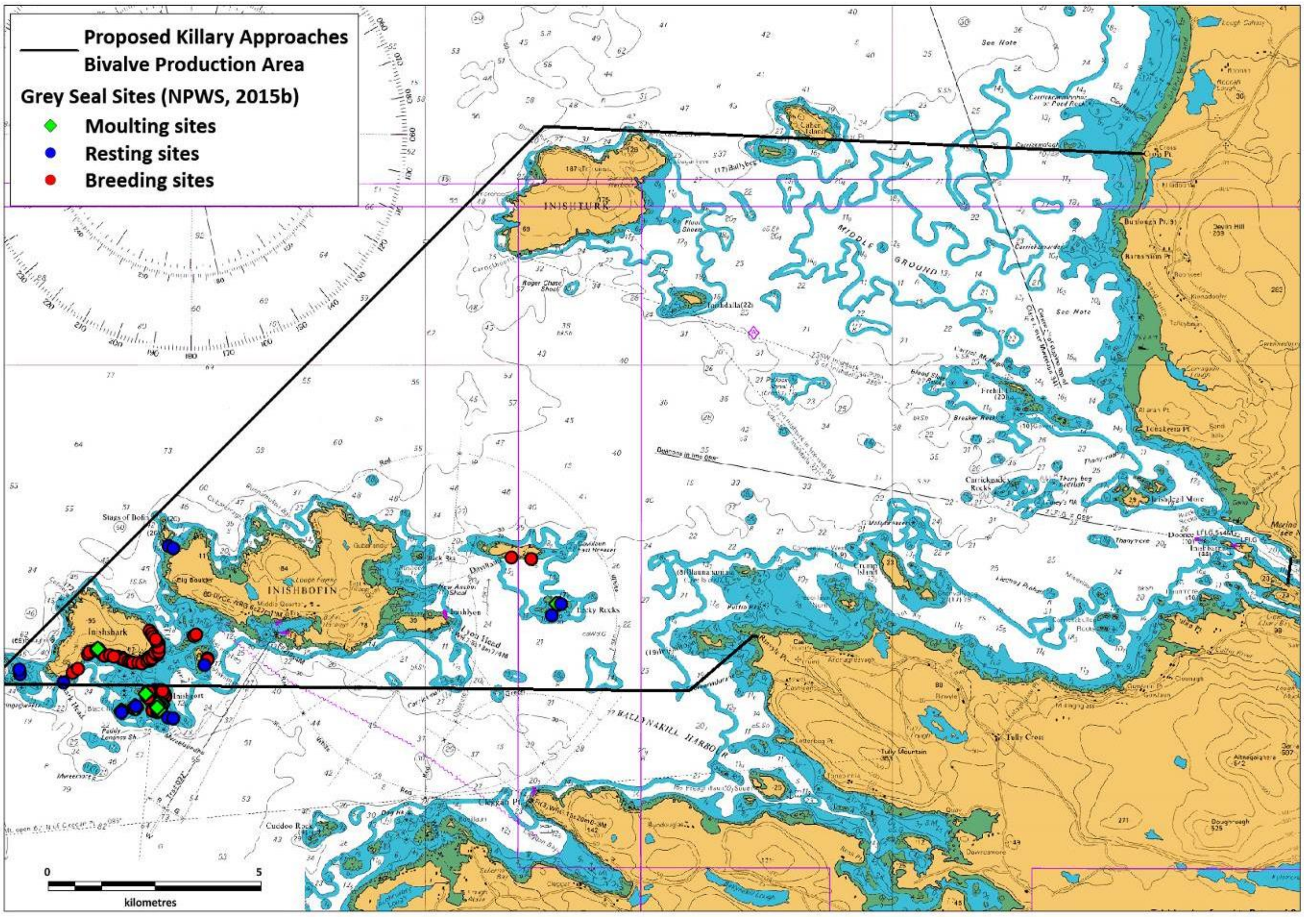


Figure 4.20: Grey seal sites within the proposed BMPA.

4.2. Shoreline Survey Report

A shoreline survey was carried out by the Sea Fisheries Protection Authority over 4 days between October 2018 and March 2019. Figure 4.21 shows the GPS (Global Positioning System) and photography sites accounted for during the 4 survey days.

The aim of this survey was to identify/confirm and mark all discharges, pollution sources, waterways and marinas along the shoreline. GPS coordinates were recorded for all features and marked on a map. In addition, all features were photographed digitally (where possible). Notes were made on the numbers and types of farm animals obvious from the shoreline and on wild fowl/populations of wild animals with an estimation of their numbers.

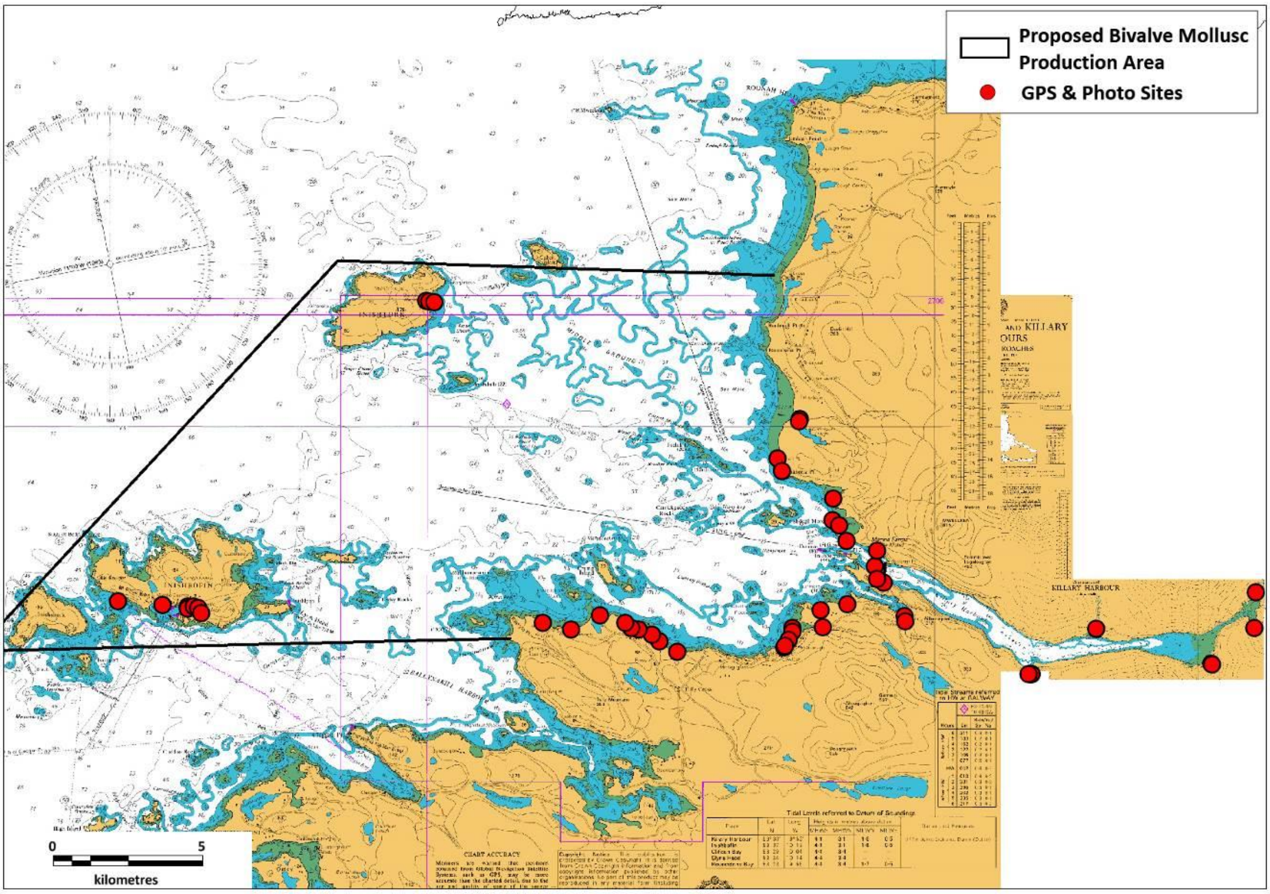


Figure 4.21: Locations of GPS and Photograph Sites.

Figure 4.22 shows the locations of all features observed during the shoreline survey. In total 49 features were identified. Of the 49 identified, 18 rivers/streams were identified, 17 drains/discharges, 8 piers/berths, 1 possible abstraction pipe, 2 agricultural usages, and 1 was septic tank. Figures 4.23 to 4.34 show aerial imagery of the location of the features and Figures 4.35 to 4.38 shows images of most of these features. Table 4.15 details all features identified and the numbering used is cross-referenced to Figures 4.22 to 4.38.

Table 4.11: Features identified during the shoreline survey. Refer to Figures 4.22 – 4.30 for locations and Figures 4.31 to 4.33 for photographs.

Map ID	Feature	Latitude	Longitude	Easting	Northing
1	Inishboffin Razor Bed	53.6149	-10.247	51349.854	265113.87
2	Drain	53.61383	-10.22446	52837.551	264947.93
3	Drain - Considerable enrichment, two geese	53.61344	-10.21189	53667.945	264878.6
4	Inishboffin Outer Pier	53.61271	-10.21196	53660.794	264797.52
5	Drain	53.61325	-10.20888	53866.467	264851.27
6	Inishboffin Inner Pier	53.612864	-10.20658	54017.321	264803.6
7	Inishboffin harbour/berths	53.61142	-10.20514	54107.632	264639.95
8	Inishturk Pier - Only one v small vessel	53.70499	-10.0912	62007.687	274800.23
9	Inisturk berths - Only one boat	53.70474	-10.08969	62052.641	274794.12
10	Inishturk Razor Bed	53.70453	-10.08727	62211.751	274766.06
11	Stream - Low flow, running through agricultural land	53.66966	-9.9025	74308.27	270543.02
12	Small river running off beach	53.66899	-9.9027	74293.06	270468.81
13	Natural field drain	53.65773	-9.91348	73546.922	269234.87
14	Field drain	53.65393	-9.91148	73667.761	268808.43
15	Stream crossing beach	53.64583	-9.88546	75364.059	267861.09
16	Ugool Beach RazorBed	53.63928	-9.88587	75317.62	267132.89
17	Stream on beach	53.63773	-9.88255	75532.614	266954.58
18	Killary mouth razor bed	53.63301	-9.87885	75763.444	266422.84
19	Killary salmon farm	53.625511	-9.864544	76687.82	265563.41
20	Little Killary Inner berths- Number of small boats	53.61037	-9.8494	77645.882	263852.29
21	Stream Little Killary	53.60884	-9.84898	77669.25	263681.3
22	Stream on to beach	53.614	-9.87838	75738.674	264306.49
23	Field drain	53.61235	-9.89199	74833.17	264146.73
24	Culfinn River	53.60701	-9.89062	74908.04	263550.07
25	Caravan septic tank	53.60682	-9.90621	73875.669	263556.46
26	Field soakage drain	53.60566	-9.9061	73879.488	263427.17
27	Stream	53.60329	-9.9079	73753.28	263166.61
28	Stream small river	53.6015	-9.90973	73626.808	262970.67
29	Field drain run off	53.60113	-9.91013	73599.225	262930.21
30	Stream	53.59972	-9.96435	70005.922	262871.01
31	Field drain stream	53.6028	-9.97351	69409.088	263230.53
32	Field drain stream	53.60476	-9.97697	69186.135	263455.01
33	Field drain	53.60641	-9.98384	68736.551	263651.28
34	Field drain	53.60688	-9.98777	68477.907	263710.84

Map ID	Feature	Latitude	Longitude	Easting	Northing
35	Field drain	53.60847	-9.99046	68304.824	263892.75
36	Outflow from Rusheenduff Lough	53.61073	-10.00354	67446.27	264168.56
37	Road drain	53.6064	-10.01788	66483.629	263713.52
38	Field drainage pipe	53.60847	-10.03222	65541.132	263970.88
39	Bundorragha River	53.60657	-9.75263	84039.48	263267
40	Erriff River	53.61758	-9.67157	89433.76	264363.8
41	Unnamed River	53.60683	-9.67245	89347.21	263168.8
42	Discharge pipes x 2	53.59588	-9.69393	87896.32	261983.9
43	Letterbrickaun River	53.59615	-9.69437	87868.3	262014.3
44	Bunowen River	53.59297	-9.78517	81848.21	261807
45	Possible abstraction pipe	53.59313	-9.78527	81842.05	261825.6
46	Pasture	53.59302	-9.78653	81757.91	261814.8
47	Pier	53.62048	-9.86008	76968.31	264996.1
48	Jetty (salmon farm)	53.62158	-9.86327	76760.85	265124.1
49	Sheep	53.63005	-9.86312	76795.45	266066.1

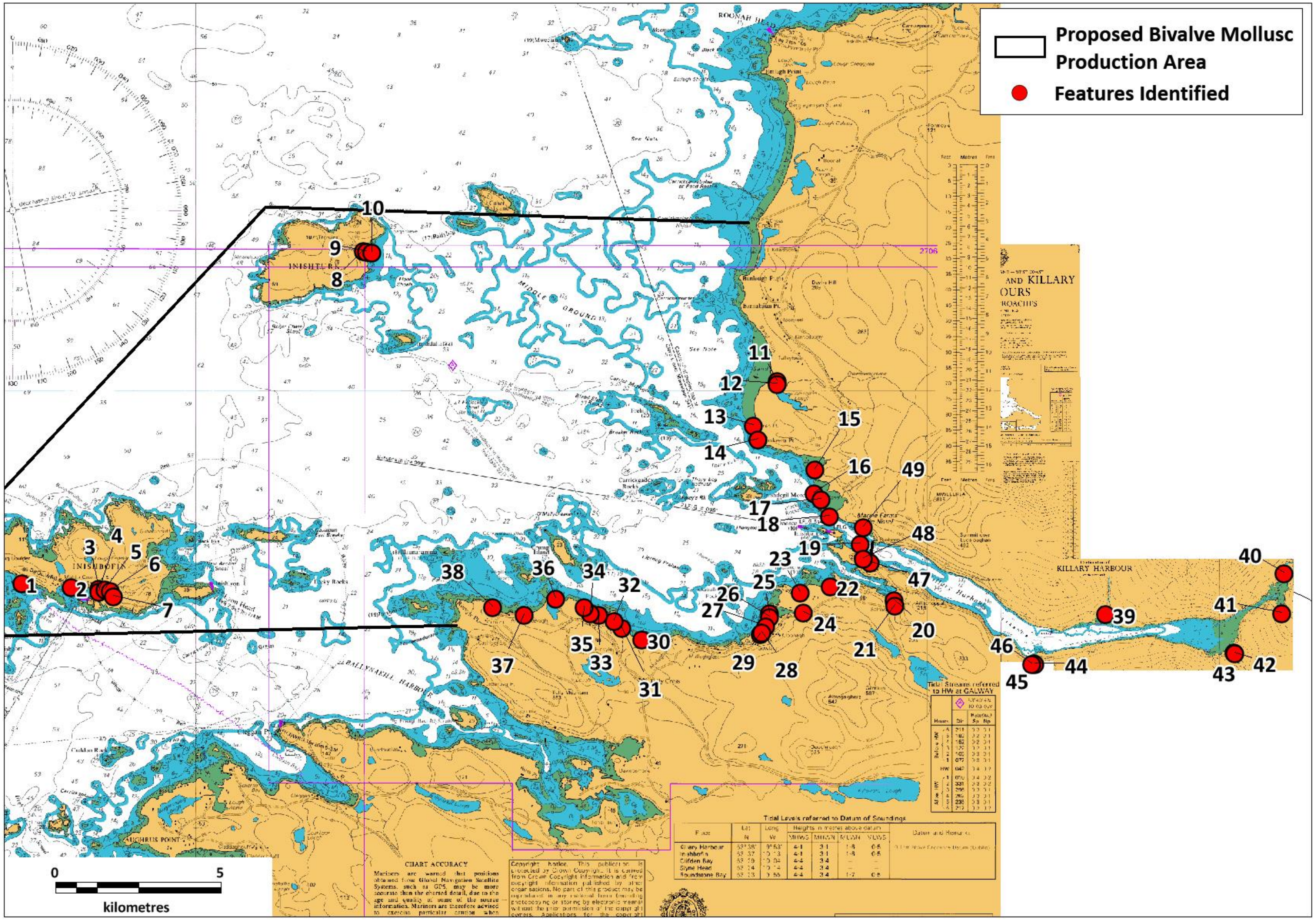


Figure 4.22: All features (numbering cross-reference to Table 4.15) identified during the shoreline survey.

Figure 4.23: Features 1-7 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

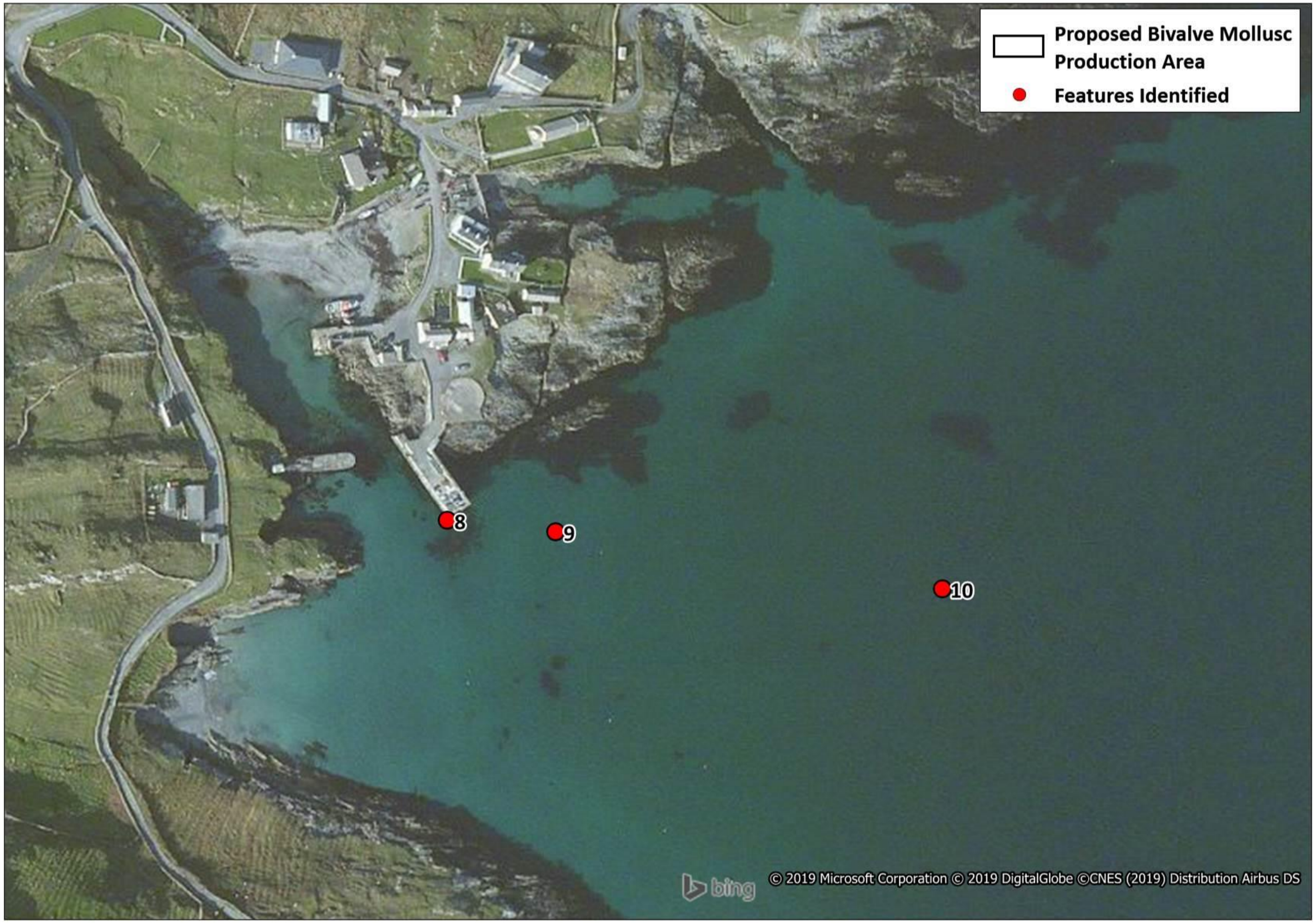


Figure 4.24: Features 8-9 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

Figure 4.25: Features 11-14 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

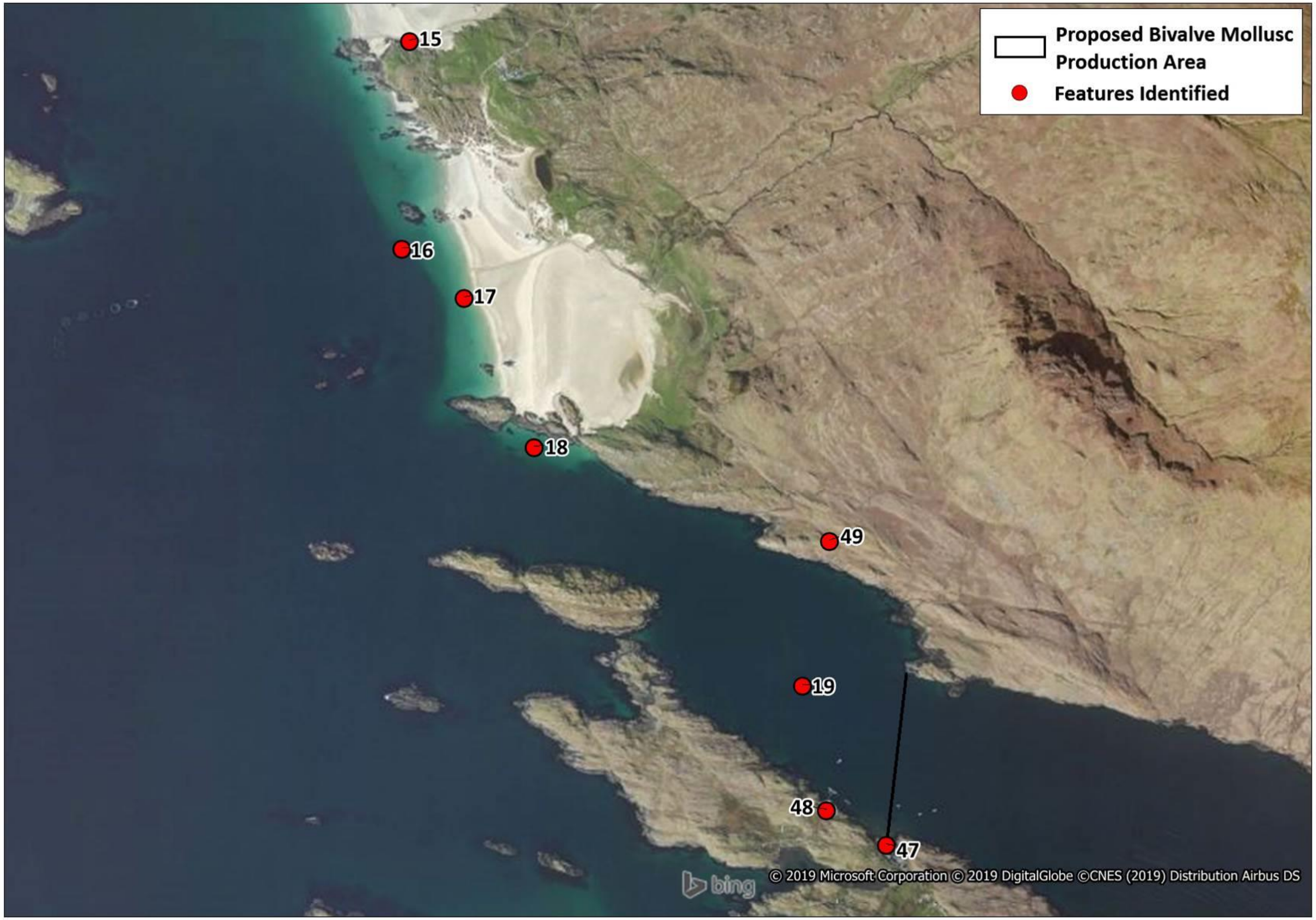


Figure 4.26: Features 15-19, 47-49 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

Figure 4.27: Features 20-24 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

Figure 4.28: Features 24-29 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

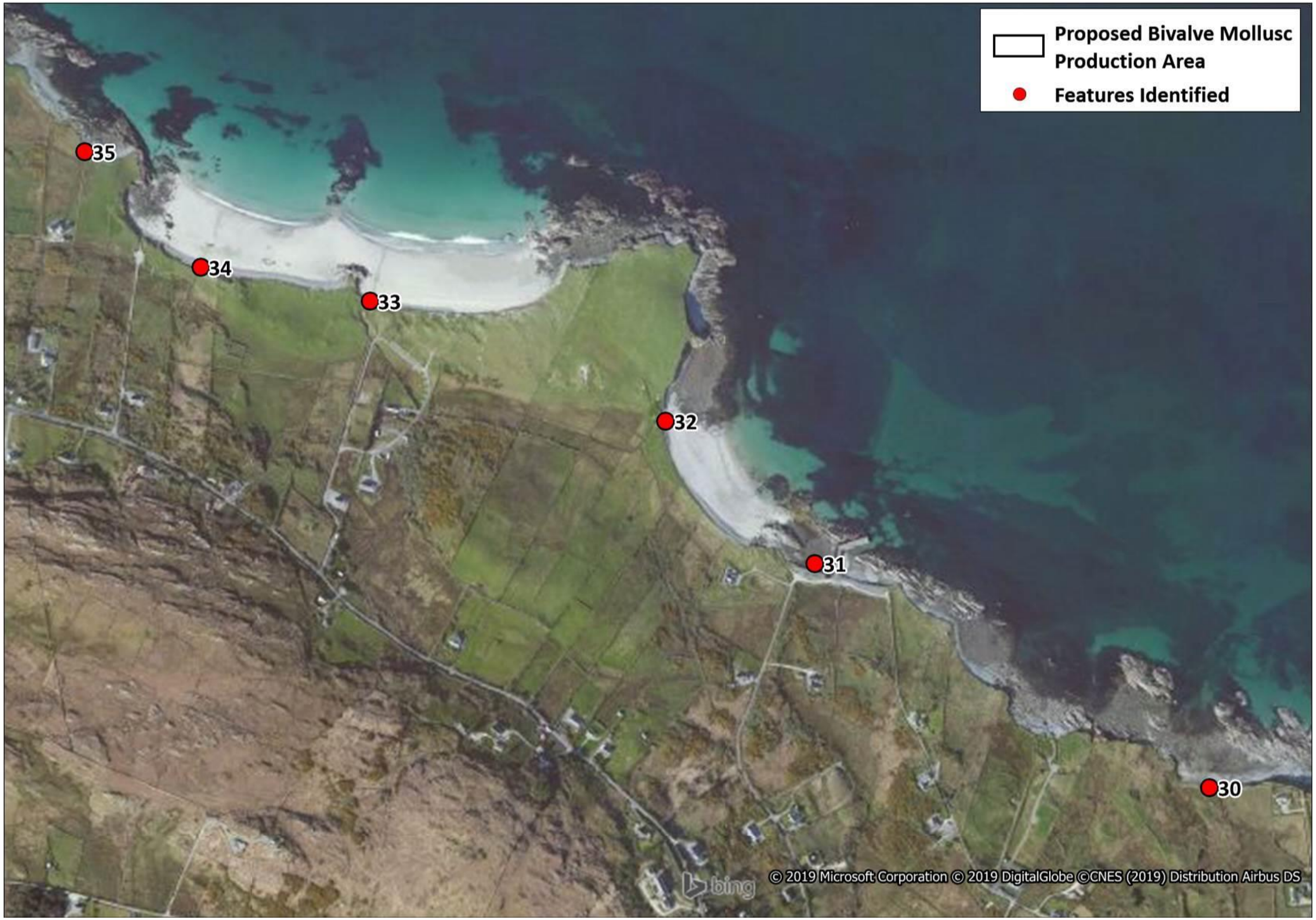


Figure 4.29: Features 30-35 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

Figure 4.30: Features 36-38 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

Figure 4.31: Feature 39 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

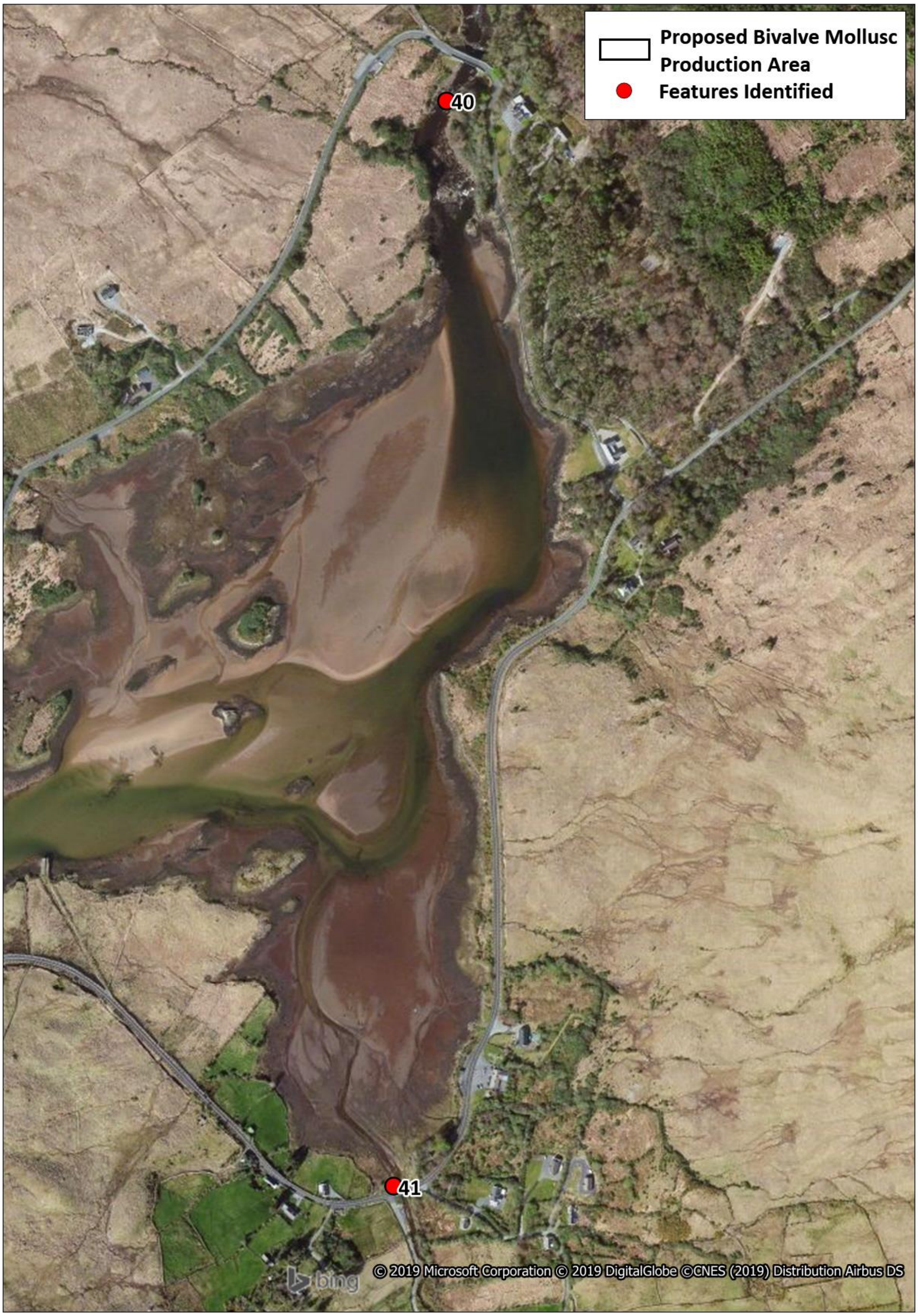


Figure 4.32: Features 40-41 (numbering cross-reference to Table 4.15) identified during the shoreline survey.

Figure 4.33: Features 42-43 (numbering cross-reference to Table 4.15) identified during the shoreline survey

Figure 4.34: Features 44-46 (numbering cross-reference to Table 4.15) identified during the shoreline survey

Figure 4.35: Features (1-17) identified during the shoreline survey. Refer to Figures 4.22- 4.26 for site locations.

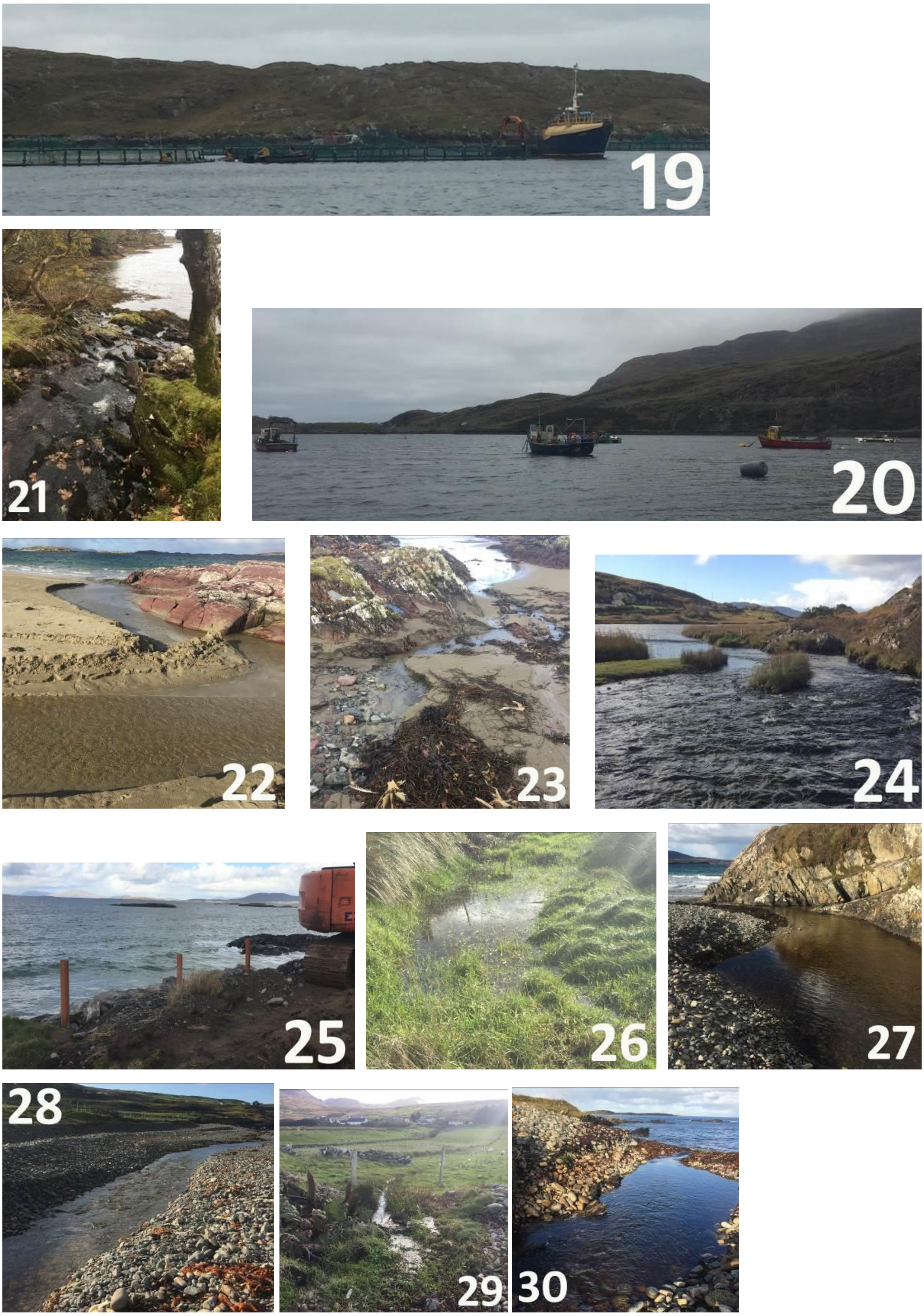


Figure 4.36: Features (19-30) identified during the shoreline survey. Refer to Figures 4.22 and 4.26-4.29 for site locations.

Figure 4.37: Features (29-42) identified during the shoreline survey. Refer to Figures 4.22 and 4.29-4.33 for site locations.

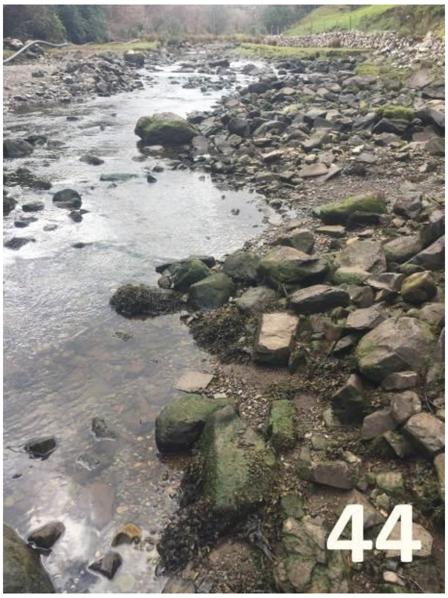


Figure 4.38: Features (43-48) identified during the shoreline survey. Refer to Figures 4.22, 4.26 and 4.33-4.34 for site locations.

4.3. *Locations of Sources*

Figures 4.39 and 4.40 show all watercourses discharging into Killary Harbour and Killary Harbour Approaches and Table 4.12 provides cross-referenced details for this map. Figure 4.41 shows all discharges in the Killary Harbour and Killary Harbour Approaches catchment area and Tables 4.13 to 4.15 provides cross-referenced details for the WWTP, drain and pipe discharges and Section 4 discharges respectively.

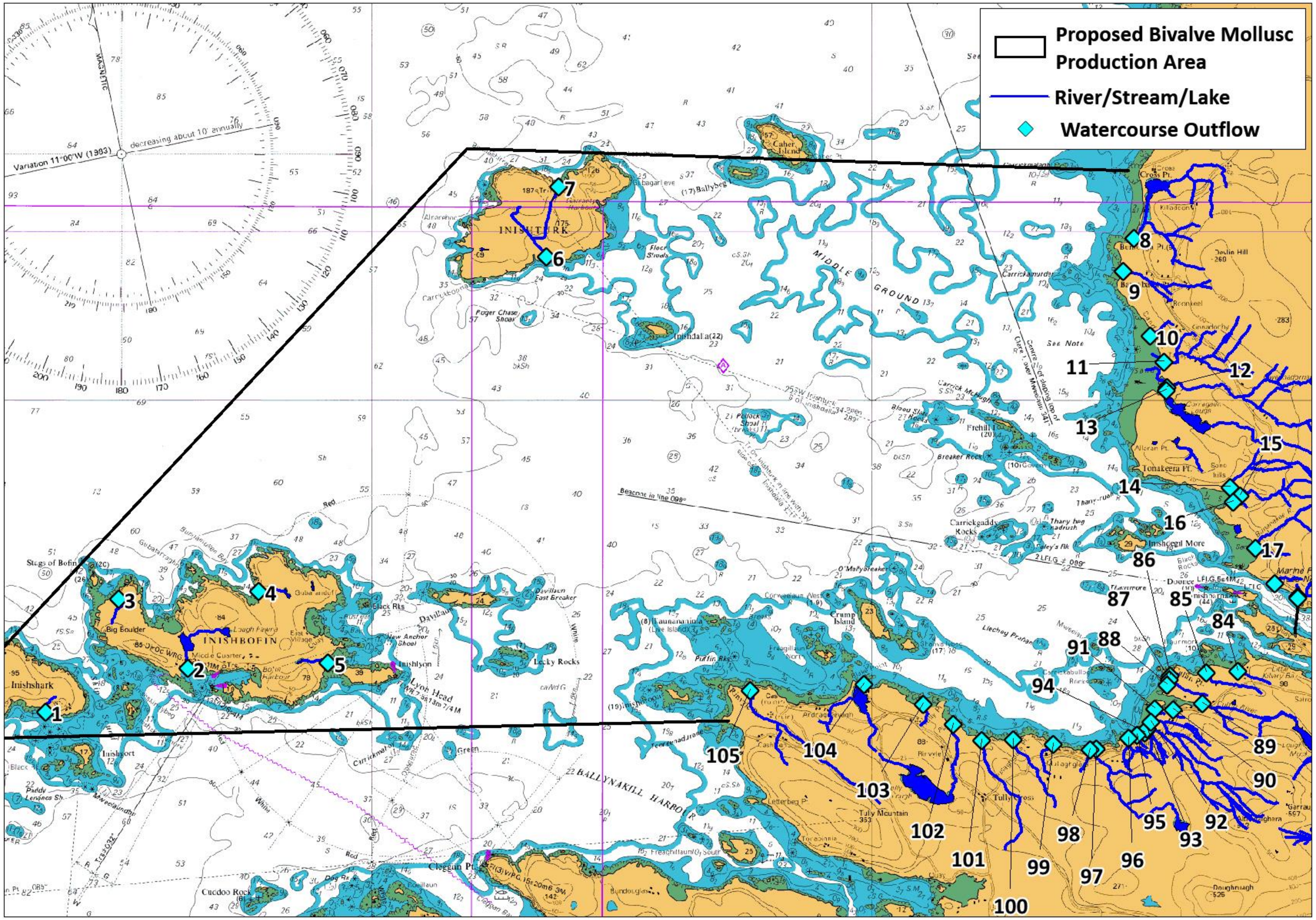


Figure 4.39: Location of all watercourses discharging into Killary Approaches and Killary Harbour.

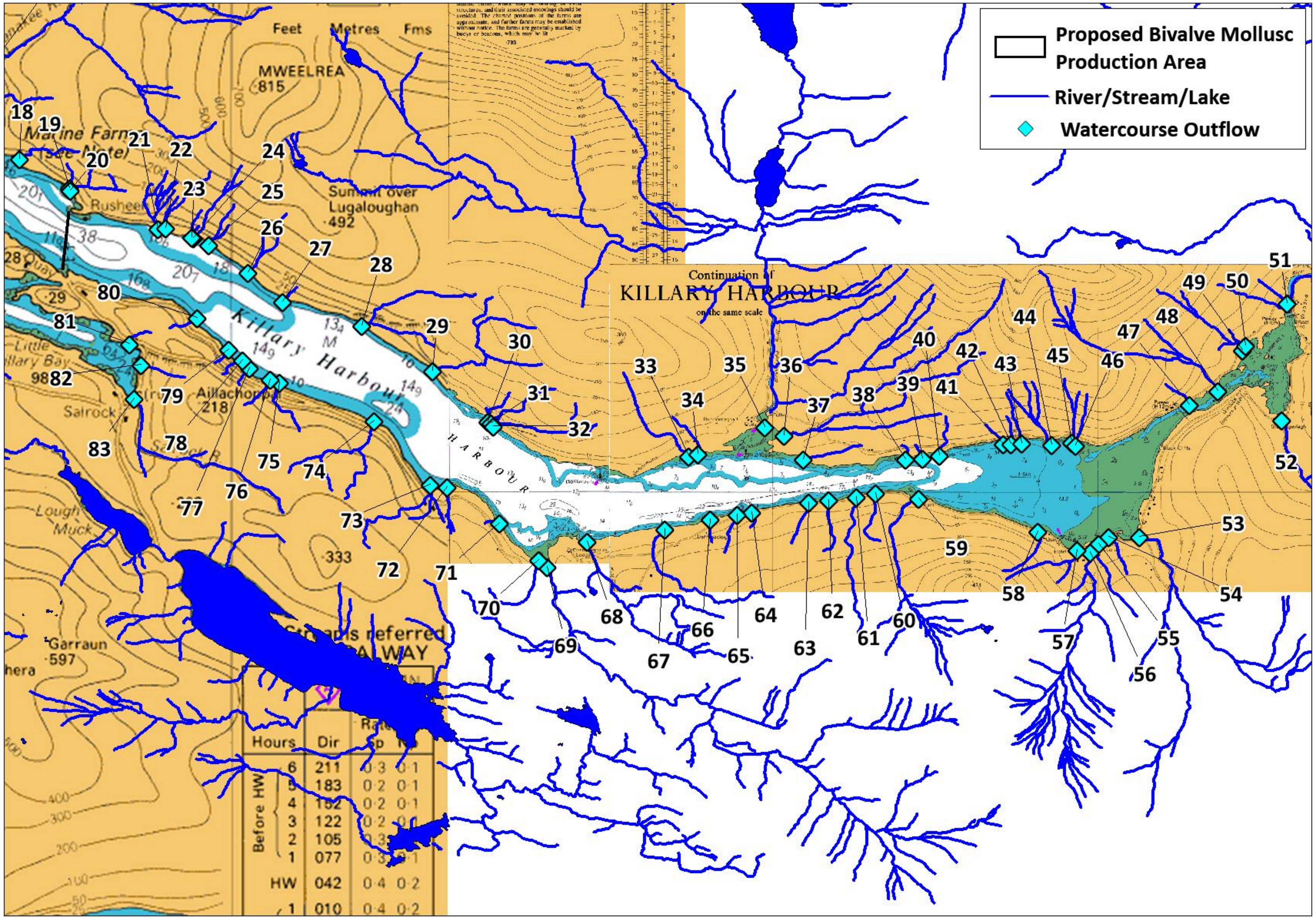


Figure 4.40: Location of all watercourses discharging into Killary Approaches and Killary Harbour.

Table 4.12: Cross-referenced tables for Figure 4.39 and 4.40 Watercourses.

Map ID	Watercourse	Map ID	Watercourse
1	Unnamed Stream	54	Unnamed Stream
2	Unnamed Stream	55	Unnamed Stream
3	Unnamed Stream	56	Unnamed River
4	Unnamed Stream	57	Unnamed Stream
5	Unnamed Stream	58	Unnamed Stream
6	Unnamed Stream	59	Laghtyfahaghaun
7	Unnamed Stream	60	Unnamed Stream
8	Flow from Cross Lough	61	Unnamed Stream
9	Unnamed Stream	62	Unnamed Stream
10	Unnamed Stream	63	Unnamed Stream
11	Unnamed River	64	Unnamed Stream
12	Stream off Owennadornaun River	65	Unnamed Stream
13	Owennadornaun River	66	Unnamed Stream
14	Unnamed River	67	Sruffaungarve
15	Unnamed Stream	68	Unnamed River
16	Unnamed Stream	69	Bunowen River
17	Bunakee River	70	Unnamed Stream
18	Unnamed Stream	71	Unnamed Stream
19	Unnamed Stream	72	Unnamed Stream
20	Unnamed Stream	73	Unnamed Stream
21	Unnamed River	74	Owenearhaghbeg
22	Unnamed River	75	Unnamed Stream
23	Unnamed Stream	76	Unnamed Stream
24	Sruhaundoo	77	Unnamed Stream
25	Unnamed Stream	78	Unnamed Stream
26	Unnamed Stream	79	Unnamed Stream
27	Unnamed Stream	80	Unnamed Stream
28	Sruhaunglass	81	Unnamed Stream
29	Sruhaunatallan	82	Unnamed Stream
30	Unnamed Stream	83	Sruffaunbleanagaddy
31	Unnamed Stream	84	Unnamed Stream
32	Shruhaunclogacapeen	85	Unnamed Stream
33	Sruhaunaskeheen	86	Unnamed Stream
34	Unnamed Stream	87	Unnamed Stream
35	Bundorragha River	88	Unnamed Stream
36	Sruhaungarre	89	Culfinn River
37	Unnamed Stream	90	Unnamed Stream
38	Unnamed Stream	91	Unnamed Stream
39	Unnamed Stream	92	Unamed Stream
40	Unnamed Stream	93	Unnamed Stream
41	Glennagevlagh River	94	Unnamed Stream

Map ID	Watercourse	Map ID	Watercourse
42	Unnamed Stream	95	Unnamed Stream
43	Unnamed Stream	96	Unnamed Stream
44	Unnamed Stream	97	Keeraun River
45	Unnamed Stream	98	Unnamed Stream
46	Unnamed Stream	99	Unnamed Stream
47	Unnamed Stream	100	Unnamed Stream
48	Unnamed Stream	101	Unnamed Stream
49	Unnamed Stream	102	Unnamed Stream
50	Unnamed Stream	103	Unnamed Stream
51	Erriff River	104	Flow from Rusheenduff Lough
52	Unnamed River	105	Unnamed Stream
53	Letterbrickaun River		

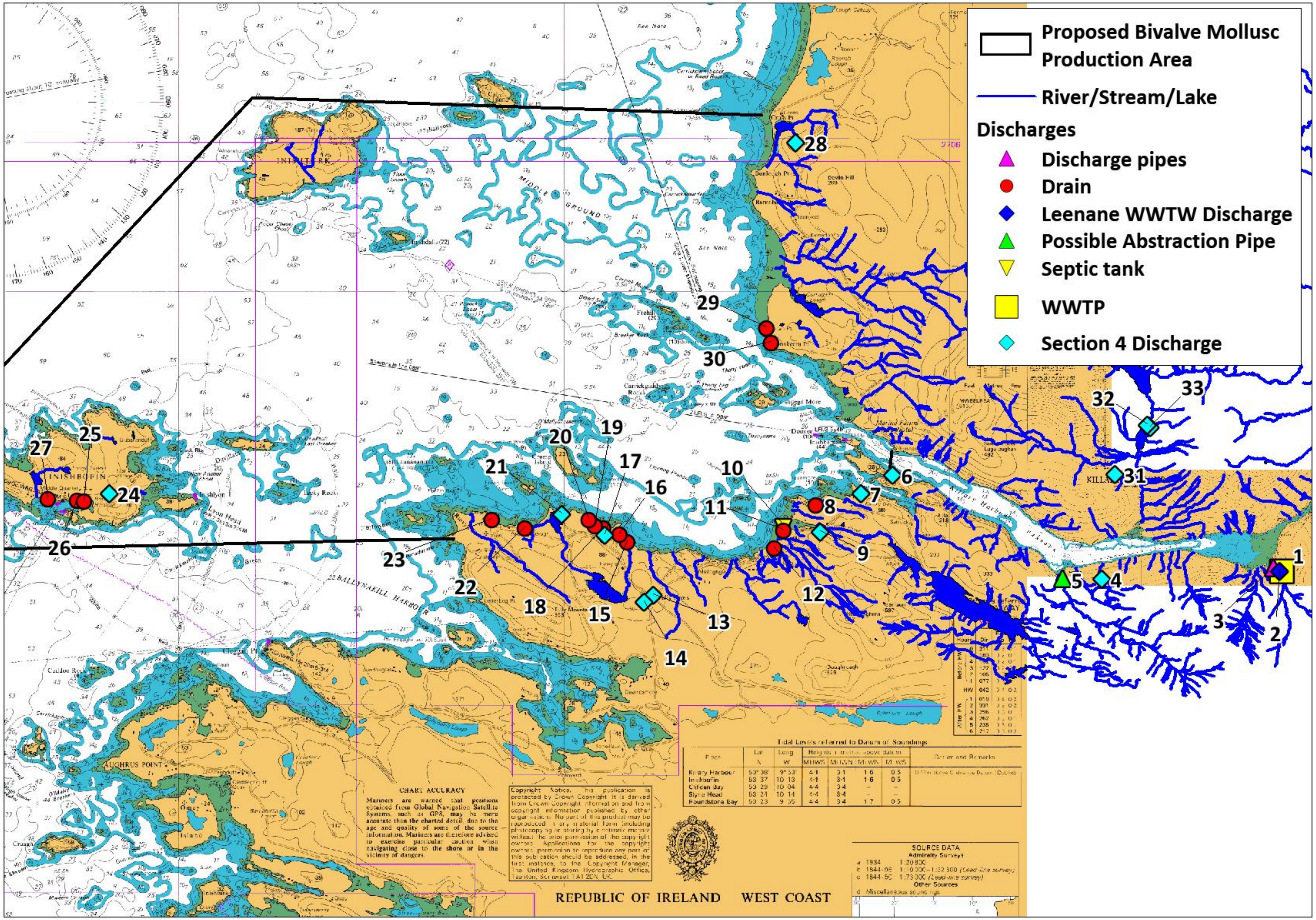


Figure 4.41: Discharges within the Killary Approaches and Killary Harbour Catchment Area.

Table 4.13: Cross-referenced table for WWTP shown in Figure 4.41 Discharges.

Map ID	Name	Easting	Northing	Longitude	Latitude	p.e.
1	Leenane Sewage Treatment Works	88,128.5	261,916.5	-9.69040	53.59533	550

Table 4.14: Cross-referenced table for drain and pipe discharges shown in Figure 4.41 Discharges.

Map ID	Discharge	Latitude	Longitude	Easting	Northing
2	Leenane WWTW Discharge	53.59527	9.691330	88067	261912
3	Discharge pipes	53.59588	-9.69393	87896.32	261983.9
5	Possible Abstraction Pipe	53.59313	-9.78527	81842.05	261825.6
8	Drain	53.61235	-9.89199	74833.17	264146.7
10	Septic tank	53.60682	-9.90621	73875.67	263556.5
11	Drain	53.60566	-9.9061	73879.49	263427.2
12	Drain	53.60113	-9.91013	73599.23	262930.2
15	Drain	53.6028	-9.97351	69409.09	263230.5
16	Drain	53.60476	-9.97697	69186.14	263455
18	Drain	53.60641	-9.98384	68736.55	263651.3
19	Drain	53.60688	-9.98777	68477.91	263710.8
20	Drain	53.60847	-9.99046	68304.82	263892.8
22	Drain	53.6064	-10.0179	66483.63	263713.5
23	Drain	53.60847	-10.0322	65541.13	263970.9
25	Drain	53.61325	-10.2089	53866.47	264851.3
26	Drain	53.61344	-10.2119	53667.95	264878.6
27	Drain	53.61383	-10.2245	52837.55	264947.9
29	Drain	53.65773	-9.91348	73546.92	269234.9
30	Drain	53.65393	-9.91148	73667.76	268808.4

Table 4.15: Cross-referenced table for Section 4 discharge shown in Figure 4.41 Discharges.

Map ID	Licence holder	Longitude	Latitude	Easting	Northing
4	Little Killary Adventure Centre Ltd.	-9.76835	53.59324	82962.41	261809.5
6	Purple Spade Ltd.	-9.85862	53.61994	77063.36	264933.6
7	Scubadive Limited	-9.87243	53.61528	76136.34	264438.5
9	Laffey Caravan Park	9.89004	53.60524	74941.34	263352.5
13	Connemara West Ltd.	-9.96243	53.5891	70100.3	261685.5
14	Maol Reidh Lodge	-9.9663	53.58722	69838.3	261483.5
17	Pauline Mortimer	-9.98322	53.60462	68772.29	263450.5
21	Vincent Flannery (Renvyle House Hotel)	-10.002	53.60982	67544.28	264064.5
24	Pat and Mary Coyne	-10.1977	53.61531	54611.17	265057.6
28	Paraic O'Malley.	-9.90074	53.70542	74531.34	274519.6
31	Seedlings Investment Ltd, Delphi Lodge	-9.7624	53.62017	83430.42	264796.6
32	Delphi Fishery	-9.74871	53.6329	84371.42	266191.6

Map ID	Licence holder	Longitude	Latitude	Easting	Northing
33	Peter Mantle, The Delphi Estate, Fishing Leaune, Co. Galway	-9.7473	53.63216	84462.42	266106.6

5. Shellfish and Water Sampling

5.1. Historical Data

5.1.1. Shellfish Water Quality

As Killary Approaches BMPA is not currently classified, no water quality monitoring is carried out. No other sources of data are available.

5.1.2. Shellfish Flesh Quality

In accordance with Annex II of the EU Hygiene Regulation 854/2004, the Sea Fisheries Protection Authority (SFPA) are required to establish the location and fix the boundaries of shellfish harvesting areas. 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. While Killary Approaches is not currently classified, SFPA have been monitoring a location since April 2017 for classification purposes. Figure 5.1 shows the location of the sampling point monitored since 2017.

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 5.1 summarises this system.

Table 5.2 lists the *E. coli* results for razor clams from Killary Approaches from April 2017 to January 2019 (where available). Figure 5.2 shows the data in graphical form. *E. coli* counts ranged from 18 to 1300 MPN/100g during the sampling period. Since April 2017, an A category results was recorded 93% (13 sampling occasions) of the time and a B category result was recorded 7% of the time (1 occasion).

Table 5.1: Classification system for shellfish classified production areas.

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

*There are degrees of tolerance with A class and B class classifications. For example with A class areas, 'samples of live bivalve molluscs from these areas must not exceed, in 80% of samples collected during the review period, 230 *E. coli* per 100 g of flesh and intravalvular liquid. The remaining 20 % of samples must not exceed 700 *E. coli* per 100 g of flesh and intravalvular liquid.' For B class areas, 'the competent authority may continue to classify as being of Class B areas for which the relevant limits of 4,600 *E. coli* per 100 g are not exceeded in 90 % of the samples.

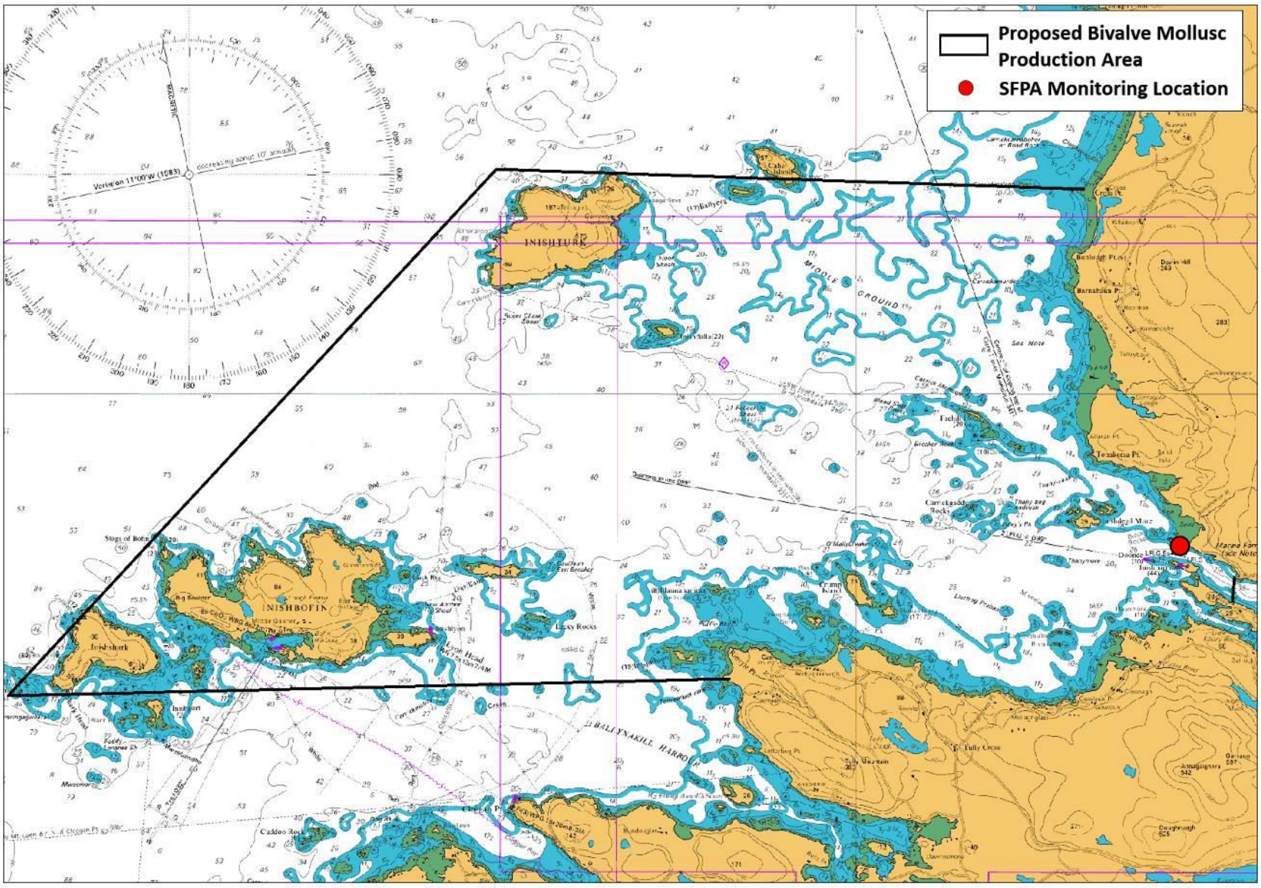


Figure 5.1: **Location of SFPA shellfish monitoring point for classification purposes.**

Table 5.2: *E. coli* results from razor clams from Killary Approaches from April 2017 to January 2019 (Source: SFPA).

Date	MPN *E. coli* /100g	Category
10-Apr-17	18	A
8-May-17	18	A
29-Aug-17	18	A
19-Sep-17	18	A
9-Oct-17	18	A
21-Mar-18	18	A
29-May-18	18	A
26-Jun-18	18	A
11-Jul-18	18	A
31-Jul-18	18	A
13-Aug-18	170	A
1-Oct-18	18	A
14-Jan-19	18	A

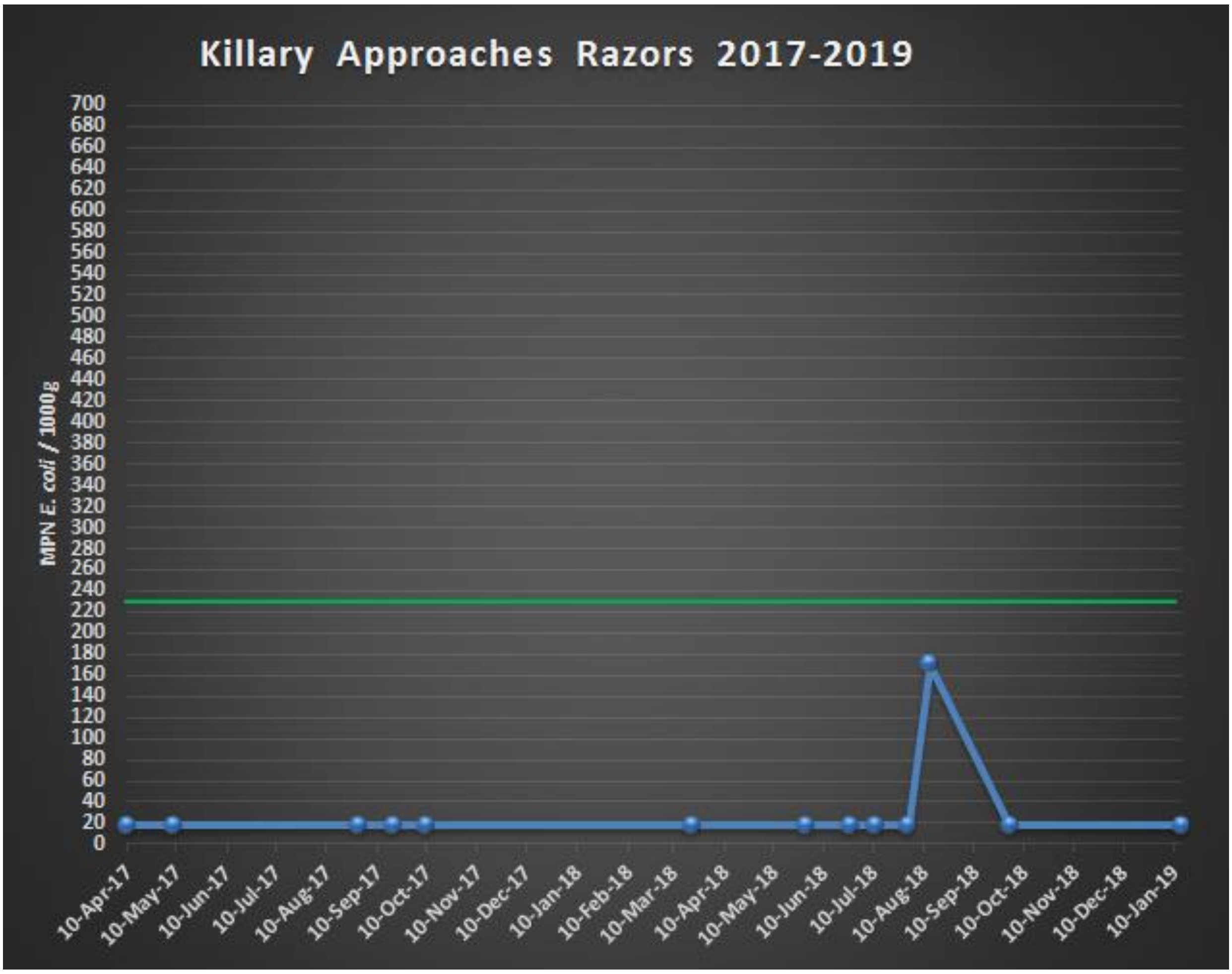


Figure 5.2: *E. coli* levels from razor clams at Killary Approaches from April 2017 to January 2019 (Source: SFPA).

5.1.3. Norovirsus (NoV)

Norovirus (formerly Norwalk agent) is a small (27-30 nm), genetically diverse single stranded RNA virus (Doré, 2009) (taxonomic family Caliciviridae) that causes approximately 90% of epidemic non-bacterial outbreaks of gastroenteritis around the world (Lindesmith *et al.,* 2003). People infected with a NoV typically experience relatively mild gastroenteritis with typical symptoms being stomach cramps, diarrhoea, vomiting and slight fever. The virus is life threatening to those with post-operative stress, the very young and very old (EPA, 2011). NoV often occurs in outbreaks and is the most common cause of Infectious Intestinal Disease (IID) in the community (Doré, 2009). It has a strong seasonal occurrence and is known as the 'winter vomiting disease'. Transmission is via the faecal-oral route and the virus is highly infectious requiring only low numbers to be present to cause infection (Doré, 2009). Direct person to person spread is most common, especially in closed communities and outbreaks are often associated with highly publicised closures of hospital wards and other care settings. Because of the high rate of infection in the community, it is no surprise that NoVs are present in large numbers in municipal waste water (Doré, 2009), an infected person may excrete 0.15 billion NoV particles per day to the sewer system (EPA, 2011). The true extent of NoV removal during waste water treatment is unclear; however, it is clear that significant numbers of NoV remain in treated waste water discharges into the aquatic environment even where traditional bacterial indicators have been reduced to comply with current environmental standards (Doré, 2009). The inappropriate discharge of waste water into the environment may contaminate shellfisheries and drinking water supplies and represent a significant public health risk.

As this site is not currently classified, no information on norovirus levels in the area are available.

5.2. Recent Data

5.2.1. Sampling Sites & Methodology

Eight water sampling sites were sampled within the proposed Killary Approaches BMPA between October 2018 and January 2019. The locations of these sites can be seen in Figure 5.3 and Table 5.3 shows the station coordinates. Four stations were sampled on the 24th October 2018 (Stations 1-4), there was no rain on the day of sampling and in the 2 days prior to sampling and total rainfall for the 2 weeks prior to sampling was 42.4mm. Three stations were sampled on the 1st November 2018 (Stations 5-7). There was no rain on the day of sampling and 29.6mm of rainfall in the 2 weeks prior to sampling. Sample 8 was collected on the 21st January 2019. There was *c.* 25mm of rain on the day of sampling and 80mm of rainfall in the 2 weeks prior to sampling. Samples 9 to 13 were collected on the 26th March 2019. There was no rain on the day of sampling and 0.2mm of rainfall in the previous 48 hours. Of the 8 water samples collected, 4 were taken from river/stream outflows (stations 5-8) and 4 were taken over the razor beds (stations 1-4).

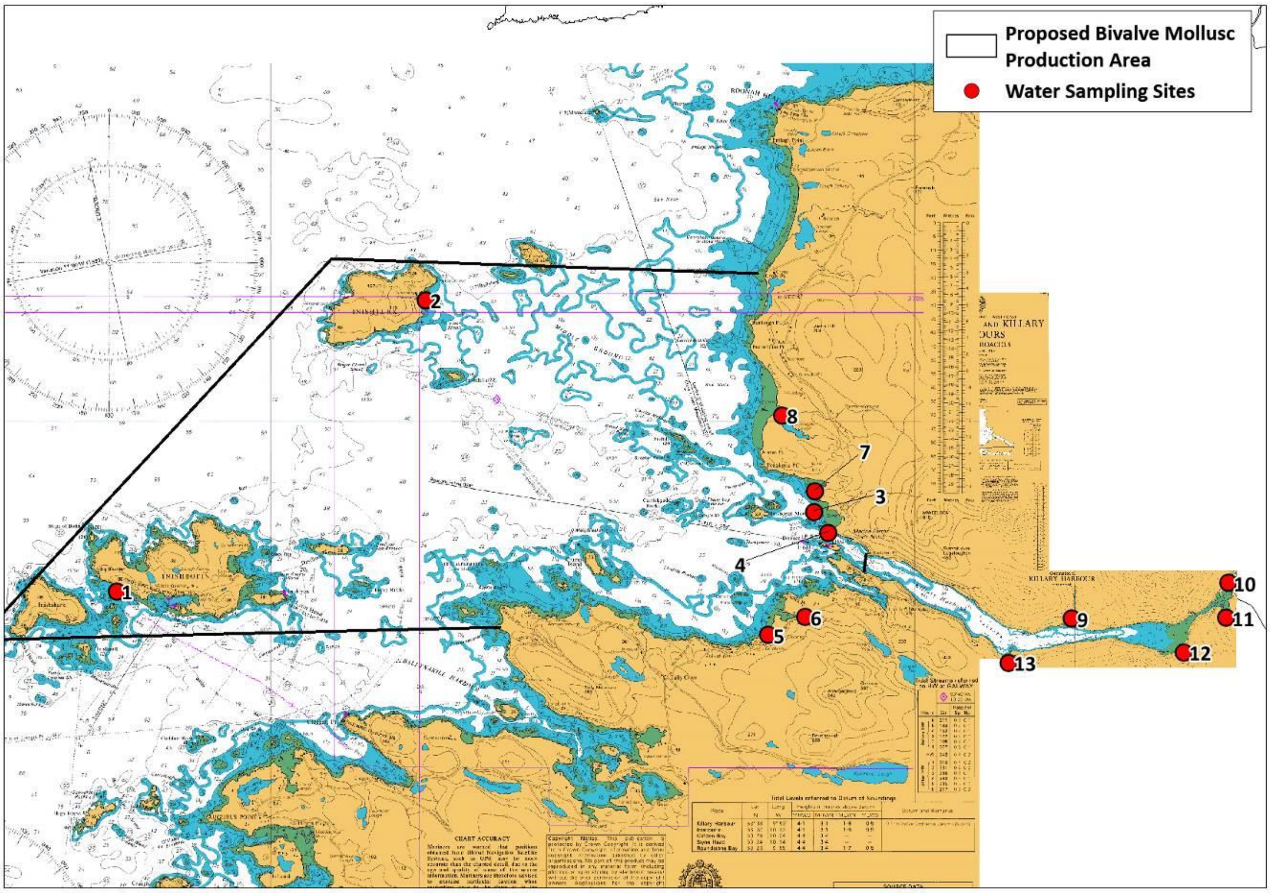


Figure 5.3: Water sampling sites.

Table 5.3: Water sample coordinates with date of sampling.

Station No.	Feature	Latitude	Longitude	Easting	Northing	Sampling date
1	Inishboffin Razor Bed	53.6149	-10.247	51349.85	265113.9	24/10/2018
2	Inishturk Razor Bed	53.70453	-10.0873	62211.75	274766.1	24/10/2018
3	Ugool Beach Razor Bed	53.63928	-9.88587	75317.62	267132.9	24/10/2018
4	Killary mouth razor bed	53.63301	-9.87885	75763.44	266422.8	24/10/2018
5	Unnamed Stream	53.6015	-9.90973	73626.81	262970.7	01/11/2018
6	Culfin River	53.60701	-9.89062	74908.04	263550.1	01/11/2018
7	Stream crossing beach	53.64583	-9.88546	75364.06	267861.1	01/11/2018
8	Owennadornaun River	53.66899	-9.9027	74293.06	270468.8	21/01/2019
9	Bundorragha River	53.60657	-9.75263	84039.48	263267	26/03/2019

Station No.	Feature	Latitude	Longitude	Easting	Northing	Sampling date
10	Erriff River	53.61758	-9.67157	89433.76	264363.8	26/03/2019
11	Glennagevlagh River	53.60683	-9.67245	89347.21	263168.8	26/03/2019
12	Letterbrickaun River	53.59615	-9.69437	87868.3	262014.3	26/03/2019
13	Bunowen River	53.59297	-9.78517	81848.21	261807	26/03/2019

All water samples were collected in sterile plastic water bottles. These samples were stored in a cool box until delivery to either Aqualab in Killybegs, Co. Donegal or CLS in Ros Muc, Co. Galway (within 24hrs of collection). Both labs are INAB accredited and the *E. coli* analysis was carried out on the water samples by membrane filtration. Appendix 2 contains the result certificates from the lab.

5.2.2. Microbial Analysis Results

Table 5.4 shows the water sample analysis results (Refer to Appendix 2 for result certificates). Within the Killary Approaches waterbody highest *E. coli* levels came from the Owennadornaun River (station 8; 98 cfu/100ml), followed by an unnamed stream on the south shore (station 5; 90 cfu/100ml). A value of 62 cfu/100ml was recorded at the stream just north of the Ugool Beach razor bed and a value of 15 cfu/100ml was recorded from the Culfin River on the south shore. Values from the open sea over the razor beds were virtually non-existent.

Values from the Killary Harbour waterbody ranged from a high of 400 cfu/100ml from the Letterbrickaun River (station 12) to a low of 20 cfu/100ml in the Erriff River (station10). The value from the Bunowen River was 170cfu/100ml (station13), from the Glennagevlagh River was 140cfu/100ml and 50 cfu/100ml from the Bundorragha River.

These results reflect the fact that the higher *E. coli* loadings come from Killary Harbour as opposed to the discharges from the shoreline of the Killary Approaches waterbody. Within Killary Harbour, on the day of sampling, higher loadings came from the Letterbrickaun River which contains the discharge from the Leenane WWTP.

Table 5.4: Water *E. coli* results for Killary Approaches.

Station No.	*E. coli* (cfu/ 100ml)
1	0
2	1
3	0
4	0
5	90
6	15

Station No.	*E. coli* (cfu/ 100ml)
7	62
8	98
9	50
10	20
11	140
12	400
13	170

6. Expert Assessment of the Effect of Contamination on Shellfish

In this area of the Irish mainland of Co. Galway and Co. Mayo, population concentrations are overall low with only two conurbations present. These are at Rinvyle and Tully Cross. Other than these areas, houses are spread out throughout the lower lying areas of land. Much of the area, particularly around Killary Harbour, is mountainous and is not suitable for dwelling houses. However, the area is a popular tourist destination in the Summer and areas such as Rinvyle, Glassillaun/Lettergesh in Co. Galway and around Killadoon, Co. Mayo are popular locations for visitors.

Only two of the islands in the area are inhabited and these are Inishbofin and Inishturk. During the Winter months population numbers are *c.* 200 for Inishbofin and *c.* 70 for Inishturk; however, in the Summer months these figure can double due to tourism.

The level of industrial activity is very low in this area.

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

A number of studies have reported a strong association between intensive livestock farming areas and faecal indicator concentrations of microorganisms in streams and coastal waters due to run-off from manure, especially during high flow conditions, both from point and non-point sources of contamination (*e.g.* Crowther *et al.,* 2002).

The most significant input of freshwater is from Killary Harbour where 4 rivers, the Erriff, Letterbrickaun, Bundorragha and Bunowen, discharge. The catchments of these rivers include upland areas of Mweelrea, the Sheffry, the Maamturk and the Partry mountains all of which are used for grazing sheep. When the combined freshwater loads enter the sea at the mouth of Killary Harbour, the plume deflects northwards due to:

1. A clockwise moving lower salinity current around Ireland
2. The Coriolis effect and
3. The northward flowing longshore drift direction in this area.

Therefore, whatever the level of faecal pollution is present in the freshwater, it is the marine waters along the south western section of Co. Mayo that may be impacted. However, as the marine waters in this area are deep, turbulent, high in salinity and low in suspended solids, ultraviolet light from the sun can penetrate the sea effectively and thereby eradicate many of the coliform bacteria in the water column that may be present. Additionally, as the lighter fresher water will float and eventually be absorbed into the heavier, deeper sea water in the upper *c.* 5m and as the bacteria do not have the mass to settle to the sea bed where the shellfish are, the only way that the bacteria can come in contact with the molluscs is if they are attached to some sediment particle or organic floc.

Other than that source of faecal pollution from either agriculture or septic tanks, marine water quality in the remaining parts of the study area is high, *E.coli* levels classify the waters as A in quality.

There are a number of sea bird colonies in the area and these predominantly occur at the islands that are present. Species include the 4 species of auks, shag, fulmar, 5 species of gull and tern, 1 shearwater, 1 petrel and 1 species of skua. Seabird droppings are typically far more liquid in nature than solid in consistency and droppings from either the colonies or from flying birds will fall into the sea and, as was described above, the marine waters in the area are deep, turbulent, high in salinity and low in suspended solids. The droppings will quickly dilute and disperse. Ultraviolet light from the sun can penetrate the sea effectively and thereby eradicate any coliform bacteria in the water. The effect of this is that molluscs that live in the sea bed will only rarely come in contact with bacteria from bird droppings.

Two species of seals are known to occur in the area and these are the Grey and Common Seal. As seal faeces are known to contain similar levels of *E.coli* as that found in raw sewage, they have the potential to cause faecal coliform contamination in shellfish. However, as the haul out and breeding sites for both species are quite remote from shellfish harvesting sites, it is considered that due to the distances involved *i.e.* several kilometres and also salinities, water depths, water transparency and turbulence, the bacteria will either have been destroyed by high salinities or UV or will have been so diluted and dispersed that they will not be of concern as a serious source of bacterial contamination to the shellfish. It is entirely possible that individual seals will pass through/over the harvesting sites but again, due to salinities, water depths, water transparency and turbulence, it is considered that the risk of contamination from seal faeces is low.

7. Sampling Plan

7.1. Identification of Production Area Boundaries & RMPs

As described in Section 6 above, due to oceanographic conditions that operate in this shellfish production area and largest volumes of freshwater entering it, the most likely location where water quality might be compromised is to the northwest of the mouth of Killary Harbour. For this reason, it is entirely appropriate that the RMP is located in that area. The razors sampled at this location will be representative of the razors further west towards Inishturk and Inishbofin. Therefore it is also entirely appropriate that the full area be treated as one Production Area the boundaries of which can be seen in Figure 7.1 below. Figure 7.1 also shows the razor beds in each area from the latest Marine Institute surveys (Inishturk – 2015, Inishbofin – 2016 and Killary Approaches – 2018).

The coordinates of the Production Area can be seen in Table 7.1 and the coordinate of the RMP can be seen in Table 7.2. The RMP allows for a radius of tolerance of 250m. This is to allow for the fact that fishing effort moves in relation to the areas where the largest concentration of market sized stock is located.

Table 7.1: Coordinates of the Production Area

Corner	Latitude	Longitude	Easting	Northing
NE	53.712222°	-9.915433°	73,581.24	275,302.51
NW	53.716666°	-10.135833°	59,045.8	276,211.9
SW	53.599583°	-10.31895°	46,533.59	263,562.26
SE	53.603333°	-10.048655°	64,437	263,430.4

Table 7.2: Coordinates of the RMP.

RMP	Latitude	Longitude	Easting	Northing
RMP	53.633333°	-9.879722°	75,706.7	266,460.3

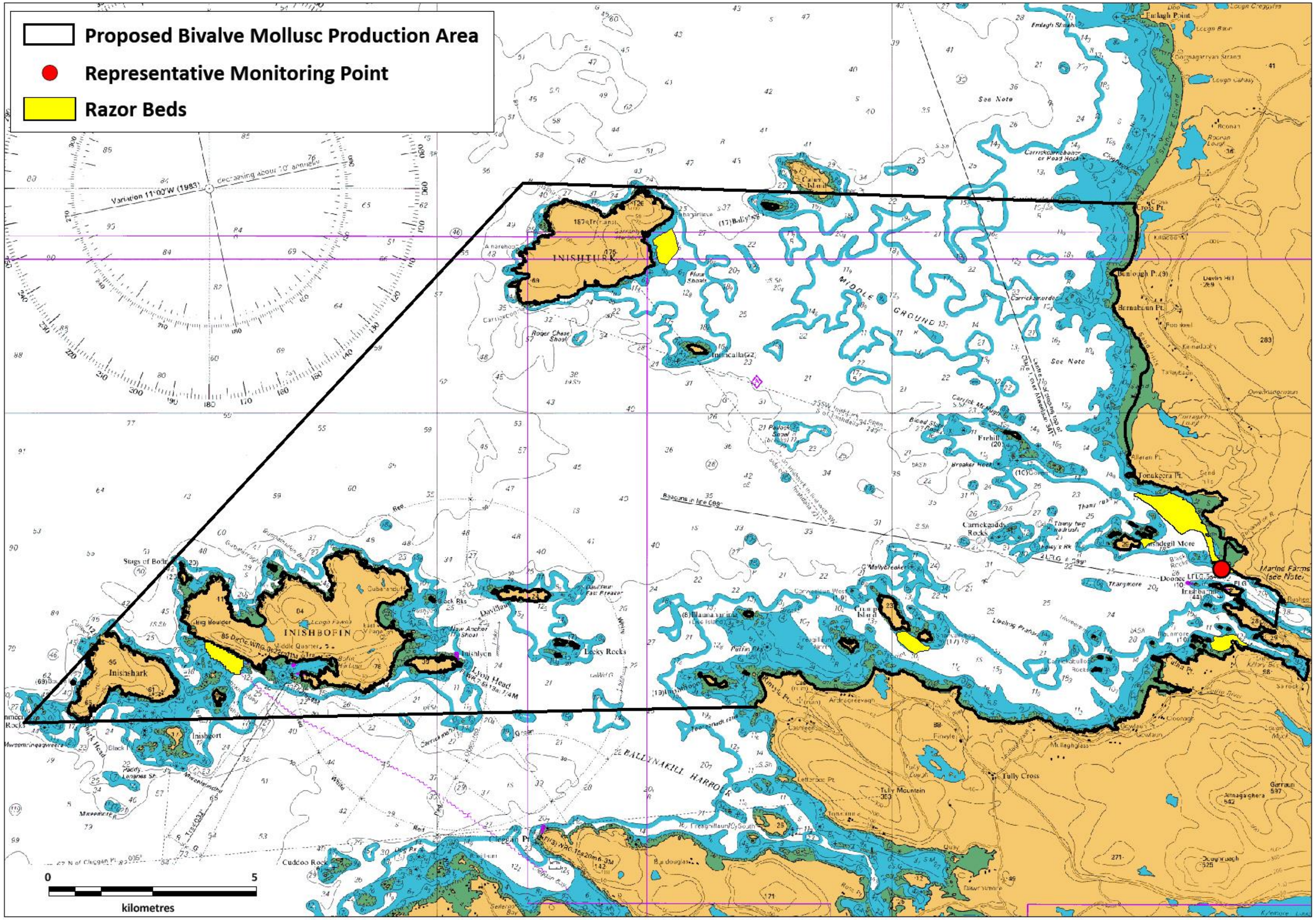


Figure 7.1: Killary Approaches Production Area and RMP.

7.2. Sampling Plan

7.2.1. Sampling Methodology

All sampling should follow the Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application (CEFAS, 2017) recommendations and SFPA's own Code of Practice for the Microbiological Monitoring of Bivalve Mollusc Production Areas (SFPA, 2017), which are outlined below.

7.2.1.1. Time of sampling

Sampling shall be undertaken, where practical, on as random a basis as possible with respect to likely influencing environmental factors *e.g.* tidal state, rainfall, wind, etc. so as to avoid introducing any bias to the results. In addition, as it is a wild fishery, sampling should be carried out only when fished.

7.2.1.2. Frequency of Sampling

All sampling should be carried out on a monthly basis until sufficient data has been collected (3 years) to determine the sites full classification. As this is a wild fishery that will be fished seasonally, once a full classification of the site has been determined, it may be appropriate to monitor for a reduced part of the year and award short-term classifications in order to cover the seasons that the wild fishery are fished. In general, reduced sampling should start at least 1 month prior to the harvesting season for class A areas and two months prior to the season for class B areas and then continue throughout the season.

7.2.1.3. Sampling method

Wherever possible, species shall be sampled by the method normally used for commercial harvesting as this can influence the degree of contamination. For samples taken as part of the harvesting area classification programme, the sampling officer should take the temperature of the surrounding seawater at the time of sampling and record this on the collection form. Where intertidal shellfish are sampled dry, the temperature of the shellfish sample should be recorded immediately after collection. In this case, the temperature should be measured by placing the thermometer or probe in the centre of the bagged shellfish sample.

7.2.1.4. Size of individual animals

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

7.2.1.5. Sample composition

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

Razor clams (*Ensis* spp.)	12-18

The minimum number acceptable is 10 and the minimum size is 10cm. The number of animals given above is intended to satisfy these requirements and to include a small additional allowance in case animals become moribund during transit.

7.2.1.6. Preparation of samples

After the bivalves have been removed from the water and closed, any mud and sediment adhering to the shellfish should be removed. This is best achieved by rinsing/scrubbing with fresh water of potable quality or seawater from the immediate area of sampling. Do not totally re-immerse the shellfish in water as this may cause them to open. Allow to drain before placing in a food grade plastic bag. A waterproof label should be affixed to each bagged sample and should contain the following information: sample reference number, sample date and time ad any other relevant information (e.g. species). The bag should be placed inside a second bag or other container and sealed to prevent cross contamination.

7.2.1.7. Sample transport

Samples should be transported in cool boxes at a temperature between 1°C and 8°C. Samples should not be frozen and freezer packs should not come into direct contact with the samples or sample bags. Analysis should be undertaken as soon as practically possible after sampling and must be transported to the testing laboratory within 24 hours of sampling. Samples received after this time may not be tested or if tested the results may not be used in the classification programme.

During transport samples must be maintained below 15ºC. Testing laboratories will record the temperature of the sample on receipt. Samples received above 15ºC may not be tested or the results may not be used in the classification programme. If samples are transported to the laboratory within 4 hours the temperature on receipt in the laboratory does not have to be below 15ºC.

The cool boxes used for such transport should be validated using appropriate temperature probes, to ensure that the recommended temperature is achieved and maintained for the appropriate period. The number and arrangement of freezer packs, and the sample packing procedure, shown to be effective in the validation procedure should be followed during routine use. Where validation data already exist for a specific type of cool box, there is no need to undertake a local revalidation.

Where the receiving laboratory has indicated that it wishes to measure the temperature of the received material by means of a water sample, a plastic universal bottle containing approximately 25 ml of water at ambient temperature should be placed amongst the bagged samples at the time the last sample is placed in the cool box. The bottle should be clearly marked as being for temperature measurement.

7.2.1.8. Sample Submission form

Sample point identification number and name, map co-ordinates, time and date of collection, species sampled, method of collection and seawater temperature should be recorded on a submission form. Any other information deemed relevant should also be recorded.

7.2.1.9. Delivery of samples

Samples should be properly labelled and accompanied by a completed sample submission form. Samples should be brought within 48 hours to the chosen accredited laboratory for analysis.

7.2.1.10. Receiving laboratory

All laboratories undertaking testing of bivalve molluscs under a competent authority monitoring programme (including those contributing results of samples taken by, or on behalf of the industry) must be accredited to EN ISO/IEC 17025 for the specific method used for *E. coli* in bivalve molluscs. The status and continued compliance of accredited laboratories is monitored by the Marine Institute.

All testing laboratories must use the five-tube three-dilution most probable number technique based on EN/ISO 16649-3 for detection of *E. coli.* All shellfish must be analysed within 24 hours of receipt in the laboratory. Results of analysis are reported to the Marine Institute, the SFPA sampling co-ordinator and local area SFPO on the day they become available.

8. References

AQUAFACT. 1999. A comparison of conditions induced by different wave climates at three locations off the west coast of Ireland. Unpublished Report prepared on behalf of Killary Salmon Company.

AQUAFACT. 2001. Inishturk Harbour Development Bathymetric and Hydrographic Survey. Unpublished Report prepared on behalf of Malachy Walsh & Partners.

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.

Bolton, D.J., Byrne, C.M., Sheridan, J.J., McDowell, D.A. & I.S. Blair. 1999. The survival characteristics of a non-toxigenic strain of *Escherichia coli* O157:H7.*Journal of Applied Microbiology* **86**: 407– 411.

BWI. 2019. Site Summary Table for 0G983 Inishbofin. https://f1.caspio.com/dp/f4db3000060acbd80db9403f857c Accessed March 2019.

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

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

CLAMS. 2002. CLAMS Co-Ordinated Local Aquaculture Management Systems Killary Harbour. pp. 93.

Clarke, R.B. 2001. *Marine Pollution.* Oxford University Press, New York.

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 February 2019

CSO. 2019b. Census of Agriculture 2010. http://census.cso.ie/censusagriculture Accessed February 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. https://gis.epa.ie/EPAMaps/SewageTreatment Accessed February 2019.

EPA. 2019b. EPA HydroNet http://epa.ie/hydronet/#Flow Accessed February 2019.

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

FEAS, 2016. Report of Surveys of Razor Clams (*Ensis arcuatus, Ensis siliqua and Ensis Ensis*) off the West coast of Ireland in 2016 Final Report. Inshore Fisheries Team, Fisheries Ecosystems Advisory Services, Marine Institute, Rinville, Oranmore, Galway.

FEAS, 2019. Unpublished partial report of surveys of Razor Clams (*Ensis arcuatus, Ensis siliqua and Ensis Ensis*) from Killary Harbour and Ballynakill Bays 2018. Inshore Fisheries Team, Fisheries Ecosystems Advisory Services, Marine Institute, Rinville, Oranmore, Galway.

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. 2019. Sea Fishing. Western Regional Fisheries Board. http://www.fishinginireland.info/sea/west.htm

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

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

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

Kudva, I.T., Blanch, B. & C.J. Hovde. 1998. Analysis of *Escherichia coli* O157:H7 survival in bovine manure and bovine slurry. *Applied and Environmental Microbiology* **64**: 3166– 3174.

Lee, R.J. & O.C. Morgan. 2003. Environmental factors influencing the microbial contamination of commercially harvested shellfish, *Water Science and Technology* **47:** 65-70.

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.

Mallin, M.A., Ensignm S.H., McIver, M.R. Shank, G.|C. & P.K. Fowler. Demographic, landscape and meterologial factors controlling the microbial pollution of coastal waters. *Hydrobiologica* **460:** 185-193.

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. Monthly Weather Bulletins 2014-2015. https://www.met.ie/climate/past-weather-statements. Accessed February 2019.

Met Eireann. 2019b. Historical Data Mace Head 2016-2018. https://www.met.ie/climate/available-data/historical-data Accessed February 2019.

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

Met Eireann. 2019e. Historical Data Inishbofin 2014-2018. https://www.met.ie/climate/available-data/historical-data Accessed February 2019.

Met Eireann. 2019f. Historical Data Killadoon 2014-2018. https://www.met.ie/climate/available-data/historical-data Accessed February 2019.

Met Eireann. 2019g. Historical Data Leenane (Glanagimla) 2014-2018. https://www.met.ie/climate/available-data/historical-data Accessed February 2019.

Met Eireann. 2019h. Return period rainfall depths for sliding durations (76300E; 265300N). www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

NPWS. 2010. High Island, Inishshark and Davillaun SPA Site Synopsis (Site Code: 004144). https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004144.pdf

NPWS. 2013. Inishbofin and Inishshark SAC Site Synopsis (Site Code: 000278) https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY000278.pdf

NPWS. 2014a. West Connacht Coast SAC Site Synopsis (Site Code: 002998). https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY002998.pdf

NPWS. 2014b. Inishbofin, Omey Island and Turbot Island SPA Site Synopsis (Site Code: 004231). https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004231.pdf

NPWS. 2015a. Cross Lough (Killadoon) SPA Site Synopsis (Site Code: 004212). https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004212.pdf

NPWS. 2015b. Conservation Objectives: Inishbofin and Inishshark SAC 000278. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO000278.pdf

Ó Cadhla, O., Keena, T., Strong, D., Duck, C. & L. Hiby. 2013. Monitoring of the breeding population of grey seals in Ireland, 2009 - 2012. Irish Wildlife Manuals, No. 74. National Parks and Wildlife Service, Department of the Arts, Heritage and the Gaeltacht, Dublin, Ireland.

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.

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.

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.

Stoddard, R.A., Gulland, F.M.D., Atwill, E.R., Lawrence, J., Jang, Sp. & P.A. Conrad. 2005. *Salmonella* and *Campylobacter* spp. in Northern Elephant Seals, California. *Emerg. Infect. Dis.* **11(12):** 1967–1969.

Wang, G., Zhao, T. & M.P. Doyle. 1996. Fate of enterohaemorrhagic *Escherichia coli* O157:H7 in bovine feces. *Applied and Environmental Microbiology* **62**: 2567–2570.

Webster, P. 2018. Bathing Water Quality in Ireland 2017. Environmental Protection Agency. ISBN: 078-1-84095-775-4

Webster, P. 2017. Bathing Water Quality in Ireland 2016. Environmental Protection Agency. ISBN: 978-1-84095-718-1

Webster, P. & M. Lehane. 2016. Bathing Water Quality in Ireland 2015. Environmental Protection Agency. ISBN: 978-1-84095-636-8

Webster, P. & M. Lehane. 2015. Bathing Water Quality in Ireland 2014. Environmental Protection Agency. ISBN: 978-1-84095-592-7

Appendix 1

Leenane WWTP

Emissions Limits

Table D.1(i)(b): EMISSIONS TO SURFACE/GROUND WATERS - Characteristics of The Emission (Primary Discharge Point)

Discharge Point Code: SW-1

Substance	As discharged			
	Unit of Measurement	Sampling Method	Max Daily Avg.	kg/day
pH	pH	24 hr composite	= 6.0	
Temperature	℃	24 hr composite	= 17.5	
Electrical Conductivity (@ 25℃)	µS/cm	24 hr composite	= 362	
Suspended Solids	mg/l	24 hr composite	= 2	
Ammonia (as N)	mg/l	24 hr composite	= < 0.257	
Biochemical Oxygen Demand	mg/l	24 hr composite	= 8	
Chemical Oxygen Demand	mg/l	24 hr composite	= 61	
Total Nitrogen (as N)	mg/l	24 hr composite	= 18.8	
Nitrite (as N)	mg/l	24 hr composite	= < 0.348	
Nitrate (as N)	mg/l	24 hr composite	= 17.1	
Total Phosphorous (as P)	mg/l	24 hr composite	= 0.348	
OrthoPhosphate (as P)	mg/l	24 hr composite	= 3.25	
Sulphate (SO_4)	mg/l	24 hr composite	= 17.4	
Phenols (Sum)	µg/l	24 hr composite	< 0.5	

For Orthophosphate: this monitoring should be undertaken on a sample filtered on 0.45µm filter paper
For Phenols: USEPA Method 604, AWWA Standard Method 6240, or equivalent.

Table D.1(i)(c): DANGEROUS SUBSTANCE EMISSIONS TO SURFACE/GROUND WATERS - Characteristics of The Emission (Primary Discharge Point)

Discharge Point Code: SW-1

Substance	As discharged			
	Unit of Measurement	Sampling Method	Max Daily Avg.	kg/day
Triazine herbicides (Atrazine, Simazine)	µg/l	24 hr composite	< 0.040	
Dichloromethane,Toluene, Xylenes (VOC Suite)	µg/l	24 hr composite	< 0.5	
Tributyltin	µg/l	24 hr composite	< 0.03	
Arsenic	µg/l	24 hr composite	1	
Chromium	µg/l	24 hr composite	< 0.5	
Copper	µg/l	24 hr composite	= 23	
Cyanide	µg/l	24 hr composite	< 10	
Flouride	µg/l	24 hr composite	< 0.2	
Lead	µg/l	24 hr composite	= 1	
Nickel	µg/l	24 hr composite	= 4	
Zinc	µg/l	24 hr composite	= 83	
Boron	µg/l	24 hr composite	= 13	
Cadmium	µg/l	24 hr composite	< 0.5	
Mercury	µg/l	24 hr composite	< 0.05	
Selenium	µg/l	24 hr composite	< 0.5	
Barium	µg/l	24 hr composite	= 15	

For Orthophosphate: this monitoring should be undertaken on a sample filtered on 0.45µm filter paper
For Phenols: USEPA Method 604, AWWA Standard Method 6240, or equivalent.

Appendix 2

Water Sampling *E. coli* Results