Larne Lough

Sanitary survey report for Larne Lough

Prepared by AFBI Fisheries and Aquatic Ecosystems Branch for the Food Standards Agency

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Executive Summary

EU Regulation 854/2004 (section 6, Annex II) highlights the necessity for competent authorities to establish microbiological monitoring programmes for shellfish harvesting areas. This involves carrying out a number of tasks which are collectively referred to as a "Sanitary Survey". The Agri Food and Bioscience Institute (AFBI) is undertaking sanitary surveys in Northern Ireland on behalf of the Food Standards Agency (FSA).

Potential sources of microbiological contamination within Larne Lough were identified through a desktop survey. Thirty seven sites were identified as having running discharges (and therefore as a potential source of microbiological contamination) during the shoreline survey, some of which were in addition to the possible contamination sources noted during the desktop survey. Water samples were collected at these sites and sent for microbiological analysis.

Levels of microbiological contamination from discharges into Larne Lough were found to be high within the Inner Lough area as Faecal coliform counts per 100ml were of a magnitude that would be classified as "Poor" under the Bathing Water Regulations 2008 in all but three out of the twenty-one water samples collected in the Inner Lough are during the shoreline survey. However the majority of potential sources of contamination sampled were low flowing discharges which would have been diluted at high tide. No evidence of sewage derived litter was observed during the course of the survey and there was little evidence of shoreline contamination from wild or domestic animals.

Hydrodynamic modelling within this area (undertaken through the course of the Sustainable Mariculture in Northern Irish Sea Lough Ecosystems (SMILE) project, Ferriera *et al.* 2007) identified the Inner Larne Lough area has a residence time of approximately 17 days, whilst the outer Lough area has a residence time of less than 2 days. For locations of the Inner and Outer Lough Areas please refer to Figure 1.

Four sites (the coordinates of which are outlined in Table 4) are recommended as the representative monitoring points (RMP) for this area. Four RMP's are required due to the potential for microbiological contamination within the inner Lough identified during the shoreline survey and the fact that more than one species of shellfish is cultured within these areas. A mussel, an oyster and a clam aquaculture site need to be sampled within the inner Lough area, and the outermost of the aquaculture sites also needs to be

sampled. The sites chosen will be representative of the level microbiological contamination within the remaining aquaculture sites within Larne Lough.

Contents

1. Introduction

With regard to the establishment of microbiological monitoring programmes for shellfish harvesting areas, EU Regulation 854/2004 Section 6 of Annex II stipulates that:

"*If the competent authority decides in principle to classify a production or relaying area, it must:*

1. *Make an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area;*

2. *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, waste water treatment etc;*

3. *Determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area;*

4. *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 activities outlined within points 1 to 3 above constitute a Sanitary Survey. The main elements of a sanitary survey are:

a. Desktop study – acquisition and analysis of relevant data and information.
b. Shoreline survey – practical survey to confirm information obtained during the desktop study and to identify other potential sources of contamination.
c. Bathymetry and hydrodynamics – to determine whether the potential sources actually impact on the shellfishery and to what extent.
d. Bacteriological survey – testing of samples from a number of points to determine differences in contamination across the shellfishery – this should only be undertaken if the outcome of the other elements are unclear.

Shellfish Hygiene

In accordance with EC Regulation 854/2004, the Food Standards Agency NI (FSANI), as Competent Authority, is responsible for classifying shellfish harvesting areas according to the degree of *E. coli* contamination detected within samples of shellfish flesh.

Regulation (EC) 854/2004 outlines the requirements for Competent Authorities to put in place Official Controls to protect public health. FSANI is responsible for carrying out an Official Control monitoring programme in classified shellfish production areas in Northern Ireland.

Flesh samples from classified harvesting areas are periodically monitored to check the microbiological quality of the shellfish (*E-coli* is used as an indicator of faecal contamination). Harvesting areas are also monitored for the presence of toxin producing phytoplankton in shellfish waters, specifically *Alexandrium* spp. and marine biotoxins (DSP, PSP and ASP) in shellfish flesh.

In accordance with EU legislation, a sanitary survey must be carried out on all classified shellfish areas in order to assess possible sources of contamination and establish microbiological sampling points which are representative of the area.

2. Desktop Study

2.1 Study Area – General Description

Larne Lough is a sea lough in County Antrim situated on the east coast of Northern Ireland, enclosed to the east by the peninsula of Islandmagee. Larne Lough is a shallow marine bay generally split into north (generally referred to as the Outer Lough) and south (generally referred to as the Inner Lough) basins at Barney's Point (Charlesworth and Service 2003) (Figure 1).

Figure 1: The Location of Larne Lough within Northern Ireland

The catchment of Larne Lough covers an area of approximately 115km^2 and the Lough's main freshwater sources are Glynn and Larne rivers. The Glynn River is approximately 13km in length and the Larne River is approximately 48km in length. The remaining area of the catchment is drained by several smaller rivers and streams.

2.2 Potential Sources of Microbiological Pollution

2.2.1 Land use patterns

The patterns of land use within the Larne Lough area are shown in Figures 2 and 3.

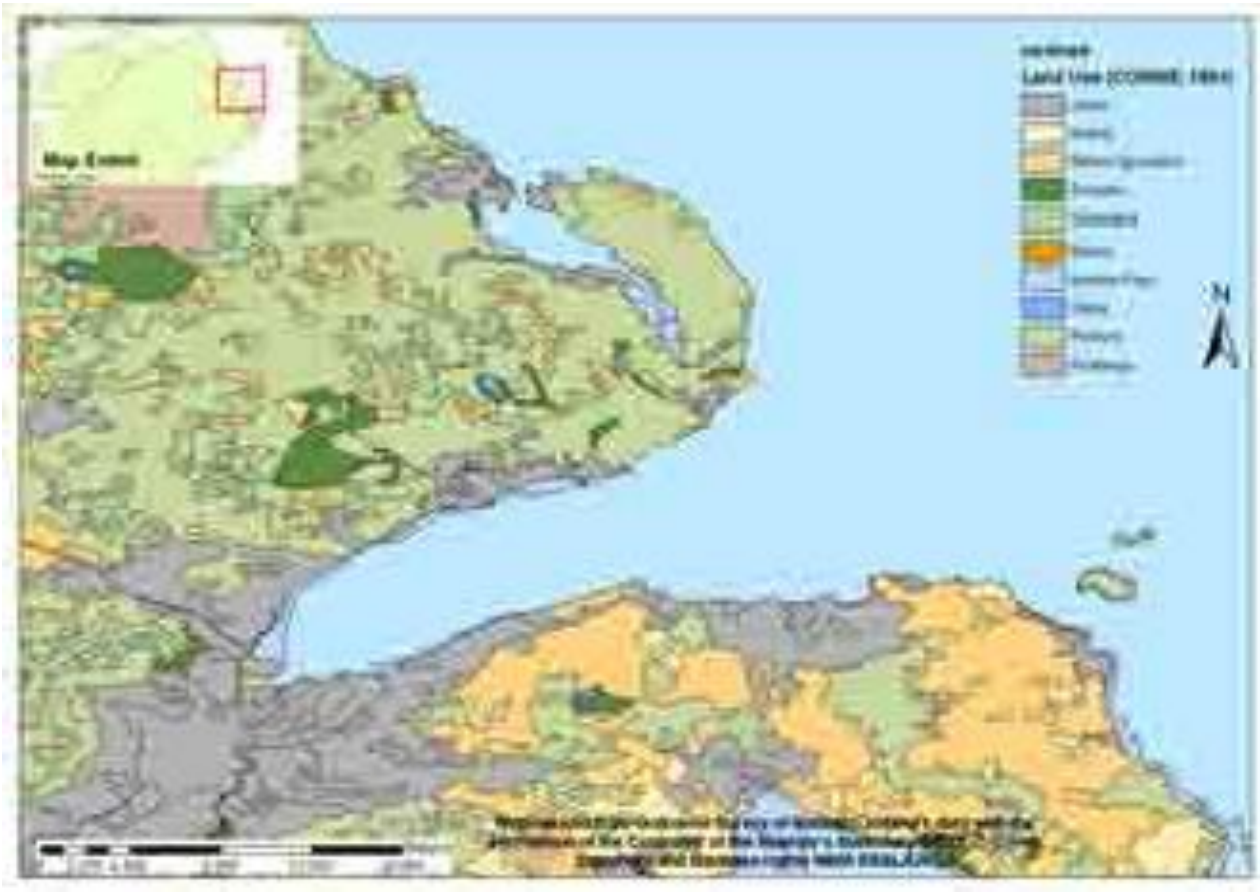


Figure 2: Land use classification – Antrim and North Down

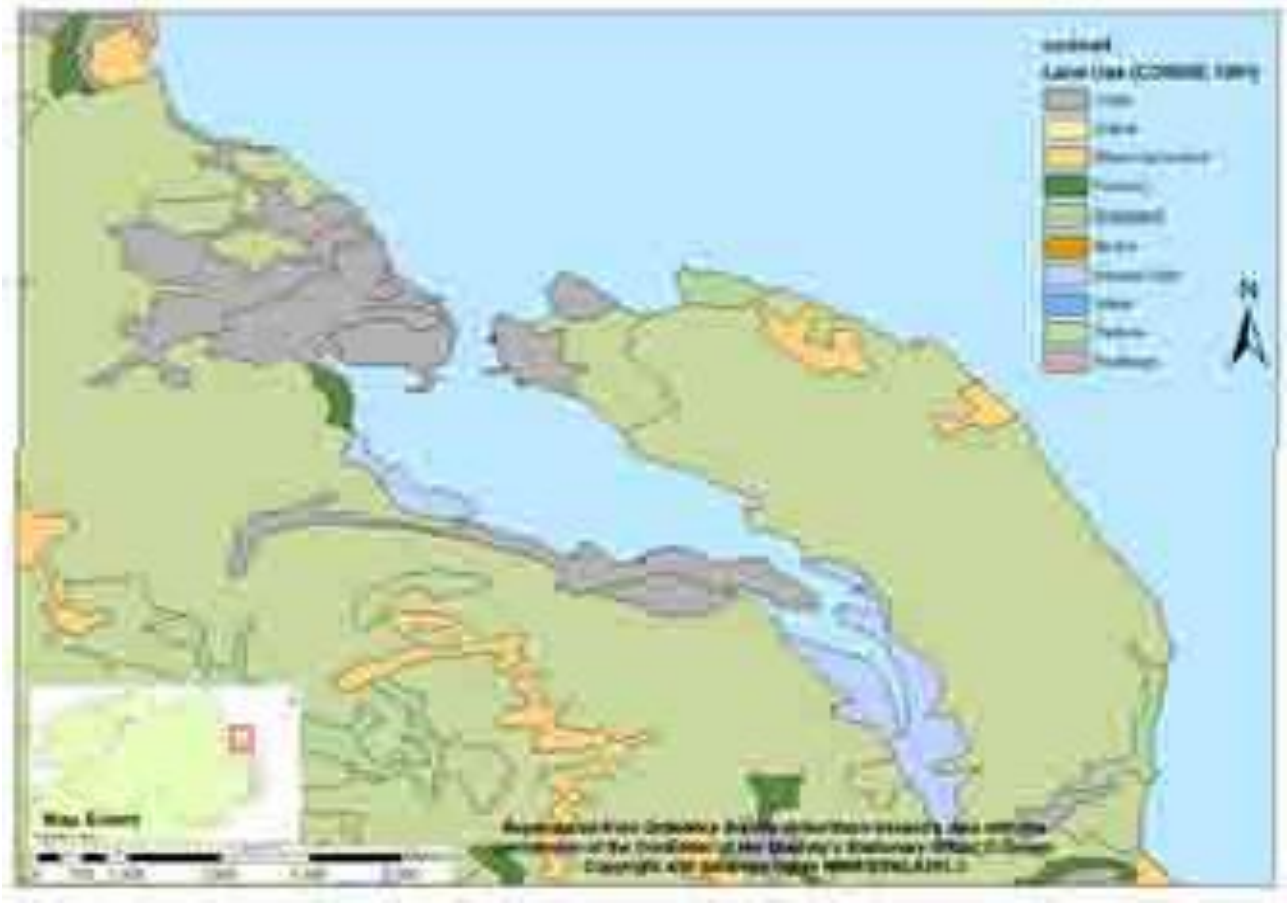


Figure 3: Land Use Classification – Larne Lough Area

There is a general predominance for pasture and grasslands on Islandmagee on the Eastern side of the Lough. The Western shoreline is predominantly urban with areas of intertidal flats at the head of the Lough. The urban areas around the Lough are the main potential source of microbiological contamination, although faecal contamination from grazing livestock on the areas designated as pasture and any large aggregations of birds on the intertidal flats also have the potential to contribute to microbiological contamination.

Figure 4: Council Districts – Larne & Carrickfergus 2008 (DARD)

Figure 5: Larne Lough catchment including rivers

Table 1: Livestock numbers within the Larne and Carrickfergus district council 2008 DARD

District	cattle	sheep	pigs	poultry
Carrickfergus	4,927	14,636	535	7
Larne	35,041	120,954	4,364	128

Table 1 illustrates the constitution of livestock within the district council areas of Larne and Carrickfergus (Figure 4), which includes the Larne Lough catchment area (Figure 5). The most common animal is the sheep with a total of 135590 animals in the area. Different types of animal have different faecal loading equivalents associated with them and therefore this affects the total potential loading in the system. The total potential loadings are summarised in Table 2.

2.2.2 Human populations

At the mouth of the Lough lies Larne Town with a population of approximately 17,600 (Larne Area Plan 2010: Planning service website), home to the busy port of Larne and on the Eastern shore the town of Ballylumford (Figure 6).

Figure 6: Settlements around Larne Lough

A total of 71,300 people live within the Larne and Carrickfergus local government district (NISRA 2008).

Table 2: Potential daily faecal coliform loadings – Human and Animal in Larne and Carrickfergus council district (Formula adapted from Geldrich E.E. (1978); Ashbolt J. et al. (2001);Wither et al. (2005))

Type	Potential Faecal coliform Load per day
human population	1.35×10^{13}
Cattle	1.94×10^{14}
Sheep	2.44×10^{15}
Pigs	4.36×10^{12}
Poultry	3.11×10^{10}

Table 2 illustrates the potential loading, per day in the way of Faecal coliforms. Note that this is for all of the Larne and Carrickfergus districts, so the figure for the Larne Lough catchment (figure 5) would be smaller. This figure does not represent final loading to the system as natural die off and sewage treatment will reduce inputs.

2.2.3 Industry

The principle industrial discharge belongs to the power station at Ballylumford (Figure 7). There are a number of smaller industrial developments in Larne which largely link to the principle sewerage system. Although the power station has only a small direct contribution to faecal contaminants, it has the potential to relay wastewater from the sewage treatment works (STW) through its cooling water circulation system. This may act to direct part of the discharge from Larne STW into the main body of the outer Lough.

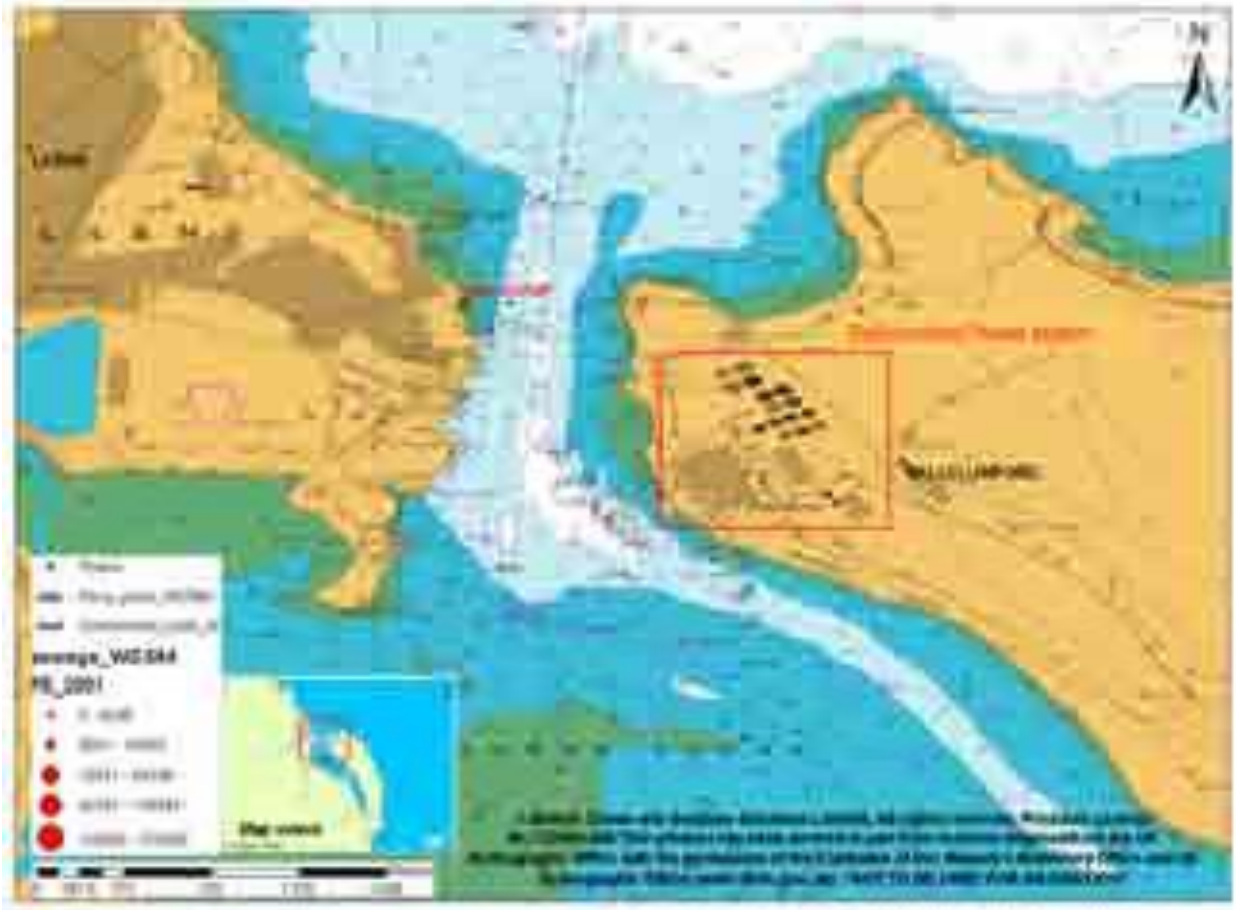


Figure 7: The Location of Ballylumford Power Station within Larne Lough

2.2.4 Tourism

During the summer months the town of Larne may see an influx of tourists due to the ferry services which operate from Larne to Stranraer, Troon, Cairnryan and Fleetwood. Holiday makers may choose to stay overnight in the vicinity of Larne in order to catch early morning ferries. These seasonal increases of people into the town of Larne have the potential to put pressure on sewage treatment systems during these months, although there is no direct data on this.

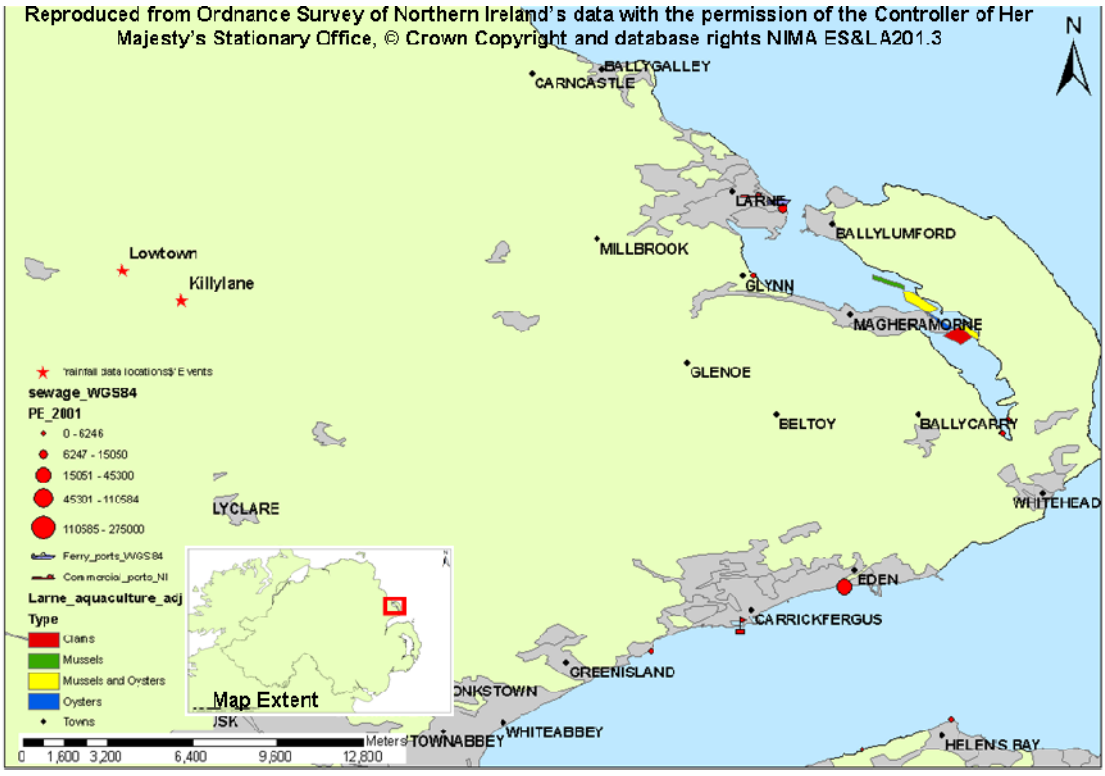
2.2.5 Boats/Marinas

There are no marinas within Larne Lough although there is both a commercial and a passenger ferry port located within the town of Larne (see Figure 7). Discharges of sewage and garbage from ships are regulated under the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL). This prohibits any discharges from ships whilst in Port.

2.2.6 Rainfall Information

Rainfall is gauged at several locations in the vicinity of Larne Lough, at Killylane and Lowtown (Figure 8 a). However recent rainfall information is only available for Killylane (Figure 8 b). This graph shows a seasonal pattern of rainfall with the highest amount of rainfall being detected within the winter months. However short term events can also occur which will affect survey results.

Rainfall data should be logged alongside sample collection data. All future investigations within this area should include an analysis of the relationship (if any) between rainfall events and bacteria levels in shellfish.



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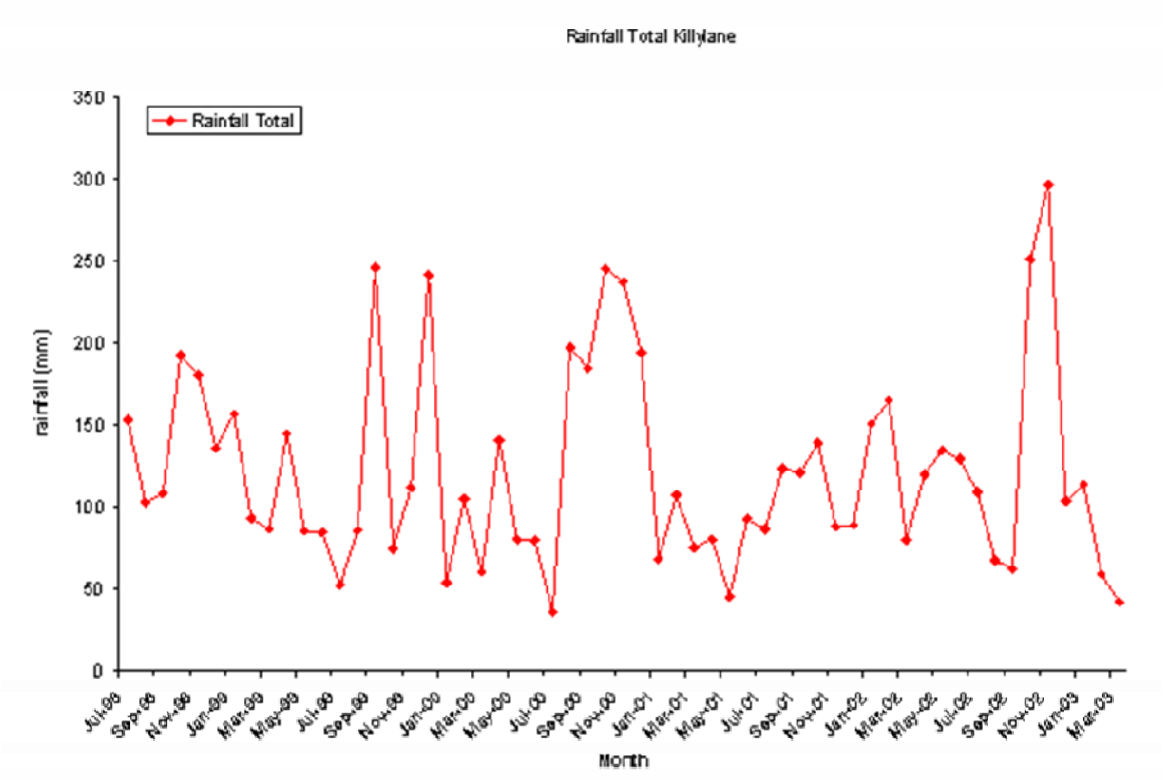


b)

Figure 8: a) Location of weather stations in the vicinity of Larne Lough b) Monthly rainfall for Killylane weather station; five year trend

2.2.7 Aquaculture and Fisheries

There are currently six licensed aquaculture sites within Larne Lough (Figure 9). The Food Standards Agency have granted seven classifications for five beds with two taxa, oysters and mussels being classified within two beds. These sites occupy a combined area of approximately 89 hectares and produce both native and pacific oysters, manila and native clams (clams) and mussels (Charlesworth and Service 2003).

Oysters are cultivated within bags on trestles placed in the lower intertidal zone whilst bottom culture of mussels is undertaken at the three classified sites where mussels are harvested.

Figure 9: Licensed aquaculture sites within Larne Lough

2.3 Inputs and Contaminant Status

From Figure 10 it can be seen that the largest sewage treatment works at Larne, Sandy Bay, discharges to the Outer Lough area. The two largest Rivers in the catchment, the Glynn and the Larne which dominate riverine inputs to the system also discharge to the Outer Lough although there are a number of smaller rivers and streams along the shores of the Inner Lough (Figure 11).

The treatment works at Larne, Sandy Bay carries out Secondary Treatment with UV sterilisation (see glossary for definition of Secondary Treatment). The Treatment works at Ballycarry and Mounthill undertake secondary treatment whilst the works at Ballystrudder only undertakes primary treatment (see glossary for definition of primary treatment). There is presently a proposal to screen and pump flows from Whitehead and Ballycarry to Ballystrudder where all flows received will be screened and discharged via a long sea outfall to Cloughfin Bay (NIEA pers. comm.). Population Equivalent (PE) discharge data for 2009 for the above waste water treatment works was obtained from NIEA Water Management Unit and is shown in Table 3 below.

Table 3: Larne Lough Waste Water Treatment Works discharging into Larne Lough adapted from table received from NIEA.

Station Name	Receiving water	PE	Type of Treatment
Larne (Sandy Bay) New WWTW commissioned in 2006	Larne Lough	20,000	Secondary Treatment with UV sterilisation, Feacal Coliform standard is 20,000 counts per 100ml.
Ballystrudder	Larne Lough	1,250	Primary Treatment
Ballycarry	Larne Lough	1,150	Secondary Treatment
Mounthill	Trib. Of Glynn river	131	Secondary Treatment

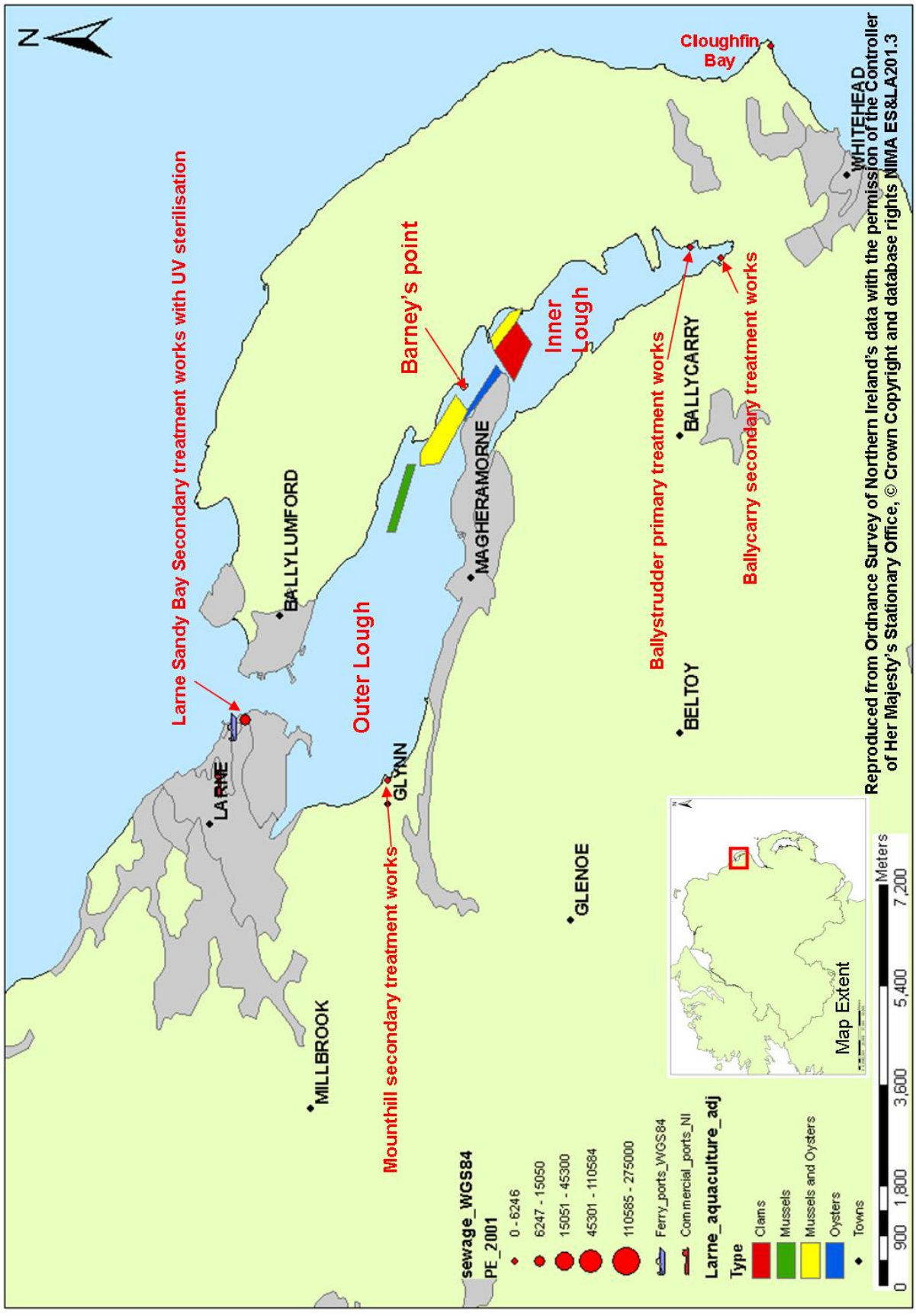


Figure 10: Overview of Larne Lough, including sewage outlets and Ports

Figure 11: Rivers and Towns within the vicinity of Larne Lough

Work resulting from the Sustainable Mariculture in northern Irish Sea Lough Ecosystems (SMILE) project, Ferreira *et al* (2007) has indicated that the inner Lough will have a residence time in the order of 18 -19 days whereas the outer Lough will tend to have a much shorter residence time of around 2 days (see Figure 1 for the location of the Inner and Outer Lough Areas). In short this indicates that most major discharges will be flushed out of the system relatively quickly whereas the inner Lough has the potential to retain contaminants.

Discharge from the Sandy Bay waste water treatment works at Larne while nominally discharging out of the main body of the Lough into the North Channel may enter the Lough on the flood tide. This effect may become exacerbated during Northerly winds as the buoyant plume may tend to be driven inwards. Direct inputs to the Inner Lough are liable to come from the Ballycarry and Ballystrudder waste water Treatment Works and catchment run off which may contain bacterial contamination from septic tanks and agriculture.

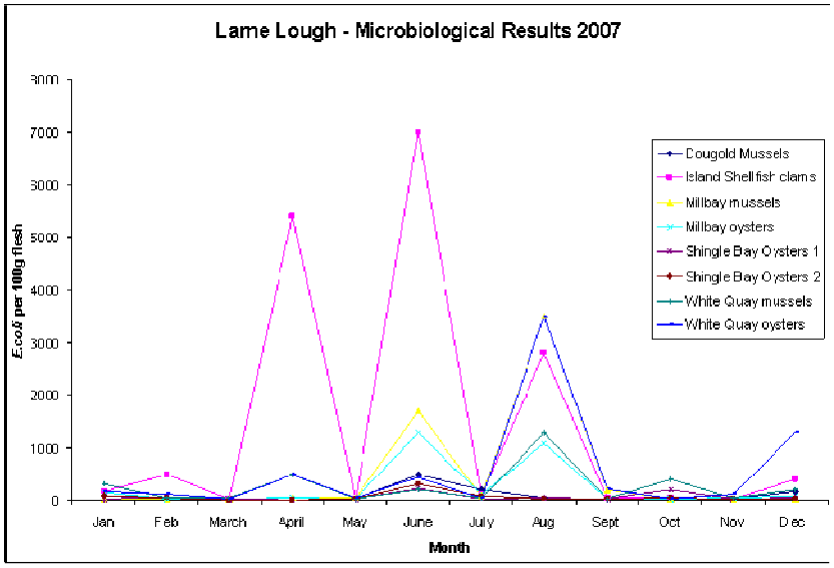
2.4 Food Standard Agency Historical data

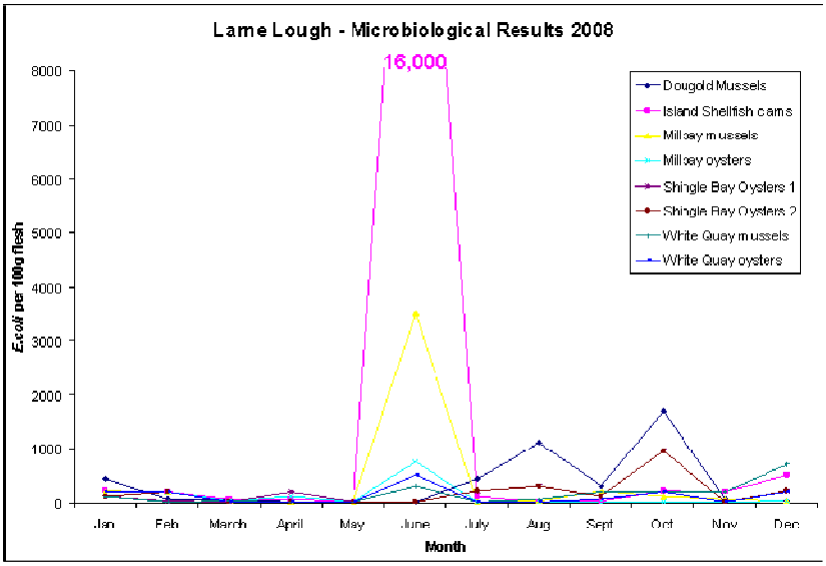
Within Northern Ireland the quality of shellfish for consumption is monitored by the Food Standards Agency Northern Ireland. This is achieved through monthly sampling and classification of shellfish harvesting areas. Areas are classified according to the levels of *Escherichia coli* (*E*. *coli*) *per* 100g of shellfish flesh weight. Areas with an *E. coli* value less than 230 are classified A and shellfish from these areas can go directly for human consumption. Areas with *E. coli* values less than 4,600 are classified B and must be subject to purification, relaying in a Class A area, or cooked by an approved method before being sold for human consumption. Areas with *E. coli* levels less than 46,000 are classified C and shellfish from these areas must be relaid for a period of at least two months or cooked by an approved method before being sold for human consumption.

The results of this sampling programme for the active shellfish harvesting areas within Larne Lough for 2007 – 2009 are shown in Figure 12 below. Several peaks in *E. coli* per 100g of flesh occurred during the 3 years represented in Figure 12.

Island Shellfish clams had 2 shellfish flesh results that were of a Category C status in 2007 and 1 in 2008. All other results for this and the additional beds in Larne Lough were either Category A or B status throughout the year. (See Figure 13 for location of these beds).

All classified beds have their classification reviewed annually and the classification is based on the last 3 years results. All beds in Larne Lough were awarded a B classification for 2010 with the exception of Shingle Bay oysters that received a provisional A classification.





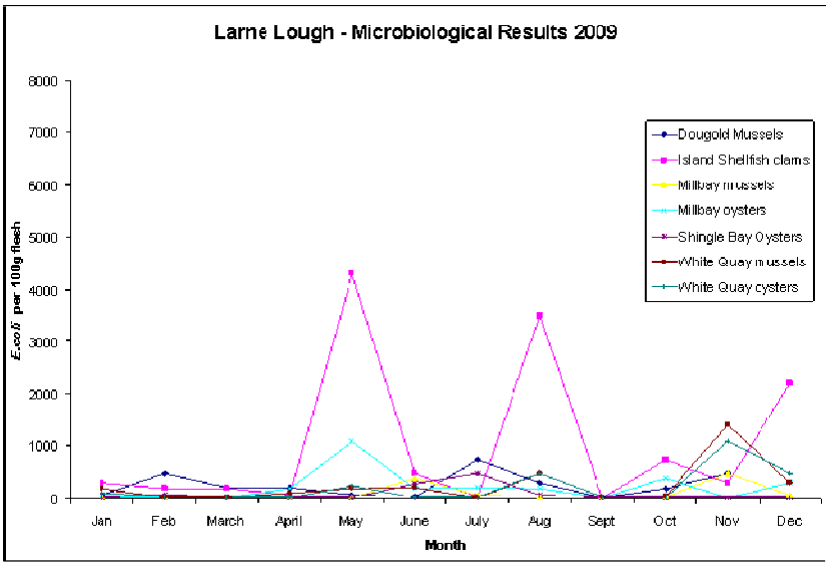


Figure 12: Graphs representing the FSA microbiological data for Larne Lough for the years 2007-2009.

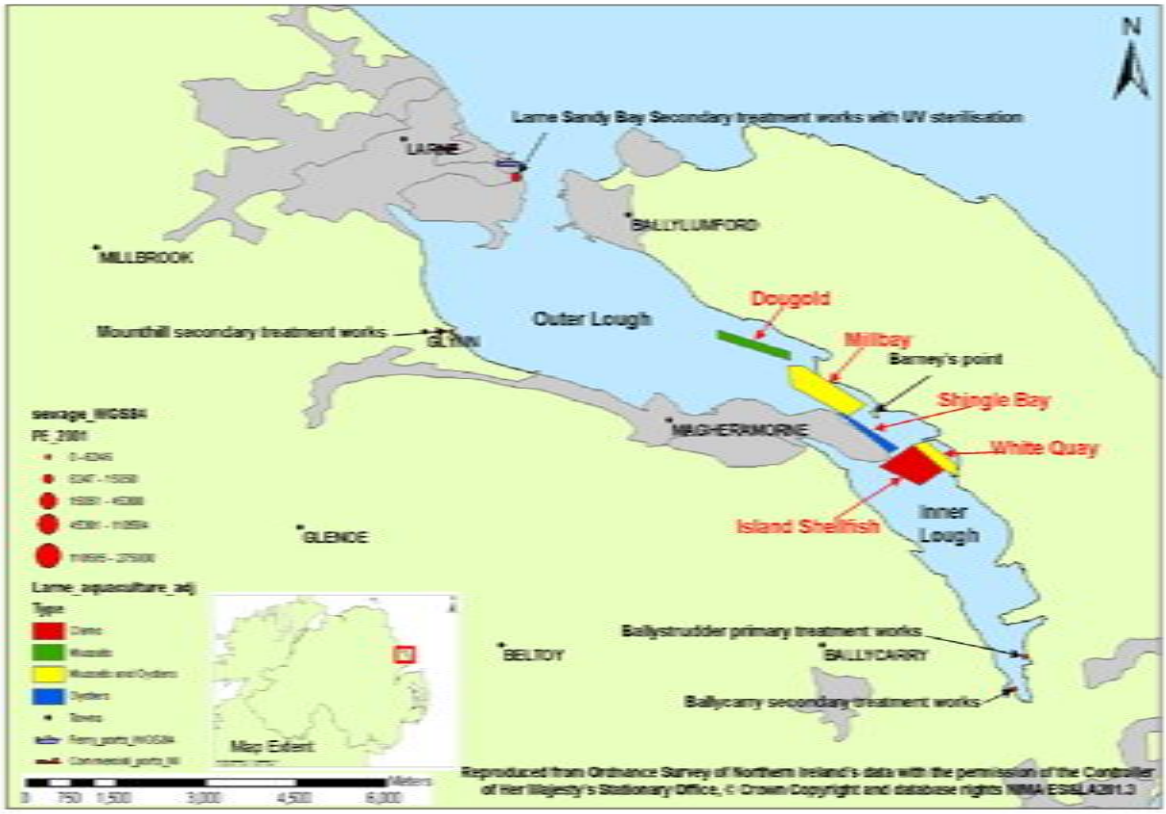


Figure 13: FSA Microbiological sampling beds and waste water treatment works within Larne Lough.

2.5 Conservation and Habitats

All of the intertidal zone along the shores of Larne Lough (an area of approximately 398ha), with the exception of the built up area at the mouth of the Lough, has been designated as a Special Protection Area (SPA), an Area of Special Scientific Interest (ASSI) and as a Ramsar site (Figure 14).

Larne Lough qualifies as a SPA under Article 4.1 of EC Directive 79/409 on the Conservation of Wild Birds by regularly supporting internationally important numbers of Light-bellied Brent Geese *Branta bernicla hrota* in winter (the five year peak mean for the period 1991/92 to 1995/96 was 227 which comprises 1.1 % of the international population).

Larne Lough has been designated as an ASSI as it contains the following habitats; Brackish Lake and Coastal Saltmarsh. Larne Lough also has important Invertebrate, Sea Bird and Waterfowl Assemblages.

Larne Lough qualifies as a Ramsar site under Criterion 3c of the Ramsar Convention by regularly supporting internationally important numbers of light-bellied Brent Geese in winter. Larne Lough also qualifies under Criterion 2a by supporting an important assemblage of vulnerable and endangered Irish Red Data Book bird species.

Large aggregations of birds on the intertidal zone have the potential to cause microbiological contamination of shellfish beds due to the addition of increased faecal matter within the area.

The species for which the Larne Lough SPA is designated, Light-bellied Brent Geese, feed primarily on eel grass of the species *Zostera* which is found growing on the intertidal zone and therefore have the potential (through faecal matter) to contribute to microbiological contamination within the shellfish aquaculture sites. However this species of bird arrive in the UK during the winter months when pressures on sewage systems are likely to be low

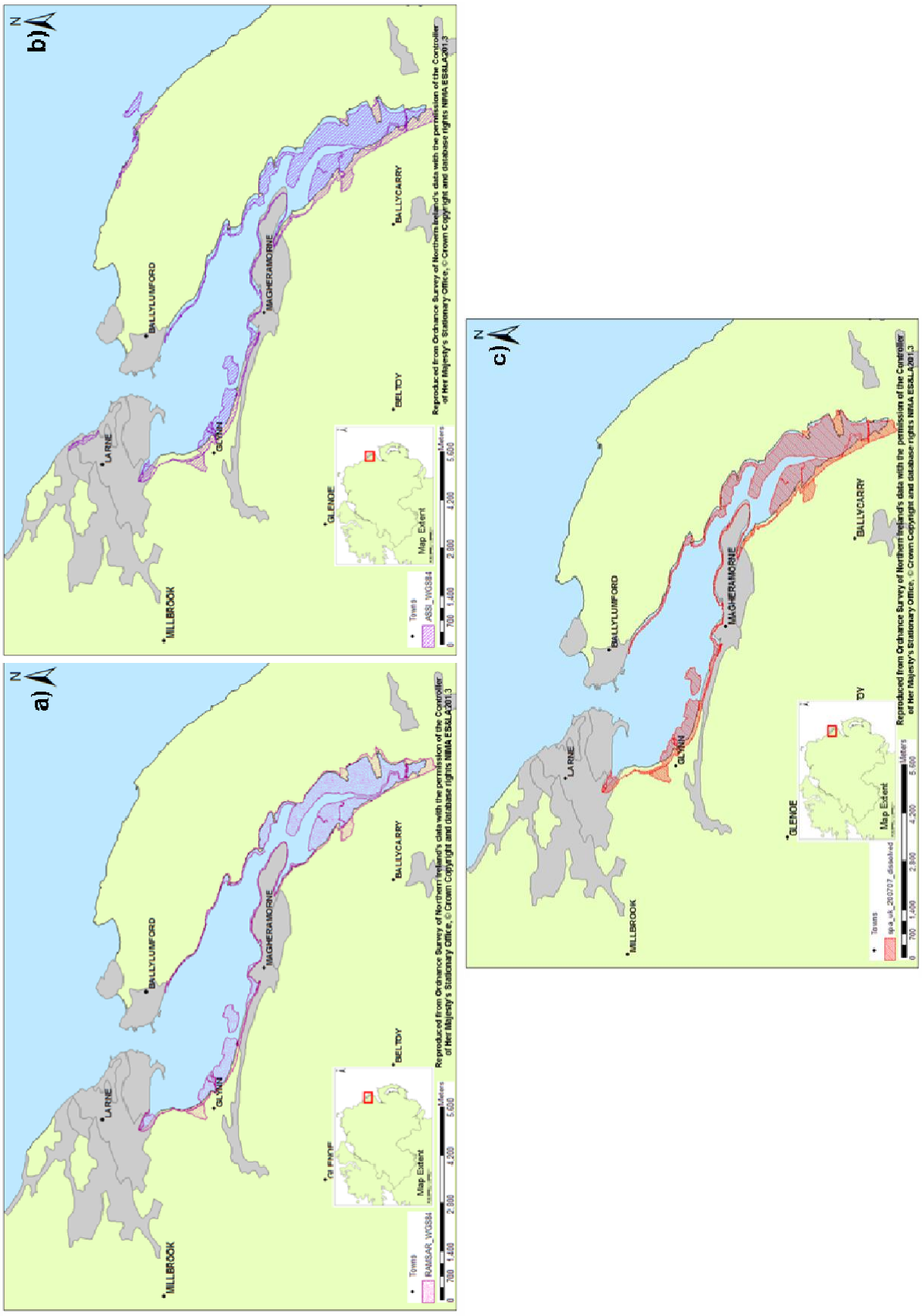


Figure 14: Larne Lough Conservation areas a) Ramsar boundary b) ASSI boundary c) SPA boundary

2.6 Other Management Units. Water bodies defined for Water Framework Directive (WFD) implementation.

Management options implemented through the WFD depend upon the division of water bodies into “functional” units based on hydrological and morphological characteristics. These water bodies have been divided into transitional (basically estuarine) and coastal types. Further divisions have been put forwards which are based upon the morphological and hydrological properties of these bodies. Figure 15 shows the water body definitions for Northern Ireland.

As can be seen from Figure 15 a), the entire area of Larne Lough is classified as being CW8, euhaline, mesotidal and sheltered. The Northern Ireland Environment Agency (NIEA) have an obligation to undertake surveys of each of the defined water bodies within Northern Ireland and as a result of which classify each area according to its environmental characteristics. If NIEA determine an area to be in an unfavourable condition under WFD criteria then steps will need to be taken to “clean up” the environment within this area which could in turn have implications for the aquaculture sites in Larne Lough. Figure 15b shows that Larne Lough has been divided into three regions for management purposes, Larne Lough North, Larne Lough Mid and Larne Lough South. Larne Lough North and Larne Lough Mid are within the Outer Lough Area and the majority of Larne Lough South is within the Inner Lough area (see Figure 18). NIEA (2008a, b and c) found these three areas to all be in a “Moderate” condition and they were downgraded on the biological classification. Although not directly related to microbiological classification any measures put in place to improve the status of the water body may well have an impact of the former.

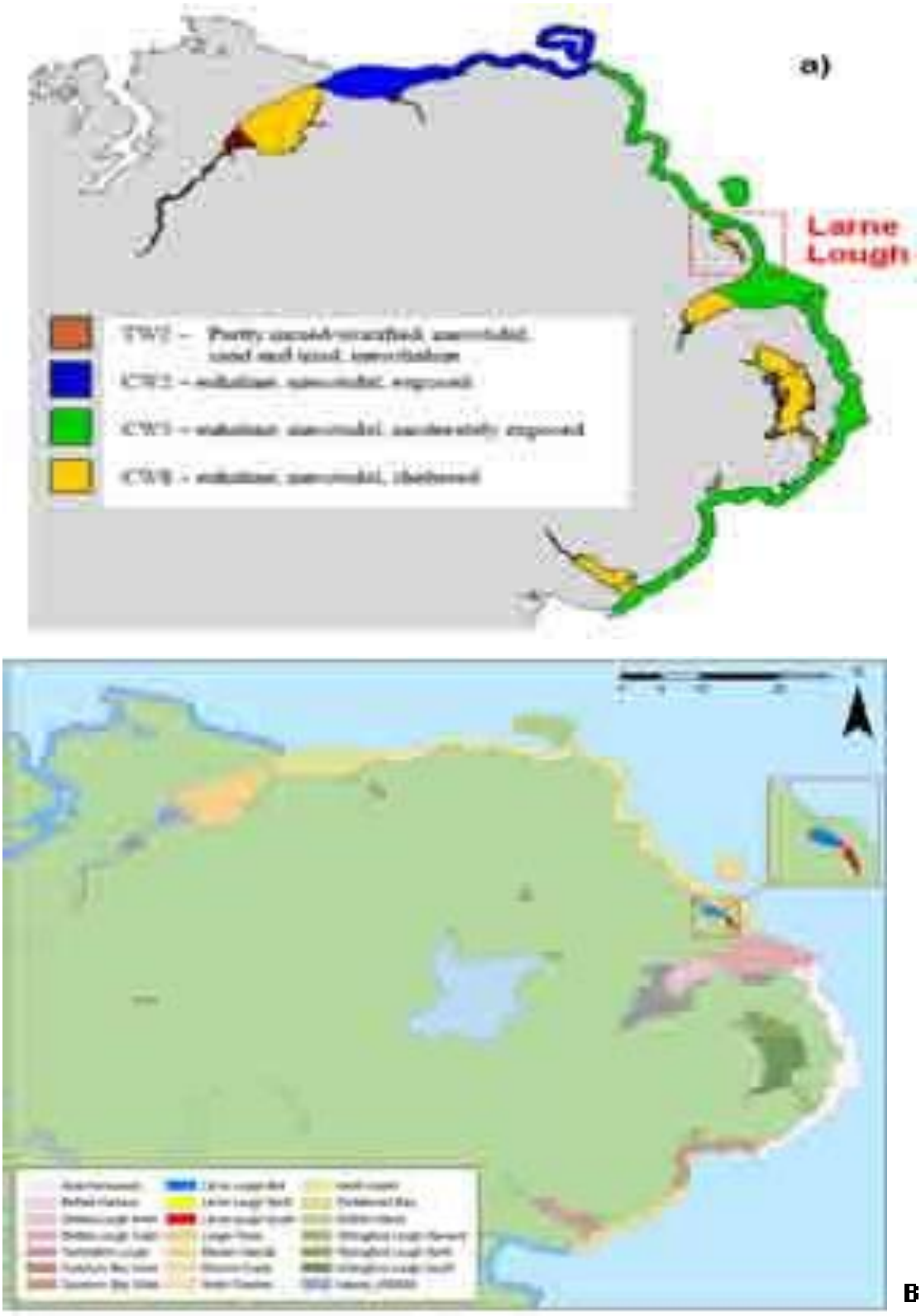


Figure 15: WFD water bodies within Northern Ireland based on a) typology and b) for transitional and coastal systems (taken from A. Sequeira *et al* 2006).

3. Bathymetry and Hydrography

The Outer Lough Area has a channel approximately 10m depth running along the eastern shore, whilst the western shore is comprised of large mudflats (Figure 16). The Inner Lough Area is generally less than 5m in depth and consists mainly of intertidal mudflats (Charlesworth and Service 2003).

Figure 16: Bathymetry of Larne Lough

Larne Lough has been the subject of detailed hydrological modelling as part of the DARD funded Sustainable Mariculture in northern Irish Sea Lough Ecosystems (SMILE) project, Ferreira *et al* (2007) and this report should be referred to for a more detailed explanation of the hydrodynamic studies described below (http://www.ecowin.org/smile/larnelough.htm). The SMILE project brought together data from a variety of water quality studies of Larne Lough and some summary data is represented in Table 4.

Table 4: General Characteristics of Larne Lough

Volume	(millions m^3)	27
Total Area	(km^2)	8
Maximum Depth	(m)	10
Catchment Area	(km^2)	115
Temperature Range*	(^oC)	4-16
Mean Salinity	(psu)	33
Residence Time	(days)	2-19
Freshwater run-off	(millions m^3 y^{-1})	101

Nutrients

Mean nutrient concentration (µmol l-1)				Nutrient load (ton year-1)	
Ammonium	Nitrate	Phosphorus	Silicate	Nitrogen	Phosphorus
2.57	8.13	0.63	9	300	6

Aquaculture

Licensed sites	6 (5 Classified)**
Total aquaculture area (km2)	0.9
Species	Mussels, oysters and clams

*localised temperature variations may exceed this range

** One bed not currently active

3.1 Physical Data

The SMILE project divided Larne Lough into a series of boxes in order to facilitate enhanced management of aquaculture within the area. These boxes were defined according to homogenous physical conditions (morphology, currents and vertical stratification). Morphology is analysed through bathymetry data. Vertical stratification assessment is carried out by comparing surface and bottom density as calculated from salinity and water temperature data collected by AFBI (Figure 17 shows the location of the SMILE sampling stations within the Lough).

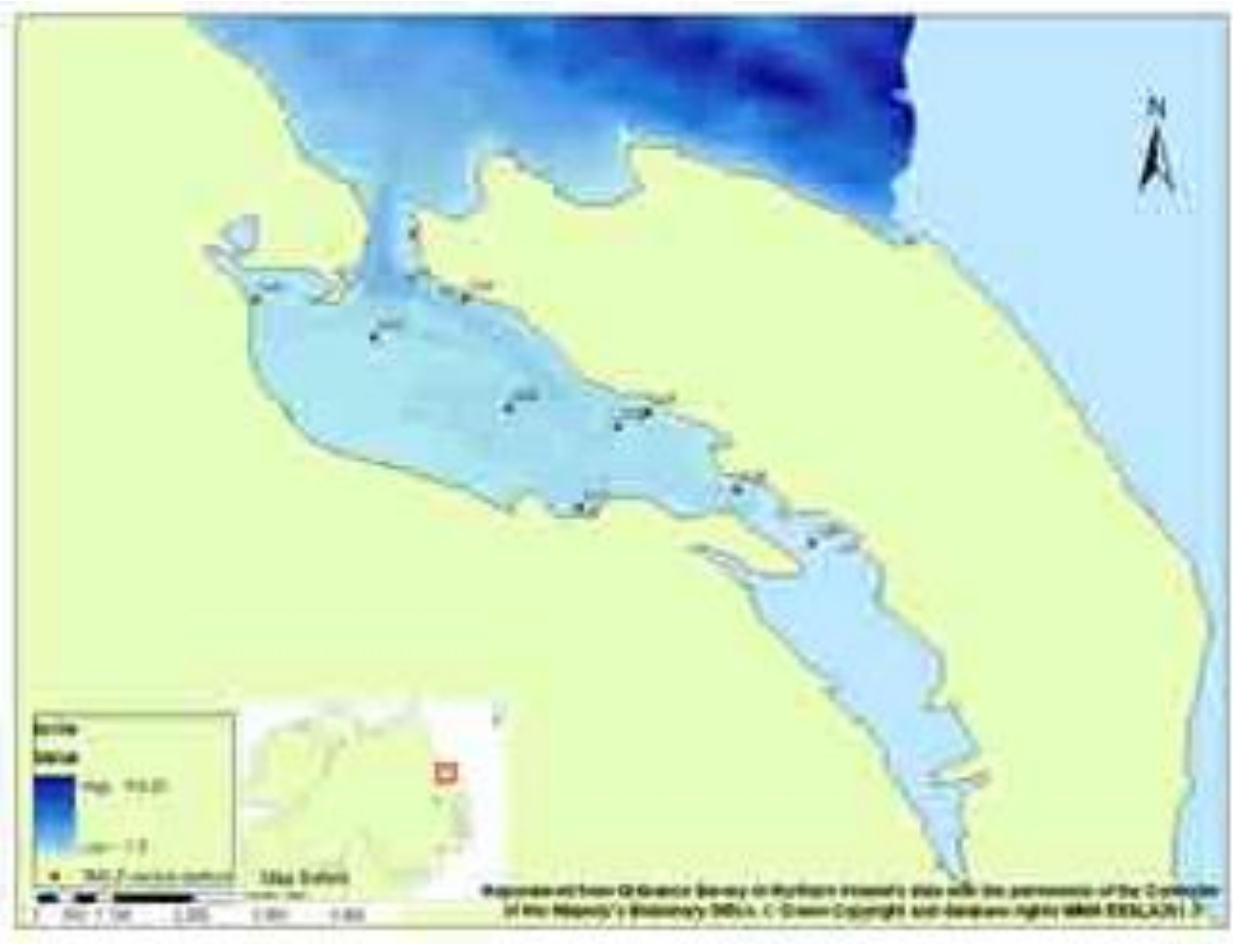


Figure 17: Water sampling stations in Larne Lough

The hydrographic boxes produced are illustrated within Figure 18. Each box is divided vertically into a surface (numbers 1-10) and a bottom box (numbers 11-20).

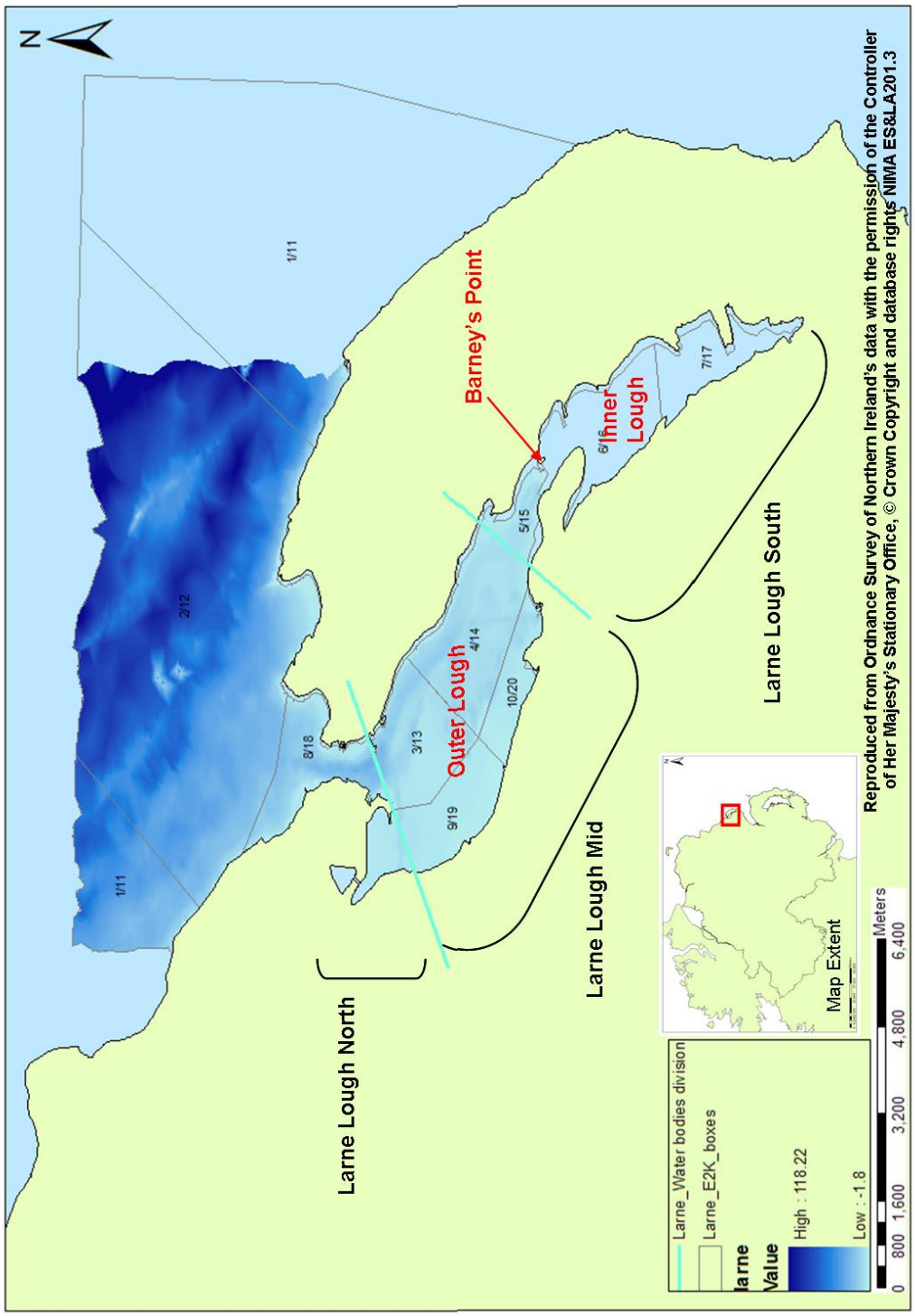


Figure 18: Larne Lough hydrographic management boxes. The bright blue lines show where the Lough has been divided as per the WFD management areas.

The aquaculture areas within Larne Lough are shown within Figure 19 along with the proposed hydrographic boxes. As can be seen from Figure 19 the aquaculture sites within Larne Lough are within boxes 4/14, 5/15 and 6/16.

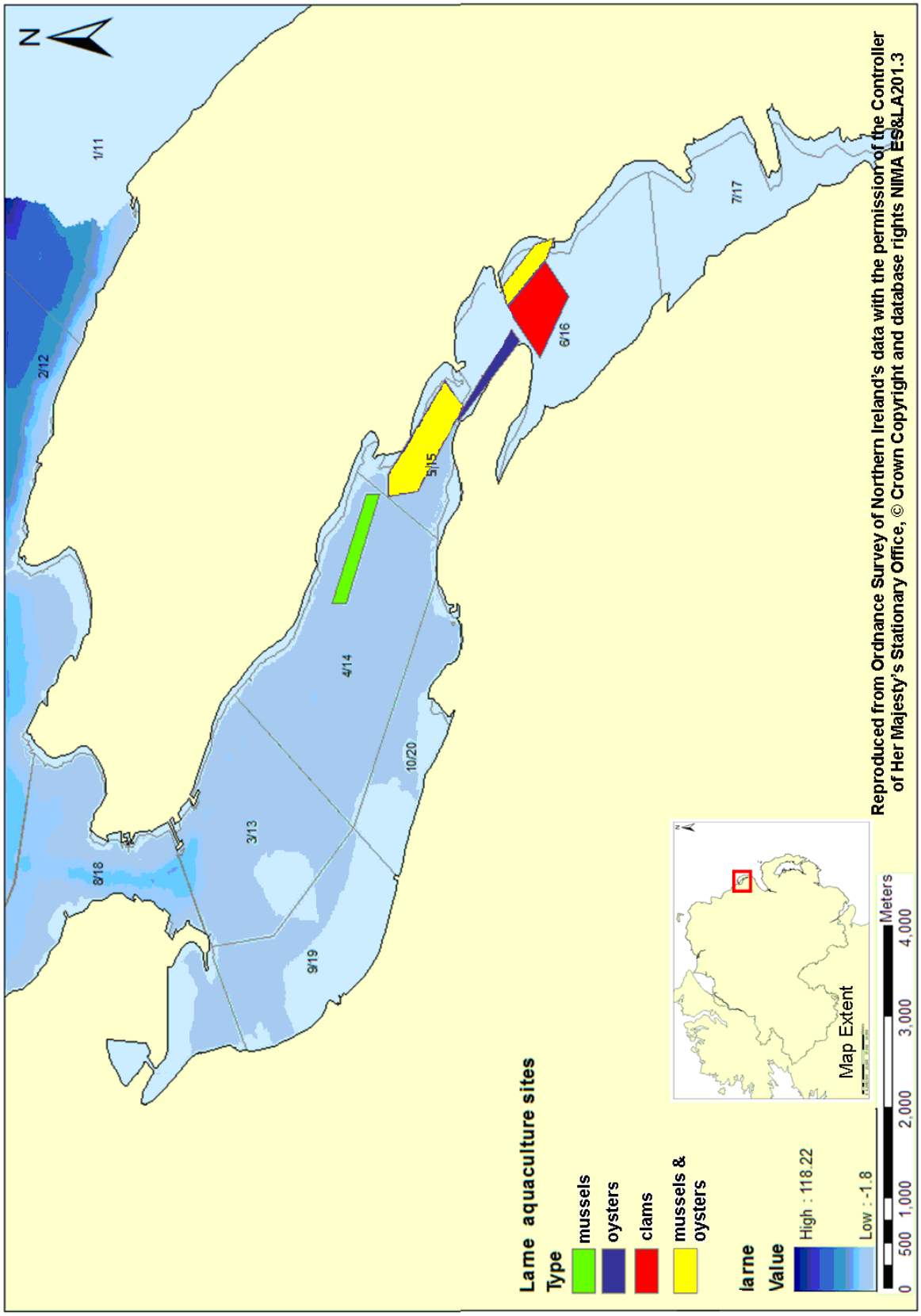


Figure 19: Aquaculture areas within Larne Lough overlapped with the proposed hydrographic boxes.

Detailed hydrographic modelling was undertaken within Larne Lough area as part of the SMILE project using both the Delft 3D and the Ecowin model. These models showed that the area within box 14 had a residence time of approximately 2-3 days and that boxes 15 and 16 had similar properties and residence times of up to 17days (Figure 20). These boxes had the some of the longest residence times within the whole system which indicates that this is poorly flushed area. This means that if a microbiological contaminant is released into the waters within the inner basin, in a period of around 17 days contamination levels will have decreased to 30% of the original concentration released. This is a worst case scenario as this modelling was based on a simulation using a conservative tracer i.e. an inert molecule. In reality this residence time would be less due to mortality within the microbiological contaminant.

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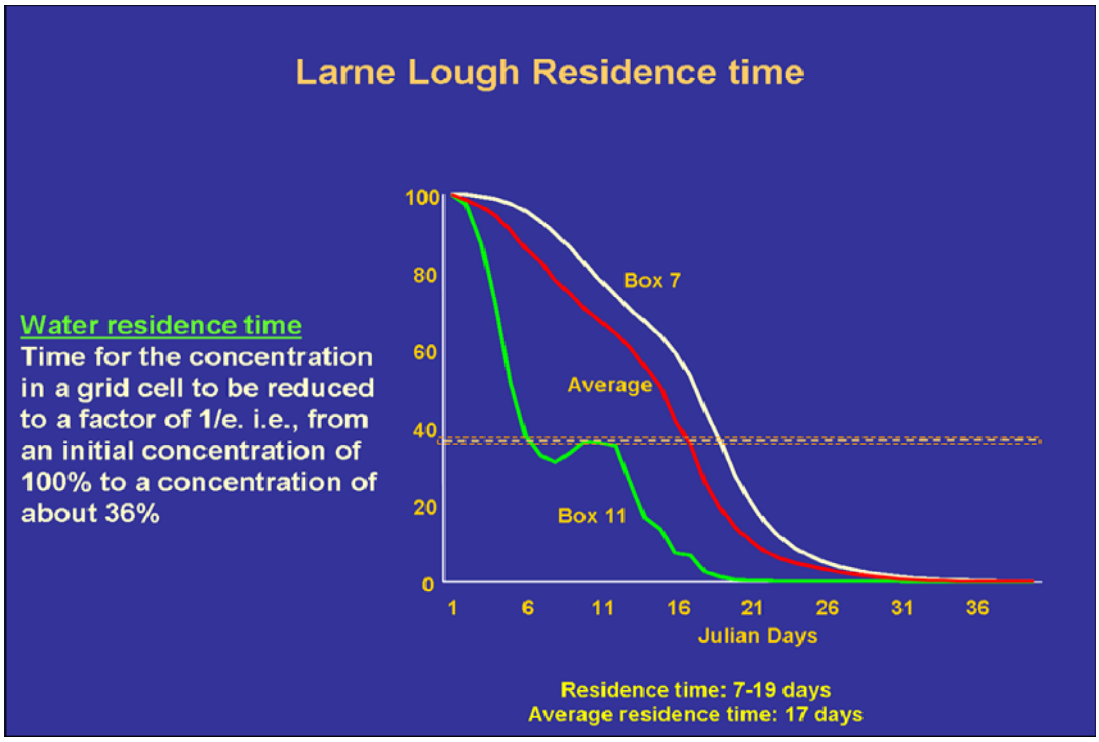


Figure 20: Water residence time within Larne Lough (taken from J. G. Ferreira *et al* 2006)

4. The Shoreline Survey

4.1 General

The survey was conducted over 3 days: 16th, 17th and 27th of July 2009. A total of 31.2 Kilometres was covered, encompassing all accessible areas of the shoreline of Larne Lough (Figure 21). Preceding days had periods of sustained rainfall therefore it was concluded that most discharges would be running during the period of the survey. As can be seen within Figure 21 a short stretch of shoreline (approximately 2.5km shown as a red line on Figure 21) between the towns of Glynn and Magheramourne was not covered within the survey due to issues with access resulting from the train tracks. This area was too shallow for access via boat.

Figure 21: Location of Shoreline Survey area within Larne Lough. Purple dots represent all observed potential sources of contamination into Larne Lough.

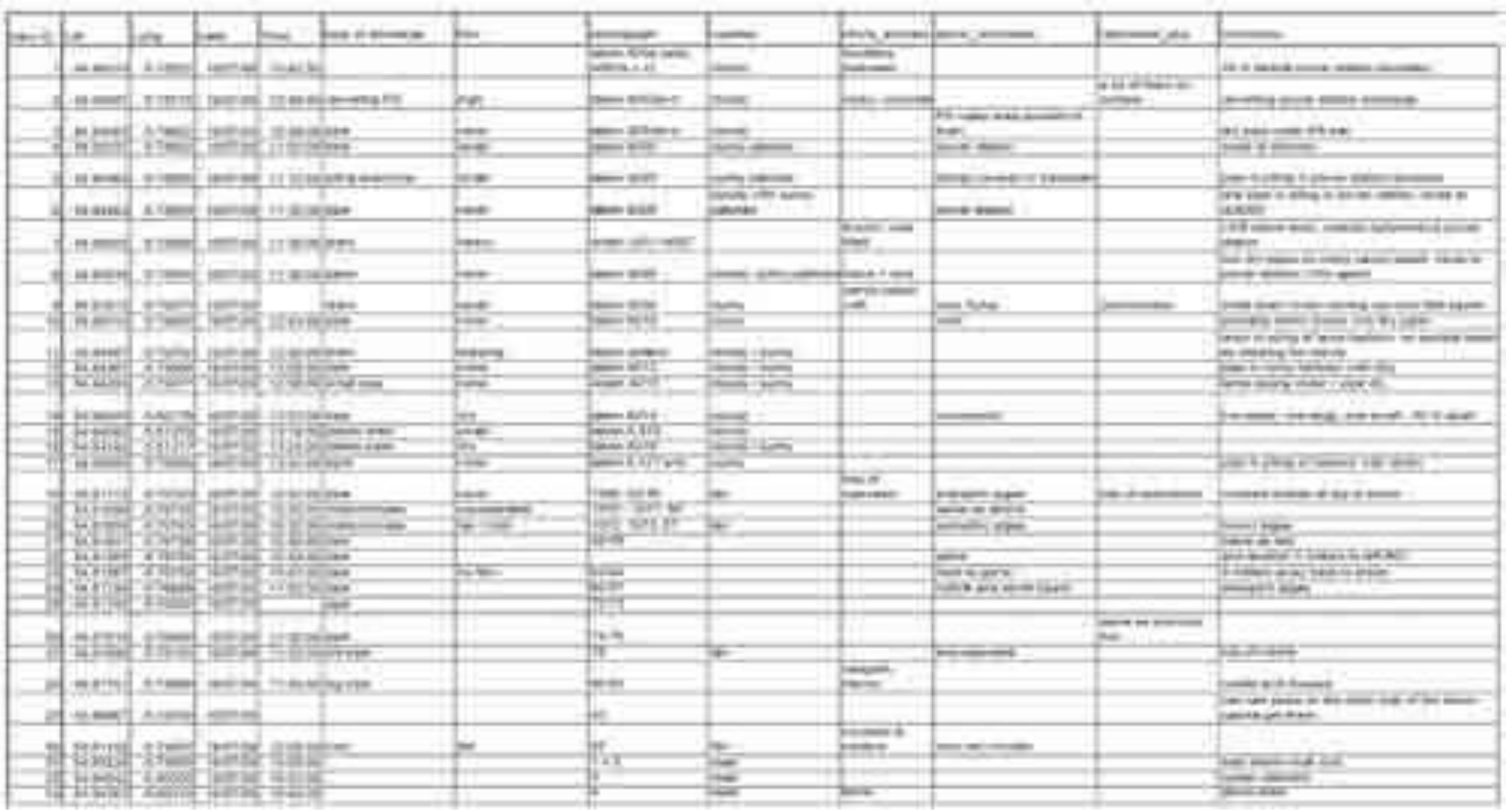
All running outfalls were sampled, with the exception of outfalls where no discharge was present, or where the outfall was clearly for drainage from a path. When a new running outfall was discovered and a sample collected the following procedures were undertaken:

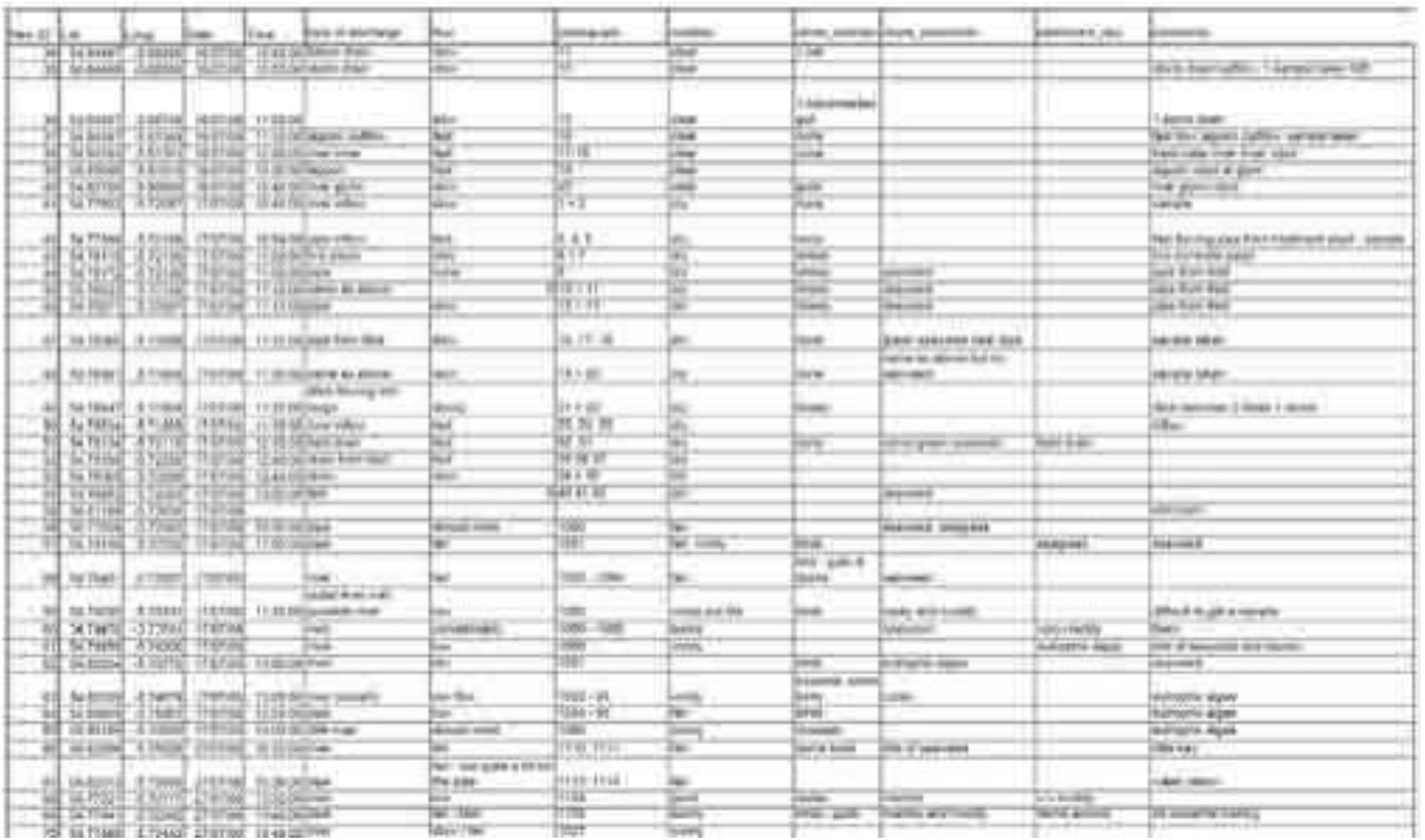
- GPS position of sample logged using a Garmin GPS 60,
- Site description and wildlife present recorded,
- Notes taken on litter present and discharge type (Table 5),
- Photographs of outfall taken,
- Water sample collected, labelled and stored in a sterile 200ml sample bottle (with long handle to prevent contamination).

On return to the laboratory all water samples were logged into the AFBI Food Microbiology Lab (UKAS accredited) for coliform analysis. All samples were vacuum filtered then the filters were incubated overnight at 37^{o}C. Suspects were isolated and confirmatory tests performed using Tryptone water. Total coliform count per 100ml was determined as was faecal coliform count per 100ml. Site descriptions and discharge types are summarised within Table 5.

The GPS positions of all sample sites were imported into GIS and all attributes added within a GIS project detailing all the information collected from the survey. A visual representation of all the water sample results can be seen within Figures 22 to 25.

Table 5: Site descriptions from Shoreline Survey. Each site represents an identified potential source of contamination.





4.2 Results

As it can be seen from Table 5 no contamination from sanitary waste was observed during the duration of the shoreline survey. Water samples were collected at thirty seven sites along the coast which were identified as having flowing discharges. All but three of the sites returned positive results for total coliforms and all but five of the sites returned positive results for faecal coliforms. When present, total coliform counts ranged from 20 – 115,000 coliforms/100ml, and faecal coliform counts from 60 - >30,000 faecal coliforms/100ml (Table 6). Faecal coliforms are coliforms which have a faecal origin. The dominant and most important of which is *Escherichia coli.* Therefore faecal coliform counts can be viewed as an indicator of *E. coli* contamination. Under Schedule 4 of The Bathing Water regulations 2008 (Statutory Instruments 2008 No. 1097) the Standards for *E. coli* (cfu/100 ml) within coastal and transitional waters are as follows; 250 (based upon a 95 percentile evaluation) represents “Excellent”; 500 (based upon a 95 percentile evaluation) represents “Good” and 500 (based upon a 90 percentile evaluation) represents “Sufficient”. Any values greater than 500 cfu/ml are classified as “Poor”. If the Bathing Water regulations criteria is applied to the results for Larne Lough water samples it can be observed that the majority of the counts would have been classified “Poor”, with only 11 out of a total of 37 samples being classified as either “Excellent” or “Good”. This is included for purely indicative purposes as no standards exist for effluent at source.

However it must be noted that the majority of the water samples collected were from discharge sources that had only a small amount of water flowing through them (see table 5) and the high concentrations of faecal coliforms observed within the samples would be diluted at high tide.

Table 6: Analysis of water samples collected during the shoreline survey

ID	Lat	Long	Date	Time	Total coliform 100mls	Faecal coliform 100mls	E.coli Equiv 100mls
4	54.84337	-5.78862	16/07/09	11:02:00	9000	2100	1617
5	54.84365	-5.78925	16/07/09	11:12:00	20	0	
7	54.84555	-5.78980	16/07/09	11:29:00	80	0	
9	54.83512	-5.78273	16/07/09		5500	200	154
15	54.84092	-5.81270	16/07/09	13:18:00	52000	30000	23100
19	54.81696	-5.76745	16/07/09	10:30:00	1400	200	154
30	54.81142	-5.75457	16/07/09	12:50:00	0	2600	2002
34	54.84467	-5.80296	16/07/09	10:45:00	710	700	539
35	54.84499	-5.80558	16/07/09	10:55:00	6600	3300	2541
37	54.84597	-5.81349	16/07/09	11:10:00	600	600	462
38	54.84763	-5.81761	16/07/09	12:00:00	11800	3500	2695
39	54.83046	-5.81015	16/07/09	12:20:00	30	0	
40	54.82750	-5.80600	16/07/09	12:40:00	2100	1200	924
41	54.77802	-5.72087	17/07/09	10:45:00	30000	9000	6930
42	54.77948	-5.72106	17/07/09	10:54:00	30000	30000	
43	54.78115	-5.72130	17/07/09	11:00:00	30000	9000	6930
46	54.78271	-5.72097	17/07/09	11:13:00	12000	6700	5159
47	54.78360	-5.71989	17/07/09	11:12:00	1700	800	616
48	54.78391	-5.71943	17/07/09	11:20:00	17100	8800	6776
49	54.78447	-5.71894	17/07/09	11:25:00	30000	21200	16324
50	54.78534	-5.71805	17/07/09	11:35:00	30000	12700	9779
57	54.78150	-5.72782	17/07/09	11:05:00	18400	2100	1617
58	54.78401	-5.72927	17/07/09		26700	10400	8008
59	54.79030	-5.73341	17/07/09	11:35:00	30000	30000	23100
60	54.79450	-5.73791	17/07/09		30000	30000	23100
61	54.79858	-5.74206	17/07/09		6500	400	308
62	54.80234	-5.74572	17/07/09	13:00:00	30000	2100	1617
63	54.80339	-5.74679	17/07/09	13:05:00	30000	30000	23100
64	54.80859	-5.75061	17/07/09	13:29:00	115000	30000	23100
65	54.80169	-5.74500	17/07/09	14:04:00	14000	5100	3927
66	54.82396	-5.75028	27/07/09	10:32:00	27200	1420	1093
67	54.82513	-5.75045	27/07/09	10:38:00	2100	60	46
68	54.77221	-5.72177	27/07/09	13:32:00	13100	90	69
69	54.77441	-5.72342	27/07/09	13:40:00	24800	530	408
70	54.77469	-5.72443	27/07/09	13:49:00	11900	420	323

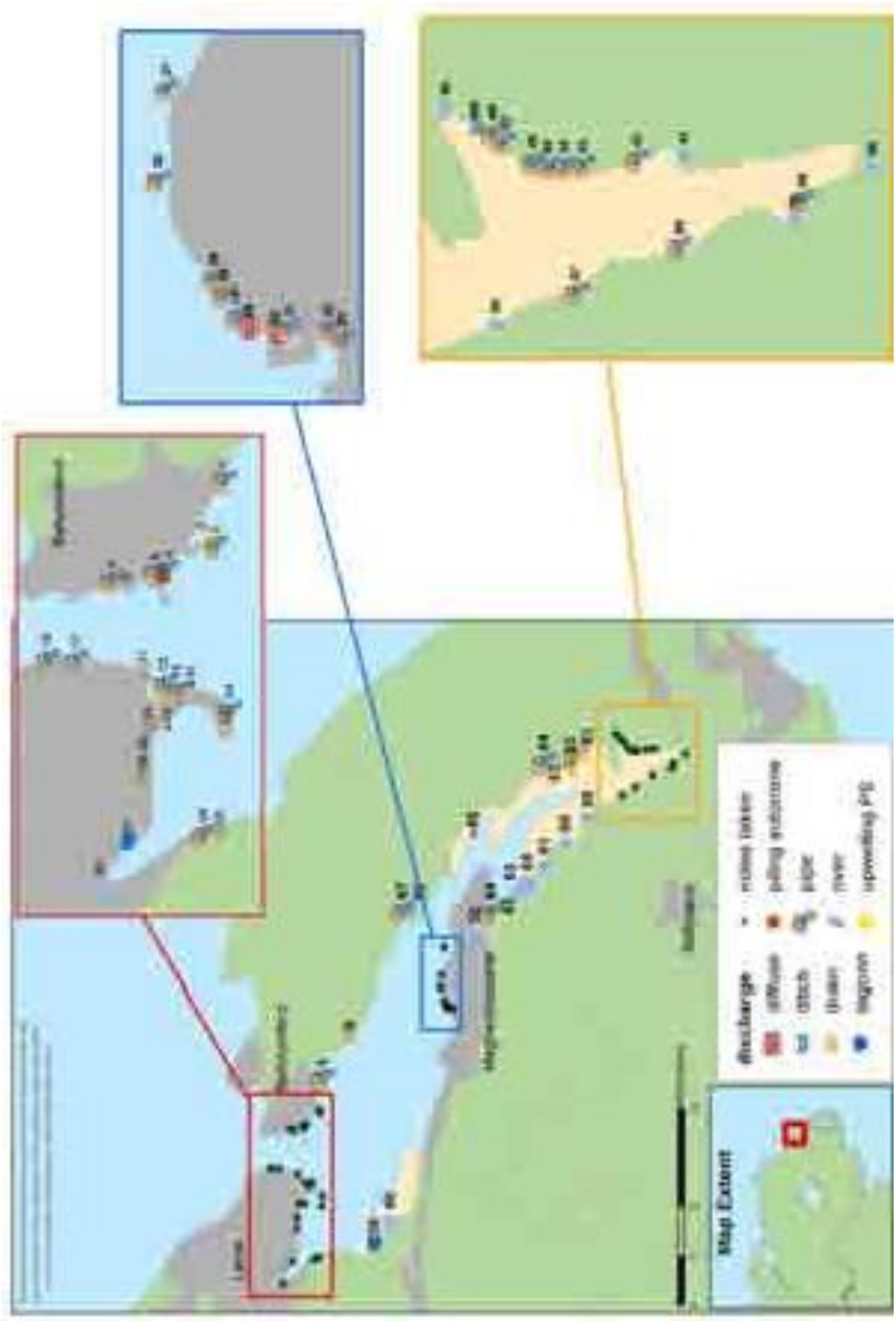


Figure 22: Observed potential sources of contamination into Larne Lough

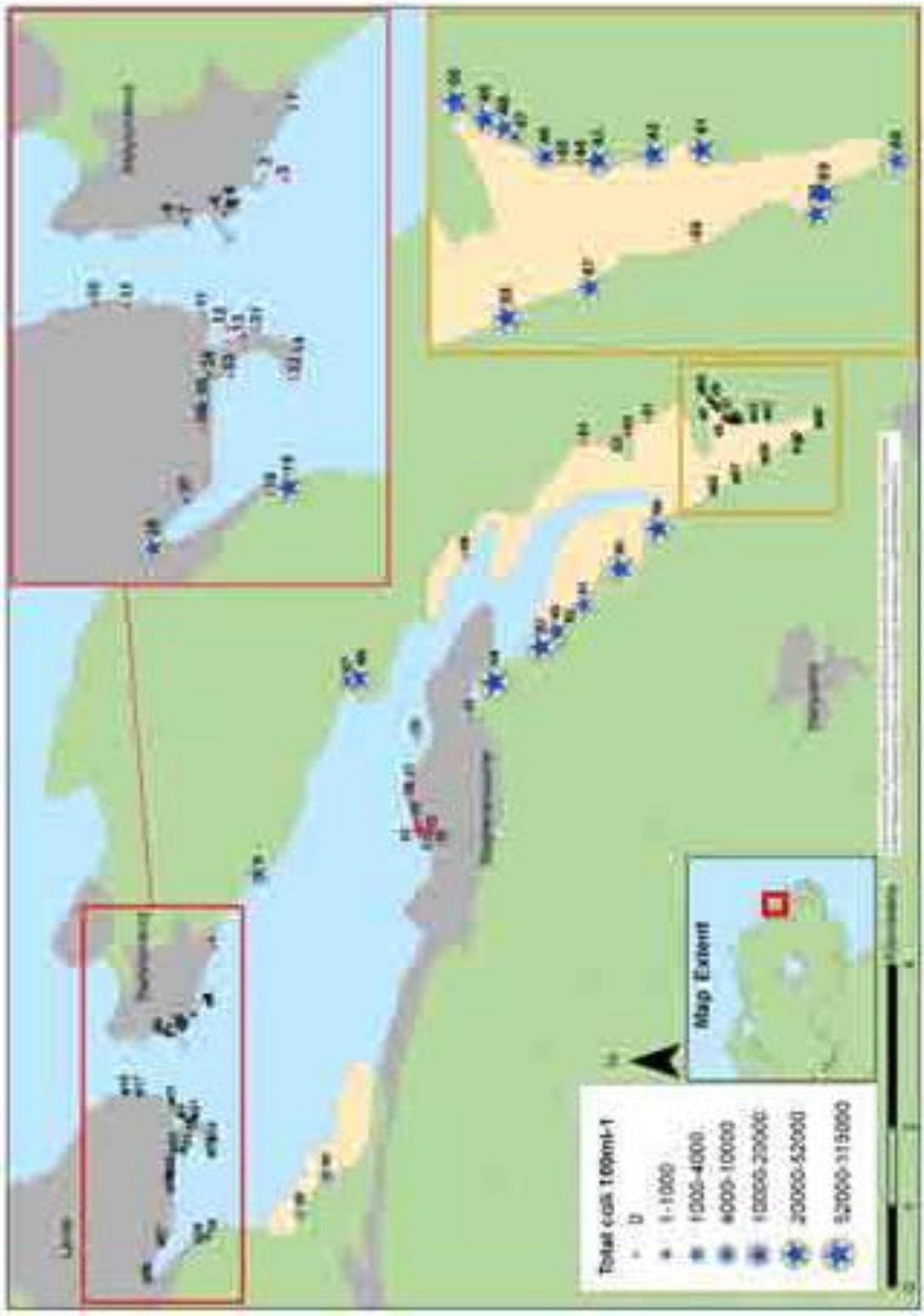


Figure 23: Total Coliform counts from water sample analysis

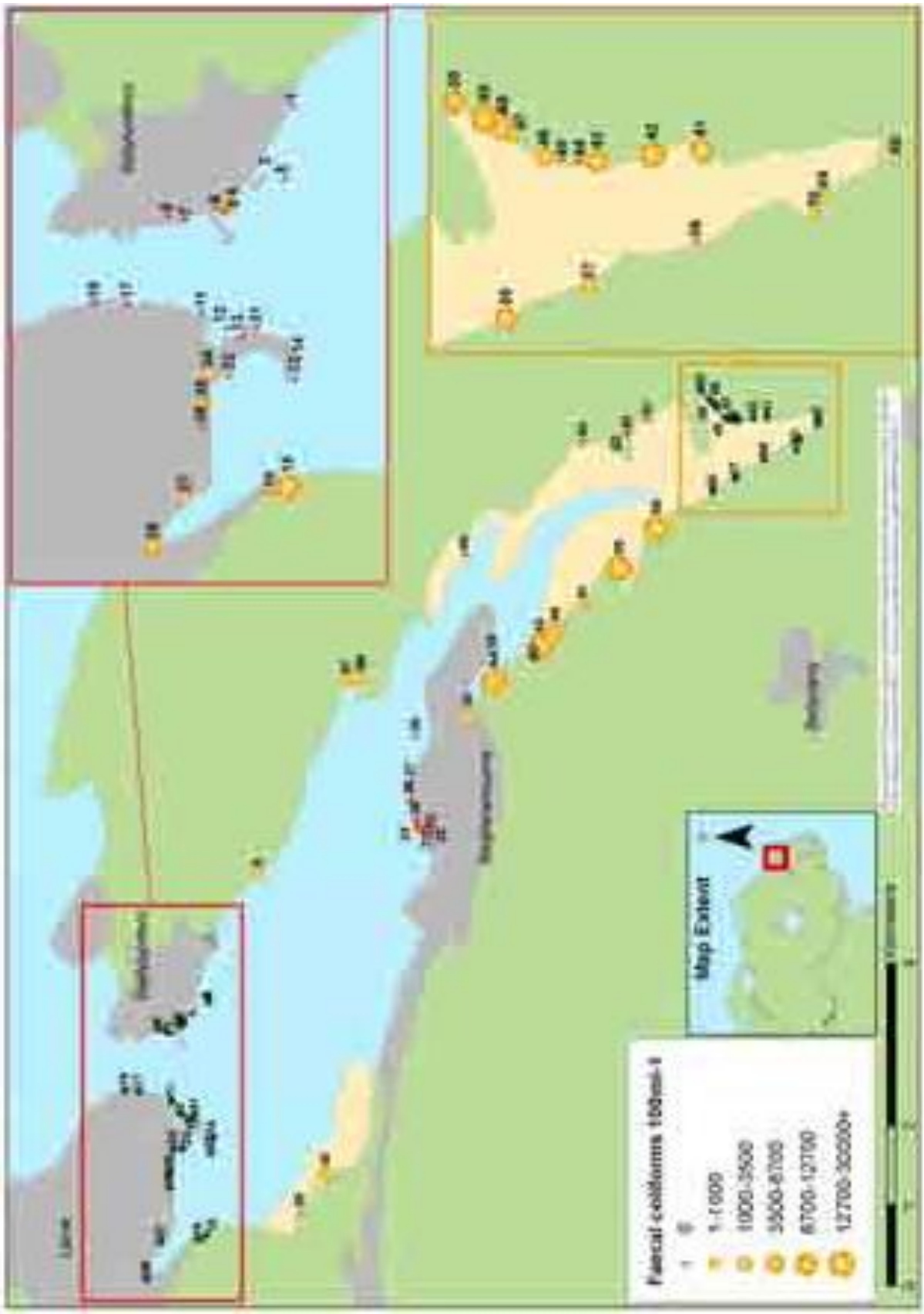


Figure 24: Faecal coliform counts from water sample analysis

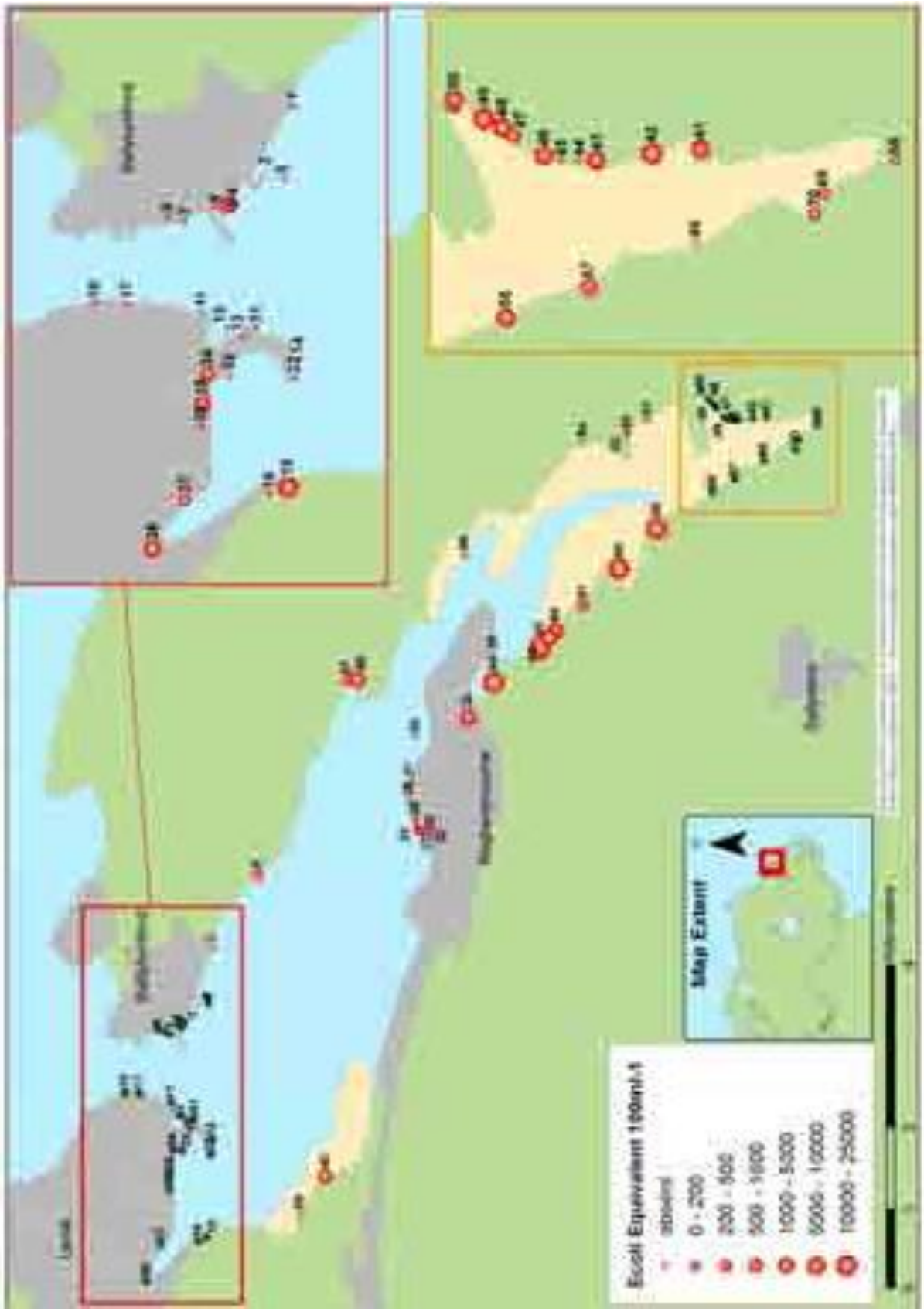


Figure 25: E-coli equivalent coliform counts from water sample analysis

4.3 Discussion

Numerous additional discharges into Larne Lough were observed within the Shoreline Survey that were not indicated on the available maps or charts. As the survey followed a period of heavy rainfall most outflows that looked to be in use were running and were therefore sampled. The majority showed evidence of faecal contamination, particularly those within the inner Lough in the vicinity of Ballystrudder primary treatment works and Ballycarry secondary treatment works (see Figure 27). However as mentioned previously the majority of the water samples collected were from discharge sources that had only a small amount of water flowing through them so therefore the high concentrations of faecal coliforms observed within the samples would be diluted at high tide. No evidence of sewage derived litter was observed along the areas of shoreline surveyed. There was also little evidence of shoreline contamination from wild or domestic animals although significant bird aggregations may occur within intertidal areas.

5. Discussion

5.1 Desktop Study

Larne Lough is a shallow marine bay which can be split into north and south basins, generally referred to as the Outer and Inner Lough areas (see Figure 26). The Outer Lough area has a channel approximately 10m depth running along the eastern shore, whilst the western shore is comprised of large mudflats. The Inner Lough area is generally shallower (less than 5m depth) and consists mainly of intertidal mudflats. The Outer Lough has been identified as well flushed with a short residence time whereas the Inner Lough is poorly flushed with a long residence time. In short this indicates that most major discharges will be flushed out of the system relatively quickly whereas the inner Lough has the potential to retain contaminants.

The desktop study identified several potential sources of microbiological contamination within Larne Lough. These included several wastewater treatment works, the Rivers Larne and Glynn along with numerous other small rivers, and the potential from runoff from urban and pasture land. Periods of heavy rainfall combined with an overloading of sewage systems and runoff from agriculture land into rivers has the potential to cause microbiological contamination within the shellfish aquaculture sites. All potential sources of contamination were sampled during the course of the Shoreline survey (see section 5.3 below for details).

5.2 Hydrodynamic modelling

Modelling work discussed within section 3 proposed the use of distinct boxes to enable the management of shellfish culture. The boxes within Larne Lough are shown in Figure 26 and are numbered according to their model unit (top layer/bottom layer).

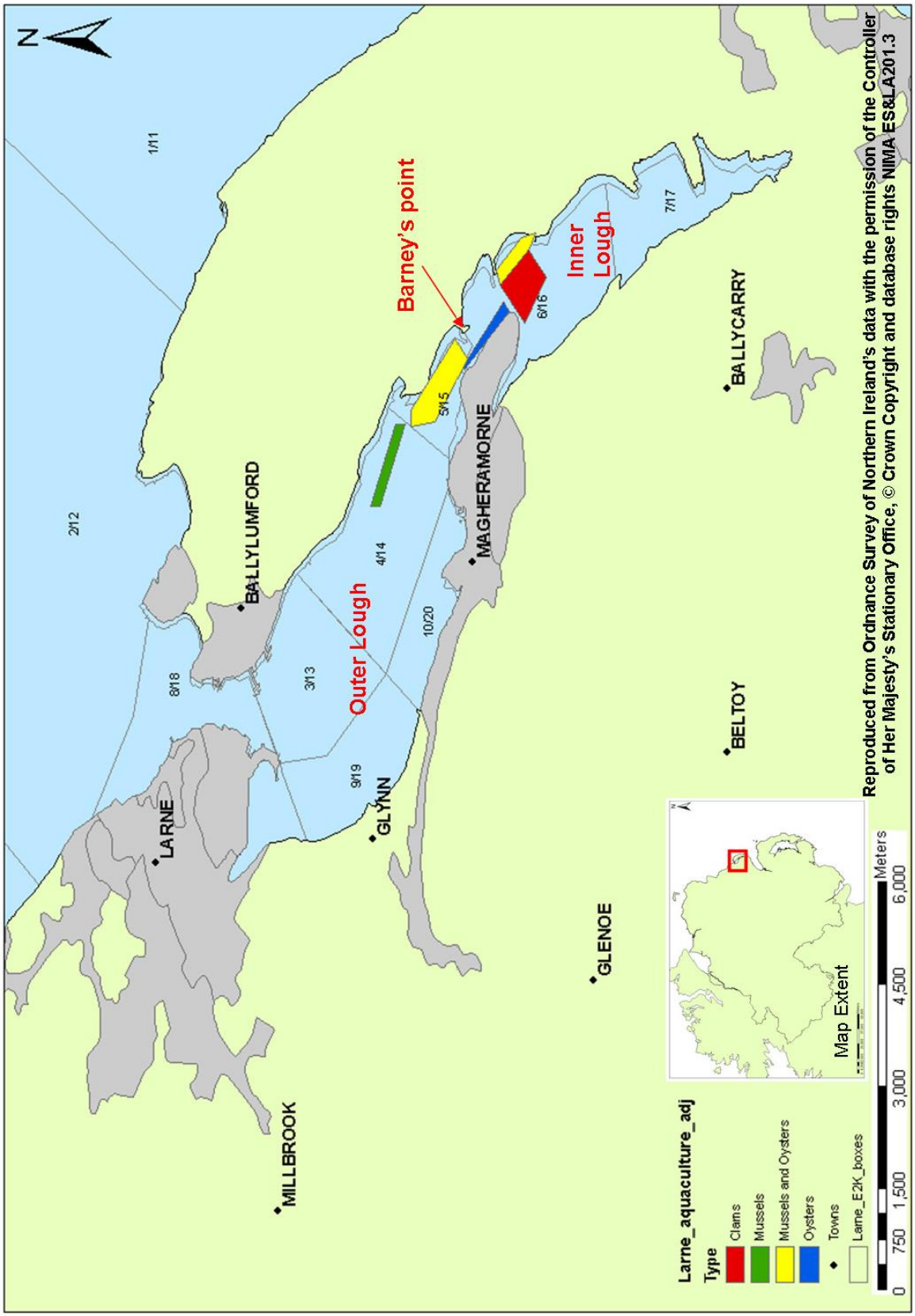


Figure 26: Model boxes within Larne Lough

The model boxes are split into two layers at their mid depth to form a surface and bottom box. For the purposes of this Sanitary Survey the bottom boxes were chosen as they will represent the conditions prevailing in the locality of the shellfish bed. As can be seen from the map in Figure 26 the aquaculture sites within Larne Lough are located within Boxes 14, 15 and 16. Figure 27 shows the licensed aquaculture beds in relation to the sewage outfalls and faecal coliform levels at the shoreline survey sample collection sites.

Figure 27: Aquaculture sites, sewage outfalls, and faecal coliform levels from water samples collected during the shoreline survey, within Larne Lough

Examination of residence times for the boxes using a simulated conservative tracer suggested that boxes, 15 and 16 will have similar residence times. As box 16 is within the inner Lough and close to a number of discharges it is felt that both the oyster, clam and mussel beds within this site should be sampled, and as box 14 is closest to the power station at Ballylumford (which, as previously mentioned, has the potential for bringing sewage derived contaminants into the lough, through its water cooling system), it is recommended that the mussel bed within this box also be sampled.

5.3 Shoreline Survey

The shoreline survey identified several further potential sources of microbiological contamination along the shoreline of Larne Lough that were not found on any maps throughout the course of the desktop study. In total 37 sites of potential microbiological contamination were sampled. Water samples collected at 11 out of 37 of these sites, indicated that faecal coliform contamination was low and within acceptable levels (as defined within the Bathing Water Regulations 2008). The remaining sites had high levels of faecal coliform contamination that would have been classified as “Poor” under the Bathing Water Regulations. However the majority of potential sources of contamination sampled were low flowing discharges which would have been diluted at high tide. Reference to bathing water standards is indicative only.

Throughout the course of the shoreline survey no large aggregations of birds were observed. Over wintering birds may however have a localised impact, which would require a separate study to quantify.

The shoreline survey identified the inner Lough area as a having several localised point sources of microbiological contamination.

5.4 Recommendations

Taking the above into account it is considered that microbiological sampling of shellfish flesh can be rationalised to the four sites shown in Figure 28. Samples are to be collected within 250m of the designated co-ordinates in Table 7. It is felt that four representative monitoring points (RMP) are required even though the areas in which the shellfish sites are located all have similar residence times due to the potential for microbiological contamination within the inner Lough identified during the shoreline survey and the fact that more than one species of shellfish is cultured within these areas. A mussel, an oyster and a clam aquaculture site will need to be sampled within model box 16 as this is the inner most box, and the aquaculture site within box 14 will also need to be sampled (for the reasons already stated). It is felt that the sites sampled within box 16 will be representative of the sites within box 15 so therefore they will not require to be sampled.

Table 7: Coordinates of the RMP within Larne Lough

Site no	Species	Box No.	Latitude	Longitude	Name of Bed
1	mussels	14	54° 49.5622' N	005° 45.8006' W	Outer Millbay (Dougold)
2	mussels	16	54° 48.5883' N	005° 44.0909' W	White Quay (Don Saville)
3	oysters	16	54° 48.5883' N	005° 44.0909' W	White Quay (Don Saville)
4	clams	16	54° 48.4978' N	005° 44.3169' W	Prospec Ireland (Prospec Ireland)

Samples should be collected monthly at high tide to allow for worst case scenario and to account for seasonal changes.

The sampling therefore represents the beds with the highest residence time, most risk to accumulate contaminants and covers the three taxa harvested.

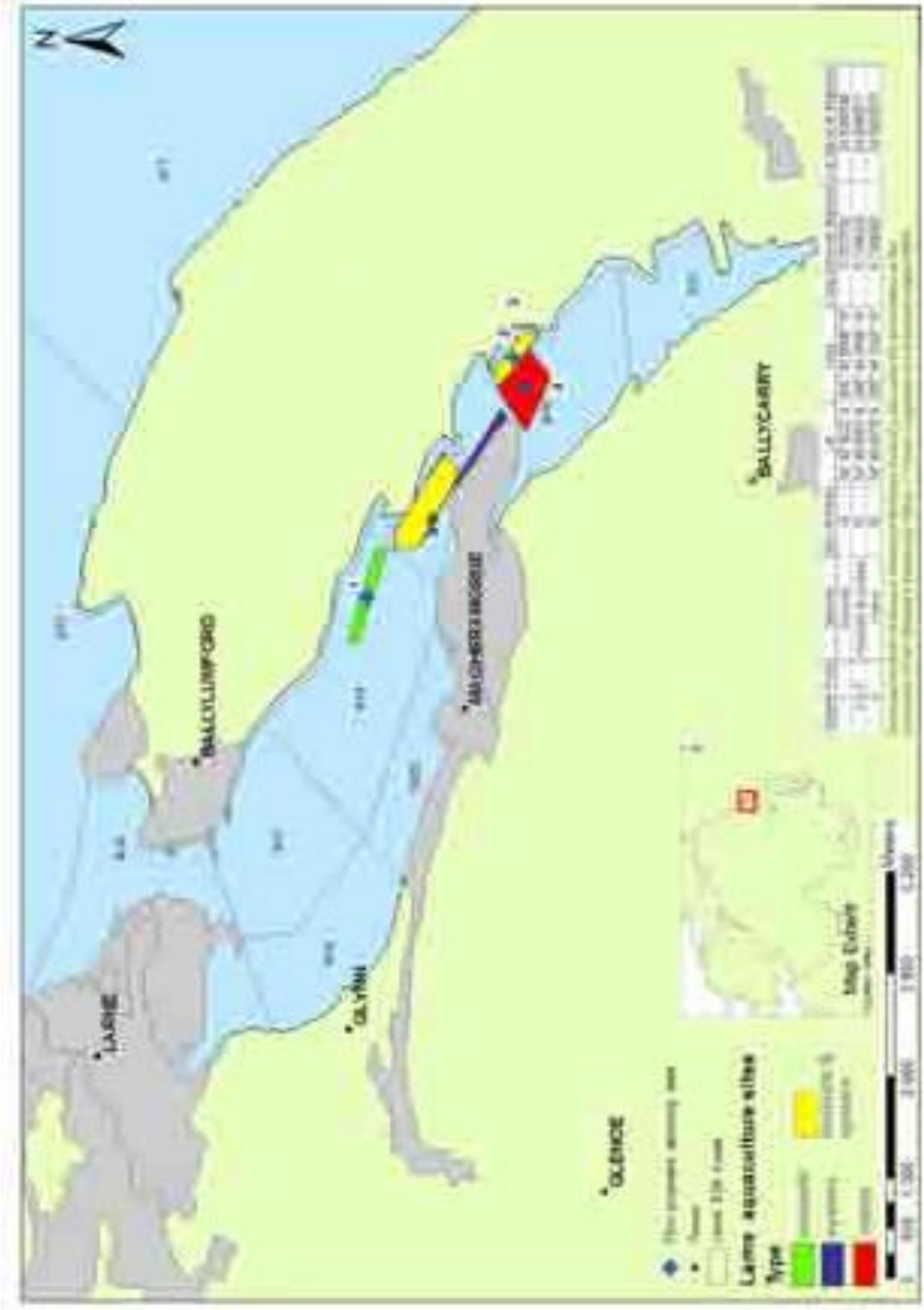


Figure 28: Proposed aquaculture sites for sampling

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Glossary

Euhaline A reference to waters containing between 30 and 40 parts per thousand of dissolved salts; that is, in most cases, normal sea water.

Eutrophication – 'the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorous, causing an accelerated growth of algae and higher plant life to produce an undesirable disturbance to the balance of organisms in the water and to the quality of the water concerned' (EEC, 1991a).

GIS – Geographic Information System.

Halocline – the sharp vertical gradient of salinity in stratified waters.

Mesohaline - Moderately brackish water with a salinity range of 5-18 ppt.

Mesotidal - coastal ocean or waterway with a moderate mean tidal range, eg, between 2 and 4 meters

Population Equivalent (PE) - refers to the amount of oxygen demanding substances whose oxygen consumption during biodegradation equals the average oxygen demand of the waste water produced by one person (http://stats.oecd.org/glossary/detail.asp?ID=2086)

Primary Treatment – Urban sewage is predominantly water. It is preliminarily screened to remove large solids it is then macerated to produce a slurry and grit extracted. In primary treatment facilities this slurry is placed in settlement tanks so that larger suspended solids can settle to the bottom of the tank. The resulting liquid will still have a high Biochemical Oxygen Demand (BOD) and a certain proportion of suspended solids (Clark, R. B. (ed.) 1997. pp27, Marine Pollution. Oxford University Press)

Ramsar - The Ramsar Convention (The Convention on Wetlands of International Importance, especially as Waterfowl Habitat) is an international treaty for the conservation and sustainable utilisation of wetlands. It is named after the town of Ramsar in Iran.

Salinity – a measure of salt in seawater measured in p.s.u. (practical salinity units) which is a dimensionless number.

Secondary Treatment – The resulting liquid from primary treatment (see above) is then filtered through beds of 5-15cm rocks or coke which provides a large surface layer for bacteria to degrade organic mater in the water as it percolates through the bed (Clark, R. B. (ed.) 1997. pp27, Marine Pollution. Oxford University Press)

Stratified - water bodies that have a sharp vertical interface, above and below which is water of different physical and/or chemical properties.