Northern Ireland Sanitary Survey Review

Larne Lough

Sanitary Survey Review

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Review Specification and Introduction

Sanitary surveys are used to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004, whereby if the competent authority decides in principle to classify a production or relay area it must:

- make an inventory of pollution sources of human/animal origin likely to be a contamination source for the production areas;
- examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, wastewater treatment, etc.;
- determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal regime in the production area;
- establish a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.

The EURL Good Practice Guide (GPG) for the monitoring of bivalve molluscs harvesting areas recommends the re-evaluation of sanitary surveys every six years. Location, extent and nature of fisheries and faecal pollution sources may change over time and the review is conducted to determine whether the sampling plan and/or production area boundaries remain appropriate and protective of public health.

As specified by the Food Standards Agency, this review is comprised of a brief desktop search of publicly available information together with a shoreline survey. No additional data requests are normally submitted to external bodies. The review is intended to identify significant changes in:

- Historic microbiological data
- Sewage treatment and sewerage infrastructure
- Housing and development
- Harvester operations

The output of the review is a report identifying any new information that has been obtained and/or whether major elements of the original sanitary survey can be regarded as essentially unchanged. That report includes an overall assessment as to whether the RMPs should be modified from those recommended in the original report.

A sanitary survey was undertaken by AFBI in 2009 for Larne Lough. The survey was conducted to identify the location, extent and nature of the shellfishery and the potential sources of faecal contamination to the shellfishery, and to recommend sampling plans for the classified licensed sites within the lough.

The present report constitutes a review of publicly available information in order to assess changes that have occurred since the 2009 sanitary survey report (see the Review Specification section for further detail). It is not intended to present detailed information relating to pollution sources that were identified in the previous report. This review should be read in conjunction with the 2009 sanitary survey report.

Contents

APPENDICES

1. Area Description and Fishery

Larne Lough is an inlet on the west coast of Northern Ireland (see Figure 1.1). It is located in the County of Antrim. The town of Larne is located on the west side of the mouth of the lough. The east side of the lough is bounded by a peninsula of land called Islandmagee, which is joined to the mainland south of the lough head.

Figure 1.1 Location of Larne Lough

The 2009 sanitary survey report identified seven classified fisheries operating within five shellfish beds. Cultivated species included native and Pacific oysters, manila and native clams and common mussels. Common mussels and clams were grown using bottom culture techniques, with oysters grown on trestles on the lower intertidal area.

According to the current 2014/15 Food Standards Agency Northern Ireland (FSANI) classification document, three shellfish beds are classified within Larne Lough. One of the beds contains both oysters and mussels. Summary details are listed in Table 1.1.

Table 1.1 Larne Lough classified shellfish beds 2014/15

Production area	Assoc. sites/beds	Species	2014 Status	Culture method
Larne Lough	Millbay (L5)	Common mussels	Open	Bottom culture
		Oysters	Open	Trestle
	Shingle Bay (L3)	Oysters	Open	Trestle
	Island Shellfish (L1)	Clams	Open	Bottom culture

Three of the RMPs recommended in the 2009 Sanitary Survey report were located within the White Quay (L2) and Dougold (L6) beds. Further to the aquaculture licence for White Quay being revoked by DARD in 2014, the site was declassified by FSA in NI (as of 28/04/14) and the White Quay (L2) mussel and oyster RMPs were temporarily relocated to Millbay (L5) oysters and mussels. The Millbay (L5) bed was selected because it was the closest bed to the original RMP and Millbay (L5) was the only mussel and oyster bed currently active in Larne Lough. The locations of the licensed shellfish sites (as provided by DARD in December 2014) and the current RMPs as stated by FSA in NI are shown in Figure 1.2, with details of the RMPs listed in Table 1.2.

Table 1.2 Current RMPs in Larne Lough

Site	Species	2014/15 FSANI RMP
Mill Bay (L5)	Mussels	54° 49'.215 N 005° 45'.056 W
	Oysters	54° 49'.373 N 005° 45'.170 W
Island Shellfish (L1)	Clams	54° 48'.4978 N 005° 44'.3169 W

Since completion of the sanitary survey review and publication of the report, the clam has been declassified by FSA in NI.

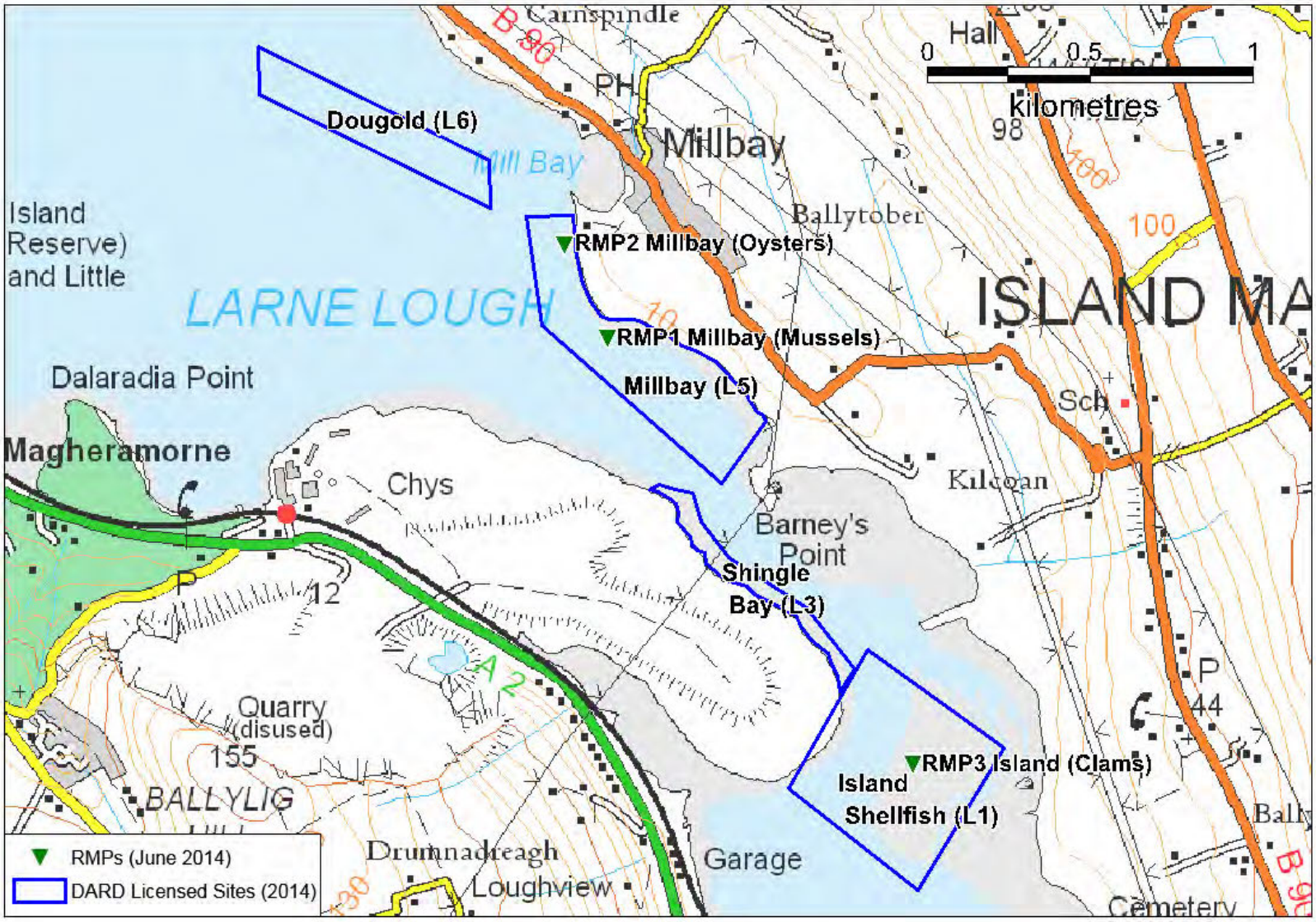

Figure 1.2 Larne Lough Shellfisheries

No fishery observations were made during the 2009 shoreline survey. Fishery observations made during 2014 are displayed in Figures 1.3 and 1.4 and were as follows:

Millbay (L5): This is primarily a Pacific oyster site comprised of two trestle areas; split into northerly and southerly areas. Empty poches and broken trestles were littered along much of the shoreline between these two areas and extending southward beyond the southerly area. The northerly trestle area mainly consisted of empty oyster trestles, lying in disarray. The southerly area consisted of 12 predominantly empty trestles. Three poches containing native oysters were noted on a trestle at the southwest extent of the site. A concreted area on the foreshore adjacent to the southerly site was being used to store 56 trestles and 12 empty poches. No observations were made of the Millbay (L5) mussel site.

Shingle Bay (L3): four areas of trestles were observed; two to the north and two to the south. The two northerly areas were comprised of predominantly empty and rusty trestles that were covered in dense seaweed growth. Stray poches littered the lower shore, most of which contained empty oyster and mussel shells. However, some contained mussels of harvestable size which had also colonised parts of the trestle frames and the immediate seabed. The upper shoreline consisted of native and Pacific oyster shells (shingle). The two southerly areas consisted of one cluster of several empty trestles and another larger area of >60 lines of 2-4 trestles. Trestles in the larger area appeared to have been recently placed on the shoreline, as they had very little seaweed growth. Nine poches with mussels were noted to the south-easterly extent of this trestle area, where the shoreline was also noted to have dense aggregations of shore mussels.

Island Shellfish (L1): No explicit positional locations of the clam fishery within Island Shellfish (L1) were recorded during the shoreline survey. Later information from the sampling officer identified that clams were grown on an area approximately 100 m x 50 m in size centred on 54° 48’.597 N, 5° 44’.162 W. It was also identified that the clams are harvested, and sampled, by hand. This area apparently lies outside of the L5 licensed area and therefore is unclassified. Subsequent to the consultation phase of this report, the harvester reported via his Environmental Health Officer that he has not harvested clams here in recent years, and DARD advised that there has been no recent production from this site.

The L1 area is licensed by DARD for the cultivation of a number of species other than clams, including native oysters. Information was received that native oyster seed has been placed in the area. However, no application has been made for classification.

The locations of fishery observations made during the 2014 shoreline survey are displayed in Figures 1.3 and 1.4.

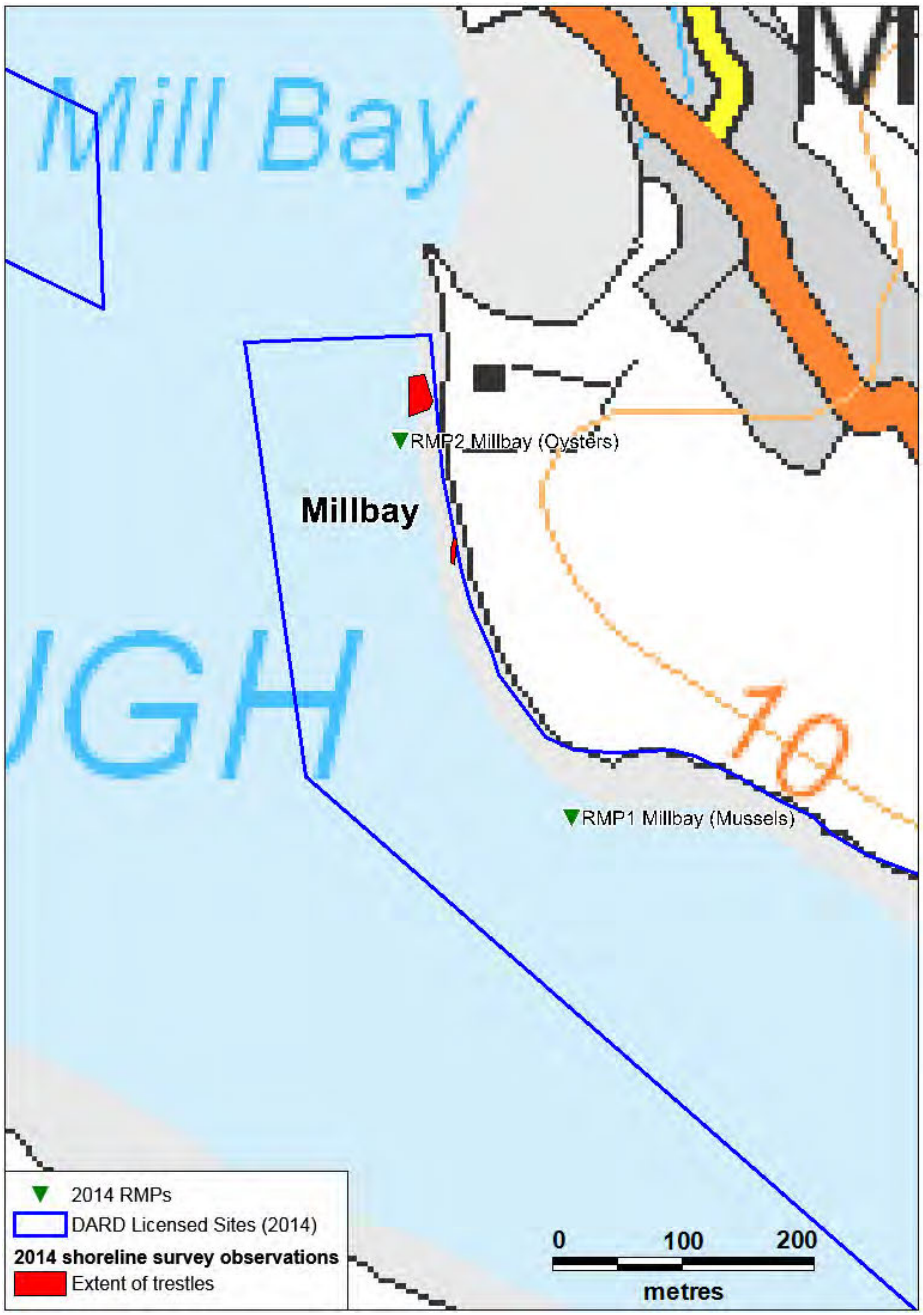

Figure 1.3 Larne Lough Millbay (L5) shellfishery observations

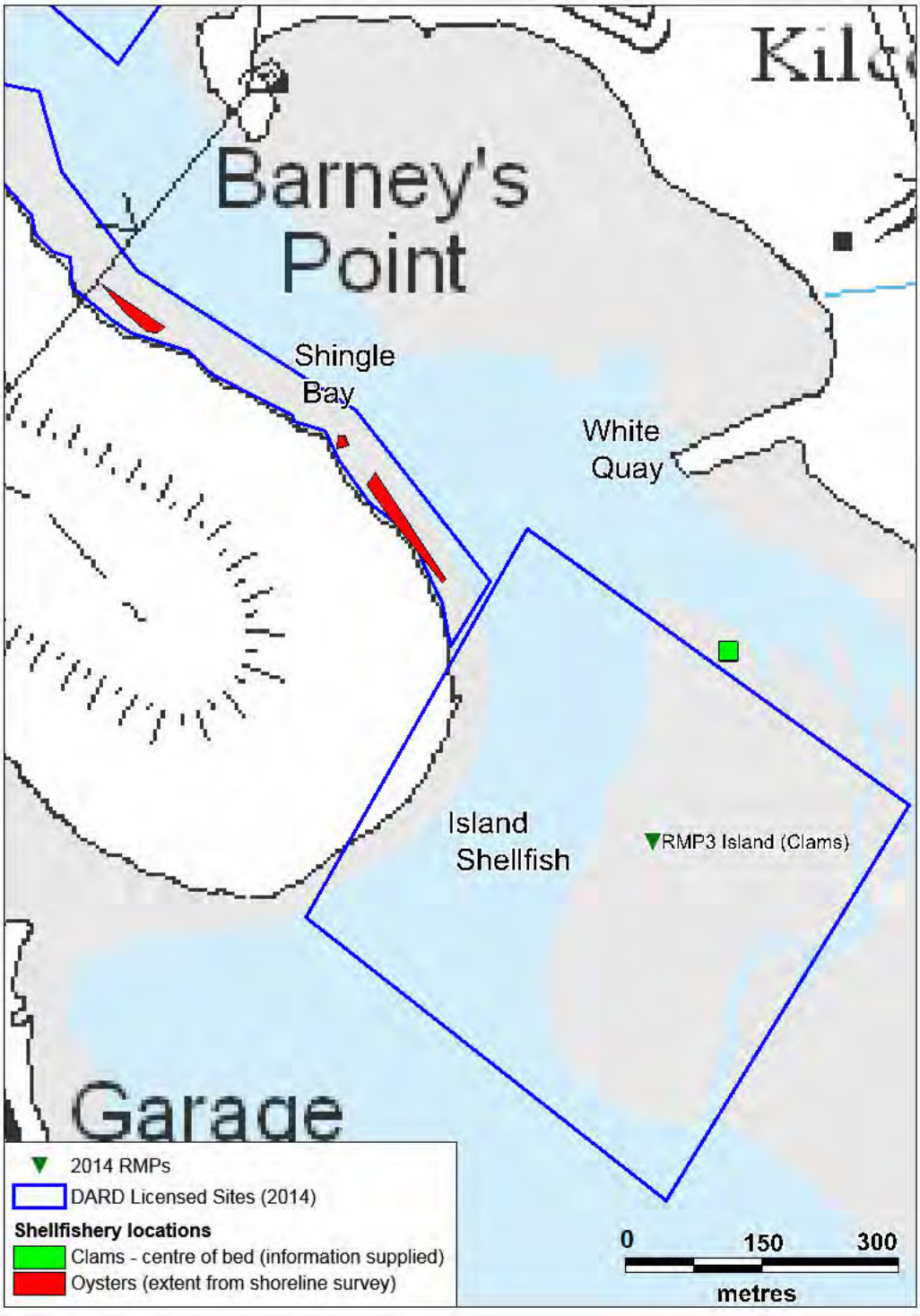

Figure 1.4 Larne Lough Shingle Bay (L3) observations, together with information on the clam fishery location

2. Population and Human Sewage Impacts

2.1 Population

The town of Larne is located to the northwest of the lough. It was identified in the sanitary survey report as being a large urban area and the main centre of population in the area. Smaller urban areas were noted at Glynn and Magheramorne on the west shore and at Ballylumford and Millbay on the east shore. The Ballylumford Power Station was the only industrial premises noted in the area and its cooling water intake pipes were identified as having the potential to relay faecal contamination to the outer lough area. The town of Larne was also noted to receive increased numbers of tourists during summer months, as it has direct ferry links to Scotland and England. The accompanying shoreline survey identified Larne Harbour/docklands and East Antrim Boat Club on the northwest side of the lough entrance near Curran Point. No observations on number or size of boats were made during the 2009 shoreline survey.

The Borough of Larne covers the town of Larne and the area immediately around Larne Lough, as well as areas inland of, and to the north of, the lough. Usual resident population figures for Larne Borough according to the 2001 and 2011 censuses are listed in Table 2.1 (Office for National Statistics, 2012).

Table 2.1 Northern Ireland Government census data for years 2001 and 2011

Census area	2001 data	2011 data	% increase
Larne	30,832	32,180	4.4
Northern Ireland	1,685,267	1,810,863	7.5

There was a small increase (4.4%) in human population in Borough of Larne area between 2001 and 2011. The 2011 total accounts for 1.8% of the 2011 total Northern Ireland human population. Population density was only available for the entirety of the Larne District Council area and was 96 persons/km^2 in 2011 (Office for National Statistics, 2012).

Since the 2009 sanitary survey report, a large number of planning applications have been submitted to the Department of Environment Northern Ireland for the areas around Larne Lough. These were downloaded from the planning portal (Department of the Environment Northern Ireland, 2014) in November 2014, and their distribution was viewed through Geopii (Geopii, 2014). A full list of the applications can be found in Appendix 1. A large number of applications had been made to the Port of Larne and Curran Business Parks located to the north of the lough, to change or build new industrial premises, as well as new apartment blocks.

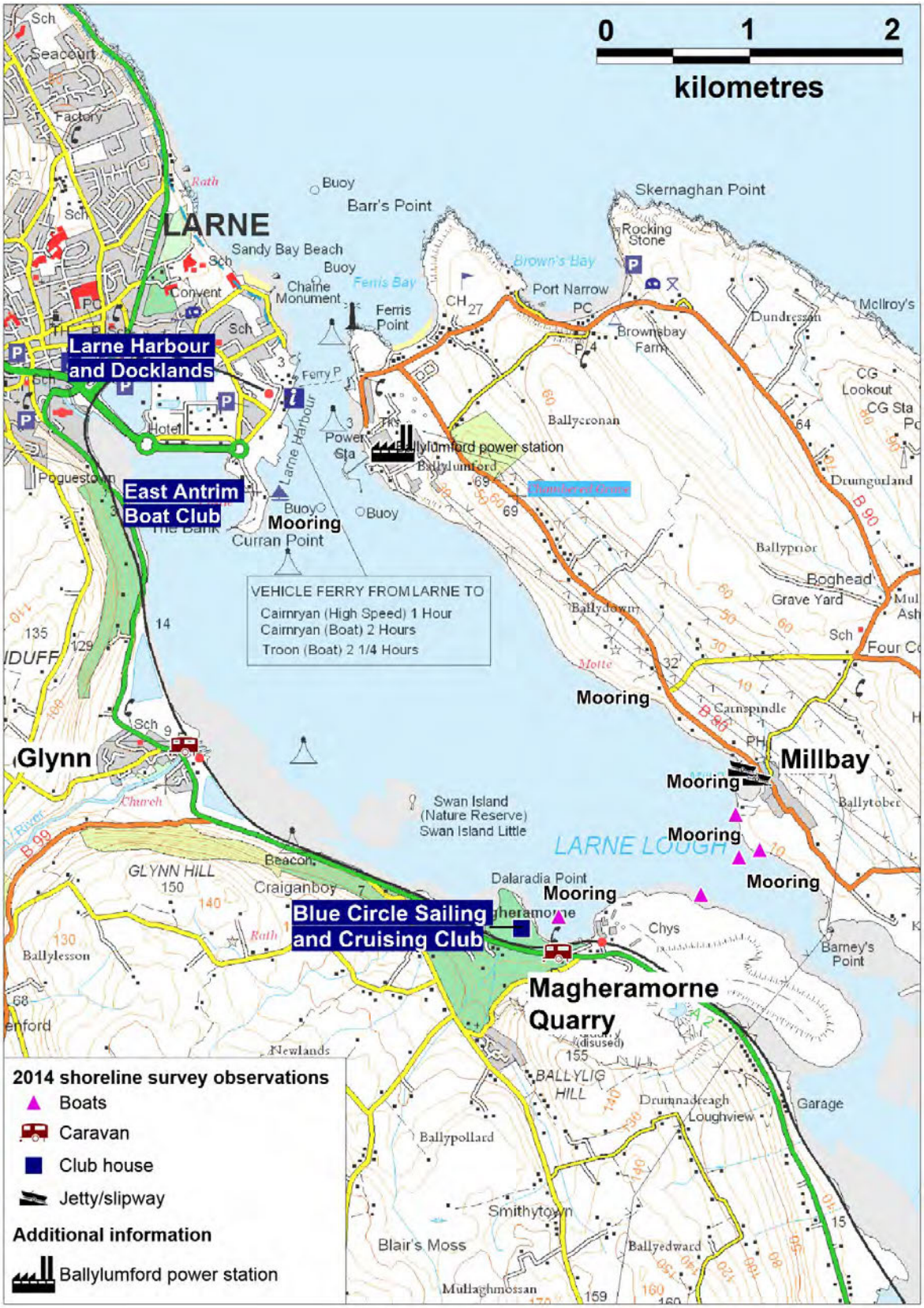

Figure 2.1 Population-related observations around Larne Lough

Of particular note was the 2013 application to extend and upgrade the existing Millbay waste water pumping station (WwPS), with installation of new pipelines. No observations were made of this WwPS during the 2014 shoreline survey. Planning permission was granted in July 2009 for the redevelopment of Ballystrudder waste water treatment plant (WwTP). Satellite imagery (Microsoft Corportation, 2014) dated July 2011 indicated the site was being modified, with diggers clearing areas of land in the vicinity of the works and new pipes ready to be installed.

Permission for a cycling and diving centre was granted in April 2013 for the disused Magheramorne quarry. The owners of the quarry (Lafarge Cement) also plan to turn the old works area adjacent to the shoreline into an eco-village with a nature reserve, railway museum and film studios. No details concerning sewage disposal were identified in the planning application. No sign of redevelopment on the site was noted during the 2014 survey, though the quarry was being used as a film set at the time of the survey. Internet searches identified that the developer is still waiting to secure funding (Larne Times, 2012).

Larne is a busy commercial port. Two P&O ferries (Ro-Ro) operate from the Larne docks, with between 14 and 20 sailings per day depending on the time of year (daily services increase between July and August for the Larne-Cairnryan/Troon service) (Port of Larne, 2014). Larne is considered the gateway to County Antrim, which contains a large number of country parks and the Giant's Causeway, which receives a large number of visitors per year (National Trust, 2014). Stenaline discontinued service between Larne and Fleetwood (England) at the end of 2010 due to low passenger numbers (Ferryto.co.uk, 2014). The docks are also used by commercial freightliners (Port of Larne, 2014).

Larne Lough is also a relatively popular area for recreational boating. The main anchorages are located adjacent to the East Antrim Boat Club (EABC) at Wymers Jetty on Curran Point and adjacent to the Blue Circle Boat Club at Magheramorne (vistiMyHarbour.com, 2013). The EABC anchorages are noted to get very busy during summer months. A small boat dock is also located at Ballylumford, though it is predominantly used by local fishing and angling boats. A foot ferry operates between Larne and Ballylumford for workers at the power station. . Moorings are reported outside the lough at Ferris and Brown's bays, whilst within the lough moorings are noted at Ballydowan and Mill Bay. An annual regatta is held in July at the EABC (East Antrim Boat Club, 2013), where several races for boats of varying size classes are held.

During the 2014 shoreline survey, 22 of the 30 moorings in the bay adjacent to the Blue Circle Sailing and Cruising Club at Magheramorne were being used by motor/sailing boats. A motor boat was also observed just south of the sailing club. Moorings and four slipways were also noted in the vicinity of Millbay.

Overall, human population remains centred around the town of Larne. The total human population has increased slightly since the 2009 sanitary survey report, which is reflected in the number of planning applications to the surrounding areas. Visitor numbers to the area will increase once the cycling and diving centre are built at Magheramorne quarry. There is also a significant amount of leisure boating activity around the area, which will be greatest during summer months in the vicinity of the EABC in Larne.

2.2 Sewage Discharges

The 2009 report provided information on five community sewage discharges within Larne Lough. These were Larne, Sandy Bay, Ballycarry, Mounthill, and Ballystrudder WwTWs. Overall the Sustainable Mariculture in Northern Irish Sea Lough Ecosystems (SMILE) project concluded the majority of discharges would not affect the lough as contaminants would be quickly flushed, excluding those in the inner lough where contaminants had the potential to be retained for longer (Ferreira, *et al*., 2007). Contamination inputs to the inner lough were noted to include Ballycarry and Ballystrudder WwTWs and private ST runoff/leaching. It was also considered that there was also the potential for discharges from Sandy Bay (located just outside the mouth of the lough, on the northeast side of Larne) to enter Larne Lough on a flood tide, and that this would be exacerbated during periods of northerly winds.

Raw data from the 2009 report was unavailable. A request for up-to-date information on all consented discharges containing a faecal component (or likely to contain faecal indicator bacteria, such as pulp mill waste) in the Larne Lough area was therefore submitted to the Northern Ireland Environment Agency (NIEA). NIEA provided information on a large number of community and private discharges. Those discharges that were deemed to be likely to enter watercourses flowing into other water bodies were excluded from consideration within this review. The request area and a full list of community discharge information supplied by NIEA can be found in Appendix 2.

Information relating to Northern Ireland Water (NIW) community discharges was provided by NIEA. the locations of the discharges are displayed in Figure 2.2. Summary information relating to the continuous discharges is listed in Table 2.2. NIEA did not provide any consented flow information, so data provided in the 2009 report has been included where available.

NIW confirmed that wastewater improvements had been delivered for Ballystrudder, Ballycarry and Whitehead WWTWs (the latter previously discharged to outer Belfast Lough). A rationalisation scheme had been delivered for the catchments of Whitehead, Ballycarry and Ballystrudder with a single 500m marine outfall provided, discharging to Cloughfin Bay. At Whitehead the existing pumped effluent outfall at LWMMT was decommissioned and FFT fine-screened and pumped via Ballystrudder to the long sea outfall. The existing combined storm/emergency overflow which

discharges at LWMMT to Outer Belfast Lough at Whitehead, was fitted with fine screening. Ballycarry WwTW continues to provide biological secondary treatment. Storm tank capacity was provided to limit spill frequency (agglomerated with Ballystrudder) to 12 spills per year. Formula A flow is discharged via Ballystrudder to the long sea outfall. The combined storm/emergency overflow is fine-screened and discharged through the existing outfall at LWMMT to Larne Lough at Old Church Bay. At Ballystrudder, Formula A will be fine-screened and blended with Whitehead and Ballycarry flows to discharge to the long sea outfall. Storm tank capacity and permanent back-up generator will be provided to limit spill frequency (agglomerated with Ballycarry) to 12 spills per year. The combined storm/emergency overflow is fine-screened and discharged through the existing outfall to Larne Lough at Old Church Bay.

Formula A = PG+E+I+1360P+2E l/d

Where: P=population
G=average daily consumption per head l/h/d
E=Industrial & commercial discharges to sewer l/d
I=infiltration l/d

Table 2.2 NIW continuous discharges (infomation provided by NIEA)

Discharge Name	Discharge Type	Discharge Location	PE (taken from 2009 survey)
Glenoe WwTW	WwTW	[redacted]	-
Larne WwTW	WwTW		20000
Mounthill WwTW	WwTW		131
Magheramorne WwTW	WwTW		-
Ballylumford Cottages ST	Septic Tank		-
Ferris Bay 50 ST	Septic Tank		-
Belfast Road 56-58 ST	Septic Tank		-

- Data not available, PE = Population Equivalent

Internet searches identified reports of Millbay WwPS malfunctioning in 2012 owing to sustained wet weather, and of four houses that were misconnected to the mains sewage. This resulted in raw sewage being discharged into Mill Bay and the stream (Ballytober drain) that runs through the hamlet of Millbay (Beggs, 2012; Larne Times, 2012). Three of the houses have subsequently been connected to the mains sewage system, with additional modifications to the pumping station also planned (Larne Times, 2012). No information was available as to whether the discharge from the fourth property has been addressed. Plans for an upgrade to Millbay WwPS were found during an internet search. The plan (granted in July 2014) included expansion of the site and facilities, (Department of the Environment Northern Ireland, 2014). No information was found as to whether the works have been completed since planning permission was granted.

The original sanitary survey provided no flow data for Magheramorne WwTW and none was received in response to the data request raised for this review. The likely location of the plant was identified using publicly available satellite imagery, which apparently showed a very small works with a single trickling filter located between the A2 and the rail line on the west side of the lough approximately 350 m west of the reported outfall location. The reported outfall location is unusual, in that it lies across a body of water from the works.

NIEA also provided information on 26 private sewage discharges. These were split by NIEA according to industry type among three categories: domestic; emergency overflows and unspecified. Information on these 26 discharges is presented in Table 2.3.

Table 2.3 NIEA private discharge consents

Consent Number	Discharge Location	Receiving Body	Industry Type	MDF (m^3/day)
481/13	[redacted]	U	Domestic	-
2238/12		-	Domestic	-
2015/12		-	Domestic	-
1039/13		U	Domestic	-
2901/12		U	Domestic	-
2002/12		U	Domestic	-
2884/12		W	Domestic	-
3058/12		U	Domestic	-
2896/12		U	Domestic	-
980/13		U	Domestic	-
2381/12		U	Domestic	-
2842/12		W	Domestic	-
2957/12		U	Domestic	-
2176/12		U	Domestic	-
147/07		W	Emergency Overflow	-
438/08		C	Emergency Overflow	-
318/07		C	Emergency Overflow	-
114/02		W	Emergency Overflow	-
18/04		W	Emergency Overflow	-
58/07		W	Emergency Overflow	-
119/04		V	Unspecified	-
56/09		U	Unspecified	-
1966/80		W	Unspecified	-
1966/80		W	Unspecified	-
1966/80		W	Unspecified	-
1966/80		W	Unspecified	-
95/10		W	Unspecified	-
247/13		U	Unspecified	4.5
91/10		U	Unspecified	1
20/08		W	Unspecified	0.3
33343/05		U	Unspecified	2
12490/99		U	Unspecified	9
127/05		U	Unspecified	2
231/06		U	Unspecified	4

- No information given, W = Waterway, C = Coastal, E = Estuarine and U = Underground, V = Watercourse via underground stratum

Where flow data was given, the values are low and the discharges would be only be likely to significantly impact on the fisheries if they were located near to these.

The 2014 shoreline survey recorded ten sewage related observations, which are listed in Table 2.4 and displayed in Figure 2.2.

The majority of observations were made in the outer lough area. Two pipes were observed in the River Larne (observation 1), which are thought to relate to Minnis Fleck Inver River CSO which plots within 100 m of the recorded observation location. The relatively new Glynn WwPS and associated outfall pipe were noted at the mouth of the River Glynn (observations 2&3). It should be highlighted that the observed pipe appeared to have been recently installed and according to NIEA information is both a CSO and EO. An iron pipe noted further up the River Glynn was thought to be an old, disused sewage pipe (observation 4).

Table 2.4 Discharge-related observations made during the 2014 shoreline survey

No.	Date	NGR	Description
1	02/09/2014	J 40184 02200	Two pipes: one pipe with a lid, the other with a grill cage covering the end
2	02/09/2014	J 40915 99972	Glynn PS - relatively new/refurbished and associated with pipe
3	02/09/2014	J 40974 99923	Discharge pipe - dry.
4	02/09/2014	J 40874 99876	Iron discharge pipe seen on left side of river - dry
5	02/09/2014	J 42890 98747	Discharge pipe to small river, cotton buds around grassy river banks. Discharging, though no associated smell. Freshwater sample result 210 *E. coli* cfu/100 ml
6	02/09/2014	J 42867 98756	Sanitary debris on grassy bank above discharge pipe in river
7	02/09/2014	J 43277 98685	One caravan that appeared to be lived in with a grey pipe coming from below the caravan, but no visible pipe on the adjacent shoreline
8	03/09/2014	J 44489 99474	Seawater sample, 34 ppt, taken adjacent to dripping pipe. Seawater sample results 1 *E. coli* cfu/100 ml
9	03/09/2014	J 44515 99477	Freshwater sample (contaminated) from sewage pipe mentioned above. Flow too little to measure. Freshwater sample results: 400,000 *E. coli* cfu/100 ml
10	03/09/2014	J 44509 99473	Sewage water - grey in colour with sewage fungus on surrounding rocks. Dripping pipe above shore below boat/scrap yard

A small iron pipe was noted above the banks of an unnamed watercourse just north of Magheramorne (observation 5&6). Sewage related debris was also noted on the surrounding banks. A freshwater sample taken of the small discharge from the pipe returned a relatively low result of 210 *E. coli* cfu/100 ml. A static caravan that appeared to be lived in was also noted at Blue Circle Sailing and Cruising Club (observation 7). Although a grey pipe was visible below the caravan, it was unclear whether it was associated with sewage or whether it discharged to the surrounding bay.

Only one sewage input was observed within the inner lough area, which was located adjacent to the Millbay oyster fishery and was associated with a boat/scrap yard. Surveyors observed a dripping pipe with grey sewage and sewage fungus on the surrounding shoreline. A sample taken from the dripping pipe returned a high result of 400,000 *E. coli* cfu/100 ml, though a seawater sample taken adjacent to the pipe returned a low result of 1 *E. coli* cfu/100 ml. The latter result would indicate that the output from the pipe may not have been causing significant contamination of the surrounding seawater at the time of the shoreline survey, this would depend on the water movement in the vicinity.

Conclusions

Most of the inputs of sewage to Larne Lough are located towards the head of the lough where the community sewage system and several private STs discharge directly or diffusely via watercourses. The intermittent discharges from Millbay WwPS will directly impact the Millbay (L5) oyster site if they operate (e.g. if the CSO discharges following heavy or prolonged rainfall). The discharge from Magheramorne WwTW enters the lough in the vicinity of the Island Shellfish (L1) and Shingle Bay (L3) sites. Private septic systems discharging to the central area of the lough, either directly or via watercourses, may also affect the microbiological quality at the shellfisheries.

Overall, faecal contamination levels associated with sewage are expected to have decreased in the inner lough area since 2009. This relates directly to the removal of continuous inputs from Ballycarry and Ballystrudder WwTW, as well as the work undertaken to reduce spills from Millbay WwPS.

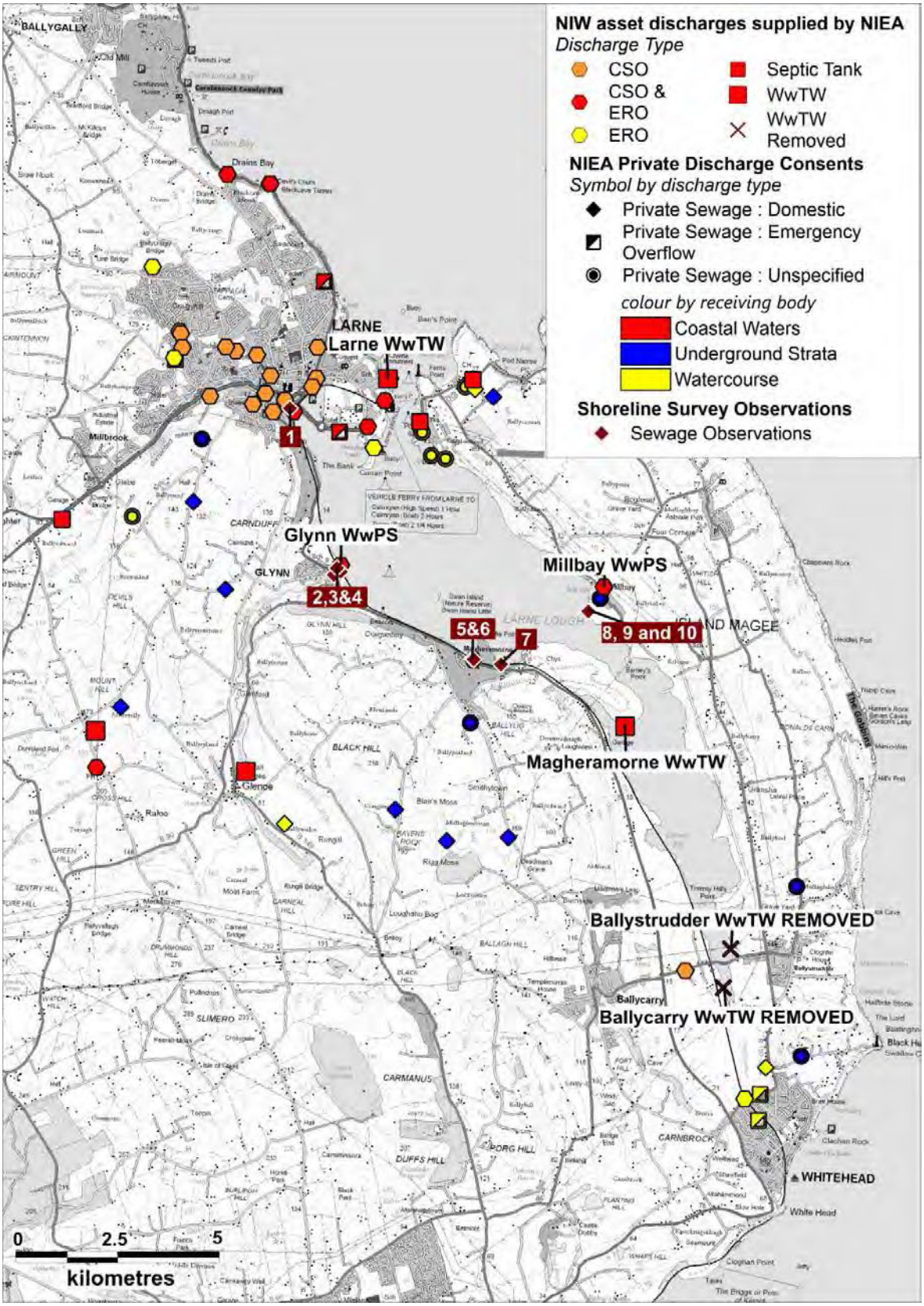

Figure 2.2 Map of sewage discharges potentially impacting on Larne Lough

3. Farm Animal Population and Agricultural Impacts

The 2009 sanitary survey report included 2008 agricultural census data with livestock numbers for the Carrickfergus and Larne districts from the Department of Agriculture and Rural Development (DARD). This is listed alongside 2013 census data in Table 3.1. The 2009 report identified that pasture and grassland dominated the eastern coastline on Islandmagee. During the 2009 shoreline survey, sheep were noted on five occasions along the shoreline south of Barney's Point, although no number of animals was recorded. The report concluded that agricultural based contamination had the potential to impact the shellfisheries in Larne Lough and was expected to enter from watercourses or via land runoff from pasture land.

Table 3.1 Agricultural census data from districts of Carrickfergus and Larne in 2008 and 2013 (DARD)

	Carrickfergus				Larne			
Year	Cattle	Sheep	Pigs	Poultry	Cattle	Sheep	Pigs	Poultry
2008	4,927	14,636	535	7	35,041	120,954	4,364	128
2013	4,667	12,255	760	1	33,243	114,607	3,788	149

Decreases have been recorded in the number of cattle and sheep in both districts between 2008 and 2013. Greater decreases were noted in the Larne district than in Carrickfergus. An increase was noted in poultry in both districts although the absolute numbers remain very low. Impacts from livestock within the Larne district are expected to be greater than those in the Carrickfergus district, which only covers a small area adjacent to the southern extent of Larne Lough.

Additional information on agricultural based contamination sources for this review have been obtained through internet searches and via the 2014 shoreline survey conducted in September.

A review of publicly available satellite imagery from July 2011 (http://mvexel.dev.openstreetmap.org/bing/) indicated that Islandmagee remains dominated by pasture and grassland, whilst pasture land continues to be limited to the south of the western shoreline. Larne port is the only approved port of entry in Northern Ireland for livestock imports and exports (DARDNI, 2014): it is not clear what the arrangements are for handling associated faecal waste. A riding centre is located approximately 1.5 km from Millbay on Islandmagee (http://www.islandmageeridingcentre.co.uk/).

The majority of agriculture-related observations made during the 2014 shoreline survey were for locations on the east side of the lough on Islandmagee. Fenced areas of improved grassland dominated land adjacent to the shoreline. Ninety-three sheep and 41 cattle (including three calves) were observed along this shoreline. Two farms and 15 cattle were seen near Magheramorne quarry. Observations made during the survey are dependent upon the viewpoint of the observer some animals may have been obscured by the terrain. A large farm consisting of four large

buildings/sheds was observed set back from the shoreline on a hillside at the southern extent of the shoreline walk.

Fields of improved grassland containing 15 cattle were noted around two farms located on the hillside south of the Magheramorne quarry. A tractor was also observed from the opposite shoreline to be applying a white spray to a recently ploughed field on the hillside southwest of the quarry.

Two empty wooden structures were noted just north of Barney's Point on Islandmagee. Their purpose remained unclear, though it may be suggested they are used as feeding stations. Cattle hoof prints were noted on the muddy shoreline at Barney's Point, where the sampling officer stated he had previously seen cattle. In the adjacent field there was a gate to the shoreline, where a hay pile and sheep spoil were also noted on the foreshore. Horse droppings were noted on the grassy verges around Mill Bay, where a chicken was also noted on the shore.

Conclusions

It is difficult to determine from the available information whether the potential for contamination from farm animals has changed significantly since the 2009 sanitary survey. Direct inputs are also expected from livestock accessing the shoreline at Barney's Point, whilst contamination from horses and chickens is expected around Millbay (L5). Overall contamination impacts from livestock are expected to be greatest at White Quay (L2) and to a lesser extent at Millbay (L5) from contamination entering from livestock on the eastern coastline. Watercourses located on the western and southern sides of the lough may contain faecal contamination from farm animals located some way from the lough itself.

Figure 3.1 Map of farm animals and associated observations made during the 2014 shoreline survey

4. Wildlife

The 2009 sanitary survey report included information on the Larne Lough Special Protection Area (SPA) and RAMSAR site, designated to protect internationally important numbers of light-bellied brent geese in the winter, with the RAMSAR site qualifying by means of supporting an assemblage of vulnerable and endangered Irish Red Book bird species. Reference was also made to the Larne Lough Area of Special Scientific Interest (ASSI) which covers brackish lake and coastal saltmarshes in the lough, with important seabird and waterfowl assemblages. The 2009 shoreline survey noted the presence of gulls, oystercatchers, ducks and herons. The sanitary survey report concluded that significant bird aggregations occurred on intertidal areas, particularly during winter months.

Information on wildlife for this review has been obtained through a desk-based internet search and the shoreline survey conducted in September 2014. Wildlife observations from the 2014 shoreline survey are displayed in Figure 4.1.

Conservation areas

Conservations areas referred to in the sanitary survey report have been noted above. Swan Island SPA, located to the northwest of Magheramorne Quarry, is a separate designation within Larne Lough and was designated in 1992 due to its summer breeding populations of roseate and common tern (DOENI, 2009). It also supports sandwich tern populations.

Pinnipeds

The Special Committee on Seals 2013 report did not identify the presence of any seals within Larne Lough during their aerial surveys. The Maidens special area of conservation (SAC) is located approximately 5 km north of the entrance to Larne Lough. Surveys have shown that approximately 70 grey seals regularly use the site for hauling out and it is now recognised as being an important area for feeding, pupping and breeding (Anon., 2010). Common seals are also noted to be present at the Maidens, though no numbers were reported (Anon., 2010).

Five seals were observed during the 2014 shoreline survey. This included two juvenile seals; one adjacent to Magheramorne quarry and the other at Mill Bay: a local stated that he saw the latter hauled out on the same rock every day. The remaining three other seals were observed around Barney's Point.

Cetaceans

Northern Ireland inshore waters are reported to host both resident and migratory cetacean species, with dolphins and harbour porpoise most commonly spotted near-shore (Sea Watch Foundation, 2012). Bottlenose dolphins and harbour porpoise are

noted as being present at the Maidens SAC (Anon., 2010). No cetaceans have been noted within Larne Lough and none was observed during the 2014 shoreline survey.

Seabirds

The BTO 2014 report identified that the Maidens SAC is home to a large breeding colony of European shags (British Trust for Ornithology, 2014). The report also identified that within Larne Lough there are breeding colonies of black-headed gulls, sandwich terns, common terns and Mediterranean gulls, and that the last pair of roseate terns in NI were reported in 2013 on Swan Island. Increases in black guillemots (105 adults) were noted in 2013.

Birds were the most common wildlife observed during the 2014 shoreline survey. Species included guillemots, herons, cormorants, oystercatchers, gulls, crows, swans, ducks and eider ducks. Gulls were the most common, with one observation relating to 100 gulls on the intertidal area east of White Quay. An estimated 200 seabirds were noted on the intertidal area adjacent to Glynn railway station, with smaller aggregations southwest of Magheramorne quarry. Possible bird feeding areas were noted at two locations on the eastern shoreline. Bird faeces were also noted on the northern area of trestles at Shingle Bay and on the shoreline southeast of the Island Shellfish clam fishery.

Otters

The Eurasian otter (*Lutra lutra*) is a priority species under the NI biodiversity action plan (BAP). Increases in coastal otter populations have been reported across NI populations, with the Lagan, Belfast Lough and East Down district (inclusive of Larne Lough) noted to have contained 40 tracks in the 2010 survey (Preston & Reid, 2010). This equated to a statistically significant difference and a +59% change since the last survey conducted in 2001/2. No otters were observed during the 2014 shoreline survey.

Dogs

The Clean Neighbourhoods and Environment Act Northern Ireland came into force in April 2011 and specified particular legislation regarding dog fouling which came into force in April 2013. It states charges may be up to £1000 for offenses relating to failing to pick faeces up after your dog has fouled etc (Larne Borough Council, 2013). During the 2014 shoreline survey, dog faeces were noted around Mill Bay, where a dog was also being walked. A dog and dog walker were also observed at the Blue Circle Cruising and Sailing Club.

Conclusions

Direct inputs are expected from birds accessing the intertidal mudflats located around Larne Lough, which are expected to impact the trestle shellfish sites at the

Millbay (L5) oyster and Shingle Bay (L3) sites. These sites are also anticipated to be impacted by birds defecating on trestles, which may also impact offshore shellfisheries from birds resting on buoys/cages. However, it is difficult to determine from the available information whether the potential for contamination from wildlife has changed since the 2009 sanitary survey.

Figure 4.1 Map of wildlife observations made during the 2014 shoreline survey

5. Watercourses

The 2009 sanitary survey report identified the main freshwater inputs to Larne Lough were from Glynn River and Larne (Inver) River, with several smaller watercourses identified to also drain into the lough. In total, freshwater runoff was calculated at 101 million m^3/y by the SMILE project (Ferreira, *et al*., 2007). The 2009 report concluded that freshwater inputs from watercourses and runoff from surrounding pasture land had the potential to impact the shellfisheries within Larne Lough.

An internet search was conducted for this review in order to obtain information relating to watercourses entering into Larne Lough.

No gauging stations were found on watercourses entering into Larne Lough. Under the Water Framework Directive, Larne Lough falls into the North Eastern River Basin District and is managed as its own local management area (LMA) (NIEA, 2014). The Larne Lough LMA covers a total area of approximately 141 km² and includes the River Larne and the River Glynn.

Shoreline survey observations

The 2009 sanitary survey report did not present watercourse measurements or flow data, preventing comparisons of estimated loadings with those calculated from the 2014 shoreline survey data. Freshwater samples taken in the 2009 shoreline survey were examined for faecal coliforms (although *E. coli* concentrations were calculated using a factor) and thus it is not possible to directly compare the faecal indicator concentrations from the two shoreline surveys.

Light rain was reported to have fallen in the 48 hours prior to the 2014 survey, though both survey days remained dry. The freshwater sample associated with watercourse 5 listed in Table 5.1 was taken on the 17th September, when no rainfall had been recorded.

Table 5.1 gives estimated watercourse loadings obtained from the 2014 shoreline survey measurements and samples. The watercourse observations are shown in Figure 5.1. In addition to the five listed watercourses, eight areas of land drainage and one bog area were noted during the survey: these were not sampled or measured.

Table 5.1 Watercourse loadings to Larne Lough estimated from measurements made during the 2014 shoreline survey

No.	Description	Irish National Grid	Loading (*E. coli*/day)
1	Glynn River	J 4087 9988	$9.8x10^{10}$
2	Section of Larne River	J 4018 0220	$2.6x10^{11}$
3	Unknown watercourse	J 4286 9877	$1.8x10^{9}$
4	Ballytober drain	J 4464 9967	$6.2x10^{10}$
5	Unknown watercourse	J 4571 9853	$1.1x10^{10}$

The *E. coli* loading was highest in the River Larne. However, this is expected to be an under-representation of total loading as only a section of the river was measured. The four remaining watercourses contained moderate contamination levels, with watercourse expected to impact on the northern end of the Shingle Bay site and watercourses 4 and 5 on the Millbay (L5) oyster and White Quay (L2) sites respectively.

Conclusions

The highest estimated loadings were associated with the Rivers Larne and Glynn. These enter the outer lough area and are located >3 km from the nearest shellfish site. Depending on particle transport distance, these may impact at the northern end of the sites or at least contribute to background levels within the lough. The other recorded watercourses may directly impact on the fisheries, especially on the oyster sites on or close to shore. Other watercourses located in the eastern lough may also contribute to contamination at the fisheries.

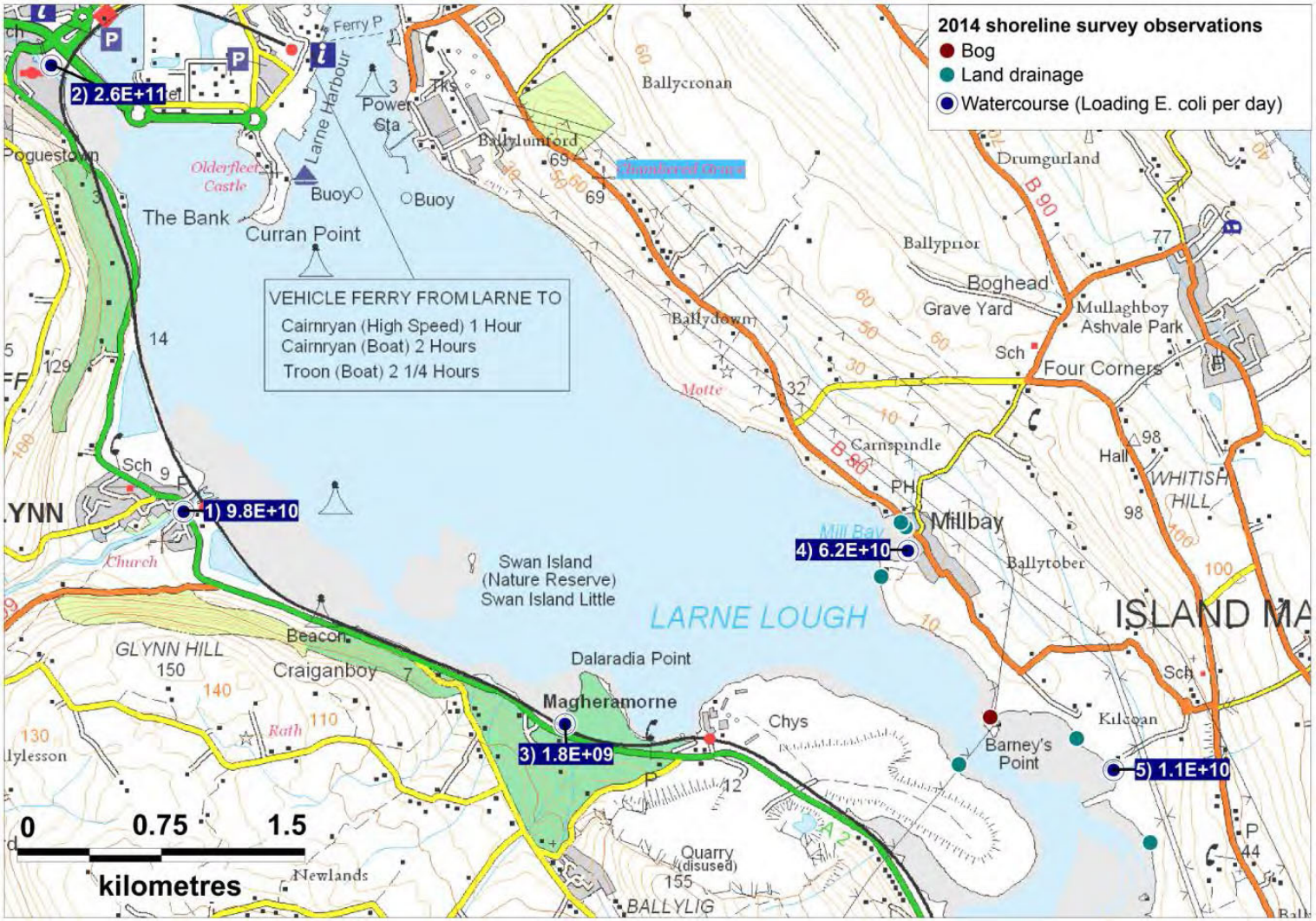

Figure 5.1 Watercourse loadings at Larne Lough, 2014 shoreline survey

Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is $1x10^3$, in digital format it is written as 1E+03.

6. Meteorological data

Average monthly rainfall data from Killylane weather station for the 2000-2003 period was used in the 2008 report and has not been replicated for this review. They are available to view in the original 2009 report. For the purposes of this review, rainfall data from Ballycarry weather station has been purchased from the Meteorological Office, owing to there being missing data in the Killylane dataset. Ballycarry weather station lies approximately 4 km southwest of Larne Lough, with rainfall considered representative of that within the catchment of Larne Lough. Rainfall data was used for the period 01/01/2007-31/12/2013 and is recorded in total daily rainfall (mm), where there were no missing records.

Wind data were not included in the 2009 report. For the purposes of this review, wind roses have been purchased from the UK Meteorological Office for Orlock Head weather station, which lies approximately 20 km southeast of Larne Lough. Wind roses for the period 2003-2007 and 2008-2012 have been purchased for comparison in this review and are displayed in Figures 6.3 to 6.6.

6.1 Rainfall

Storm events and high rainfall levels are commonly associated with increased faecal contamination of coastal waters through surface water run-off from land where livestock or wild animals are present and through sewer and waste water treatment plant (WWTP) overflows (Mallin, *et al*., 2001; Lee & Morgan, 2003).

The Ballycarry weather station rainfall dataset for 2007-2013 is presented by year in Figure 6.1 and by month in Figure 6.2.

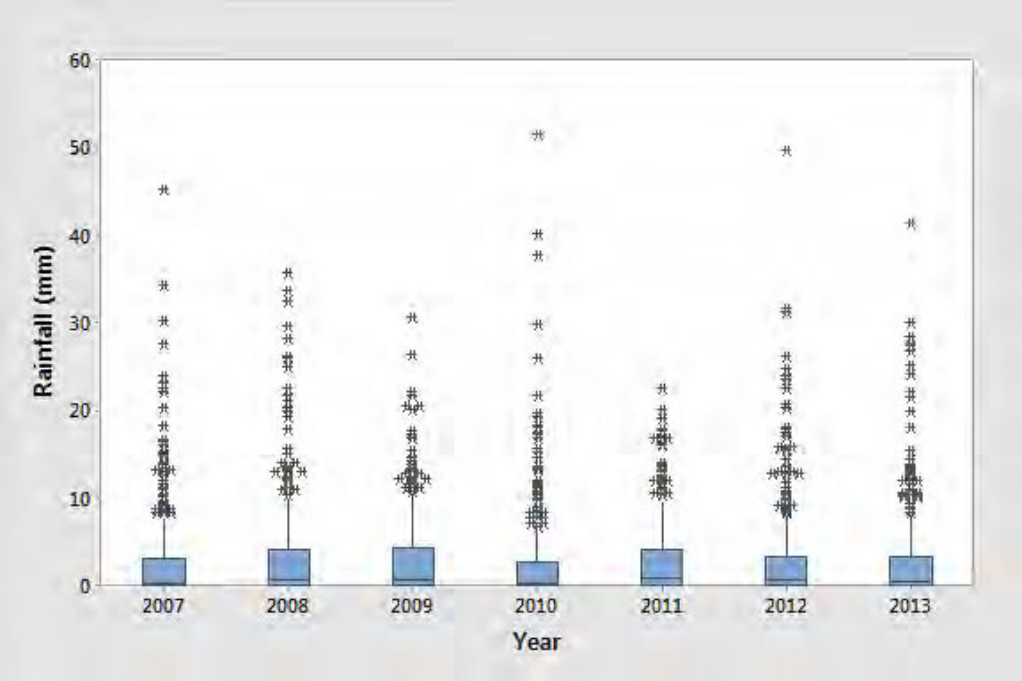

Figure 6.1 Boxplot of daily rainfall at Ballycarry by year (2007-2013)

The bulk of the observations were below 10 mm rainfall/day. The wettest year was 2008 (1204 mm total rainfall). Rainfall events exceeding 30 mm/day occurred in all years except 2011, with one extreme rainfall event of >50 mm/d occurring in 2010 and an event of 49.9 mm occurring in 2012.

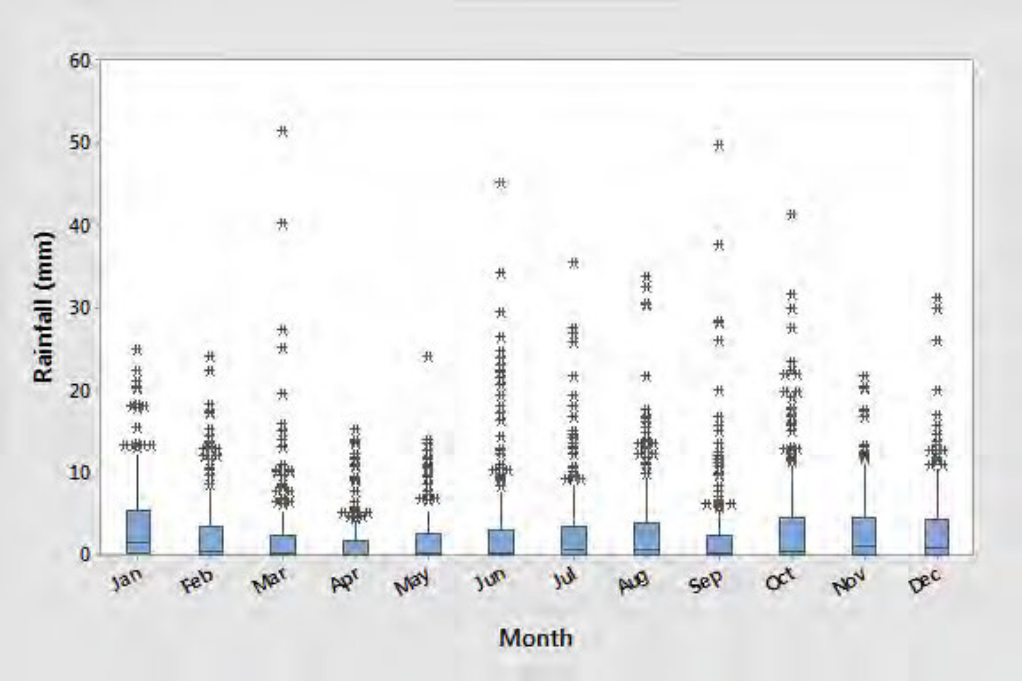

Figure 6.2 Boxplot of daily rainfall at Ballycarry by month (2007-2013)

A short-term monthly dataset provided in the 2009 sanitary survey report showed that highest monthly rainfall levels occurred during autumn and early winter.

The 2007-2013 dataset indicates that the wettest period has extended to include January, with the driest months being March, April and September. A rainfall event where >50 mm rain fell in one day occurred in March, with an event of 49.9 mm occurring in September.

6.2 Wind

Wind speed and direction drive surface water and currents that play an integral part in particulate dispersal. Winds typically drive surface water at ca. 3% of the wind speed (Brown, 1991) so a gale force wind (a minimum of 34 knots/17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s.

Figures 6.3 and 6.4 show seasonal wind roses for Orlock Head for the periods 2003-2007 and 2008-2012 respectively.

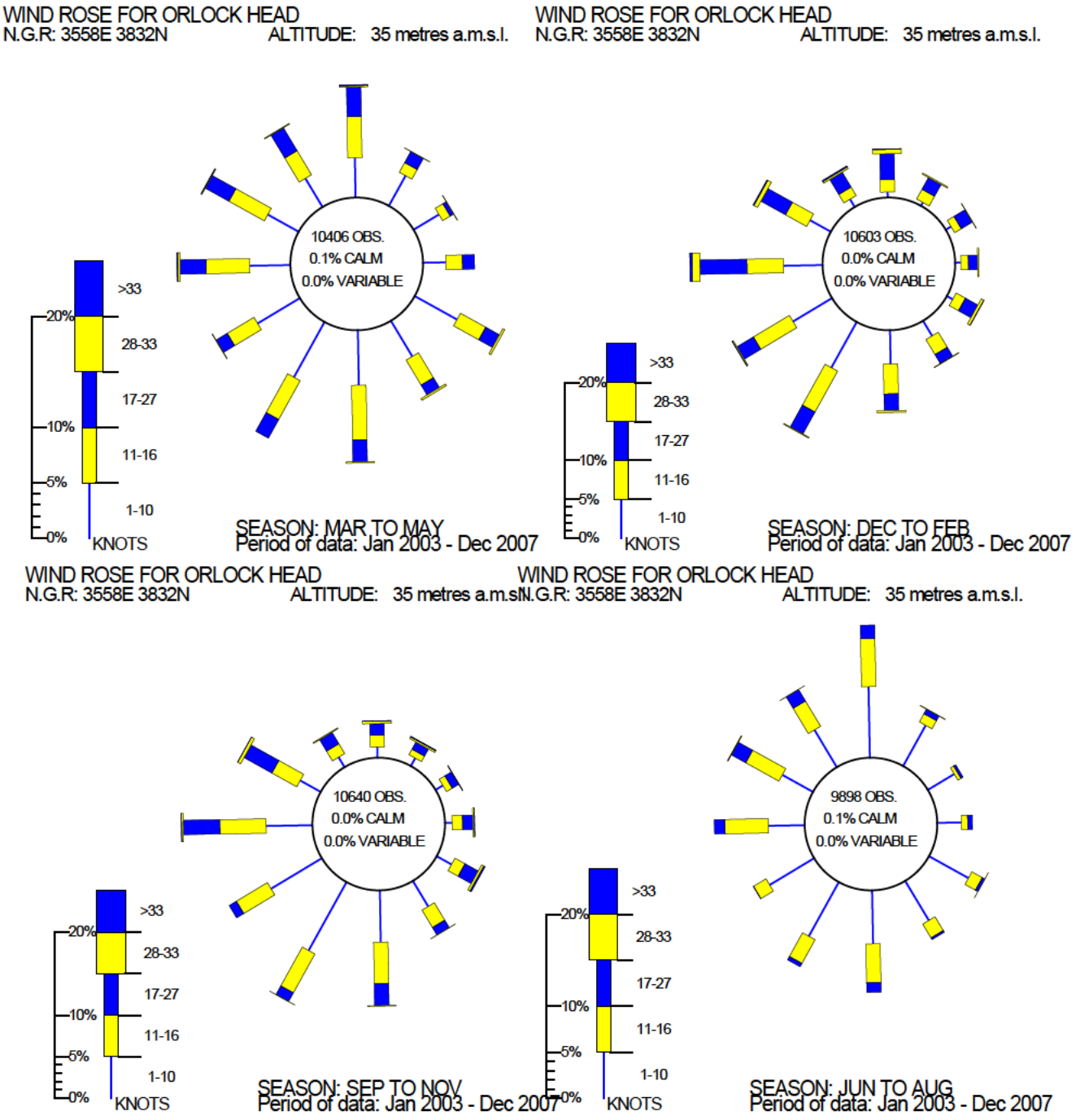

Figure 6.3 Seasonal wind roses for Orlock (2003-2007)

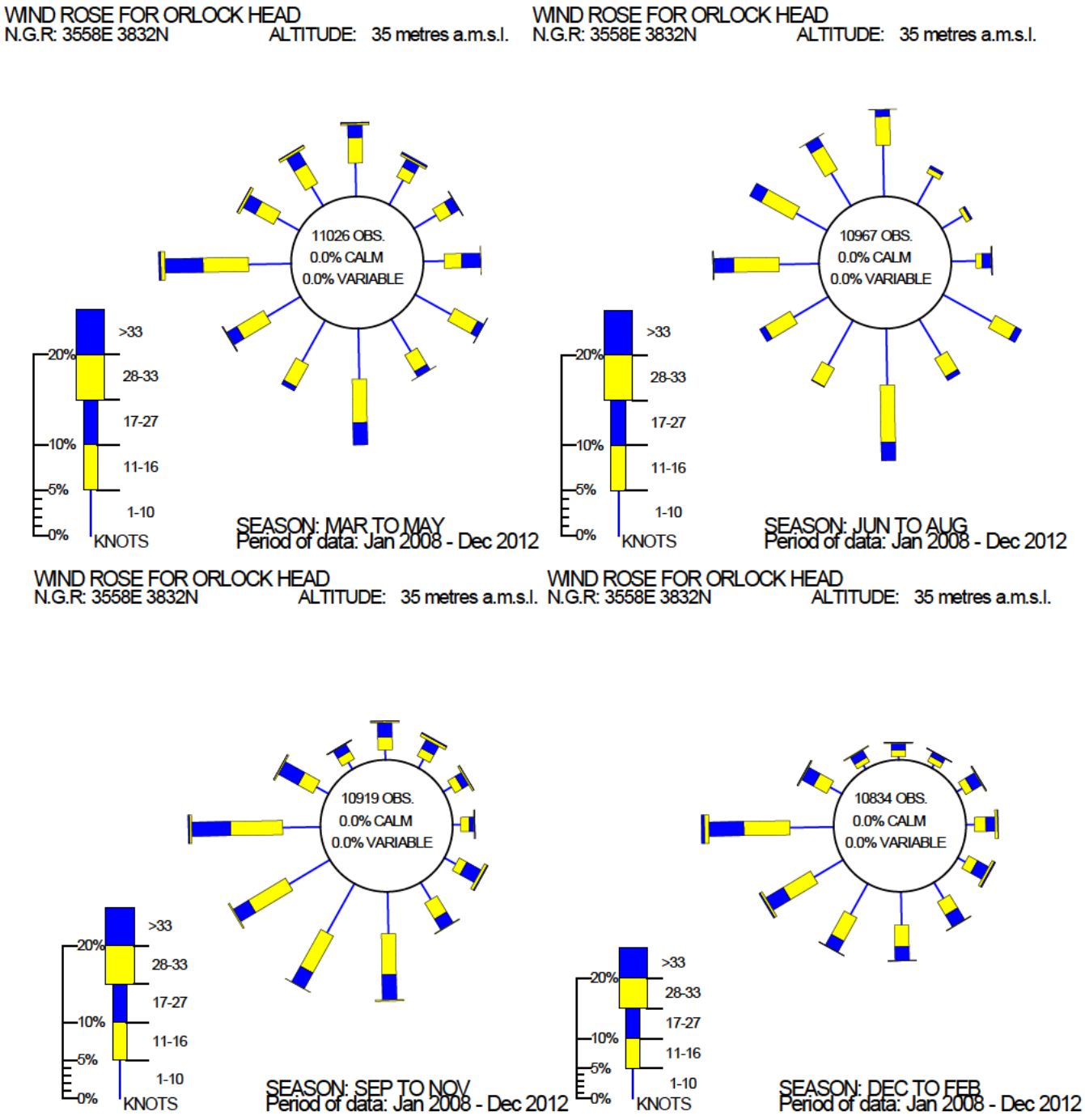

Figure 6.4 Seasonal wind roses for Orlock (2008-2012)

Prevailing winds throughout all four seasons are generally westerly. However, southerly winds also occur over a reasonable proportion of time from spring to autumn and northerly winds in summer. This trend is seen in both 2003-2007 and 2008-2012 datasets. Figures 6.5 and 6.6 show annual wind roses for the same period.

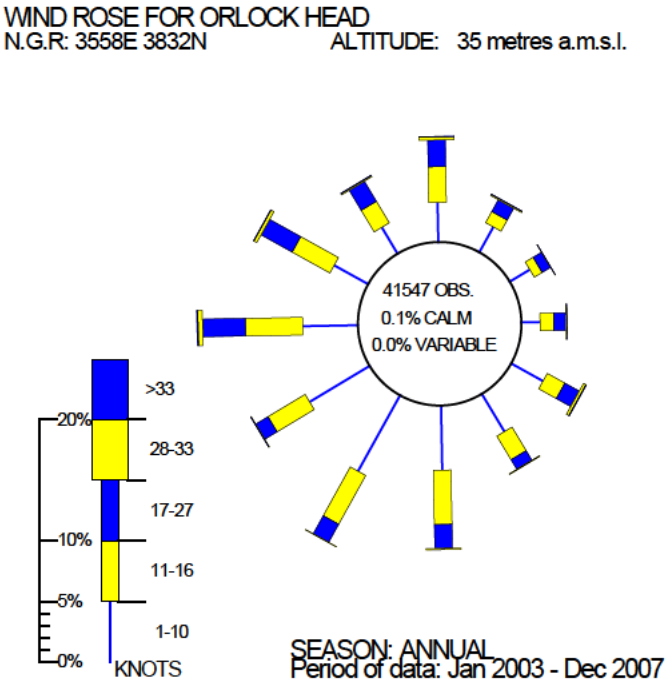

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Figure 6.5 Annual wind rose for Orlock Head (2003-2007)

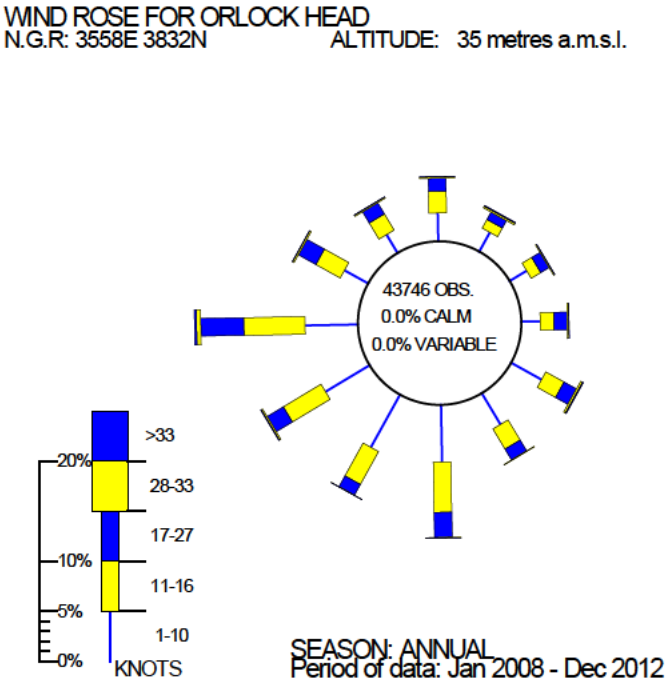

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Figure 6.6 Annual wind rose for Orlock Head (2008-2012)

Overall, the strongest winds range from westerly to southerly. In the earlier period, northerly to north-westerly winds were also significant.

7. Historical *E. coli* Data

Historical *E. coli* sample results were presented from the eight classified monitoring sites in Larne Lough between 01/01/2007 and 31/12/2009 in the 2009 sanitary survey report: no statistical assessments were undertaken. In this review, results for White Quay and Millbay mussel and oyster beds and Island Shellfish clams for the period between January 2010 and July 2014 were supplied by FSA in NI in July 2014. All *E. coli* results were reported as most probable number per 100 g of shellfish flesh and intravalvular fluid.

E. coli results reported as <20 were reassigned a value of 10 *E. coli* MPN/100 g for the purposes of statistical evaluation and graphical representation.

7.1 Summary of microbiological results

Sampling and results summaries for all classified shellfish beds within Larne Lough are displayed in Tables 7.1 to 7.3. In order to facilitate comparison, and owing to changes in monitoring locations from White Quay (L2) to Millbay (L5), results for the same species at different sites are shown alongside each other in the same table.

Table 7.1 Sampling summary results for Pacific oysters in Larne Lough 2007-2014

Sampling Summary								
Production area	Larne Lough							
Bed name	White Quay (L2)				Millbay (L5)			
Species	Pacific oyster							
Location	Various							
Years	2007-2009		2010-2014		2007-2009		2014	
Total no. of samples	37		48		36		3	
	2007	12	2010	11	2007	12	2010	-
	2008	12	2011	11	2008	12	2011	-
	2009	13	2012	12	2009	12	2012	-
			2013	12			2013	-
			2014	4			2014	3
Results Summary								
Minimum	<20		<20		<20		20	
Maximum	3500		5400		1300		50	
Median	70		20		40		45	
Geometric mean	89		40		57		-	
90 Percentile	620		310		855		-	
95 Percentile	1520		490		1130		-	
No. Exceeding 230/100g	9 (24%)		5 (10%)		6 (17%)		0	
No. Exceeding 1000/100g	3 (8%)		1 (2%)		3 (8%)		0	
No. Exceeding 4600/100g	0		1 (2%)		0		0	
No. Exceeding 18000/100g	0		0		0		0	

Table 7.2 Sampling summary results for common mussels in Larne Lough 2007-2014

Sampling Summary								
Production area	Larne Lough							
Bed name	White Quay (L2)				Millbay (L5)			
Species	Common mussel							
Location	Unknown							
Years	2007-2009		2010-2014		2007-2009		2014	
Total no. of samples	38		51		36		3	
	2007	11	2010	12	2007	12	2010	-
	2008	12	2011	12	2008	12	2011	-
	2009	15	2012	12	2009	12	2012	-
			2013	12			2013	-
			2014	3			2014	3
Results Summary								
Minimum	<20		<20		<20		78	
Maximum	1700		5400		3500		230	
Median	90		50		40		220	
Geometric mean	88		70		55		-	
90 Percentile	740		1150		740		-	
95 Percentile	1320		3170		3500		-	
No. Exceeding 230/100g	9 (24%)		10 (20%)		5 (14%)		0	
No. Exceeding 1000/100g	3 (8%)		5 (10%)		3 (8%)		0	
No. Exceeding 4600/100g	0		1 (2%)		0		0	
No. Exceeding 18000/100g	0		0		0		0	

Comparison of the summary statistics for mussels between sites and between assessment periods for the data from 2010 onwards is not possible due to the shift in RMPs during that time and due to the very small number of recent results available for Millbay (L5).

Table 7.3 Sampling summary results for Island Shellfish 2007-2014

Sampling Summary				
Production area	Larne Lough			
Bed name	Island Shellfish (L1)			
Species	Clams			
Location	Unknown			
Years	2007-2009		2010-2014	
Total no. of samples	36		50	
	2007	12	2010	12
	2008	12	2011	12
	2009	12	2012	7
			2013	12
			2014	7
Results Summary				
Minimum	<20		<20	
Maximum	16000		35000	
Median	200		150	
Geometric mean	206		163	
90 Percentile	4630		2650	
95 Percentile	8350		10010	
No. Exceeding 230/100g	14 (40%)		21 (42%)	
No. Exceeding 1000/100g	7 (19%)		11 (22%)	
No. Exceeding 4600/100g	3 (8%)		3 (6%)	
No. Exceeding 18000/100g	0		1 (2%)	

There is no marked difference in the summary statistics for the clams at Island Shellfish between the two assessment periods.

In general, higher *E. coli* results have been seen in the clams than in the oysters and mussels.

7.2 Geographical patterns of results

Geographical locations were only available for samples taken from February 2013 until June 2014. These sampling locations are displayed in Figure 7.1, alongside the fishery locations from the 2014 shoreline survey and RMPs according to June 2014.

Sampling locations for mussel and oyster samples in Larne Lough changed in May 2014 following the declassification of the White Quay (L2) mussel and oyster site. The mussel and oyster RMPs located at White Quay (L2) were therefore moved to the closest active mussel and oyster site, which was at Millbay (L5). Mussel samples taken since May 2014 at Millbay (L5) have been taken approximately 30 m northeast of the current RMP (54° 49'.215 N 5° 45'.056 W). Oyster samples taken since May 2014 at Millbay (L5) have been

taken approximately 30 m northeast of the current RMP (54° 49'.373 N 5° 45'.170 W). This sampling location lies on the southeast extent of the trestle area noted during the 2014 shoreline survey.

There has been no change in the location of clam sampling at Island Shellfish (L1) between February 2013 and June 2014. All samples plotted at the same location (54° 48'.67 N 5° 44'.14 W), approximately 360 m northeast of the current RMP (54° 48'.4978 N 5° 44'.3169 W) and northwest of the fishery location estimated during the 2014 shoreline survey.

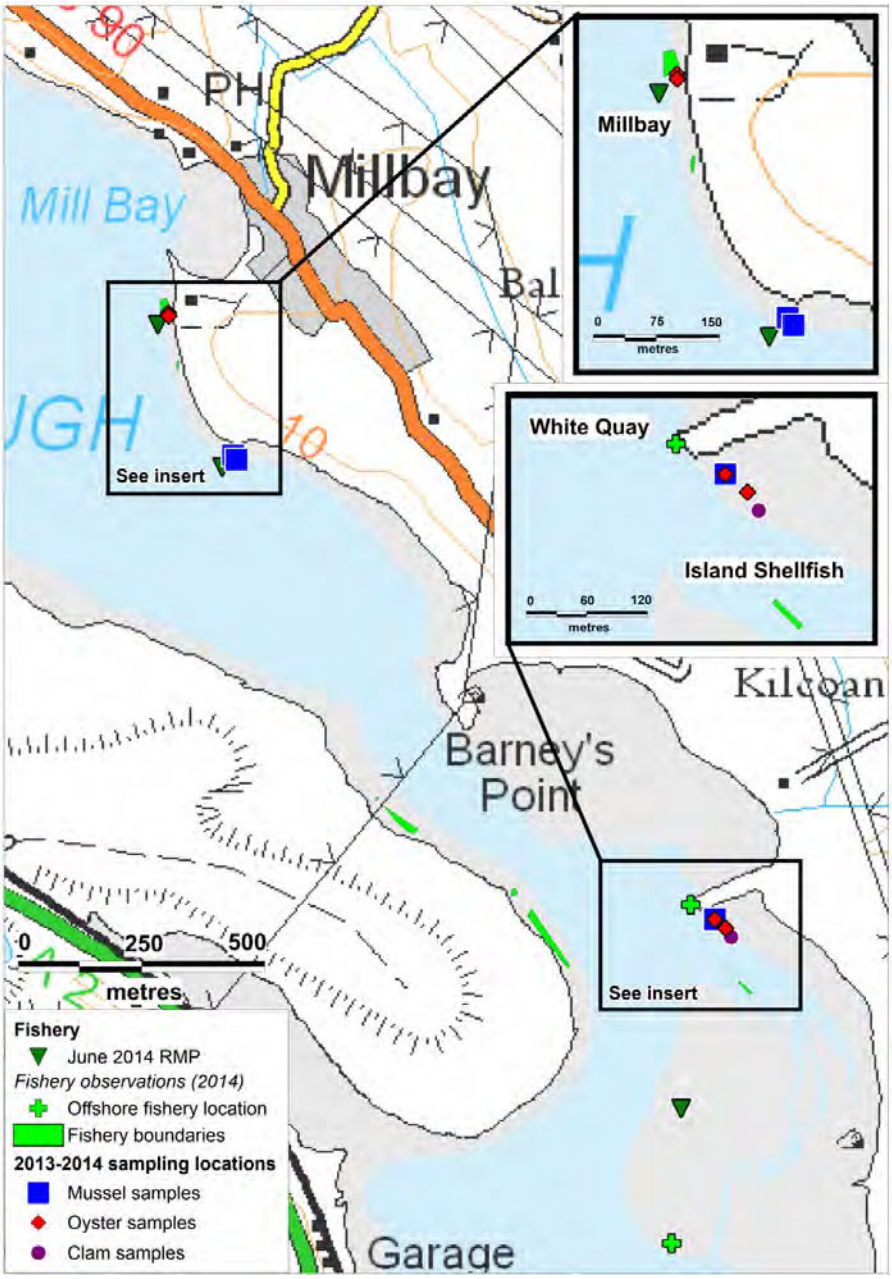

Figure 7.1 Sampling locations between February 2013 and June 2014

Due to the fact that temporal variability is usually a significant factor with respect to observed *E. coli* results in shellfish (Lee & Silk, 2013), spatial

comparisons are best undertaken when samples have been taken on the same dates at the locations for which the data sets are to be compared.

For mussels, results were available from samples taken at both Millbay (L5) and White Quay (L2) on twenty-seven occasions between February 2007 and November 2009. A paired t-test undertaken on the log_{10}-transformed *E. coli* results showed no significant difference in mean (transformed) *E. coli* levels at the two sites (T=0.63, p=0.532). However, the two highest results (both 3500 *E. coli* MPN/100 g) occurred at Millbay (L5).

For oysters, results were available from samples taken at both Millbay (L5) and White Quay (L2) on twenty-four occasions between January 2007 and December 2008. A paired t-test undertaken on the log_{10}-transformed *E. coli* results showed a significant difference in mean (transformed) *E. coli* levels at the two sites (T=2.58, p=0.017) with higher results generally being seen at White Quay (L2). The highest result of 3500 *E. coli* MPN/100 g was seen at White Quay (L2).

7.3 Temporal patterns of results

Temporal trends for all five site/species combinations are displayed in Figures 7.2-7.6. The datasets are fitted with a lowess trend line. Lowess trendlines allow for locally weighted regression scatter plot smoothing. At each point in the dataset an estimated value is fitted to a subset of the data, using weighted least squares. The approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the lowess line is influenced more by the data close to it (in time) and less by the data further away. A trend line helps to highlight any apparent underlying trends or cycles.

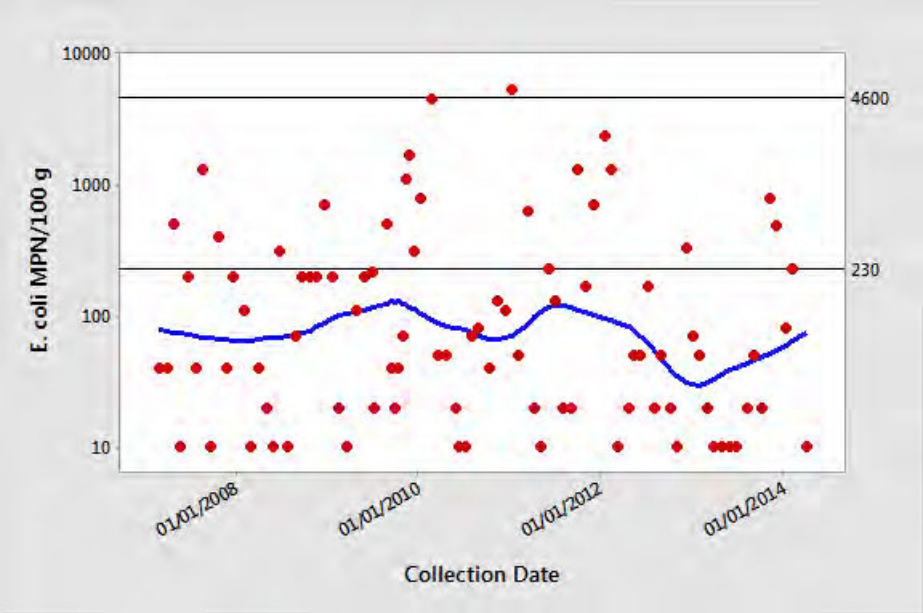

Figure 7.2 Scatterplot of White Quay (L2) mussels *E. coli* results by date (2007-2014)

E. coli levels in mussels from White Quay (L2) have not shown any marked variation over the assessment period although the two highest results occurred in February 2010 and January 2011.

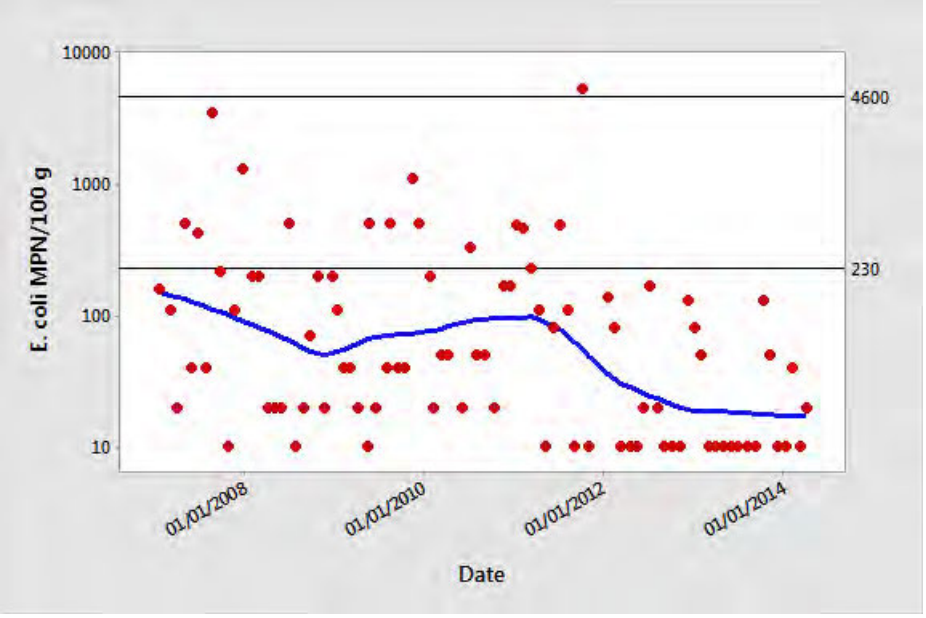

Figure 7.3 Scatterplot of White Quay (L2) oysters *E. coli* results by date (2007-2014)

E. coli levels in oyster samples from White Quay (L2) have decreased over the assessment period. There has been an increase in the proportion of samples yielding results <20 *E. coli* MPN/100 g since 2011 and no results greater than 230 *E. coli* MPN/100 g have been reported since October 2011.

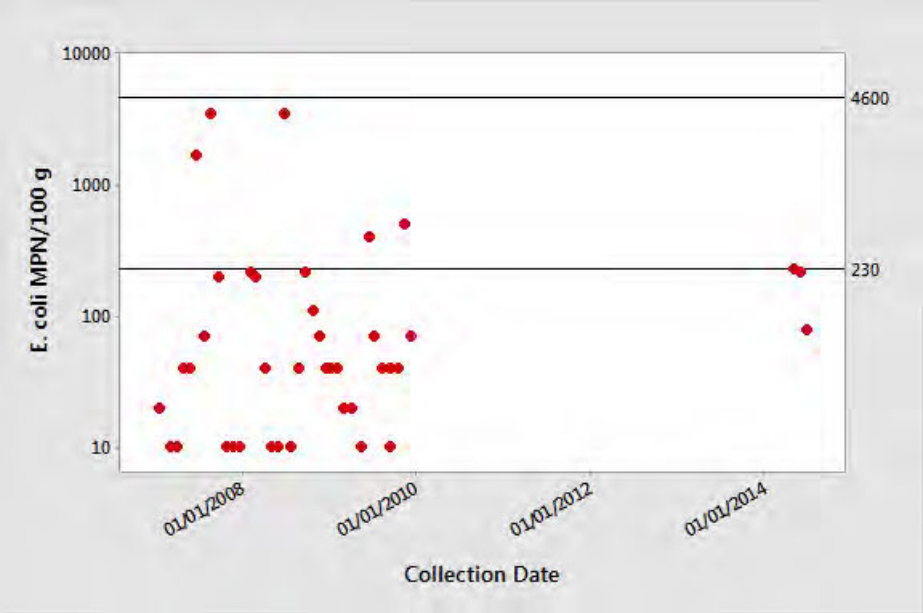

Figure 7.4 Scatterplot of Millbay (L5) mussel *E. coli* results by date (2007-2014)

It is not possible to assess whether any trend is present in the results for Millbay (L5) mussels due to the large gap in sampling between the end of 2009 and the beginning of 2014 (due to the area being represented by the White Quay (L2) mussel RMP during the intervening period).

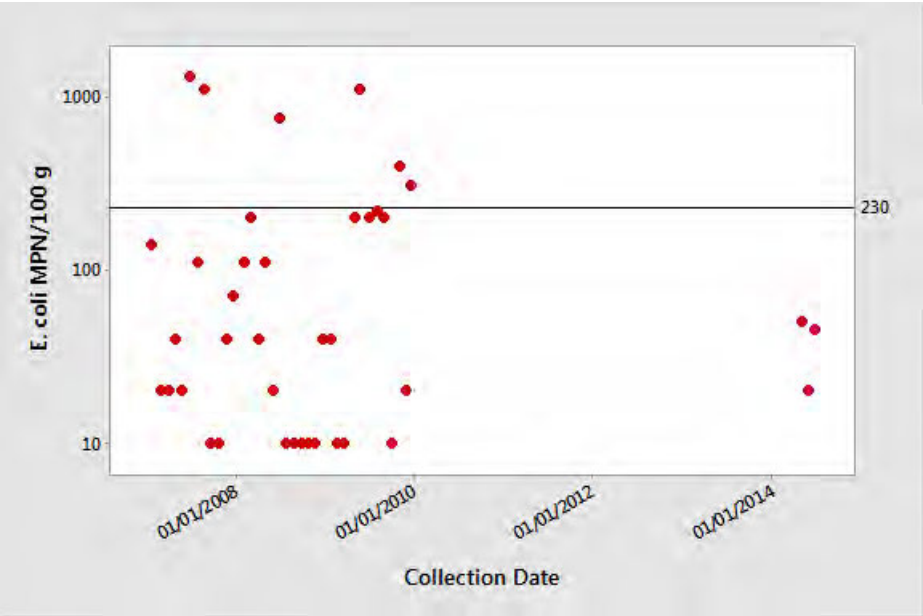

Figure 7.5 Scatterplot of Millbay (L5) oyster *E. coli* results by date (2007-2014)

Similarly, it is not possible to assess whether any trend is apparent in the results for Millbay (L5) oysters due to the large gap in sampling between the end of 2009 and the beginning of 2014 (due to the area being represented by the White Quay (L2) oyster RMP during the intervening period).

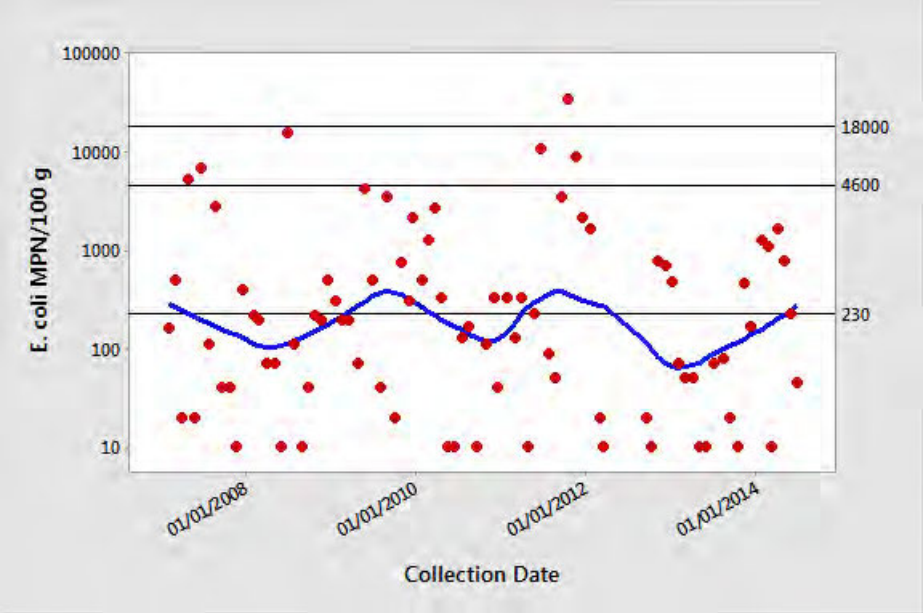

Figure 7.6 Scatterplot of Island Shellfish (L1) clam *E. coli* results by date (2007-2014)

E. coli levels in the clams at Island Shellfish (L1) have not varied markedly over time although there were two peaks in the trend-line in 2009 and 2011.

7.4 Comparison of oyster and mussel results

Consideration of results from different species was undertaken at the request of FSA in NI in order to determine whether an indicator species approach would be appropriate for Larne Lough. Such comparisons can be confounded by the different species being sampled at different locations and on different dates. With respect to this, no comparisons could be undertaken for clams at Island Shellfish (L1) against other species because the reported sampling locations for mussels and oysters were some distance from the reported clam sampling location.

Oysters and mussels had been sampled at White Quay (L2) on the same date on seventy occasions between February 2007 and April 2014. A paired t-test was undertaken on the $\log_{10}$-transformed *E. coli* results. No significant difference was found between the mean transformed results for the two shellfish types (T=0.47, p=0.638). The maximum value for both mussels and oysters was 5400 *E. coli* MPN/100 g. The median and lower quartile values for mussels were slightly higher than those for oysters (median 50 versus 40; Q1 20 versus <20).

7.5 Conclusions

The only marked temporal trend was that seen in the oysters at White Quay where the *E. coli* levels reduced greatly between 2007 and the beginning of 2014.

It has not been possible to undertake a full spatial assessment of the *E. coli* results for any of the three shellfish species. In general, clams yielded higher results than both oysters and mussels but it is not possible to determine whether this is mainly due to species or differences in location. A comparison of relatively small paired data sets for mussels and oysters at Millbay (L5) and White Quay (L2) showed significantly higher average *E. coli* levels in oysters at White Quay (L2) than at Millbay (L5) but no significant difference in average *E. coli* levels for the mussels. However, the two highest results for mussels were seen at Millbay (L5). The paired data sets for mussels were from 2007-2009 and for oysters from 2007-2008. Given the observation on the reduction in oyster *E. coli* results over time at White Quay (L2), it is not possible to determine whether the relationships derived from these earlier data sets would still apply.

The outcome of the comparison of mussel and oyster results at White Quay (L2) would support the conclusions an England and Wales study that mussels can be used as an indicator species to represent both Pacific and native oysters (Younger & Reese, 2013).

8. Movement of contaminants

The 2009 report drew conclusions from data reported in the SMILE project (Ferreira, *et al.*, 2007), which were computed from hydrodynamic models such as Delft 3D and Ecowin. These were as follows:

- The inner lough, where the majority of the shellfish farms are located, will have a residence time of 18-19 days, whereas the outer lough will tend to have a shorter residence time of around 2 days

- total freshwater runoff calculated at 101million m^3 y^{-1}

No data on current speeds or estimates of particle transport distance were given in the 2009 sanitary survey report. There are no UKHO tidal stream predictions for Larne Lough and no current data for the area was available from the British Oceanographic Data Centre. It is known that current data has been gathered as part of an EU-funded project, SPRES, but no data was given on the project website (http://spres.ihcantabria.com/). Reference was made to modelling from the SMILE project within the 2009 sanitary survey report (Ferreira, *et al*., 2007). Simulations from that modelling indicate current speeds of up to approximately 1.0 m/s within the Inner Lough, ignoring any effects of wind (Sustainable Mariculture in Northern Irish Lough Ecosystems, 1995).

Additional information was sought from internet searches conducted for this review. It was found that within Larne Lough, currents tended to be unidirectional and faster along the east than the west side. This is due to the presence of a deeper channel on the east side than on the west side of the lough (vistiMyHarbour.com, 2013). Information also indicated that approximately half way through a flood tide, a weak counter current flows past Ballylumford power station jetty and reaches a maximum speed of a knot (approximately 0.5 m/s) at spring tides.

Modelling undertaken for Northern Ireland Water in support of improvements to the assets impacting on Larne Lough showed that current speeds in the vicinity of Barney's Point are in the region of 1 m/s on a flooding spring tide and generally less than this on an ebbing spring tide. Currents are weaker than this in the inner and outer basins (McCurdy, 2010). Particle transport distances over the single phase of a tidal cycle would be expected to be in excess of 5 km at spring tide, ignoring the effect of dilution and dispersion. The transport distances would be expected to be greater on a flood than an ebb tide. The relatively high current speeds through the narrows at Barney's Point would be expected to cause significant mixing of any contaminants in the water column at that location.

9. Overall Assessment

This assessment considers the information obtained since the 2009 report and the potential changes in extent and location of faecal contamination.

Human sewage Impacts

The community and private discharges entering Larne Lough will at least contribute to background levels of faecal contamination within the lough. The continuous and intermittent discharges from Magheramorne WwTW and intermittent discharges from Millbay WwPS will be the main direct discharges to the areas of the shellfisheries. The reported location of the Magheramorne discharge lies approximately 500 metres from the southern end of the oyster trestles at Shingle Bay and on the opposite shore from the works itself, which seems unusual. The original sanitary survey reported no flow data for this discharge, and no data was received in response to the request submitted for this review. No sample results were available from this site. Therefore, it is not possible to assess the impact from the Magheramorn WwTW discharge on the southeastern end of the trestles at Shingle Bay. There are also some private discharges located in the vicinity of the shellfisheries. However, in general, there should have been some improvement in the general water quality within the lough associated with the improvements made to the NIW assets and network.

Agricultural impacts

The spatial definition of the publicly available data is not sufficient to determine the relative abundance of farm animals within the lough catchments. However, from observations made during the shoreline survey, Islandmagee represents a significant area of farmland, where the majority of livestock were observed in fields adjacent to the shoreline. This included evidence of cattle using the shoreline at Barney's Point. Impacts from agricultural based contamination are therefore expected to be greatest in the vicinity of White Quay (L2) and Millbay (L5) sites.

Wildlife Impacts

The primary impact associated with wildlife will be from birds. Although these occur in significant numbers around the intertidal areas of the lough, there will be some tendency for greater populations towards the head of the lough, in the vicinity of Swan Island and around Glynn. There may also be some input from seals, which are known to use the lough.

Seasonal Variation

There is expected to be a summer influx of tourists via the ferries at Larne. Boating activity from private boats/yachts is also expected to increase during the summer months, particularly around July when the EABC have their regatta. Impacts from livestock are also expected to peak during the spring to summer months, from the lambing and calving season.

Increases in freshwater inputs are expected when rainfall levels are highest, between October and January. Over this period, the number of intermittent discharges from CSOs and EOs is also likely to increase.

Watercourses

Loadings estimated from measurements and samples taken during the shoreline survey were moderate. With respect to the shellfisheries, the greatest impacts from freshwater sources are expected to be at the Shingle Bay (L3) and Millbay (L5) sites and the experimental oyster farm at White Quay (L2), arising from watercourses at Magheramorne, Millbay and Kilcoan.

Movement of contaminants

Current speeds over a spring flood tide are expected to be in the order of 0.5 to 1 m/s in the vicinity of the shellfisheries with a particle transport distance exceeding 5 km. This means that, ignoring the effect of dilution and dispersion, a large proportion of the potential sources identified within the lough could impact at the shellfisheries.

Analysis of Results

Historical monitoring results

The *E. coli* results from the clams tend to be higher than those in both oysters and mussels. A decreasing trend in results was shown for the oysters at White Quay (L2). A lack of comparable data from the various sites limited the extent of spatial assessment that could be undertaken. A comparison of paired data sets for mussels and oysters at Millbay (L5) and White Quay (L2) showed significantly higher average *E. coli* levels in oysters at White Quay (L2) than at Millbay (L5) but no significant difference in average *E. coli* levels for the mussels. The two highest results for mussels were seen at Millbay (L5). The paired data sets for mussels were from 2007-2009 and for oysters from 2007-2008. No recent paired data is available and so it is not know whether the outcome of these comparisons still applies. A comparison of results for both mussels and oysters and White Quay (L2) showed no significant difference.

Shoreline Survey results

Two shore mussel samples were taken; one from the northern area of the northerly trestle area of Shingle Bay (L3) and the second from the shore adjacent to the White Quay (L2) site. Both samples returned low results of <18 *E. coli* MPN/100 g. Accompanying seawater samples returned results of 3 and 21 *E. coli* cfu/100 ml respectively.

A further five seawater samples were taken, with results varying between <1 and 28 *E. coli* cfu/100 ml.

Conclusions

The principal contamination sources that are localised around the shellfish beds include continuous and intermittent sewage inputs from Magheramorne WwTW and intermittent inputs from Millbay WwPS and potentially from private sewage discharge associated with the boat/scrap yard adjacent to the Millbay (L5) oyster site. Due to the lack of information with regard to discharges from Magheramorne and monitoring in shellfish at Shingle Bay, there is a risk that contamination levels at the southeast end of the trestles at Shingle Bay will not be adequately represented by monitoring results at Millbay. However, the monitoring point at Millbay is likely to represent the largest sewage inputs to the area.

Input of agricultural-source contamination will come from watercourses at Mill Bay and from an area north of White Quay (L2) marine site while direct inputs from livestock accessing the shoreline are also expected at Barney's Point. The large number of birds using the intertidal areas around the lough will also contribute to the microbiological status of the waters, with the greatest contribution expected towards the north and south of the lough.

In addition to the sources close to the fisheries, the estimated particle transport distance means that other sources in the inner and outer lough may also impact on the microbiological quality at the shellfisheries. However, it would be expected that the spatial effects across the shellfisheries due to these sources will be less.

10. Recommendations

The findings in this review have been taken into account with respect to the sampling plan. The recommended sampling plan for all shellfish sites is discussed below.

RMPs

The recommended locations for both RMPs are given in Table 10.1 to 10 m accuracy in Irish Grid reference and also in WGS84 latitude/longitude format.

Millbay (L5) Oysters and Shingle Bay (L3) Oysters

On the basis of the previous study in England and Wales, and the comparison of mussel and oyster results at White Quay (L2) undertaken for this review, it is recommended that oysters at these two sites be represented by mussels at Millbay (L5) provided that the mussel RMP be moved to the recommended location at the oyster trestles. If the mussel RMP is not moved, then it is recommended that oysters be sampled at the recommended mussel RMP location given in Table 10.1.

Millbay (L5) Mussels (RMP 1)

As the precise location and extent of the mussel bed is not known, to better reflect sources of contamination at Millbay, and to assist ease of sampling, it is recommended that RMP 1 be moved to the oyster trestles at Millbay (L5). It is recommended that bagged mussels be placed on the oyster trestles. The recommended location is closer to the identified sources of contamination with Mill Bay than that previously specified for the oyster RMP. The mussels should be *in situ* for at least two weeks prior to sampling. A tolerance of 10 metres is recommended.

Island Shellfish (L1) Clams (RMP 3)

The existing RMP location does not reflect the known sources of contamination in the area. It is recommended that it be moved to the southwest of the current specified location. During the consultation process, both the harvester and DARD identified that this area is not actively harvested. The location of the RMP should be reviewed upon resumption of an active shellfishery at this location. A nominal 20 m tolerance is applied given that the harvested area is relatively small and the samples are gathered by hand, however this should also be reviewed should the shellfishery become active.

Other sites

Dougold (L6)

Although the Dougold site is still licensed, it is not classified and so has not been considered here. However, if commercial activity for mussels resumes at this site, it could be represented by the mussel RMP (RMP 1) at Millbay (L5) if that is moved to the position recommended above. If RMP 1 is kept at the current location, then the Dougold site (L6) should be considered for separate monitoring.

Similarly, native oysters within Site L1 have not been considered as this site is currently used only for seed oysters and so they have not been identified for classification. Should classification of oysters at L1 be sought in the future, a further review should be conducted to identify a suitable RMP for this species.

Table 10.1 Recommended RMP sampling locations for Larne Lough shellfish sites 2014

RMP	Site name	Associated beds	Species	RMPs				
				NGR	Latitude*	Longitude*	Tolerance	Frequency
1	Millbay (L5)	Millbay (L5) Oysters Shingle Bay (L3) Oysters	Mussels	J 4448 9955	54° 49'.375 N	5° 45'.172 W	10 m	Monthly
2	Island Shellfish (L1)	None	Clams	J 4547 9778	54° 48'.404 N	5° 44'.302 W	20 m	Monthly

*Latitude/longitude positions are given as WGS84.

Depth

Not applicable to bottom culture or trestle based fisheries.

Frequency

Sampling at both sites is recommended to remain as monthly.

Figure 10.1 Recommended RMP locations for shellfish sites in Larne Lough

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12. List of Figures and Tables

Appendix 1

Planning Applications

Planning applications expected to change the human population and overall faecal loading to Larne Lough are listed in Table 1.

Table 1 Planning applications to areas around Larne Lough

ID	Date	Status	Location	Description
F/2012/0151/O	Jul-12	Granted	Ferris Bay Road Islandmagee Larne	Proposed Replacement Dwelling - Retaining Dwelling Structure for Inclusion as Utility/Stores
F/2011/0166/F	Jul-11	Granted	Ballylumford Road Islandmagee Larne BT40 3RN	Erection of new 2 storey 4 bedroom dwelling
F/2010/0126/F	Apr-10	Granted	Ballylumford Road, Islandmagee, Larne	Replacement dwelling (formerly derelict)
F/2011/0065/F	Mar-11	Granted	Ballylumford Road Islandmagee Larne	Two storey dwelling with attached single storey granny flat
F/2010/0265/F	Aug-10	Pending	Ballylumford Road, Islandmagee	Proposed 4 new replacement dwellings
F/2011/0157/F	Jul-11	Granted	Hollow Road Islandmagee.Larne BT40 3RL	Replacement dwelling and garage for a presently derelict dwelling
F/2012/0216/F	Oct-12	Granted	Millbay Road Carnspindle Larne BT40 3RJ	Existing barn alteration to provide single storey granny flat accommodation
F/2007/0410/F	Oct-07	Granted	Millbay Road, Islandmagee, Larne	Residential development - 25 Residential units (15 Dwellings and 10 Apartments).
F/2014/0072/O	Apr-14	Granted	Ballytober Road Islandmagee	Proposed infill site for 2no. dwellings and garages
F/2013/0071/O	Mar-13	Granted	Millbay Road Larne	Site of dwelling and garage
F/2014/0176/RM	Oct-14	Pending	Millbay Road Larne	New Dwelling and garage wit associated site works
F/2010/0289/F	Sep-10	Granted	Millbay Road, Islandmagee, Larne	Proposed 8 No. 3 Bedroom detached dwellings with associated site works and landscaping
F/2013/0031/RM	Feb-13	Granted	Millbay Road Islandmagee Larne	Dwelling on a farm
F/2014/0019/O	Feb-14	Granted	Millbay Road Islandmagee	Proposed dwelling and garage on a farm
F/2014/0076/O	Apr-14	Granted	Millbay Road Islandmagee	Proposed Site for New Dwelling

ID	Date	Status	Location	Description
F/2010/0058/F	Feb-10	Granted	Millbay Road, Islandmagee, Larne	Erection of farm dwelling and garage
F/2010/0049/F	Feb-10	Granted	Millbay Road, Islandmagee, Larne	Single storey farm dwelling with roofspace rooms
F/2011/0240/O	Nov-11	Granted	Low Road Islandmagee	Replacement of 3 no. existing terrace cottages with 2 no. detached houses
F/2012/0138/F	Jul-12	Granted	Low Road Islandmagee Larne BT40 3RF	Proposed erection of family dwelling with 4 bedrooms and double garage as well as erection of stonewall feature around using reclaimed stone from a nearby existing ruin
F/2011/0237/F	Nov-11	Granted	Low Road Islandmagee Larne BT40 3TG	Proposed erection of family dwelling with 4 bedrooms and double garage as well as erection of stonewall feature around dwelling using reclaimed stone from existing ruin
F/2010/0221/F	Jun-10	Granted	Lower Island Road, Ballycarry	Dwelling and garage on a farm
F/2010/0034	Feb-10	Granted	Mill Lane, Larne Road, Carrickfergus	Proposed conversion of existing joinery workshop into residential dwelling with integrated home office
F/2010/0297/LB	Sep-10	Granted	Redhall Drive, Ballycarry	Proposed change of use to 2no self contained self-catering tourist units.
F/2011/0231/O	Nov-11	Granted	Shore Road Magheramorne Ballyedward Larne	Site of Replacement Dwelling
F/2011/0197/F	Sep-11	Granted	Shore Road Larne BT40 3HY	Erection of general purpose agricultural shed area for storage of silage bales holding pens for livestock (retrospective)
F/2013/0090/F	Apr-13	Granted	Shore Road Magheramore	Erection of farm dwelling
F/2013/0091/RM	Apr-13	Pending	Magheramorne Quarry and Peninsula 100 Shore Road Magheramorne Larne	Cycling centre comprising 17km of downhill and cross country trails four cross track skills area finish arena uplift track car and coach parking viewing platforms landscaping and ancillary works
F/2011/0118/F	May-11	Granted	Ballylesson Road Craiganboy Magheramourne Larne BT40 3HL	Replacement dwelling and garage
F/2013/0030/RM	Feb-13	Granted	Ballylesson Road Magheramorne Larne	Dwelling and garage

ID	Date	Status	Location	Description
F/2009/0332/O	Nov-09	Granted	Ballylesson Road, Larne	Site of dwelling on a farm
F/2011/0238/F	Nov-11	Granted	Ballylesson Road Larne BT40 3HL	Proposed dwelling with intergral garage under Policy CTY 10 of PPS21
F/2010/0318/F	Sep-10	Granted	Coastal Road (A2) Glynn	Erection of residential development of 84 units with associated car parking and landscaping (3no apartments & 81 houses including detached/townhouses/semi-detached). Amendment to previous apprvoal F/2007/0327
F/2013/0216/F	Nov-13	Granted	Main Road Glynn Larne BT40 3EX	Proposed replacement dwelling
F/2013/0179/F	Aug-13	Granted	Upgrades of the Existing Pumping Station Facility to Include Site Expansion to Accommodate New Underground and Overground Plant and Machinery. New Gates and Fencing around the Extended Site	Millbay Waste Water Pumping Station Lands Opposite 1-3 Ballytober Road Millbay Islandmagee
F/2009/0206/F	Jul-09	Granted	Ballystrudder Waste Water Treatment Works, Lough Road, Larne	Proposed re-development of Ballystrudder WWTP to include pumping station, screening facility, storm storage tanks and retention of existing control house

Appendix 2. Northern Ireland Water assets identified by NIEA

Sewage discharge information requested from NIEA.

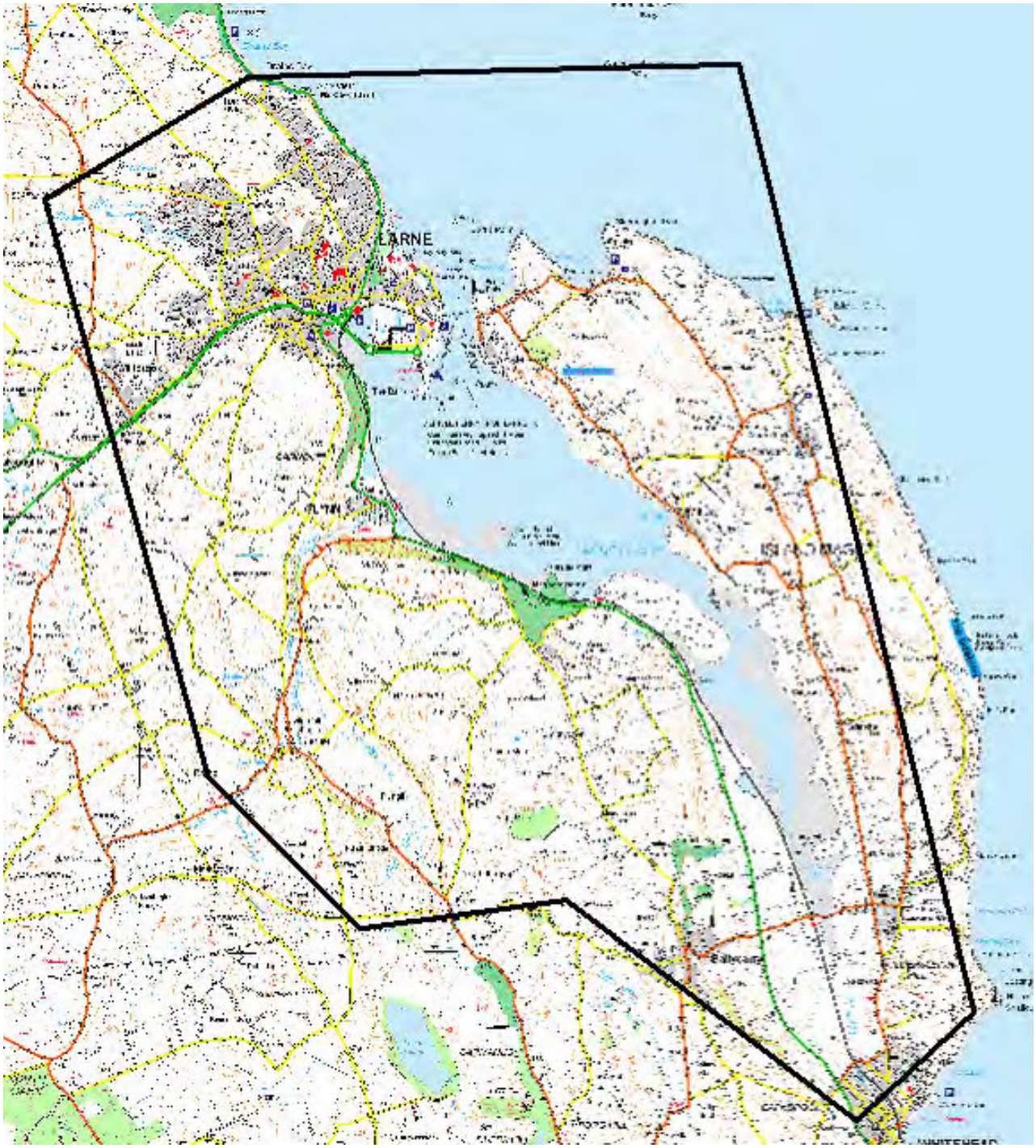

Figure 1 Area from which sewage discharges were requested for NIEA

Table 2 Northern Ireland Water assets identified by NIEA

Name	Type	Asset Grid Ref	Discharge Grid Ref
Kitsons Yard CSO	CSO	[redacted]	[redacted]
Bank Road Larne CSO	CSO	[redacted]	[redacted]
Cross Street Pound CSO	CSO	[redacted]	[redacted]
Larne High School CSO	CSO	[redacted]	[redacted]
Inver Primary School CSO	CSO	[redacted]	[redacted]
Casements CSO	CSO	[redacted]	[redacted]
Knocklayde CSO	CSO	[redacted]	[redacted]
Mill Brae Two CSO	CSO	[redacted]	[redacted]
Mill Brae One CSO	CSO	[redacted]	[redacted]
Blackarch East CSO	CSO	[redacted]	[redacted]
Blackcave CSO	CSO	[redacted]	[redacted]
Upper Cairnscastle Road CSO	CSO	[redacted]	[redacted]
Cairngorm Drive CSO	CSO	[redacted]	[redacted]
Cranfield Park East CSO	CSO	[redacted]	[redacted]
Cranfield Park West CSO	CSO	[redacted]	[redacted]
Churchill Road CSO	CSO	[redacted]	[redacted]
Island Road Lower CSO	CSO	[redacted]	[redacted]
Curran Road Loughview CSO	CSO	[redacted]	[redacted]
Larne Harbour WwPS	CSO & ERO	[redacted]	[redacted]
Murrayfield WwPS	CSO & ERO	[redacted]	[redacted]
Olderfleet Road WwPS	CSO & ERO	[redacted]	[redacted]
Glynn WwPS	CSO & ERO	[redacted]	[redacted]
Drains Bay WwPS	CSO & ERO	[redacted]	[redacted]
Cranbourne WwPS	ERO	[redacted]	[redacted]
Blackarch WwPS	CSO & ERO	[redacted]	[redacted]
Blackcave WwPS	CSO & ERO	[redacted]	[redacted]
Crawford Park Manor WwPS	CSO & ERO	[redacted]	[redacted]
Millbay WwPS	CSO & ERO	[redacted]	[redacted]
Newpark Shore WwPS	CSO & ERO	[redacted]	[redacted]
Coastguard Road WwPS	ERO	[redacted]	[redacted]
Chaine Memorial WwPS	CSO & ERO	[redacted]	[redacted]
Meadowbridge Surgery WwPS	ERO	[redacted]	[redacted]
Lindara Park WwPS	ERO	[redacted]	[redacted]
Ballylumford Cottages ST	Septic Tank	[redacted]	[redacted]
Ballystrudder WwTW	WwTW	[redacted]	[redacted]
Ferris Bay 50 ST	Septic Tank	[redacted]	[redacted]
Belfast Road 56-58 ST	Septic Tank	[redacted]	[redacted]
Glenoe WwTW	WwTW	[redacted]	[redacted]
Ballycarry WwTW	WwTW d	[redacted]	[redacted]
Larne WwTW	WwTW	[redacted]	[redacted]
Mounthill WwTW	WwTW	[redacted]	[redacted]
Magheramorne WwTW	WwTW	[redacted]	[redacted]

Appendix 3

Shoreline Survey Report

Production area:	Larne Lough
Site name:	Millbay (L5), Shingle Bay (L3) and Island Shellfish (L1)
Species:	Native oysters, Pacific oysters, clams and common mussels
Harvester:	F. W. Johnston and Warren Shanks (Fabrice Shanks)
Status:	Sanitary Survey Review
Dates Surveyed:	2-3/09/2014
Surveyed by:	Jessica Larkham and Liefy Hendrikz
Accompanied by:	03/09/2014 Jon Erskine (Sampling officer) Louise Connolly (FSA N.I) Anthony Higgins (FSA N.I)
Existing RMPs:	RMP1: J44592 99237 (54 49.215 N, 005 45.056 W); RMP2: J44461 99526 (54 49.373 N, 005 45.170 W) and RMP3: J45426 97933 (54 48.4978 N, 005 44.3169 W)
Area Surveyed:	The survey was split into two sections: the west shore (Blue sailing club to south of Magheramorne Quarry) and east shore (White Quay to Millbay).

Weather

Light rain fell in the 48 hrs prior to the survey, though both survey days were dry. The first survey day started and remained cloudy, with the second day starting bright and sunny, turning increasingly cloudy from mid morning. Temperatures varied between 14 and 18^{o}C, with little wind on both days and a calm sea state.

Fishery

The boundaries of Millbay oyster and mussel farm were recorded, with observations also made at Island Shellfish clam fishery. As Island Shellfish clams were located offshore and were submerged at the time of the survey, boundaries of these sites were unable to be determined. Boundaries of four unused trestle areas on the west shore were also recorded. Two areas of disused trestles were located along the mid-west shore. This site was assumed to be Shingle Bay oysters, with oyster shingle covering the shoreline. Two areas of trestles were also observed further south and was comprised of neat lines of trestles. These appeared to be newly placed trestles, as fouling was limited. Dense numbers of shore mussels were located in places on both the east and west shores. Common mussel samples were taken from broken poches on the west shore from the northern extent of the northernmost area of trestles and on the eastern shore adjacent to White Quay.

Sewage Sources

Six sewage related pipes were seen during the survey; five on the west side of the lough and one on the east side. The pipes on the west side of the lough consisted of an iron pipe entering a watercourse north of the Blue Circle sailing club, which was dripping slightly during the survey, a dry iron pipe with a lid located upstream from the mouth of the River Glynn, a relatively new pipe close to the mouth of the River Glynn coming from Glynn pumping station (PS) and a pipe with a lid and a pipe with a grill located in Larne River. On the east side of the lough a plastic pipe coming from the boat/scrap yard building unit and was dripping and surrounded by raw effluent. Although a suspected septic tank (ST) hatch was observed in the garden of a house on the southeast extent of the shoreline route, no associated pipe was observed, though the sampling officer indicated that the ST discharged into the river that runs alongside the property.

Population and Seasonal Population

Very few houses were observed on the areas of shoreline that were surveyed and none appeared to be hotels or B&B's. Human population was centred in the town of Larne to the north of the lough where hotels and B&B's were observed and to a lesser extent in the village of Glynn on the mid west shore and in Millbay on the east shore. Some houses in the Millbay area, appeared to be unoccupied at the time of the survey, but were well looked after and may therefore be used as holiday homes seasonally.

Boats/Shipping

Large ferries and boats were observed at Larne marina to the north of the lough, where several smaller pleasure boats were also observed. Adjacent to the Blue Circle Cruising and Sailing Club on the west shore, approximately 22 out of the 30 moorings were being used by pleasure boats, with a further 49 rowing boats and 29 medium yachts observed ashore. Several medium sized boats, a jet-ski and a kayak were also observed ashore at the Millbay boat/scrap yard, with one pleasure boat moored just south of this area. A dinghy was noted ashore just north of Barney's Point and kayaks were present at a house in Millbay. An empty mooring was present adjacent to a slipway along the mid-east shore, with slipways also noted at the sailing club where there was also a jetty, at Millbay boat/scrap yard and several were seen attached to houses within Millbay itself.

Farming and Livestock

Two farm buildings associated agricultural fields and 15 visible cattle were observed on the western side of the lough on the hillside set back from the

shoreline. A tractor applying fertiliser to a newly ploughed field on the western hillside was also observed from the eastern shore on Islandmagee. The majority of the agricultural observations were made on the eastern shore, where a large farm was located, and a total of 47 cattle (inc. one bull and three calves) and 94 sheep were visible. The entire farm was not in view from the survey route. Large numbers of farms, cattle and sheep were also observed set back from the shoreline whilst driving to and from Islandmagee. Fields adjacent to the shoreline to the north of Barney's Point had gates to the shoreline, with evidence of cattle on the shoreline at Barney's Point. A strong smell of manure was present at the start locations on both survey days. Sheep spoil was noted just above the high tide mark at Barney's Point, whilst unidentified droppings (possibly sheep/horse) were observed on grassy verges south of Millbay. Several separate deposits of dog faeces including one on the beach at Mill Bay were also noted.

Land Use and Land Cover

The western extent of the survey route was mainly covered by the Magheramorne Quarry, which consisted of a wild area with some trees, brambles and dense grasses dominating. Football pitches were also noted attached to the Blue Circle Cruising and Sailing Club, which was followed by a wooded area further north of the sailing club. The surrounding hillsides on the west side were comprised of mostly agricultural and forestry areas. Glynn and Larne were largely urban areas. The east shore in comparison was mostly agricultural land, with a large number of farms and associated farmland including improved grassland observed over much of Islandmagee.

Watercourses

Five watercourses were measured and sampled during the survey. The two largest watercourses, the River Glynn and the River Larne, were located on the northwest side of the lough, while a smaller moderately sized watercourse was noted on the west shore, and two were noted on the east shore. Owing to a delay in the arrival of samples to the laboratory on the second day, the southerly watercourse on the east shore had to be re-sampled.

Wildlife/Birds

Seabirds were common, with the majority observed along the east side of the lough. Observations were made of individuals, small groups and large aggregations of seabirds. Gulls were the most common, with oystercatchers, herons and crows also fairly common. Evidence such as shellfish shells, crab carcasses and bird faeces suggesting possible bird feeding areas were noted on several locations along the east shore. The whole of the Magheramorne Quarry was noted to have turned into a nature reserve owing to there being

little human influence and the area could essentially become wild. The quarry supervisor indicated that otters, foxes, rabbits and birds, including eagles, were now common in the area. However no wildlife was noted in this area at the time of the survey. Seals were noted on three occasions, with a juvenile seal hauled out adjacent to Magheramorne quarry, three hauled out just north of Barney's Point and another juvenile noted at Mill Bay.

Figure 1. Larne Lough shoreline survey observation waypoints

Figure 2. Larne Lough Sample Locations

Table 1 Shoreline Observations

No.	Date/time	Irish Grid	Easting	Northing	Associated photograph	Associated sample	Description
1	02/09/2014 8:26	J 43170 98864	343170	398864	Photo 01		Start of west shore survey. Weather grey and overcast, 15°C, dry and no wind, sea glassy. Smell of manure in the air. 1 dog walker. Total of 30 moorings visible, 22 sailing boats moored. One slipway and one jetty.
2	02/09/2014 8:31	J 43180 98859	343180	398859		LLSW01	Seawater sample, salinity reading 34 ppt
3	02/09/2014 8:32	J 43178 98859	343178	398859			Three gulls
4	02/09/2014 8:36	J 43145 98846	343145	398846			18 rowing boats ashore above slipway
5	02/09/2014 8:39	J 43205 98747	343205	398747	Photo 02		Concrete road used for storing boats running parallel to shore. 29 medium to large sailing and motorboats ashore, many undercover. 23 rowing boats also ashore.
6	02/09/2014 8:42	J 43277 98685	343277	398685			Possible mussel float ashore, 8 rowing boats, one caravan that appeared to be lived in, with a grey pipe seen coming from below the caravan, but no visible pipe on the adjacent shoreline. No further access to shoreline between here and quarry owing to dangerous shoreline and rail lines.
7	02/09/2014 8:49	J 43148 98773	343148	398773			Blue Circle Cruising and Sailing club house, with football grounds also attached to the club house and a large car park
8	02/09/2014 8:49	J 43151 98781	343151	398781			Oil tank and inspection cover
9	02/09/2014 8:56	J 42951 99025	342951	399025			12 seabirds on the shoreline around an intertidal area
10	02/09/2014 9:08	J 42867 98756	342867	398756			Sanitary debris on grassy bank above discharge pipe in river
11	02/09/2014 9:10	J 42890 98747	342890	398747	Photo 03	LLFW01	Discharge pipe to small river, cotton buds around grassy river banks. Discharging, though no associated smell, sample taken. Pipe width: 24 cm, wetted width: 7 cm, flow: 3 seconds (averaged from three trials) to fill seawater container
12	02/09/2014 9:18	J 42889 98746	342889	398746			Unidentified small watercourse (photo). End of shoreline survey route.
13	02/09/2014 10:08	J 44957 98479	344957	398479	Photo 04		Start of second part of west shore survey at Magheramorne Quarry. Shoreline largely comprised of native oyster shells, with some mussel, clam and scallop shells also present. Shingle Bay oyster site (disused) trestles on shore comprising of two distinct areas.
14	02/09/2014 10:12	J 44992 98494	344992	398494			Southeast extent of trestle area
15	02/09/2014 10:13	J 44984 98488	344984	398488			Southwest extent of trestle area, with rusty trestles

No.	Date/time	Irish Grid	Easting	Northing	Associated photograph	Associated sample	Description
16	02/09/2014 10:15	J 44972 98489	344972	398489			Southwestern area of trestles
17	02/09/2014 10:15	J 44948 98510	344948	398510			Western area of trestles
18	02/09/2014 10:17	J 44928 98534	344928	398534			Northwest extent of trestles
19	02/09/2014 10:18	J 44922 98542	344922	398542			Northeast extent of trestles, with a second trestle area 15 m east of this location
20	02/09/2014 10:19	J 44906 98553	344905	398553			Second trestle area southwest extent - no poches
21	02/09/2014 10:20	J 44910 98558	344910	398558			Southeast extent of trestle area, mostly mussel shells
22	02/09/2014 10:21	J 44908 98562	344908	398562			Northeast extent of trestles, land drainage
23	02/09/2014 10:21	J 44903 98558	344903	398558			Northwest extent of trestles, bird faeces. Heavy fucoid cover on all trestles
24	02/09/2014 10:26	J 44909 98562	344909	398562		LLSW02, LLSF01	Seawater sample taken in front of the second trestle area, which had more poches full of mussels. Shellfish sample of shore mussels
25	02/09/2014 10:48	J 45091 98418	345091	398418			Poche of Pacific oysters - mostly empty
26	02/09/2014 10:49	J 45106 98410	345106	398410			Shoreline made from native oyster shells
27	02/09/2014 10:50	J 45128 98412	345128	398412			Second area of trestles on west shore. Possibly the former Dougold site? Two areas of trestles: bare trestles, 1 poche with oysters, 10 m north of waypoint are two broken trestles
28	02/09/2014 10:53	J 45182 98375	345182	398375			Northwest extent of trestles - no poches. 1 heron, 2 crows
29	02/09/2014 10:54	J 45190 98376	345190	398375			Northeast extent of trestle area
30	02/09/2014 10:55	J 45180 98361	345180	398361			Southwest extent of trestle area
31	02/09/2014 10:56	J 45193 98364	345193	398364			Southeast extent of trestle area
32	02/09/2014 10:57	J 45213 98321	345213	398321			Second trestle area (possibly Dougold site) to the southwest shore, northwest corner
33	02/09/2014 10:58	J 45222 98334	345222	398334			Northeast corner, first 10 trestles no poches and look to have been placed relatively recently as little fucoid cover. 3 m south of first trestle - 7 poches high fucoid coverage.
34	02/09/2014 11:00	J 45235 98289	345235	398289			West extent of trestles, mostly empty
35	02/09/2014 11:03	J 45295 98214	345295	398214			Southwest extent of trestle area

No.	Date/time	Irish Grid	Easting	Northing	Associated photograph	Associated sample	Description
36	02/09/2014 11:03	J 45300 98218	345300	398218			Southeast extent of trestle area, 9 poches with mussels, lots of shore mussels and very few oyster shells. Over 60 rows of trestles comprising of 2-4 trestles - mostly empty and does not look in use - verified by sampling officer. Strong smell of manure
37	02/09/2014 11:07	J 45290 98109	345290	398109			Two oystercatchers, 3 cormorants, 1 gull, 6 eider ducks. Clam shellfishery out in the lough approx. 500 m from shore. Lots of shore mussels around
38	02/09/2014 11:20	J 45184 97956	345184	397956			Thirty gulls, 14 oystercatchers, 1 cormorant out on sand flat. 15 cows in field back from dwellings on hillside, 8 dwelling houses including two farms.
39	02/09/2014 11:42	J 44897 98544	344897	398544			Six crows
40	02/09/2014 11:47	J 44782 98687	344782	398687			Five cormorants, 3 gulls, 1 crow
41	02/09/2014 11:50	J 44673 98776	344673	398776			Juvenile seal hauled out on rock, 3 gulls, 4 crows
42	02/09/2014 12:00	J 44240 98934	344240	398934			Disused rusty, broken pipe above shoreline looked to be associated with quarry. One boat on mooring, 6 eider ducks, 2 gulls in water.
43	02/09/2014 12:04	J 44165 98997	344165	398997			Two herons. End of shoreline survey route.
44	02/09/2014 1:07	J 40874 99876	340874	399876	Photo 05	LLFW02	Freshwater sample: Glynn River. 7 m width, two depth and flow samples taken: at 2.5 m across: depth 0.25 m, flow: 0.199 SD 0.006, at 5 m: depth 0.23 m, flow 0.222, SD 0.003. 8 m below waypoint the river goes under a road and splits into two, with a third watercourse joining further downstream. Dry, iron discharge pipe seen on left side of river.
45	02/09/2014 1:26	J 40974 99923	340974	399923			Glynn train station: adjacent shoreline: 1 heron, >200 seabirds on intertidal area
46	02/09/2014 1:26	J 40974 99923	340974	399923	Photo 06		Discharge pipe - dry. Looks newly built or to have been refurbished with parts of the pipe exposed near a green shed. 7 ducks in river. Caravan on field behind house that appears to be lived in.
47	02/09/2014 1:32	J 40915 99972	340915	399972			Glynn PS - relatively new/refurbished and associated with pipe from previous waypoint (46)
48	02/09/2014 1:57	J 40184 02200	340184	402200		LLFW03	Freshwater sample: Larne River. Two swans, 1 signet, 1 heron, 6 ducks.
49	02/09/2014 1:57	J 40184 02200	340184	402200	Photo 07		Larne River: 2.5 m width of rocky section of Larne River: depth 0.25 m, flow 0.738 SD 0.000. Also visible were two pipes: one pipe with a lid, the other with a grill cage covering the end.
50	02/09/2014 2:28	J 42858 98770	342858	398770		LLFW04	Freshwater sample. Watercourse: width 0.50 m, depth: 0.15 m, flow 0.348 SD 0.024.

No.	Date/time	Irish Grid	Easting	Northing	Associated photograph	Associated sample	Description
51	03/09/2014 8:42	J 45747 98512	345747	398512			Start of second survey day on the east side of Larne Lough on Islandmagee. Bright start, with clear skies, sunshine, 14^{o}C, no wind and calm sea. Joined by Louise Connolly (FSA NI), Antony Higgins (FSA NI) and Jon Erskine (Sampling officer). Farms and farmland containing sheep and cattle seen on drive to survey location.
52	03/09/2014 9:10	J 45892 97269	345892	397269			Old stony outcrop covered in grass. One oystercatcher, 5 gulls, four white buoys approximately 200 m northwest are associated new floating cages being trialled by the harvester from White Quay. Rocky shoreline with high level of fucoid cover along the lower shore.
53	03/09/2014 9:16	J 45913 97792	345913	397792	Photo 08		Four large farm buildings (sheds) two fields back from the shore. 25 sheep in a field to the left of the farm, 12 cattle in field just below farm
54	03/09/2014 9:19	J 45925 97906	345925	397906			Fenced grassy field behind shore, no livestock present
55	03/09/2014 9:21	J 45934 97954	345934	397954			Shore littered with lots of empty mussel shells
56	03/09/2014 9:23	J 45927 97980	345927	397980			Three gulls
57	03/09/2014 9:26	J 45915 98062	345915	398062			Bird faeces and lots of shellfish shells - suggest a bird feeding area
58	03/09/2014 9:28	J 45915 98095	345915	398095			Six gulls
59	03/09/2014 9:30	J 45913 98129	345913	398129			Seven cattle in field behind shoreline
60	03/09/2014 9:31	J 45903 98154	345903	398154			Lots of freshwater reed plants along the upper shore thought to be associated with high levels of freshwater runoff. Freshwater could be heard seeping down, but was not observed so no sample taken
61	03/09/2014 9:34	J 45860 98201	345860	398201			4 gulls
62	03/09/2014 9:38	J 45778 98270	345778	398270	Photo 09		Island Shellfish site - southeast extent of fishery. Sampling officer says there are three beds, with the longest on the east side.
63	03/09/2014 9:41	J 45751 98295	345751	398295			Northeast extent of Island Shellfish. 1 gull on fishery, approximately 150-200m offshore. 1 cow in fields back from this waypoint
64	03/09/2014 9:43	J 45731 98315	345731	398315			12 cows, 3 calves –may be more beyond view as field stretches out of sight
65	03/09/2014 9:45	J 45722 98323	345722	398323			Empty clam shells on shore
66	03/09/2014 9:47	J 45705 98333	345705	398333			1 heron, 1 gull, two fields behind shore a further 5 cattle
67	03/09/2014 9:51	J 45604 98360	345604	398360			Empty poche. Sampling officer noted that black guillemots have made a good comeback in the area

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68	03/09/2014 9:53	J 45596 98358	345596	398358			Empty poche
69	03/09/2014 9:58	J 45557 98350	345557	398350	Photo 10		White Quay - floating oyster cages - a new venture by harvester. Also located here are floating cages for spat collection (photo)
70	03/09/2014 9:59	J 45552 98358	345552	398358	Photo 11		100 gulls on shore - mudflats
71	03/09/2014 10:03	J 45558 98376	345558	398376		LLSF02	Shellfish sample (shore mussels). Intertidal area covered in shore mussels.
72	03/09/2014 10:16	J 45572 98387	345572	398387			Empty poche
73	03/09/2014 10:39	J 45695 98551	345695	398551			Plastic pipe below house adjacent to shore - not flowing and expected to be land drainage
74	03/09/2014 10:42	J 45686 98558	345686	398558	Photo 12		Possible ST in garden, slight smell. Seven cows in field to the left of the house. Sampling officer says house ST discharges into watercourse
75	03/09/2014 10:44	J 45650 98591	345650	398591			Possible bird feeding area - shellfish shells on shore
76	03/09/2014 10:47	J 45564 98649	345564	398649			Eight crows, 40 gulls
77	03/09/2014 10:50	J 45520 98697	345520	398697			Algae on shore in stagnant water. Strong smell of sulphur and reeds behind shore suggesting freshwater runoff
78	03/09/2014 10:53	J 45439 98792	345439	398792			Dwelling behind grassy field
79	03/09/2014 11:03	J 45070 98807	345070	398807			Boggy area at Barney's Point. Lots of hoof marks and the sampling officer said that cattle are sometimes kept on this area, which is not fenced from the shore. 3 seals hauled out on rocks, stagnant pool
80	03/09/2014 11:09	J 45100 98881	345100	398881			Sheep spoil and hay pile, small dinghy on shore by field gate
81	03/09/2014 11:10	J 45091 98882	345091	398882			Sanitary debris
82	03/09/2014 11:13	J 45091 98982	345091	398982			Clay substrate and empty poche on fence - grassy fields behind shore
83	03/09/2014 11:15	J 45062 99009	345062	399009			Eight sheep, 1 bull, 4 gulls
84	03/09/2014 11:20	J 45026 99062	345026	399062			Two wooden fenced areas - unclear of use, 1 gull
85	03/09/2014 11:25	J 44956 99161	344956	399161			Approximately 60 sheep in field next to wooden seating area, 2 gulls
86	03/09/2014 11:30	J 44915 99176	344915	399176			Empty poche on shore, 1 oystercatcher
87	03/09/2014 11:38	J 44764 99255	344764	399255			Winkle shells on shore, 1 gull, 1 empty poche
88	03/09/2014 11:41	J 44660 99291	344660	399291			1 mooring

No.	Date/time	Irish Grid	Easting	Northing	Associated photograph	Associated sample	Description
89	03/09/2014 11:42	J 44643 99291	344643	399291			Unoccupied shed, caravan and port-a-loo. No pipe associated. 1 slipway to shore, with an empty mooring out to sea. Slick on water. Two empty poches on the shoreline
90	03/09/2014 11:44	J 44617 99294	344617	399294		LLSW07	Seawater sample at end of slipway adjacent caravan site. Salinity recorded – 32 ppt
91	03/09/2014 11:52	J 44601 99297	344601	399297			Empty poche, a holiday boat moored (photo)
92	03/09/2014 11:55	J 44548 99356	344548	399356			Two empty poches
93	03/09/2014 11:57	J 44522 99414	344522	399414			Four empty poches. On opposite shoreline a tractor is spraying a newly ploughed field with white spray
94	03/09/2014 11:59	J 44508 99427	344508	399427			Stray broken trestle outlying the main trestle area.
95	03/09/2014 12:00	J 44502 99429	344502	399429	Photo 13		Southeast extent of trestle area
96	03/09/2014 12:01	J 44499 99431	344499	399431			Southwest extent of trestle area
97	03/09/2014 12:02	J 44499 99442	344499	399442			Within the trestle area, there are three poches on the trestles at this waypoint containing native oysters. Area consists of 12 empty trestles
98	03/09/2014 12:03	J 44501 99449	344501	399449			Northwest extent of trestle area
99	03/09/2014 12:03	J 44504 99448	344504	399448			Northeast extent of trestle area
100	03/09/2014 12:04	J 44508 99449	344508	399449			Broken trestle, 4 buoys out to sea from slipway. Possibly associated with Millbay fishery
101	03/09/2014 12:06	J 44509 99473	344509	399473	Photo 14		Sewage water - grey in colour with sewage fungus on surrounding rocks. Pipe above shore below boat/scrap yard dripping. Empty poche
102	03/09/2014 12:12	J 44515 99477	344515	399477		LLFW06	Freshwater sample (contaminated). Flow too little to measure. Two guillemots, 4 oystercatchers
103	03/09/2014 12:17	J 44489 99474	344489	399474		LLSW08	Seawater sample, recorded salinity 34 ppt, taken adjacent to dripping pipe. Weather changing with cloud cover having increased to 100% and a dip in air temperature.
104	03/09/2014 12:21	J 44496 99490	344496	399490			Two broken trestles
105	03/09/2014 12:22	J 44491 99498	344491	399498			Broken trestle with empty poche
106	03/09/2014 12:23	J 44493 99512	344493	399512			Sleepers at the top of the shoreline holding back a walkway where 7 stacks of 8 trestles are stored and 12 empty poches are scattered on the shoreline

No.	Date/time	Irish Grid	Easting	Northing	Associated photograph	Associated sample	Description
107	03/09/2014 12:24	J 44487 99523	344487	399523			Slipway- leading to work yard where there are a number of cars and 6 small boats
108	03/09/2014 12:26	J 44496 99530	344493	399530			Five broken trestles
109	03/09/2014 12:27	J 44494 99542	344494	399542			Broken trestle
110	03/09/2014 12:28	J 44502 99539	344502	399539			Plastic pipe - dry, no smell
111	03/09/2014 12:29	J 44483 99548	344483	399548			Southeast extent of trestles
112	03/09/2014 12:30	J 44469 99543	344469	399543			Southwest extent of trestles a further 2 m offshore. Lots of oyster shells on shore - empty. 3 poches, 2 gulls
113	03/09/2014 12:32	J 44486 99555	344486	399555			Eastern extent of trestles
114	03/09/2014 12:32	J 44479 99575	344479	399575			Northeast extent of trestles
115	03/09/2014 12:33	J 44469 99573	344469	399573			Northwest extent of trestles plus 2 m offshore - most trestles in disarray and are lying parallel to the shore as have been pushed by the tide. 1 house adjacent that is owned by the licencee of the fishery
116	03/09/2014 12:38	J 44496 99659	344496	399659			1 seal on rock, dog walker with one dog on shore, four lots of dog faeces on grassy verge above Mill bay. >14 houses on the land adjacent to the bay, with possible horse droppings on the grassy verge
117	03/09/2014 12:43	J 44576 99620	344576	399620			1 mooring in bay (unoccupied), clay substrate
118	03/09/2014 12:47	J 44643 99673	344643	399673		LLFW07	Freshwater sample. Watercourse: width 85 cm, 34 cm, flow 0.211, SD 0.000. Watercourse contained lots of rubbish, 4 gulls on shoreline
119	03/09/2014 12:55	J 44638 99734	344638	399734			Dog faeces on shore
120	03/09/2014 12:57	J 44628 99771	344628	399771			Slipway next to house
121	03/09/2014 12:58	J 44632 99790	344632	399790			Plastic pipe below house - land drainage

No.	Date/time	Irish Grid	Easting	Northing	Associated photograph	Associated sample	Description
122	03/09/2014 12:59	J 44629 99798	344629	399798			Three pipes across concreted wall - land drainage
123	03/09/2014 1:00	J 44606 99821	344606	399821			At least another 7 more plastic pipes from concrete wall
124	03/09/2014 1:03	J 44530 99835	344530	399835			House with slipway
125	03/09/2014 1:06	J 44509 99828	344509	399828		LLSW09	Seawater sample (ppt 28) at Mill Bay adjacent to house close to shore. 1 chicken on shore, slick on water, 2 herons on rocks
126	03/09/2014 1:42	J 45558 98382	345558	398382		LLSW10	Seawater sample (ppt 33) at shore mussels location (LLSF02) in waypoint 73
127	03/09/2014 2:15	J 42017 02179	342017	302179		LLSW11	Seawater sample (ppt 32) at Ballylumford Power Station. Several pleasure boats located on the opposite shore at Larne Marina, with a passenger ferry also docked.
128	17/09/2014	J 45713 98531	345713	398531		LLFW05	Freshwater sample. Watercourse: width 1.9 m, depth 18 cm, flow 0.045 SD 0.000

Note: seawater salinities recorded in the table of observations were recorded on the day of the survey using a refractometer.

Photographs referenced in the table are included as Figures 1-14.

Sampling

Samples were collected at sites marked on the map shown in Figure 2. Samples were transported during the shoreline survey in back packs containing ice packs and then transferred to Biotherm insulated boxes with ice packs and posted to Glasgow Scientific Services (GSS) for *E. coli* analysis. All samples were posted on the day of collection. Samples from the first sampling day were received and analysed the following day, with sample temperatures on arrival to the laboratory at 8.7˚C for the water samples and 10.8˚C for the shellfish sample. Samples from the second day of sampling were posted on the day of collection, but were delayed in the post. When the samples arrived at the laboratory, two samples (one freshwater, one seawater) lay outside the 48 hour window for analysis and the results could not be used. The remaining samples fell within the 48 hr window, with sample temperatures upon arrival at 8.3˚C for the water samples and 6.5˚C for the shellfish sample. Although the receipt temperatures for most of the samples exceeded the target of 8˚C, they were within the range that the UK NRL has shown results in no significant change in *E. coli* concentration in shellfish at 48 hours.

The freshwater sample that was received more than 48 hrs after collection was re-sampled on 17/09/2014, as the location was close to the White Quay fishery. The box temperature upon arrival at the laboratory of the sample was 6.4˚C.

Seawater samples were tested for salinity by GSS and the results reported in mg Chloride per litre and are presented alongside seawater sample results in Table 4. These results have been converted to parts per thousand (ppt) using the following formula:

$$\text{Salinity (ppt)} = 0.0018066 \times Cl^{-} \text{ (mg/L)}$$

The results are shown in Tables 3 (freshwater samples), 4 (seawater samples) and 5 (shellfish samples).

Table 3. Freshwater Sample Results

No.	Date	Sample	Grid Ref	*E. coli (cfu/100ml)*
1	02/09/2014 09:10	LLFW01	J 42890 98747	210
2	02/09/2014 13:07	LLFW02	J 40874 99876	320
3	02/09/2014 13:57	LLFW03	J 40184 02200	660
4	02/09/2014 14:28	LLFW04	J 42858 98770	80
5	03/09/2014 10:23	LLFW05	J 45713 98531	830
6	03/09/2014 12:12	LLFW06	J 44515 99477	400000
7	17/09/2014	LLFW07	J 44643 99673	1170

Table 4. Seawater Sample Results

No.	Date	Sample	Grid Ref	*E. coli (cfu/100ml)*	Salinity (ppt)
1	02/09/2014 08:31	LLSW01	J 43180 98859	28	35
2	02/09/2014 10:26	LLSW02	J 44909 98562	3	35
4	03/09/2014 11:44	LLSW03	J 44617 99294	3	35
5	03/09/2014 12:17	LLSW04	J 44489 99474	1	35
6	03/09/2014 13:06	LLSW05	J 44509 99828	21	33
7	03/09/2014 13:42	LLSW6	J 45558 98382	<1	35
8	03/09/2014 14:15	LLSW7	J 42017 02179	11	33

Note: salinities recorded in Table 4 were those calculated at GSS.

Table 5. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (MPN/100g)
1	02/09/2014 10:26	LLSF01	J 44909 98562	Shore mussels	<18
2	03/09/2014 10:03	LLSF02	J 45558 98376	Shore mussels	<18

Salinity Profiles

No salinity profiles were taken during this shoreline survey.

Photos

Figure 1 Moorings adjacent to Blue Circle Cruising and Sailing Club.

Figure 2 Boats ashore at Blue Circle Cruising and Sailing Club.

Figure 3 Discharge pipe associated with NIW asset and sample LLFW01.

Figure 4 Trestle area south of Magheramorne Quarry.

Figure 5 Sewage pipe (dry) to the side of Glynn River.

Figure 6 Glynn PS discharge pipe, with lived-in caravan in field behind house.

Figure 7 Pipes in Larne River.

Figure 8 Photo looking back over the farm buildings and livestock fields adjacent to the shoreline associated with waypoint 53.

Figure 9 Island Shellfishery – clam bed eastern extent.

Figure 10 White Quay fishery, spat collectors and a trial floating cage system for oyster cultivation.

Figure 11 intertidal area with approximately 100 gulls and shore mussels.

Figure 12 Possible ST hatch in garden below house.

Figure 13 Trestles, mostly empty, at Millbay.

Figure 14 Dripping sewage pipe from the boat/scrap yard adjacent to Millbay fishery.