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Sanitary Survey Report
and
Sampling Plan
for Carlingford Lough

Produced by

AQUAFACT International Services Ltd

On behalf of

The Loughs Agency
The Food Standards Agency in Northern Ireland
The Sea Fisheries Protection Authority

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Glossary

AFBI	Agri-Food and Biosciences Institute
ANOVA	Analysis Of Variance
APP	Average Physical Product
ASP	Amnesic Shellfish Poisoning
Bathymetry	The measurement of water depth at various places of a water body
Benthic	Of, pertaining to, or occurring at the bottom of a body of water
Biogenic	Produced by living organisms or biological processes
Bioturbation	The stirring or mixing of sediment or soil by organisms
BOD	Biochemical Oxygen Demand
BTO	British Trust for Ornithology
Bysso-pelagic drifting	Drifting or dispersal that is aided by long byssus threads produced by young post-larval mussels
Byssus Threads	Strong filaments by which mussels attach themselves to fixed surfaces
CD	Chart Datum
CEFAS	Centre for Environmental, Fisheries & Aquaculture Science
CSO	Central Statistics Office
CSO	Combined Sewer Overflow
DARD	Department of Agriculture and Rural Development
DED	District Electoral Divisions
Depuration	The process of purification or removal of impurities
Detrital/Detritus	Non-living, particulate, organic fragments which have been separated from the body to which they belonged
DSP	Diarrhetic Shellfish Poisoning
DWF	Dry Weather Flow
EC	European Communities
E. coli	*Escherichia coli*
EMS	Environmental Monitoring Stations
Epifauna	Animals living on the surface of marine or freshwater sediments
Epiflora	Plants living on the surface of marine or freshwater sediments
Fecundity	A measure of fertility or the capability to produce offspring
Fetch	The distance a wave can travel towards land without being blocked
FSA in NI	Food Standards Agency of Northern Ireland

Gamete	A reproductive cell that fuses with another gamete to produce a zygote, which develops into a new individual
Gametogenesis	The formation or production of gametes or reproductive cells
Genotype	The genetic makeup of an organism
Geometric Mean	The nth root of the product of n numbers (The average of the logarithmic values of a data set, converted back to a base 10 number).
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine environmental Pollution
GIS	Geographical Information Systems
GPS	Global Positioning System
GSM	Global System for Mobile Communication
Heterozygosity	Having two different alleles of the same gene
Hydrodynamic	Forces in or motions of liquids
Hydrography	The description and analysis of the physical conditions, boundaries, flows and related characteristics of water bodies
IID	Infectious Intestinal Disease
INAB	Irish National Accreditation Board
Interspecific Competition	Competition for resources between different species
Intraspecific competition	Competition for resources between members of the same species
Intervalvular	Between valves
I-WeBS	Irish Wetland Bird Survey
LAT	Lowest Astronomical Tide
Marpol 73/78	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. Marpol is short for Marine Pollution, 73 for 1973 and 78 for 1978.
Metamorphosis	The transformation from the larval to the adult form that occurs in the life cycle of many invertebrates and amphibians
MPN	Most Probable Number
MSD	Marine Sanitation Device
Multilocus	Occurring at more than one position or locus on a chromosome
NAP	Nitrates Action Programme
ND	Not Detectable
NH_4	Ammonium
NIEA	Northern Ireland Environment Agency
NISRA	Northern Ireland Statistics and Research Agency

NITB	Northern Ireland Tourist Board
Nitrification	The conversion of ammonia to nitrate
NI Water	Northern Ireland Water
NO_2	Nitrite
NO_3	Nitrate
NoV	Norovirus
NRFA	National River Flow Archive
NRL	National Reference Laboratory
OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
P	Phosphorus
PAH	Polycyclic Aromatic Hydrocarbons
Pathogenic	Capable of causing disease
PCB	Polychlorionated Biphenyls
PCP	Pentachlorophenol
p.e.	Population Equivalent
Plankton/Planktonic	Pertaining to small, free-floating organisms of aquatic systems
PMFSC	Pacific States Marine Fisheries Commission
Pseudofaeces	Material rejected by suspension or deposit feeders as potential food before entering the gut
PSP	Paralytic Shellfish Poisoning
PSU	Practical Salinity Units
RAMSAR	A term adopted following an international conference, held in 1971 in Ramsar in Iran, to identify wetland sites of international importance, especially as waterfowl habitat.
Regulation (EC) 854/2004	REGULATION (EC) No 854/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption
RIB	Rigid Inflatable Boat
RMP	Representative Monitoring Point
RNA	Ribonucleic Acid
SAC	Special Area of Conservation
SFPA	Sea Fisheries Protection Authority

SMILE	Sustainable Mariculture in northern Irish Lough Ecosystems
SOA	Super Output Areas or ward
SPA	Special Protection Area
SPM	Suspended particulate Matter
SPS	Sewage Pumping Station
SS	Suspended Solids
STW	Sewage Treatment Works
Suspension feeders	Animals that feed on small particles suspended in water
TBTO	Tributyl Tin Oxide
Telemetry	The measurement and transmission of data from remote sources to receiving stations for recording and analysis
TPP	Total Physical Product
UKAS	United Kingdom Accreditation Service
UKHO	United Kingdom Hydrographic Office
Vector	A carrier, which transmits a disease from one party to another
WeBS	Wetland Bird Survey
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Works

1. Executive Summary

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

Carlingford Lough is a 51km^2 flooded river valley located along the eastern coast of Ireland between Co. Louth in the Republic of Ireland and counties Armagh and Down in Northern Ireland. Extensive expanses of intertidal flats (more sand than mud) occur along the southern shore, particularly between Greenore Point and Carlingford Harbour. The flats in the area are broken by outcropping reefs and some shingle deposits and saltmarsh on drier higher rocks. Intertidal mudflats are also present in Mill Bay, where dwarf eelgrass (*Zostera nolti*) is present. These flats are very important feeding grounds for wildfowl and waders. The shore around Rostrevor Bay is a sheltered boulder shore very rich in invertebrate species. The Lough is generally shallow with water depths ranging from 2 to 5m, the narrow navigation channel can extend to depths of 25m with the deepest part of the Lough reaching a depth of 36m. The Lough supports populations of blue mussels (*Mytilus edulis*), Pacific oysters (*Crassostrea gigas*) and razor clams (*Ensis* spp.), all of which have designated fisheries within the Lough.

This report attempts to document and quantify all known sources of pollution to the Lough. It was concluded that the main sources of pollution in Carlingford Lough come from direct sewage discharges into the Lough and into the Newry/Clanrye River, mainly from the Warrenpoint WWTW, Newry WWTW and the untreated discharges from Omeath and Greenore sewage schemes. In addition, there is a large quantity of intermittent discharges, septic tanks and overflows draining into the Newry/Clanrye River which ultimately flow into the Lough. There are also some seasonal contributions from wildfowl (birds), boats (shipping and recreational activity) and tourism.

The northwestern section of the Lough is more vulnerable to pollution due to the shallow depths (increased suspended sediment concentration) and weak currents compared with the outer part of the Lough. It was on the basis of hydrodynamic and spatial features (i.e. areas of similar depth, tidal currents, suspended sediment levels and freshwater influence) that resulted in the Lough being divided into 6 production areas.

Each of these production areas contain one Representative Monitoring Point (RMP) for each of the species cultivated within it i.e. blue mussel, Pacific oyster and razor clam. In total there are 8 RMPs in the Lough to be sampled on a monthly basis.

2. Overview of the Fishery/Production Area

2.1. Location/Extent of Growing/Harvesting Area

The shellfish designated waters in Carlingford Lough cover an area of approximately 37km^2 and can be seen in Figure 2.1. Of this area, 25km^2 is in Northern Irish waters and approximately 12km^2 in Republic of Ireland waters. Pacific oyster and bottom mussel cultivation is predominant in Carlingford Lough.

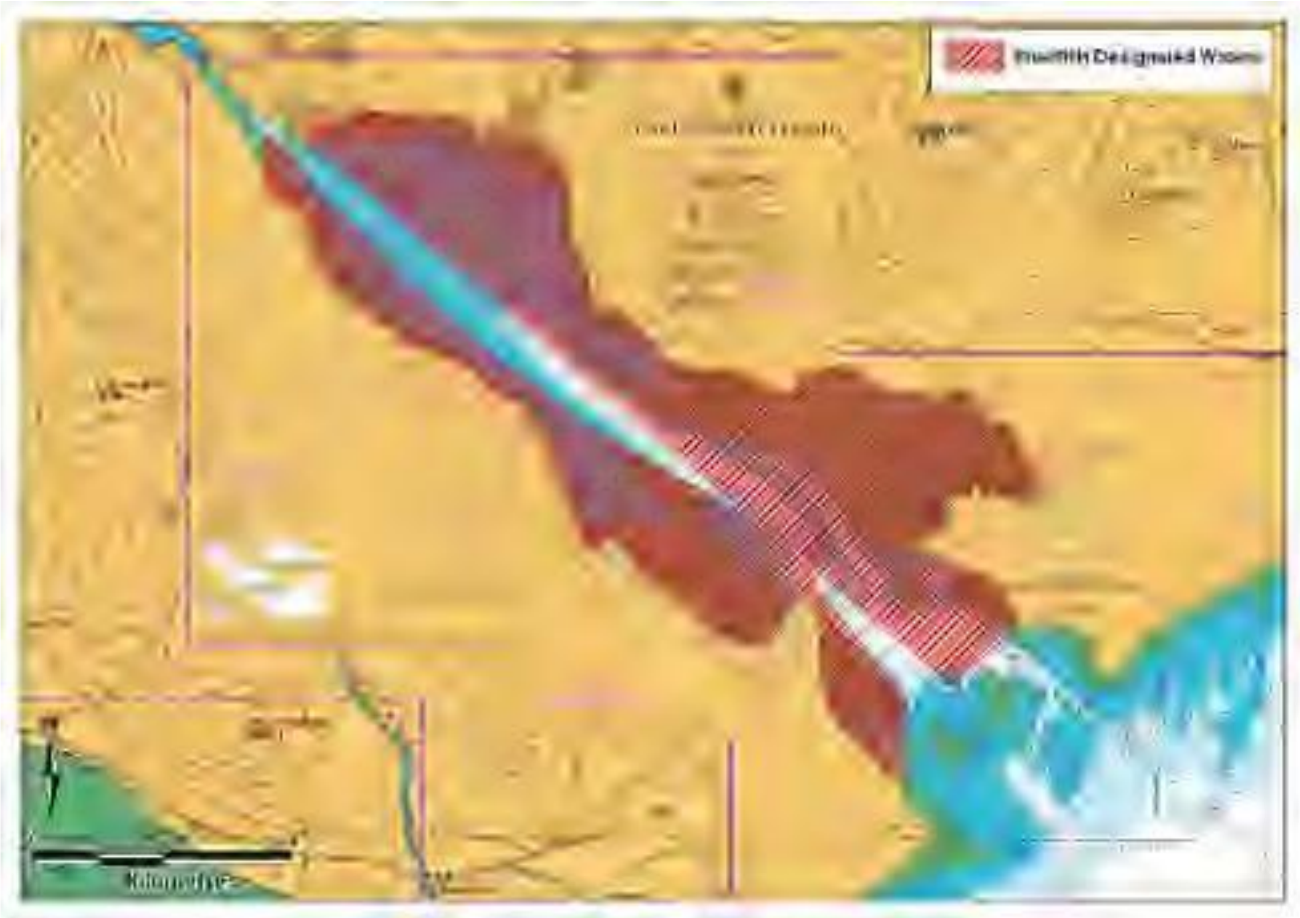


Figure 2.1: Shellfish designated waters within Carlingford Lough.

Figure 2.2 shows the current locations of licenced shellfish sites within Carlingford Lough. The northern shore is currently licenced for mussels and oysters in the locations shown in Figure 2.2. It should be noted that the Fairgreen site (see location in Figure 2.2) is currently only licenced for Pacific oysters; however, there is the possibility that this site will also be licenced for mussels in the near future. The southern shore is licenced for oysters, mussels and clams. Approximately 74% of the licenced area is occupied by mussels (8.26km^2), 2.17km^2 by oysters, 0.2km^2 by oysters and clams and 0.57km^2 by mussels and oysters.

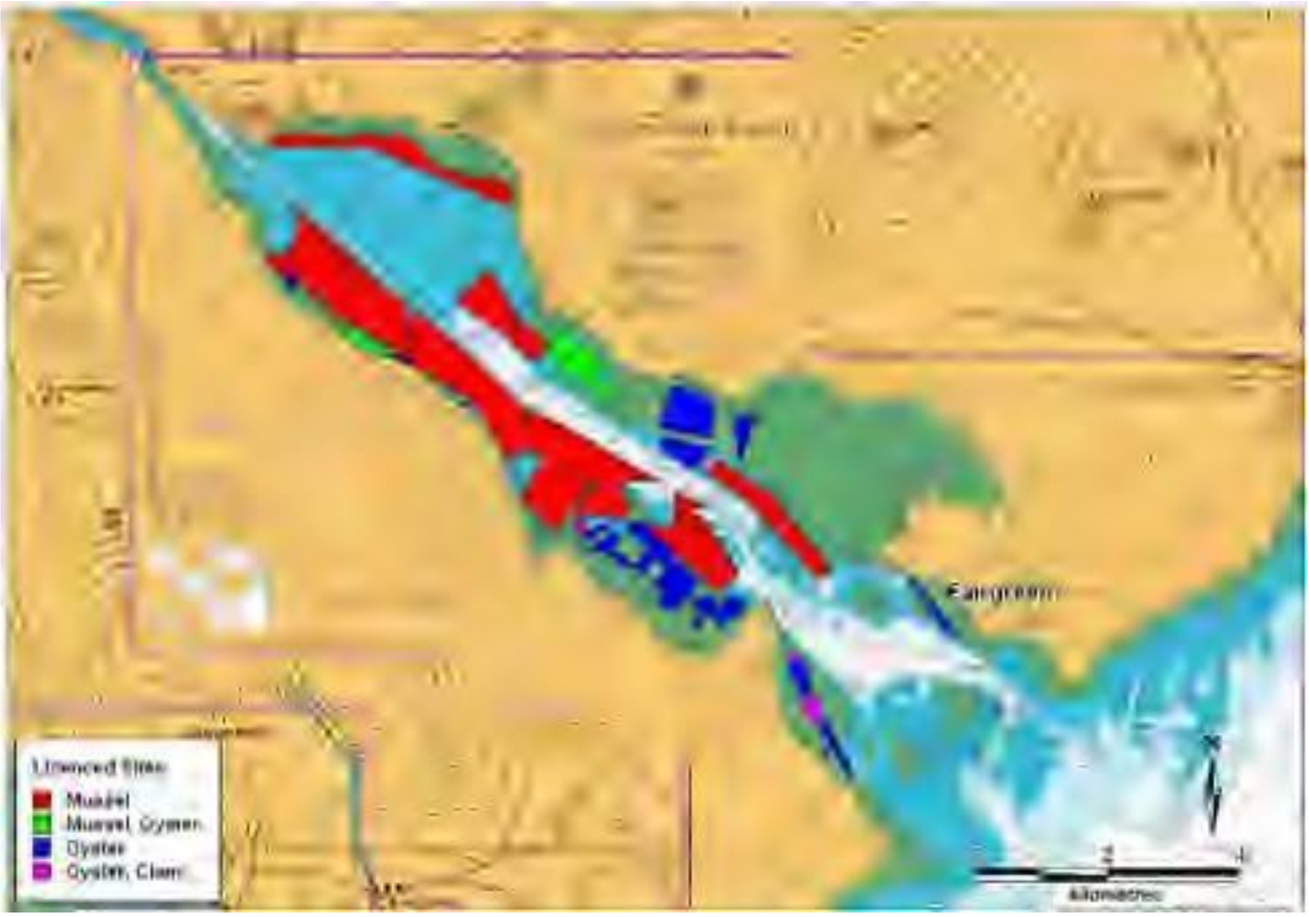


Figure 2.2: Licenced harvesting areas located within Carlingford Lough (Source: DARD & Loughs Agency).

2.2. Description of the Area

Carlingford Lough is a 51km^2 flooded river valley located along the eastern coast of Ireland between Co. Louth in the Republic of Ireland and counties Armagh and Down in Northern Ireland (see Figure 2.3). It is approximately 15km in length and approximately 3.7km in width at its widest point. The Newry (or Clanrye) River flows into the Lough through Warrenpoint, Co. Down and the Lough has a catchment of approximately 474km^2. The Lough is generally shallow with water depths ranging from 2 to 5m, the narrow navigation channel can extend to depths of 25m with the deepest part of the Lough (36m) located approximately 2.3km north of Carlingford Harbour, Co. Louth and 1.3km south of Killowen Point, Co. Down.

The Lough exhibits a range of unusual and rich littoral communities (Ramsar, 2008). The shore 1.5km north from Killowen Point (Rostrevor Bay) is a sheltered boulder shore which is very rich in invertebrate species. A number of normally sublittoral species occur here within the intertidal zone including the anemone *Metridium senile*, the featherstar *Antedon bifida*, the starfish *Solaster endeca* and the green sea urchin

Psammechinus miliaris. Saltmarsh vegetation is located along the foreshore of Mill Bay. This area supports the largest remaining intact block of saltmarsh in Northern Ireland. Small patches of saltmarsh are also located on the southern shoreline on the drier sections of outcropping reefs and at the landward edge of the site. Dwarf eelgrass *Zostera noltii* covers the intertidal mudflats in this area. This is an important food source for the internationally important population of pale bellied Brent geese at the site.

Figure 2.3: Location of Carlingford Lough.

Stony banks or shingle are found along the southern shore and vary in width from less than a metre to approximately 50m, south of Ballagan Point. The perennial vegetation of the upper beach of these shingle banks is wide ranging, well developed and often stable.

Extensive expanses of intertidal flats (more sand than mud) occur along the southern shore, particularly between Greenore Point and Carlingford Harbour. The flats in the area are broken by outcropping reefs and some shingle deposits and saltmarsh on drier higher rocks. These flats are very important feeding grounds for wildfowl and waders. Patches of green algae (*Ulva* sp. and *Enteromorpha* sp.) and lugworm (*Arenicola marina*) casts occur in places, while fucoid seaweeds are common on the more stony flats. Abundant barnacles and lichens are also present on many of the rocks. Eelgrass beds (*Zostera* sp.) are also found on the flats along the southern shore.

Carlingford Lough is designated as a Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar Site. The southern shoreline is designated in the Republic of Ireland as an SAC due to the presence of two Annex I habitats of the EU Habitats Directive: stony banks and drift lines (Site Name: Carlingford Shore, Site Code: IE002306). Grey seals and harbour seals (Annex II species) are also present within the site. Part of the Co. Louth shoreline is designated as an SPA due to the presence of a nationally important population of wintering cormorants (Site Name: Carlingford Lough SPA, Site Code: IE004078). A range of other waterfowl species occur, notably Brent goose, oystercatcher, dunlin, bar-tailed godwit, redshank and turnstone. The bar-tailed godwit is an Annex I species of the EU Birds Directive. In addition, an SPA is present along the Co. Down coastline due to the presence of two Annex I species: the common tern and the sandwich tern (Site Name: Carlingford Lough, Site Code: UK9020161). The Ramsar Site (Site Code: UK12004) overlaps the Co. Down SPA and is designated due to the populations of sandwich terns and light bellied Brent goose.

Carlingford Lough supports a wide diversity of species, especially shellfish. The designated shellfish area within the Lough is 37km^2 and the licenced shellfish sites cover an area of 10.2km^2. Pacific oysters and mussels are the dominant shellfish cultivation species in the Lough.

Land cover along the coastal regions of the catchment area is a mixture of forestry, pastures, agricultural land, natural vegetation, with small areas of arable land. The inland regions of the catchment are dominated by a mix of pastures, natural grassland and moors and heathland. The main freshwater input is the Newry (Clanrye) River. Other rivers on the northern side of the Lough include the Ryland, Moygannon, the Rostrevor, the White Water, the Ballincurry, the Cassey Water and the Ghann.

The population of the catchment is approximately 61,000[1]. The main settlements are Newry City with a population of 27,433[2], Warrenpoint with a population of 7,000[2] and Rostrevor with a population of 2,444[2], all of which are in Northern Ireland. On the southern side of the Lough, Carlingford has a population of 623[3] people and Omeath a population of 439[3].

[1] Calculation explained in Section 4.2.1

[2] Source: Northern Ireland Statistics website: www.nisra.gov.uk. Crown copyright material is reproduced with the permission of the Controller of HMSO. 2001 Data

[3] Source: Central Statistics Office website http://census.cso.ie/Census/TableViewer/tableView.aspx?ReportId=75471 2006 Data

There are a number of shellfish fisheries within the Lough. Lobster and crab fishing is carried out around the Lough's entrance (CLAMS, 2005). This pot fishery is more productive on the stretch of rocky coastline between Ballagan Point and Gyle's Quay. A number of boats involved in potting also fish for mussels seasonally. There are some scallop beds present in low densities within the Lough and these are occasionally harvested by divers. The principal dredge fishery within the Lough is for mussels. There is a public fishery within the main channel of the Lough and a number of small boats dredge this fishery for wild mussels (CLAMS, 2005). Wild mussel dredging is an important source of shellfish products in Carlingford Lough, corresponding to about 1000 tonnes per year (Ferreira *et al.,* 2007). Aquaculture producers also fish here for mussel seed (CLAMS, 2005). The mussel settlement in this fishery is variable but in good years amounts of up to 3,000 tonnes are not uncommon (CLAMS, 2005). Periwinkles and cockles are gathered at low tide in the Lough. Periwinkles are predominantly picked along the coast from Greenore to Carlingford while some cockle harvesting occurs at Mill Bay.

Carlingford Lough has numerous functions and processes, which are listed below:

- Dispersal of water quality characteristics brought about by the movement of water masses;
- Nutrient exchange;
- Bioturbation;
- Gas exchange;
- Primary and secondary production;
- Provision of habitats and ecosystems;
- Supports plankton populations, benthic infauna, epifauna, fish populations, bird populations;
- Propagule (e.g. seed stock/larvae) dispersion brought about by the movement of water masses;
- Fishing activities;
- Navigation/trade;
- Aquaculture activities;
- Socio-economic activities; and
- Recreational activities.

Oyster beds themselves perform important ecological functions including supporting oyster populations, providing refuge for fish and invertebrates that retreat from exposed intertidal flats and estuarine marshes at low tide, and serving as spawning and nursery areas for numerous species of aquatic animals. Oysters are an important food source for many other animals including starfish, crabs, fishes, and waterfowl.

Beds of mussels provide substratum for epiflora and epifauna, while the mussel matrix provides interstices and refuges for a diverse community of organisms. The buildup of mussel muds under the bed supports infaunal species and in sedimentary habitats, the underlying sediment may support an enriched infauna. The diversity and species richness increases with the size and age of the mussel bed. In sedimentary habitats, mussel beds stablise and modify the substratum, and mussel beds have a higher biodiversity than surrounding mudflats. Mussel beds may also form biogenic reefs and *Mytilus edulis* is considered to be a habitat engineer (Holt *et al*, 1998; Hild & Günther, 1999).

In addition, larval production represents a significant contribution to the zooplankton, forming an important food source for herring larvae and carnivorous zooplankton (Seed & Suchanek, 1992). Dense beds of bivalve suspension feeders increase turnover of nutrients and organic carbon in estuarine (and presumably coastal) environments by effectively transferring pelagic phytoplanktonic primary production to secondary production (pelagic-benthic coupling) (Dame, 1996).

Ferreira *et al.* (2007) produced a carrying capacity assessment of Carlingford Lough as part of the SMILE (Sustainable Mariculture in northern Irish Lough Ecosystems) Project. The approach used in the SMILE Project combined field data acquisition, experimental work on shellfish feeding behaviour, database and GIS and the implementation and coupling of various types of dynamic models. The concept of carrying capacity of an ecosystem for natural populations is derived from the logistic growth curve in population ecology, and defined as the maximum standing stock that can be supported by a given ecosystem for a given time. Carrying capacity estimates in terms of aquaculture (production) may be defined as the stocking density at which production levels are maximised without having a negative impact on growth. Subsequently, carrying capacity for shellfish culture has been further defined as the standing stock at which the annual production of the marketable cohort is maximized. This will differ substantially from the ecological carrying capacity and is termed the sustainable aquaculture carrying capacity.

For bivalve suspension feeders, the dominant factors determining the sustainable carrying capacity at the ecosystem scale are primary production, detrital inputs and exchange with adjacent ecosystems. At the local scale, carrying capacity depends on physical constraints such as substrate, shelter and food transported by tidal currents, and density-dependent food depletion. Mortality is a critical factor, and high seed mortality due to sub-optimal seed deployment, particularly in bottom culture, is a key factor in reducing production yield and economic competitiveness.

Table 2.1 shows the summary of SMILE model results for Carlingford Lough. The average physical product (APP) is defined as the ratio between harvested biomass (total physical product – TPP) and seed biomass, and is a measure of ecological and economic efficiency. The total production per unit of area is also shown and varies within the system depending on the location of the aquaculture.

Table 2.1: Summary of SMILE model results for Carlingford Lough (Source: Ferreira *et al.* 2007).

Ecosystem and Species		Aquaculture Area (ha)	TPP (tons)	APP	TPP per ha
Carlingford Lough	Blue Mussel	868 (ROI & NI) 167.9 (NI)	1300 (ROI & NI) 320 (NI)	2.5 (NI)	1.5 (ROI & NI) 1.9 (NI)
	Pacific Oyster	198 (ROI & NI) 83.2 (NI)	280 (ROI & NI) 110 (NI)	5.3 (NI)	1.4 (ROI & NI) 1.3 (NI)

2.3. Description of Species

2.3.1. Blue Mussels (*Mytilus edulis*)

2.3.1.1. General Biology

Mytilus edulis is a filter feeding marine bivalve. It occurs from the high intertidal to the shallow subtidal attached by fibrous byssus threads to suitable substrata. It is found on the rocky shores of open coasts attached to the rock surface and in crevices, and on rocks and piers in sheltered harbours and estuaries, often occurring as dense masses. They are a gregarious species and at high densities form dense beds of one or more (up to 5 or 6) layers, with individuals bound together by their byssus threads. Young mussels colonise spaces within the bed increasing the spatial complexity, and the bed provides numerous niches for other organisms. Overcrowding results in mortality as underlying mussels are starved or suffocated by the accumulation of silt, faeces and pseudofaeces, especially in rapidly growing populations (Richardson & Seed, 1990). Death of underlying individuals may detach the mussel bed from the substratum, leaving the bed vulnerable to tidal scour and wave action (Seed & Suchanek, 1992).

Growth rates in *Mytilus* spp. are highly variable. Part of this variation is explained by genotype and multilocus heterozygosity (Gosling, 1992) but the majority of variation is probably environmentally determined. The following factors affect growth rates in *Mytilus* species: temperature, salinity, food availability, tidal exposure, intraspecific competition for space and food and parasitism.

Several factors may work together, depending on location and environmental conditions (Seed & Suchanek, 1992) or the presence of contaminants (e.g. Thompson *et al.*, 2000). For example, in optimal conditions *Mytilus edulis* can grow to 60-80mm in length within 2 years but in the high intertidal growth is significantly lower, and mussels may take 15-20 years to reach 20-30mm in length (Seed & Suchanek, 1992). Bayne *et al.*

(1976) demonstrated that between 10-20°C water temperature had little effect on scope for growth and Carter & Seed (1998) showed that latitudinal variations in temperature influences shell structure in *Mytilus* species.

Several factors contribute to mortality and the dynamics of *Mytilus edulis* populations e.g. temperature, desiccation, storms and wave action, siltation and bio-deposits and intra- and inter-specific competition, but predation is the single most important source of mortality. Many predators target specific sizes of mussels and, therefore, influence population size structure. The vulnerability of mussels decreases as they grow, since they can grow larger than their predators preferred size. *Mytilus* sp. may be preyed upon by neogastropods such as *Nucella lapillus*, starfish such as *Asterias rubens*, the sea urchin *Paracentrotus lividus*, crabs such as *Carcinus maenas* and *Cancer pagurus*, fish such as *Platichthys flesus* (plaice), *Pleuronectes platessa* (flounder) and *Limanda limanda* (dab), and birds such as oystercatcher, eider, scooter, sandpiper, knot, turnstone, gulls and crows (Seed & Suchanek, 1992; Seed, 1993).

Fouling organisms, e.g. barnacles and seaweeds, can also increase mussel mortality by increasing weight and drag, resulting in an increased risk of removal by wave action and tidal scour. Fouling organisms may also restrict feeding currents and lower the fitness of individual mussels. However, *Mytilus edulis* is able to sweep its prehensile foot over the dorsal part of the shell (Thiesen, 1972, Seed & Suchanek, 1992). Fouling by ascidians can be a problem in rope-cultured mussels (Seed & Suchanek, 1992).

In addition, the polychaete *Polydora ciliata* may burrow into the shell of *Mytilus edulis* which weakens the shell leaving individuals more susceptible to predation by birds and shore crabs resulting in significant mortality, especially in mussels >6 cm (Holt *et al.*, 1998).

Longevity is dependent on locality and habitat. On the lower shore, few individuals probably survive more than 2-3 years due to intense predation as discussed above whereas high shore populations are composed of numerous year classes (Seed, 1969a). Specimens have been reported to reach 18-24 years of age (Thiesen, 1973).

Spawning is protracted in many populations, with a peak of spawning in spring and summer. Resting gonads begin to develop from October to November, gametogenesis occurring throughout winter so that gonads are ripe in early spring. A partial spawning in spring is followed by rapid gametogenesis, gonads ripening by early summer, resulting in a less intensive secondary spawning in summer to late August or September (Seed, 1969b). Mantle tissues store nutrient reserves between August and October, ready for gametogenesis in winter when food is scarce (Seed & Suchanek, 1992). Larvae spawned in spring can take advantage of the phytoplankton bloom. The secondary spawning is opportunistic, depending on favourable environmental conditions and food availability. Reproductive strategies in *Mytilus edulis* probably vary depending on environmental conditions (Newell *et al.*, 1982). Fertilisation is external and can occur successfully between 5-22°C and at salinities of 15-40psu (Bayne, 1965; Lutz & Kennish, 1992).

Fecundity and reproductive effort increase with age and size, young mussels diverting energy to rapid growth rather than reproduction. Reproductive output is influenced by temperature, food availability and tidal exposure and can therefore vary from year to year. An individual female (ca 7mm) can produce 7-8 million eggs, while larger individuals may produce as many as 40 million eggs (Thompson, 1979).

In optimal conditions larval development may be complete in less than 20 days but growth and metamorphosis in the plankton between spring and early summer, at ca. 10 °C, usually takes 1 month. However, it is not unusual for planktonic life to extend beyond 2 months in the absence of suitable substrata or optimal conditions (Bayne, 1965; Bayne, 1976). Pediveligers (the third and final free swimming larval stage, prior to settlement or attachment to a substrate) can delay metamorphosis for up to 40 days at 10 °C (Lutz & Kennish, 1992) or for up to 6 months in some cases (Lane *et al.*, 1985). The duration of the delay is mainly determined by temperature, with longer delays at low temperature (Strathmann, 1987). Larvae become less selective of substrata the longer metamorphosis is delayed. In many populations *Mytilus edulis* exhibits a two stage settlement, the pediveliger settling on filamentous substrates such as, bryozoans, hydroids, filamentous algae such as *Polysiphonia* sp., *Corallina* sp. and *Mastocarpus* sp., or the byssus threads of previously settled adults and then moving on to suitable adult substrata by bysso-pelagic drifting. Post-larvae may remain on their primary attachment until 1-2mm in size (sometimes larger), and many late post-larvae over-winter on algae, moving to adult substrata in spring, although many will leave the algae earlier due to winter storms or death of the algae (Seed & Suchanek, 1992). Newly settled mussels are termed 'spat'.

Dispersion is dependent on the duration of planktonic life. Maintenance of their position in the water column by active swimming ensures that larvae can be potentially dispersed over great distances by currents. In addition, post-larvae can become bysso-pelagic up to 2-2.5 mm in size, which may take ca. 2 months to achieve, during which time they may be transported significant distances by currents. Recruitment is dependent on larval supply and settlement, together with larval and post-settlement mortality. Larval mortality is probably due to adverse environmental conditions, especially temperature, inadequate food supply (fluctuations in phytoplankton populations), inhalation by suspension feeding adult mytillids, difficulty in finding suitable substrata and predation (Lutz & Kennish, 1992). Recruitment in many *Mytilus* sp. populations is sporadic, with unpredictable pulses of recruitment, possibly from the pool of young mussels on filamentous algae (Seed & Suchanek, 1992). *Mytilus* sp. is highly gregarious and final settlement often occurs around or in between individual mussels of established populations (AQUAFACT, 2007). Competition with surrounding adults may suppress growth of the young mussels settling within the mussel bed, due to competition for food and space, until larger mussels are lost (Seed & Suchanek, 1992). Persistent mussel beds can be maintained by relatively low levels of recruitment.

Mytilus edulis is a filter feeding organism, which collects algae, detritus and organic material for food but also filters out other contaminants in the process. Shumway (1992) noted that mussels are likely to serve as vectors for any water-borne disease or contaminant. Mussels have been reported to accumulate faecal and pathogenic bacteria and viruses, and toxins from toxic algal blooms. Bacteria may be removed or significantly reduced by depuration (placing contaminated mussels into clean water) although outbreaks of diseases have resulted from poor depuration and all viruses may not be removed by depuration. Recent improvements in waste water treatment and shellfish water quality regulations may reduce the risk of bacterial and viral contamination. The accumulation of toxins, by the mussels, from toxic algal blooms may result in paralytic shellfish poisoning (PSP), diarrhetic shellfish poisoning (DSP) or amnesic shellfish poisoning (ASP). These toxins are not destroyed by cooking. Shumway (1992) suggested that mussels should only be collected from areas routinely monitored by public health agencies, or obtained from approved sources and never harvested from waters contaminated with raw sewerage.

Mytilus edulis is not listed as threatened or endangered; however, intertidal *Mytilus edulis* beds are listed as threatened or in decline in the OSPAR [Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)] List of Threatened and/or Declining Species and Habitats (OSPAR, 2008).

2.3.1.2. Distribution

There is a public fishery within the main channel of the Lough and a number of small boats dredge this fishery for wild mussels (CLAMS, 2005). Wild mussel dredging is an important source of shellfish products in Carlingford Lough, corresponding to about 1000 tonnes per year (Ferreira *et al.,* 2007). There is also a wild mussel producing area located at Narrow Water. Aquaculture producers also fish here for mussel seed (CLAMS, 2005). The mussel settlement in this fishery is variable but in good years amounts of up to 3,000 tonnes are not uncommon (CLAMS, 2005). Figure 2.4 shows the currently licenced mussel harvesting areas within Carlingford Lough. This covers an area of 8.83km^2 (approximately 79% of the entire licenced area). The majority of these sites (approximately 70%) are located along the southern shore.

Figure 2.4: Mussel licenced sites in Carlingford Lough (Source: Loughs Agency, DARD).

2.3.1.3. Fishery

Bottom mussel farming within Carlingford Lough is a form of extensive culture (CLAMS, 2005). Seed is transferred from the naturally occurring wild seed beds in the autumn of each year and cultured on licenced plots. The seed is laid at careful densities and managed through observation and turning to allow an even shell growth and optimum meat conditions. After approximately 1.5 – 2.5 years the mussels are ready for harvest. The majority are sold live to the Netherlands or to processing facilities in Ireland or the UK. The meat content of Carlingford mussels (up to 30%) is amongst the highest in Europe and makes them much sought after.

Figure 2.5 shows the total mussel production in Carlingford Lough from 2003 to 2009 (Source: Bord Iascaigh Mhara [BIM] and the Department of Agriculture and Rural Development [DARD]). Values increased from a low of 1,810 tonnes in 2003 to a maximum of 7,079 tonnes in 2006. There was a slight decrease in 2007 (6,520 tonnes), increasing slightly to 6,790 tonnes in 2008 and decreasing to approximately 2005 levels in 2009 (5,826 tonnes). On average, approximately 75% of mussel production occurred in the Republic.

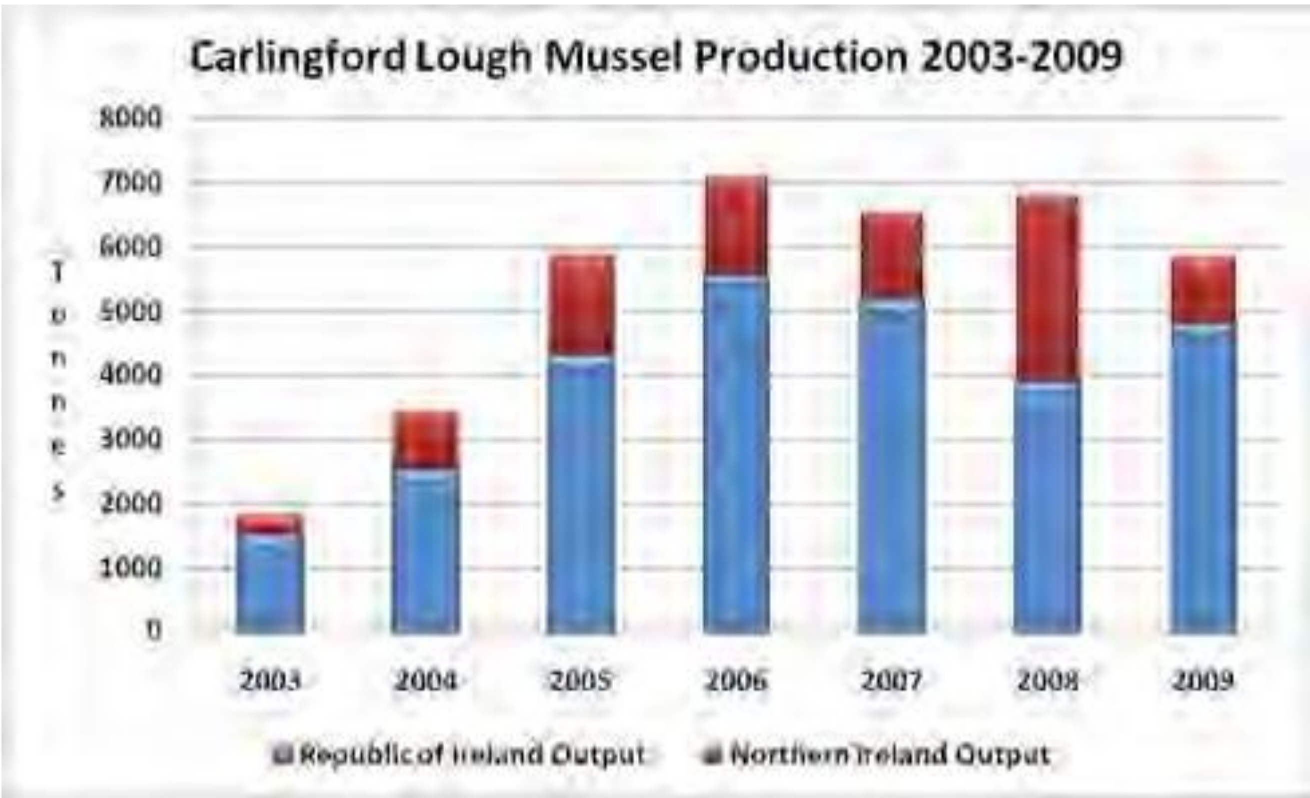


Figure 2.5: Mussel production in Carlingford from 2003-2009 (Source: BIM and DARD).

2.3.2. Pacific Oysters (*Crassostrea gigas*)

2.3.2.1. General Biology

Pacific oysters are not native to Irish waters; they were introduced from the Pacific coasts of Asia. They can be found in intertidal and subtidal zones. They prefer to attach to hard or rocky surfaces in shallow or sheltered waters but have been known to attach to muddy or sandy areas when the preferred habitat is scarce. They can also be found on the shells of other animals. Larvae often settle on the shells of adults, and great masses of oysters can grow together to form oyster reefs.

Pacific oysters need a temperature of above 18°C to reproduce (PMFSC [Pacific States Marine Fisheries Commission], 1996). The larvae are planktonic and spend several weeks in this phase. Then after that time, once an acceptable location has been found the oyster drops out of the plankton and attaches itself to its chosen surface, at which point it is known as 'spat'. It spends the first year of its attached life as a male, before eventually becoming female. Un-harvested oysters can live up to 30 years. The conservation status of *Crassostrea gigas* is not listed.

2.3.2.2. Distribution

Figure 2.6 shows the locations of licenced intertidal farmed Pacific oyster sites in Carlingford Lough. These farmed sites cover an area of 2.94km^2. The farms in Carlingford are located on the intertidal areas of foreshore, notably at Ballagan, Oysterman, Carlingford, Mill Bay, Cranfield and southeast of Omeath.

Figure 2.6: Licenced Pacific oyster harvesting sites in Carlingford Lough (Source: The Loughs Agency, DARD).

2.3.2.3. Fishery

Following the decline of the native oyster fishery in Carlingford Lough, BIM introduced the Pacific oyster as part of a trial which set out to revitalise the local shellfish industry by developing intensive farming techniques (CLAMS, 2005). The pacific oyster was ideally suited and following successful trials, a number of commercial farms were established. These farms which were among the first in Ireland are still in operation today.

Oysters feed on plankton and suspended organic matter, which is naturally present in the water column. The oysters are placed in plastic mesh bags and held off the seabed on trestles (CLAMS, 2005). Trestles are metal frames which measure 3m x 1m and stand 0.4m in height. Each trestle can hold 5-7 bags. Bags are fastened to the trestle by the use of metal hooks and rubber bands. The bags vary in mesh size depending on the size of oyster being held. The bags and trestles are reusable and remain on the shore all year round. Oyster sites are accessed by farmers at low tide using a tractor and trailer. The farms are positioned between Mean Low Water Spring and Mean Low Water Neap, allowing 2.5-3.5 hrs exposure per day, depending on weather conditions. This in turn translates to approximately 15% visual exposure during day light hours over a typical month.

The production cycle begins in spring of each year when new seed is introduced to the Lough (CLAMS, 2005). This is purchased from approved disease free specialist hatcheries. The seed can range in size from 6-12mm depending on producer preference, site conditions and availability. Once delivered to the farm the seed is placed in the appropriate size mesh bag at a density of approx. 1,000 oysters per bag. During the year the bags are turned to avoid algal growth and shaken to ensure proper shape of the oyster. At regular intervals the seed is taken ashore and graded on special graders to ensure uniform growth. The density of seed is gradually decreased over the production period to a density of approximately 150 oysters per bag at harvest time.

Harvesting is year round with a peak for the Christmas market (CLAMS, 2005). The majority of oysters are sold abroad to France, with sales also made to the UK, Belgium, Italy, Spain and Germany. Carlingford oysters are renowned for their taste and meat content.

Figure 2.7 shows the total oyster production in Carlingford Lough from 2003 to 2009 (Source: BIM and DARD). Values decreased from 495 tonnes in 2003 to a minimum of 367 tonnes in 2004. Values increased to approximately 600 tonnes per annum in 2005 and 2006 are reached a maximum of 755 tonnes in 2007. There was a significant decrease to 409 tonnes in 2008 increasing to 537 tonnes in 2009. On average, approximately 90% of oyster production occurred in the Republic.

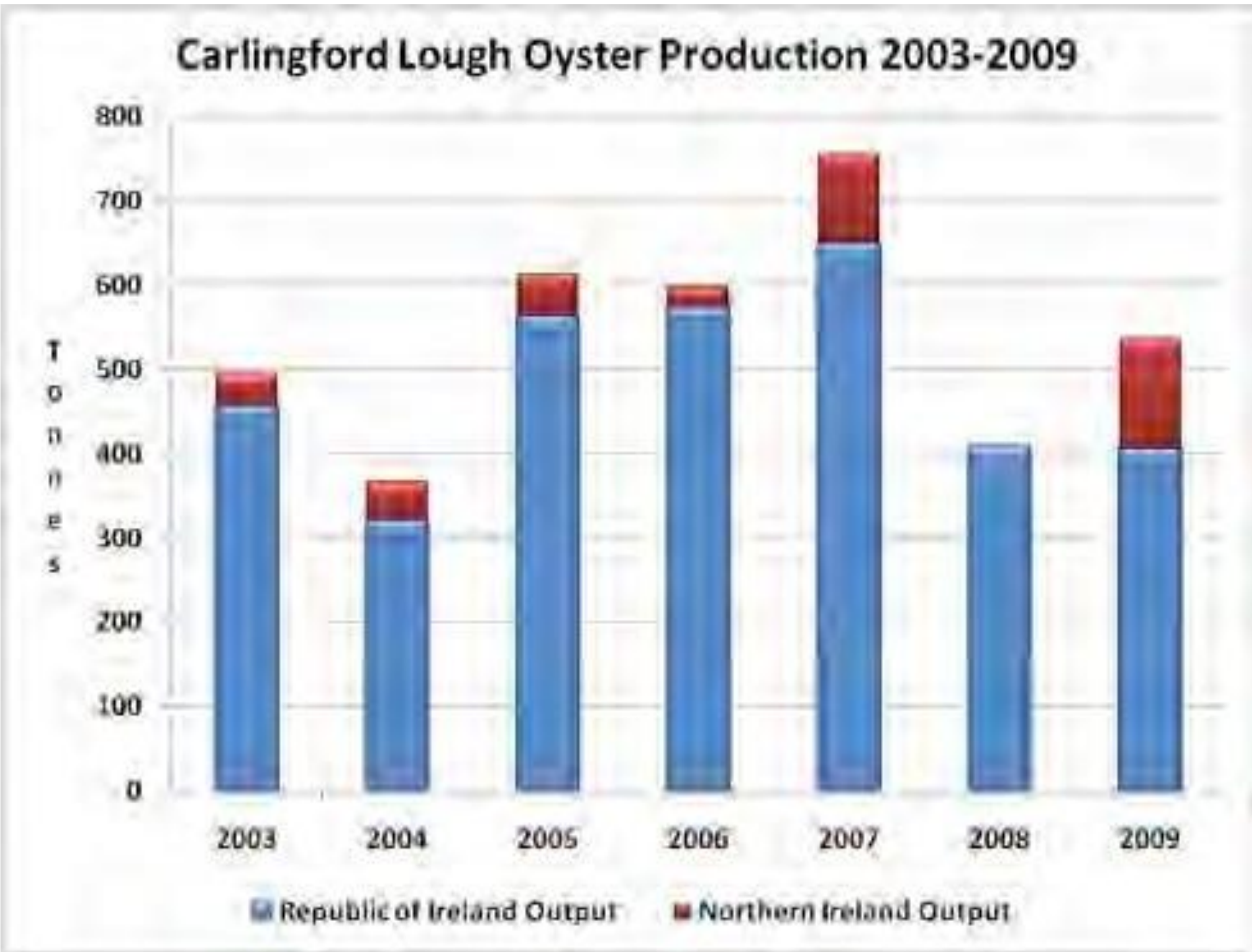


Figure 2.7: Oyster production in Carlingford from 2003-2009 (Source: BIM and DARD).

2.3.3. Razor Clam (*Ensis* spp.)

2.3.3.1. General Biology

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

2.3.3.2. Distribution

There are 5 areas in Carlingford Lough that are licenced for razor clams and they can be seen in Figure 2.8 below.

Figure 2.8: Locations of razor clam licenced areas in Carlingford Lough (Source: The Loughs Agency).

2.3.3.3. Fishery

The razor clam fishery in Carlingford Lough is a small operation operated by a small number of vessels. The fishery is generally located between the low spring tide mark seaward to approximately 15m depth in areas of fine sediment (Marine Institute, 2010). The razors are collected by dredge and are quite small with little commercial value. Razor clam production values for Carlingford Lough were unavailable.

3. Hydrography/Hydrodynamics

3.1. *Simple/Complex Models*

The Sustainable Mariculture in northern Irish Sea Lough Ecosystems (SMILE) project, which was commissioned by the Department of Agriculture and Rural Development (DARD) in Northern Ireland in 2004 to develop and apply a range of tools for decision-support in the sustainable development of shellfish aquaculture, within the context of integrated coastal zone management (Ferreira *et al.,* 2007). Carlingford Lough was one of 5 Northern Irish Loughs studied in the project. Figure 3.1 shows the general modelling framework used in SMILE (Ferreira *et al.,* 2007).

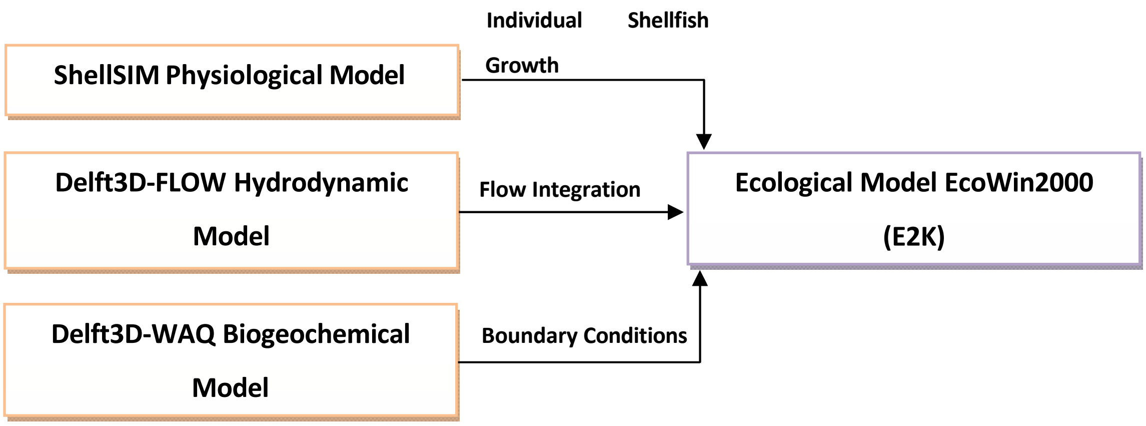


Figure 3.1: General modelling framework used in SMILE (Ferreira *et al.,* 2007).

The Delft3D-FLOW hydrodynamic model was used to simulate the tidal, wind and ocean currents within the Lough (Ferreira *et al.,* 2008). This model was combined with the Delft3D-WAQ model to stimulate circulation and phytoplankton productivity for periods of up to 1 year and used to generate aggregated water exchange and boundary conditions for the Lough. ShellSIM is a generic dynamic model structure which simulates feeding, metabolism and growth. EcoWin2000 (E2K) is an ecological model that provides a platform for integration of the various other models. It typically divides coastal systems into (<100) boxes, which can be structured in one, two or three dimensions and performs simulations at the system scale, using water exchange across box faces and system boundaries which are up-scaled from detailed hydrodynamic models.

In addition, Ferreira *et al.,* (1998) produced a one-dimensional ecosystem box model for carrying capacity assessment in Carlingford Lough and Taylor *et al.* (1999) applied a tidal box model to the Lough in order to model the residence times of water within the ‘boxes’ and gain a greater understanding of the dynamics and behaviour of physical, chemical and biological parameters within the Lough.

3.2. Depth

Carlingford Lough is generally shallow with water depths ranging from 2 to 5m. The narrow navigation channel can extend to depths of 25m with the deepest part of the Lough (36m) located approximately 2.3km north of Carlingford Harbour, Co. Louth and 1.3km south of Killowen Point, Co. Down. The narrowest point of the Lough is at the Narrow Water site where the channel is only 40m wide at low tide (CLAMS, 2005). Intertidal sand/mud flats (approximately 15km^2) are present along the southern shore, particularly between Greenore Point and Carlingford Harbour and in the Mill Bay area of the northern shore. In addition, a series of limestone rocks guard the shallow mouth of the Lough. Figure 3.2 shows a bathymetric map of Carlingford Lough.

Figure 3.2: Depths in Carlingford Lough (Source: The Loughs Agency).

3.3. Tides & Currents

The tidal cycle in Carlingford Lough ranges from a mean high water of 5.1m to a mean low water of 0.9m during spring tides (UKHO, 2004). The characteristic tidal levels in Carlingford Lough can be seen in Table 3.1.

These are taken from the Admiralty Chart 2800 (UKHO, 2004). Levels are presented in metres Chart Datum, which is approximately equal to Lowest Astronomical Tide (LAT).

Table 3.1: Carlingford Lough tidal characteristics (Source: UKHO, 2004).

Admiralty Chart 2800 Levels (m CD)	MHWS	MHWN	MLWN	MLWS
Cranfield Point	4.8	4.3	1.8	0.9
Warrenpoint	5.1	4.3	1.6	0.9

Ball *et al.* (1997) reported that maximum current speeds at the mouth of the Lough regularly exceed 0.87m/s, with speeds regularly exceeding 0.35m/s in the vicinity of the Rostrevor Narrows. The greatest tidal movements occur in the narrow channels that run along the centre of the Lough (Taylor *et al.,* 1999).

Tidal streams with the mean spring rate (m/s) can be seen in Figure 3.3 below and this information was taken from the most up-to-date admiralty charts for Carlingford Lough (UKHO, 2004). The flood and ebb flow rate outside the entrance to the Lough is 0.26m/s on a spring tide and imperceptible at all other times.

On a flooding spring tide, tidal flows increase to 1.3m/s northwest of the Hoskyn Channel at the mouth of the Lough. This flow decreases to 0.5m/s on approaches to Haulbowline Rock and rapidly increases to 2.3 and 2.6m/s as the tide enters the Lough through the channel northeast of the Limestone Rocks. The tidal flow decreases then to 1.3 and 0.8m/s on approach to Greenore where it increases to 2.6m/s as it flows around Greenore. Beyond this point the flow is imperceptible. On the ebbing spring tide, the flow is imperceptible to just north of Greenore where it reaches speeds of 1m/s within the channel. This flow decreases slightly to 0.8m/s east of Greenore and increases again to 1.3m/s as the tides moves into the channel and around Limestone Rocks. From here the tides increases to 1.8m/s as it exits along the channel and to 2.6m/s as it flows southwest towards the Hoskyn Channel.

A series of current meters were deployed in Carlingford Lough as part of the Greenore Port redevelopment project (Hydrographic Surveys Ltd., 2007). All of the meters were deployed within 1km from Greenore Port. Figure 3.4 shows tidal graphs for one of the current meter locations (approximately 420m southeast of Greenore Point) over a spring and neap tide. Lowest velocities were recorded generally around high water and low water and velocities peaked during mid-flood and mid-ebb. During the neap tide, surface velocities were generally faster during the ebbing tide in comparison with those recorded at mid-depth and the bottom. During the flood tide, surface velocities were generally lower than at the other two depths. During the spring tide, velocities were consistent throughout the water column during the flooding tide.

Figure 3.3: Tidal streams within Carlingford Lough (UKHO, 2004).

During the ebb tide, there is variation throughout the water column with the bottom velocities showing the lowest values. Table 3.2 shows the lowest and highest velocities recorded from this site.

The results also showed that the direction of flow is predominantly northerly during a flooding tide and southerly during the ebbing tide.

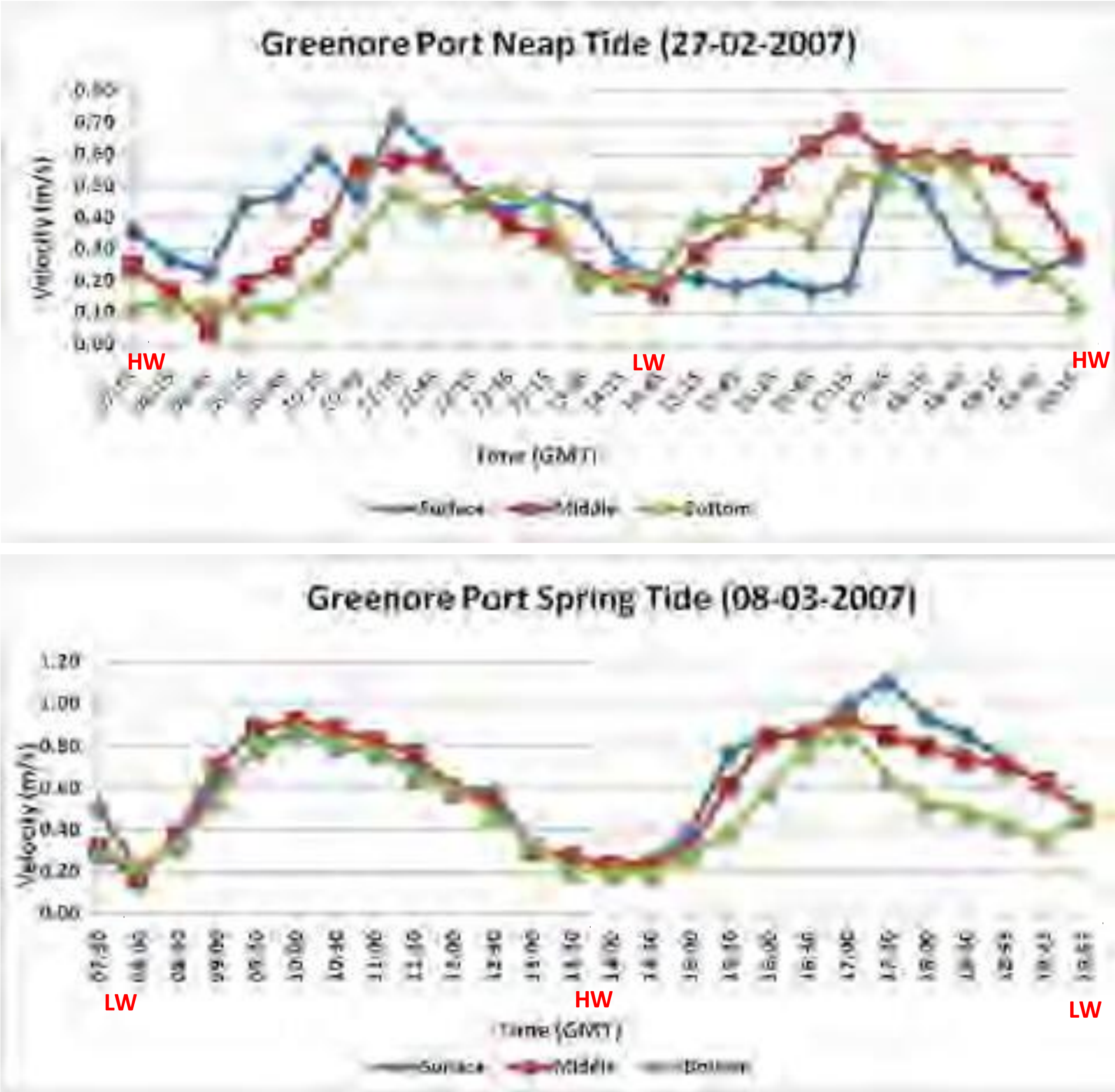


Figure 3.4: Tidal velocity (knots) over spring and neap tide at Greenore, Carlingford Lough (Source: Hydrographic Surveys Ltd., 2007).

Table 3.2: Lowest and highest velocities recorded over a spring and neap tide at Greenore, Carlingford Lough (Source: Hydrographic Surveys Ltd., 2007).

Position	**Spring**		**Neap**	
	Lowest Velocity	**Highest Velocity**	**Lowest Velocity**	**Highest Velocity**
Surface	0.2m/s @LW & HW	1.11m/s @HW+4	0.17m/s @HW-4	0.72m/s @HW+3hr15min
Mid	0.17m/s @LW	0.92m/s @HW-3hr 30min	0.05m/s @HW+45min	0.7m/s @HW-3hr30min
Bottom	0.2m/s @HW+20min	0.88m/s @HW-3hr & HW+3hr	0.11m/s @HW+1hr 15min	0.58 @HW-2hr30min

Outputs from the Delft3D-FLOW hydrodynamic model which was developed during the SMILE Project were provided by the Agri-Food and Biosciences Institute (AFBI). Figure 3.5 shows the direction and magnitude of spring tide surface and bottom flood flows. Figure 3.6 shows the direction and magnitude of spring tide surface and bottom ebb flows. Figure 3.7 shows the direction and magnitude of neap tide surface and bottom flood flows and Figure 3.8 shows the direction and magnitude of neap tide surface and bottom ebb flows.

Tidal movements in Carlingford Lough are relatively simple entering in the southeast and moving in a northwesterly direction up through the Lough. During a flooding spring tide, maximum velocities are seen around Cranfield Point and Greencastle Point (1.3 – 1.4m/s at the surface and 0.5-0.7m/s at the bottom). Surface flows remain in the region of 1m/s as they flow past Mill Bay, decreasing to approximately 0.4m/s beyond Mill Bay. Surface velocities increase slightly around Killowen Point (0.8m/s) and decrease to approximately 0.4m/s in Rostrevor Bay. Velocities increase to approximately 0.7m/s as the tide enters the Newry River. Surface flood flows within Mill Bay range from 0.01 – 0.33m/s and bottom flood flows range from 0.03 – 0.13m/s. On the ebbing tide, bottom flows are highest in the Newry River, approximately 0.9m/s and surface flows are highest around Greencastle and Cranfield Point (1.1 -1.2m/s). Ebb flows in Mill Bay range from 0.02 – 0.3m/s at the surface and between 0.06 – 0.4m/s at the bottom.

On a flooding neap tide, maximum bottom speeds are found around Cranfield Point and maximum surface speeds around Cranfield Point range from 0.8 – 0.9m/s, around Greencastle Point range from 0.8 – 0.95m/s and within the Newry River velocities are in the region of 0.8m/s. Ebb surface flows in the Newry river are also in the region of 0.8m/s and flows around Greencastle Point and Cranfield are in the region of 0.9m/s with bottom flows approximately 3m/s slower in these regions. Surface flood flows in Mill Bay range from

0.05 – 0.26m/s with bottom flows ranging from 0.04 – 0.18m/s. Surface ebb flows range from 0.03 – 0.26m/s and bottom ebb flows range from 0.03 – 0.19m/s.

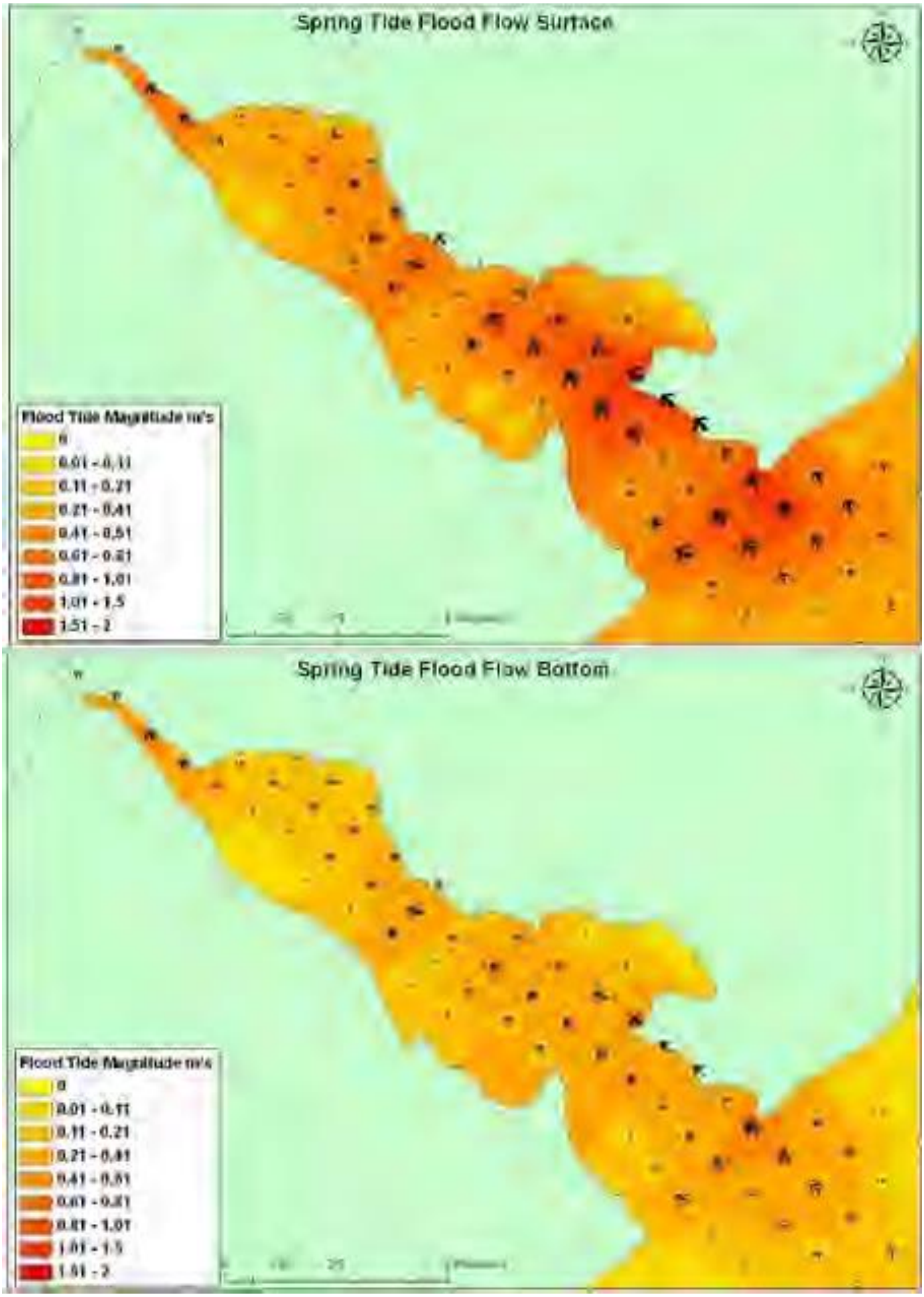


Figure 3.5: Surface and bottom current velocities and direction during a spring tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

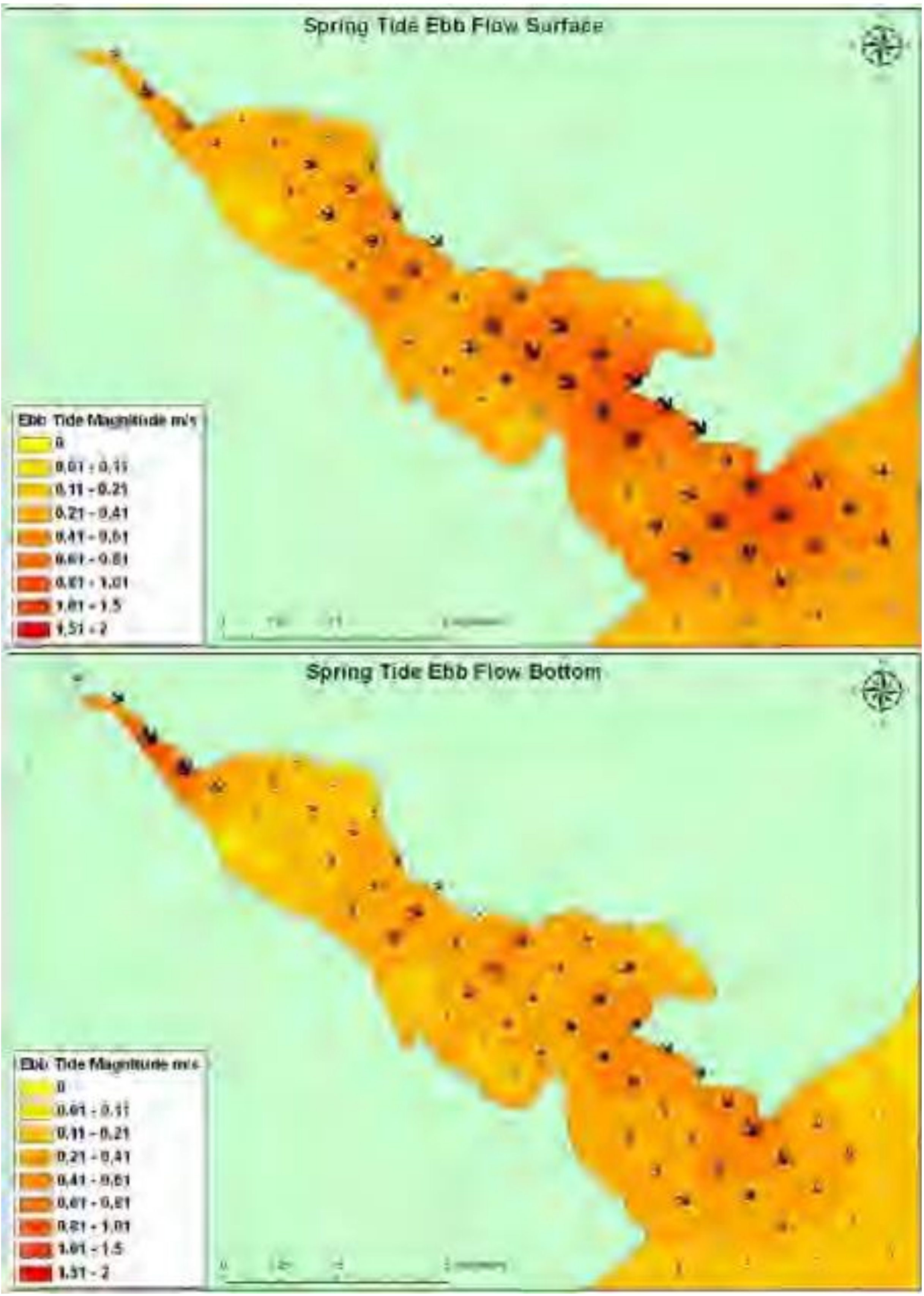


Figure 3.6: Surface and bottom current velocities and direction during a spring tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

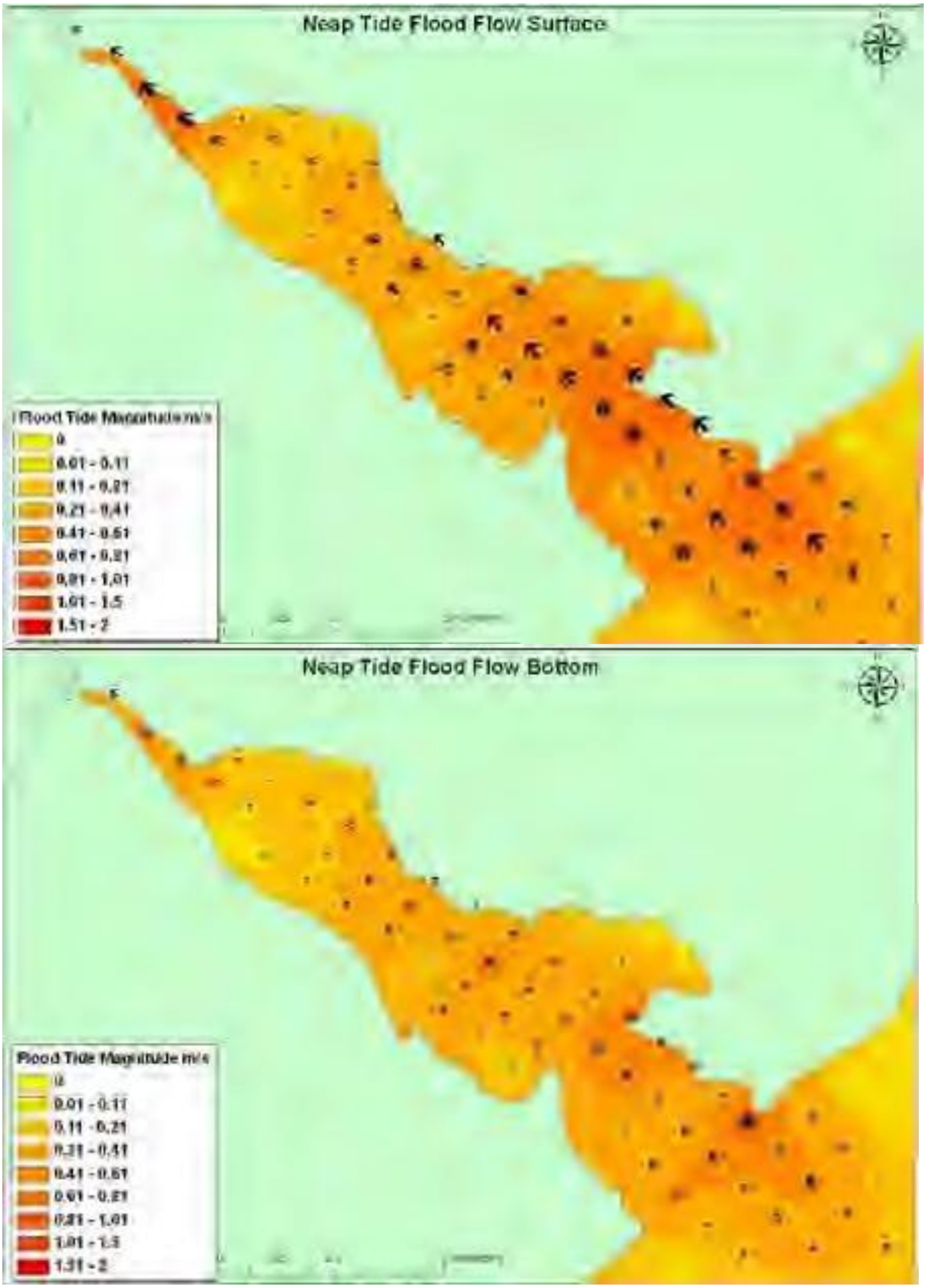


Figure 3.7: Surface and bottom current velocities and direction during a neap tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

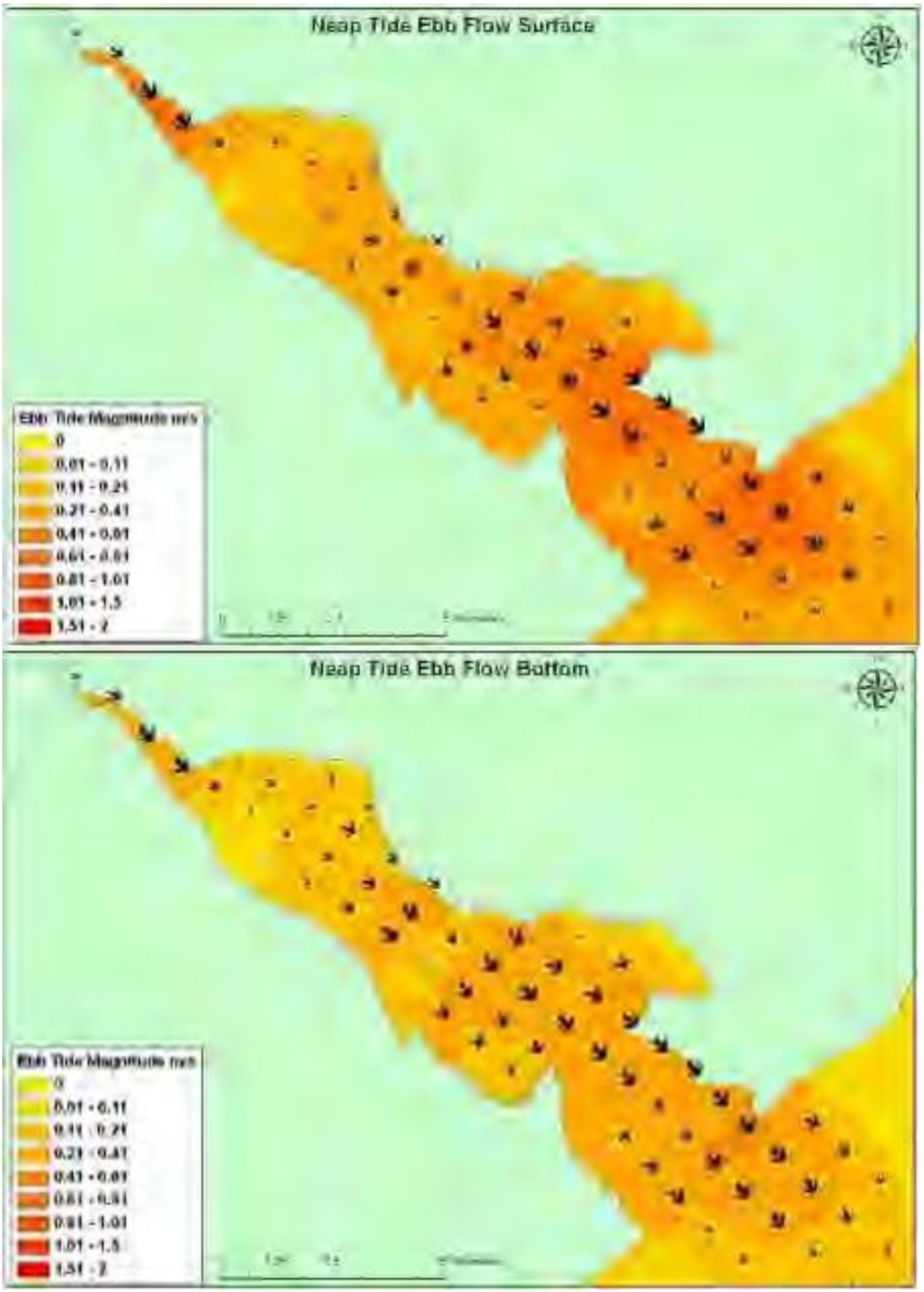


Figure 3.8: Surface and bottom current velocities and direction during a neap tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

3.4. Wind and Waves

Wind data from 2005 to 2010 are displayed in Table 3.3 below and wind roses for each year can be seen in Figure 3.9 below. From January 2005 to March 2008 the data were recorded at the Clones station (Co. Monaghan, located approximately 65km west of Carlingford Lough) and from April 2008 to December 2010 the data were recorded at the Ballyhaise station (Co. Cavan, located approximately 69km southwest of Carlingford Lough). In 2005, 27% of the wind came from the south and the northwest, while 20% can from the south southwest. The strongest winds came from the west/west northwest direction (11.3kn). In 2006, 29% of the wind came from the south, 21% from the northwest and 14% from the west northwest and the south southeast. The strongest winds (9.4kn) came from the south southwest. In 2007, 24% of the wind came from the west and 12% came from the north northwest, south southwest and southeast. The strongest winds (10.5kn) came from the west/west southwest. In 2008, 18% of the winds came from the southwest, with 12% coming from the northwest, west and south southeast. The strongest winds (9.8kn) came from the northwest. In 2009, 21% of the wind came from the west southwest and the south and 16% came from the southwest. The strongest winds (8.1kn) came from the southwest. In 2010, 33% of the wind came from the southwest, 13% came from the west southwest and a further 13% came from the south southeast. The strongest winds (6.6kn) came from the west southwest. It can be seen from these data that the prevailing wind direction varies from the south to the northwest.

Table 3.3 shows the seasonal averages from 2005 to 2010. Seasons were selected by grouping the results from the following periods: spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). Seasonal averages over the past 6 years indicate that winds are typically strongest in the winter months (7.5kn), followed very closely by spring (7.4kn), decreasing to 7.1kn in autumn and decreasing further to 6.2kn during the summer months.

Table 3.3: Wind speed and direction data for Clones/Ballyhaise from 2005-2010 (Source: Met Eireann, 2010a).

	2005		2006		2007		2008		2009		2010	
Month	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**
January	11.3	280	7.9	180	10.5	260	9.2	210	7.3	170	5.6	120
February	8.2	300	7.5	190	7.8	170	9.1	280	6.2	90, 250	4.3	130
March	8	200	8.4	150	8.9	130	9.8	310	7.9	230	6.1	230
April	8.3	210	7.6	320	6.7	290	7.2	260	6.7	180	5.5	170
May	7.9	310	8	190	7.5	280, 230	5.7	160	7.4	230	5.4	10, 220
June	6.4	310	6.2	270	6.9	160, 130	6.2	240	5.3	250	5.2	240
July	5.9	190	6	300	6.4	290	6.2	160	6.1	160	6.6	250
August	6.4	190	6.3	290, 310	6.7	200	6	220	7.2	170, 240	5.5	230
September	7.8	310, 190	7.5	150	6.6	280, 330	5.6	360	5.9	170	6.2	220
October	8.6	150, 180	7.4	310	6.5	200	7.2	230	6.1	240	6.2	160
November	7.8	210	9	170	7.6	310	6.8	310	8.1	220	6.5	160,230
December	6.9	310	9.4	200	9.1	260	5.9	230	6	60	3.3	310

Degrees Direction Key: 0°/360° = N; 23° = NNE; 45° = NE; 68° = ENE; 90° = N; 113° = ESE; 135° = SE; 158° = SSE; 180° = S; 203° = SSW; 225° = SW; 248° = WSW; 270° = W; 293° = WNW; 315° = NW; 338° = NNW

Table 3.4: Seasonal averages (knots) for Dublin Airport wind data (Source: Met Eireann, 2010a).

Season	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**6-year Average**
Winter	4.4	6.5	8.1	9.1	8.3	8.8	7.5
Spring	5.7	7.3	7.6	7.7	8	8.1	7.4
Summer	5.8	6.2	6.1	6.7	6.2	6.2	6.2
Autumn	6.3	6.7	6.5	6.9	8	8.1	7.1

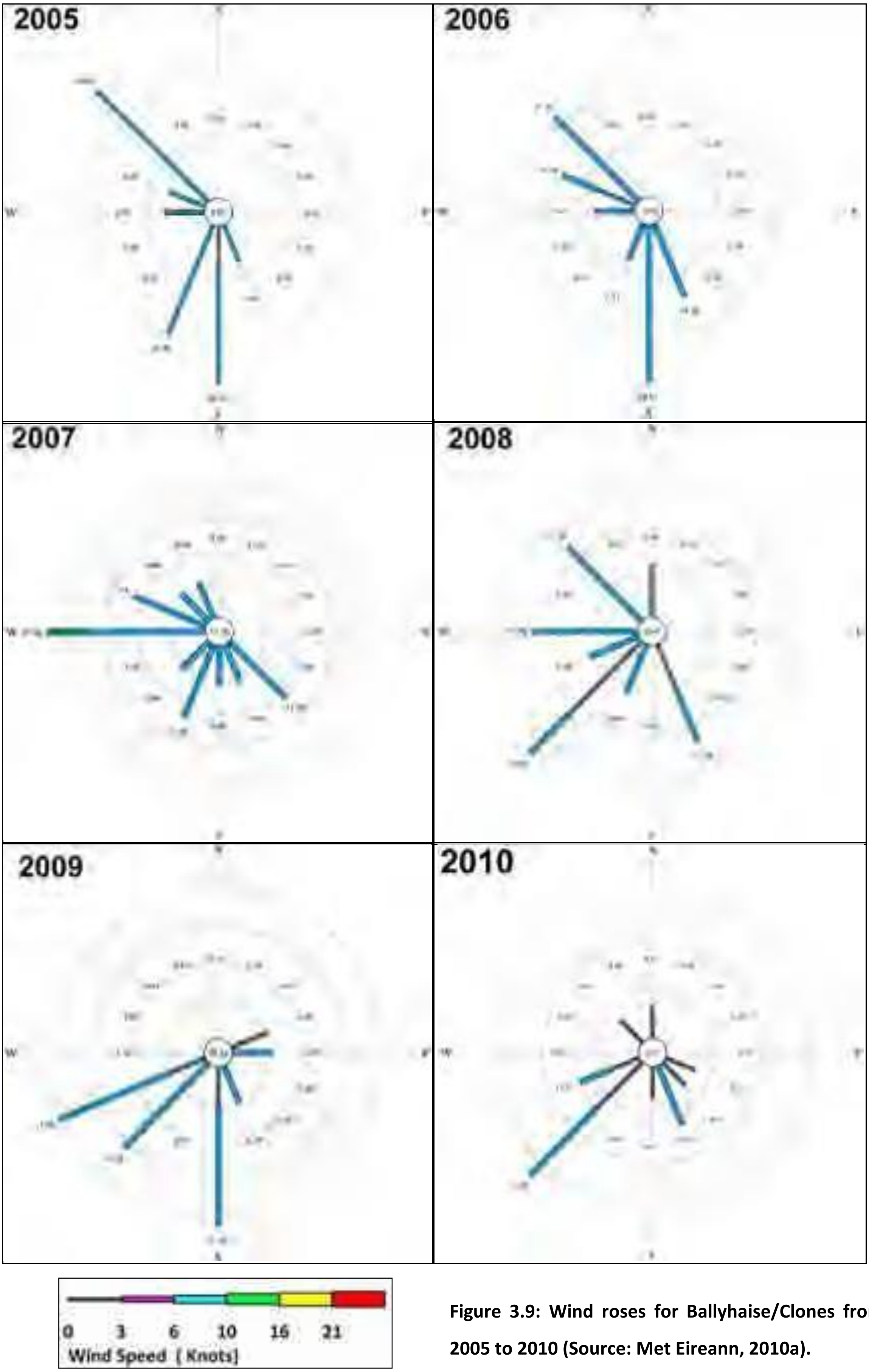


Figure 3.9: Wind roses for Ballyhaise/Clones from 2005 to 2010 (Source: Met Eireann, 2010a).

Wind conditions affect the hydrodynamic conditions in Carlingford Lough by generating wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Wind waves are produced by the local prevailing wind. They travel in the direction of the prevailing wind, i.e. a southwesterly wind will produce northeasterly moving waves. The height of wind waves depends on:

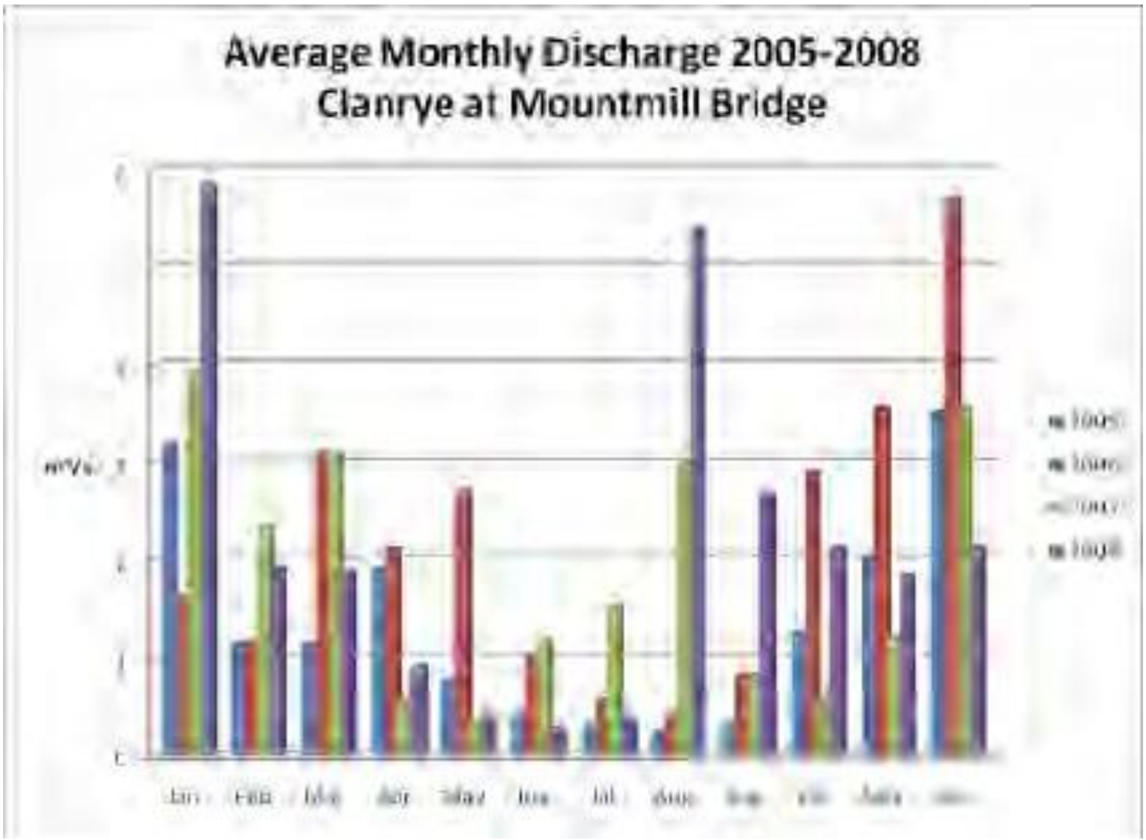
- the strength of the wind;
- the time the wind has been blowing; and
- the fetch.

In Carlingford Lough the prevailing wind direction has the effect of directing water towards the northern coastline of the Lough. Especially over the shallow areas of Carlingford Lough, wave-induced bottom friction may lead to resuspension of material and entrainment of sediments in the water column, with resulting higher turbidity levels in these areas.

3.5. River Discharges

The Newry (Clanrye) River is Carlingford Lough's major freshwater source. The quantities of freshwater from this source are relatively small with a small flow rate that can vary from $1m^3/s$ in summer to $9m^3/s$ in winter (Ferreira *et al.,* 2007). Other freshwater discharges include the Ryland, Moygannon, Rostrevor, Whitewater, Ballincurry, Cassey Water and Ghann Rivers (CLAMS, 2005). The majority of these are spate rivers which feed off the mountains. These low levels generally do not affect the salinity of the Lough (Loughs Agency, 2010). Figure 3.10 below shows the $474km^2$ catchment area of Carlingford Lough with seven measuring stations, operated by the Rivers Agency. Of these 7 stations, data are available for 2 of them; Clanrye at Mountmill Bridge and Jerretspass at Jerretspass. The mean flow of the Clanrye River at Mountmill Bridge is $2.04m^3/s$ and the mean flow at Jerretspass is $0.82m^3/s$ (NRFA [National River Flow Archive], 2010a). Figure 3.11 shows the averaged and total flow of the Clanrye River at Mountmill Bridge from 2005 to 2008. Over the past 4 years, June and July have had the least flow with flow levels increasing towards and into the winter months. One notable exception to this is the relatively high flow levels seen in August 2008, which corresponds with the relatively high rainfall levels seen during this period.

Figure 3.10: River monitoring stations (Source: EPA, 2010).



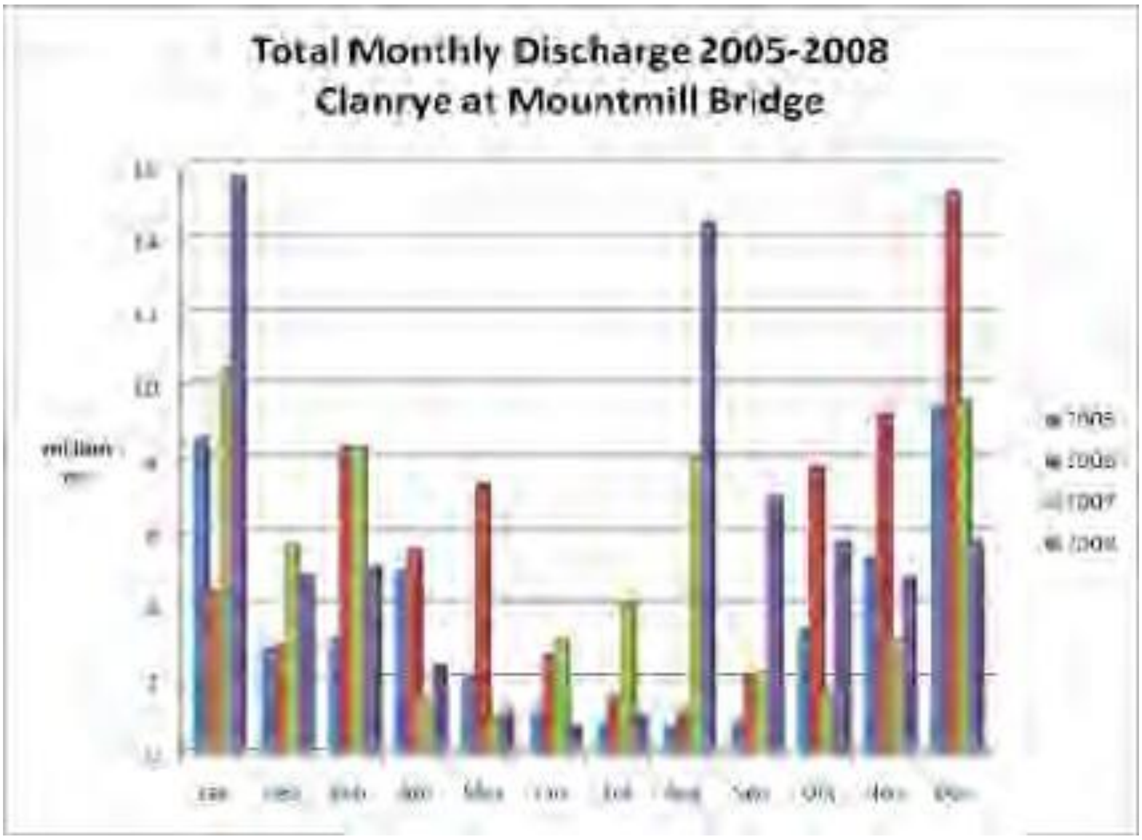


Figure 3.11: Average and monthly flow data from the Clanrye River at Mountmill Bridge (Source: NRFA, 2010b)

3.6. Rainfall Data

3.6.1. Amount & Time of Year

Figures 3.12 and 3.13 show the average monthly rainfall data for Northern Ireland (Met Office, 2010) from 1971 to 2000. Table 3.5 shows the average rainfall range and median value along the Carlingford Lough coastline. During the period 1971 to 2000, the average rainfall along the Northern Ireland coastline of Carlingford Lough ranged from 40-180mm, with the lowest levels occurring in May (40-90mm) and the highest levels occurring in January (100-180mm). The lowest median value was 65mm in May and the highest was 140mm in January. Figure 3.14 shows the seasonal averages for Northern Ireland from 1971 to 2000. Table 3.6 shows the median seasonal rainfall values. Seasonally, spring was the driest season (200mm) and autumn was the wettest season (320mm).

Table 3.5: Rainfall range and median monthly rainfall (mm) data along the Carlingford Lough coastline (Source: Met Office, 2010).

Month	Rainfall Range (mm)	Median Value (mm)
January	100-180	140
February	70-130	100
March	50-110	80
April	60-100	80
May	40-90	65
June	40-95	67.5
July	40-100	70
August	50-110	80
September	80-110	95
October	50-160	105
November	50-130	90
December	60-140	100

Table 3.6: Median seasonal rainfall values (mm) from 1971-2000 (Source: Met Office, 2010).

Season	Median
Spring	200
Summer	230
Autumn	320
Winter	300

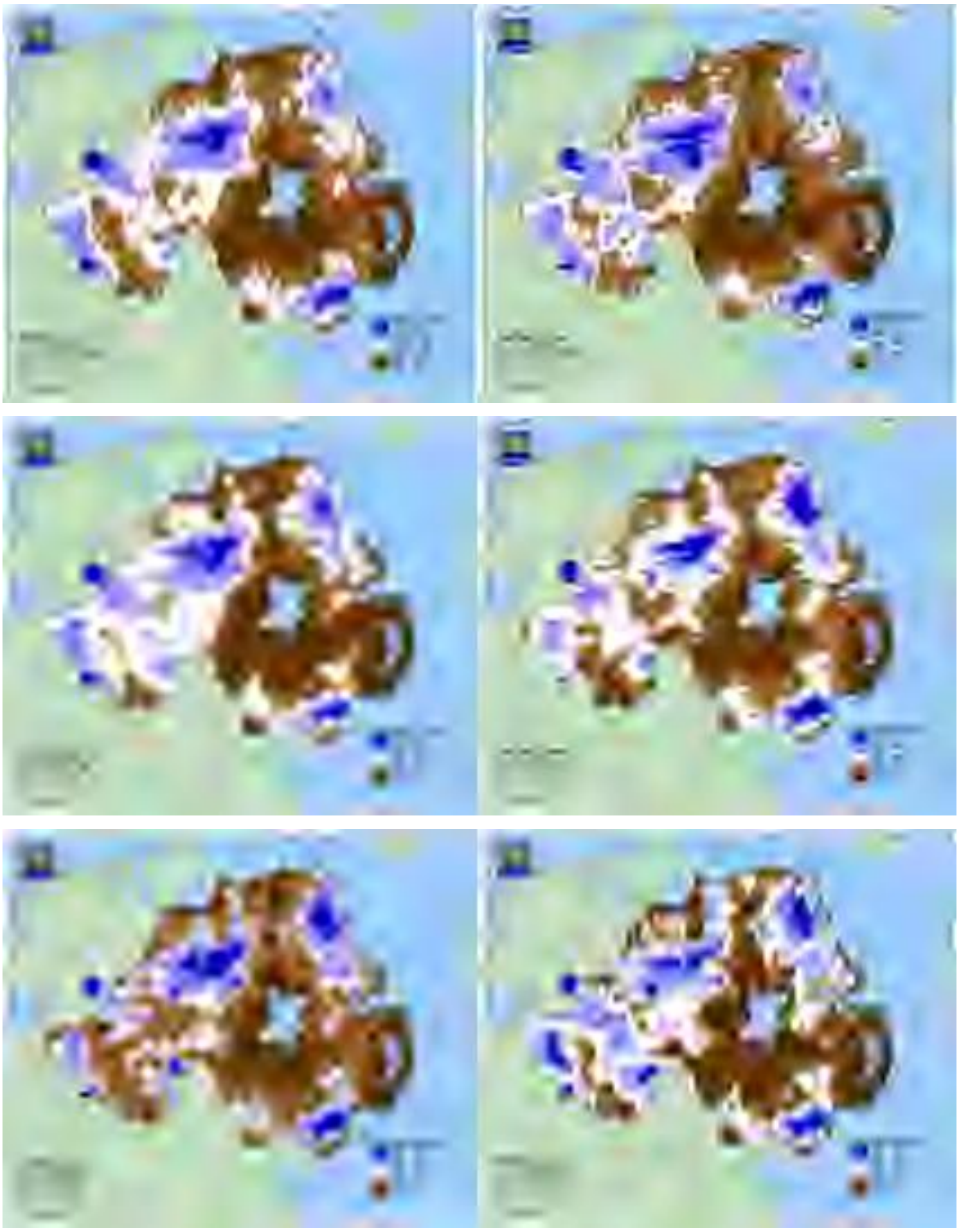


Figure 3.12: Average monthly rainfall (mm) data for January to June from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

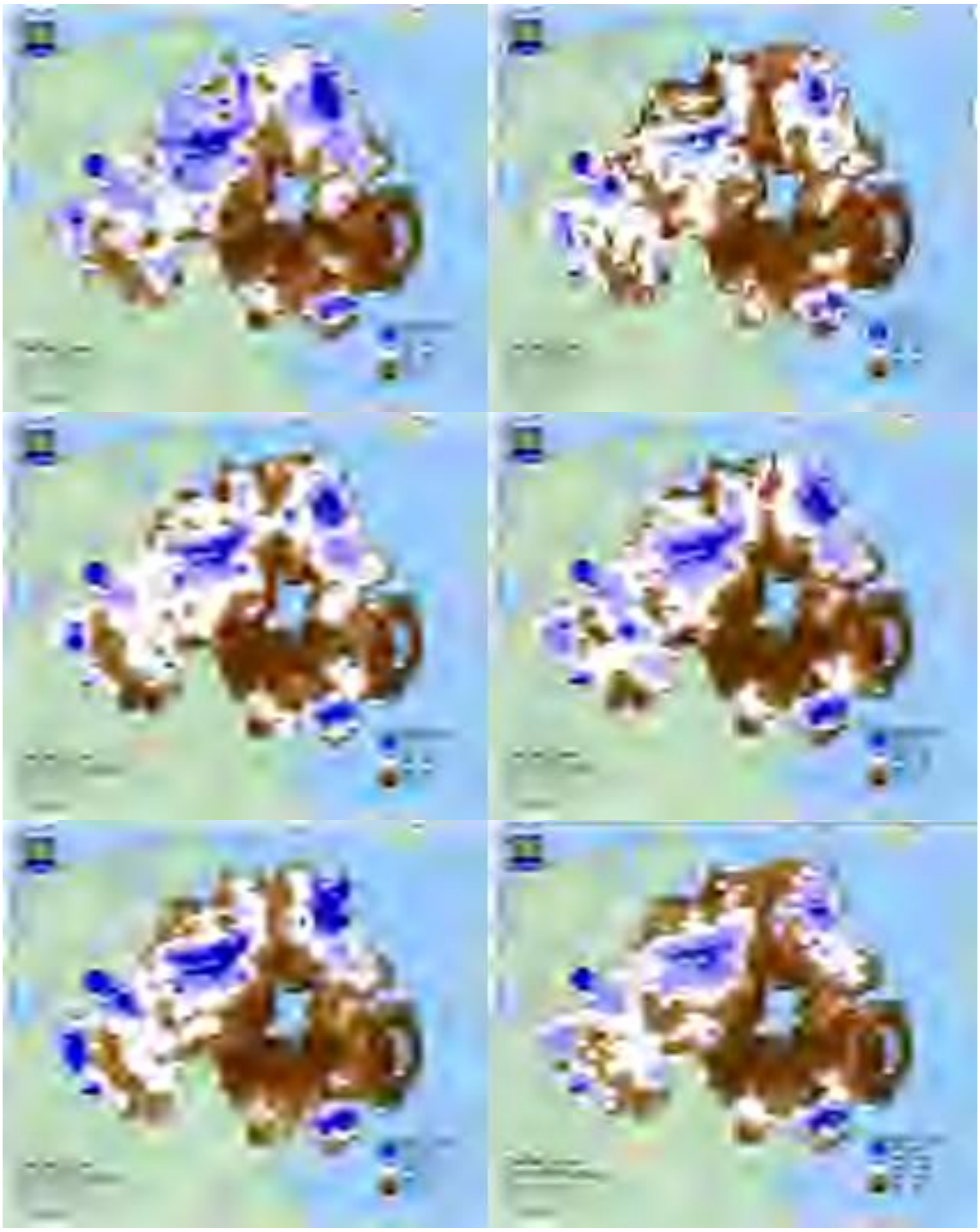


Figure 3.13: Average monthly rainfall (mm) data for July to December from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

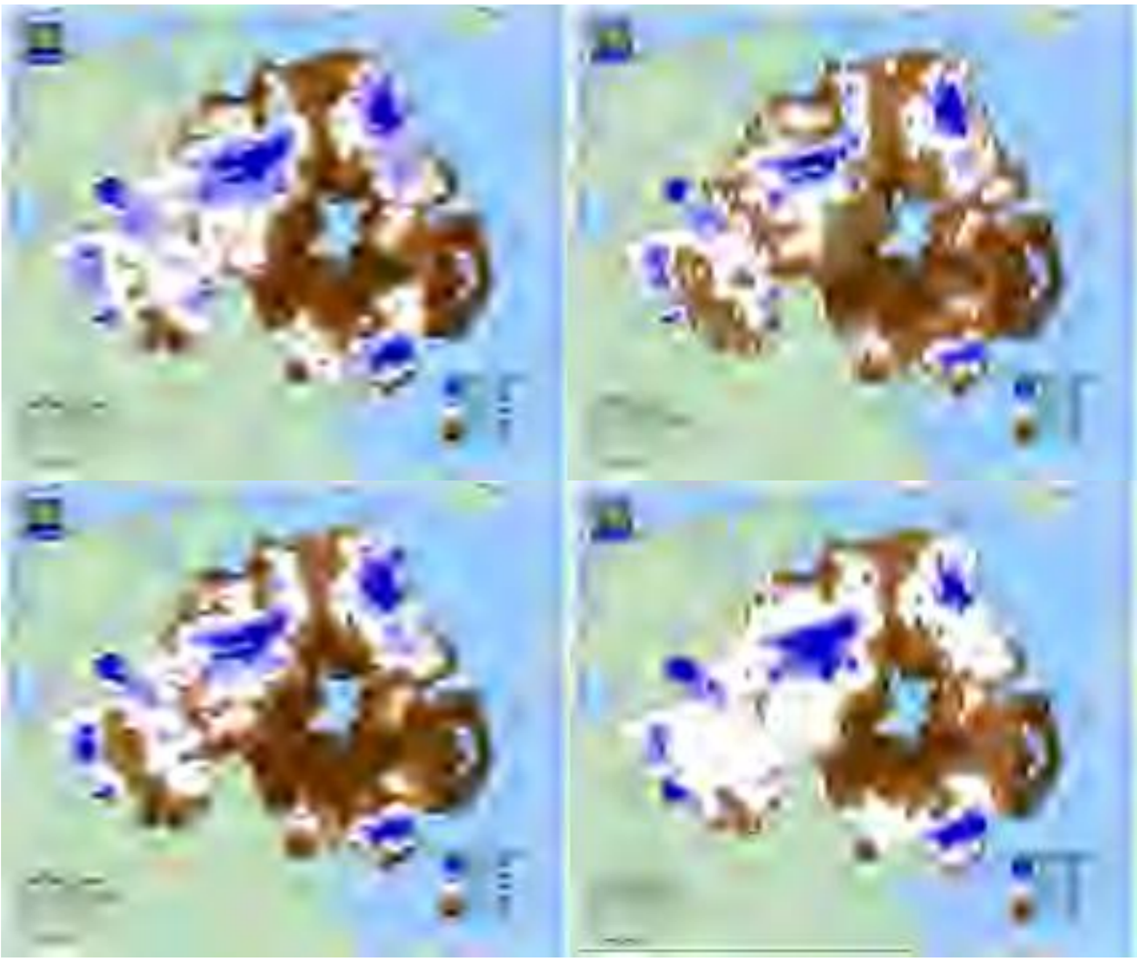


Figure 3.14: Seasonal rainfall averages (mm) from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

Table 3.7 shows average monthly rainfall data at the closest Met Eireann station (Carrickmacross/Ardee) to Carlingford Lough from 2005 to 2010 (Met Eireann, 2010a). From 2005 to July 2009, the closest station was Ardee, Co. Louth and from August 2009 to December 2010 the closest station was Carrickmacross, Co. Monaghan. Table 3.8 shows the total seasonal rainfall at Carrickmacross/Ardee from 2005-2010 (Met Eireann, 2010a). The Ardee station is located approximately 33km southwest of Carlingford Lough and the Carrickmacross station is located approximately 35km southwest of Carlingford Lough. Rainfall ranged from 11.1mm in April 2007 to 166.9mm in August 2008. The following seasonal fluctuations were observed from 2005-2010: In 2005 and 2006, summer was the driest season and autumn was the wettest, in 2007 and 2008, spring was the driest and summer was the wettest, in 2009 winter was the driest and summer was the wettest and in 2010 spring was the driest season and autumn was the wettest season. These data were collected from Met Eireann Monthly Weather Bulletins from 2005 to 2010. These reports included all Ireland monthly rainfall maps, a sample of which (year 2009) are reproduced in Figure 3.15 below. Tables 3.9 and 3.10 show the average and median monthly rainfall values from 2005 to 2010 from Met Eireann's rainfall maps for the entire Carlingford Lough coastline (Met Eireann, 2010a).

Table 3.7: Average monthly rainfall (mm) data at Carrickmacross, Co. Monaghan/Ardee, Co. Louth, from 2005 to 2010 (Source: Met Eireann, 2010a).

Year	2010	2009	2008	2007	2006	2005	Monthly Total	Monthly Average
Jan	59.7	72	115.5	58.5	18.9	61.5	386.1	64.4
Feb	40.5	17.3	28.1	74.3	25.5	32.3	218	36.3
Mar	66.3	27.1	47.5	45.7	102.4	52.5	341.5	56.9
Apr	42	73.7	28.6	11.1	34.3	59.4	249.1	41.5
May	42.7	72	27.2	61.3	145.4	46	394.6	65.8
Jun	51.6	52	56.9	132.8	24.9	14.1	332.3	55.4
Jul	147.7	127.7	125.8	118.3	37.1	44.5	453.4	90.7
Aug	36.6	112.5	166.9	96.3	62.7	27	465.4	93.1
Sep	148.9	26.5	n/a	24.2	108.8	66.4	225.9	56.5
Oct	45.6	93.6	91.8	25.7	103.7	97.6	412.4	82.5
Nov	84.8	160.4	48.1	74.9	78.2	50.5	412.1	82.4
Dec	53.6	61	49.4	77	96.6	80.2	364.2	72.8
Annual Total	820	895.8	785.8	800.1	838.5	632	-	
Annual Average	68.3	74.7	71.4	66.7	69.9	52.7	-	-

Table 3.8: Total seasonal rainfall (mm) at Carrickmacross, Co. Monaghan/Ardee, Co. Louth from 2005-2010 (Source: Met Eireann, 2010a).

Season/Year	2010	2009	2008	2007	2006	2005
Spring	151	172.8	103.3	118.1	282.1	157.9
Summer	235.9	292.2	349.6	347.4	124.7	85.6
Autumn	279.3	280.5	139.9*	124.8	290.7	214.5
Winter	153.8	150.3	193	209.8	141	174

* No data available for September 2008.

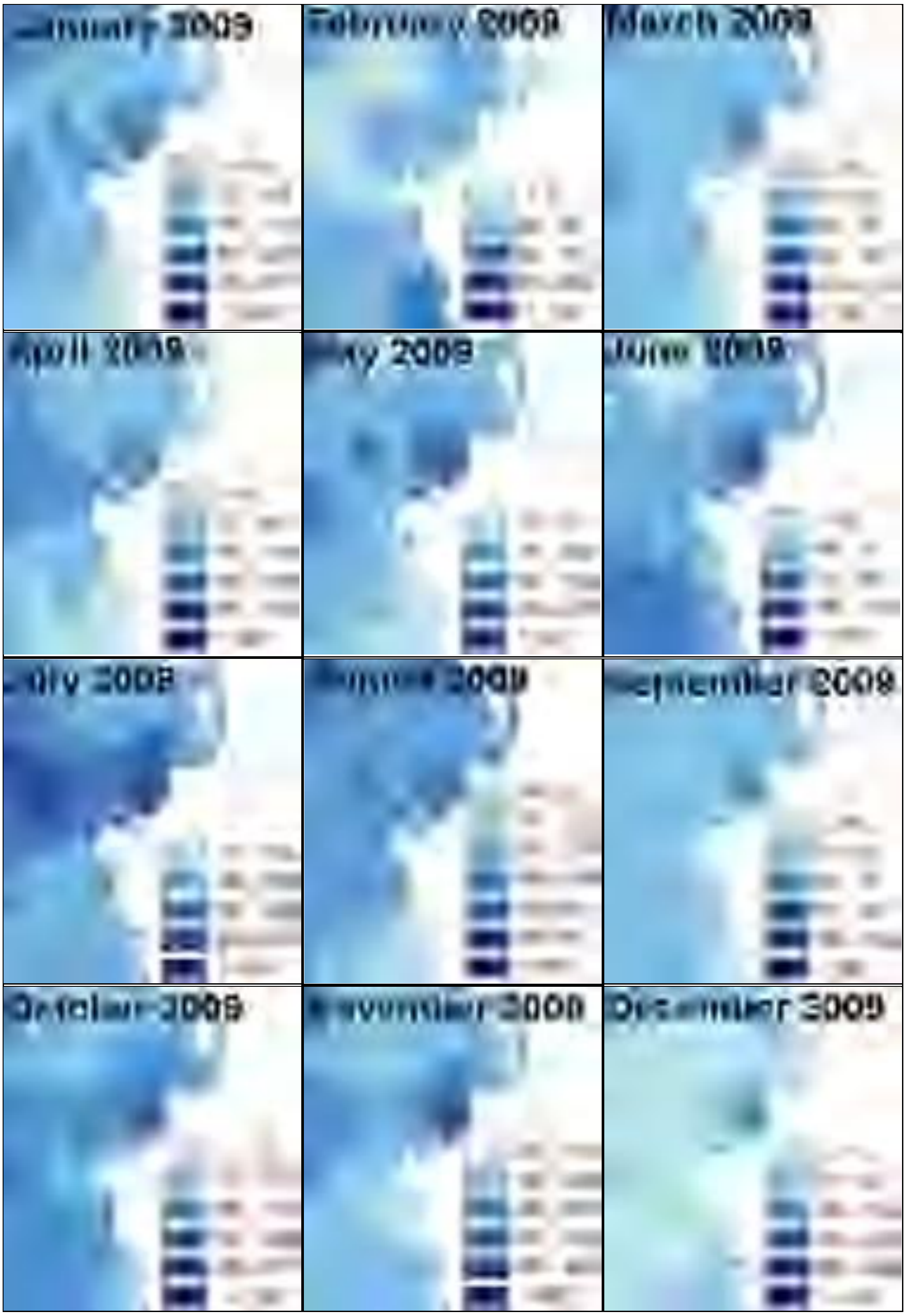


Figure 3.15: Average monthly rainfall (mm) data for 2009 (Source: Met Eireann, 2010a).

Table 3.9: Averaged monthly rainfall (mm) data summarised for the Carlingford Lough area (Source: Met Eireann, 2010a).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	50-150	50-100	75-150	50-100	50-100	50-100	100->200	50-150	150-300	50-150	100-300	50-150
2009	75-200	25-50	25-75	75-150	75-150	50-150	100-300	100-200	25-75	100-200	150-300	<75-150
2008	100-300	25-75	75-150	25-50	<25-50	<75-150	100->200	200->300	100->200	100-200	50-100	75-200
2007	75-150	50-150	50-150	<25	50-100	150-400	100-300	100-200	25-75	25-75	75-150	75-200
2006	25-75	25-75	100-200	25-100	100-200	25-75	25-150	50-200	100-300	100-200	75-300	100-300
2005	75-200	25-75	50-100	50-150	50-150	25-75	50-100	25-100	75-200	100-300	50-150	75-150

Table 3.10: Median monthly rainfall (mm) data summarised for the Carlingford Lough area (Source: Met Eireann, 2010a).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	100	75	113	75	75	75	200	100	225	100	200	100
2009	138	38	50	113	113	100	200	150	50	150	225	94
2008	200	50	113	38	31	94	200	300	200	150	75	138
2007	113	100	100	13	75	275	200	150	50	50	113	138
2006	50	50	150	63	150	50	88	125	200	150	188	200
2005	138	50	75	100	100	50	75	63	138	200	100	113

Table 3.11: Total seasonal rainfall (mm) values from 2005-2010 based on median rainfall values (Source: Met Eireann, 2010a).

Year	Spring	Summer	Autumn	Winter
2010	263	375	525	275
2009	276	450	225	270
2008	182	594	425	388
2007	188	625	213	351
2006	363	263	538	300
2005	275	188	438	301

It can be seen from Table 3.9 and Figure 3.15 that the lowest rainfall in the past 5 years occurred in April 2007 (<25mm) with the highest occurring in August 2008 (200->300mm). Figure 3.15 indicates that for the most part, rainfall values along the northern shore of Carlingford Lough are higher than those experienced along the southern shore. Table 3.11 shows seasonal rainfall figures for the Carlingford Lough area based on median rainfall values from 2005-2010 (Met Eireann, 2010a). The following seasonal fluctuations were observed from 2005-2010: In 2005 and 2006, summer was the driest season and autumn was the wettest, in 2007 and 2008, spring was driest and summer was the wettest, in 2009 autumn was the driest and summer was the wettest and in 2010 spring was the driest and autumn was the wettest These values compare well with the data from the Carrickmacross/Ardee stations, located approximately 34km southwest of Carlingford Lough.

3.6.2. Frequency of Significant Rainfalls

Figures 3.16 and 3.17 show the average monthly rainfall for the Carlingford Lough area from 1971-2000 and 2005-2010 respectively. Figure 3.18 shows the average monthly rainfall data at the Carrickmacross/Ardee stations from 2005-2010. Over the past 5 years, July and August have on average been the wettest months, followed by October and November and of these 5 years, 2008 and 2009 were the wettest on average. During these months there may be an increased risk of contamination from land run-off and rainfall associated sewer overflows. These data highlight the fact that it is not just the winter months that are at risk of increased contamination.

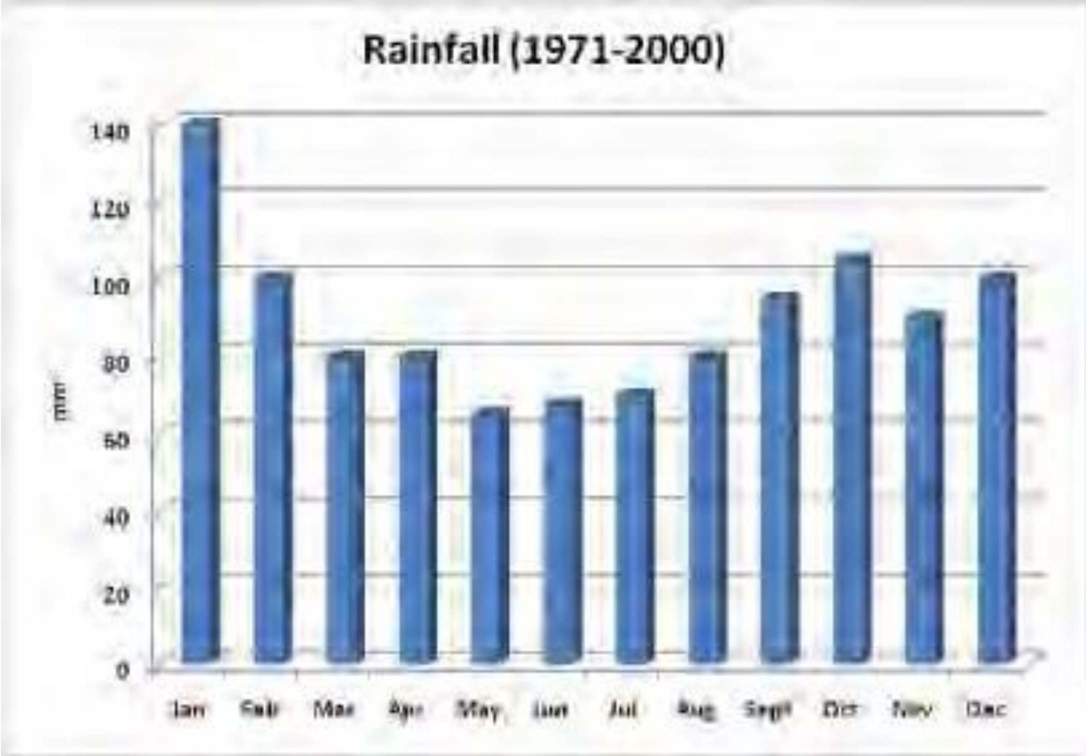


Figure 3.16: Average monthly rainfall (mm) data along the Carlingford Lough coast from 1971-2000 (Source: Met Office, 2010).

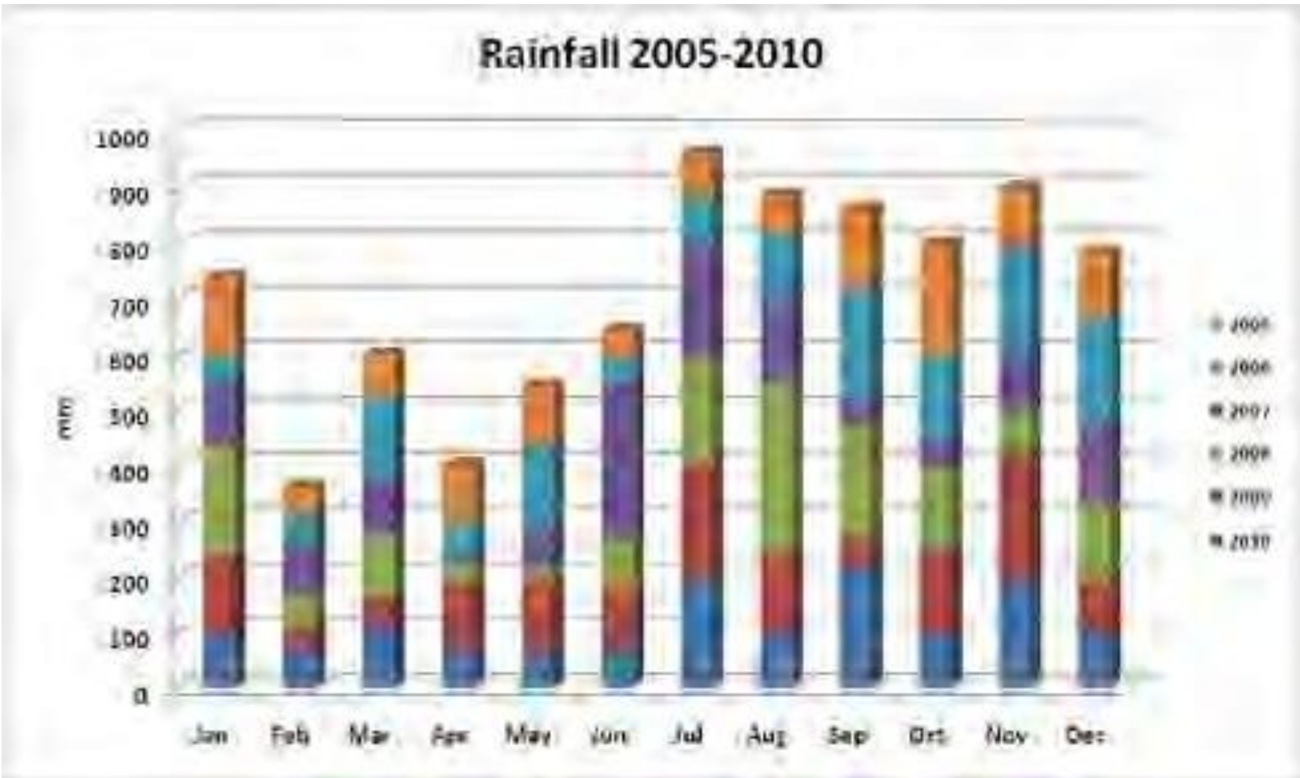


Figure 3.17: Average monthly rainfall (mm) data along the Carlingford Lough coast from 2005-2010 (Source: Met Eireann, 2010a).

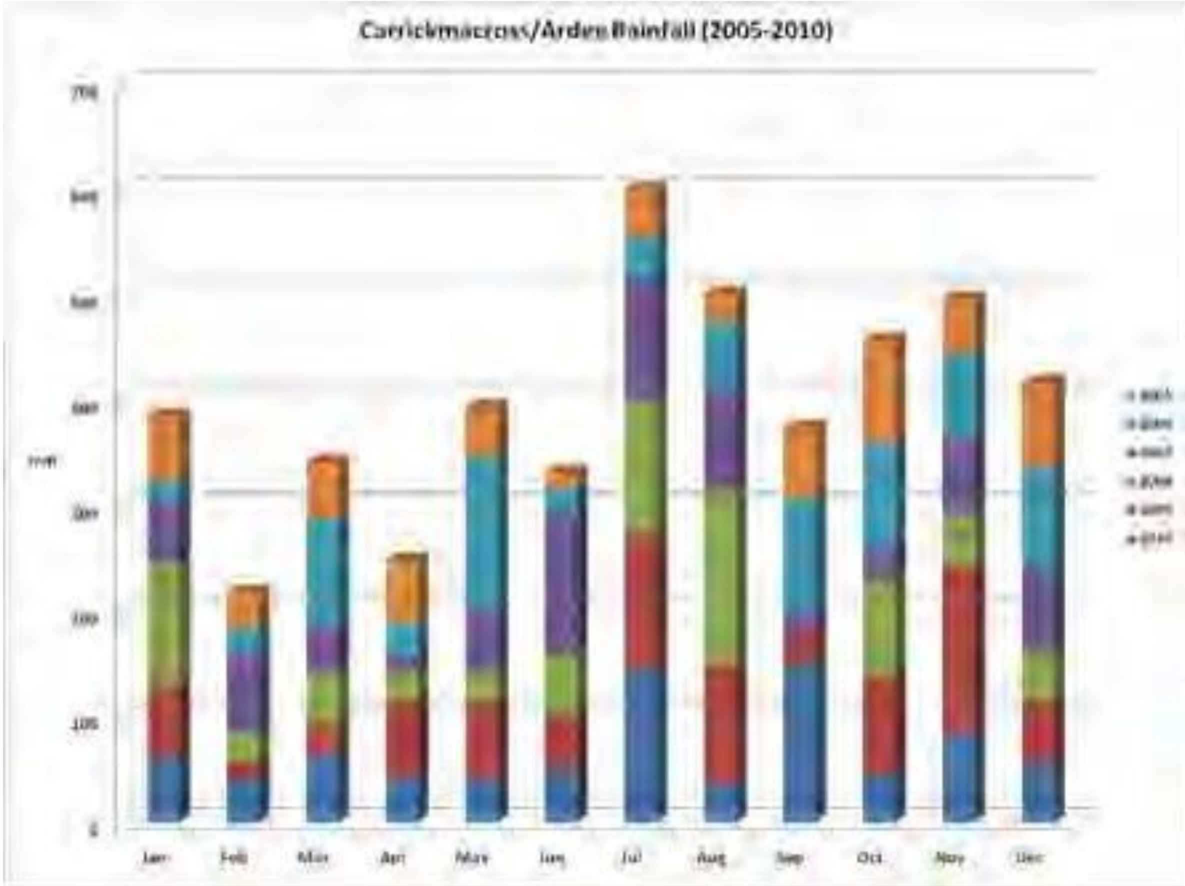


Figure 3.18: Average monthly rainfall (mm) data at Carrickmacross, Co. Monaghan/Ardee, Co. Louth from 2005 to 2010 (Source: Met Eireann, 2010a).

3.7. Salinity

The Loughs Agency collects data on coastal water quality including salinity via a network of remotely moored Environmental Monitoring Stations (EMS) in Carlingford Lough. AFBI manage and process these data. The EMS consists of an electronic unit which houses the data storage devices for capturing real time data and the GSM (Global System for Mobile Communication) telemetry system for communication of these data with a base station on-land. There are two EMS stations located within Carlingford Lough, North and South (See Figure 3.19). The Carlingford Lough North EMS is located approximately 650m southwest of Killowen Point and the Carlingford Lough South EMS is located approximately 2.1km southeast of Greenore. Salinity data are collected daily. In addition, the Loughs Agency hold salinity data from a number of growth monitoring sites located with Carlingford Lough. These can be seen in Figure 3.19, CU1 is located approximately 1.5km southeast of Omeath, Co. Louth and CU2 is located approximately 800m north of Carlingford, Co. Louth. Data are collected monthly. Northern Ireland Environment Agency (NIEA) Water Management Unit collect water samples for salinity analysis (amongst other parameters – see Section 5.1.1) from various locations around

Carlingford Lough (See Figure 3.19). Data are collected quarterly.

Figure 3.19: Location of the salinity monitoring sites in Carlingford Lough.

Figure 3.20 shows the mean, minimum and maximum salinity values from all of the salinity sites within the Lough. The stations west of an imaginary line drawn from Carlingford Point to Killowen Point have a lower average salinity than those stations east of the line, i.e. towards the Irish Sea. The minimum recorded salinity value of 4.8 psu was recorded at Station CU2 (between Carlingford Town and Carlingford marina) and the maximum of 37.85 psu was recorded at station EMS South (between Greenore and Ballagan). Taylor *et al.* (1999) reported similar results and trends within the Lough and noted that the range within stations was greater at the inner sites, reflecting the influence of freshwater inputs. Douglas (1992) also reported similar results.

The flow from the Newry River (which represents 70% of the total riverine flow into the Lough) is small in comparison to the tidal prism of Carlingford Lough: the average recorded daily flow of the Newry River is 470,707m^3, compared with a tidal prism volume of approximately 146 x 10^{6}m^3 (Taylor *et al,* 1999). In addition, Wilson (1974) carried out an analysis of salinity variation over the tidal cycle and his results indicated that even in the inner Lough the influence of rivers on salinity was only significant at low tide.

Figure 3.20: Mean, minimum and maximum salinity values from 2007-2009 (Source: NIEA, Loughs Agency).

3.8. Turbidity

Turbidity is a measure of the degree to which water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Taylor *et al.* (1999) monitored light penetration (Secchi depth) and Suspended Particulate Matter (SPM) in Carlingford Lough from January 1997 to June 1998. Table 3.12 shows the Secchi depth and SPM at 17 stations located throughout Carlingford Lough.

Within the Lough, Secchi depth increased in the direction of the Irish Sea and SPM levels decreased in the same direction (See Figure 3.21). Secchi depth ranged from a minimum of 0.20m at station 1 to a maximum of 7.25m at station 15 and was lowest during the winter months of October to February. The low Secchi depths recorded at the innermost stations most likely reflects the high suspended matter loadings originating from the Newry River and the resuspension of bed sediments in the shallower water depths from wind, wave and tidal action. It is likely that some of this suspended load arises from the flood banks that protect the reclaimed land on the far side of the river from the canal (Department of Industrial & Forensic Science, 1976). SPM ranged from an average level 46.76 mg/L at station 1 to an average of 26.02 mg/L at station 15 (Table 3.12). Suspended Particulate Matter loads are a function of freshwater input, tidal range, salinity and wind stress (Dyer, 1972).

Table 3.12: Light penetration and SPM in Carlingford Lough from January 1997 to June 1998 (Taylor *et al.,* 1999).

Station	Secchi depth (m)			SPM (mg/L)		
	Min	Mean	Max	Min	Mean	Max
1	0.20	**0.88**	1.50	23.60	**46.76**	132.67
2	0.40	**1.17**	2.25	24.30	**44.76**	187.40
3	0.20	**1.57**	3.50	20.28	**36.19**	104.66
4	0.25	**1.49**	3.80	22.80	**35.94**	87.80
5	0.25	**2.01**	4.00	21.43	**31.69**	61.60
6	0.25	**2.00**	4.00	18.86	**39.60**	218.57
7	0.75	**2.35**	4.75	18.29	**30.42**	47.20
8	0.25	**2.45**	3.75	19.42	**29.37**	57.68
9	0.75	**2.55**	4.00	16.86	**28.31**	43.60
10	0.75	**3.06**	5.75	19.00	**27.85**	54.85
11	0.5	**3.53**	6.25	16.10	**29.18**	55.00
12	0.75	**3.80**	7.00	16.20	**27.58**	58.40
13	0.5	**3.75**	7.00	18.25	**26.87**	60.56
14	0.75	**4.01**	7.00	17.15	**27.88**	58.04
15	0.75	**4.24**	7.25	12.29	**26.02**	47.00
16	0.75	**4.16**	6.70	15.53	**26.52**	51.60
17	0.90	**3.31**	5.50	18.85	**26.92**	42.50

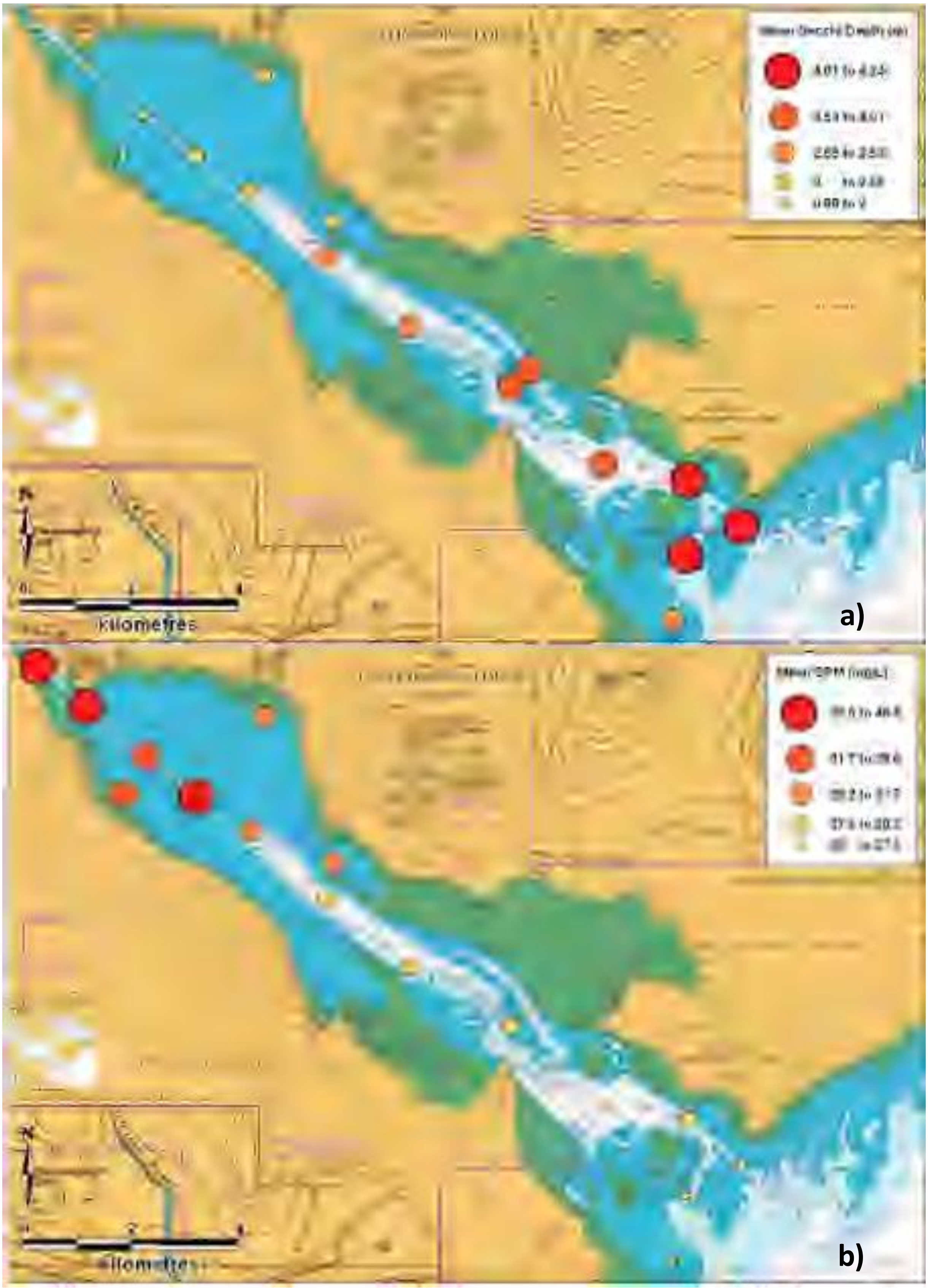


Figure 3.21: a) Secchi depth and b) SPM levels in Carlingford Lough from January 1997 to June 1998 (Source: Taylor *et al.,* 1999).

3.9. Residence Times

Residence time can be defined as the average amount of time that a molecule of water of a particle spends in a particular system (in this case Carlingford Lough). Residence times are important because of the way they govern productivity rates as well as the vulnerability to water quality degradation. The residence times within the Lough during the summer can be seen in Figure 3.22 (Source: Ferreira *et al.,* 2007). These values are calculated from the SMILE Delft3D Model. Carlingford Lough can be divided into three zones of long (> 20 days), mid (8–20 days) and short (< 8 days) residence times.

These residence time gradients have important ecological implications because they modulate the dynamical relationship between nutrient dispersion/transport and its utilisation by phytoplankton. Domains with long residence times are vulnerable to both nutrient depletion and low production if the main supply flux is from the coast and to eutrophication if the land based flux is much larger than the advection/dispersion rates. Ecologically the upper reaches are likely to be predominantly regeneration production driven in contrast to the short residence time areas near the mouth which will be largely new production driven.

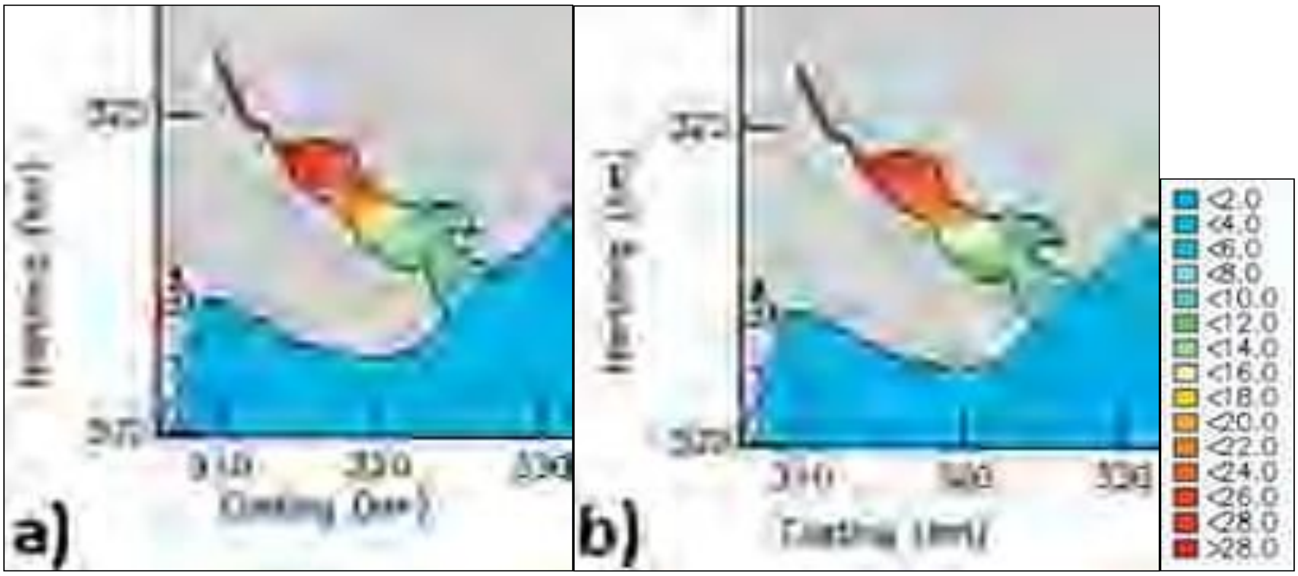


Figure 3.22: Residence times (days) within Carlingford Lough a) near surface and b) near bottom (Source: Ferreira *et al.,* 2007).

3.10. Discussion

The inner section of Carlingford Lough (inside Killowen Point) is shallow (<5m depth), has relatively weak tidal currents and receives approximately 70% of the Loughs freshwater input from the Newry/Clanrye River.

These three factors combine to result in a turbid slow moving sink with a long residence time (>20 days). In contrast the outer part of the Lough experiences strong tidal currents, deeper depths and shorter residence times (<8 days), which all results in a faster moving well flushed area. Any contamination in the outer section of the Lough will be diluted and dispersed rapidly, whereas the inner part of the Lough can act as a sink for contaminants. In addition, the prevailing wind direction in the area has the effect of pushing water towards the northern shoreline, into Rostrevor Bay and Mill Bay and given their shallow nature these areas may also act as sinks for contaminants.

4. Identification of Pollution Sources

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

4.1. Desktop Survey

Pollution sources were considered within the catchment area of Carlingford Lough (see Figure 4.1). The catchment area covers an area of 477.4km^2, approximately 21.5km east west at its widest point and 40km north south at its longest point.

Figure 4.1: Carlingford Lough catchment area used for assessment of the pollution sources.

4.1.1. Human Population

Figure 4.2 shows all of the counties which fall within the Carlingford Lough catchment area: Louth, Armagh and Down. Population census data for Northern Ireland is given in units of Super Output Areas (SOA) or wards and District Electoral Divisions (DED) are used by the Central Statistics Office (CSO) for Co. Louth. Figure 4.3 shows the Northern Ireland SOA/wards and the Republic of Ireland DEDs within the Carlingford Lough catchment area.

Figure 4.2: Counties within the Carlingford Lough Catchment Area.

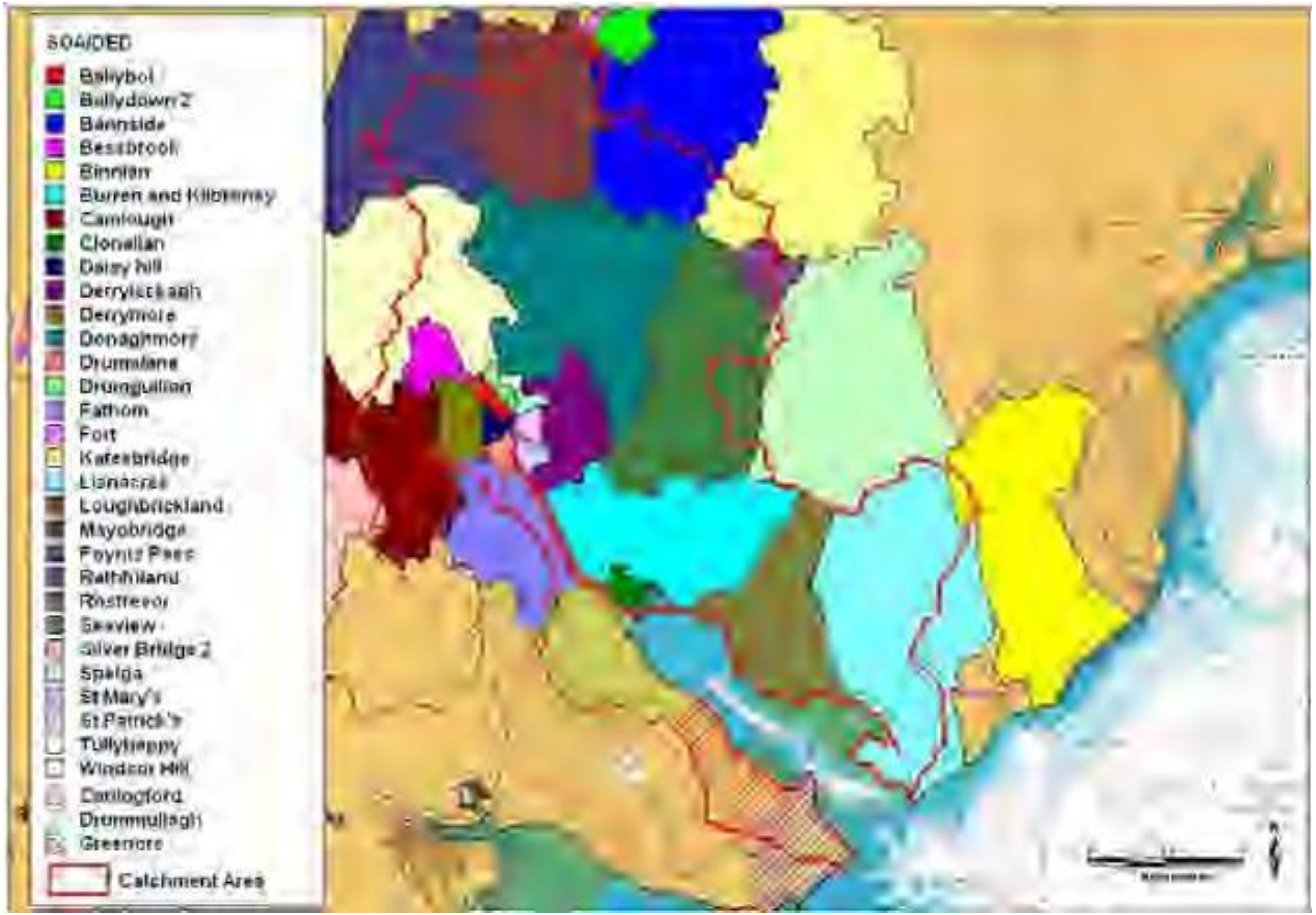


Figure 4.3: SOAs and DEDs within the Carlingford Lough Catchment Area.

Data on human populations for 2008 for Northern Ireland were obtained from The Northern Ireland Statistics and Research Agency (NISRA) website. The Republic of Ireland data were obtained through the Central Statistics Office (CSO) online census programme (CSO, 2010a) for the year 2006. Figure 4.4 shows the human population within the Carlingford Lough catchment area and Table 4.1 shows these data in tabular form.

The largest population centres in the study area are Derryleckagh (4,493 people), Clonallan (4,490 people) and Burren and Kilbroney (4,220). These areas are located to the east of Newry and incorporate Warrenpoint. Population sizes ranging from 2,106 (Ballybot) to 3,789 (Mayobridge) are present all around Newry Town. Along the southern shore of the Lough, the smallest population is in Greenore (979 people), the largest is in Carlingford (1,384) and Drummullagh has a population size of 1,120 people. Along the northern shoreline, as mentioned previously, the largest population is centred around Warrenpoint (Clonallan – 4,490 people; Burren and Kilbroney – 4,220 people and Seaview – 3,163 people). Moving southeast along the northern shore, Rostrevor has a population of 2,718 people and Lisnacree has a population of 2,867 people. It is clear from Figure 4.5 that the areas with a denser population are located along the northern shoreline and in the area of Newry and Warrenpoint. The total population within the Carlingford Lough catchment is estimated at approximately 61,000 people[4].

Figure 4.5 and Table 4.2 shows the 2008[5] population size in the main urban centres within the catchment area (NISRA, 2011; CSO, 2011). Newry City (29,946) and Warrenpoint (7,605) are the largest population centres, located to the north of the Lough. The remaining coastal centres are all villages/intermediate settlements with populations ranging from 439 (Omeath) to 2,556 (Rostrevor).

Human population in given areas is obtainable from census data; however, relating this information to the level of microbial contamination in coastal waters is difficult and is constrained by the geographic boundaries used. Nonetheless, it is clear that areas with a higher population will have higher levels of sewage and wastewater entering the Carlingford Lough system. Therefore, the highest levels of sewage and waste enter the Lough from the Newry/Warrenpoint area, followed by the rest of the northern shoreline and then from the southern shoreline.

[4] Some DEDs/SOAs extended beyond the catchment area, therefore in order to estimate the population size within the catchment area only, the percentage of the DED/SOA lying within the catchment was calculated in GIS and from this value the population size was calculated e.g. if 50% of DED/SOA lies within catchment area then 50% of the total population was taken to be the population size of the area within the catchment.

[5] Data for Republic of Ireland is from 2006

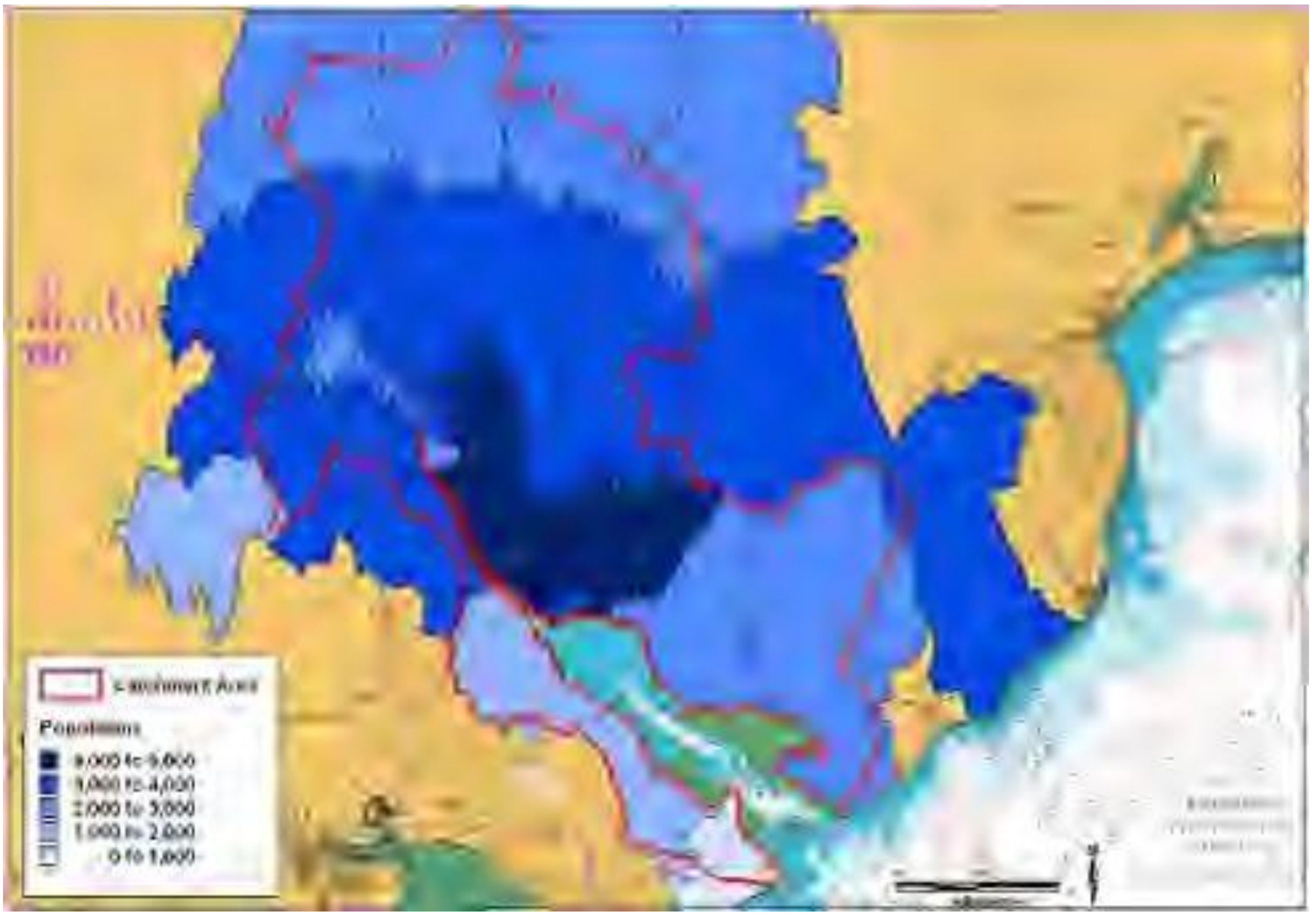


Figure 4.4: Human population within the Carlingford Lough Catchment Area (Source: NISRA, 2010; CSO, 2010a).

Table 4.1: Human population within the Carlingford Lough Catchment Area (Source: NISRA, 2010; CSO, 2010a).

DED/SOA	Population	DED/SOA	Population
Carlingford	1,384	Derrymore	3,203
Greenore	979	Derryleckagh	4,493
Drummullagh	1,120	Daisy Hill	3,388
Windsor Hill	3,120	Clonallan	4,490
Tullyhappy	3,179	Camlough	3,448
St. Patrick's	3,701	Burren & Kilbroney	4,220
St. Mary's	2,401	Binnian	3,177
Spelga	3,147	Bessbrook	2,396
Silverbridge 2	1,918	Ballybot	2,106
Seaview	3,163	Rathfriland	2,800
Rostrevor	2,718	Loughbrickland	2,698
Mayobridge	3,789	Katesbridge	2,651
Lisnacree	2,867	Fort	2,501
Fathom	3,260	Bannside	2,754
Drumalane	3,211	Ballydown 2	2,500
Drumgillion	3,164	Poyntz Pass	2,493
Donaghmore	3,349		

Figure 4.5: Population size of urban areas within the Carlingford Lough catchment area (Source: NISRA, 2011; CSO, 2011).

Table 4.2: Population size of urban areas within Carlingford catchment area (Source: NISRA, 2011; CSO, 2011)

Name	Town/Village	Population
Rostrevor	Intermediate Settlement	2556
Warrenpoint	Small Town	7605
Newry	Large Town	29946
Rathfriland	Intermediate Settlement	2575
Omeath	Village	439
Carlingford	Village	623

4.1.2. Tourism

In 2009, 1.8 million tourists visited the East and Midlands Region of Ireland (Failte Ireland, 2010). This figure was made up of 759,000 overseas tourists, 947,000 domestic tourists and 106,000 Northern Irish tourists. Of the overseas tourists, 89,000 visited Co. Louth. There is no way of estimating what percentage of these visitors spent time along the Cooley Peninsula. The East and Midlands region had a significant growth in tourist numbers between 2005 and 2007; however, in 2009 the underlying trend shows a return to levels experienced in the post 9/11 and Foot and Mouth years (Fáilte Ireland, 2010).

Of the overseas tourists, 47% were visiting family and friends and 32% were holidaying, 35% of them arrived between June and August, 19% between October and December and 17% between January and March and 56% stayed with family and friends (Fáilte Ireland, 2010). Of the domestic tourists visiting the East and Midlands region, 42% were holidaying, 40% were visiting family and friends. The timing of these visits was fairly evenly spread throughout the year (28% between October and December; 27% between July and September; 25% between April and June and 21% between January and March) (Fáilte Ireland, 2010).

In 2009, 1,918,000 tourists visited Northern Ireland (NITB {Northern Ireland Tourist Board}, 2009) compared with 2,076,000 in 2008. This was the lowest figure recorded since 2004 and is a 3.4% decrease on 2004 figures and a 7.6% decrease on 2008 numbers. Of these tourists, 47% were visiting family and friends and 26% were holidaying, 32% of them arrived in between July and September and 26% of them arrived between April and June and 59% stayed with family or friends while 27% stayed in a hotel. A NITB local authority survey revealed that in 2009, 936,000 trips were made to the Newry & Mourne area[6] with an estimate value of £12.7 million (NITB, 2010). This represents approximately 3% of the visitors who visited Northern Ireland in 2009. There is however no way of estimating the number of tourists who visited the Rostrevor/Greencastle area during their stay.

There are numerous activities which tourists can partake in along the shores of Carlingford Lough, i.e. walking, climbing, water activities, golf, camping, caravanning, water sports, adventure centres, beaches, angling and yachting and there is one Blue Flag Beach located in Cranfield Bay and a marina located in Carlingford. Figure 4.6 shows all tourism related activity sites within the Carlingford Lough catchment area. These data were gathered from a Loughs Agency Marine Tourism Audit and from Ordnance Survey maps.

Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Carlingford Lough area. In addition, Papadakis *et al.* (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria. In 2007, Elmir *et al.* (2007) showed the role of human skin as an intermediate mechanism of pathogen transmission to the water column. The main swimming beach in Carlingford Lough is Cranfield Bay. In addition, waste can enter the Lough from recreational vessels. Carlingford marina is the only tourism based marina in the Lough and it has in place waste disposal arrangements to prevent the contamination of water from vessel waste.

[6] The Carlingford Lough area is located within the Newry & Mourne district council/local authority area, which includes the Northern Irish coastline of the Lough, the Mourne mountains and extends north and west of Newry.

In order to identify any significant differences in *E. coli* levels based on seasonality, a one-way analysis of variance (ANOVA) was performed on *E. coli* results from 9 water sampling sites at Cassey Water and Ballyedmond and on *E. coli* results from shellfish flesh taken at a number of beds around the Lough (Refer to Sections 5.1.1 and 5.1.2 for more details on these sampling points). For this analysis, all shellfish flesh results that returned a less than (<) value (i.e. <1) were halved (i.e. <1 becomes 0.5) and all samples that returned a ND (Not Detectable) result were given a value of 0. Only those years with ≥6 shellfish flesh samples per year were used. Table 4.3 shows the data periods (by shellfish bed) used for the analyses.

Figure 4.6: Tourist facilities within the Carlingford Lough Catchment Area.

Table 4.3: Data periods used for analysis of seasonal variation in *E. coli* levels in Carlingford Lough.

Shellfish Bed	Species	Data Date Period
Ballyedmond	Oyster	2006-2010
Carriganean	Oyster	2006-2010
Fair Green	Oyster	2006-2010
Flynn	Mussel	2006-2010
Narrow Water	Mussel	2007, 2009-2010
Rostrevor	Mussel	2006-2010
Killowen	Mussel	2009-2010
Ballagan	Oyster	2006-2010
Ballagan	Razor Clam	2006, 2008
Greenore	Mussel	2006-2010

Shellfish Bed	Species	Data Date Period
Greenore	Oyster	2006-2010
McCarthy	Mussel	2007, 2009-2010
Inner	Mussel	2009-2010

Figure 4.7 shows box-plots produced for each shellfish bed after grouping the data by season. These graphs are frequently used to assess and compare sample distributions of microbiological data and are generally composed by a median line (or the middle line of the data), the bottom box, which indicates the first quartile value (25% of the data values are less than or equal to this value), the top box which indicates the third quartile (75% of the data values are less than or equal to this value), the lower whisker or lower limit and the upper whisker or the highest data value within the upper limit. Outliers (large and small) are represented by an asterisk. It should be noted that some of the shellfish bed box plots are shown twice in Figure 4.7, this is due to the fact that the first plot shows a very large outlier which resulted in an illegible distribution; the second plot shows the distribution without the outlier.

There were no significant differences in *E. coli* concentrations in shellfish flesh from 2006 to 2010 with the exception of the Inner (mussel) site between summer and autumn. In addition, it can be seen in Figure 4.7 that for the most part, *E. coli* concentrations were higher during the autumn and winter months compared with the summer months. This scenario is expected given higher rainfall in autumn and winter and increased hours of sunlight in the summer months (UV light inactivates *E. coli* therefore lower numbers in the summer months). No significant increases in *E. coli* levels during the summer months were evident from this analysis, implying that in Carlingford Lough the effects of increased rainfall and subsequent run-off has more of an effect on *E. coli* levels than from any increase in population during the summer months.

No significant differences between water *E. coli* concentrations were seen between 2005 and 2010; however, it must be noted that there were large gaps in the data.

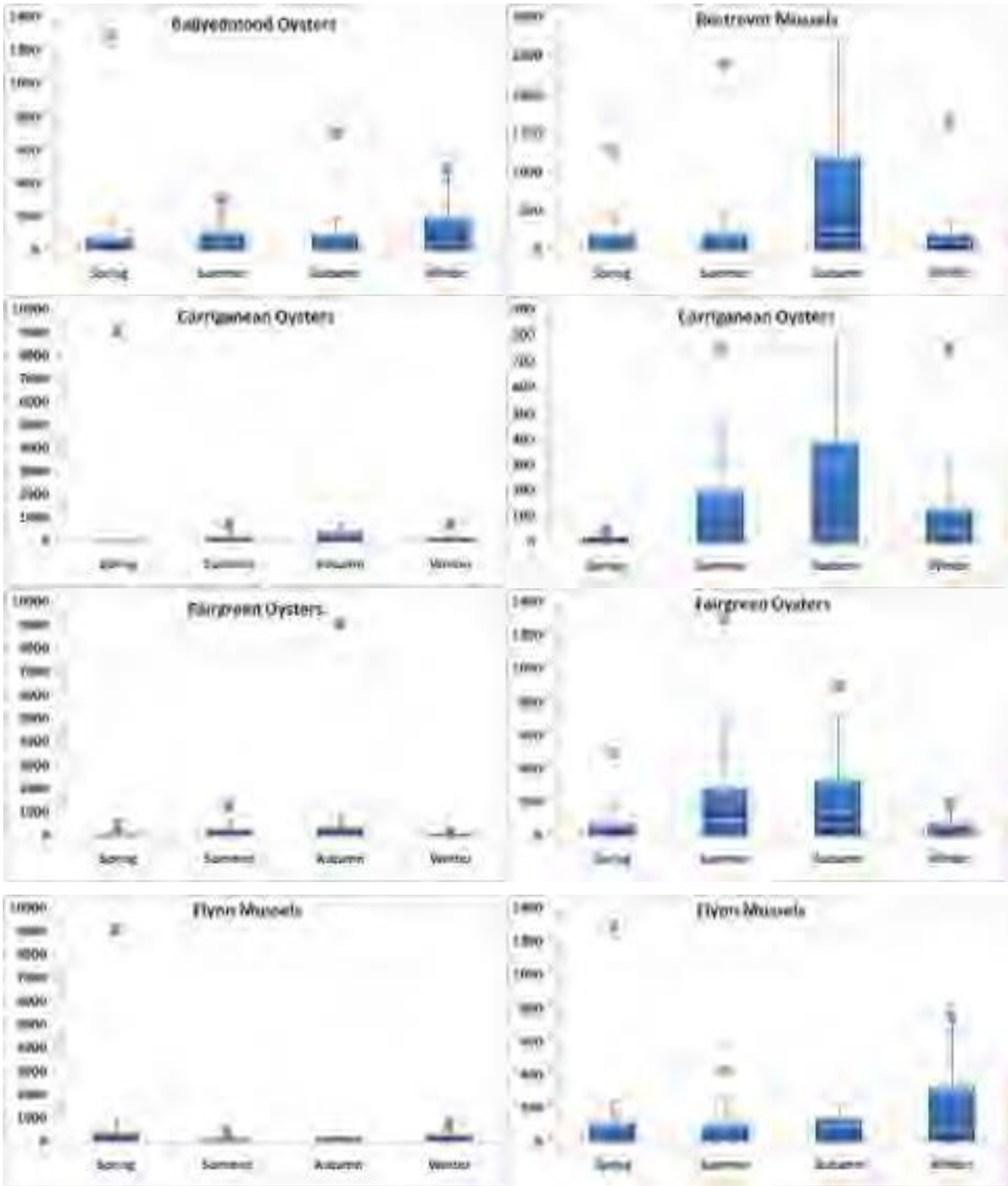


Figure 4.7: Seasonal variation of *E. coli* in shellfish flesh from Carlingford Lough.

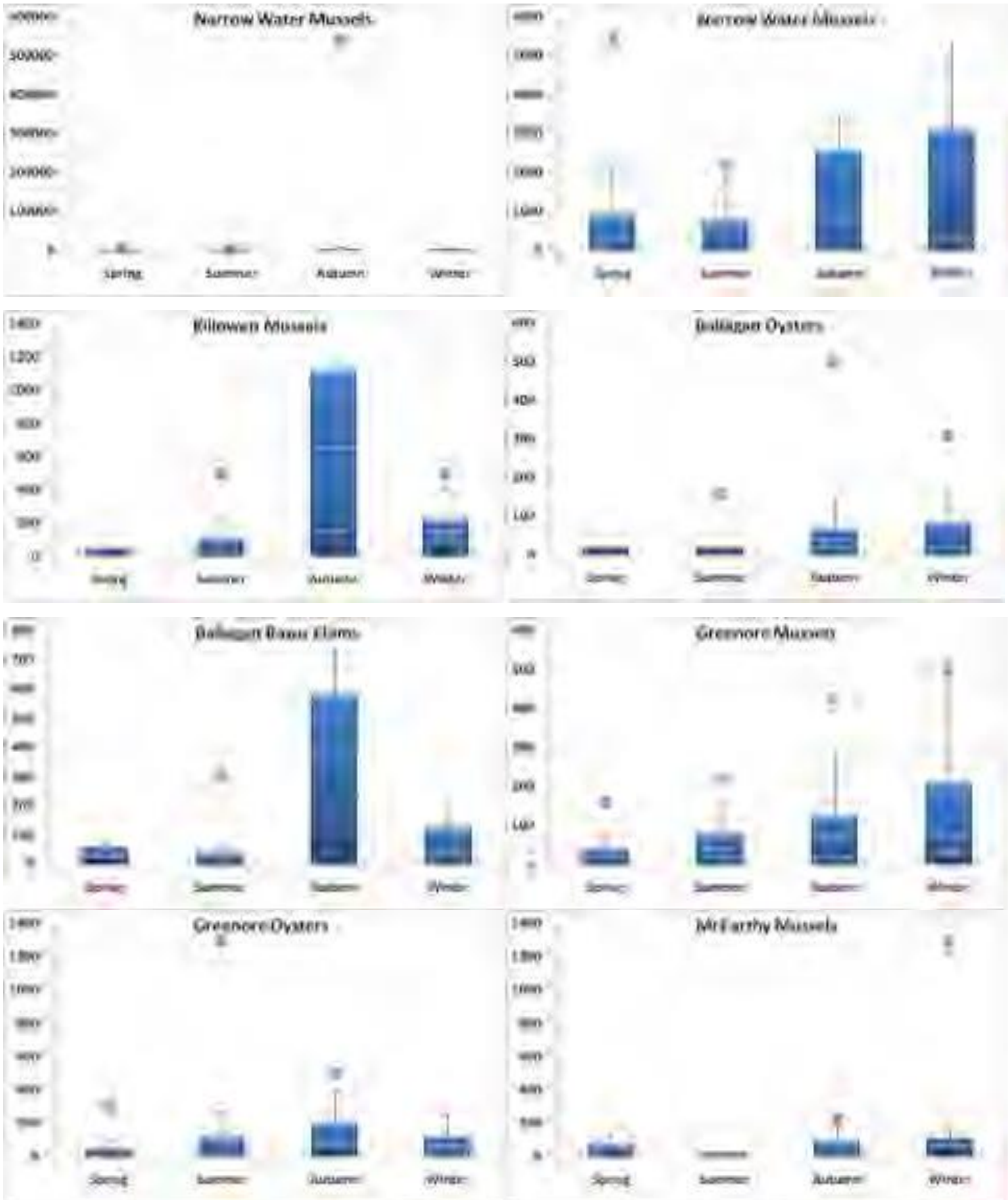


Figure 4.7 (Cont'd).

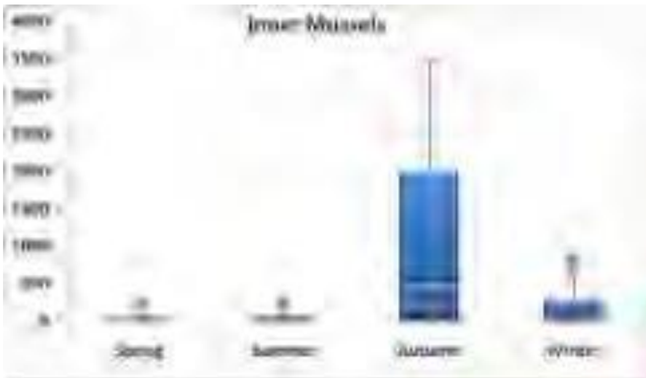


Figure 4.7 (Cont'd).

4.1.3. Sewage Discharges

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

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

Treatment of sewage ranges from:

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

Figure 4.8 shows all 21 Waste Water Treatment Works (WWTW)/Sewage Schemes within the Carlingford Lough catchment area. Table 4.4 shows the coordinates and population equivalents (p.e.) of these plants.

Figure 4.8: WWTWs and Sewage Schemes within the Carlingford Lough Catchment Area (Source: The EPA, NIEA Water Management Unit, The Loughs Agency, NI Water).

Table 4.4: WWTWs and Sewage Schemes within the Carlingford Lough Catchment Area (Source: The EPA, NIEA Water Management Unit, The Loughs Agency; NI Water).

Map Code	Name	Easting	Northing	Longitude	Latitude	p.e.
1	Greenore Sewage Scheme	[Redacted]	[Redacted]	[Redacted]	[Redacted]	n/a
2	Carlingford Sewage Scheme	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1200
3	Omeath Sewage Scheme	[Redacted]	[Redacted]	[Redacted]	[Redacted]	487
4	Newry WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	63915
5	Damolly WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	>250
6	Mullaghglass WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	168
7	Jerrettspass WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	39
8	Lurganare WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	407
9	Corgary Cottages WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	18
10	Beech Hill South WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	48
11	Glen Villas WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	<250
12	Killysavan WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	30
13	Poyntzpass WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	880
14	Acton WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	83
15	Bankside WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	57
16	Rathfriland WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	3455
17	Ballyrussel WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	24
18	Warrenpoint WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	14936
19	Attical WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	111
20	Ballymaderphy WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	66
21	Cranfield WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	3681

4.1.3.1. Continuous Sewage Discharges

Figure 4.9 shows the continuous sewage discharges associated with the WWTWs/Sewage Schemes within the Carlingford Lough catchment area and all discharges identified from the admiralty charts. A large-scale cross-referenced map can be found in Section 4.3 Location of Sources.

All of the WWTW/Sewage Schemes shown in Figure 4.8 above have associated continuous discharge pipes associated with them; however, coordinates for some discharge pipes associated with the plants were not available i.e. Beech Hill South WWTW therefore assumptions were made based on the location of the plant. It was also assumed that each of these plants had one continuous discharge pipe. In addition to WWTW discharge pipes; there are 2 discharge pipes from sewage schemes discharging untreated waste into Carlingford Lough from Omeath and Greenore. Any plans in the future that would allow for the primary or secondary treatment of these discharges should be seen in a favourable light as treatment will help improved the quality of water in the Lough.

In total, there are 4 direct discharges into Carlingford Lough and the remainder discharge into rivers which ultimately discharge into the Lough. Table 4.5 shows details on the continuous discharges (Source: WWTW Public Register). Those which have a Y in the Discharge Data column of Table 4.5 have accompanying discharge analysis results (Source: NI Water), which can be found in Appendix 1 (for 2010). The following parameters are available for these discharges: Ammonia, Nitrate, Nitrite, Nitrogen oxides, Total Nitrogen, Phosphorus, Biochemical Oxygen Demand, Suspended Solids, pH and metals.

The largest volumes discharged by these plants come from the Newry WWTW, which discharges secondary treated waste water into the Newry River and ultimately Carlingford Lough (41,990 m^3/day) and the Warrenpoint WTWW, which discharges secondary treated waste water directly into Carlingford Lough (7,860 m^3/day).

Figure 4.9: Location of Continuous Sewage Discharges within the Carlingford Lough Catchment Area (Source: The EPA, NIEA Water Management Unit, The Loughs Agency, NI Water).

Table 4.5: Continuous Discharges within the Carlingford Lough Catchment Area (Source: The EPA, NIEA Water Management Unit, The Loughs Agency, NI Water).

Map ID	Name	Discharge A	Easting	Northing	Longitude	Latitude	Receiving Body	Max Discharge/ day (m^3)	DWF/ day (m^3)	Discharge Data
1A	Greenore Sewage Scheme	Untreated	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	0		
2A	Carlingford Sewage Scheme	Secondary	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	0		
3A	Omeath Sewage Scheme	Untreated	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	0		
4A	Newry WWTW	Secondary treated waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Newry River	41990	13997	Y
5A	Damolly WWTW	Secondary treated waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Newry River	807	333	
6A	Mullaghglass WWTW	Secondary treated waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Unnamed Trib.	96.3	43.3	Y
7A	Jerrettspass WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Newry Canal	31	10	
8A	Lurganare WWTW	Secondary treated waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]		0		Y
9A	Corgary Cottages WWTW	Good secondary treated effluent with nitrification	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Of Newry River	48	16	
10A	Beech Hill South WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]		0		
11A	Glen Villas WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Newry River	160	53	
12A	Killysavan WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Newry River	24	8	
13A	Poyntzpass WWTW	Secondary treated waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Newry Canal	585	195	Y

Map ID	Name	Discharge A	Easting	Northing	Longitude	Latitude	Receiving Body	Max Discharge/ day (m^3)	DWF/ day (m^3)	Discharge Data
14A	Acton WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Newry Canal	162	54	
15A	Bankside WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Clanrye River	24	8	
16A	Rathfriland WWTW	Secondary treated waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Clanrye River	3111	1183	Y
17A	Ballyrussel WWTW	Good secondary treated effluent with nitrification	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Moygannon River	31	10	
18A	Warrenpoint WWTW	Secondary treated waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	7860	3164	Y
19A	Attical WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Yellow Water	120	40	
20A	Ballymaderfy WWTW	Secondary treated effluent	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Carlingford Lough	117	26	
21A	Cranfield WWTW	Fine screened waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	6910	50 (1/10 - 30/4), 2300 (1/5 - 30/9)	

4.1.3.2. Rainfall Dependent Sewage Discharges

In addition to WWTW having a continuous discharge pipe a number of them also have intermittent discharge pipes. These can be seen in Figure 4.10 and are detailed in Table 4.6. Figure 4.10 also shows septic tanks in the catchment and Table 4.7 details these. Figure 4.11 shows all overflows (i.e. CSO [Combined Sewer Overflows] and SPS [Sewage Pumping Station] overflows) within the catchment area and Table 4.8 details these overflows. It should be noted that while no septic tanks/overflows are shown for the Co. Louth area, it must be assumed that they are present in the area (unfortunately details on their locations was not available). Large-scale cross-referenced maps can be found in Section 4.3 Location of Sources.

Figure 4.10: Intermittent discharges and septic tanks within the Carlingford Lough Catchment Area (Source: EPA, NIEA, The Loughs Agency, NI Water).

Table 4.6: Details on intermittent discharges.

Map ID	Source	Intermittent	Easting	Northing	Longitude	Latitude	Receiving Body	Discharge Details
2B	Carlingford Sewage Scheme	Storm water overflow	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Harbour	n/a
4B	Newry WWTW	Screened storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Newry River	Volume is limited to that which overflows when flow exceeds 486 l/s (41991m3/day) due to rain/snow melt
5B	Damolly WWTW	Storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Newry River	Volume is limited to that which overflows when flow exceeds 9.34 l/s (807m3/day) due to rain/snow melt
6B	Mullaghglass WWTW	Screened unsettled storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Unnamed Trib.	Volume is limited to that which overflows when flow exceeds 1.11 l/s (96.3m3/day) due to rain/snow melt
6C	Mullaghglass WWTW	Screened unsettled storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Unnamed Trib.	Volume is limited to that which overflows when flow at the boundary storm overflow weir exceeds 3.19l/s (276m3/day) due to rain/snow melt
8B	Lurganare WWTW	Screened settled storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. River Jerretspass	Volume is limited to that which overflows when flow exceeds 2.24 l/s (193.7m3/day) due to rain/snow melt
8C	Lurganare WWTW	Screened settled storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. River Jerretspass	Volume is limited to that which overflows when flow at the boundary storm overflow weir exceeds 6.48 l/s (559.7m3/day) due to rain/snow melt
10B	Beech Hill South WWTW	Settled storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Clanrye River	Volume is limited to that which overflows when flow exceeds 1.62 l/s (140m3/day) due to rain/snow melt
13B	Poyntzpass	Screened	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Unnamed stream	Volume is limited to that which overflows when

Map ID	Source	Intermittent	Easting	Northing	Longitude	Latitude	Receiving Body	Discharge Details
	WWTW	storm waste water						flow exceeds 6.8 l/s (586m3/day) due to rain/snow melt
14B	Acton WWTW	Screened storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Newry Canal	Volume is limited to that which overflows when flow exceeds 1.88 l/s (162m3/day) due to rain/snow melt
16B	Rathfriland STW	Screened storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Clanrye River	Volume is limited to that which overflows when flow exceeds 36 l/s (3110 m3/day) due to rain/snow melt
16C	Rathfriland STW	Settled storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Trib. Clanrye River	Volume is limited to that which overflows when flow at the boundary storm overflow weir exceeds 62l/s (5357m3/day) due to rain/snow melt
18B	Warrenpoint STW	Screened settled storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	Volume is limited to that which overflows when flow exceeds 90.97 l/s (7860m3/day) due to rain/snow melt
18C	Warrenpoint STW	Screened storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	Volume is limited to that which overflows when flow at the boundary storm overflow weir exceeds 291.5 l/s (25189m3/day) due to rain/snow melt
19B	Attical STW	Screened storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Yellow Water	Volume is limited to that which overflows when flow exceeds 1.39l/s (120m3/day)due to rain/snow melt
21B	Cranfield STW	Screened storm waste water	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Carlingford Lough	Volume is limited to that which overflows when flow at inlet pumps exceeds the pass forward due to rain/snow melt

Table 4.7: Septic tanks within the Carlingford Lough Catchment Area (Source: The Loughs Agency, NI Water).

Map ID	Name	Easting	Northing	Longitude	Latitude
105	Corrinshingo	Redacted	Redacted	Redacted	Redacted
106	Armagh Road No.1 (144-146)	Redacted	Redacted	Redacted	Redacted
107	Goragh Road (15-17)	Redacted	Redacted	Redacted	Redacted
108	Armagh Road No.3 (189-193)	Redacted	Redacted	Redacted	Redacted
109	Armagh Road No.2 (202-206)	Redacted	Redacted	Redacted	Redacted
110	Maytown Road (43-45)	Redacted	Redacted	Redacted	Redacted
111	Jockeys Brae	Redacted	Redacted	Redacted	Redacted
112	Demoan Villas	Redacted	Redacted	Redacted	Redacted
113	Greenan	Redacted	Redacted	Redacted	Redacted
114	Lakeview Road	Redacted	Redacted	Redacted	Redacted
115	Glascar Road	Redacted	Redacted	Redacted	Redacted
116	Glaskerbeg Road (11)	Redacted	Redacted	Redacted	Redacted
117	Knock Terrace	Redacted	Redacted	Redacted	Redacted
118	Glen View	Redacted	Redacted	Redacted	Redacted
119	Hilltown Road (20-26)	Redacted	Redacted	Redacted	Redacted
120	Newry Rd (80-83)	Redacted	Redacted	Redacted	Redacted
121	St Patricks Villas	Redacted	Redacted	Redacted	Redacted
122	Shinn Road	Redacted	Redacted	Redacted	Redacted
123	Mountain View Tullymurry	Redacted	Redacted	Redacted	Redacted
124	Fourmile	Redacted	Redacted	Redacted	Redacted
125	Corcreeghy Road	Redacted	Redacted	Redacted	Redacted
126	Savalmore Cottages WWTW	Redacted	Redacted	Redacted	Redacted
127	Lurgancahone Rd (35-39)	Redacted	Redacted	Redacted	Redacted
128	Lurgancahone Rd (57-59)	Redacted	Redacted	Redacted	Redacted
129	Hilltown Road (4-6)	Redacted	Redacted	Redacted	Redacted
130	Commons School Road (8-10)	Redacted	Redacted	Redacted	Redacted
131	Lurgancanty Rd (16-18)	Redacted	Redacted	Redacted	Redacted
132	Drumgrevagh Lurgancanty STW	Redacted	Redacted	Redacted	Redacted
133	Ballymaconagh WTW (ST)	Redacted	Redacted	Redacted	Redacted
134	Ballymaconaghy Rd 19	Redacted	Redacted	Redacted	Redacted
135	Kilbroney Park	Redacted	Redacted	Redacted	Redacted

Figure 4.11: Overflows located within the Carlingford Lough Catchment Area (Source: Loughs Agency, NI Water).

Table 4.8: Overflows within the Carlingford Lough catchment Area (Source: The Loughs Agency, NI Water).

MapID	Name	Function	Easting	Northing	Longitude	Latitude
22	Drumalane Road CSO	Combined	Redacted	Redacted	Redacted	Redacted
23	Dublin Road Newry CSO	Combined	Redacted	Redacted	Redacted	Redacted
24	Bridge Street SPS	Combined	Redacted	Redacted	Redacted	Redacted
25	Kiln Street CSO	Foul	Redacted	Redacted	Redacted	Redacted
26	Patrick Street CSO	Foul	Redacted	Redacted	Redacted	Redacted
27	James Connolly Park Patrick Street CSO	Surface	Redacted	Redacted	Redacted	Redacted
28	Not Assigned	Surface	Redacted	Redacted	Redacted	Redacted
29	Win SPS	Foul	Redacted	Redacted	Redacted	Redacted
30	Violet Hill Avenue	Foul	Redacted	Redacted	Redacted	Redacted
31	Not Assigned	Foul	Redacted	Redacted	Redacted	Redacted
32	Camlough Road CSO	Combined	Redacted	Redacted	Redacted	Redacted
33	Camlough SPS	Combined	Redacted	Redacted	Redacted	Redacted
34	Cashel Close SPS	Combined	Redacted	Redacted	Redacted	Redacted
35	Chapel Road St Malachys CSO	Surface	Redacted	Redacted	Redacted	Redacted
36	Mill Road CSO	Combined	Redacted	Redacted	Redacted	Redacted
37	Derrymore Road CSO	Combined	Redacted	Redacted	Redacted	Redacted
38	Millvale SPS	Combined	Redacted	Redacted	Redacted	Redacted
39	Bracken Grove	Foul	Redacted	Redacted	Redacted	Redacted
40	Carnbane WWTW SPS	Foul	Redacted	Redacted	Redacted	Redacted
41	Carnbane (2) SPS	Combined	Redacted	Redacted	Redacted	Redacted
42	Carnbane SPS	Foul	Redacted	Redacted	Redacted	Redacted
43	Adria Factory Carnbane SPS	Foul	Redacted	Redacted	Redacted	Redacted
44	Carnbane Gardens SPS	Combined	Redacted	Redacted	Redacted	Redacted
45	Lisduff SPS	Foul	Redacted	Redacted	Redacted	Redacted
46	Newry Depot SPS	Foul	Redacted	Redacted	Redacted	Redacted
47	Cluain Air	Foul	Redacted	Redacted	Redacted	Redacted
48	Acton CSO	Combined	Redacted	Redacted	Redacted	Redacted
49	Loughbrickland	Foul	Redacted	Redacted	Redacted	Redacted
50	Oaklands Loughbrickland SPS	Foul	Redacted	Redacted	Redacted	Redacted
51	Newry Road Loughbrickland	Combined	Redacted	Redacted	Redacted	Redacted
52	Ashleigh Grove	Unknown	Redacted	Redacted	Redacted	Redacted
53	Bernaghview	Foul	Redacted	Redacted	Redacted	Redacted
54	Iveagh Cresent CSO	Foul	Redacted	Redacted	Redacted	Redacted
55	Not Assigned	Foul	Redacted	Redacted	Redacted	Redacted
56	Sleepvalley Rathfriland SPS	Foul	Redacted	Redacted	Redacted	Redacted
57	Ivan Cottages Rathfriland SPS	Foul	Redacted	Redacted	Redacted	Redacted
58	Ivy bridge	Foul	Redacted	Redacted	Redacted	Redacted
59	Savall Beg SPS	Combined	Redacted	Redacted	Redacted	Redacted
60	Ashtree Cottages SPS	Foul	Redacted	Redacted	Redacted	Redacted
61	Ardfreelin SPS	Foul	Redacted	Redacted	Redacted	Redacted
62	Crown Bridge SPS	Combined	Redacted	Redacted	Redacted	Redacted
63	Mayobridge SPS	Foul	Redacted	Redacted	Redacted	Redacted

MapID	Name	Function	Easting	Northing	Longitude	Latitude
64	Derryleckagh SPS	Combined	Redacted	Redacted	Redacted	Redacted
65	Arthur Street Windsor Hill CSO	Combined	Redacted	Redacted	Redacted	Redacted
66	Islandbank SPS	Combined	Redacted	Redacted	Redacted	Redacted
67	Bagot Street Stream Street CSO	Combined	Redacted	Redacted	Redacted	Redacted
68	Kildare Street Town Hall CSO	Combined	Redacted	Redacted	Redacted	Redacted
69	Well Lane SPS	Foul	Redacted	Redacted	Redacted	Redacted
70	Windmill Road SPS	Foul	Redacted	Redacted	Redacted	Redacted
71	Greenbank Industrial Estate	Foul	Redacted	Redacted	Redacted	Redacted
72	Warrenpoint Road 1 SPS	Combined	Redacted	Redacted	Redacted	Redacted
73	Rampart Road SPS	Foul	Redacted	Redacted	Redacted	Redacted
74	Greenbank 3	Surface	Redacted	Redacted	Redacted	Redacted
75	Greenbank 2 SPS	Foul	Redacted	Redacted	Redacted	Redacted
76	Warrenpoint Road 2 SPS	Combined	Redacted	Redacted	Redacted	Redacted
77	Loughway Business Park Entrance	Foul	Redacted	Redacted	Redacted	Redacted
78	Loughway Business Park East	Foul	Redacted	Redacted	Redacted	Redacted
79	Loughway Business Park Central	Surface	Redacted	Redacted	Redacted	Redacted
80	Loughway Business Park Canal	Surface	Redacted	Redacted	Redacted	Redacted
81	Carrickmacstay SPS	Foul	Redacted	Redacted	Redacted	Redacted
82	Mound Road SPS	Combined	Redacted	Redacted	Redacted	Redacted
83	Spring Meadows	Combined	Redacted	Redacted	Redacted	Redacted
84	Warrenpoint Golf Club SPS	Foul	Redacted	Redacted	Redacted	Redacted
85	The Docks Warrenpoint SPS	Combined	Redacted	Redacted	Redacted	Redacted
86	Warrenpoint Main SPS	Combined	Redacted	Redacted	Redacted	Redacted
87	Springfoeld Road SPS	Combined	Redacted	Redacted	Redacted	Redacted
88	Seafields	Foul	Redacted	Redacted	Redacted	Redacted
89	Dobbines Point SPS	Combined	Redacted	Redacted	Redacted	Redacted
90	Drumsesk Road SPS	Combined	Redacted	Redacted	Redacted	Redacted
91	Shore Road Rostrevor SPS2	Combined	Redacted	Redacted	Redacted	Redacted
92	Horners Lane CSO	Combined	Redacted	Redacted	Redacted	Redacted
93	Water Street CSO	Combined	Redacted	Redacted	Redacted	Redacted
94	Cherry Hill South CSO	Combined	Redacted	Redacted	Redacted	Redacted
95	Pinewood SPS	Foul	Redacted	Redacted	Redacted	Redacted
96	Killowen SPS	Foul	Redacted	Redacted	Redacted	Redacted
97	Greencastle Pier Road (1)	Foul	Redacted	Redacted	Redacted	Redacted
98	Greencastle Pier Road (2)	Foul	Redacted	Redacted	Redacted	Redacted
99	Cranfield 1 Crossroads SPS	Foul	Redacted	Redacted	Redacted	Redacted
100	Cranfield 3 Grange Chapel SPS	Foul	Redacted	Redacted	Redacted	Redacted
101	Cranfield 4 Snadbank SPS	Foul	Redacted	Redacted	Redacted	Redacted
102	Cranfield 2 Chestnutts SPS	Foul	Redacted	Redacted	Redacted	Redacted
103	Cranfield (WWTW)	Final Effluent	Redacted	Redacted	Redacted	Redacted

4.1.3.3. Emergency Discharges

Figure 4.12 shows all emergency discharges located within the Carlingford Lough catchment area. All of these are in connection with WWTWs and their details can be seen in Table 4.9 (Source WWTW Public Register). No data on pollution incidences in Carlingford Lough were available from NIEA during the timeframe of this project. A large-scale cross-referenced map can be found in Section 4.3 Location of sources.

Figure 4.12: Emergency discharges within the Carlingford Lough Catchment Area (Source: WWTW Public Register).

Table 4.9: Details on emergency discharges (WWTW Public Register).

Map ID	Source	Intermittent	Easting	Northing	Longitude	Latitude	Receiving Body	Discharge Details
9D	Lurganare STW	Secondary treated waste water	Redacted	Redacted	Redacted	Redacted	Trib. River Jerretspass	The pump shall be capable of passing forward to the discharge point all flows up to a flow of 193.7m3/day (2.24l/s)
17C	Beech Hill Newry STW	Secondary treated effluent in Emergency	Redacted	Redacted	Redacted	Redacted	Trib. Clanrye River	The pump shall be capable of passing forward for treatment all flows up to a flow of 140m3/day (1.62l/s)
71	Well Road Housing Development	Private Sewage: Emergency Overflow	Redacted	Redacted	Redacted	Redacted	Unnamed	Unknown

4.1.4. Industrial Discharges

Figure 4.13 shows the industrial discharges within the Carlingford Lough catchment area accounted for during the desk-based assessment. A large-scale cross-referenced Figure can be found in Section 4.3 Location of Sources. In total there are 18 industrial discharges. The discharges consist of water treatment plants (WTP), abstractions, sewage, site drainage and fisheries discharges. Six of these flow directly into the Lough, 1 at Mill Bay, 1 at Greencastle Point and 4 at Warrenpoint. The remainder flow into streams/rivers that ultimately discharge into the Lough. Details on these industrial discharges can be seen in Tables 4.10 and 4.11.

Figure 4.13: All industrial discharges within the Carlingford Lough Catchment Area (Source: NIEA, EPA).

Table 4.10: Details on industrial discharges with the Carlingford Lough Catchment Area (Source: NIEA).

Map ID	Station	File Ref	Industry	Easting	Northing	Longitude	Latitude
1	64486	TC25/10	Private Sewage : Unspecified	Redacted	Redacted	Redacted	Redacted
2	62685	TC168/05	Food Processing : Shell Fishery	Redacted	Redacted	Redacted	Redacted
3	63914	TC145/08	Site Drainage : Unspecified	Redacted	Redacted	Redacted	Redacted
4	63915	TC146/08	Site Drainage : Unspecified	Redacted	Redacted	Redacted	Redacted
5	64018	TC147/08	Site Drainage : Unspecified	Redacted	Redacted	Redacted	Redacted
6	63221	TC324/06	Site Drainage : Unspecified	Redacted	Redacted	Redacted	Redacted
7	62424	TC174/04	Food Processing : Fish Farm	Redacted	Redacted	Redacted	Redacted
8	63216	TC298/06	Private Sewage : Unspecified	Redacted	Redacted	Redacted	Redacted

Table 4.11: Abstractions and water treatment plants located within the Carlingford Lough Catchment Area (Source: EPA).

Map ID	Code	Name	Class	Subclass	Easting	Northing	Longitude	Latitude
9	NB_ABS0003	Shallow Well	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
10	NB_ABS0004	Shallow Well	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
11	NB_ABS0010	Carlingford Borehole	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
12	NB_ABS0015	Jenkins Well	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
13	NB_ABS0016	Mountain Stream	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
14	NB_ABS0017	Muchgrange Springs	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
15	NB_ABS0018	Lislea Borehole	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
16	NB_ABS0019	Ryland Riverside	Pressures	Abstractions	Redacted	Redacted	Redacted	Redacted
17	NB_WTP0014	Mountain Stream	Pressures	WTP	Redacted	Redacted	Redacted	Redacted
18	NB_WTP0015	Ryland Riverside	Pressures	WTP	Redacted	Redacted	Redacted	Redacted

4.1.5. Landuse Discharges

Figure 4.14 shows the Corine land use within the Carlingford Lough catchment area. Figure 3.10 (page 34) shows all rivers/streams within the catchment area. Within the catchment area, landuse is dominated by pastures (311.52km^2; 63.2%), followed by natural grassland (48.45km^2; 9.8%) and moors and heathland (29.03km^2; 5.9%) (see Figure 4.15). Forestry (coniferous, broad-leafed and mixed) makes up 4% of the landuse in the area (19.54km^2). In total, agricultural activities (non-irrigated arable land, pastures, complex cultivation patterns and agriculture/natural vegetation) comprise 70.7% (348.4km^2) of the landuse in the area.

Figure 4.14: Land use within the Carlingford Lough Catchment Area (Source: The Loughs Agency, EPA).

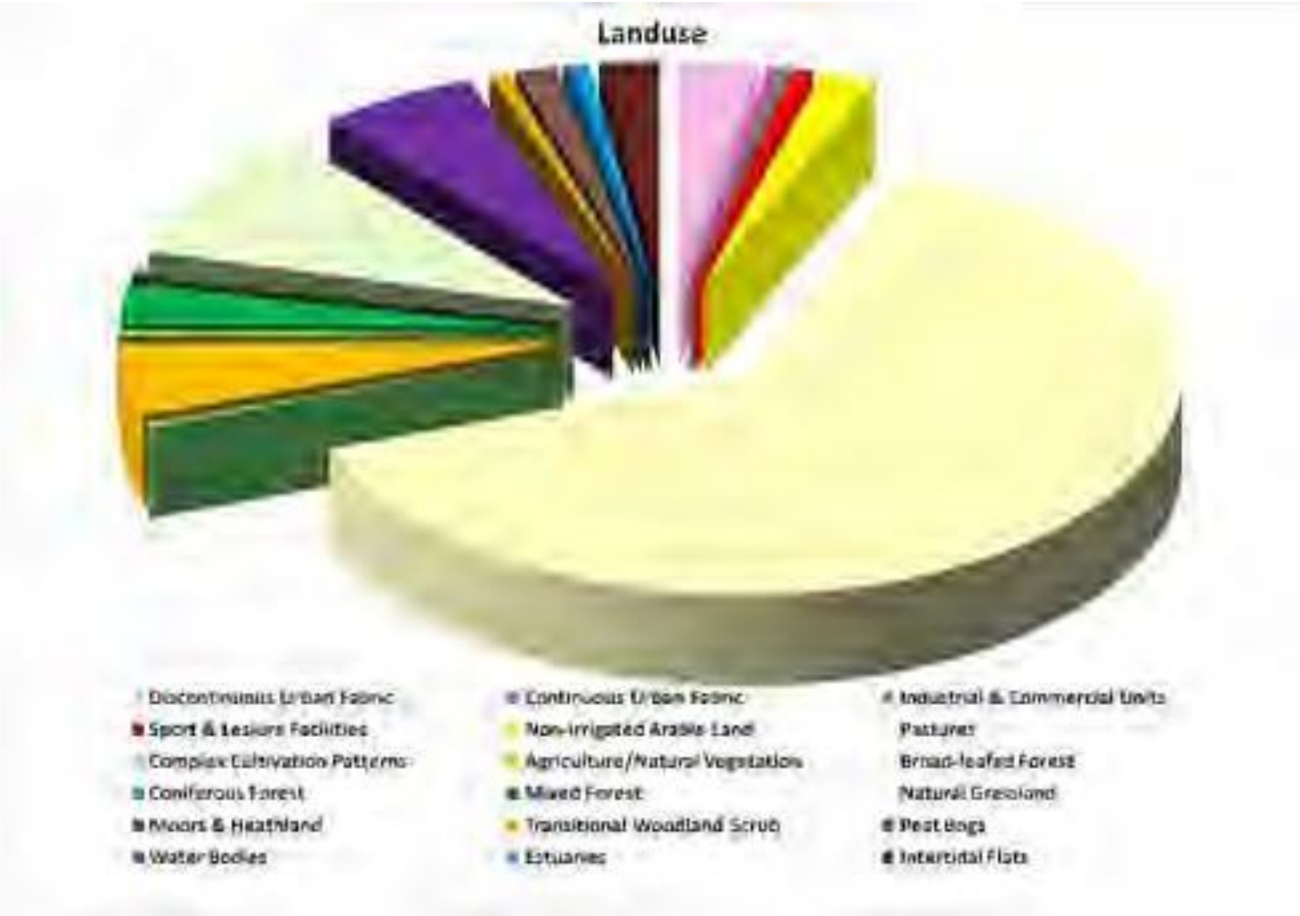


Figure 4.15: Breakdown of landuse within the Carlingford Lough Catchment Area.

Data from the Department of Agriculture and Rural Development Farm Census 2008 (DARD, 2008) and from the Census of Agriculture 2000 (CSO, 2000) can be seen in Table 4.12 below. Figures 4.16 to 4.23 show thematic maps for each category in Table 4.12. There are no farms or agricultural activity in the following areas: Newry (Ballybot, Daisy Hill, Drumgullion, St. Patrick's and Windsor Hill), Warrenpoint (Seaview) and Banbridge (Fort).

Numbers of farms within the catchment area ranged from 6 in Clonallan, Co. Down and St. Mary's (Co. Down/Armagh) to >200 in Spelga (Co. Down and Silver Bridge (Co. Armagh).

The total area farmed within the catchment area varied from 95ha. in St. Mary's (Co. Armagh/Down) to >6,000 ha in Bannside and Katesbridge in Co. Down.

The total crops farmed within the catchment area varied from 0ha. in Bessbrook (Co. Down), Clonallan (Co. Down), Drumalane (Co. Down/Armagh), St. Mary's (Co. Down/Armagh), Drummullagh (Co. Louth) and

Greenore (Co. Louth) to >1,000 ha in Bannside (Co. Down).

Total grass and rough grazing areas within the catchment area ranged from 95ha. in St. Mary's (Co. Armagh/Down) to >4,000 ha in Lisnacree (Co. Down), Mayobridge (Co. Down), Silver Brisge (Co. Armagh), Spelga (Co. Down), Tullyhappy (Co. Armagh/Down), Bannside (Co. Down), Katesbridge (Co. Down) and Poyntz Pass (Co. Armagh).

The total number of cattle within the catchment area ranged from 62 in St. Mary's (Co. Down/Armagh) to >10,000 in Donaghmore (Co. Armagh), Tullyhappy (Co. Down/Armagh), Bannside (Co. Down), Katesbridge (Co. Down) and Poyntz Pass (Co. Armagh).

The total number of sheep within the catchment area ranged from 0 in Derrymore (Co. Armagh) to >20,000 in Lisnacree (Co. Down) and Spelga (Co. Down).

No data for pigs were available for the Republic of Ireland. Numbers of pigs within the catchment area ranged from 0 in Bessbrook (Co. Down), Derryleckagh (Co. Down/Armagh), Derrymore (Co. Armagh), St. Mary's (Co. Down/Armagh), Ballydown (Co. Down) and Rathfriland (Co. Down) to >4,000 in Binnian (Co. Down) and Tullyhappy (Co. Down/Armagh).

No data for poultry were available for the Republic of Ireland. Numbers of poultry within the catchment area ranged from 0 in Bessbrook (Co. Down), Binnian (Co. Down), Camlough, Co. Armagh), Clonallan (Co. Down), Drumalane (Co. Down/Armagh), Fathom (Co. Armagh), Rostrevor (Co. Down), Silver Bridge (Co. Armagh), St. Mary's (Co. Down/Armagh), Ballydown (Co. Down) and Rathfriland (Co. Down) to >100,000 in Donaghmore (Co. Armagh), Spelga (Co. Down) and Tullyhappy (Co. Down/Armagh).

Table 4.12: Farm census data for all DEDs/SOAs within the Carlingford Lough Catchment Area (Source: DARD, 2008 and CSO, 2000).

DED/SOA	County	No. Farms	Area Farmed (ha)	Total Crops (ha)*	Total Grass & Rough Grazing (ha)#	Cattle	Sheep	Pigs$	Poultry ('000)$
Ballybot	Down/Armagh	0	0	0	0	0	0	0	0
Bessbrook	Down	12	347	0	347	645	120	0	0
Binnian	Down	147	2,842	215	2,618	5,710	13,229	4,546	0
Burren And Kilbroney	Down	145	2,860	14	2,772	4,709	10,198	1,131	1
Camlough	Armagh	131	2,772	53	2,715	5,590	2,932	3,200	0
Clonallan	Down	6	99	0	98	84	291	3	0
Daisy Hill	Down/Armagh	0	0	0	0	0	0	0	0
Derryleckagh	Down/Armagh	50	889	4	863	2,066	556	0	96
Derrymore	Armagh	17	377	19	357	943	0	0	7
Donaghmore	Armagh	165	4,672	762	3,878	10,353	9,439	3,675	129
Drumalane	Down/Armagh	7	124	0	123	233	104	18	0
Drumgullion	Down/Armagh	0	0	0	0	0	0	0	0
Fathom	Armagh	92	1,635	1	1,621	2,697	2,770	201	0
Lisnacree	Down	165	4,835	233	4,538	6,023	21,644	944	22
Mayobridge	Down	163	4,284	244	4,028	9,817	12,854	4	34
Rostrevor	Down	40	932	30	883	1,139	7,138	1,222	0
Seaview	Down	0	0	0	0	0	0	0	0
Silver Bridge	Armagh	215	4,687	17	4,649	7,039	5,295	1	0
Spelga	Down	223	5,504	249	5,243	6,991	37,669	1,629	110
St Marys	Down/Armagh	6	95	0	95	62	916	0	0
St Patricks	Down	0	0	0	0	0	0	0	0
Tullyhappy	Down/Armagh	173	5,812	453	5,322	16,791	7,454	5,732	101
Windsor Hill	Down	0	0	0	0	0	0	0	0
Ballydown	Down	20	999	125	872	2,349	1,792	0	0
Bannside	Down	189	6,529	1,214	5,263	11,973	11,667	2,531	1
Fort	Down	0	0	0	0	0	0	0	0
Katesbridge	Down	185	6,120	993	5,083	12,367	15,584	2,210	56
Loughbrickland	Down	93	3,246	397	2,818	7,021	3,166	764	9

DED/SOA	County	No. Farms	Area Farmed (ha)	Total Crops (ha)*	Total Grass & Rough Grazing (ha)#	Cattle	Sheep	Pigs$	Poultry ('000)$
Rathfriland	Down	20	479	33	446	1,124	1,826	0	0
Poyntz Pass	Armagh	150	6,252	798	5,386	15,167	11,850	1,356	24
Carlingford	Louth	53	877	253	623	274	7264	n/a	n/a
Drummullagh	Louth	58	716	0	597	499	6713	n/a	n/a
Greenore	Louth	42	1,101	0	487	822	2202	n/a	n/a

* For the Republic of Ireland DEDs, Total Cops includes Fruit and Horticulture.

For the Republic of Ireland DEDs, Total Grass and Rough Grazing was taken to be the sum of Total Pasture, Total Silage, Total Hay and Rough Grazing.

$ No data were available for Pigs and Poultry for the Republic of Ireland DEDs.

The figures given for Silver Bridge and Ballydown are for the entire SOAs not just the sections within the catchment area (e.g. Ballydown 2 and Silver Bridge 2)

Figure 4.16: Number of farms within the Carlingford Lough Catchment Area (Source: DARD, 2008 and CSO, 2000).

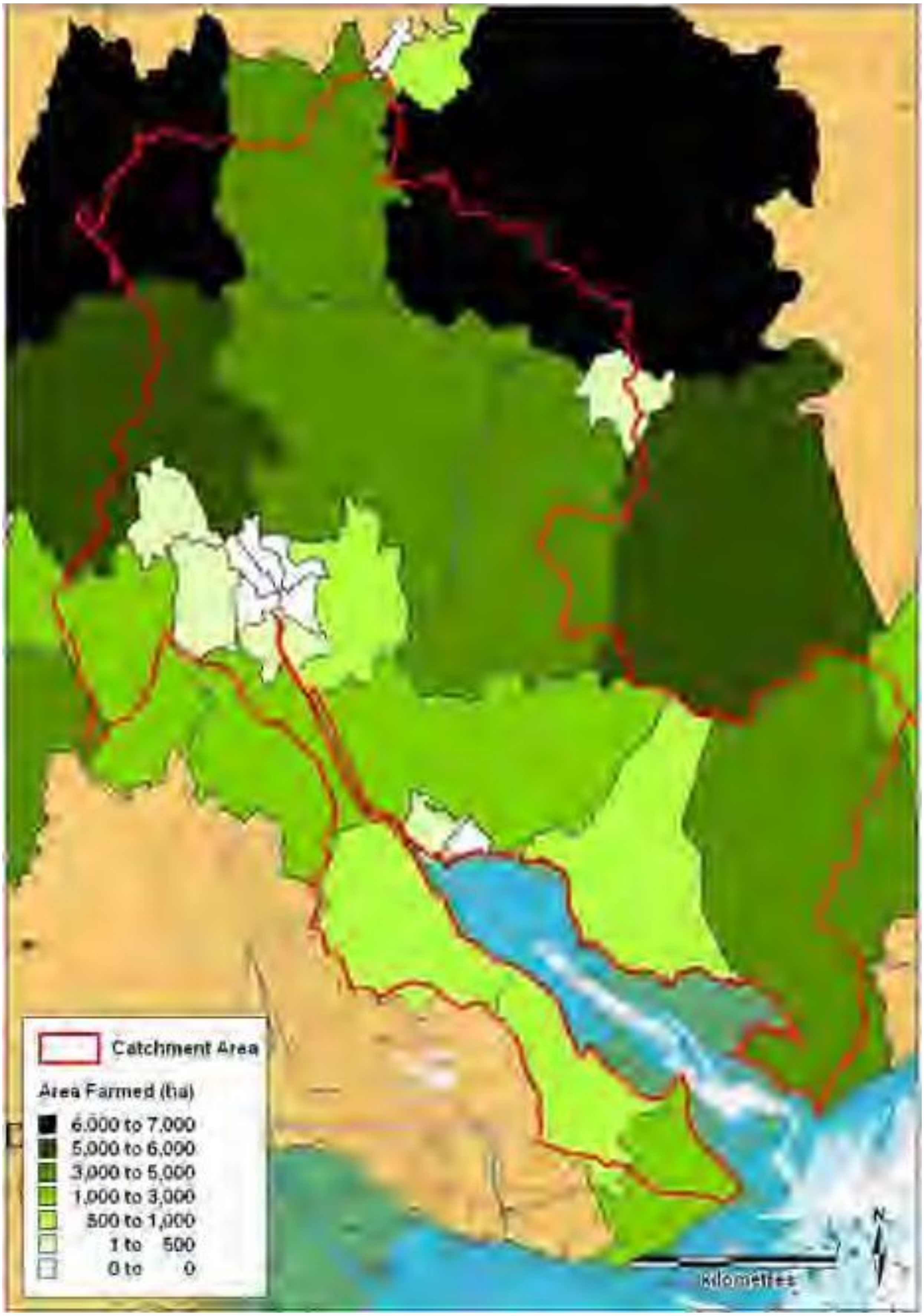


Figure 4.17: Area farmed (ha) within the Carlingford Lough Catchment Area (Source: DARD, 2008 and CSO, 2000).

Figure 4.18: Total crops within the Carlingford Lough Catchment Area (Source: DARD, 2008 and CSO, 2000).

Figure 4.19: Total grass and rough grazing within the Carlingford Lough Catchment Area (Source: DARD, 2008 and CSO, 2000).

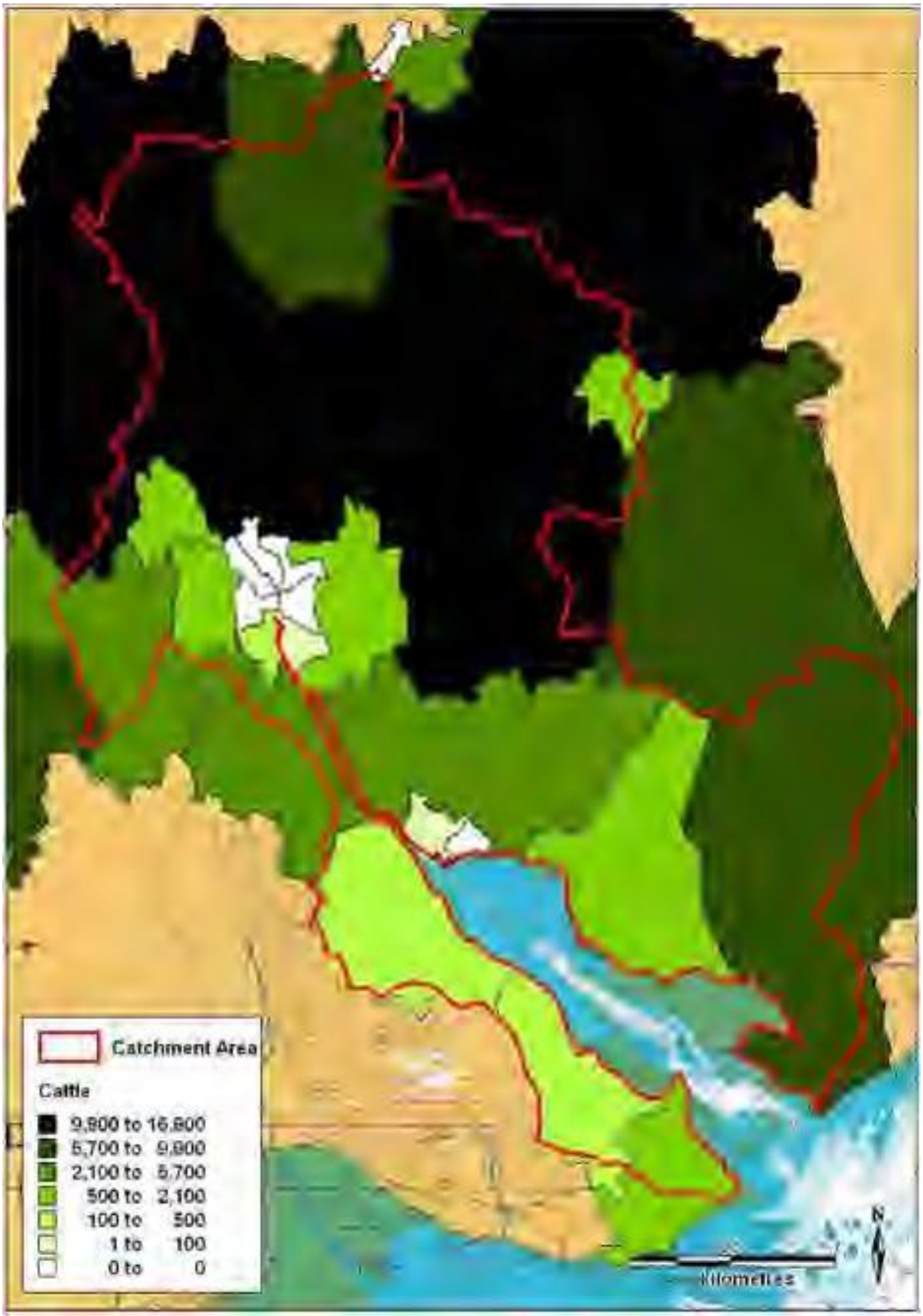


Figure 4.20: Cattle within the Carlingford Lough Catchment Area (Source: DARD, 2008 and CSO, 2000).

Figure 4.21: Sheep within the Carlingford Lough Catchment Area (Source: DARD, 2008 and CSO, 2000).

Figure 4.22: Pigs within the Carlingford Lough Catchment Area (Source: DARD, 2008). No data available for Co. Louth.

Figure 4.23: Poultry ('000) within the Carlingford Lough Catchment Area (Source: DARD, 2008). No data available for Co. Louth.

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

As no faecal coliform data are available from the rivers flowing into the Lough, nutrient data are used in order to gain an appreciation of contamination levels entering the system. Several studies have reported correlations between nutrient levels and faecal coliform levels (i.e. there is a general tendency of an increase in faecal coliform counts with increasing nutrient concentrations) (e.g. Owilli, 2003; Petrucio *et al.*, 2005).

Taylor *et al.* (1999) calculated that the total annual loading of dissolved inorganic nitrogen (DIN: NO^-_3 + NH_4^+, of which <2% was NH_4^+) to Carlingford Lough was 1,311 tonnes. Approximately 77% (1,016 tonnes) of the DIN originated from the Newry/Clanrye catchment, with an additional 11% from the other inflowing rivers (See Figure 4.24). The Newry and Moygannon River catchments had the highest nitrate areal loads (3116 kg km^{-2} yr^{-1} and 2700 kg km^{-2} yr^{-1} respectively) within the Carlingford Lough area and these high loads were concurrent with a high percentage of land cover given over to arable farming and grassland (90.13% and 88.1% respectively). In addition it was shown that the river nitrate loadings to Carlingford Lough were seasonal with highest concentrations during the winter months.

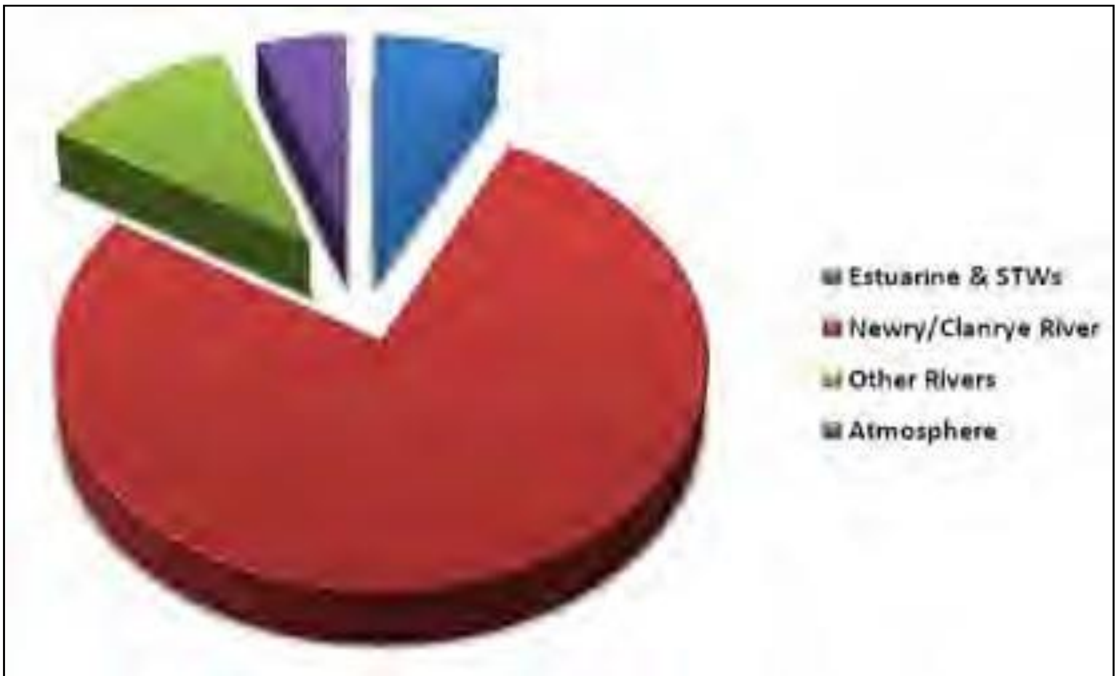


Figure 4.24: Partitioning of the total annual dissolved inorganic nitrogen (DIN) load (Source: Taylor *et al.,* 1999).

Since the Taylor *et al.* (1999) report, a number of Regulations were enforced. The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil; SSAFO) Regulations, which came into effect in Northern Ireland on the 21st July 2003 are designed to stop water pollution from agriculture. The purpose of these regulations is to minimise the risk of water pollution from silage, slurry and agricultural fuel oils by setting minimum standards for the construction and maintenance of structures used to store these substances and improve the environment for rural communities in Northern Ireland.

The Nitrates Action Programme (NAP) Regulations (NI) 2006 and the Phosphorus (Use in Agriculture) (P) Regulations (NI) 2006 were introduced on 1st January 2007 to improve the use of nutrients on farms and as a result improve water quality. These Regulations stem from the EU Nitrates Directive, which was transposed into Northern Ireland legislation by the Protection of Water Against Agricultural Nitrate Pollution Regulations (Northern Ireland) 1996 S.R. No. 217 (as amended by S.R. 1997 No. 256 and S.R. 1999 No. 3) and the Action Programme for Nitrate Vulnerable Zones Regulations (Northern Ireland) 1999 S.R. No. 156.

Under the Nitrates Action Programme (NAP) Regulations (NI) 2006, farmers can spread manure between 1st February and the 15th October each year, weather and ground conditions permitting:

- $50m^3$/ha is permitted on a single application and no further application for 3 weeks;
- Crop nitrogen requirements must be taken into consideration when the manure is spread;
- The farm nitrogen loading must not exceed 170 kg/ha/yr or 250 kg/ha/yr for a derogated farm;
- The manure must be spread 10m back from waterways (except for a number of exceptions); and
- Manure must be spread in a uniform manner.

In the Republic of Ireland, under the Nitrates Regulations (S.I. 610 of 2010) farmers must not apply more than 170kgs of nitrogen from livestock manure per hectare per year. However, grassland farmers, with grazing stock, may apply annually for a derogation to apply up to a limit of 250kg per hectare in a calendar year, under certain conditions.

In an attempt to identify the effects of these Regulations, Figure 4.25 shows the quantities of fertiliser (for agricultural and commercial horticultural use) delivered into Northern Ireland (per quarter and annually) from 1997 to 2010 (DARD, 2010). While the quantities relevant to the Carlingford catchment are unknown, it is likely that the trend in Carlingford Lough is similar to that for Northern Ireland as a whole. It can be seen from this graph that there was an overall reduction in the quantities delivered from 2004 onwards. On average, there was a 30% reduction in quantities delivered from 2004-2010 compared to 1997-2003. It can therefore be assumed that the quantities entering Carlingford Lough are approximately 30% lower than they were during the Taylor *et al.* (1999) report. It is also assumed that given the fact that manure cannot be spread from 15th October to 31st January, winter is no longer the season with the highest concentration of nitrate loadings. As there is no correlation between delivery times and spreading times, the current peak season cannot be determined

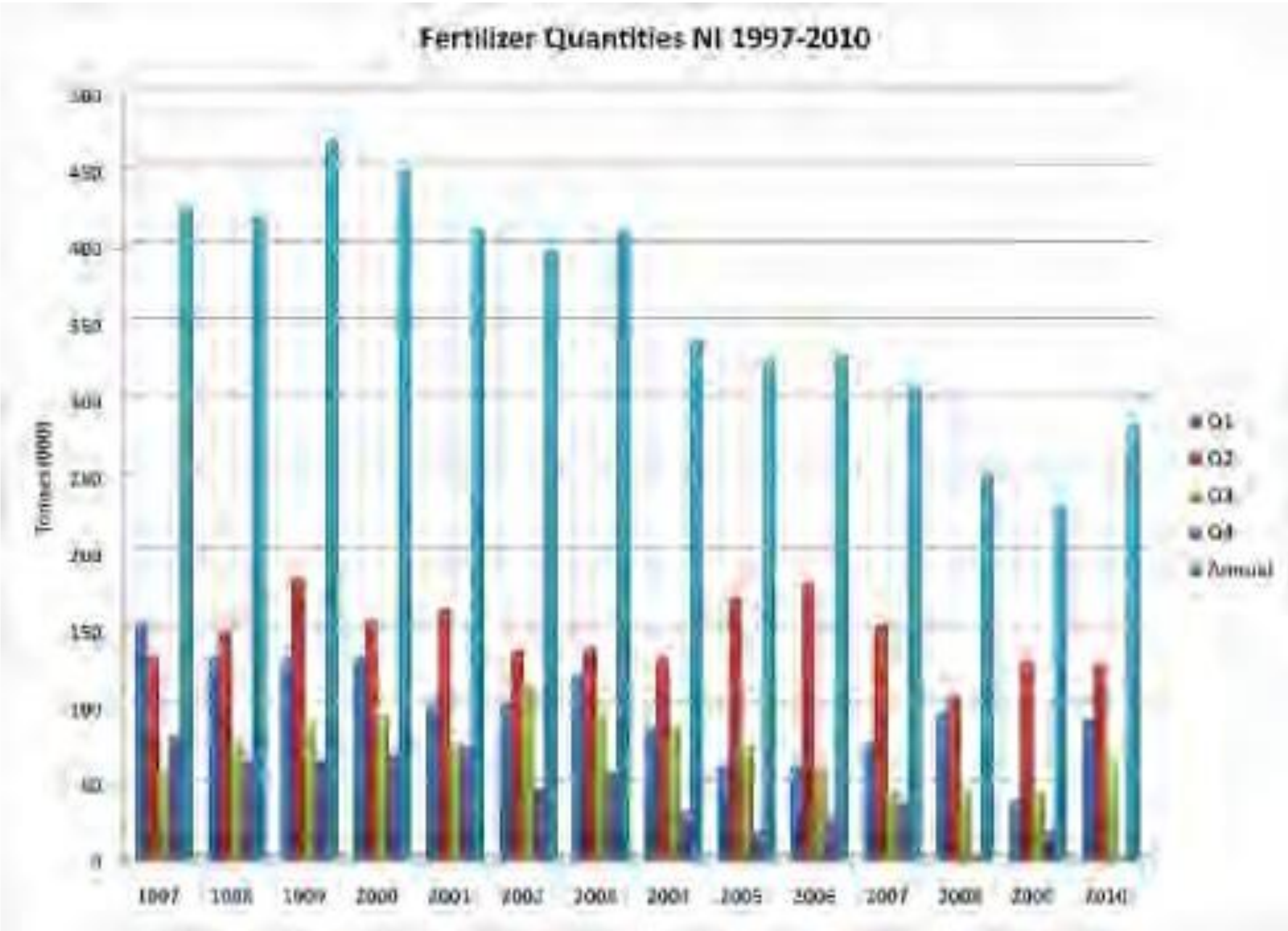


Figure 4.25: Quantities of fertilizer delivered into Northern Ireland from 1997 to 2010 (Source: DARD, 2010)

4.1.6. Other Pollution Sources

4.1.6.1. Shipping

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

Marpol Annex IV defines sewage as "drainage from medical premises, toilets, urinals, spaces containing live animals and other waste waters when mixed with sewage waste streams". Although adopted in 1973, the Annex did not come into effect until September 2003, with subsequent amendments entered into force in August 2005. Annex IV requires ships to be equipped with either a sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank. Within 3 miles of shore, Annex IV requires that sewage discharges be treated by a certified Marine Sanitation Device (MSD) prior to discharge into the ocean. Sewage discharges made between 3 and 12 miles of shore must be treated by no less than maceration and chlorination and sewage discharged greater than 12 miles from shore are unrestricted. Annex IV also established certain sewage reception facility standards and responsibilities for ports and contracting parties.

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

Figure 4.26 shows all boat facilities and activities in Carlingford Lough. The main commercial port in Carlingford Lough is Warrenpoint. There are approximately 1,000 shipping movements per year at the port of Warrenpoint and these consist of ferries and general cargo vessels (International Ship Consultants Ltd., 2006). Most of the general cargo vessels are within the 2-5,000 tonnes size class. In 2009, 961,000 tonnes of goods were received through the port (Department of Transport, 2010). Greenore Port received 390,000 tonnes of goods in 2009 (CSO, 2010b), of this 81% was made up of dry bulk goods. These goods arrived on 106 vessels throughout the year. Of these 106 vessels, 91 were in the 100-4,900 tonnes size class, 6 were in the 5,000-7,999 vessel size class, 3 were in the 8,000-19,999 vessel size class and 6 were in the 20,000-39,999 vessel size class. It has been reported that the exporting of livestock from Greenore results in animal waste discharging into the Lough; however; frequency and quantities are unknown. There are silt-traps in place along the quayside to allow quayside cargoes to be swept up and caught before discharge to the sea. Carlingford Marina can accommodate up to 180 vessels ranging from light speedboats to large cruisers and larger sailing vessels. On average, 150 vessels hold annual or seasonal licences for the marina and a further 700 short-term (1 day to 1 month) licences are issued per annum. The peak season is from May to October with approximately 70% less vessels using the facilities throughout the remainder of the year. The marina has in place waste disposal arrangements for the approved licenced disposal of galley waste, grease and oil and domestic refuse and recyclable waste.

While data on sewage discharge levels from shipping activities in Carlingford Lough are not available, it is highly likely that discharging does occur within the Lough. The effect is likely to be the greatest in enclosed areas and shallow water with little or no tidal flow in the summer and autumn when temperatures are at their highest, coinciding with the peak of the boating season. However, it is also likely that these levels are very low compared with land-based discharges.

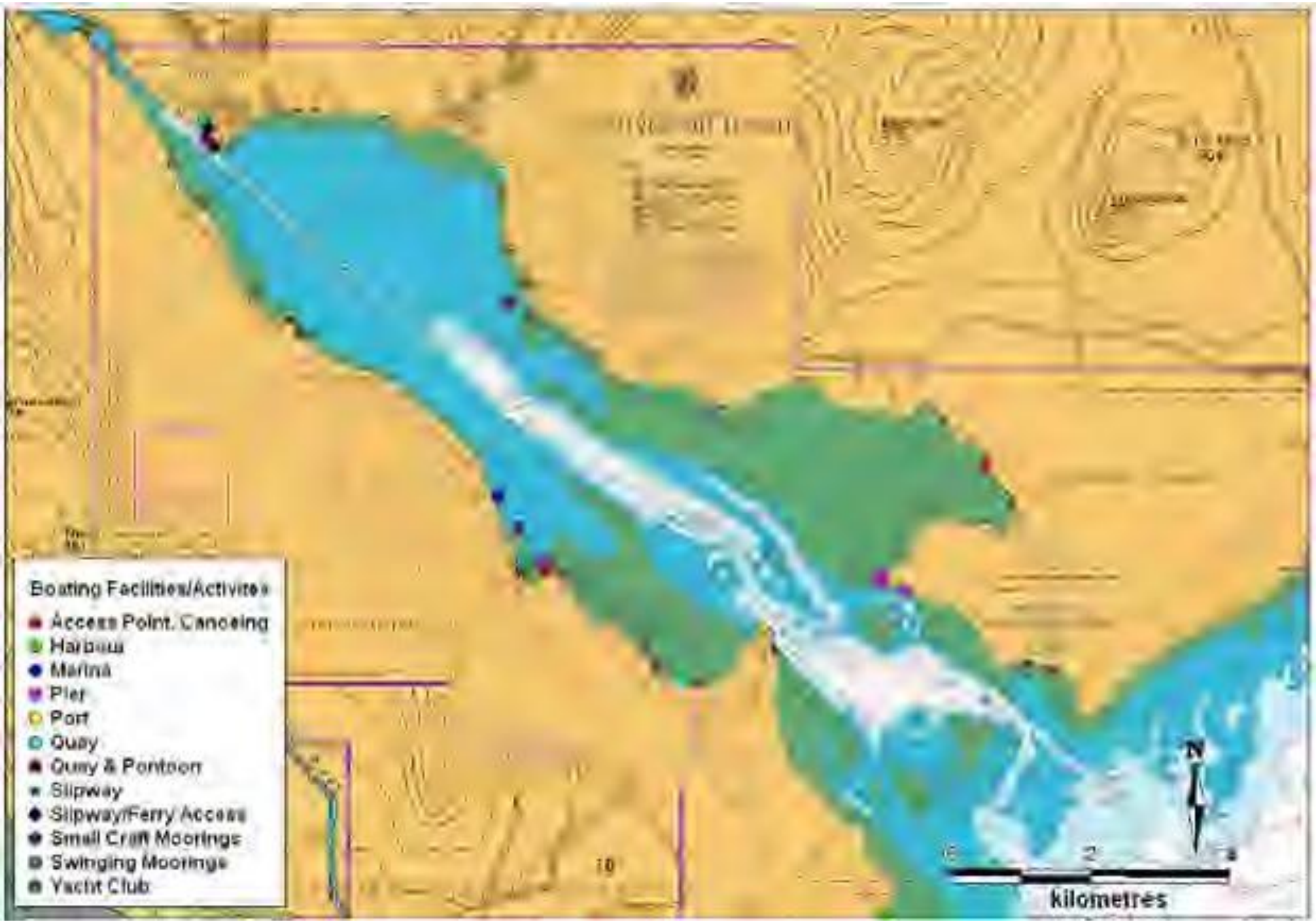


Figure 4.26: Location of all boating facilities and activities in Carlingford Lough.

4.1.6.2. Birds

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

Figure 4.27 shows the locations of the Special Protection Areas (SPA) and Ramsar Sites in Carlingford Lough. The Carlingford Lough SPA (Site Code: IE004078) is located on the County Louth coastline from Greenore to Carlingford. The Carlingford Lough SPA (Site Code: UK9020161) is located along the Co. Down coastline from Soldier's Point to Killowen Point. The Carlingford Lough Ramsar Site (Site Code: 3UK119) covers the same area as the UK SPA.

The SPA between Carlingford and Greenore covers the intertidal sand and mudflats out to the low tide mark (NPWS, 2004), with some small patches of salt marsh (Crowe, 2005). The site supports part of a nationally important population of wintering Cormorants and nationally important populations of dunlin, greenshank and redshank. Also of note is the presence of Bar-tailed Godwit as this species is listed on Annex I of the E.U. Birds Directive. A range of other waterfowl species also occur here, most notably Brent Goose, Oystercatcher and Turnstone. The intertidal flats provide feeding areas for the wintering birds. While the numbers of wintering birds are relatively low, the site does support a good range of species.

The Northern Ireland side of the Lough usually supports the majority of wintering waterbirds notable at Mill Bay (Crowe, 2005). This site comprises more extensive mudflats and saltmarsh and regularly supports internationally important numbers of Light-bellied Brent Geese and nationally important numbers of oystercatcher, ringed plover, grey plover, dunlin and redshank. During the breeding season, this site is also internationally important for breeding common and sandwich terns (Stroud *et al.* 2001).

Figure 4.27: SPA, Ramsar Site and Wetland Bird Survey Sites.

Eleven Wetland Bird Survey Sites are routinely surveyed by Birdwatch Ireland (through the I-WeBS [Irish Wetland Bird Survey] Project) and by the British Trust for Ornithology (BTO) (Through the WeBS [Wetland Bird Survey] Project). These survey sites can be seen above in Figure 4.27. Table 4.13 shows the most recent results from the wetland bird surveys that are carried out each year.

Table 4.13: Total number of waterbirds in Carlingford Lough between 2004/05 and 2008/09 (Source: Calbrade *et al.*, 2010).

Site Name	2004/05	2005/06	2006/07	2007/08	2008/09	Mean
Carlingford Lough	10,952	10,165	9,692	10,705	10,289	10,361

Bird populations in the Carlingford area are typically higher in early winter and late spring due to migratory events and they are typically higher in mid winter than spring and summer as the local birds tend to move off-site in the summer months to breed. Therefore, it is highly probable that the contribution made by wildfowl to pollution levels in Carlingford Lough is higher in the winter months. However, it is highly likely that these levels are low when compared with land-based discharges.

4.2. Shoreline Survey Report

A shoreline survey was carried out on the 14th, 15th and 19th October 2010. Sections of the Co. Louth coastline (from Ballagan Point to Greenore, from Greenore to Carlingford, from Carlingford Marina to Omeath) were surveyed on the 14th October by Dr. Caroline Roche (AQUAFACT) and Damien O'Malley (The Loughs Agency) using the Loughs Agency's Argo Cat amphibious vehicle. The remainder of the Co. Louth coastline was surveyed by Dr. Mark Costelloe (AQUAFACT) on the 19th October using AQUAFACT's RIB (Rigid Inflatable Boat). The Co. Down coastline was surveyed from Cranfield Point to Greencastle Point on the 15th October 2010 by Dr. Caroline Roche (AQUAFACT), Dawn Hynes and Stephen Moates (The Loughs Agency) using one of the Lough's Agency's jeeps. The section from Greencastle Point to Ballyedmond was also surveyed on the 15th October; however, this section was surveyed on foot, as NIEA requested that no vehicles be used within the Mill Bay area due to the presence of *Zostera* a food source to the wintering Light- bellied Brent Goose. Dr. Mark Costelloe surveyed the remainder of the Co. Down coastline on the 19th October 2010 using AQUAFACT's RIB. Figure 4.28 shows the areas covered by the RIB, Argo Cat, Jeep and on Foot. Figure 4.29 shows the GPS (Global Positioning System) and photography sites accounted for during the 3 survey days.

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

Figure 4.28: Boundaries of the RIB, Argo Cat, Jeep and Foot surveys carried out on the 14th, 15th and 19th October 2010.

Figure 4.29: Locations of GPS and Photograph Sites.

Figure 4.30 shows the locations of the discharge pipes/outfalls located during the shoreline survey. In total, 69 were identified. Figures 4.31 to 4.33 show images of these outfall/discharge locations.

Figure 4.30: Discharges/Outfalls located during the shoreline survey.

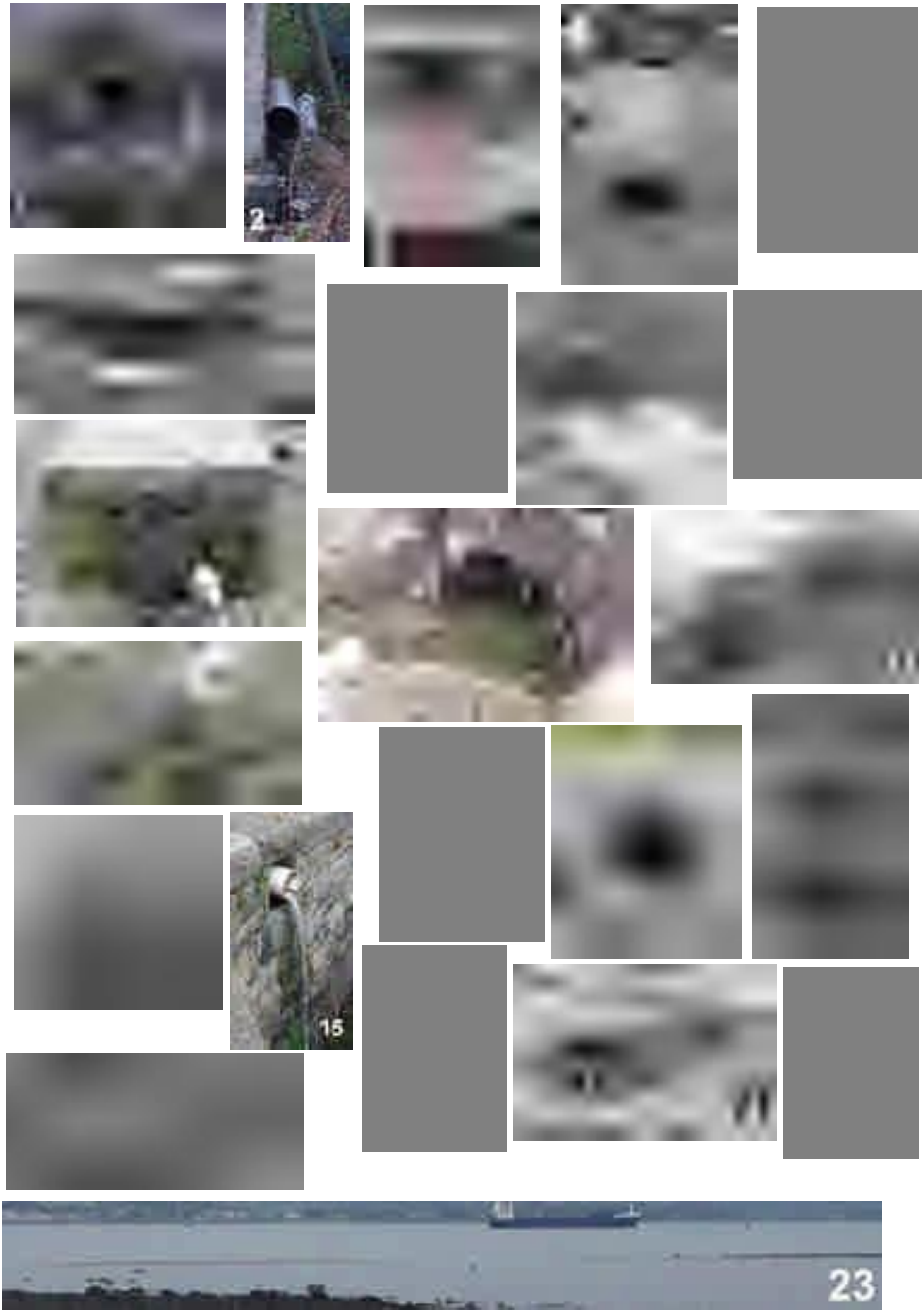


Figure 4.31: Outfall pipes/discharges located during the shoreline survey. Refer to Figure 4.30 for site locations.

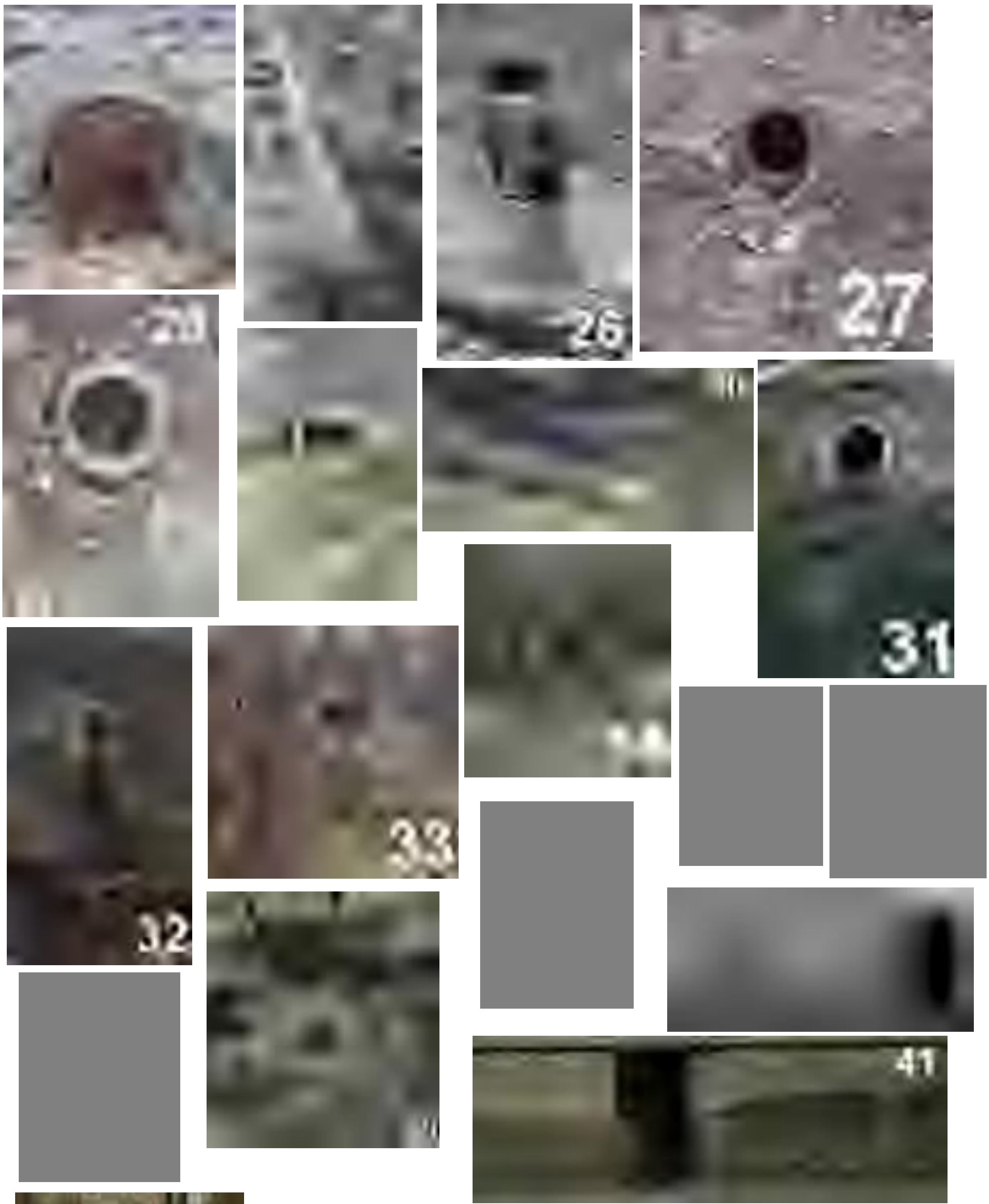


Figure 4.32: Outfall pipes/discharges located during the shoreline survey. Refer to Figure 4.30 for site locations.

Figure 4.33: Outfall pipes/discharges located during the shoreline survey. Refer to Figure 4.30 for site locations.

Figure 4.34 shows the locations of the rivers/streams/runoff/drainage channels located during the shoreline survey. In total, 37 were identified. Figures 4.35 and 4.36 show images of these sites.

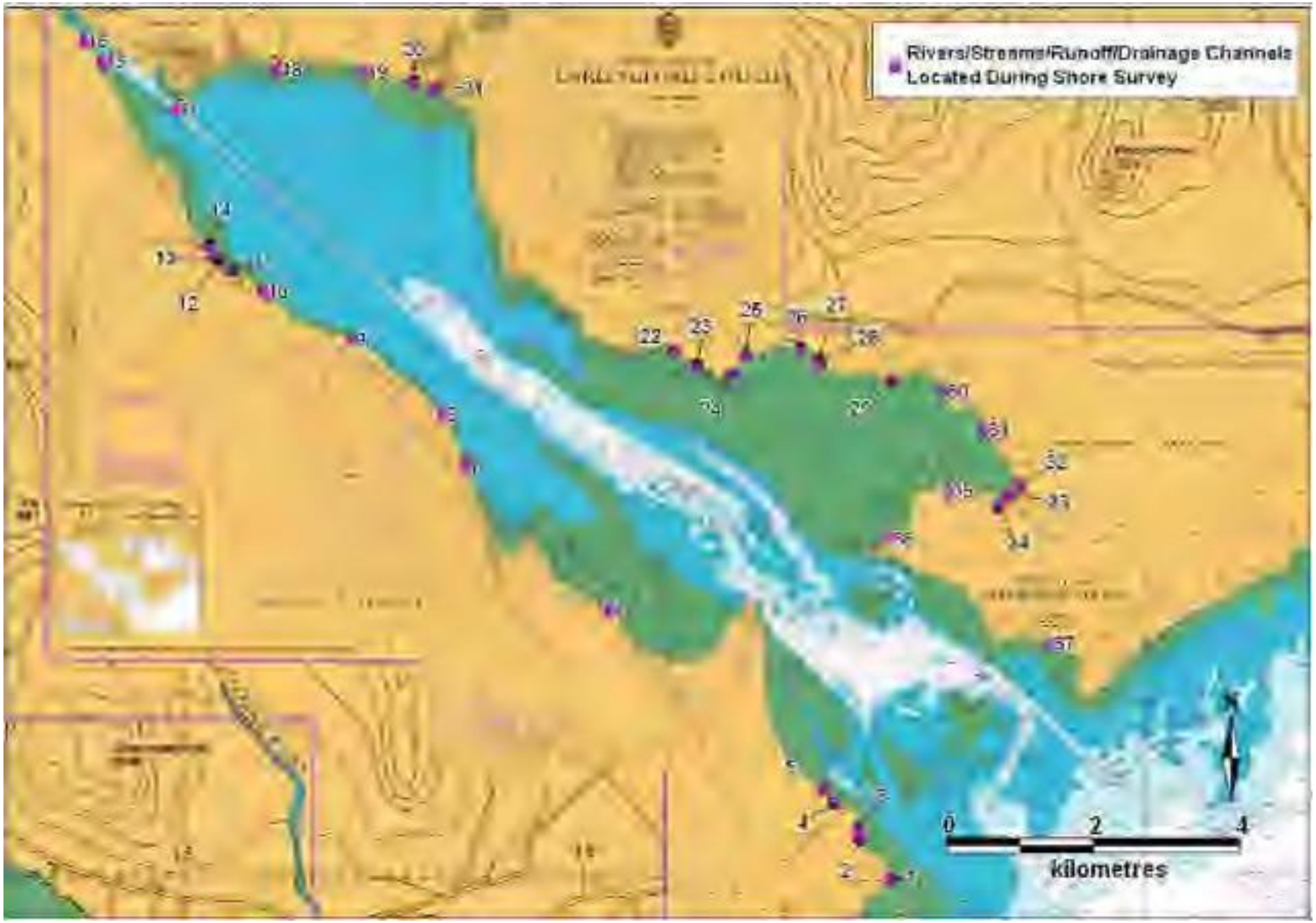


Figure 4.34: Rivers/Streams/ Runoff/Drainage Channels located during the shoreline survey.

Figure 4.35: Rivers/streams/runoff/drainage channels located during the shoreline survey. Refer to Figure 4.34 for site locations.

Figure 4.36: Rivers/streams/runoff/drainage channels located during the shoreline survey. Refer to Figure 4.34 for site locations.

Figure 4.37 shows the locations of the piers/jetties/berths/slipways/pontoons/shore access points located during the shoreline survey. In total, 37 were identified. Figures 4.38 and 4.39 show images of these sites.

Figure 4.37: Pier/Jetty/Slipways/Berths /Pontoons located during the shoreline survey.

Figure 4.38: Piers/Jetties/slipways located during the shoreline survey. Refer to Figure 4.37 for site locations.

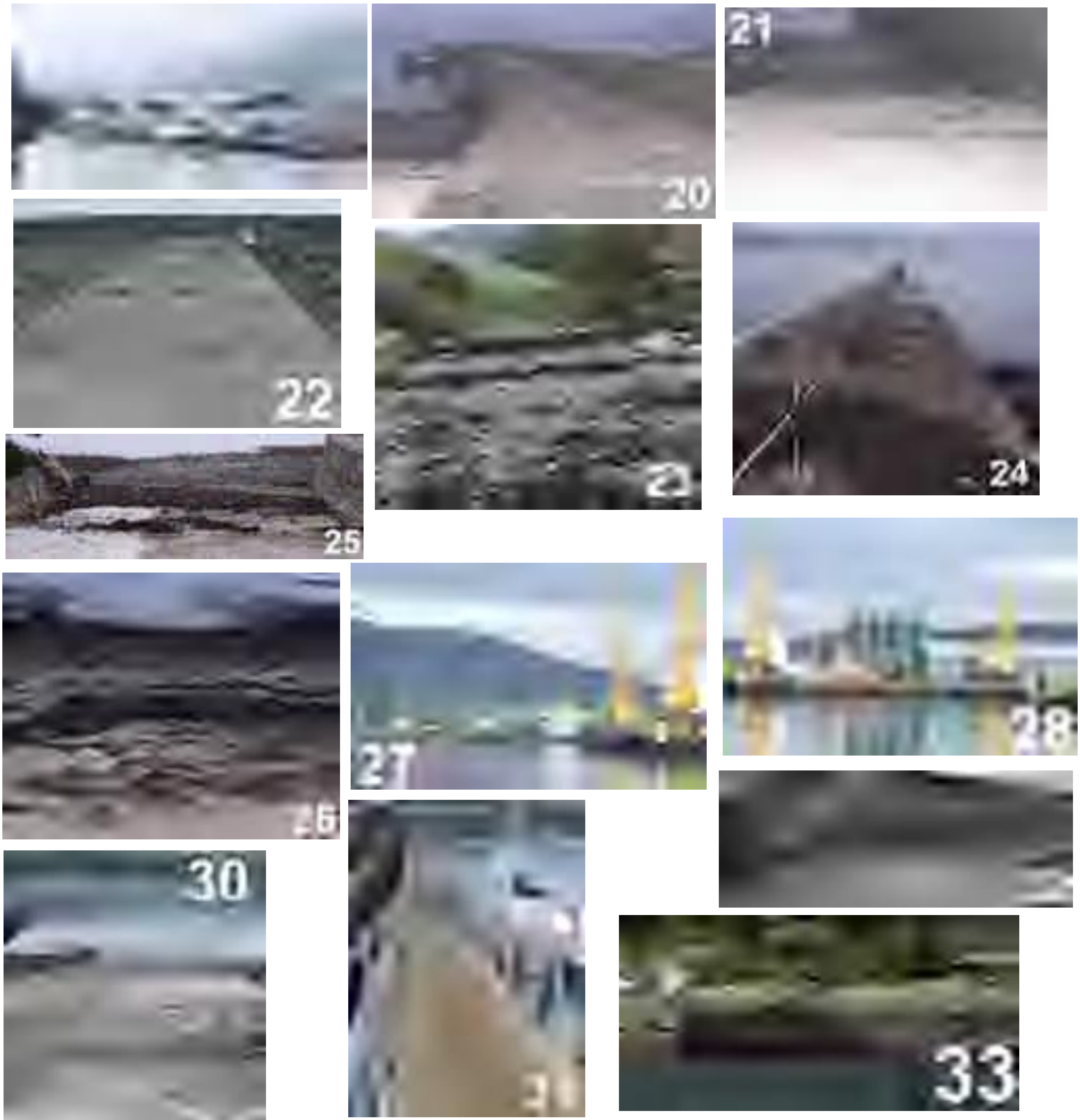


Figure 4.39: Piers /Jetties/ slipways located during the shoreline survey. Refer to Figure 4.37 for site locations.

4.3. Locations of Sources

Figure 4.40 shows all watercourses discharging into Carlingford Lough and Table 4.14 provides cross-referenced details for this map. Figure 4.41 shows all WWTWs/ Sewage Schemes in the Carlingford Lough catchment area and Table 4.15 provides cross-referenced details for the WWTW / Sewage Schemes. Figure 4.41 also shows all continuous and intermittent discharges associated with these WWTW/Sewage Schemes. Data on a large number of discharges identified from the shoreline survey are unavailable and therefore for the purposes of this mapping exercise, all were assumed to be intermittent discharges into the Lough. These can also be seen in Figure 4.41 and all discharges are cross-referenced in Table 4.16. Figure 4.42 shows all overflows, industrial and emergency discharges and septic tanks and Table 4.17 provides cross-referenced details for this map.

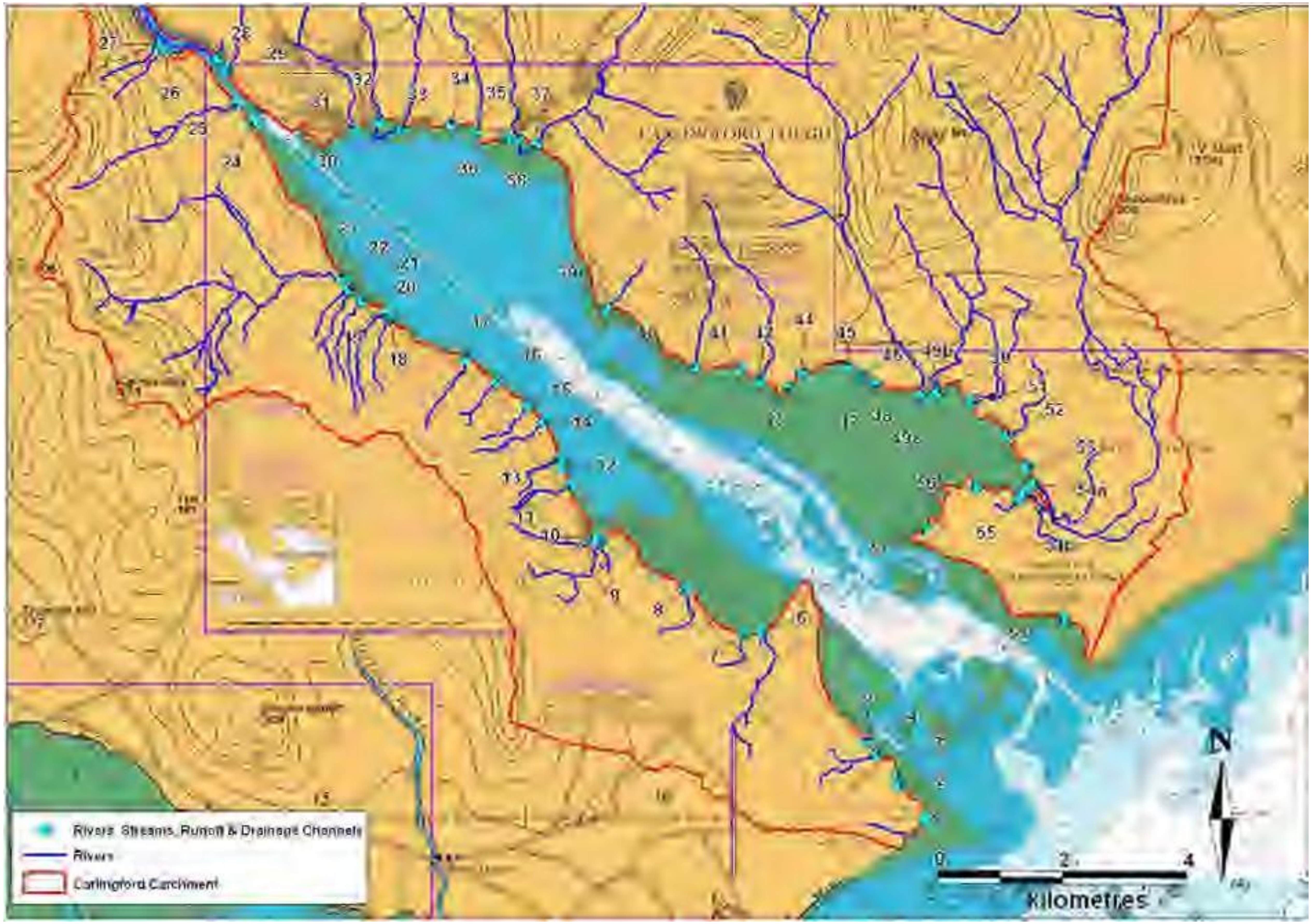


Figure 4.40: Location of all watercourses discharging into Carlingford Lough.

Table 4.14: Cross-referenced table for Figure 4.38 Watercourses.

Map ID	Name	Map ID	Name
1	Unnamed Stream	31	Unnamed River
2	Unnamed Stream	32	Unnamed River
3	Unnamed Stream	33	Moygannon River
4	Unnamed River	34	Unnamed Stream
5	Unnamed Stream	35	Unnamed River
6	Unnamed River	36	Unnamed Stream
7	Unnamed River	37	Ghann River
8	Unnamed River	38	Rostrevor River
9	Unnamed River	39	Unnamed River
10	Unnamed River	40	Unnamed River
11	Unnamed River	41	Unnamed Stream
12	Unnamed Stream	42	Ballincurry River
13	Unnamed River	43	Unnamed Stream
14	St. Patrick's River	44	Unnamed Stream
15	Unnamed River	45	Unnamed Stream
16	Unnamed River	46	Unnamed Stream
17	Two Mile River	47	Unnamed Stream
18	Unnamed River	48	Unnamed Stream
19	Unnamed River	49a	Cassey Water River
20	Unnamed River	49b	Cassey Water River
21	Unnamed River	50	Unnamed River
22	Unnamed Stream	51	Unnamed River
23	Ryland River	52	Unnamed River
24	Unnamed Stream	53	Unnamed Stream
25	Unnamed River	54a	White Water River
26	Unnamed River	54b	White Water River
27	Unnamed River	55	Unnamed River
28	Unnamed River	56	Unnamed Stream
29	Unnamed River	57	Unnamed Stream
30	Newry River	58	Unnamed Stream

Figure 4.41: WWTW / Sewage Schemes and continuous and intermittent discharges within the Carlingford Lough Catchment Area.

Table 4.15: Cross-referenced table for Figure 4.40 WWTW / Sewage Schemes.

Map Code	Name	Easting	Northing	Longitude	Latitude	p.e.
1	Greenore Sewage Scheme	[Redacted]	[Redacted]	[Redacted]	[Redacted]	n/a
2	Carlingford Sewage Scheme	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1200
3	Omeath Sewage Scheme	[Redacted]	[Redacted]	[Redacted]	[Redacted]	487
4	Newry WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	63915
5	Damolly WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	>250
6	Mullaghglass WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	168
7	Jerrettspass WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	39
8	Lurganare WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	407
9	Corgary Cottages WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	18
10	Beech Hill South WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	48
11	Glen Villas WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	<250
12	Killysavan WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	30
13	Poyntzpass WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	880
14	Acton WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	83
15	Bankside WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	57
16	Rathfriland WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	3455
17	Ballyrussel WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	24
18	Warrenpoint WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	14936
19	Attical WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	111
20	Ballymaderphy WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	66
21	Cranfield WWTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	3681

Table 4.16: Cross-referenced table for Figure 4.40 Continuous and Intermittent Discharges.

Map ID	Discharge Type	Name	Treatment	Receiving Water Body
1	Intermittent	Unknown	Details unknown	Carlingford Lough
2	Intermittent	Ferguson's Oyster Processing Plant	Details unknown	Carlingford Lough
3	Intermittent	Unknown	Details unknown	Carlingford Lough
4	Intermittent	Unknown	Details unknown	Carlingford Lough
5	Continuous	Greenore Sewage Scheme	Untreated	Carlingford Lough
6	Intermittent	Oyster depuration facility	Details unknown	Carlingford Lough
7	Intermittent	Oyster depuration facility	Details unknown	Carlingford Lough
8	Intermittent	Unknown	Details unknown	Carlingford Lough

Map ID	Discharge Type	Name	Treatment	Receiving Water Body
9	Intermittent	Unknown	Details unknown	Carlingford Lough
10	Continuous	Carlingford Sewage Scheme	Secondary treatment	Carlingford Lough
11	Intermittent	Unknown	Details unknown	Carlingford Lough
12	Intermittent	Unknown	Details unknown	Carlingford Lough
13	Intermittent	Carlingford Sewage Scheme	Storm water overflow	Carlingford Lough
14	Intermittent	Unknown	Details unknown	Carlingford Lough
15	Intermittent	Unknown	Details unknown	Carlingford Lough
16	Intermittent	Land drain	Details unknown	Carlingford Lough
17	Intermittent	Unknown	Details unknown	Carlingford Lough
18	Intermittent	Unknown	Details unknown	Carlingford Lough
19	Intermittent	Unknown	Details unknown	Carlingford Lough
20	Intermittent	Unknown	Details unknown	Carlingford Lough
21	Intermittent	Unknown	Details unknown	Carlingford Lough
22	Intermittent	Unknown	Details unknown	Carlingford Lough
23	Continuous	Omeath Sewage Scheme	Untreated	Carlingford Lough
24	Intermittent	Unknown	Details unknown	Carlingford Lough
25	Intermittent	Unknown	Details unknown	Carlingford Lough
26	Intermittent	Unknown	Details unknown	Carlingford Lough
27	Intermittent	Unknown	Details unknown	Carlingford Lough
28	Intermittent	Unknown	Details unknown	Carlingford Lough
29	Intermittent	Unknown	Details unknown	Carlingford Lough
30	Intermittent	Unknown	Details unknown	Carlingford Lough
31	Intermittent	Unknown	Discharge from domestic dwellings	Carlingford Lough
32	Intermittent	Unknown	Discharge from domestic dwellings	Carlingford Lough
33	Continuous	Newry WWTW	Secondary treated waste water	Newry River
34	Intermittent	Newry WWTW	Screened storm waste water	Newry River
35	Continuous	Damolly WWTW	Secondary treated waste water	Newry River
36	Intermittent	Damolly WWTW	Storm waste water	Newry River
37	Continuous	Mullaghglass WWTW	Secondary treated waste water	Unnamed Trib.
38	Intermittent	Mullaghglass WWTW	Screened unsettled storm waste water	Unnamed Trib.
39	Continuous	Lurganare WWTW	Secondary treated waste water	Trib. Newry River
40	Intermittent	Lurganare WWTW	Screened settled storm waste water	Trib. Jerrettspass
41	Continuous	Jerrettspass WWTW	Secondary treated effluent	Newry Canal
42	Continuous	Glen Villas WWTW	Secondary treated effluent	Trib. Newry River
43	Continuous	Killysavan WWTW	Secondary treated effluent	Trib. Newry River
44	Continuous	Poyntzpass WWTW	Secondary treated waste water	Newry Canal
45	Intermittent	Poyntzpass WWTW	Screened storm waste water	Unnamed stream
46	Continuous	Acton WWTW	Secondary treated effluent	Trib. Newry Canal

Map ID	Discharge Type	Name	Treatment	Receiving Water Body
47	Intermittent	Acton WWTW	Screened storm waste water	Trib. Newry Canal
48	Continuous	Corgary Cottages WWTW	Good secondary treated effluent with nitrification	Trib. Newry River
49	Continuous	Beech Hill South WWTW	Secondary treated effluent	Trib. Newry River
50	Intermittent	Beech Hill South WWTW	Settled storm waste water	Trib. Newry River
51	Continuous	Bankside WWTW	Secondary treated effluent	Trib. Newry River
52	Continuous	Rathfriland WWTW	Secondary treated waste water	Trib. Newry River
53	Intermittent	Rathfriland WWTW	Settled storm waste water	Trib. Newry River
54	Continuous	Ballyrussel WWTW	Good secondary treated effluent with nitrification	Trib. Moygannon River
55	Continuous	Warrenpoint WWTW	Secondary treated waste water	Carlingford Lough
56	Intermittent	Warrenpoint WWTW	Screened storm waste water	Carlingford Lough
57	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
58	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
59	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
60	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
61	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
62	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
63	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
64	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
65	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
66	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
67	Intermittent	Discharge from Industrial Estate and Port facilities	Details unknown	Carlingford Lough
68	Intermittent	Unknown	Details unknown	Carlingford Lough
69	Intermittent	Unknown	Details unknown	Carlingford Lough
70	Intermittent	Unknown	Details unknown	Carlingford Lough
71	Intermittent	Unknown	Details unknown	Carlingford Lough
72	Intermittent	Unknown	Details unknown	Carlingford Lough
73	Intermittent	Unknown	Details unknown	Carlingford Lough
74	Intermittent	Unknown	Details unknown	Carlingford Lough
75	Intermittent	Unknown	Details unknown	Carlingford Lough
76	Intermittent	Unknown	Details unknown	Carlingford Lough
77	Intermittent	Unknown	Details unknown	Carlingford Lough
78	Intermittent	Unknown	Details unknown	Carlingford Lough

Map ID	Discharge Type	Name	Treatment	Receiving Water Body
79	Intermittent	Unknown	Details unknown	Carlingford Lough
80	Intermittent	Unknown	Details unknown	Carlingford Lough
81	Intermittent	Unknown	Details unknown	Carlingford Lough
82	Intermittent	Unknown	Details unknown	Carlingford Lough
83	Intermittent	Unknown	Details unknown	Carlingford Lough
84	Intermittent	Unknown	Details unknown	Carlingford Lough
85	Intermittent	Farm Leech	Details unknown	Carlingford Lough
86	Intermittent	Unknown	Details unknown	Carlingford Lough
87	Intermittent	Unknown	Details unknown	Carlingford Lough
88	Intermittent	Unknown	Details unknown	Carlingford Lough
89	Intermittent	Unknown	Details unknown	Carlingford Lough
90	Continuous	Cranfield WWTW	Fine screened waste water	Carlingford Lough
91	Intermittent	Cranfield WWTW	Screened storm waste water	Carlingford Lough
92	Intermittent	Unknown	Details unknown	Carlingford Lough
93	Intermittent	Unknown	Details unknown	Carlingford Lough
94	Continuous	Ballymaderfy WWTW	Secondary treated effluent	Trib. Carlingford Lough
95	Continuous	Attical WWTW	Secondary treated effluent	Yellow Water
96	Intermittent	Attical WWTW	Screened storm waste water	Yellow Water

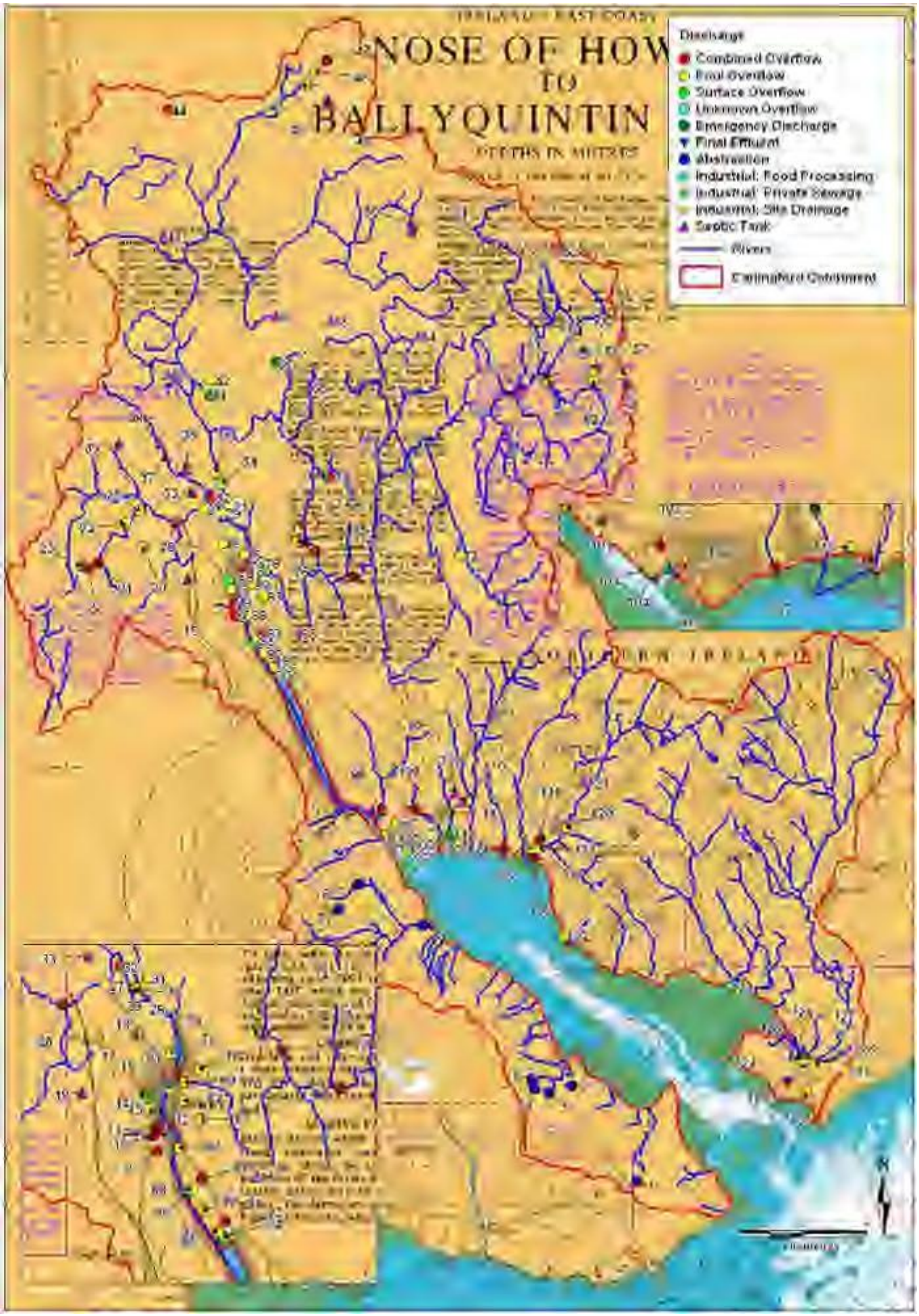


Figure 4.42: All septic tanks, overflows, emergency discharges and industrial discharges in the Carlingford Lough Catchment Area.

Table 4.17: Cross-referenced table for Figure 4.41 Septic Tanks, Emergency Discharges, Overflows and Industrial Discharges.

Map ID	Discharge Type	Name
1	Abstraction	Muchgrange Springs
2	Abstraction	Carlingford Borehole
3	Abstraction	Shallow Well
4	Abstraction	Mountain Stream
5	Abstraction	Jenkins Well
6	Abstraction	Ryland Riverside
7	Abstraction	Shallow Well
8	Abstraction	Lislea Borehole
9	Combined Overflow	Drumalane Road CSO
10	Combined Overflow	Dublin Road Newry CSO
11	Combined Overflow	Bridge Street SPS
12	Foul Overflow	Kiln Street CSO
13	Foul Overflow	Patrick Street CSO
14	Surface Overflow	James Connolly Park Patrick Street CSO
15	Surface Overflow	Not Assigned CSO
16	Foul Overflow	Win SPS
17	Foul Overflow	Violet Hill Avenue CSO
18	Foul Overflow	Not Assigned CSO
19	Septic Tank	Corrinshingo
20	Foul Overflow	Camlough Road CSO
21	Combined Overflow	Camlough SPS
22	Combined Overflow	Cashel Close SPS
23	Surface Overflow	Chapel Road St Malachys CSO
24	Foul Overflow	Mill Road CSO
25	Foul Overflow	Derrymore Road
26	Combined Overflow	Millvale SPS
27	Foul Overflow	Bracken Grove SPS
28	Combined Overflow	Carnbane (2) SPS
29	Foul Overflow	Carnbane WWTW SPS
30	Foul Overflow	Carnbane SPS
31	Foul Overflow	Adria Factory Carnbane SPS
32	Combined Overflow	Carnbane Gardens SPS
33	Septic Tank	Armagh Road No. 1 (144-146)
34	Foul Overflow	Lisduff SPS
35	Foul Overflow	Newry Depot SPS
36	Septic Tank	Goragh Road (15-17)
37	Septic Tank	Armagh Road No. 3 (189-193)
38	Septic Tank	Armagh Road No. 2 (202-206)
39	Septic Tank	Maytown Road (43-45)
40	Septic Tank	Jockeys Brae

Map ID	Discharge Type	Name
41	Emergency Discharge	Lurganare WWTW
42	Foul Overflow	Cluain Air SPS
43	Septic Tank	Demoan Villas
44	Combined Overflow	Acton CSO
45	Foul Overflow	Loughbrickland SPS
46	Foul Overflow	Oaklands Loughbrickland SPS
47	Combined Overflow	Newry Road Loughbrickland SPS
48	Septic Tank	Lakeview Road
49	Septic Tank	Greenan
50	Septic Tank	Glascar Road
51	Septic Tank	Glaskerbeg Road (11)
52	Septic Tank	Knock Terrace
53	Septic Tank	Glen View
54	Unknown Overflow	Ashleigh Grove SPS
55	Foul Overflow	Not Assigned CSO
56	Foul Overflow	Iveagh Cresent CSO
57	Foul Overflow	Bernagh View SPS
58	Septic Tank	Hilltown Road (20-26)
59	Foul Overflow	Sleepvalley Rathfriland SPS
60	Foul Overflow	Ivan Cottages Rathfriland SPS
61	Foul Overflow	Ivy Bridge SPS
62	Septic Tank	Newry Road (80-83)
63	Septic Tank	St Patrick's Villas
64	Septic Tank	Shinn Road
65	Septic Tank	Mountain View Tullymurry
66	Septic Tank	Fourmile
67	Emergency Discharge	Beech Hill South WWTW
68	Septic Tank	Corcreeghy Road
69	Septic Tank	Savalmore Cottages WWTW
70	Septic Tank	Lurgancahone Rd (35-39)
71	Septic Tank	Lurgancahone Rd (57-59)
72	Foul Overflow	Mayobridge SPS
73	Combined Overflow	Saval Beg SPS
74	Foul Overflow	Ashtree Cottages SPS
75	Foul Overflow	Ardfreelin SPS
76	Septic Tank	Hilltown Road (4-6)
77	Combined Overflow	Crown Bridge SPS
78	Foul Overflow	Arthur Street Windsor Hill CSO
79	Combined Overflow	Islandbank SPS
80	Foul Overflow	Baggot Street Stream Street CSO
81	Foul Overflow	Kildare Street Town Hall CSO
82	Foul Overflow	Well Lane SPS
83	Foul Overflow	Windmill Road SPS

Map ID	Discharge Type	Name
84	Combined Overflow	Derryleckagh SPS
85	Septic Tank	Commons School Road (8-10)
86	Foul Overflow	Greenbank Industrial Estate SPS
87	Combined Overflow	Warrenpoint Road 1 SPS
88	Foul Overflow	Rampart Road SPS
89	Surface Overflow	Greenbank 3 SPS
90	Foul Overflow	Greenbank 2 SPS
91	Combined Overflow	Warrenpoint Road 2 SPS
92	Foul Overflow	Loughway Business Park Entrance SPS
93	Foul Overflow	Loughway Business Park East SPS
94	Surface Overflow	Loughway Business Park Central SPS
95	Surface Overflow	Loughway Business Park Canal SPS
96	Foul Overflow	Carrickmacstay SPS
97	Septic Tank	Drumgrevagh Lurgancanty STW
98	Combined Overflow	Mound Road SPS
99	Foul Overflow	Warrenpoint Golf Club SPS
100	Industrial: Site Drainage	Warrenpoint Harbour Authority
101	Combined Overflow	The Docks Warrenpoint SPS
102	Combined Overflow	Warrenpoint Main SPS
103	Industrial: Site Drainage	Farrans (Construction) Ltd
104	Industrial: Site Drainage	Farrans (Construction) Ltd
105	Industrial: Site Drainage	Farrans (Construction) Ltd
106	Industrial: Food Processing	Warrenpoint Harbour Authority
107	Combined Overflow	Springfield Road SPS
108	Combined Overflow	Spring Meadows SPS
109	Septic Tank	Ballymaconaghy WTW (ST)
110	Septic Tank	Ballymaconaghy Rd (19)
111	Industrial: Private Sewage	Annett Landscaping Ltd
112	Emergency Discharge	Well Rd Housing Development Sewage
113	Foul Overflow	Seafields SPS
114	Combined Overflow	Dobbins Point SPS
115	Combined Overflow	Drumsesk Road SPS
116	Combined Overflow	Shore Road Rostrevor SPS
117	Foul Overflow	Horners Lane CSO
118	Foul Overflow	Water Street CSO
119	Combined Overflow	Cherry Hill South CSO
120	Foul Overflow	Pinewood SPS
121	Septic Tank	Kilbroney Park
122	Foul Overflow	Killowen SPS
123	Industrial: Food Processing	Unknown
124	Industrial: Private Sewage	Unknown
125	Foul Overflow	Greencastle Pier Road (1) SPS
126	Foul Overflow	Greencastle Pier Road (2) SPS

Map ID	Discharge Type	Name
127	Foul Overflow	Cranfield 1 Crossroads SPS
128	Foul Overflow	Cranfield 3 Grange Chapel SPS
129	Final Effluent	Cranfield (WWTW) SPS
130	Foul Overflow	Cranfield 2 Chestnutts SPS
131	Foul Overflow	Cranfield 4 Sandbank SPS

5. Shellfish and Water Sampling

5.1. *Historical Data*

5.1.1. Shellfish Water Quality

Douglas (1992) documented water quality results between 1985 and 1989 in Carlingford Lough. These analyses were carried out as part of the National Shellfish Sanitation Programme. Table 5.1 shows faecal coliform levels from Omeath, Carlingford and Ballagan from 1985-1989 and Table 5.2 shows data from Carlingford post September 1989 where a marked improvement could be seen.

Table 5.1: Faecal coliforms in Carlingford Lough 1985/1989 (Douglas, 1995).

Location	Range (No. per 100ml water)
Omeath	188-4608 (1985 data only)
Carlingford	0-1040 (Mean 50)
Ballagan	0-1140 (Mean 30)

Table 5.2: Faecal coliforms at Carlingford since September 1989 (Douglas, 1992).

Maximum	Minimum	Mean	Median
453	0	28	1

The Northern Ireland Environment Agency (NIEA) Water Management Unit collects water samples for analysis from various locations around Carlingford Lough (See Figure 5.1). These water samples are analysed routinely for pH, temperature, suspended solids, salinity, dissolved oxygen, faecal coliforms (*E. coli*), heavy metals, organochlorides, Polychlorionated Biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAHs), Pentachlorophenol (PCP) and Tributyl Tin Oxide (TBTO). As faecal coliforms are the main indicators of sanitation levels in water bodies such as Carlingford Lough, these results are shown in Figure 5.2 (and Table 5.3) below for all 9 sampling points from 2005 to 2009 (Note the change in cfu/100ml range for Cassey Water 2). Faecal coliforms were below 50 cfu/100ml at all sites with the exception of September 2005 when levels of 420 cfu/100ml were recorded. The Guide value for faecal coliforms under the Shellfish Directive (79/923/EEC) is <300 cfu/100ml. This figure applies not only to the shellfish flesh and intervalvular fluid but also to the waters in which they live. The guide value was only exceeded once and seems to be very localised to Station Cassey Water 2 as no other similar peaks were observed at the other stations. The averaged and totalled faecal coliform results can be seen in graphical form in Figure 5.3. However, it should be noted that not all seasons from 2005 to 2009 were equally represented and the sampling sites were not representative of the entire Lough. The total faecal coliforms recorded were highest in the winter months (with the exception at Cassey Water 2 caused by the peak in autumn) and for the most part decreased through autumn, summer and spring. At some sites, summer levels were marginally higher than autumn levels. The averaged data shows that spring had the lowest faecal coliform levels (with the exception of Ballyedmond 1 and this was due to the fact that only one spring reading of 25 cfu/100ml was recorded during the 4 year period), again with a gradual increase through to the winter months.

In addition, water quality data from 2004 to 2009 from the Cranfield Bay area can be seen in Table 5.4 below (NIEA, 2010). This area is routinely sampled (20 times annually) under the Bathing Waters Directive. Two peaks in August 2007 (1352 cfu/100ml) and July 2008 (2300 cfu/100ml) result in the high range seen in Table 5.4. If these two peaks are excluded the average falls to 23 and the maximum to 390. In 2009 the quality of these bathing waters was excellent (i.e. 90% of samples must have a faecal coliform level ≤100/100ml water).

Figure 5.1: Locations of NIEA water sampling points.

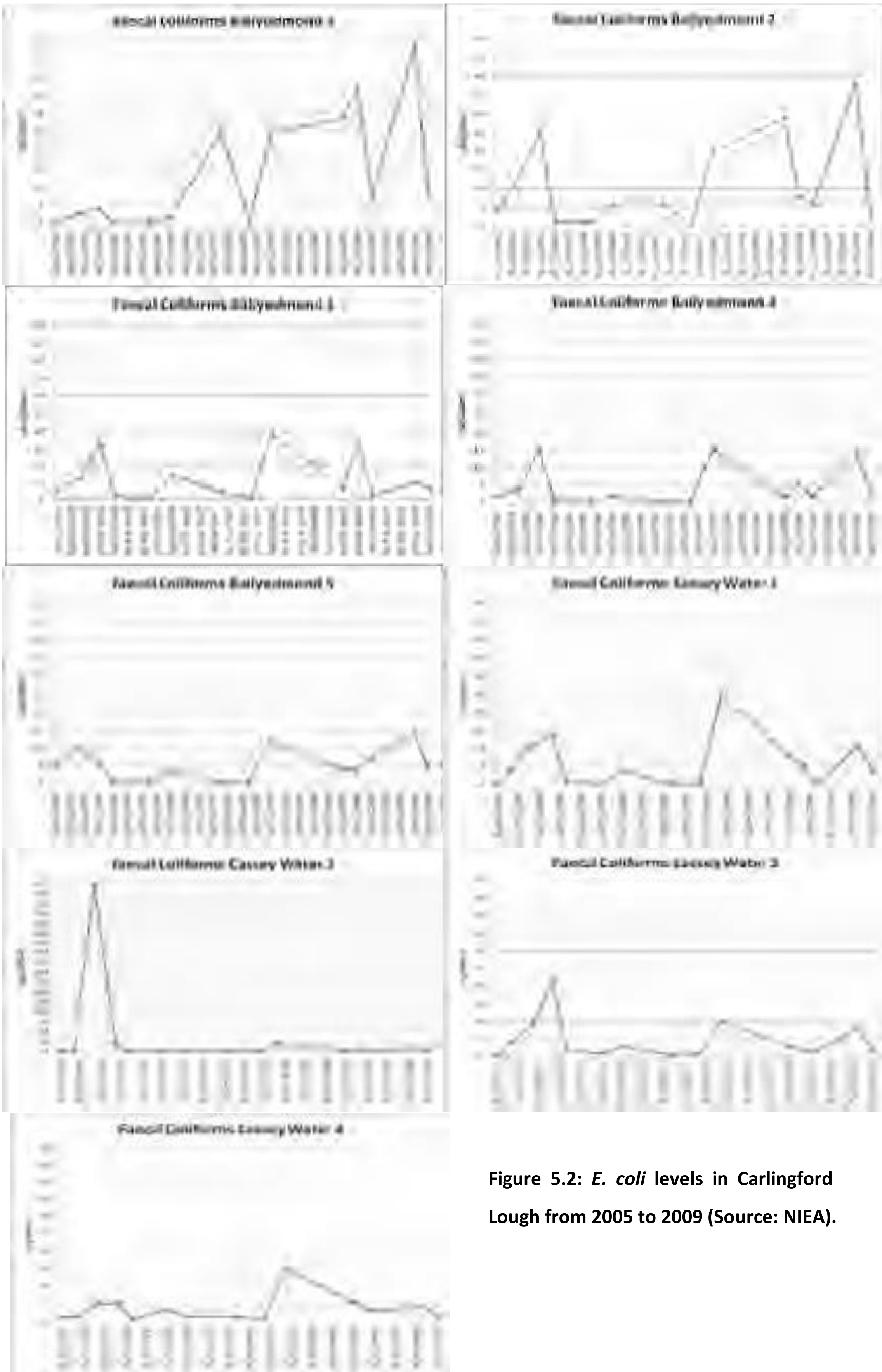


Figure 5.2: ***E. coli*** **levels in Carlingford Lough from 2005 to 2009 (Source: NIEA).**

Table 5.3: Faecal coliforms at Cassey Water and Ballyedmond 2005-2009 (Source: NIEA).

Station	Mean	Median	Minimum	Maximum
Cassey Water 1	5.96	4	<1	25
Cassey Water 2	32.77	2	<1	420
Cassey Water 3	4.67	2	<1	22
Cassey Water 4	3.27	3	<1	15
Ballyedmond 1	13.64	5.5	<1	49
Ballyedmond 2	11.46	6	<1	38
Ballyedmond 3	5.93	3	<1	19
Ballyedmond 4	4.71	2	<1	15
Ballyedmond 5	5.25	4.5	<1	14

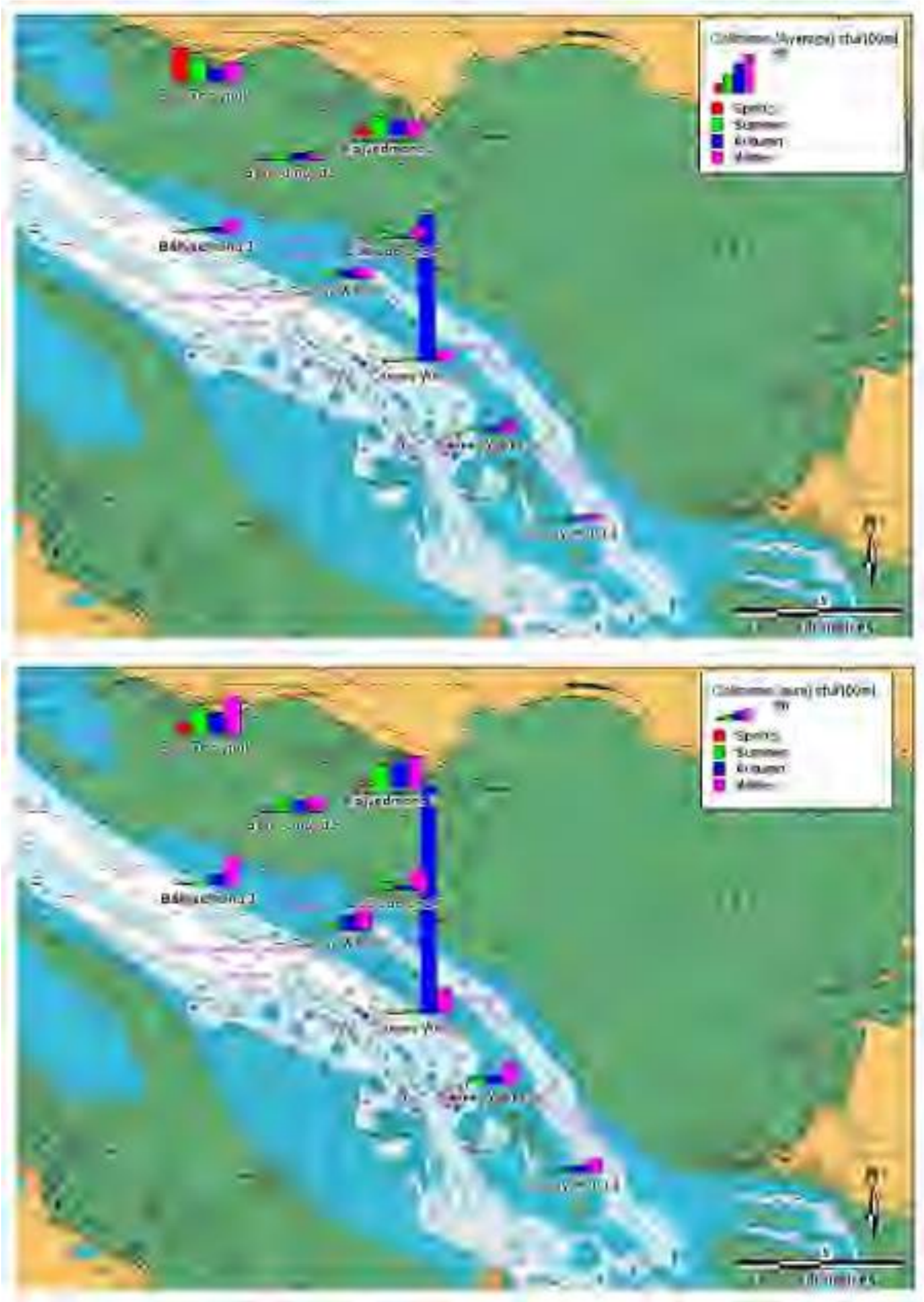


Figure 5.3: Averaged and totalled seasonal faecal coliform results from 2005 to 2009.

Table 5.4: Faecal coliform results from Cranfield Bay Bathing Waters 2004-2009 (NIEA, 2010).

Maximum	Minimum	Mean	Median
2300	<1	53	6

5.1.2. Shellfish Flesh Quality

In accordance with Annex II of the EU Hygiene Regulation 854/2004, the Food Standards Agency of Northern Ireland (FSA in NI) and the Sea Fisheries Protection Authority (SFPA) are required to establish the location and fix the boundaries of shellfish harvesting areas. The process involves regular sampling of shellfish from each area to be classified in order to establish levels of microbiological contamination which subsequently determines which classification should be awarded for that particular area. FSA in NI currently sample shellfish flesh in the Ballyedmond, Carriganean, Fair Green, Flynn, Narrow Water, Rostrevor and Killowen harvesting areas for classification purposes. SFPA currently sample shellfish flesh at Ballagan, Greenore, Inner and McCarthy harvesting areas for classification purposes. Figure 5.4 shows the locations of all sampling points monitored in 2010.

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

An A classification allows for the product to be placed directly on the market, whereas a B or C classification requires the product to go through a process of depuration, heat treatment or relaying before it can be placed on the market. Carlingford Lough has historically always been classified as a mixture of A and B harvesting areas. Table 5.5 summarises this system. Table 5.6 shows the current and historical (back to 2006) classifications within Carlingford Lough.

Table 5.5: Classification system for shellfish harvesting areas.

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

Figure 5.4: **Locations of FSA in NI and SFPA shellfish monitoring points for classification purposes.**

Table 5.6: Current and historical classification of shellfish beds in Carlingford Lough (2006 – 2011).

Boundaries	Bed Name	Species	Class					
			2006	2007	2008	2009	2010	2011
	Ballyedmond	Oysters	A	A	B	B	B	B
	Carriganean	Oysters	A	A	B	B	B	B
	Fair Green	Oysters	A	A	B	B	B	B
	Flynn	Mussels	A	A	B	B	B	B
	Killowen	Mussels	-	-	-	B*	B	B
	Narrow Water Castle	Mussels	B*	B*	B	B*	C	B
	Rostrevor	Mussels	A	A	B	B	B	B
	The Rocks	Mussels	-	-	-	B*	B*	-
	Whitehouse	Mussels	B*	-	-	-	-	-
Ballagan Pt.-Cranfield Pt & Carlingford Pt-Carrigaroan	Ballagan	Razor Clams	A	A	A	A	A	A
		Oysters	A	A	A	A	A	A
	Greenore	Oysters	A	A	A	A	A#	A
	Carlingford Outer (Greenore)	Mussels	B	B	A	A	A	A
Carlingford Pt.-Carrigaroan & Rostrevor Quay-Greer's Quay	Carlingford Middle	Mussels	B	B	A	B	B	B
Black Rock-Rostrevor Quay & Rostrevor Quay-Greer's Quay	Carlingford Inner	Mussels	-	-	-	-	B*	B*

Seasonal A 01 May – 01 Jan due to viral issues

* Preliminary/Provisional Classification - Classifications are described as preliminary/provisional when an area is being classified for the first time or after a period in suspension. The term may also be used where an incomplete dataset of results was to hand.

In addition to *E. coli* monitoring, FSA in NI, SFPA and the Marine Institute (MI) conduct monitoring for the presence of toxin producing phytoplankton in shellfish waters, including *Alexandrium spp* and *Dinophysis spp.* and for marine biotoxins (including DSP, PSP and ASP) in shellfish flesh. In Northern Ireland's harvesting areas, shellfish flesh is also monitored for chemical contaminants (e.g. metals, PAH's and dioxins). In addition, NIEA sampled shellfish flesh for heavy metals, organochlorides, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), pentachlorophenol (PCP) and Tributyl Tin Oxide (TBTO) up to July 2009.

Tables 5.7 to 5.20 list the *E. coli* results for mussels, oysters and razor clams from Ballyedmond, Carriganean, Fair Green, the Flynn site, Narrow Water, Rostrevor, Killowen, The Rocks, Ballagan, Greenore, Inner Carlingford and the McCarthy site from 2006 to 2010 (where available). ND in these tables means that *E. coli* levels were Not Detectable. Figures 5.5 to 5.18 show these data in graphical form.

As mentioned earlier, Ballyedmond has had a **B** classification since 2008, an **A** classification from 2004 to 2003 and a **B** classification in 2003. Since 2006, there were only 9 instances of a **B** result for the Ballyedmond oyster harvesting bed. *E. coli* counts ranged from 310 to 1300 MPN/100g during these B result periods. Since 2006, the Ballyedmond oyster harvesting bed had an **A** result 85% of the time and a **B** result 15% of the time (See Figure 5.5). The most recent data from Ballyedmond (December 2010) gave an A result. Ballyedmond is classified as **B** for 2011.

Carriganean has had a **B** classification since 2008, an **A** classification in 2007 and 2006, a **B** classification in 2005, an **A** classification in 2004 and a **B** classification in 2003. There was one instance of a **C** result for the Carriganean oyster harvesting bed since 2006 and it occurred in April 2006 (9,100 MPN/100g). There were 9 instances of a B result since 2006 and the *E. coli* counts ranged from 310 – 790 MPN/100g during these periods. Since 2006, the Carriganean oyster harvesting bed had an **A** result 81.8% of the time, a **B** result 16.4% of the time and a **C** result 1.8% of the time (See Figure 5.6). The most recent data from Carriganean (December 2010) gave an **A** result. Carriganean is classified as B for 2011.

Fair Green has had a **B** classification since 2008, an **A** classification from 2007 to 2005 and a **B** (provisional) classification from 2004 to 2003. Since 2006, there was one instance of a **C** result for the Fair Green oyster harvesting bed and it occurred in September 2008 (9100 MPN/100g). There has been 9 instances of **B** results since 2006 and the *E. coli* counts during these periods ranged from 310-1300 MPN/100g. Since 2006, the Fair Green oyster harvesting bed had an **A** result 82.1% of the time, a **B** result 16.1% of the time and a **C** result 1.8% of the time (See Figure 5.7). The most recent data from Fair Green (November 2010) gave an **A** result.

Fair Green is classified as **B** for 2011.

Flynn has had a **B** classification since 2008, an **A** classification from 2007 to 2005 and a **B** classification from 2004 to 2003. Since 2006, there was one instance of a **C** result for the Flynn mussel harvesting bed and it occurred in April 2007 (9100 MPN/100g). There has been 7 instances of **B** results since 2006 and the *E. coli* counts during these periods ranged from 330-1300 MPN/100g. Since 2006, the Flynn mussel harvesting bed had an **A** result 80% of the time, a **B** result 17.5% of the time and a **C** result 2.5% of the time (See Figure 5.8). The most recent data from Flynn (December 2010) was an **A** result. Flynn is classified as **B** for 2011.

Narrow Water has had a **C** classification in 2010, a **B** provisional classification in 2009, a **B** classification in 2008, a **B** provisional classification from 2007 to 2005 and a **C** provisional classification in 2004. Since 2006, there was one instance of harvesting being prohibited (November 2009, 540,000 MPN/100g), three instances of a **C** result; April 2007, December 2007 and January 2009 (5400 MPN/100g). There were 25 instances of a **B** result with *E. coli* counts ranging from 310 to 4300 MPN/100g during these periods. Since 2006, the Narrow Water mussel harvesting bed had an **A** result 30.9% of the time, a **B** result 59.5% of the time, a **C** result 7.1% of the time and prohibited 2.4% of the time (See Figures 5.9 and 5.10). The most recent data from Narrow Water (December 2010) was a **B** result. Narrow Water is classified as **B** for 2011.

Rostrevor has had a **B** classification since 2008, an **A** classification from 2007 to 2005 and a **B** provisional in 2004. Since 2006, there were 14 instances of a **B** result with *E. coli* counts ranging from 290 to 2700 MPN/100g during these periods. Since 2006, the Rostrevor mussel harvesting bed had an **A** result 73.6% of the time and a **B** result 26.4% of the time (See Figure 5.11). The most recent data from Rostrevor (December 2010) was an **A** result. Rostrevor is classified as **B** for 2011.

Killowen had a **B** classification in 2010, a **B** provisional classification in 2009, no classification from 2008 to 2006, a **B** provisional classification in 2005 and 2004. Since 2006, there were 5 instances of a **B** result with *E. coli* counts ranging from 310 to 1,200 MPN/100g during these periods. Since 2006, the Killowen mussel harvesting bed had an **A** result 76.2% of the time and a **B** result 23.8% of the time (See Figure 5.12). The most recent data from Killowen (December 2010) was an **A** result. Killowen is classified as **B** for 2011.

The Rocks mussel harvesting site was classified as **B** provisional in 2010, 2009, 2005 and 2004. This site was only sampled once by FSA in NI (August 2009) with a result of 20 MPN/100g. The Rocks mussels harvesting site is not classified for 2011.

The Ballagan oyster harvesting bed was classified as **A** since 2006. Since 2006 there were 4 instances of a **B** result with *E. coli* counts ranging from 310-500 MPN/100g. Since 2006 the Ballagan oyster bed had an **A** result 92.3% of the time and a **B** result 7.7% of the time (See Figure 5.13). The most recent data from Ballagan (December 2010) was an **A** result. The Ballagan oyster bed is classified as **A** for 2011.

The Greenore/Outer Carlingford mussel harvesting bed was classified as **A** since 2008 and **B** in 2006 and 2007. Since 2006 there were 4 instances of a **B** result with *E. coli* counts ranging from 330-500 MPN/100g. Since 2006 the Greenore/Outer Carlingford mussel bed had an **A** result 91.6% of the time and a **B** result 8.3% of the time (See Figure 5.14). The most recent data from Greenore/Outer Carlingford (December 2010) was an **A** result. The Greenore/Outer Carlingford mussel bed is classified as **A** for 2011.

The Greenore oyster harvesting bed was classified as **A** since 2006 (in 2010 it was a seasonal **A** due to viral issues). Since 2006 there were 5 instances of a **B** result with *E. coli* counts ranging from 250-1300 MPN/100g. Since 2006 the Greenore oyster bed had an **A** result 91.4% of the time and a **B** result 8.6% of the time (See Figure 5.15). The most recent data from Greenore (December 2010) was an **A** result. The Greenore oyster bed is classified as **A** for 2011.

The McCarthy mussel harvesting bed was classified as **B** since 2009, **A** in 2008 and **B** in 2007 and 2006. Since 2006 there were 7 instances of a **B** result with *E. coli* counts ranging from 310-1300 MPN/100g. Since 2006 the McCarthy mussel bed had an **A** result 77.4% of the time and a **B** result 22.6% of the time (See Figure 5.16). The most recent data from the McCarthy site (December 2010) was an **A** result. The McCarthy mussel bed is classified as **B** for 2011.

The Inner mussel harvesting bed was de-classified in 2009 and classified as **B** provisional in 2010. Since 2008 there were 5 instances of a **B** result with *E. coli* counts ranging from 330-3500 MPN/100g. Since 2008 the Inner mussel bed had an **A** result 80% of the time and a **B** result 20% of the time (See Figure 5.17). The most recent data from the Inner site (December 2010) was an **A** result. The Inner mussel bed is classified as **B** provisional for 2011.

The Ballagan razor clam harvesting bed was classified as **A** since 2006. Since 2006 there were 2 instances of a **B** result with *E. coli* counts ranging from 310-750 MPN/100g. Since 2006 the Ballagan razor clam bed had an **A** result 91.3% of the time and a **B** result 8.7% of the time (See Figure 5.18). The most recent data from the Ballagan site (November 2010) was an **A** result. The Ballagan razor clam bed is classified as **A** for 2011.

Table 5.7: ***E. coli*** **results from oysters from Ballyedmond from 2006 to 2010 (Source: FSA in NI)**

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
31/01/2006	<20	A	18/08/2008	310	B
28/02/2006	140	A	01/09/2008	200	A
14/03/2006	90	A	01/10/2008	70	A
11/04/2006	<20	A	03/11/2008	<20	A
16/05/2006	1300	B	01/12/2008	<20	A
27/06/2006	40	A	13/01/2009	<20	A
25/07/2006	ND	A	10/02/2009	20	A
08/08/2006	ND	A	09/03/2009	<20	A
12/09/2006	110	A	30/03/2009	<20	A
10/10/2006	20	A	06/04/2009	70	A
21/11/2006	40	A	11/05/2009	<20	A
05/12/2006	220	A	08/06/2009	<20	A
23/01/2007	110	A	06/07/2009	40	A
21/03/2007	ND	A	10/08/2009	310	B
24/04/2007	ND	A	25/08/2009	40	A
02/05/2007	<20	A	23/09/2009	40	A
05/06/2007	110	A	03/11/2009	700	B
17/07/2007	110	A	17/11/2009	<20	A
14/08/2007	310	B	15/12/2009	<20	A
10/09/2007	<20	A	05/01/2010	40	A
16/10/2007	20	A	23/02/2010	50	A
12/11/2007	40	A	24/03/2010	<20	A
10/12/2007	500	B	27/04/2010	230	A
21/01/2008	400	B	25/05/2010	<20	A
25/02/2008	310	B	29/07/2010	<20	A
25/03/2008	200	A	11/08/2010	20	A
21/04/2008	<20	A	22/09/2010	20	A
19/05/2008	<20	A	26/10/2010	490	B
02/06/2008	20	A	24/11/2010	50	A
21/07/2008	40	A	15/12/2010	<20	A

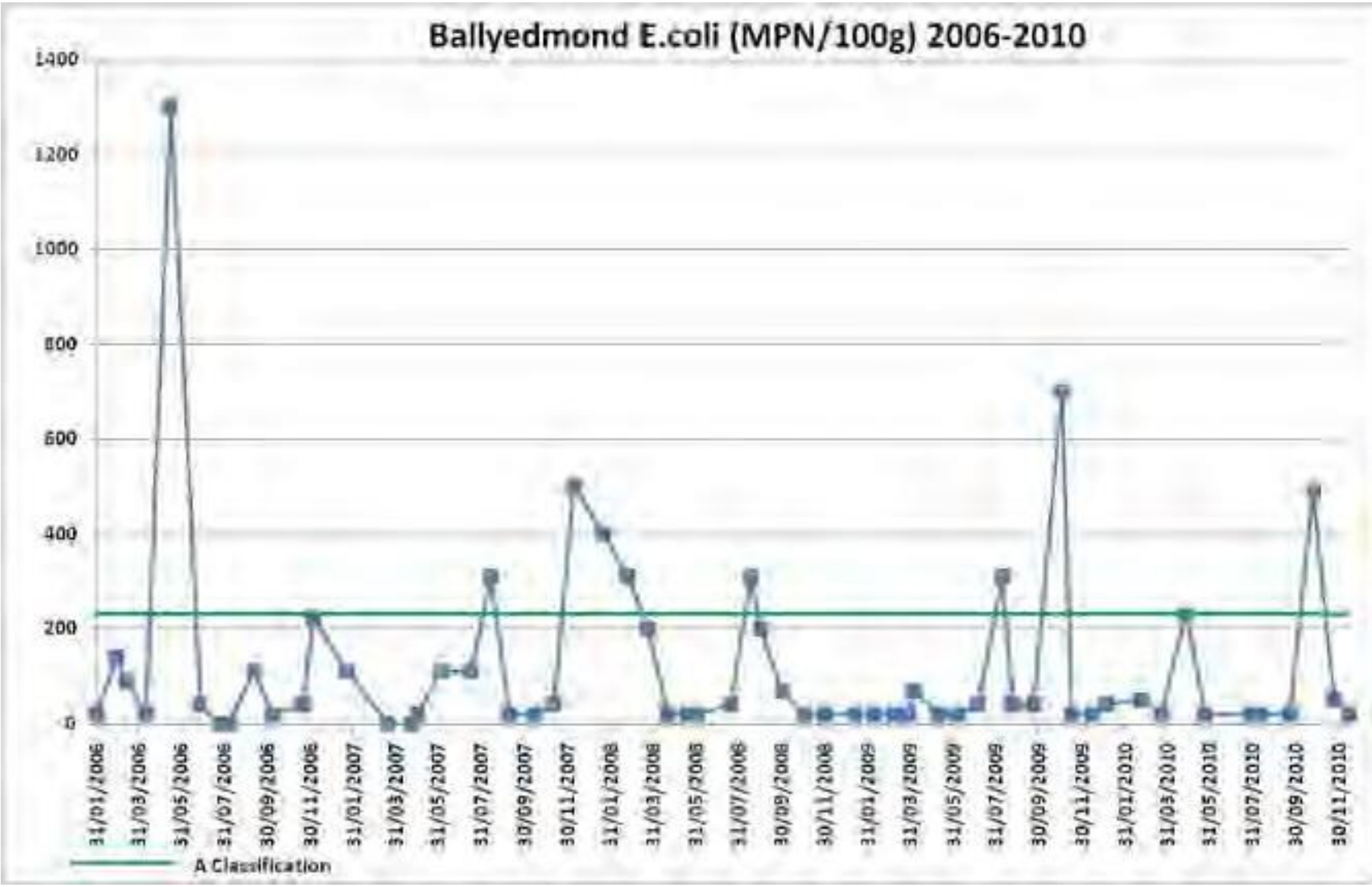


Figure 5.5: ***E*. coli results from oysters at Ballyedmond from 2006-2010 (Source: FSA in NI).**

Table 5.8: *E. coli* results from oysters from Carriganean from 2006 to 2010 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
31/01/2006	70	A	18/08/2008	750	B
28/02/2006	ND	A	01/09/2008	20	A
14/03/2006	<20	A	01/10/2008	20	A
11/04/2006	9100	C	03/11/2008	<20	A
16/05/2006	ND	A	01/12/2008	40	A
27/06/2006	ND	A	13/01/2009	<20	A
25/07/2006	ND	A	10/02/2009	<20	A
08/08/2006	20	A	09/03/2009	<20	A
12/09/2006	70	A	06/04/2009	20	A
10/10/2006	700	B	11/05/2009	40	A
23/01/2007	50	A	22/06/2009	20	A
21/03/2007	ND	A	20/07/2009	20	A
16/04/2007	20	A	08/09/2009	750	B
02/05/2007	<20	A	06/10/2009	<20	A
05/06/2007	200	A	03/11/2009	500	B
17/07/2007	310	B	03/12/2009	220	A
14/08/2007	500	B	21/01/2010	<20	A
10/09/2007	40	A	09/02/2010	130	A
16/10/2007	20	A	10/03/2010	50	A
12/11/2007	20	A	13/04/2010	20	A
10/12/2007	750	B	11/05/2010	20	A
21/01/2008	<20	A	15/06/2010	<20	A
26/02/2008	310	B	25/08/2010	80	A
25/03/2008	<20	A	08/09/2010	790	B
21/04/2008	20	A	12/10/2010	50	A
19/05/2008	<20	A	11/11/2010	50	A
16/06/2008	<20	A	07/12/2010	50	A
21/07/2008	<20	A			

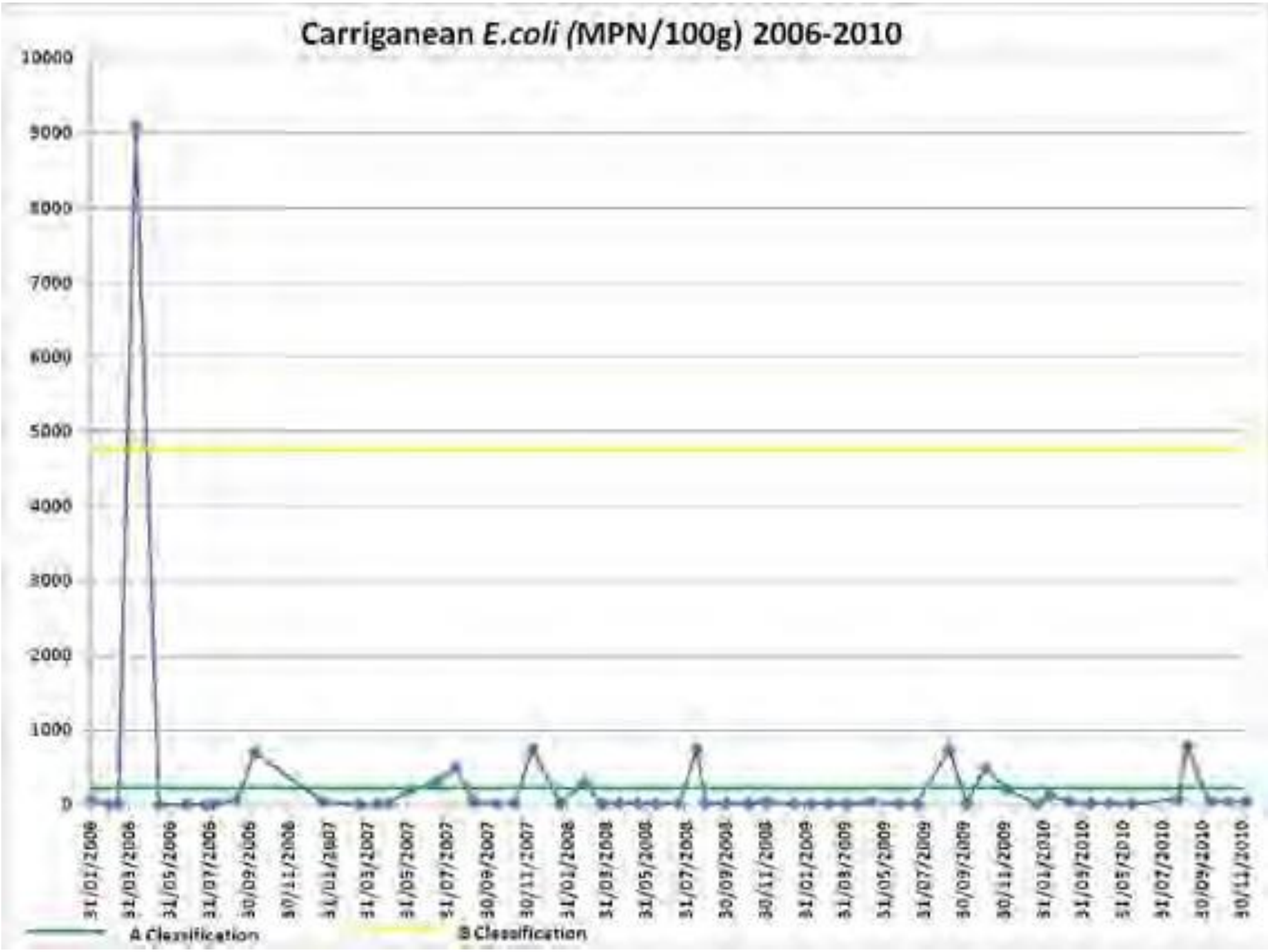


Figure 5.6: *E. coli* levels from oysters at Carriganean from 2006 to 2010 (Source: FSA in NI).

Table 5.9: ***E. coli*** **results from oysters from Fair Green from 2006 to 2010 (Source: FSA in NI)**

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
31/01/2006	20	A	04/08/2008	70	A
28/02/2006	20	A	15/09/2008	9100	C
11/04/2006	<20	A	13/10/2008	400	B
16/05/2006	500	B	17/11/2008	500	B
27/06/2006	ND	A	15/12/2008	110	A
25/07/2006	140	A	27/01/2009	70	A
09/08/2006	90	A	23/02/2009	40	A
12/09/2006	160	A	30/03/2009	20	A
10/10/2006	160	A	27/04/2009	200	A
23/01/2007	<20	A	26/05/2009	70	A
21/03/2007	ND	A	08/06/2009	<20	A
17/04/2007	20	A	06/07/2009	750	B
24/04/2007	ND	A	25/08/2009	200	A
02/05/2007	<20	A	23/09/2009	900	B
15/05/2007	20	A	20/10/2009	200	A
18/06/2007	310	B	17/11/2009	70	A
28/08/2007	1300	B	15/12/2009	70	A
25/09/2007	<20	A	05/01/2010	20	A
31/10/2007	70	A	23/02/2010	20	A
27/11/2007	20	A	24/03/2010	20	A
17/12/2007	40	A	27/04/2010	80	A
07/01/2008	<20	A	25/05/2010	<20	A
12/02/2008	200	A	29/06/2010	<20	A
25/03/2008	<20	A	29/07/2010	20	A
07/04/2008	20	A	11/08/2010	330	B
19/05/2008	70	A	22/09/2010	230	A
02/06/2008	20	A	26/10/2010	330	B
07/07/2008	110	A	24/11/2010	**20**	A

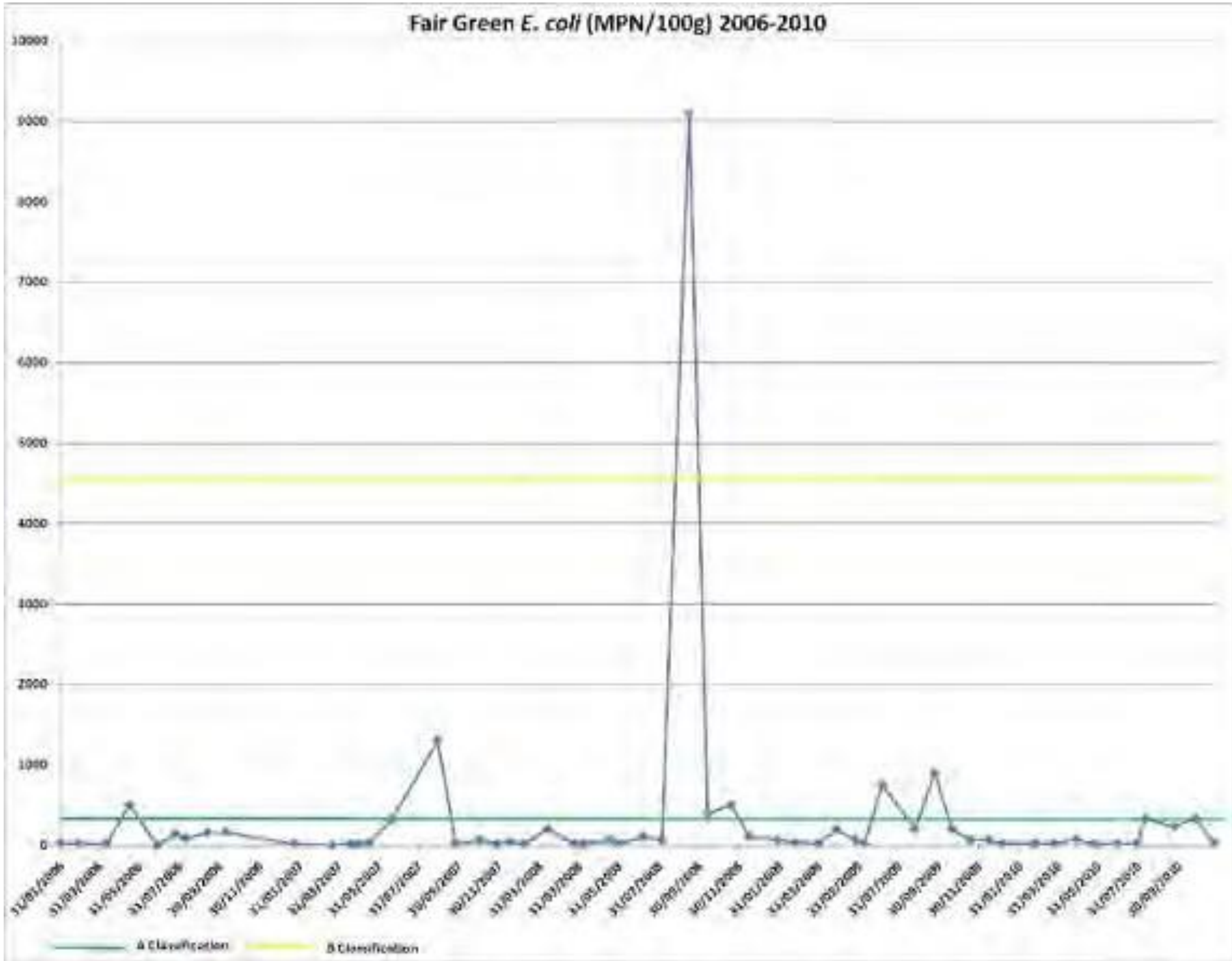


Figure 5.7: ***E. coli*** **levels in Fair Green oysters in 2006 to 2010 (Source: FSA in NI).**

Table 5.10: *E. coli* results from mussels from the Flynn site from 2006-2010 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category
10/01/2006	90	A
14/02/2006	20	A
28/02/2006	140	A
23/05/2006	1300	B
06/06/2006	<20	A
04/07/2006	ND	A
31/08/2006	ND	A
26/09/2006	110	A
24/10/2006	110	A
09/01/2007	500	B
06/02/2007	130	A
06/03/2007	70	A
03/04/2007	9100	C
17/04/2007	20	A
15/05/2007	20	A
31/07/2007	110	A
28/08/2007	40	A
12/02/2008	40	A
04/04/2008	20	A
19/05/2008	<20	A
16/06/2008	<20	A
18/08/2008	430	B
13/10/2008	220	A
23/02/2009	70	A
30/03/2009	110	A
27/04/2009	500	B
22/07/2009	<20	A
10/08/2009	200	A
23/09/2009	<20	A
20/10/2009	<20	A
03/12/2009	70	A
09/12/2009	750	B
21/01/2010	500	B
09/02/2010	80	A
11/05/2010	20	A
12/10/2010	20	A
11/11/2010	130	A
24/11/2010	170	A
07/12/2010	330	B
15/12/2010	20	A

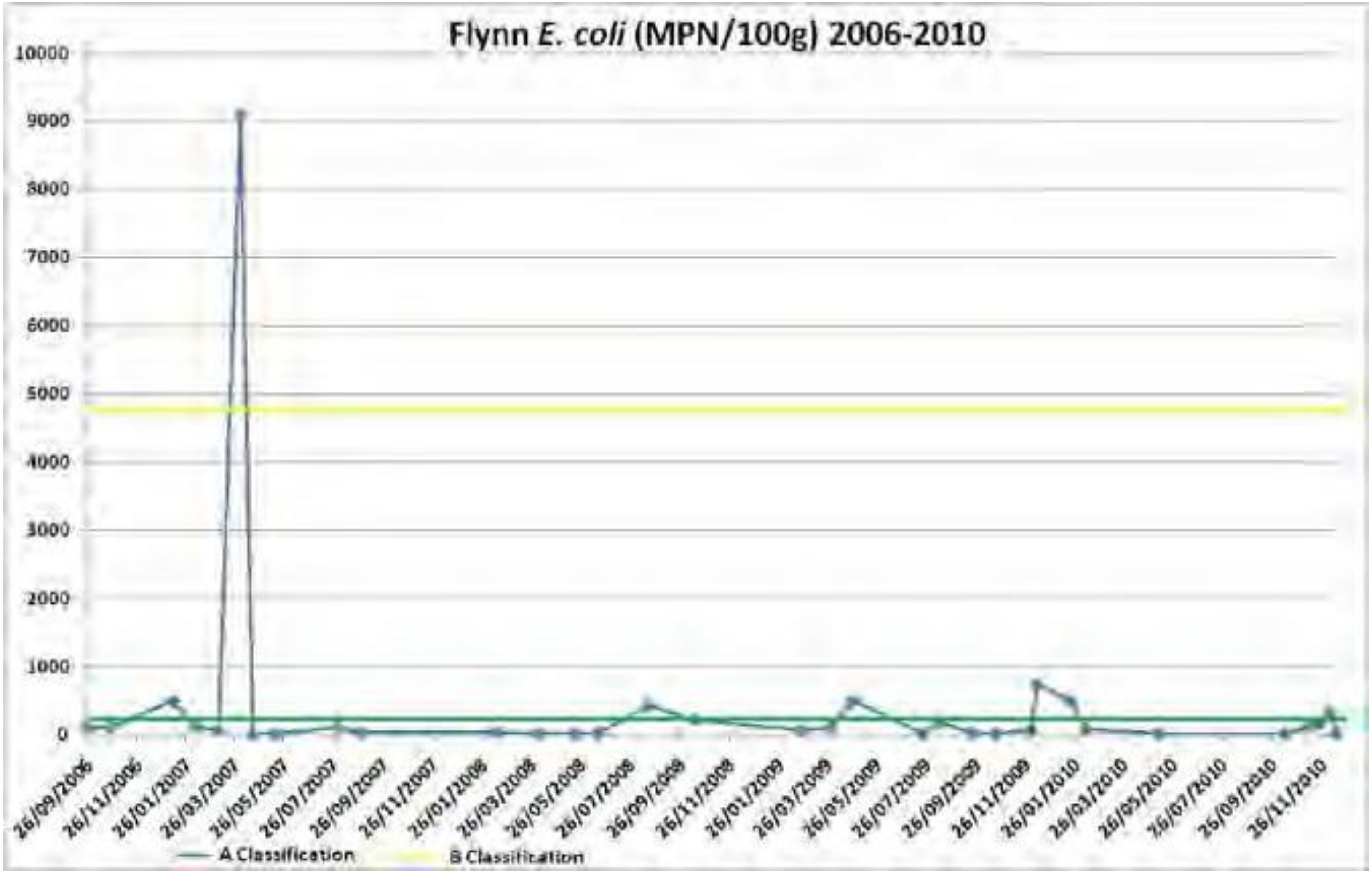


Figure 5.8: *E. coli* levels in mussels from the Flynn site from 2006-2010 (Source: FSA in NI).

Table 5.11: ***E. coli*** **results from mussels from Narrow Water from 2006-2010 (Source: FSA in NI).**

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
10/01/2006	3500	B	**09/02/2009**	400	B
25/04/2006	500	B	**30/03/2009**	200	A
12/09/2006	750	B	**08/09/2009**	1700	B
09/01/2007	220	A	**06/09/2009**	<20	A
06/02/2007	2400	B	**05/10/2009**	<20	A
06/03/2007	1300	B	**03/11/2009**	540000	PROHIB
03/04/2007	70	A	**10/11/2009**	3500	B
24/04/2007	5400	C	**17/11/2009**	2900	B
02/05/2007	310	B	**15/12/2009**	2400	B
05/06/2007	1100	B	**21/01/2010**	3100	B
17/07/2007	2200	B	**23/02/2010**	1400	B
31/07/2007	<20	A	**24/03/2010**	790	B
14/08/2007	200	A	**27/04/2010**	490	B
16/10/2007	500	B	**25/05/2010**	<20	A
13/11/2007	200	A	**29/06/2010**	<20	A
10/12/2007	5400	C	**29/07/2010**	130	A
21/01/2008	1300	B	**11/08/2010**	460	B
13/10/2008	40	A	**22/09/2010**	170	A
03/11/2008	750	B	**26/10/2010**	1700	B
01/12/2008	4300	B	**24/11/2010**	3500	B
27/01/2009	5400	C	**15/12/2010**	330	B

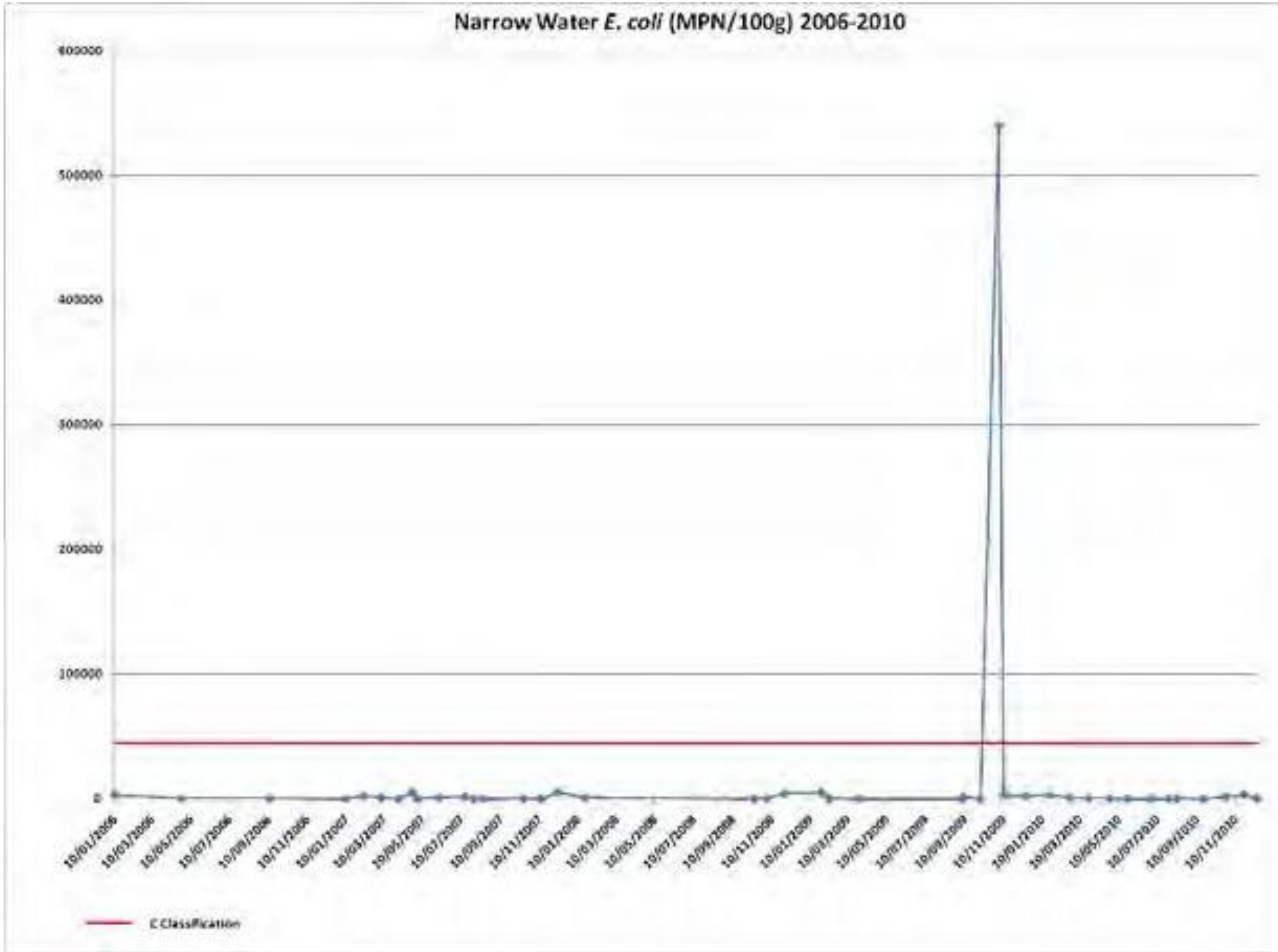


Figure 5.9: *E. coli* levels in mussels from Narrow Water from 2006-2010 (Source: FSA in NI).

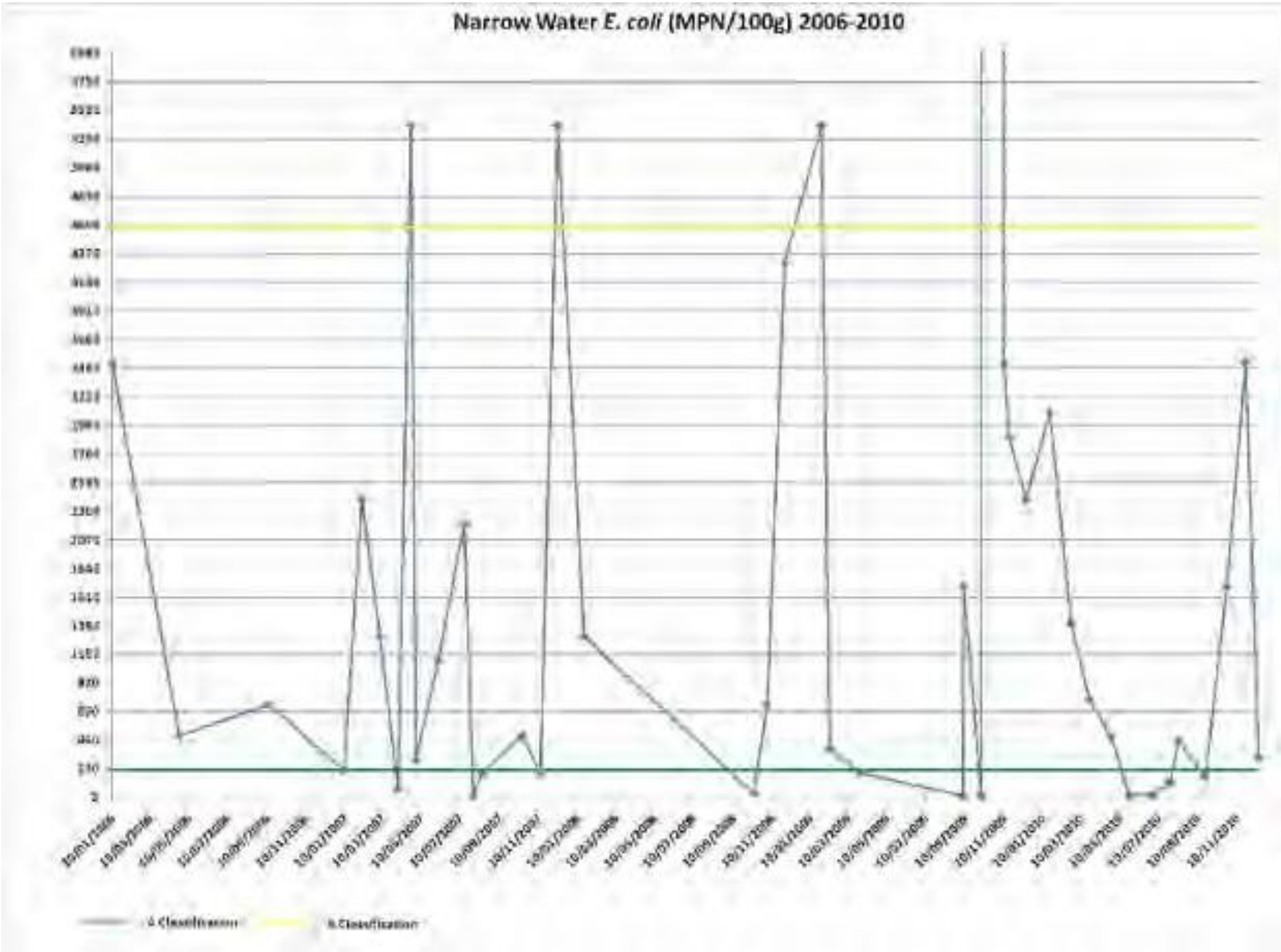


Figure 5.10: *E. coli* levels in mussels from Narrow Water from 2006-2010 (Source: FSA in NI).

Table 5.12: *E. coli* levels in mussels from Rostrevor from 2006-2010 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
10/01/2006	200	A	**17/11/2008**	1100	B
14/02/2006	110	A	**15/12/2008**	200	A
23/05/2006	160	A	**27/01/2009**	200	A
06/06/2006	70	A	**23/02/2009**	<20	A
04/07/2006	220	A	**11/05/2009**	200	A
31/08/2006	ND	A	**26/05/2009**	400	B
26/09/2006	220	A	**22/06/2009**	40	A
24/10/2006	1300	B	**07/07/2009**	40	A
09/01/2007	110	A	**25/08/2009**	310	B
06/02/2007	160	A	**08/09/2009**	110	A
06/03/2007	1300	B	**06/10/2009**	290	B
17/04/2007	ND	A	**03/11/2009**	950	B
05/06/2007	220	A	**17/11/2009**	700	B
18/06/2007	750	B	**15/12/2009**	70	A
31/07/2007	<20	A	**05/01/2010**	110	A
25/09/2007	200	A	**09/02/2010**	1700	B
31/10/2007	200	A	**10/03/2010**	<20	A
27/11/2007	20	A	**13/04/2010**	50	A
17/12/2007	110	A	**11/05/2010**	<20	A
07/01/2008	400	B	**15/06/2010**	<20	A
03/03/2008	200	A	**14/07/2010**	50	A
07/04/2008	<20	A	**25/08/2010**	20	A
19/05/2008	20	A	**08/09/2010**	2700	B
16/06/2008	20	A	**12/10/2010**	130	A
18/08/2008	2400	B	**11/11/2010**	1700	B
15/09/2008	110	A	**07/12/2010**	20	A
13/10/2008	1300	B			

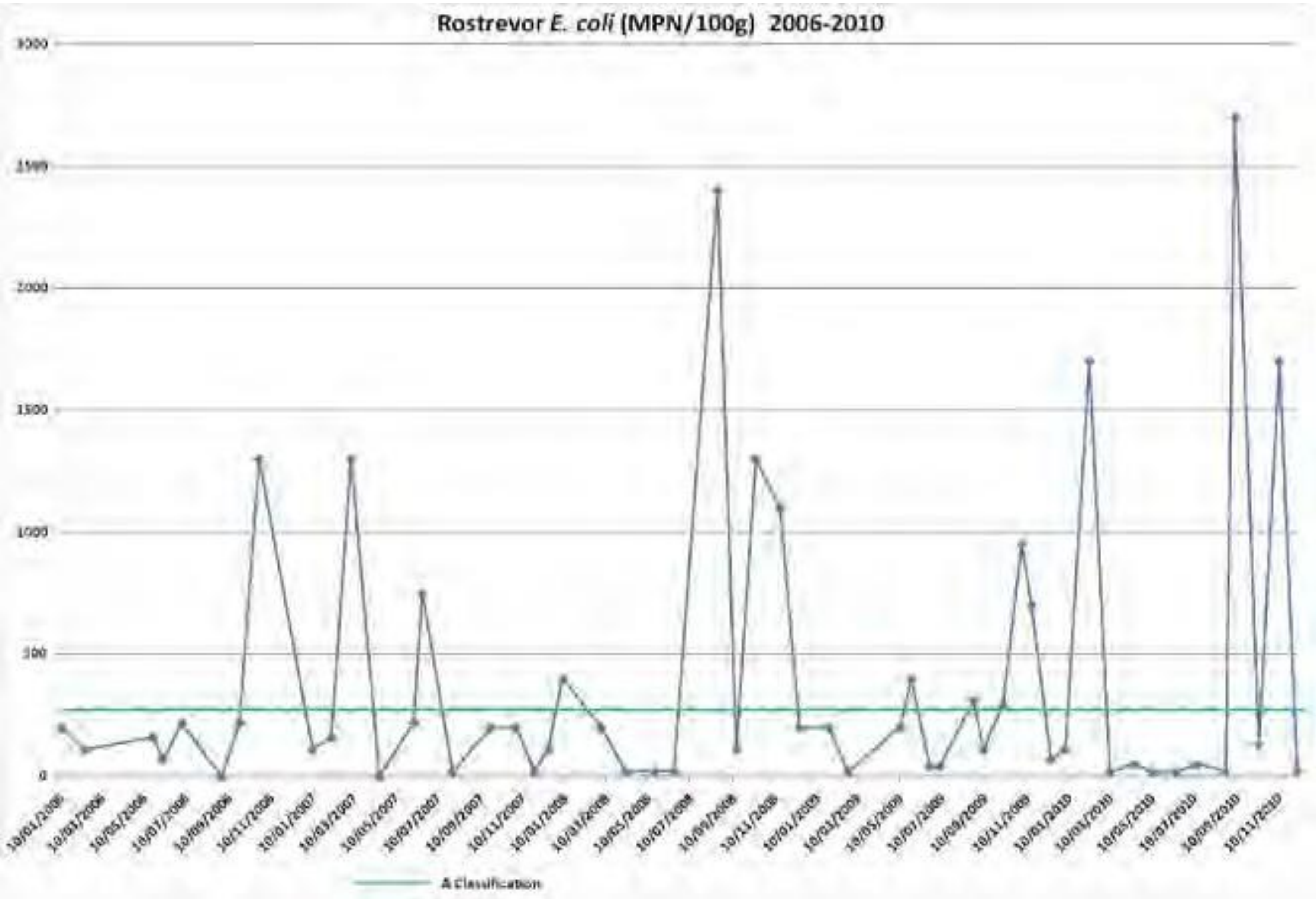


Figure 5.11: *E. coli* levels in mussels from Rostrevor from 2006-2010 (Source: FSA in NI).

Table 5.13: *E. coli* results from mussels from Killowen from 2009-2010 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category
27-Jan-09	310	**B**
23-Feb-09	200	**A**
30-Mar-09	40	**A**
22-Jul-09	20	**A**
10-Aug-09	40	**A**
25-Aug-09	500	**B**
25-Aug-09	110	**A**
23-Sep-09	1200	**B**
20-Oct-09	20	**A**
03-Dec-09	200	**A**
09-Dec-09	110	**A**
21-Jan-10	500	**B**
09-Feb-10	80	**A**
10-Mar-10	20	**A**
13-Apr-10	80	**A**
11-May-10	20	**A**
15-Jun-10	<20	**A**
11/11/2010	220	**A**
24/11/2010	1100	**B**
07/12/2010	20	**A**
15/12/2010	110	**A**

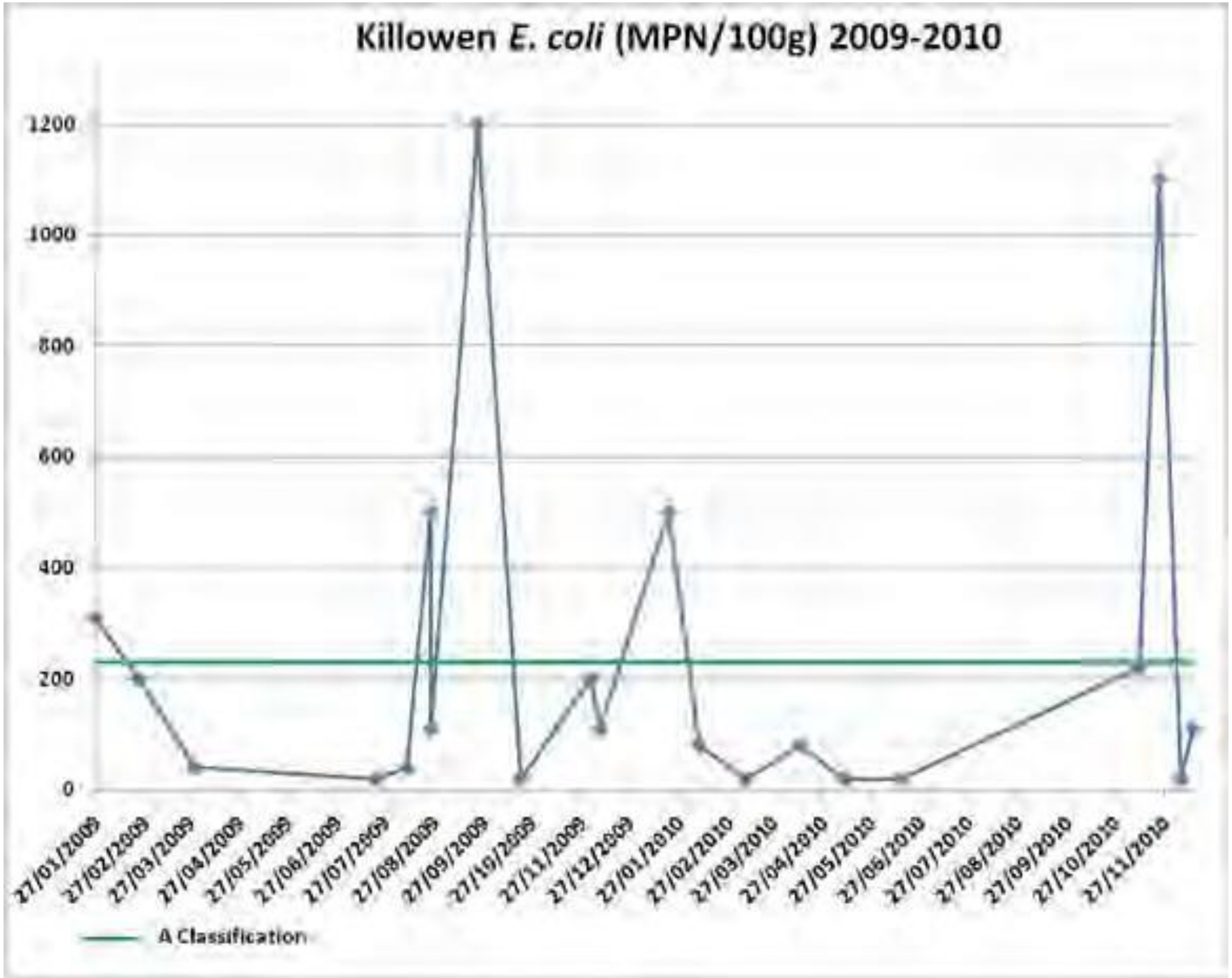


Figure 5.12: *E. coli* levels in mussels from Killowen from 2009-2010 (Source: FSA in NI).

Table 5.14: ***E. coli*** **levels in oysters from Ballagan from 2006 to 2010 (Source: SFPA).**

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
10/01/2006	20	A	10/03/2008	20	A
31/01/2006	310	B	07/04/2008	20	A
21/02/2006	20	A	25/05/2008	20	A
14/03/2006	20	A	25/05/2008	20	A
24/04/2006	20	A	22/06/2008	20	A
07/06/2006	20	A	21/07/2008	20	A
04/07/2006	40	A	24/09/2008	40	A
15/08/2006	20	A	29/09/2008	40	A
06/09/2006	70	A	21/10/2008	70	A
10/10/2006	20	A	16/11/2008	20	A
06/11/2006	20	A	15/12/2008	20	A
09/01/2007	20	A	25/02/2009	90	A
25/01/2007	20	A	09/03/2009	20	A
20/02/2007	20	A	26/04/2009	20	A
27/03/2007	20	A	23/06/2009	20	A
16/04/2007	20	A	05/07/2009	20	A
08/05/2007	20	A	11/08/2009	20	A
11/06/2007	20	A	11/10/2009	20	A
16/07/2007	160	A	09/11/2009	330	B
02/08/2007	20	A	13/12/2009	20	A
05/09/2007	500	B	18/01/2010	70	A
16/10/2007	40	A	09/02/2010	20	A
27/11/2007	40	A	08/03/2010	20	A
11/12/2007	310	B	06/04/2010	20	A
21/01/2008	110	A	17/06/2010	20	A
05/02/2008	20	A	14/12/2010	80	A

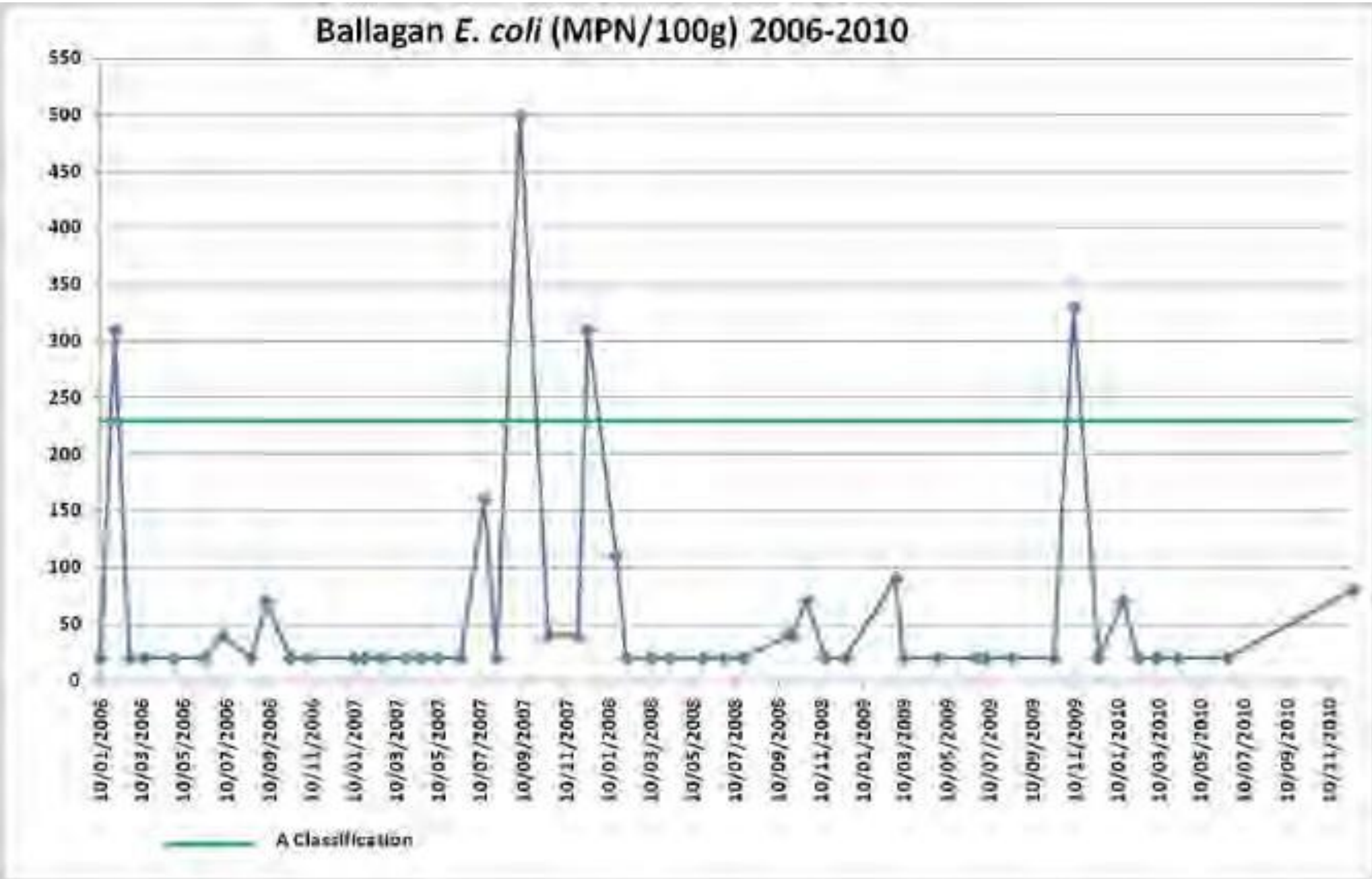


Figure 5.13: *E. coli* levels from Ballagan oysters from 2006 – 2010 (Source: SFPA).

Table 5.15: *E. coli* results for mussels from Greenore from 2006 to 2010 (Source: SFPA).

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
09/01/2006	40	A	23/09/2008	20	A
21/02/2006	40	A	21/10/2008	20	A
14/03/2006	40	A	16/11/2008	20	A
24/04/2006	20	A	14/12/2008	500	B
08/05/2006	20	A	06/01/2009	20	A
07/06/2006	20	A	25/02/2009	20	A
04/07/2006	20	A	09/03/2009	160	A
15/08/2006	20	A	26/04/2009	20	A
26/09/2006	430	B	23/06/2009	50	A
10/10/2006	160	A	05/07/2009	40	A
16/07/2007	220	A	11/08/2009	80	A
02/08/2007	20	A	14/09/2009	20	A
05/09/2007	70	A	11/10/2009	80	A
27/11/2007	90	A	09/11/2009	330	B
11/12/2007	160	A	13/12/2009	210	A
17/12/2007	40	A	18/01/2010	340	B
21/01/2008	220	A	09/02/2010	80	A
05/02/2008	40	A	08/03/2010	20	A
10/03/2008	40	A	06/04/2010	20	A
07/04/2008	40	A	17/06/2010	20	A
25/05/2008	20	A	28/07/2010	130	A
25/05/2008	20	A	10/08/2010	80	A
09/06/2008	70	A	27/10/2010	80	A
21/07/2008	20	A	14/12/2010	130	A

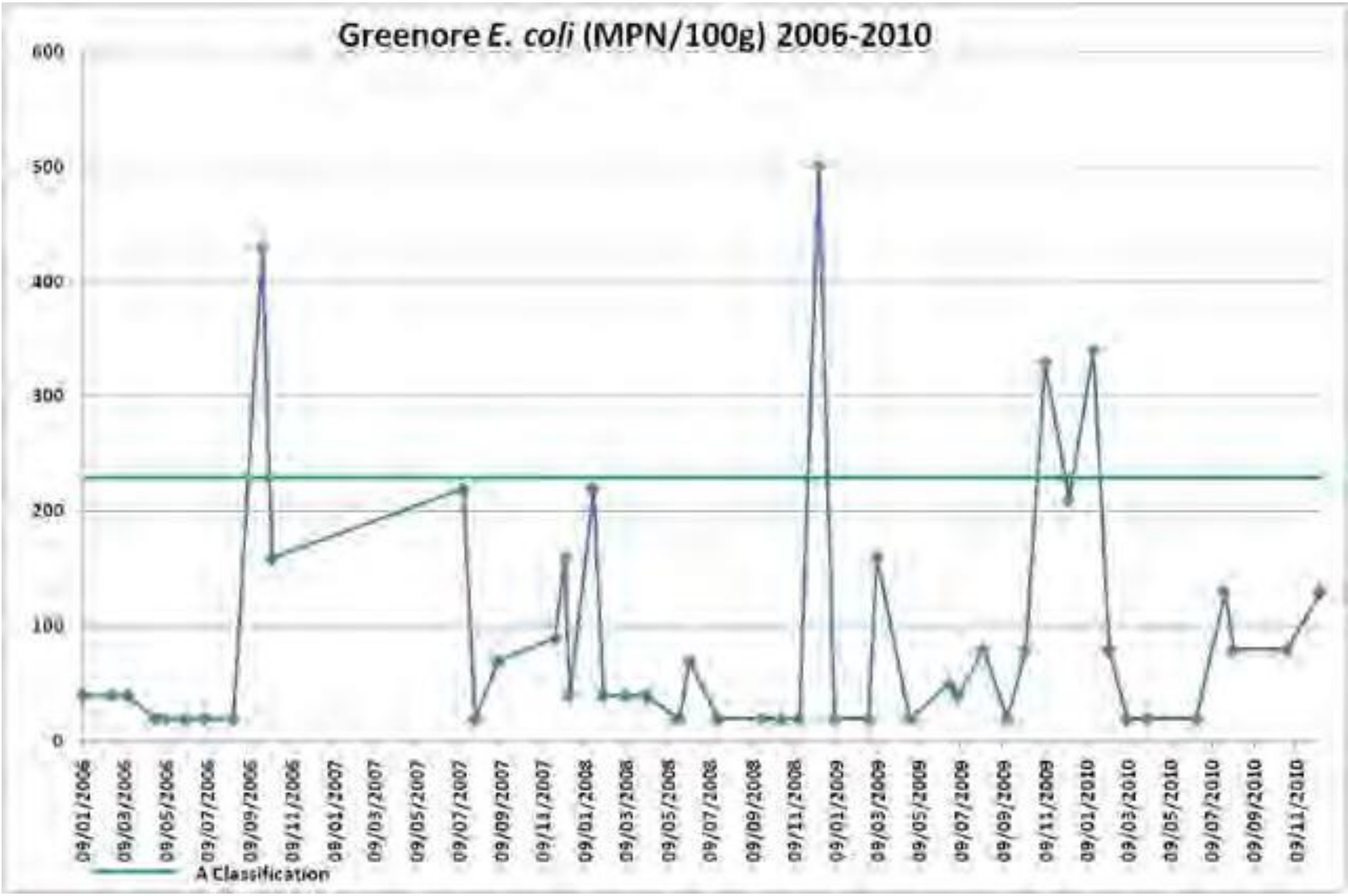


Figure 5.14: *E. coli* levels from Greenore mussels from 2006 – 2010 (Source: SFPA).

Table 5.16: *E. coli* results from Greenore oysters from 2006 to 2010 (Source: SFPA).

Date	*E. coli* (MPN/100g)	Category	Date	*E. coli* (MPN/100g)	Category
09/01/2006	20	A	07/04/2008	20	A
21/02/2006	40	A	25/05/2008	20	A
14/03/2006	220	A	25/05/2008	20	A
24/04/2006	310	B	09/06/2008	20	A
08/05/2006	20	A	21/07/2008	20	A
07/06/2006	50	A	23/09/2008	40	A
04/07/2006	20	A	29/09/2008	40	A
15/08/2006	40	A	21/10/2008	70	A
06/09/2006	70	A	16/11/2008	310	B
26/09/2006	160	A	14/12/2008	110	A
10/10/2006	200	A	06/01/2009	20	A
06/11/2006	200	A	25/02/2009	20	A
09/01/2007	50	A	09/03/2009	20	A
25/01/2007	250	B	26/04/2009	20	A
20/02/2007	20	A	23/06/2009	20	A
27/03/2007	20	A	05/07/2009	20	A
16/04/2007	160	A	11/08/2009	220	A
08/05/2007	40	A	11/10/2009	80	A
11/06/2007	40	A	09/11/2009	230	A
16/07/2007	200	A	13/12/2009	130	A
02/08/2007	40	A	18/01/2010	80	A
05/09/2007	70	A	09/02/2010	110	A
25/09/2007	500	B	08/03/2010	20	A
16/10/2007	40	A	18/04/2010	50	A
27/11/2007	110	A	17/06/2010	70	A
11/12/2007	200	A	27/07/2010	1300	B
21/01/2008	70	A	10/08/2010	170	A
05/02/2008	220	A	27/10/2010	130	A
10/03/2008	40	A	14/12/2010	50	A

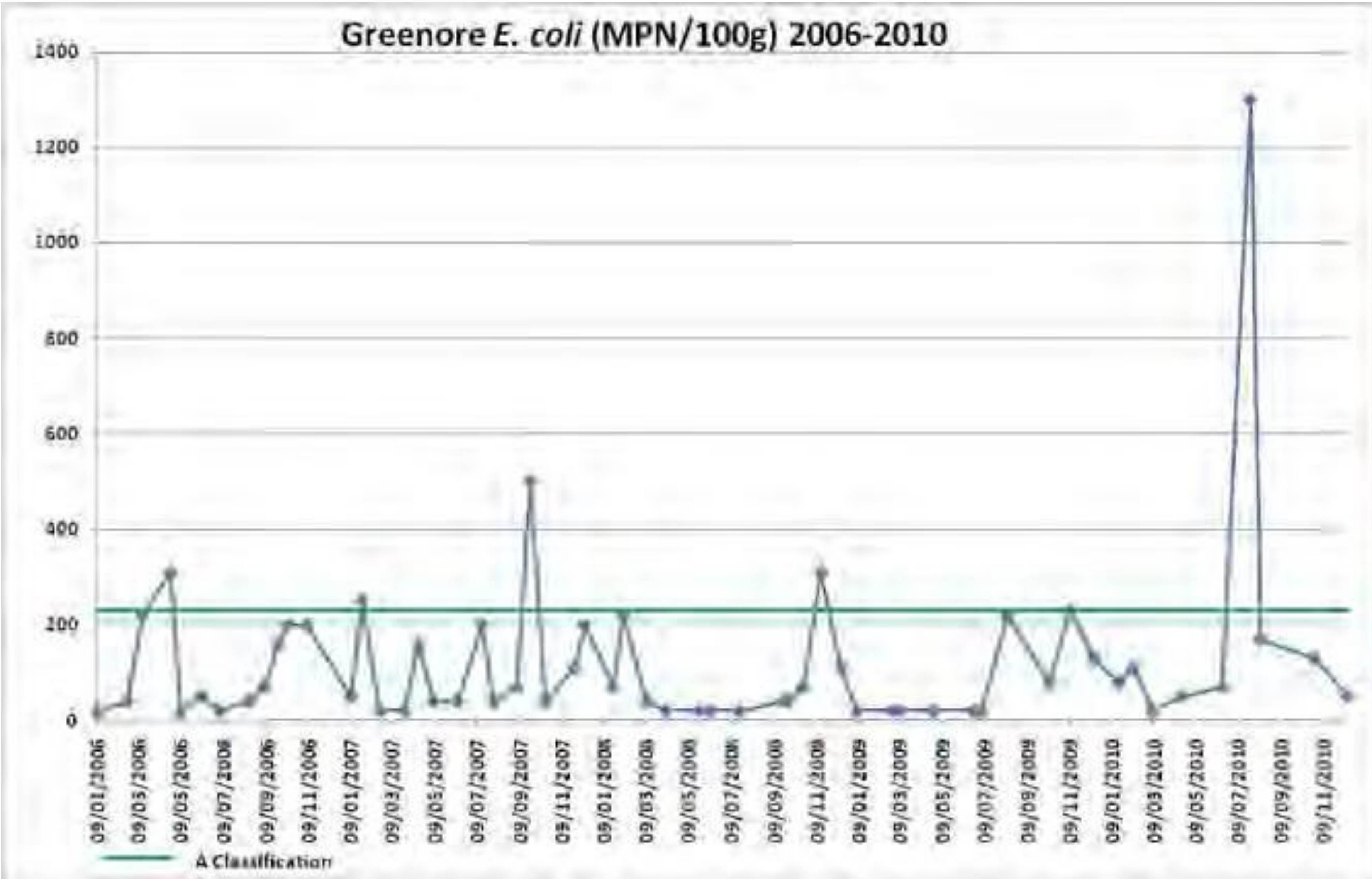


Figure 5.15: ***E. coli*** **levels from Greenore oysters from 2006 – 2010 (Source: SFPA).**

Table 5.17: *E. coli* results for mussels from the McCarthy site from 2006-2010 (Source: SFPA).

Date	*E. coli* (MPN/100g)	Category
04/07/2006	20	A
06/11/2006	40	A
24/01/2007	1300	B
26/02/2007	90	A
27/03/2007	20	A
16/04/2007	20	A
11/06/2007	20	A
16/10/2007	20	A
04/09/2008	500	B
09/09/2008	750	B
01/10/2008	500	B
21/10/2008	310	B
15/12/2008	750	B
08/01/2009	70	A
20/01/2009	70	A
27/01/2009	110	A
25/02/2009	90	A
04/03/2009	110	A
09/03/2009	40	A
14/09/2009	20	A
12/10/2009	50	A
15/12/2009	90	A
18/01/2010	330	B
09/02/2010	110	A
08/03/2010	20	A
20/04/2010	130	A
17/05/2010	20	A
22/06/2010	20	A
18/08/2010	20	A
02/11/2010	230	A
06/12/2010	80	A

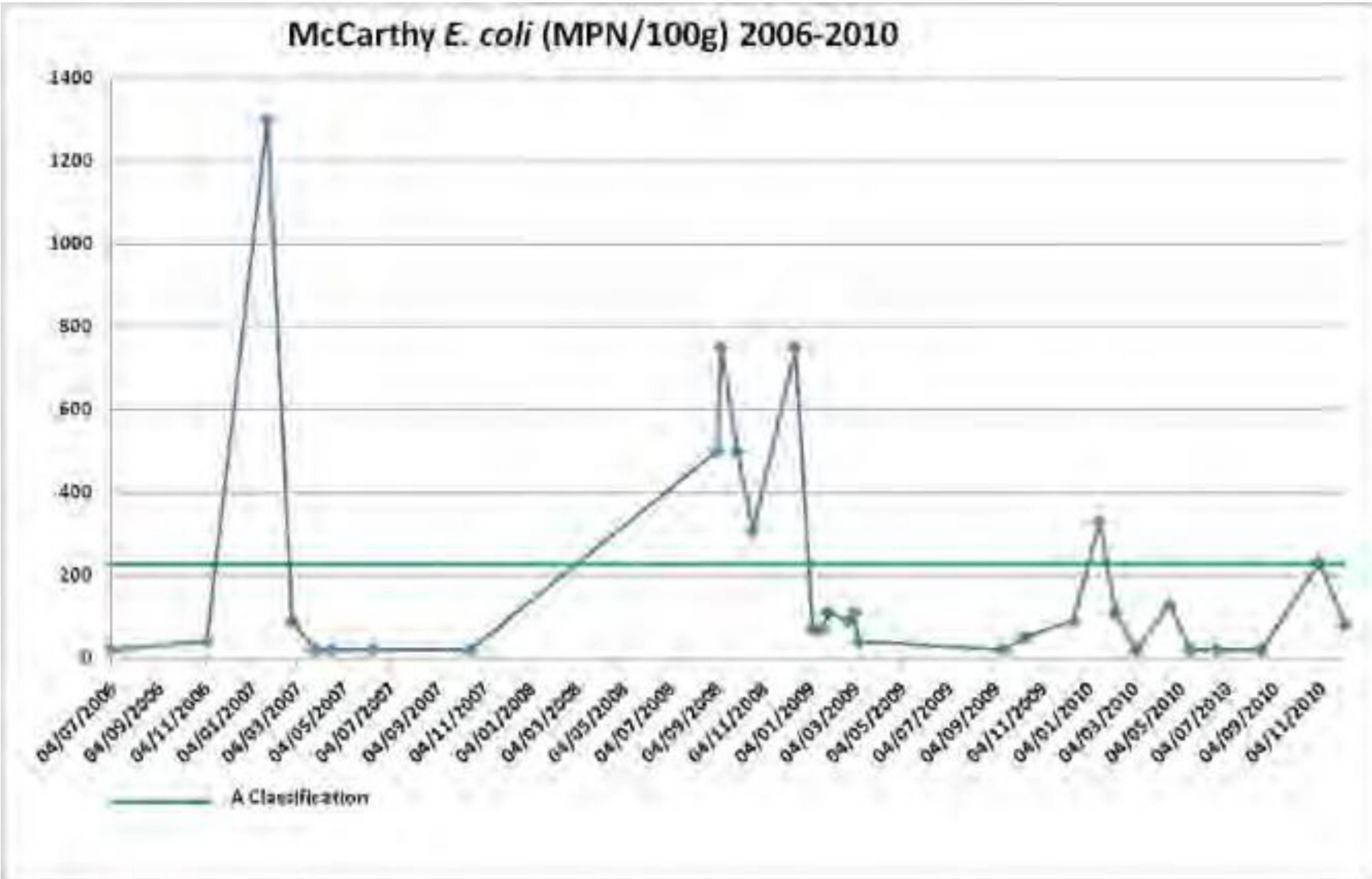


Figure 5.16: *E. coli* levels from the McCarthy site mussels from 2006 – 2010 (Source: SFPA).

Table 5.18: *E. coli* results for mussels from the Inner Carlingford site from 2008 to 2010 (Source: SFPA).

Date	*E.coli* (MPN/100g)	Category
21/10/2008	220	A
15/12/2008	3500	B
08/01/2009	20	A
20/01/2009	160	A
04/03/2009	40	A
09/03/2009	20	A
02/07/2009	20	A
07/07/2009	20	A
15/07/2009	230	A
20/07/2009	50	A
27/07/2009	110	A
11/08/2009	20	A
18/08/2009	20	A
14/09/2009	50	A
12/10/2009	3500	B
15/12/2009	50	A
31/01/2010	330	B
09/02/2010	790	B
08/03/2010	20	A
20/04/2010	230	A
17/05/2010	20	A
22/06/2010	20	A
18/08/2010	50	A
02/11/2010	490	B
06/12/2010	80	A

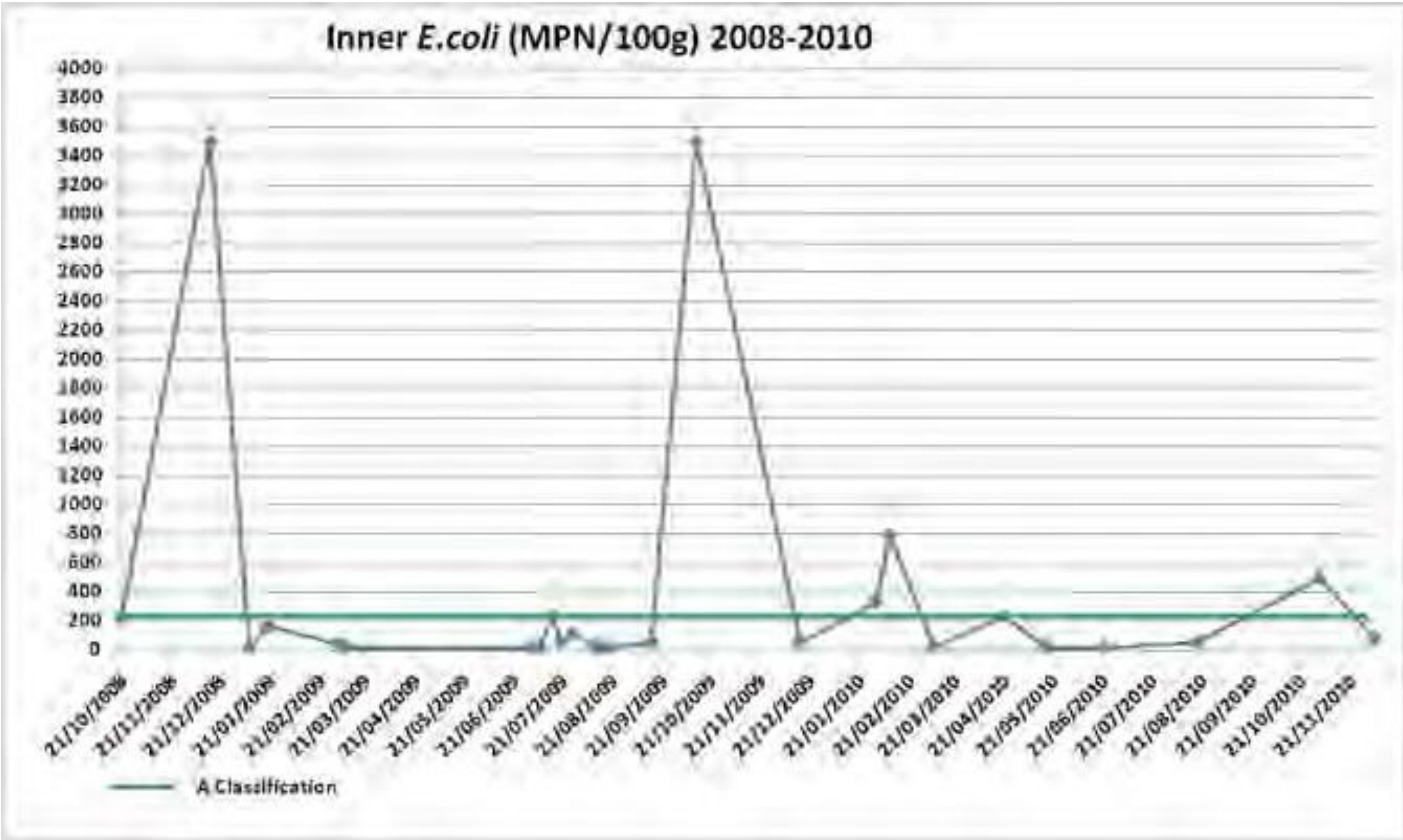


Figure 5.17: *E. coli* levels from the Inner site mussels from 2008 – 2010 (Source: SFPA).

Table 5.19: *E. coli* results for razor clams from Ballagan from 2006 to 2010 (Source: SFPA).

Date	*E. coli* (MPN/100g)	Category
10/01/2006	20	A
21/02/2006	200	A
07/03/2006	50	A
25/04/2006	70	A
08/05/2006	20	A
25/07/2006	40	A
11/06/2008	40	A
30/06/2008	20	A
08/07/2008	20	A
15/07/2008	20	A
22/07/2008	20	A
05/08/2008	20	A
21/08/2008	310	B
26/08/2008	40	A
13/10/2008	750	B
17/11/2008	70	A
16/12/2008	50	A
13/01/2009	20	A
31/03/2009	50	A
17/02/2010	50	A
01/09/2010	20	A
27/10/2010	20	A
07/11/2010	230	A

Table 5.20: *E. coli* results for razor clams from the Inner Carlingford site in 2009 (Source: SFPA).

Date	*E. coli* (MPN/100g)	Category
9-11-09	1100	B

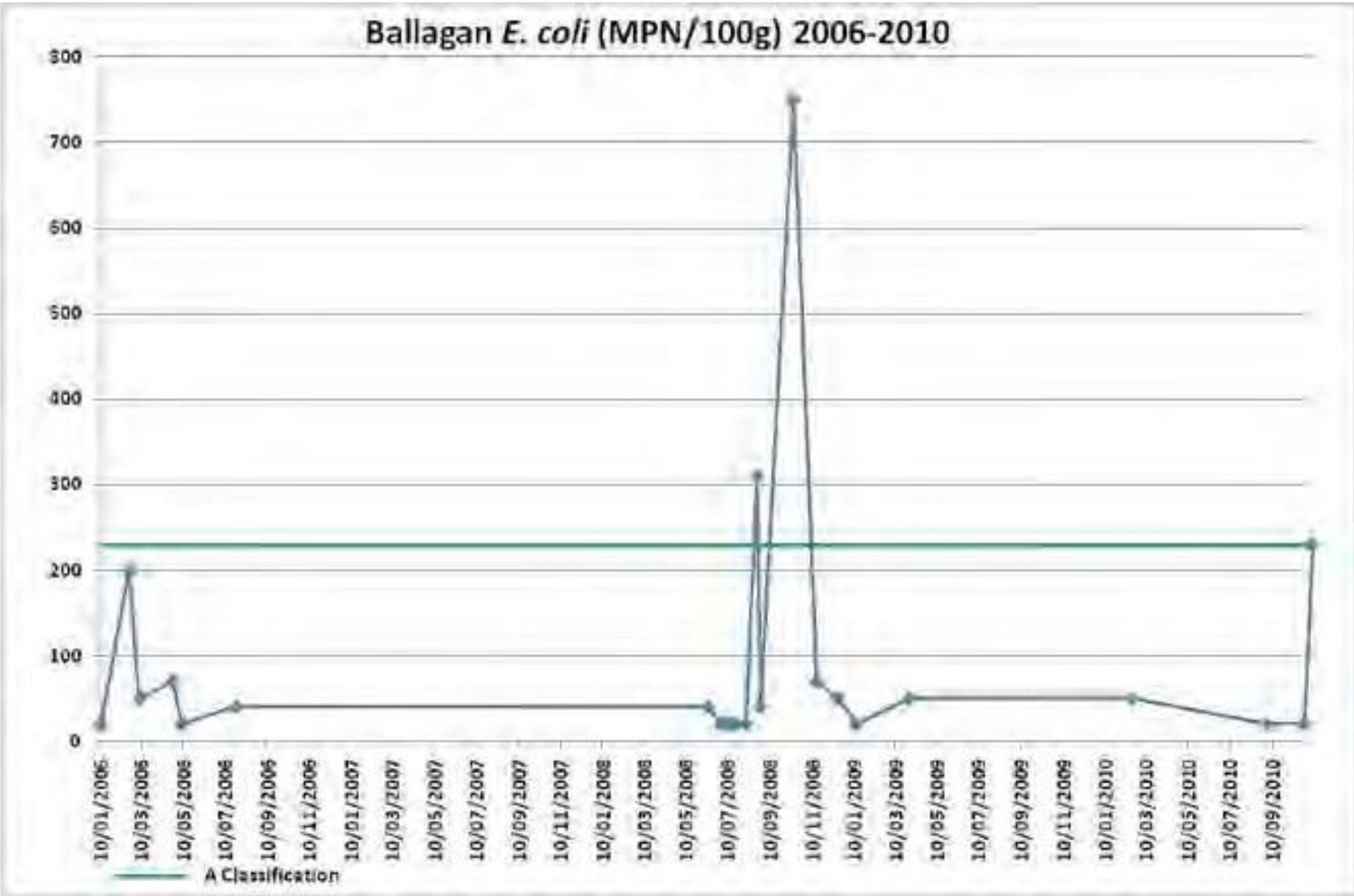


Figure 5.18: *E. coli* levels from Ballagan razor clams from 2006 – 2010 (Source: SFPA).

Table 5.21 shows the summary statistics for the *E. coli* historical data from the 12 shellfish beds classified in 2010. It should be noted that only data from 1 razor clam sample from the Inner Carlingford site was available and therefore comparisons between this site and others could not be made.

The geometric mean of *E. coli* levels was highest for mussels at Narrow Water (2006-2010), followed by mussels at Rostrevor (2006-2010) and mussels at Killowen (2009-2010). Greenore is the only site where oysters and mussels are sampled and the geometric mean over the four years from 2006 to 2010 was 1.24 times greater for the oysters than the mussels. It should be noted however, that a one-way analysis of variance (ANOVA) showed no significant differences between *E. coli* levels in oysters and mussels from Greenore.

Table 5.22 shows the variations of the annual geometric means of *E. coli* for the shellfish beds that had at least 5 samples per year from the year 2006. Figure 5.19 shows the trend in geometric mean from 2006 to 2010 for all 11 shellfish beds (The Rocks was not included in this analysis as only one result was available). It can be clearly seen that the geometric mean was highest at Narrow Water, ranging from 389.27 to 1133.06 MPN/100g. Figure 5.20 shows the same trend in detail for all beds excluding Narrow Water mussels. For all remaining beds, the geometric mean was below 190 MPN/100g for mussels since 2006 and below 110 MPN/100g for oysters since 2006.

In order to identify any significant differences in *E. coli* levels based on location, a one-way analysis of variance (ANOVA) was performed on all *E. coli* results from shellfish flesh from the various harvesting beds. For this analysis, all shellfish flesh results that returned a less than (<) value (i.e. <1) were halved (i.e. <1 becomes 0.5) and all samples that returned a ND (Not Detectable) result were given a value of 0. This analysis revealed that there was a significant difference between the Rostrevor mussel site and all of the following sites: Ballyedmond oyster site, Ballagan oyster site, Greenore mussel site, Greenore oyster site and the McCarthy mussel site. In addition, there were significant differences between the Ballagan oyster site and the Greenore oyster site and Inner mussel site.

A one-way ANOVA was also carried out on the seasonal *E. coli* counts between each harvesting location. For this analysis only harvesting beds with ≥7 results per season were used. Table 5.23 shows the shellfish beds used during each season. This analysis revealed that in spring, there were significant differences between the Narrow Water mussel site and the Ballyedmond oyster site, Fair Green oyster site and the Ballagan oyster site and between the Ballagan oyster site and the McCarthy mussel site. In summer there were significant differences between the Narrow Water mussel site and the Ballyedmond oyster site, the Ballagan oyster site and the Greenore mussel site. In autumn, there were significant differences between the Rostrevor mussel site and all other harvesting areas except Fair Green and Narrow Water. In winter, there were significant differences between the Narrow Water mussel site and all other harvesting beds; between the Fair Green oyster site and the Flynn and Killowen mussel sites and between the Killowen mussel site and the Ballagan oyster site.

This analysis shows that two stations predominantly stand out – Narrow Water and Rostrevor. Given the conditions in Narrow Water (inner sheltered location, weak currents, high organic loading from discharges and riverine input), it is no surprise that it is different to the other harvesting beds. In addition, the Rostrevor area seems to set itself apart from the other sites and again this is not surprising given the shallow nature of the area and the prevailing wind direction which may result in this area acting as a sink for contaminants. In addition, it is no surprise that that the two outer stations (Fair Green and Ballagan) feature highly in the significant differences. This is due to the stronger tidal currents, deeper depths and shorter residence times in this area, which result in a faster moving well flushed area with lower levels of contaminants.

Table 5.21: Harvesting beds used for analysis of seasonal variation in *E. coli* levels in Carlingford Lough.

Season	Shellfish Bed
Spring	Ballyedmond, Rostrevor, Carriganean, Fair Green, Flynn, Narrow Water, Ballagan (Oysters), Greenore (Mussels), Greenore (Oysters) and McCarthy
Summer	Ballyedmond, Rostrevor, Carriganean, Fair Green, Flynn, Narrow Water, Ballagan (Oysters), Greenore (Mussels), Greenore (Oysters), Inner and Ballagan (Razors)
Autumn	Ballyedmond, Rostrevor, Carriganean, Fair Green, Flynn, Narrow Water, Ballagan (Oysters), Greenore (Mussels) and Greenore (Oysters)
Winter	Ballyedmond, Rostrevor, Carriganean, Fair Green, Flynn, Killowen, Narrow Water, Ballagan (Oysters), Greenore (Mussels), Greenore (Oysters) and McCarthy

As was shown in Section 4.1.2 Tourism, there was no significant seasonal difference in *E. coli* concentrations in shellfish flesh within individual harvesting beds from 2006 to 2010 with the exception of the Inner (mussel) site between summer and autumn.

Table 5.22: Summary statistics of historical *E. coli* data monitored from shellfish beds in Carlingford Lough.

Site	Species	Date of 1st Sample	Date last Sample	Minimum *E. coli* (MPN/100g)	Maximum *E. coli* (MPN/100g)	Median *E. coli* (MPN/100g)	Geometric Mean *E. coli* (MPN/100g)
Ballyedmond	**Oysters**	31/01/2006	15/12/2010	ND	1300	40	31
Carriganean	**Oysters**	31/01/2006	07/12/2010	ND	9100	20	26.1
Fair Green	**Oysters**	31/01/2006	24/11/2010	ND	9100	70	45.9
Flynn	**Mussels**	10/01/2006	15/12/2010	ND	9100	75	56.2
Narrow Water	**Mussels**	10/01/2006	15/12/2010	<20	540000	750	629.9
Rostrevor	**Mussels**	10/01/2006	07/12/2010	ND	2700	160	103.9
Killowen	**Mussels**	27/01/2009	15/12/2010	<20	1200	110	98.61
The Rocks	**Mussels**	10/08/2009	10/08/2009	20	20	20	20
Ballagan	**Oysters**	01/01/2006	14/12/2010	20	500	20	32.6
Ballagan	**Razor Clam**	01/01/2006	07/11/2010	20	750	40	46.4
Greenore	**Mussels**	09/01/2006	14/12/2010	20	500	40	52.6
Greenore	**Oysters**	09/01/2006	14/12/2010	20	1300	50	65
McCarthy	**Mussels**	04/07/2006	06/12/2010	20	1300	80	81.5
Inner Carlingford	**Mussels**	21/10/2008	06/12/2010	20	3500	50	87.2

ND =Not Detectable

Table 5.23: Variation of annual geometric means of *E. coli* from shellfish beds monitored in Carlingford Lough (INS – Insufficient data for mean calculation).

Site	Species	2006	2007	2008	2009	2010
Ballyedmond	**Oysters**	16.66	14.50	68.79	38.77	41.44
Carriganean	**Oysters**	3.22	34.02	35.10	48.43	51.94
Fair Green	**Oysters**	28.46	11.64	109.94	105.82	46.72
Flynn	**Mussels**	12.52	128.18	54.88	86.72	83.37
Narrow Water	**Mussels**	INS	547.74	INS	1133.06	389.27
Rostrevor	**Mussels**	59.40	63.10	184.58	156.98	97.80
Killowen	**Mussels**	INS	INS	INS	117.26	81.51
Ballagan	**Oysters**	30.63	41.30	27.94	32.28	31.05
Ballagan	**Razor Clam**	47.30	INS	49.28	INS	INS
Greenore	**Mussels**	41.20	74.96	42.16	57.50	65.93
Greenore	**Oysters**	72.05	78.12	48.18	44.95	98.65
McCarthy	**Mussels**	INS	51.53	INS	64.46	62.18
Inner Carlingford	**Mussels**	INS	INS	INS	57.70	99.32

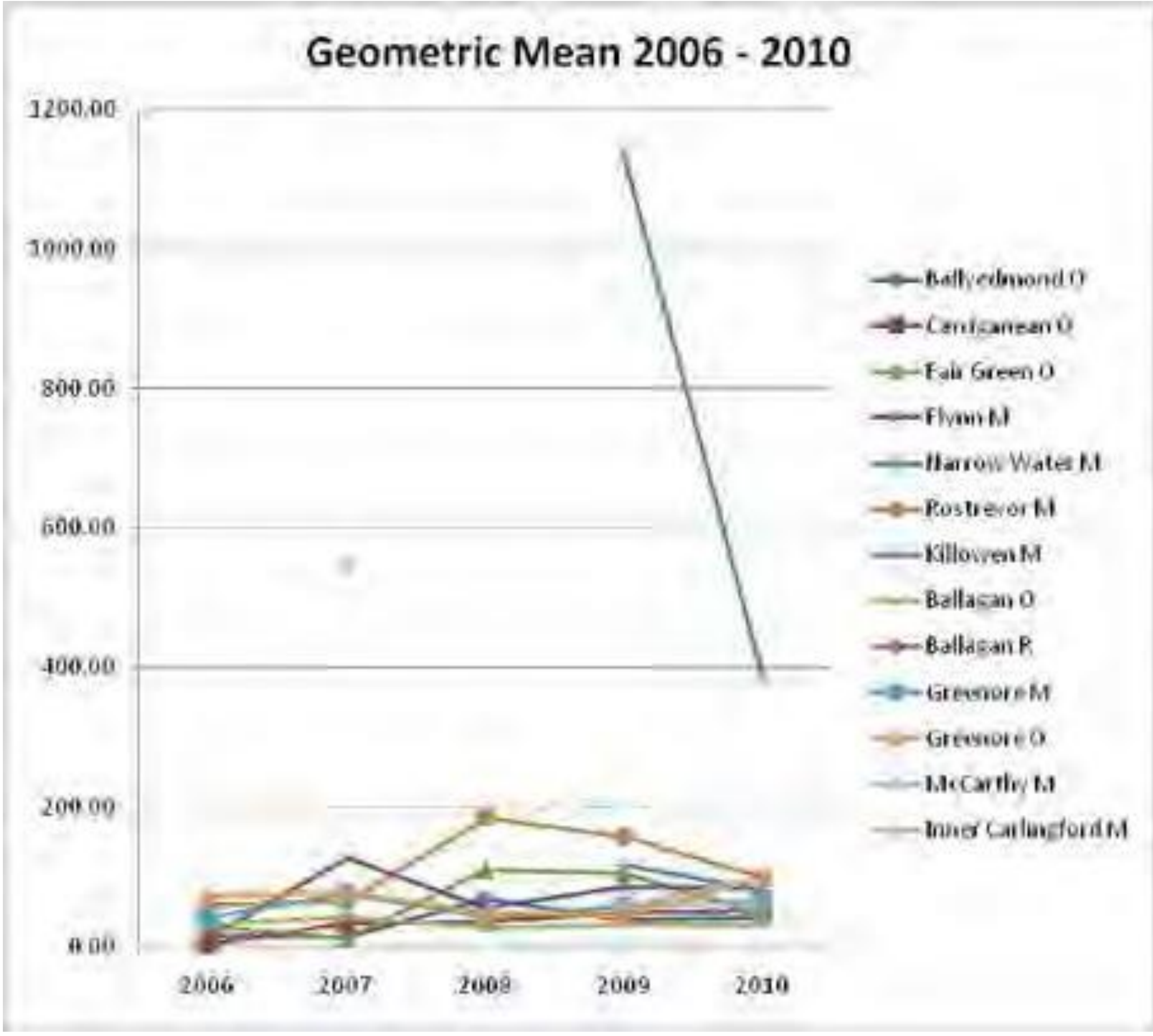


Figure 5.19: Trend in geometric mean of *E. coli* levels from 2006 to 2010 for all 11 beds.

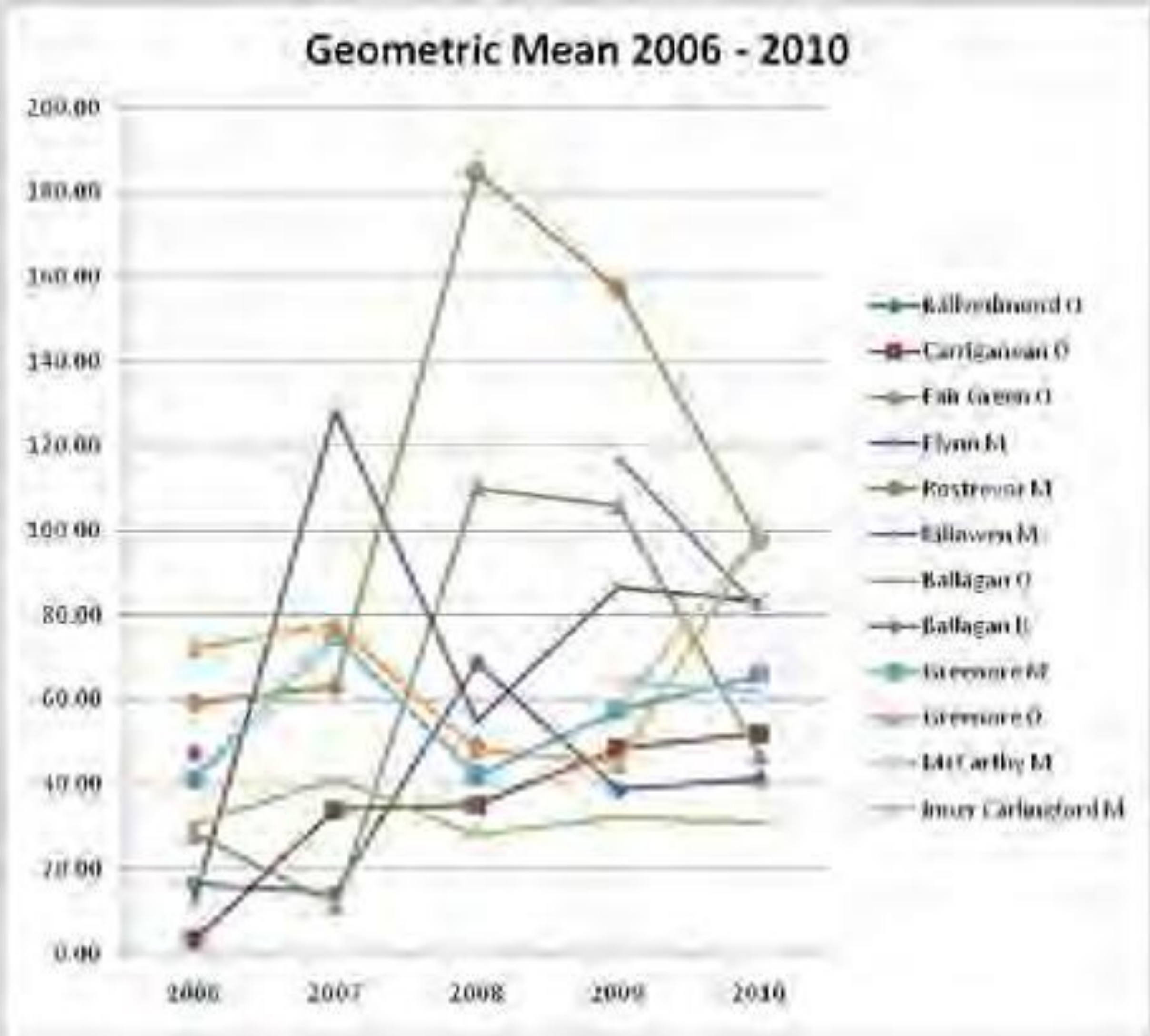


Figure 5.20: Trend in geometric mean of *E. coli* levels from 2006 to 2010 for all beds excluding Narrow Water mussels.

5.1.3. Norovirsus (NoV)

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

In February 2010, there was a series of NoV outbreaks linked to oysters harvested in Greenore in Carlingford Lough (B. Nolan SFPA *pers. comm.*). A sampling programme for the presence of NoV indicated high levels of NoV present in oysters in that area at that time. The very high levels of NoV initially detected in Carlingford were attributed to an outbreak in the community and enhanced by the colder than normal water temperatures recorded over the winter period of 2009/2010. It is believed that the source of the NoV was a waste water discharge pipe in the vicinity of the oyster beds in Greenore. Following the NoV outbreak in February, a compliance notice was issued prohibiting the placing of oysters from Carlingford on the market.

Carlingford Oyster Company Ltd. depurates its oysters as a matter of course as part of their quality control, (even though the area is an A classified site and are therefore not obliged to depurate). Initial investigations revealed that the depuration was carried out at ambient temperature and was therefore not reducing the NoV counts. Oysters were relayed in an area adjacent to Carlingford Lough (Templetown in Dundalk Bay) for a number of weeks reducing the NoV results from the high thousands of detected genomes to approx 500 detected gnomes. It was also found that by increasing the temperature of the depurating water to 17˚C for 48hours it further reduced the NoV counts to small or undetected amounts, and therefore safe to place on the market.

The compliance notice was amended on 01 July 2010 to reflect additional controls required for the placing of oysters on the market.

High levels of NoV were also detected in oysters in the Carlingford Lough area in January 2011. A sudden increase was detected 24 Jan 2011, and coupled to a number of reported illnesses possibly associated with the consumption of oysters harvested in Carlingford Lough, harvesters in the Carlingford/Greenore Area voluntarily suspended harvesting until background levels of NoV reduced below background levels. High levels detected in February 2011 caused confirmed illnesses in consumers eating oysters harvested in Carlingford, which lead to compliance orders being issued to producers to cease harvesting operations.

5.2. Current Data

5.2.1. Sampling Sites & Methodology

Eleven shellfish sampling points and 23 water sampling points were sampled within Carlingford Lough on the 19th October 2010. The weather on the sampling days was fine and dry with approximately 7/8th cloud cover.

The predicted high water level on the 19th October was at 10:00am at Warrenpoint (4.3m) and at 10:11am at Cranfield Point (4.5m). Predicted low water on the 19th October was at 16:14pm at Warrenpoint (1.3m) and 15:54pm at Cranfield Point (1.6m).

The weather conditions for the 2 week period preceding the sampling was as follows: average rainfall: 0.1mm, maximum temperature: 14.3°C, minimum temperature: 7.7°C and average wind speed was 9.6 knots (Met Eireann, 2010b).

The 11 shellfish sampling points were made up of 7 mussel sites and 4 Pacific oyster sites. Unfortunately a sample could not be retrieved from Sites PO1 and PO2 as no trestles could be located at site PO1 and site PO2 was inaccessible due to rough weather. However, a sample was successfully collected from site PO1 on the 14th December 2010.

Of the 23 water samples collected, 6 were taken from river/stream outflows, 5 were taken from discharge pipes/runoff and the remainder were taken from throughout the Lough.

All water samples were collected on the same day (19/10/2010) in approximately 3 hours. Sampling began at Station 12 and ended at Station R1. All samples were taken on the ebbing tide. Figure 5.21 shows the shellfish sampling sites and Figure 5.22 shows the water sampling sites. The coordinates of these stations can be seen in Tables 5.24 and 5.25.

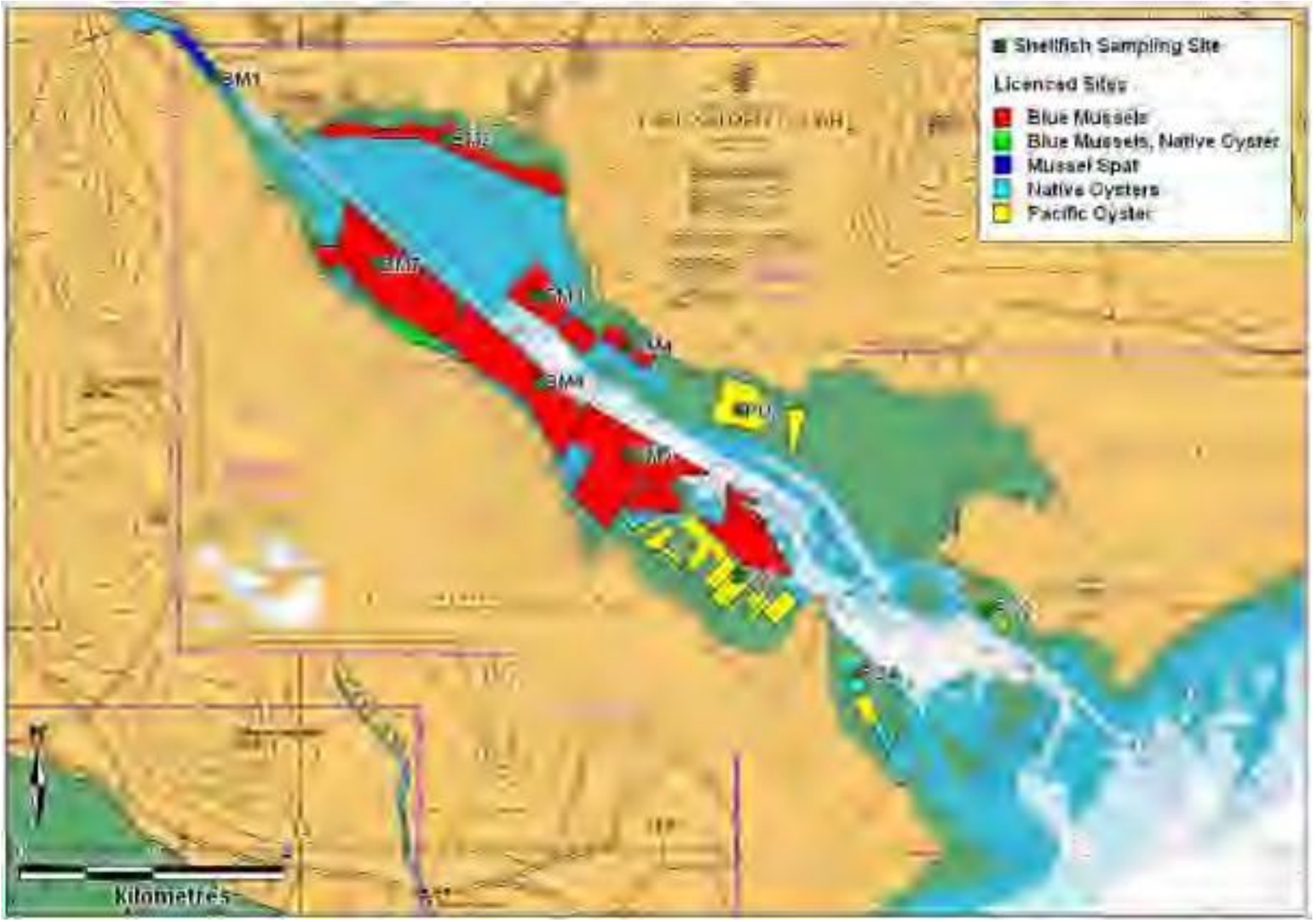


Figure 5.21: Location of shellfish sampling stations.

Figure 5.22: Location of all water sampling sites.

Table 5.24: Shellfish sample coordinates with date of sampling.

Station	Latitude	Longitude	Easting	Northing
BM1	54.1048	-6.27159	313040.6	318690.4
BM2	54.0968	-6.21808	316562.3	317887
BM3	54.0754	-6.19707	317997.2	315540.5
BM4	54.0687	-6.17591	319401.1	314830.4
BM5	54.0541	-6.17589	319444.3	313205.8
BM6	54.0638	-6.19661	318060.2	314250.4
BM7	54.0797	-6.23436	315545	315957.4
PO1	54.06	-6.1502	321109.2	313906
PO2	54.0329	-6.09241	324973.7	310990.9
PO3	54.0374	-6.15083	321133.7	311390.1
PO4	54.0246	-6.12362	322953.7	310012.6

Table 5.25: Water sample site coordinates

Station	Latitude	Longitude	Easting	Northing
W1	54.0882	-6.24601	314759.2	316884.4
W2	54.0879	-6.22906	315868.9	316878.6
W3	54.0746	-6.22253	316333.3	315409.3
W4	54.0758	-6.20648	317380.3	315569.4
W5	54.0688	-6.17879	319212.4	314836.7
W6	54.0638	-6.19661	318060.2	314250.4
W7	54.0497	-6.18055	319151.8	312708.3
W8	54.0529	-6.14201	321666.1	313130
W9	54.042	-6.14813	321297.1	311906.6
W10	54.028	-6.10942	323874	310415.7
W11	54.0215	-6.07545	326119.2	309752.4
W12	54.0062	-6.09383	324960.7	308017.3
R1	54.1048	-6.27159	313040.6	318690.4
R2	54.0952	-6.25329	314263.7	317651.5
R3	54.0783	-6.24449	314886	315785.2
R4	54.0985	-6.23259	315608.5	318052.4
R5	54.0954	-6.19995	317752.1	317761.3
R6	54.0474	-6.10684	323985.2	312579
D1	54.0901	-6.25973	313856.4	317073.6
D2	54.0294	-6.15574	320835.3	310491.4
D3	54.0742	-6.23675	315403.8	315341.5
D4	54.1003	-6.2414	315027.3	318242.3
D5	54.0993	-6.23682	315329.5	318129.1

All mussel samples were collected using a 0.025m^2 grab sampler except BM1 where they could be hand- picked from the shore. All Pacific oyster samples were also hand-picked. Only individuals within the normal commercial size range were selected. All samples were stored in food grade plastic bags and stored in a cool box (containing freezer packs) and delivered to AQUALAB within 24hrs of collection. All water samples were collected in sterile plastic water bottles. These samples were stored in a cool box until delivery to Northern Ireland Water (within 24hrs of collection). *E. coli* analysis was carried out on both the shellfish and water samples (AQUALAB: ISO 16649-3; NI Water: Colilert method). AQUALAB is an INAB (Irish National Accreditation Board) certified laboratory and Northern Ireland Water is a UKAS (United Kingdom Accreditation Service) certified laboratory.

5.2.2. Microbial Analysis Results

Table 5.26 shows the results of the shellfish *E. coli* analysis (Refer to Appendix 2 for result certificates). Figure 5.23 shows this data in graphical form. All sites, Pacific oyster and mussels had an *E. coli* level of <230 *E. coli* per 100g flesh with the exception of the mussels sites BM1 (Narrow Water – 330MPN/100g) and BM2 (Rostrevor - 1300MPN/100g). FSA in NI monitoring data recorded a level of 330 MPN/100g at PO2 approximately 7 days after this sampling programme. The BM3 and PO1 results were comparable with results from the routine monitoring programme for approximately the same time period. The high level of 1300 MPN/100g at BM2 was preceded by a 130 MPN/100g result 5 days previously (FSA in NI monitoring results). The 330 MPN/100g results from BM1 was followed 7 days later by a 1700 MPN/100g result (FSA in NI monitoring results). The 50 MPN/100g results from BM6 and BM7 were followed approximately 2 weeks later by 230 MPN/100g and 490 MPN/100g results respectively and the <20 MPN/100g results at PO3 was followed by a 130 MPN/100g results 8 days later (SFPA monitoring results).

Table 5.26: Shellfish *E. coli* results for Carlingford Lough.

Station	Species	MPN/100g
BM1	Blue Mussel	330
BM2	Blue Mussel	1300
BM3	Blue Mussel	20
BM4	Blue Mussel	20
BM5	Blue Mussel	50
BM6	Blue Mussel	50
BM7	Blue Mussel	50
PO1	Pacific Oyster	<20*
PO2	Pacific Oyster	No Sample
PO3	Pacific Oyster	<20
PO4	Pacific Oyster	<20

* please note different date for sample collection

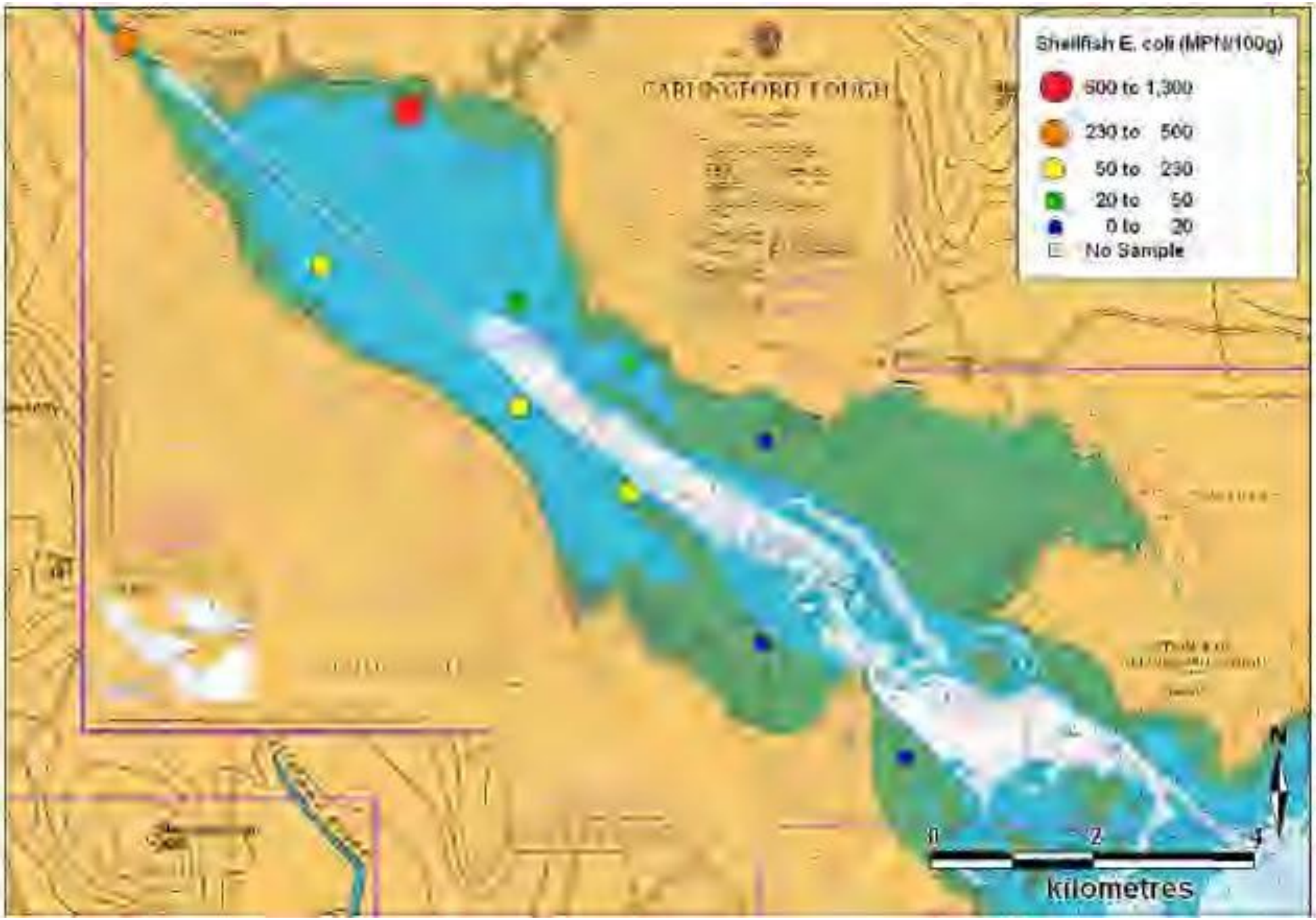


Figure 5.23: Shellfish *E. coli* results from Carlingford Lough (sampled on 19th October 2010).

Table 5.27 shows the water sample analysis results (Refer to Appendix 3 for result certificates). Figure 5.24 show in graphical form the *E. coli* results from across the Lough. Highest *E. coli* levels come from discharge pipes at Warrenpoint and Omeath. These high levels fall to <350MPN/100ml within a kilometre of the outfalls. The inner part of the Lough also has higher *E. coli* input from the rivers flowing into the area (50-350MPN/100ml) compared to the remainder of the Lough where levels are below 50MPN/100ml.

Table 5.27: Water *E. coli* results for Carlingford Lough.

Station	*E. coli* MPN/100ml	Total Coliforms MPN/100ml
W1	32	152
W2	6	34
W3	4	30
W4	2	4
W5	0	10
W6	0	6
W7	0	2
W8	10	10
W9	0	6
W10	0	0
W11	2	4
W12	0	18
R1	72	308
R2	56	304
R3	18	66
R4	8	22
R5	6	78
R6	0	4
D1	2200	241,900
D2	0	32
D3	120	1,650
D4	5,300	30,800
D5	4	42

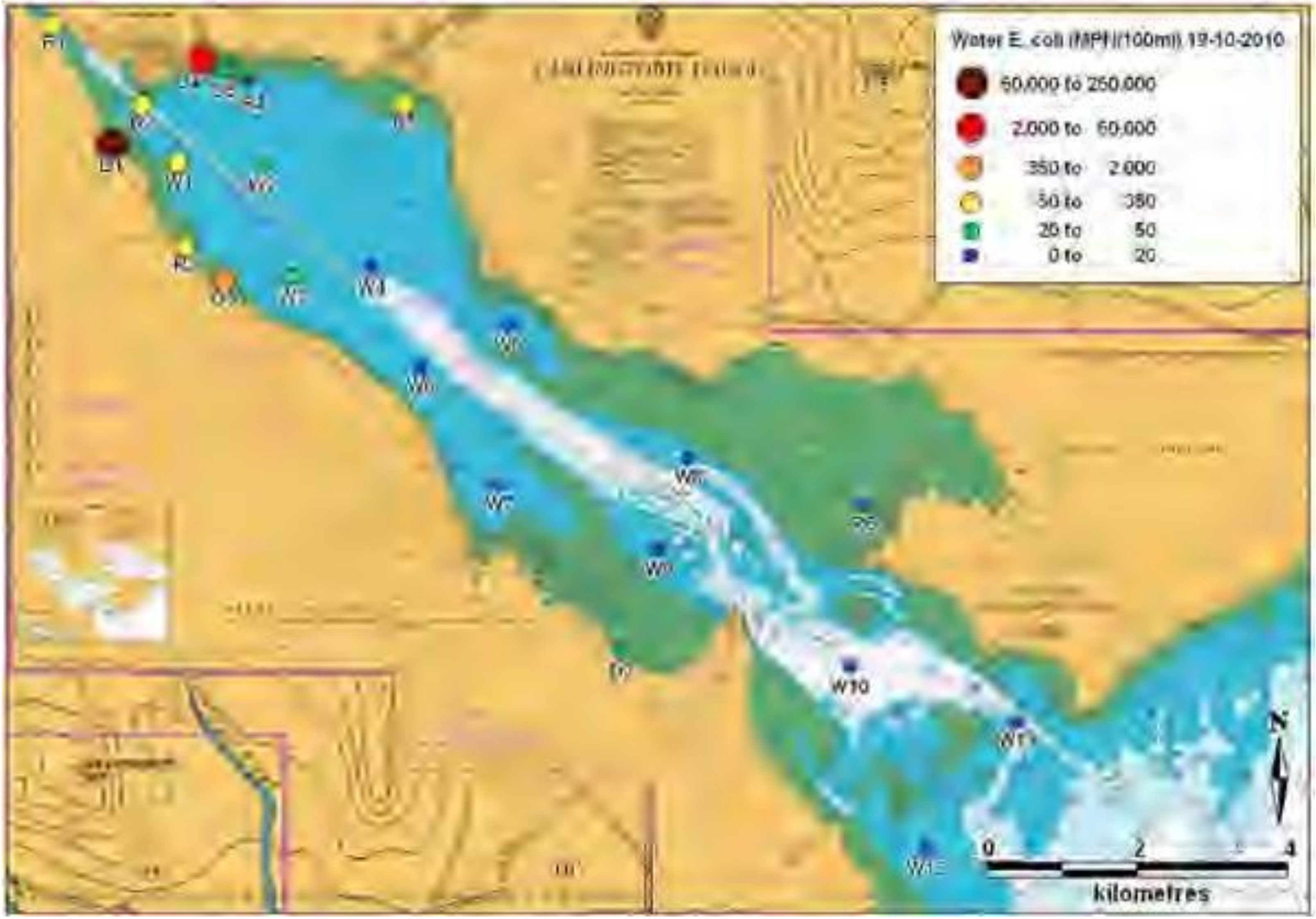


Figure 5.24: Water *E. coli* results from across Carlingford Lough.

6. Expert Assessment of the Effect of Contamination on Shellfish

Carlingford Lough is located within a predominately rural catchment, with approximately 70% of the land used for agricultural purposes. Newry city has the highest human population, followed by Warrenpoint, both located at the northwestern end of the Lough. The remaining surrounds containing smaller towns and villages typical of a rural settlement.

While no tourism data was available for the immediate area, it is safe to say that the local population does increase due to tourists mainly in the summer months. The information collated and assessed during the production of this report indicate that the main pollution sources in Carlingford Lough come from continuous and intermittent discharges mainly concentrated in the northwestern region of the Lough where the Newry/Clanrye River enters. The Newry and Warrenpoint WWTW have the highest discharges flowing into the river and subsequently into the Lough. There are also untreated discharges entering the Lough from Greenore and Omeath and various other non-point sources associated with agricultural land use, tourism and wildfowl.

Sewage has been known to lead to deterioration of water quality, alter floral and faunal assemblages near large outfalls and has been responsible for disease outbreaks attributed to faecal coliforms (Clarke, 2001). Faecal coliforms entering the marine environment from industrial discharges, wastewater and sewage discharges, contaminated freshwater input, agricultural run-off, wild fowl and shipping discharges can accumulate in bivalves that filter organic matter from the water column to feed. Varying levels of faecal coliforms in bivalve flesh determine the classification of shellfish harvesting waters. Carlingford Lough has historically always been classified as a mixture of A and B harvesting areas.

The geometric mean of *E. coli* levels was highest for mussels at Narrow Water (2006-2010), followed by mussels at Killowen (2009-2010) and mussels at Rostrevor (2006-2010). Analysis to determine the differences in *E. coli* contamination levels based on location and seasonality and the results showed that two stations predominantly stood out – Narrow Water and Rostrevor. Given the conditions in Narrow Water (inner sheltered location, weak currents, high organic loading from discharges and riverine input), it is no surprise that it is different to the other harvesting beds. In addition, the Rostrevor area seems to set itself apart from the other sites and again this is not surprising given the shallow nature of the area and the prevailing wind direction which may result in this area acting as a sink for contaminants. In addition, it is no surprise that that the two outer stations (Fair Green and Ballagan) feature highly in the significant differences. This is due to the stronger tidal currents, deeper depths and shorter residence times in this area, which result in a faster moving well flushed area with lower levels of contaminants.

Greenore is the only site where oysters and mussels are sampled and the geometric mean over the four years from 2006 to 2010 was 1.24 times greater for the oysters than the mussels. It should be noted however, that a one-way analysis of variance (ANOVA) showed no significant differences between *E. coli* levels in oysters and mussels from Greenore.

Depending on the bathymetric characteristics, current speeds and tidal conditions within different regions of the Lough and the prevailing wind direction, the fate of contaminants can vary. In the southeastern section of the Lough, deeper depths and strong current flows favour the physical dispersion and dilution of contaminants, whereas the inner northwestern region of the Lough, with shallower depths, higher suspended sediment concentrations, weaker current flows has a lower ability to disperse and dilute contaminants and therefore has the potential to accumulation contaminants.

Based on hydrodynamic conditions, suspended sediment levels, freshwater influence, contamination sources and historical classifications, the Lough was divided into 6 Production Areas. Within each of these Production Areas, one sampling site for each species was identified i.e. Pacific oyster, blue mussel and razor clam. In the selection of these sampling points, it was important to maintain as many of the existing monitoring points as possible to continue the long-term datasets. Further details on the Production Areas and the sampling sites can be seen in Section 7 Sampling Plan. This sampling plan is designed to properly reflect the control of the likely risk of pathogen contamination on the shellfish and will ensure that effective monitoring is carried out with respect to the potential polluting impacts and that public health is prioritised.

7. Sampling Plan

7.1. Identification of Production Area Boundaries & RMPs

The proposed production areas were based on hydrographical and spatial features i.e. areas of similar depth, tidal currents, residence times, suspended sediment levels and freshwater influence as well as the results from the shellfish and water sampling. Figures 7.1 to 7.6 show the base data used for the identification of production areas, i.e. spring and neap surface and bottom ebb and flood flows, the spring tide ebb and flow tidal streams, residence times, the shellfish *E. coli* results and the water *E. coli* results. In addition, analysis carried out on FSA in NI and SFPA monitoring data was also taken into consideration when determining production areas and Figures 7.7 to 7.9 show the historical classifications in Carlingford Lough from 2006.

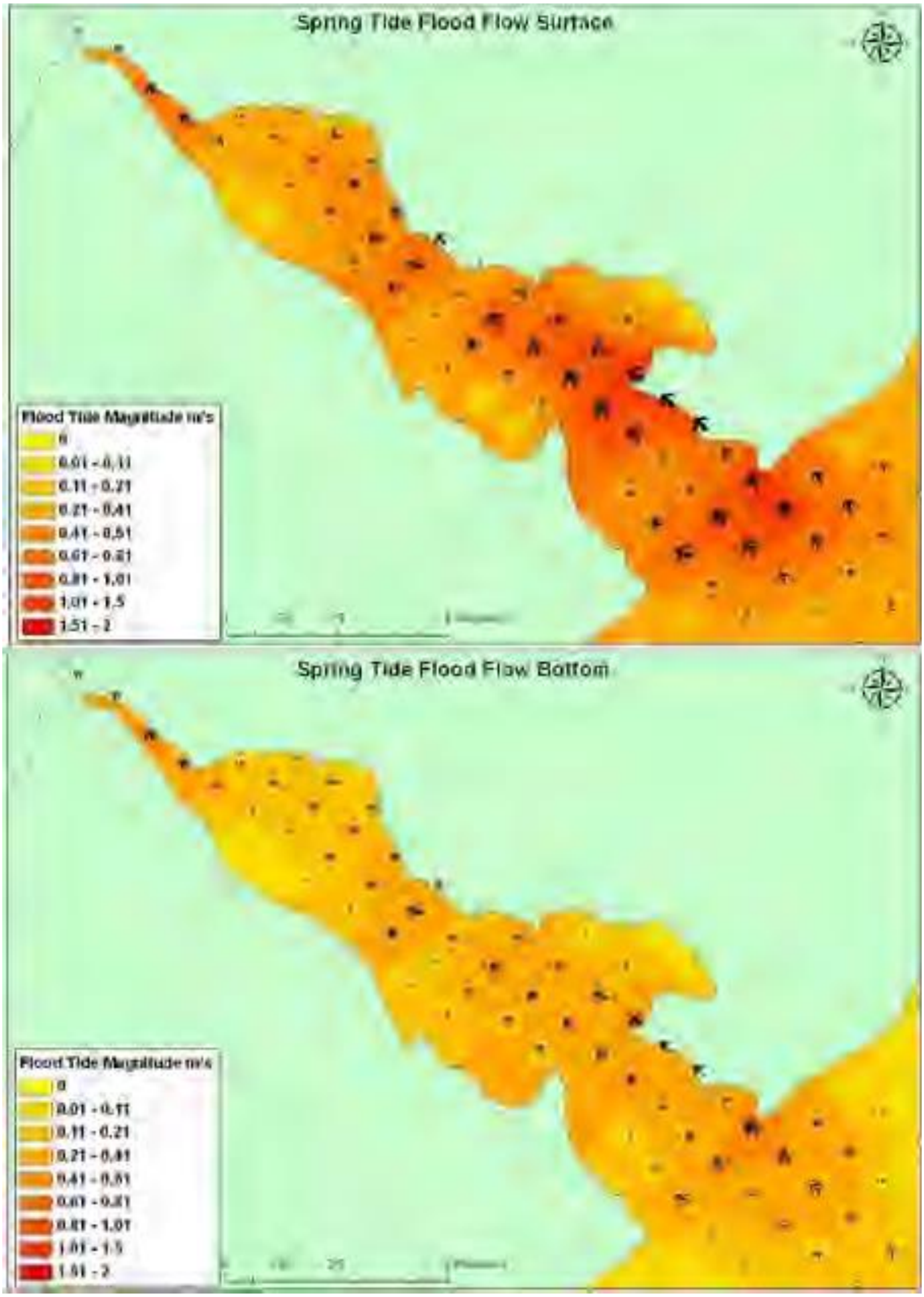


Figure 7.1: Surface and bottom current velocities and direction during a spring tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

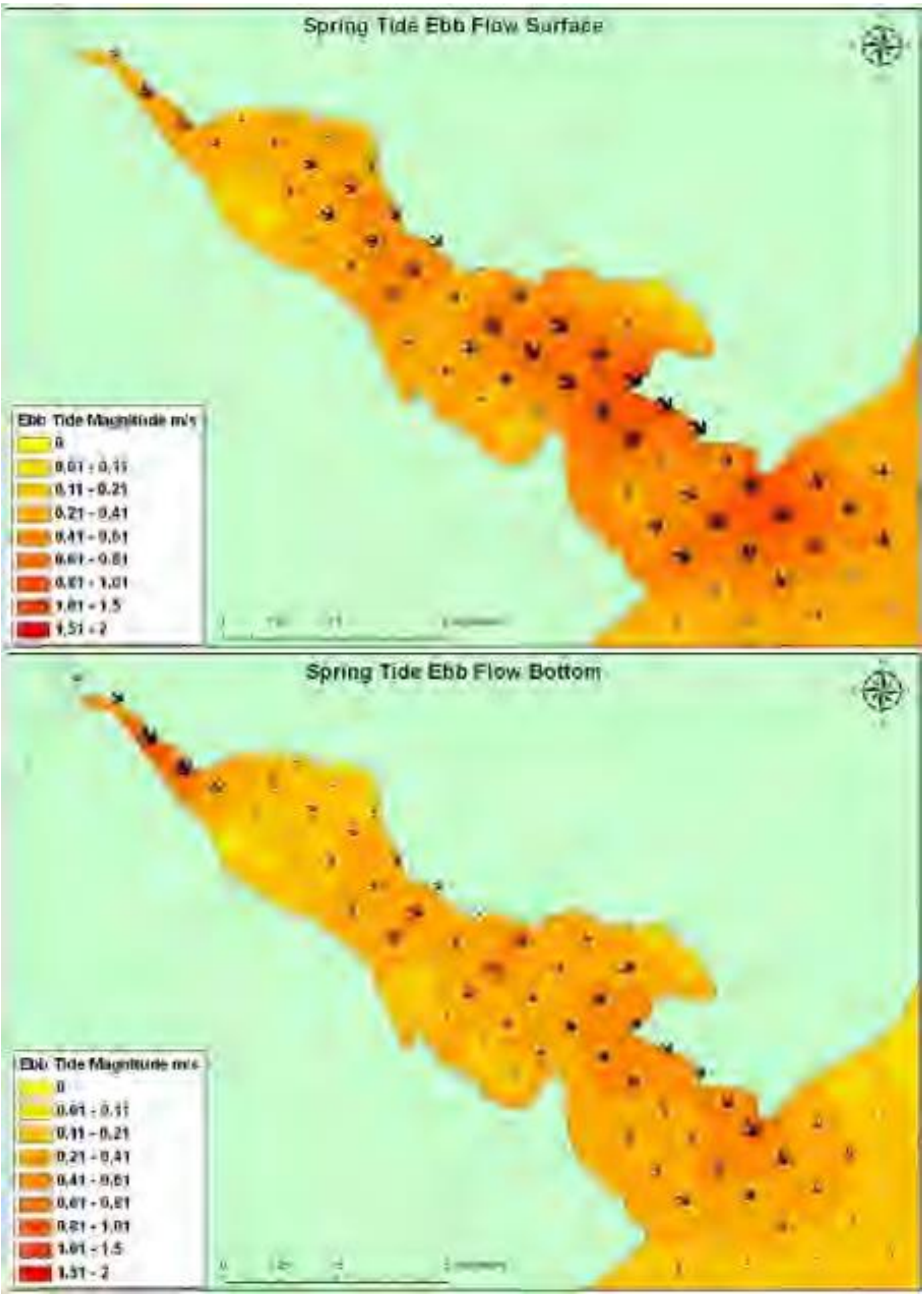


Figure 7.2: Surface and bottom current velocities and direction during a spring tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

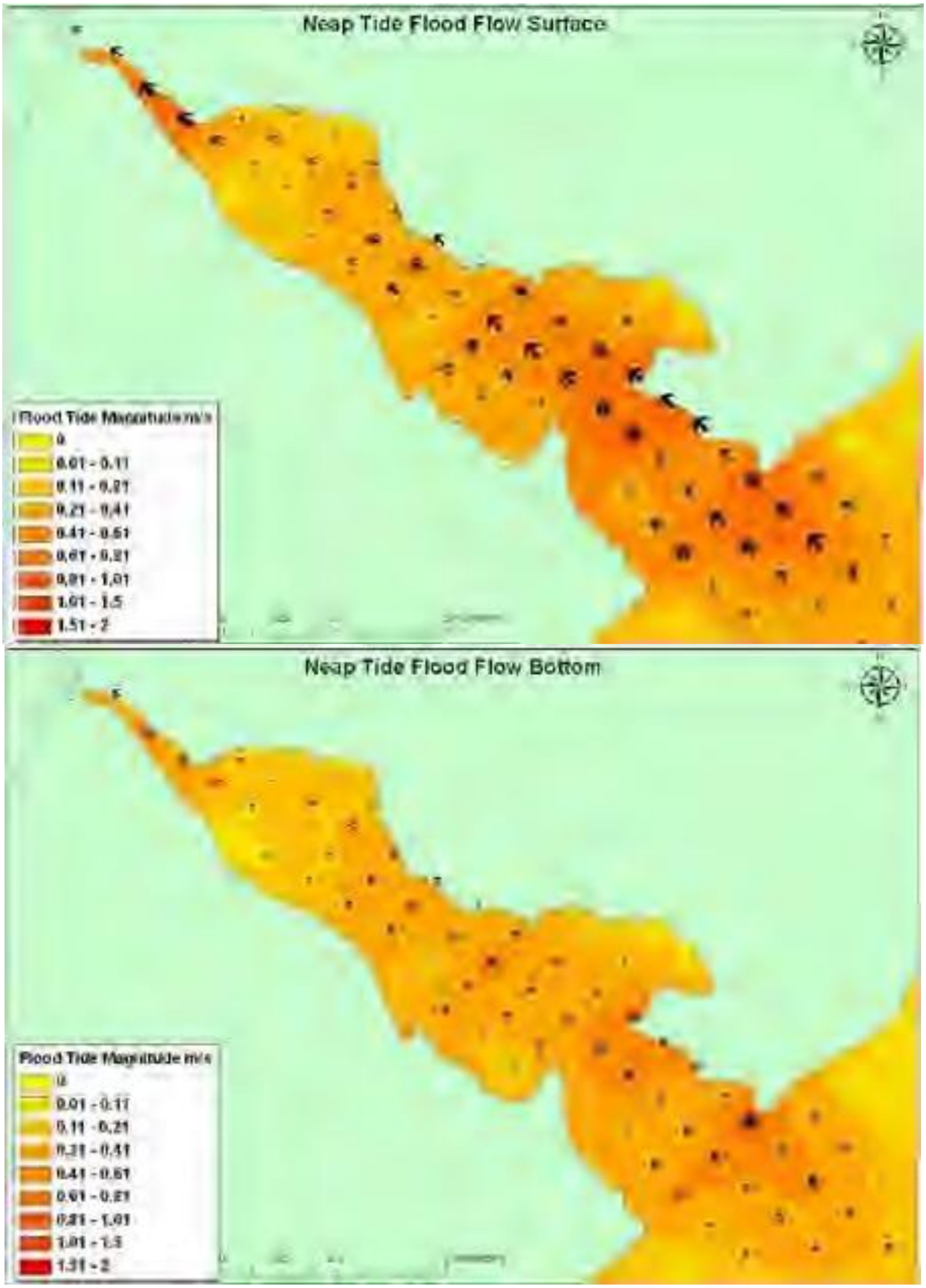


Figure 7.3: Surface and bottom current velocities and direction during a neap tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

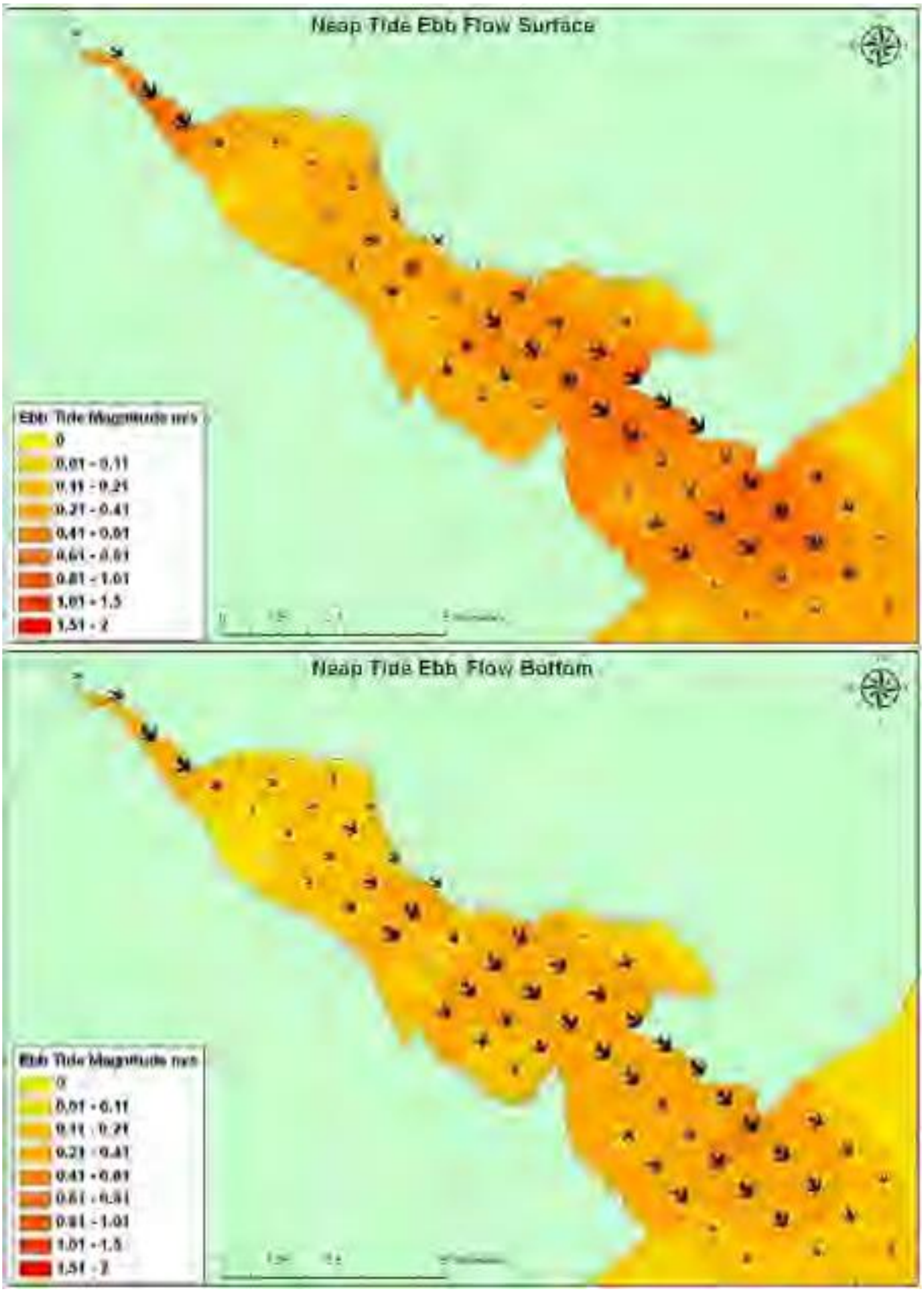


Figure 7.4: Surface and bottom current velocities and direction during a neap tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

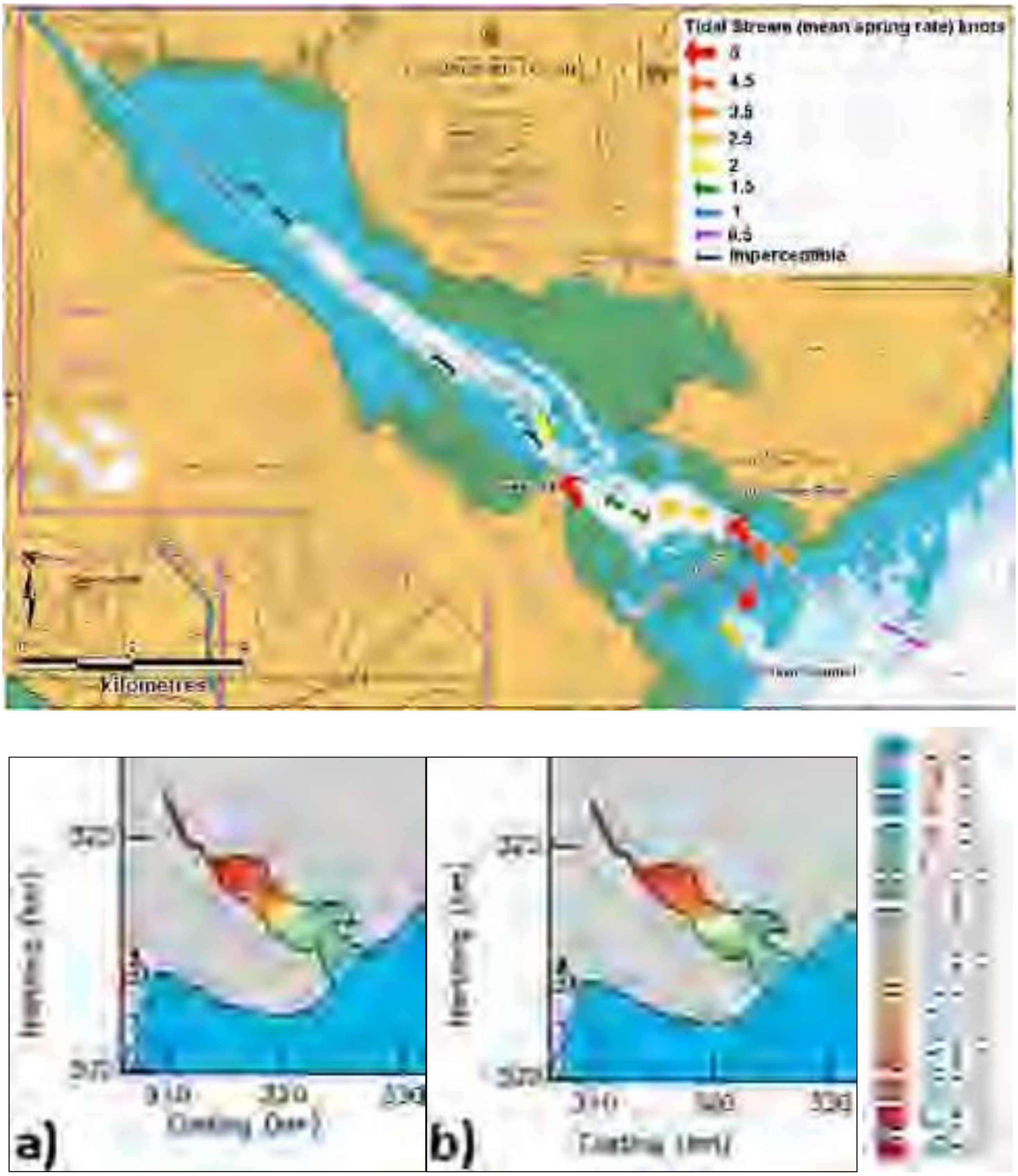


Figure 7.5: Tidal stream and residence time data for Carlingford Lough.

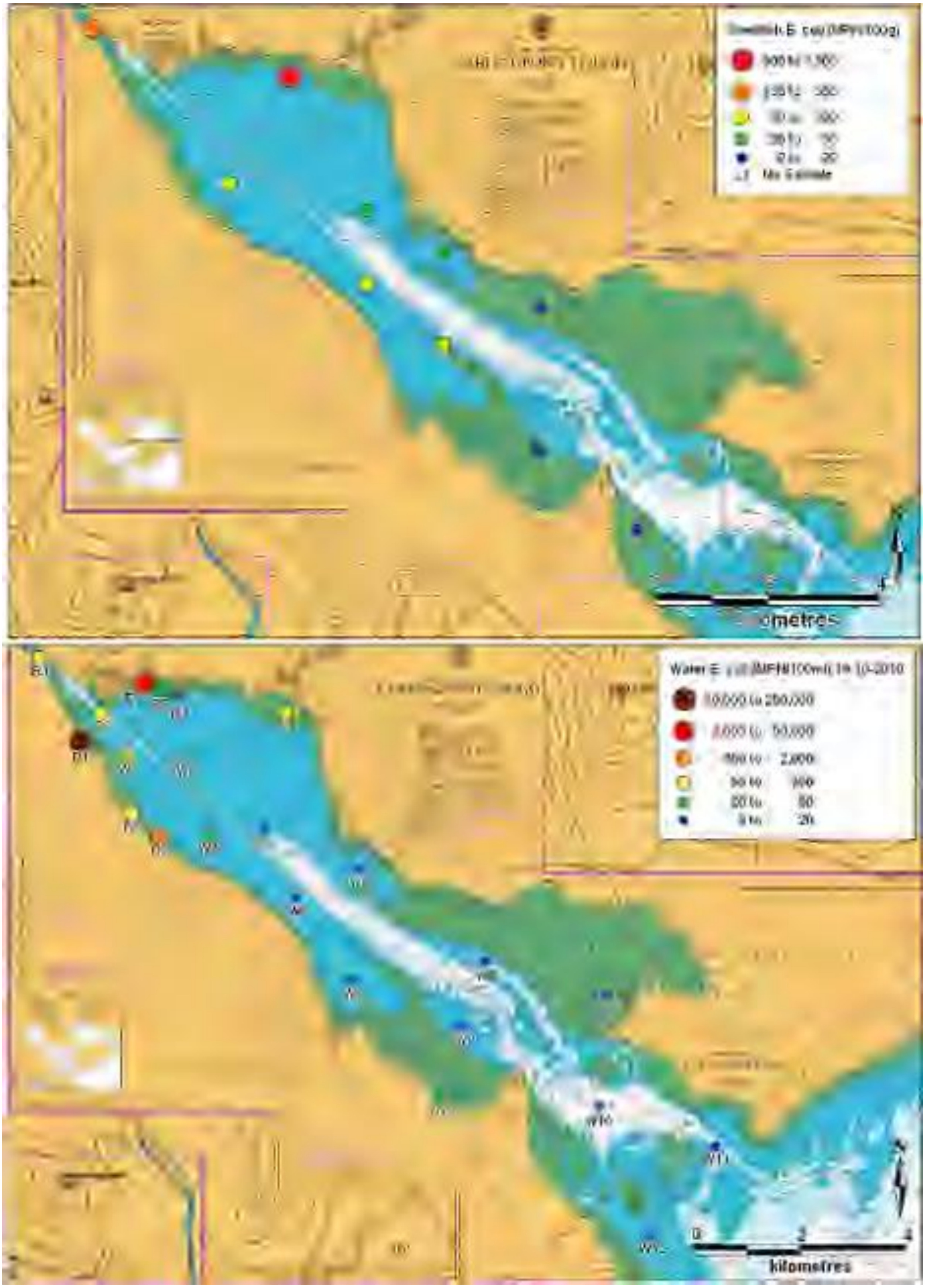


Figure 7.6: ***E. coli*** **results from shellfish and water samples in Carlingford Lough.**

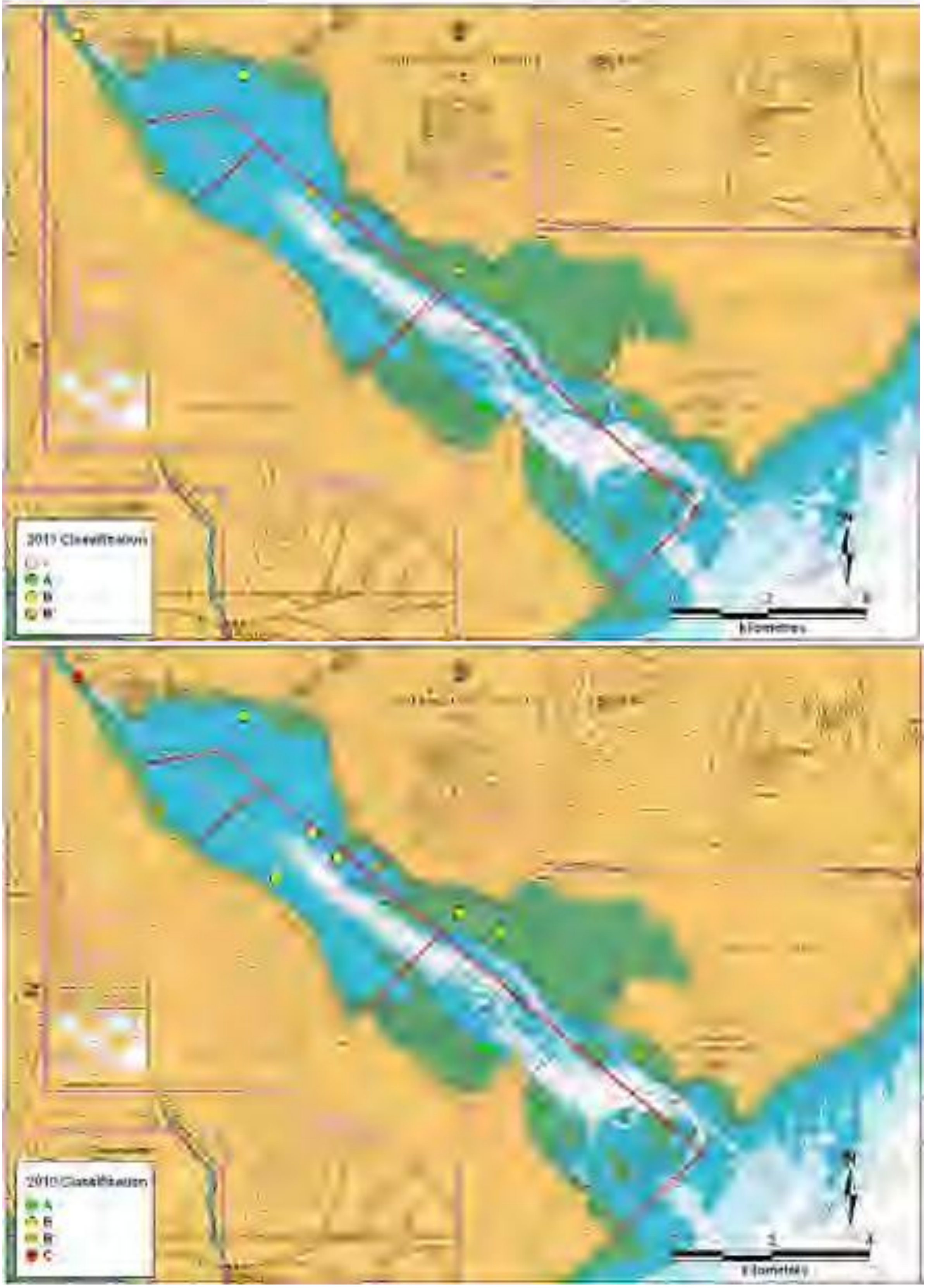


Figure 7.7: Historical classifications for Carlingford Lough in 2011 and 2010. The red lines indicate the existing boundary areas.

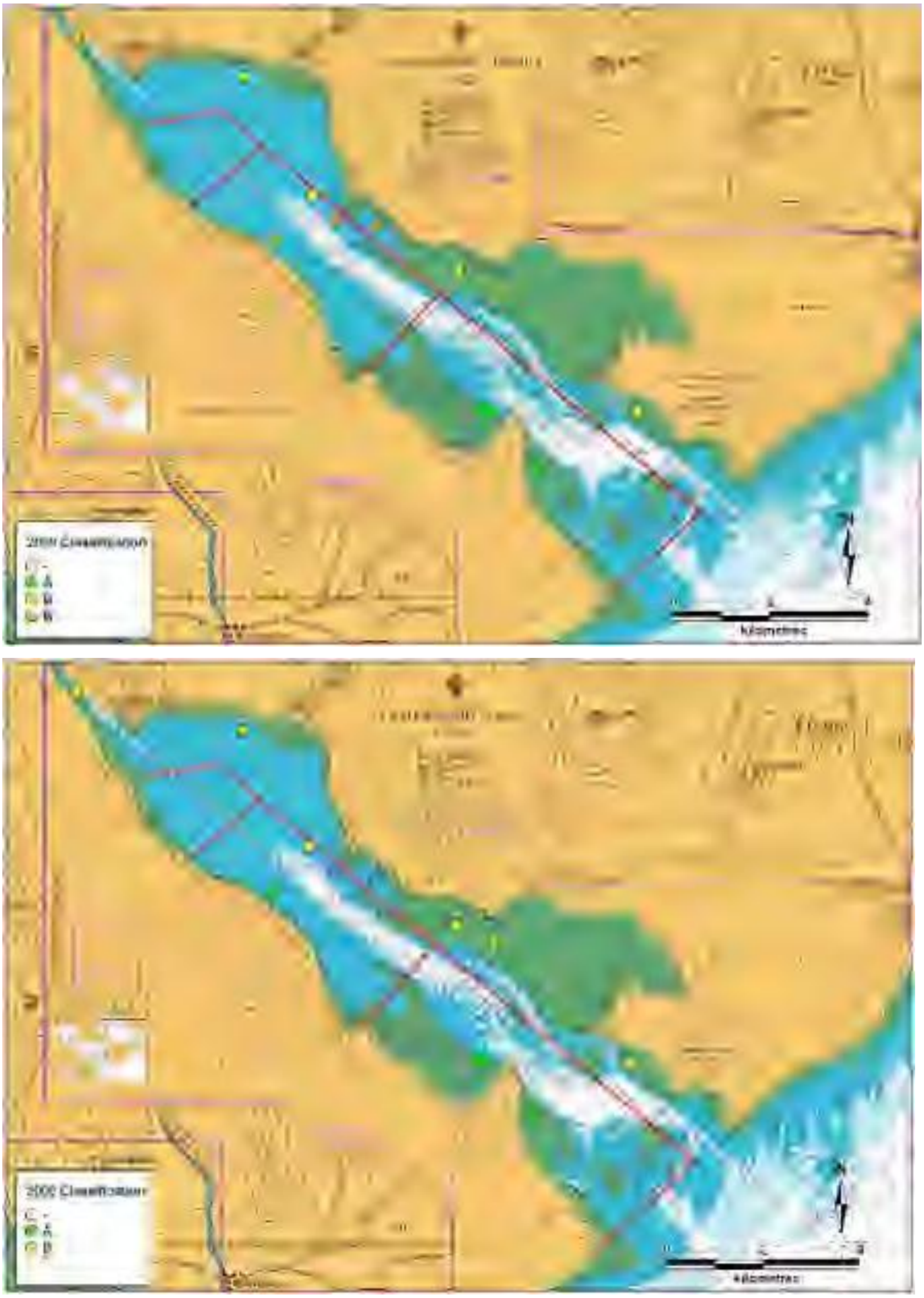


Figure 7.8: Historical classifications for Carlingford Lough in 2009 and 2008. The red lines indicate the existing boundary areas.

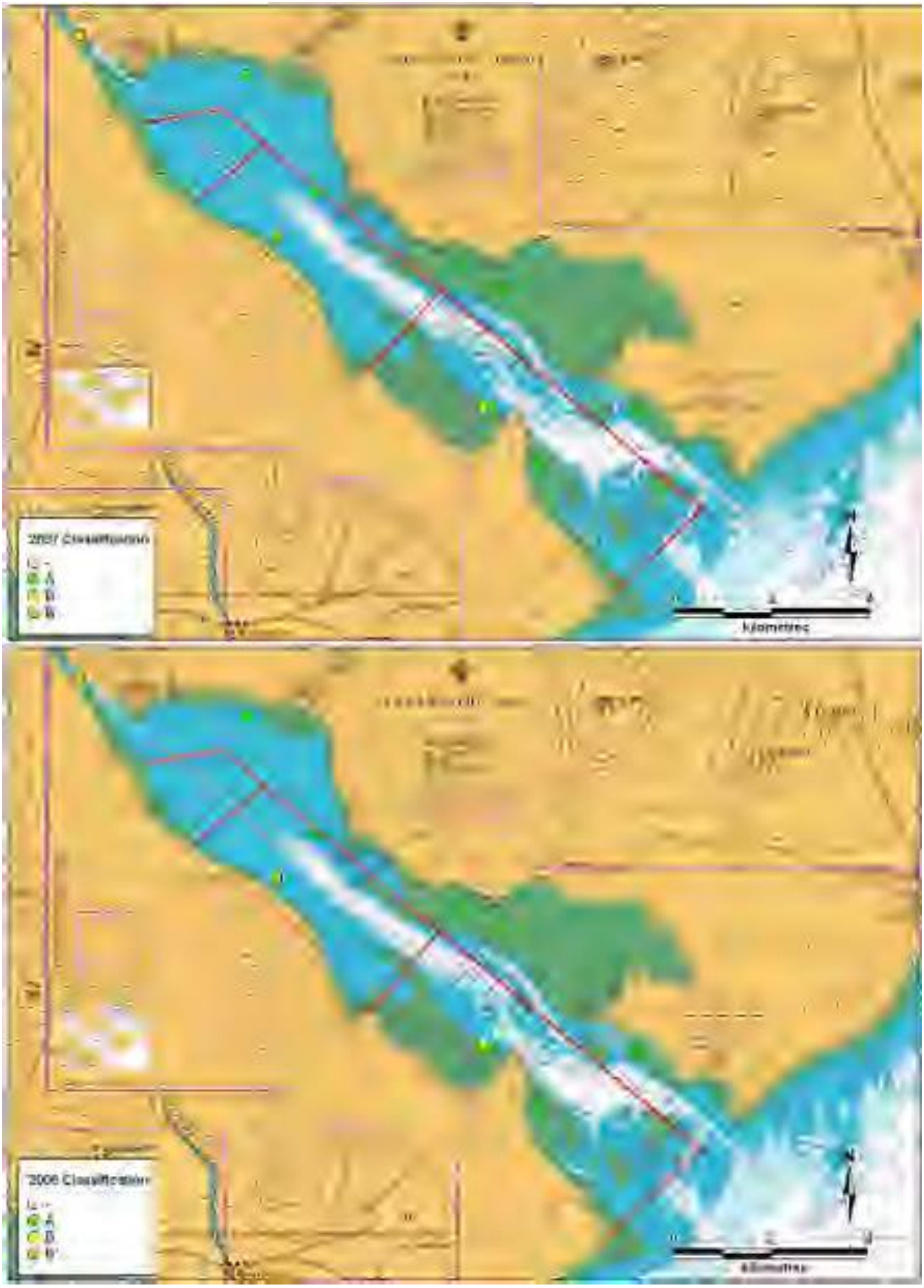


Figure 7.9: Historical classifications for Carlingford Lough in 2007 and 2006. The red lines indicate the existing boundary areas.

The inner section of Carlingford Lough is shallow, has weak tidal currents and receives approximately 70% of the Lough's freshwater input from the Newry/Clanrye River. These three factors combine to result in a turbid slow moving sink with a long residence time (>20 days). In contrast, the outer part of the Lough experiences strong tidal currents, deeper depths and shorter residence times (<8 days), which all results in a faster moving well flushed area. Any contamination in the outer section of the Lough will be diluted and dispersed rapidly, whereas the inner part of the Lough can act as a sink for contaminants. In addition, the prevailing wind direction in the area has the effect of pushing water towards the northern shoreline, into Rostrevor Bay and Mill Bay and given their shallow nature these areas may also act as sinks for contaminants.

The Lough was divided into 6 production areas based on the data shown in Figures 7.1 – 7.9 above. Figure 7.10 shows the proposed production areas and Representative Monitoring Points (RMPs) over the admiralty chart and overlain on the licenced aquaculture production sites and Figures 7.11 to 7.14 show the production areas overlain on the current flows over a spring and neap tide.

The navigational channel was used as the centre point of the Lough when dividing the north from the south. These RMPs were selected to best represent the productive shellfish sites within each Production Area. All efforts were made to maintain as many of the existing monitoring sites as possible in order to maintain the long-term datasets for these sites.

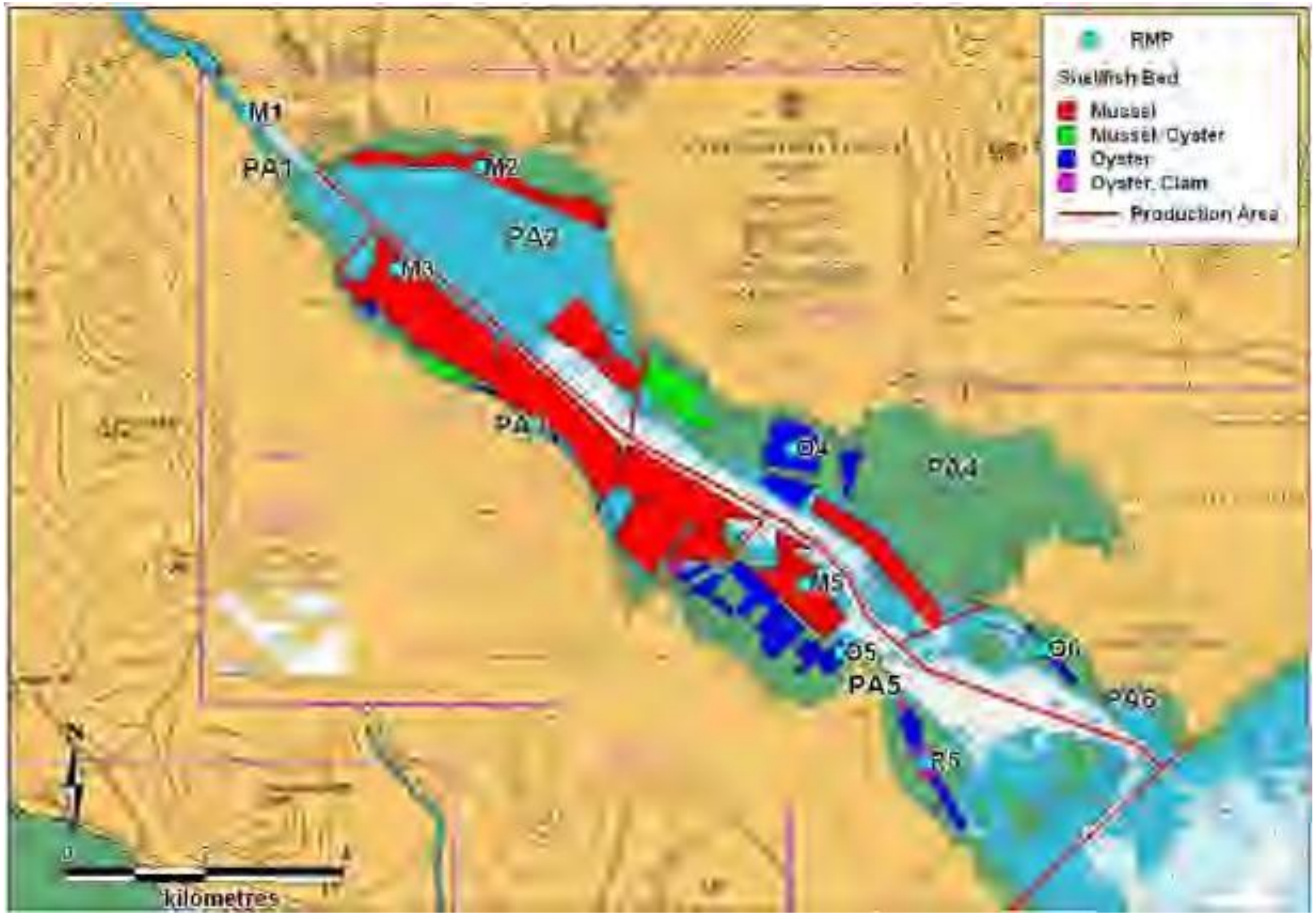


Figure 7.10: Proposed Production Areas and RMPs overlain on the licenced aquaculture sites within Carlingford Lough.

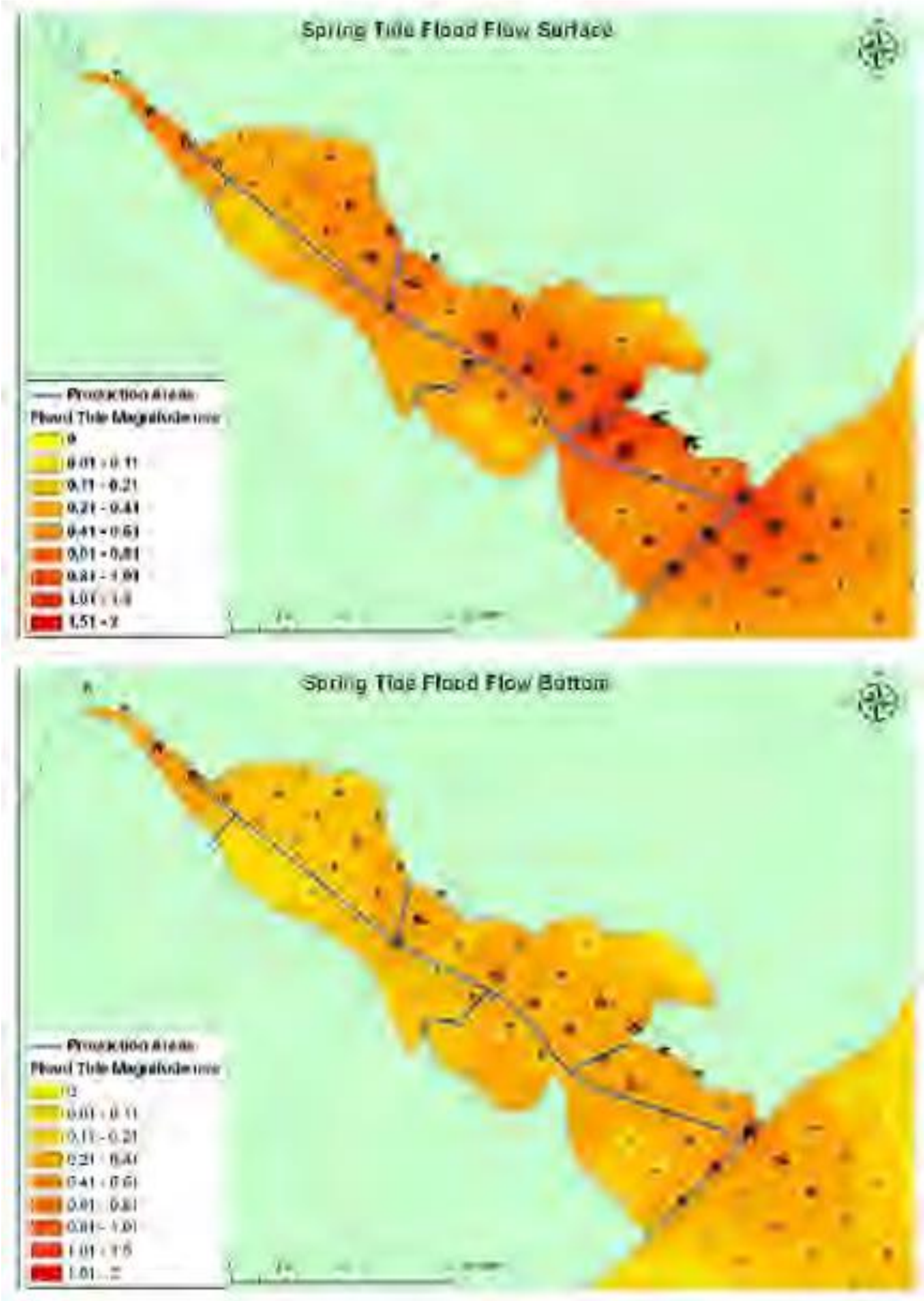


Figure 7.11: Surface and bottom current velocities and direction during a spring tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

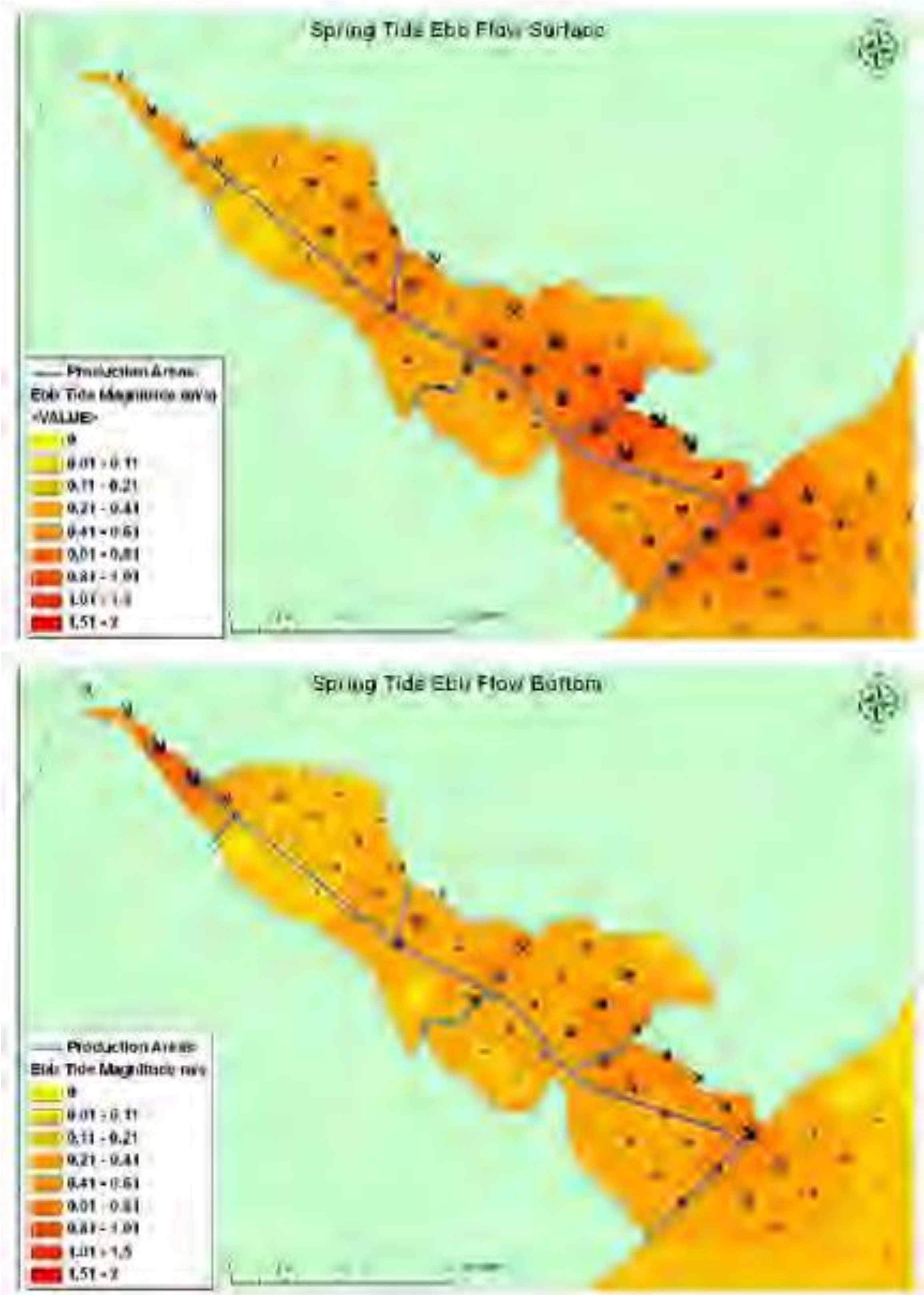


Figure 7.12: Surface and bottom current velocities and direction during a spring tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

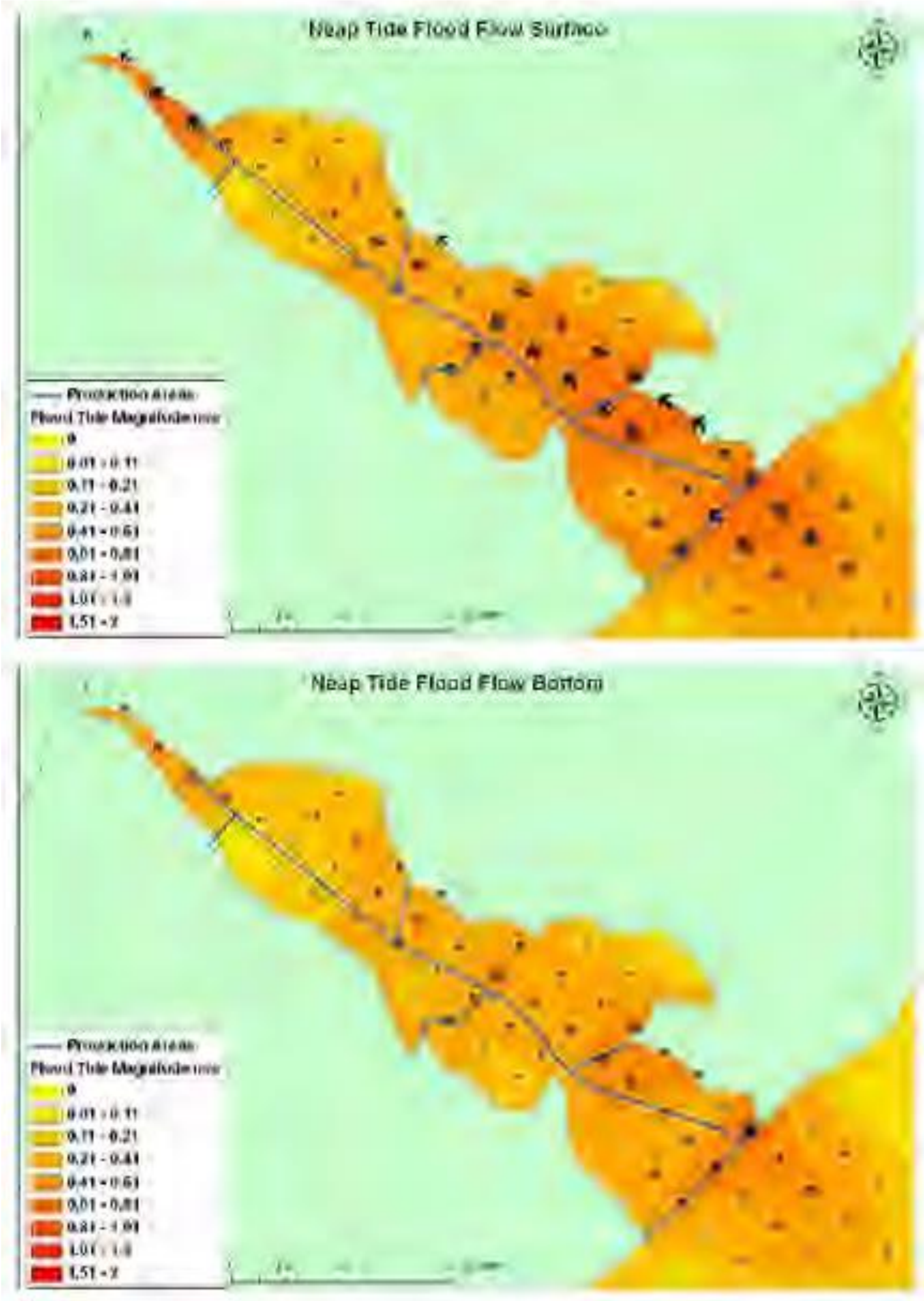


Figure 7.13: Surface and bottom current velocities and direction during a neap tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

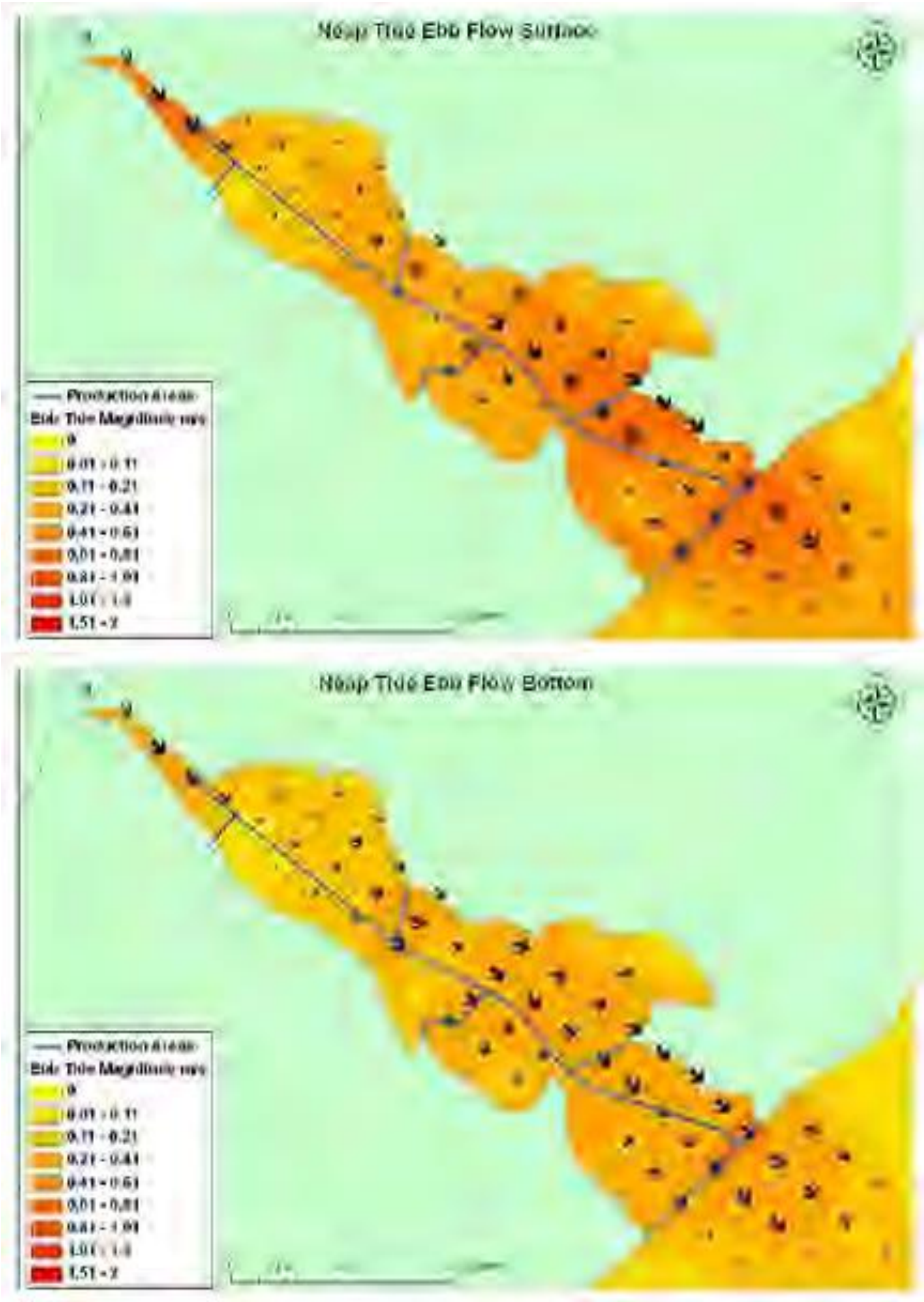


Figure 7.14: Surface and bottom current velocities and direction during a neap tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

7.1.1. Production Area 1 & RMPs

Production Area 1 is located at the mouth of the Newry River and has the largest freshwater influence (and therefore suspended sediment levels). It also receives discharges from Warrenpoint WWTW and from numerous discharges associated with the harbour and further afield. This production area was selected to keep this unlicenced (yet classified) wild mussel producing area separate from the licenced Rostrevor mussel site (Production Area 2). Its boundary extends beyond Omeath in order to keep the wild mussel fishery in the area separate from the aquaculture producers in Production Area 3. This area has predominantly been classified as a B in recent years. Figure 7.15 shows the production area, bounding coordinates, the classified wild mussel producing area and RMP M1. Table 7.1 lists the bounding coordinates of the production area.

Figure 7.15: Production Area 1 with bounding coordinates and RMP M1.

Table 7.1: Coordinates of Production Area 1.

Bounding Coordinate	Longitude	Latitude	Easting	Northing
1	-6.25242	54.0976	314380.9	317906.6
2	-6.25475	54.096	314232.2	317726
3	-6.24141	54.0894	315123.5	317009.5
4	-6.25081	54.0828	314526.5	316260.2

The RMP chosen for Production Area 1 can be seen in Figure 7.15 and its coordinates are listed in Table 7.2. Prefix M indicates Mussel RMP. The location of the RMP was selected based on areas where commercial activity is centred. This RMP coincides with the existing Narrow Water monitoring site.

Table 7.2: RMP Coordinate.

RMP	Longitude	Latitude	Easting	Northing
M1	-6.26978	54.104	313227.7	318589.6

7.1.2. Production Area 2 & RMPs

Production Area 2 encompasses Rostrevor Bay and contains 3 licenced mussel production sites. This area of the Lough is shallow, has weak currents, long residence times (24 to >28 days) and the prevailing wind direction pushes water into this bay. This area has predominantly been classified as a B in recent years. Figure 7.16 shows the production area, bounding coordinates, licenced mussel production sites and RMP M2 and Table 7.3 lists the bounding coordinates.

Figure 7.16: Production Area 2 with bounding coordinates, mussel sites and RMP M2.

Table 7.3: Coordinates of Production Area 2.

Bounding Coordinate	Longitude	Latitude	Easting	Northing
1	-6.25241	54.0976	314380.9	317906.6
2	-6.25475	54.096	314232.2	317726
3	-6.18598	54.0617	318829.2	314023.7
4	-6.1842	54.0685	318926.3	314780.3
5	-6.1828	54.0702	319013.1	314971.8
6	-6.18306	54.0737	318985.8	315366.4

The RMPs chosen for Production Area 2 can be seen in Figure 7.16 and their coordinates are listed in Table 7.4. Prefix M indicates Mussel RMP. This RMP coincides with the existing Rostrevor monitoring point.

Table 7.4: RMP Coordinates.

RMP	Longitude	Latitude	Easting	Northing
M2	-6.21872	54.0967	316587.6	317861.7

7.1.3. Production Area 3 & RMPs

Production Area 3 is located opposite PA2 and stretches from Omeath south to Carlingford Point. This is also a slow-moving shallow area with residence times of 18-28 days. This area has predominantly been classified as a B in recent years. Figure 7.17 shows the production area, bounding coordinates, licenced aquaculture sites and RMP M3. Table 7.5 lists the coordinates of the production area.

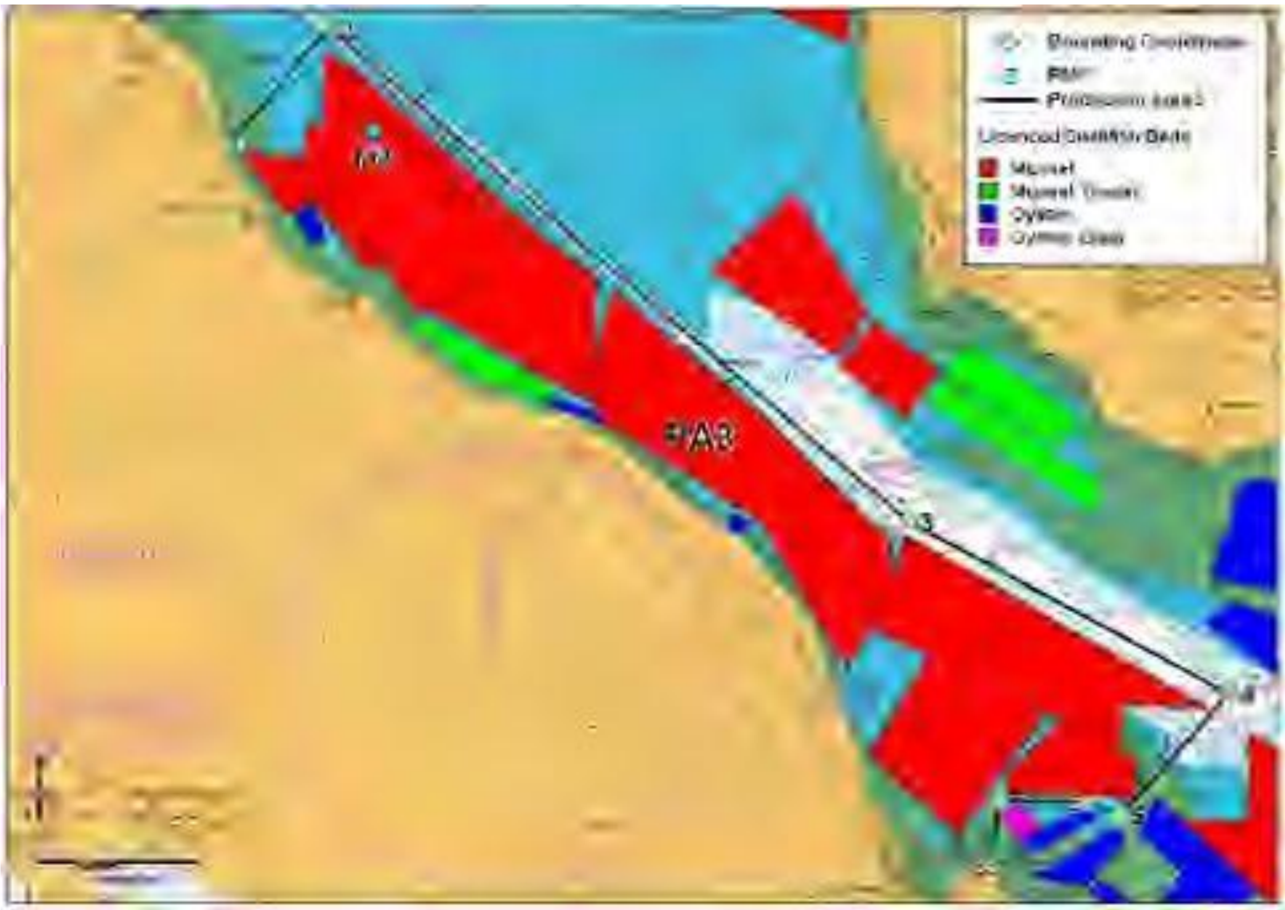


Figure 7.17: Production Area 3 with bounding coordinates, licenced shellfish beds and RMP M3.

Table 7.5: Coordinates of Production Area 3.

Bounding Coordinate	Longitude	Latitude	Easting	Northing
1	-6.25088	54.0827	314522.1	316255.2
2	-6.24141	54.0894	315123.5	317009.5
3	-6.18598	54.0617	318829.2	314023.7
4	-6.15536	54.052	320862	312990.4
5	-6.1656	54.0452	320211.1	312213.8
6	-6.16874	54.0459	320003.3	312291.3
7	-6.17722	54.046	319447.7	312291.2
8	-6.17804	54.0424	319404.5	311889

The RMPs chosen for Production Area 3 can be seen in Figure 7.17 and their coordinates are listed in Table 7.6. Prefix M indicates Mussel RMP. RMP M3 is located further towards the channel than the existing Inner site. This is due to the fact that the inner site is not as productive and may be hard to sample regularly.

Table 7.6: RMP Coordinates.

RMP	Longitude	Latitude	Easting	Northing
M3	-6.2371	54.0836	315421.7	316367.7

7.1.4. Production Area 4 & RMPs

Production Area 4 encompasses the Mill Bay area from Killowen Point to Greencastle Point. The majority of this site is made up of intertidal mud and sand flats that make up Mill Bay. Residence times in this area vary from approximately 8 to 16 days. This area has predominantly been classified as a B in recent years. Figure 7.18 shows the production area, bounding coordinates, licenced aquaculture sites and RMP O4. Table 7.7 lists the coordinates of the production area.

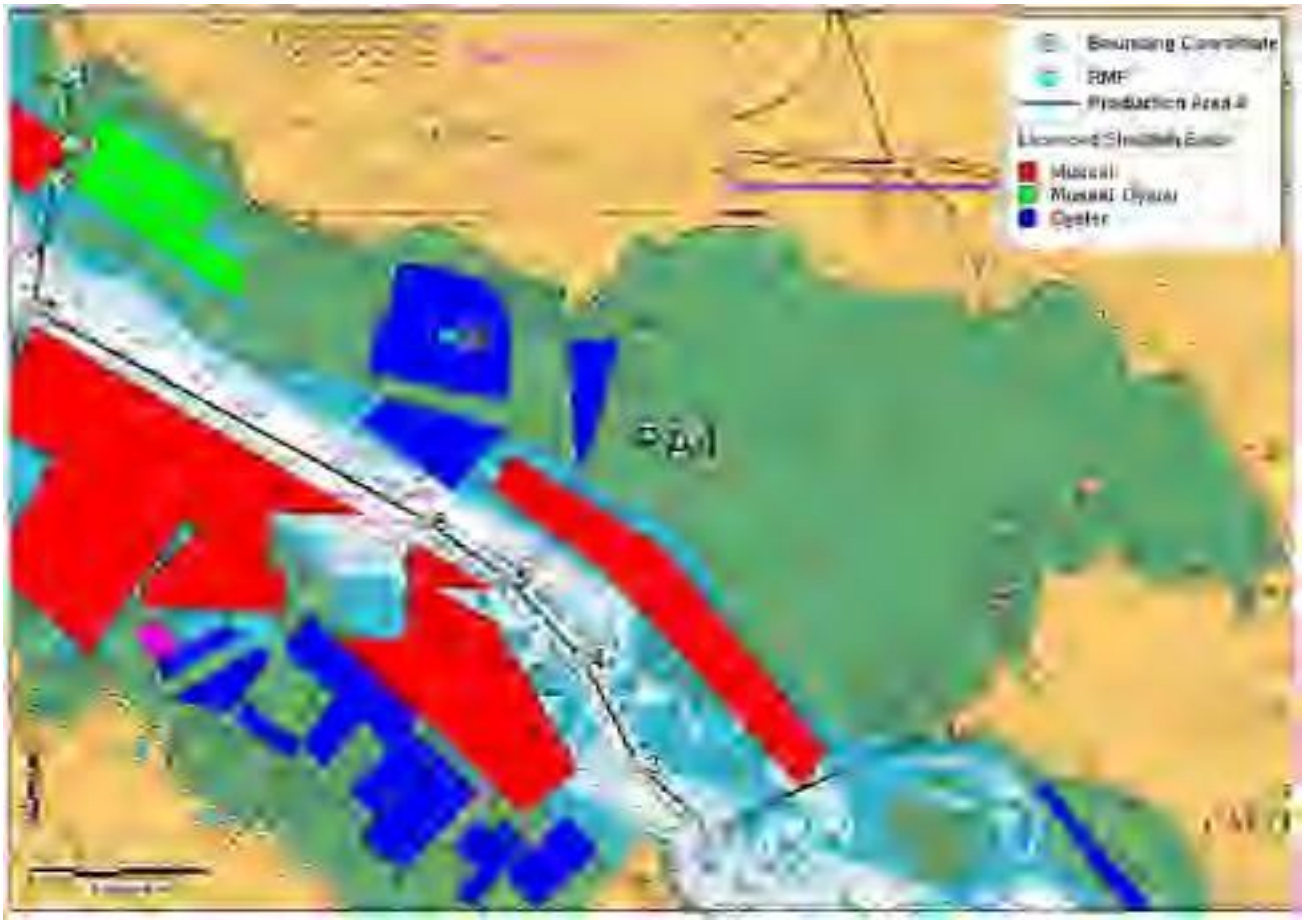


Figure 7.18: Production Area 4 with bounding coordinates, licenced aquaculture sites and RMPs.

Table 7.7: Coordinates of Production Area 4.

Bounding Coordinates	Longitude	Latitude	Easting	Northing
1	-6.10759	54.0401	324025.9	311755.1
2	-6.12726	54.0351	322752.1	311164.8
3	-6.1335	54.0385	322333	311524.1
4	-6.13825	54.0439	322006.1	312116.6
5	-6.14486	54.048	321561.2	312568.3
6	-6.15194	54.0509	321089	312879.7
7	-6.18598	54.0617	318829.2	314023.7

Bounding Coordinates	Longitude	Latitude	Easting	Northing
8	-6.1842	54.0685	318926.3	314780.3
9	-6.1828	54.0702	319013.1	314971.8
10	-6.18306	54.0737	318986.1	315366.2

The RMP chosen for Production Area 4 can be seen in Figure 7.18 and the coordinates are listed in Table 7.8. Prefix O indicates native Oyster RMP. RMP O4 coincides with the existing Ballyedmond site.

Table 7.8: RMP Coordinates.

RMP	Longitude	Latitude	Easting	Northing
O4	-6.1511	54.0605	321116.5	313947.7

7.1.5. Production Area 5 & RMPs

Production Area 5 stretches from Carlingford Point to Ballagan Point. This area has predominantly been classified as A in recent years. The area inside Greenore consists of a large portion of intertidal sand and mud flats and residence times range from 12 to 16 days and current speeds in the area are low. The area outside Greenore consists of deeper depths, faster currents, shorter residence times (2-14 days) and is well flushed. Despite the hydrographic differences, given the fact that both areas are repeatedly classified as A, it was all designated as 1 production area. This site is classified for oysters, mussels and razor clams. Figure 7.19 shows the production area, bounding coordinates, licenced aquaculture sites and RMPs. Table 7.9 lists the coordinates of the production area.

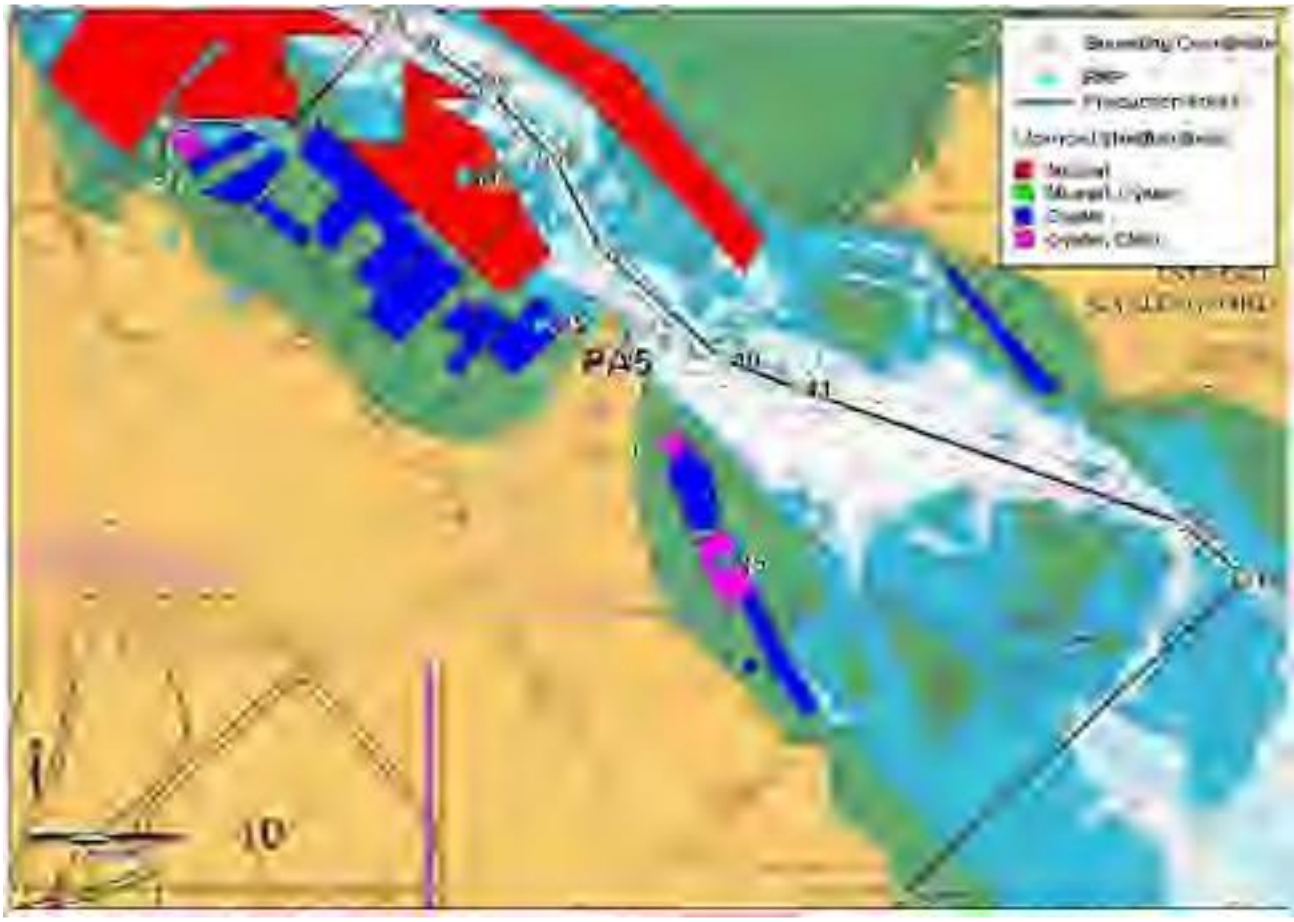


Figure 7.19: Production Area 5 with bounding coordinates, licenced aquaculture sites and RMPs.

Table 7.9: Coordinates of Production Area 5.

Bounding Coordinate	Longitude	Latitude	Easting	Northing
1	-6.17804	54.0424	319404.5	311889
2	-6.17722	54.046	319447.7	312291.2
3	-6.16874	54.0459	320003.3	312291.3
4	-6.16562	54.0451	320210.1	312212.8
5	-6.15536	54.052	320862	312990.4
6	-6.15194	54.0509	321089	312879.7
7	-6.14486	54.048	321561.2	312568.3
8	-6.13825	54.0439	322006.1	312116.6
9	-6.1335	54.0385	322333	311524.1
10	-6.12125	54.032	323155.3	310820.6
11	-6.11389	54.0303	323642	310644.5
12	-6.07522	54.0223	326199.9	309823
13	-6.0689	54.0191	326624	309482.8
14	-6.10328	54.0001	324426.9	307309.6

The RMPs chosen for Production Area 5 can be seen in Figure 7.19 and their coordinates are listed in Table 7.10. Prefix M indicates Mussel RMP, prefix O indicates native Oyster RMP and prefix R indicates Razor clam RMP. RMPs M5 and R5 is a new monitoring site and RMP O5 coincides with the existing Greenore oyster monitoring site.

Table 7.10: Coordinates of RMPs O5, M5 and R5.

RMP	Longitude	Latitude	Easting	Northing
M5	-6.1473	54.0428	321416.6	311985.2
R5	-6.12123	54.02	323191.9	309485.2
O5	-6.13951	54.0341	321952.3	311031.8

7.1.6. Production Area 6 & RMPs

Production Area 6 stretches from Greencastle Point to Cranfield Point. This site contains one production area. This site has short residence times (approximately 2-12 days), deeper depths, stronger currents and is well flushed. Figure 7.20 shows the production area, bounding coordinates, licenced aquaculture sites and RMP O6. Table 7.11 lists the coordinates of the production area.

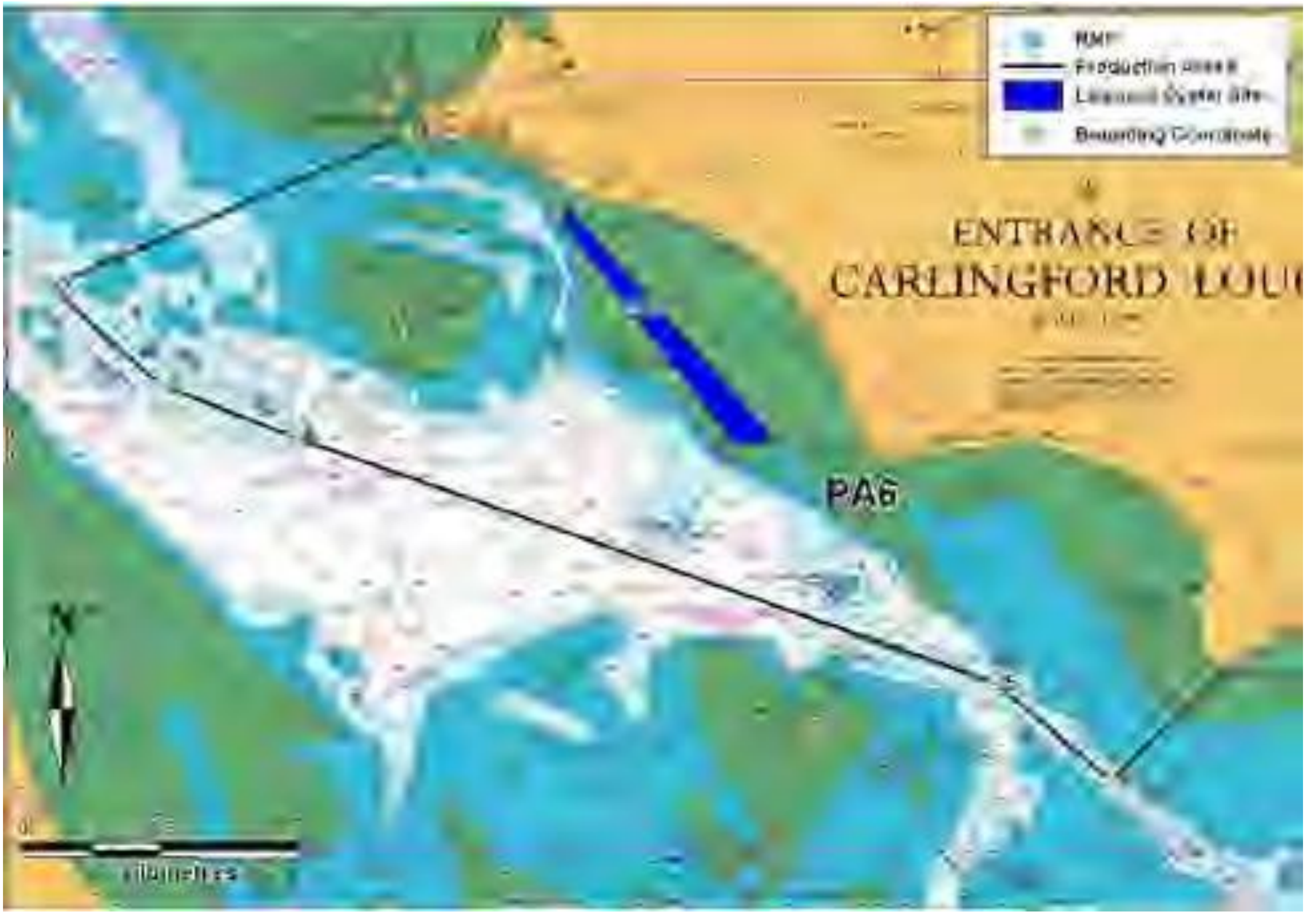


Figure 7.20: Production Area 6 with bounding coordinates, licenced aquaculture sites and RMP.

Table 7.11: Coordinates of Production Area 6.

Bounding Coordinates	Longitude	Latitude	Easting	Northing
1	-6.10759	54.0401	324025.9	311755.1
2	-6.12726	54.0351	322752.1	311164.8
3	-6.12125	54.032	323155.3	310820.6
4	-6.11389	54.0303	323642	310644.5
5	-6.07522	54.0223	326199.9	309823
6	-6.0689	54.0191	326624	309482.8
7	-6.06212	54.0228	327056.7	309910.8

The coordinates of RMP O6 can be seen in Table 7.12 below and this RMP coincides with the existing Fair Green monitoring site.

Table 7.12: Coordinates of RMP O6.

RMP	Longitude	Latitude	Easting	Northing
O6	-6.0952	54.0345	324854.5	311144.6

7.1.7. Sampling Methodology

All sampling should follow the UK NRL's (National Reference Laboratory) Recommendations for the collection and transport of LBMs for Microbiological monitoring, which outlines the following:

7.1.7.1. Time of sampling

Sampling shall be undertaken, where practical, on as random a basis as possible with respect to likely influencing environmental factors e.g. tidal state, rainfall, wind, etc. so as to avoid introducing any bias to the results.

7.1.7.2. Frequency of Sampling

All sampling should be carried out on a monthly basis.

7.1.7.3. Sampling method

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

7.1.7.4. Size of individual animals

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

7.1.7.5. Sample composition

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

Oysters (*Crassostrea gigas* and *Ostrea edulis*)	12-18
Mussels (*Mytilus* spp.)	18-35
Razor clams (*Ensis* spp.)	12-18

There is an absolute lower number of shellfish (10) and a minimum requirement of 50 g of flesh and intravalvular fluid for the test undertaken by the laboratory. The number of animals given above is intended to satisfy these requirements and to include a small additional allowance in case animals become moribund during transit.

7.1.7.6. Preparation of samples

Any mud and sediment adhering to the shellfish should be removed. This is best achieved by rinsing/scrubbing with fresh water of potable quality or seawater from the immediate area of sampling. Do not totally re-immerse the shellfish in water as this may cause them to open. Allow to drain before placing in a food grade plastic bag. The container/bag should be labelled with the sender's reference number and any other relevant information (e.g. species).

7.1.7.7. Sample transport

Samples should be transported in cool boxes at a temperature between 1°C and 8°C. Samples should not be frozen and freezer packs should not come into direct contact with the samples or sample bags. Analysis should be undertaken as soon as practically possible after sampling with a normal limit of 24 hours after sampling. Where specific geographical considerations make it impossible to consistently comply with the 24 hour limit, the upper limit may be extended to 48 hours if a validation study shows that this does not affect the *E. coli* concentration in the shellfish.

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

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

7.1.7.8. Sample Submission form

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

7.1.7.9. Delivery of samples

Samples should be properly labelled and accompanied by a completed sample submission form. Samples should be brought within 24 hours to the chosen accredited laboratory for analysis.

7.1.7.10. Receiving laboratory

The laboratory to which the samples are sent must be part of the network identified by the competent authority. It must be UKAS-accredited for the testing of shellfish for *E. coli* by ISO 16649-3 and must take part in both the HPA/CEFAS Shellfish EQA scheme and appropriate NRL ring trials.

8. References

AQUAFACT. 2007. Seed mussel transport in the Irish Sea. Report prepared on behalf of the Marine Institute.

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

Ball, B., Raine, R. & D. Douglas. 1997. Phytoplankton and particulate matter in Carlingford Lough, Ireland: An assessment of food availability and the impact of bivalve culture. Estuaries 20(2): 430 – 440.

Bayne, B.L. 1965. Growth and the delay of metamorphosis of the larvae of *Mytilus edulis* (L.). *Ophelia*, **2**, 1-47.

Bayne, B.L. 1976. The biology of mussel larvae. Cambridge: Cambridge University Press. [International Biological Programme 10.]

Bayne, B.L., Widdows, J. & R. J. Thompson. 1976. Physiological integrations. Cambridge: Cambridge University Press. [International Biological Programme 10.]

Calbrade, N.A., Holt, C.A., Austin, G.E., Mellan, H.J., Hearn, R.D., Stroud, D.A., Woton, S.R. & A.J. Musgrove. 2010. Waterbirds in the UK 2008/09. The Wetland Bird Survey. BTO/RSPB/JNCC in association with WWT, Thetford.

Carter, J.G. & R. Seed. 1998. Thermal potentiation and mineralogical evolution in *Mytilus* (Mollusca; Bivalvia). Vancouver: University of Calgary Press.

CLAMS. 2005. CLAMS Co-Ordinated Local Aquaculture Management Systems Carlingford Lough. pp. 150.

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

Crowe, O. 2005. Ireland's wetlands and their waterbirds: status and distribution. Birdwatch Ireland, Newcastle, Co. Wicklow.

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

CSO. 2000. Agricultural Census 2000. http://www.cso.ie/px/pxcoa2000/database/census%20of%20agriculture%202000/Louth/Louth.asp. Accessed 27/10/2010.

CSO. 2010a. Census 2006. http://beyond2020.cso.ie/Census/TableViewer/tableView.aspx?ReportId=75472 Accessed 1/10/2010.

CSO. 2010b. Statistics of Port Traffic 2009. http://www.cso.ie/releasespublications/documents/transport/current/spt.pdf

Dame, R.F.D. 1996. *Ecology of Marine Bivalves: an Ecosystem Approach.* New York: CRC Press Inc. [Marine

Science Series.]

CSO. 2011. http://census.cso.ie/Census/TableViewer/tableView.aspx?ReportId=75471. Populations of Towns. Accessed March 2011.

DARD. 2008. Farm Census 2008. http://www.ninis.nisra.gov.uk/mapxtreme/DataCatalogue.asp?button=Agriculture. Accessed 27/10/2010.

DARD, 2010. Fertilizer statistics. http://www.dardni.gov.uk/index/dard-statistics/agricultural-statistics/agricultural-statistics-ferts.htm. Accessed January 2011.

Department of Industrial and Forensic Science, 1976. *Carlingford Lough Survey*. Internal. Report. 36 pp.

Department of Transport. 2010 Transport Statistics Report. Maritime Statistics 2009. http://www.dft.gov.uk/adobepdf/162469/221412/221658/223721/669555/maritimestatistics2009.pdf

Doré, B. 2009. *Public Health Impact of Norovirus in the Environment*. ESAI Water Seminar, Dublin, 25th March 2009.

Douglas, D.G. 1992. Environment and mariculture: a study of Carlingford Lough. Ryland Research Ltd., Ireland.

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

Dyer, K .1972. *Estuaries: A Physical Introduction*. John Wiley & Sons, London.

EPA. 2010. Hydrometric Gauges Register 21/6/2010. Downloaded September 2010.

EPA. 2011. EPA STRIVE Programme 2007-2013. SADOSE - Safe Disposal of Sewage Effluent in Coastal Waters Designated for the Cultivation of Oysters and for Water-contact Recreation. http://www.marine.ie/home/research/ProjectsDatabase/CurrentProjects/SADOSE.htm. Accessed February 2011.

Failte Ireland. 2010. East & Midlands 2009. http://www.failteireland.ie/FailteCorp/media/FailteIreland/documents/Research%20and%20Statistics/Tourism%20Facts/2009/East_and_Midlands_2009.pdf

Ferreira, J.G., Hawkins, A.J.S., Monteiro, P., Service, M., Moore, H., Edwards, A., Gowen, R., Lourenco, P., Mellor, A., Nunes, J.P., Pascoe, P.L., Ramos, L., Sequeira, A., Simas, T. & J. Strong. 2007. SMILE – Sustainable Mariculture in northern Irish Lough Ecosystems – Assessment of Carrying Capacity for Environmentally Sustainable Shellfish Culture in Carlingford Lough, Strangford Lough, Belfast Lough, Larne Lough and Lough Foyle. Ed. IMAR – Institute of Marine Science. 100pp.

Ferreira, J.G., Hawkins, A.J.S., Monteiro, P., Moore, H., Service, M., Pascoe, P.L., Ramos, L. & A. Sequeira. 2008. Integrated assessment of ecosystem-scale carrying capacity in shellfish growing areas. *Aquaculture* **275:** 138-151.

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

Grainger, R.J.R. 1989. Fisheries and mariculture in the Irish Sea. In: *The Irish Sea: A Resource at Risk* (Ed. J.C. Sweeney). pp. 80-89. Geographical Society of Ireland, Special Publications No.3.

Grant, J., Enright, C.T. & A. Griswold. 1990. Resuspension and growth of *Ostrea edulis*: a field experiment. *Maine Biology*, **104**, 51-59.

Gosling, E.M. 1992. Genetics of *Mytilus*. Amsterdam: Elsevier Science Publ. [Developments in Aquaculture and Fisheries Science, no. 25]

Hild, A. & C-P. Günther. 1999. Ecosystem engineers: *Mytilus edulis* and *Lanice conchilega*. Berlin: Springer-Verlag.

Holt, T.J., Rees, E.I., Hawkins, S.J. & R. Seed. 1998. Biogenic reefs (Volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. *Scottish Association for Marine Science (UK Marine SACs Project)*, 174 pp.

Hydrographic Surveys Ltd. 2007. Greenore Current Metering (PN 23_07). Report prepared for RPS Consulting Engineers, Belfast.

International Ship Consultants Ltd. 2006. Navigational Risk Assessment Proposed Oriel Windfarm. Prepared on behalf of AQUAFACT International Services Ltd. August 2006.

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

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

Lane, D.J.W., Beaumont, A.R. & J.R. Hunter. 1985. Byssus drifting and the drifting threads of young postlarval mussel *Mytilus edulis*. *Marine Biology*, **84**, 301-308.

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

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

Lindesmith, L., Moe, C., Marionneau, S., Ruvoen, N., Jiang, X., Lindblad, L., Stewart, P., LePendu, J. & R. Baric. 2003. Human susceptibility and resistance to Norwalk virus infection. *Nat. Med.* **9** (5): 548–53. doi:10.1038/nm860. PMID 12692541.

Loughs Agency. 2009a. Lough Foyle Native Oyster Survey 2009.

Loughs Agency. 2010. http://www.loughs-agency.org/conservation/content.asp?catid=338. Accessed September 2010.

Lutz, R.A. & M.J. Kennish. 1992. Ecology and morphology of larval and early larval postlarval mussels. Amsterdam: Elsevier Science Publ. [Developments in Aquaculture and Fisheries Science, no. 25]

Marine Institute. 2010. Shellfish stocks and fisheries: Review 2009. pp. 72-75.

MERC Consultants Ltd. 2008. Status of Irish Aquaculture 2007. Prepare by MERC Consultants on behalf of the Marine Institute, Bord Iascaigh Mhara and Údarás na Gaeltachta (Editors R. Browne, B. Deegan, L. Watson, D. Mac Giolla Bhríde, M. Norman, M. Ó'Cinnéide, D. Jackson and T. O'Carroll).

Met Eireann. 2010a. Monthly Weather Bulletins 2005-2010. http://www.met.ie/climate/monthly-weather-bulletin.asp. Accessed September 2010.

Met Eireann. 2010b. Daily Data Reports for Dublin Airport. http://www.met.ie/climate/daily-data.asp. Accessed January 2011.

Met Office. 2010. Regional Mapped Climate Averages. http://www.metoffice.gov.uk/climate/uk/averages/regmapavge.html. Accessed January 2010.

Newell, R.I.E., Hilbish, T.J., Koehn, R.K. & C.J. Newell. 1982. Temporal variation in the reproductive cycle of *Mytilus edulis* L. (Bivalvia, Mytilidae) from localities on the east coast of the U.S.A. *Biological Bulletin, Marine Biological Laboratory, Woods Hole,* **162**, 299-310.

NIEA. 2010. Microbiological results for Cranfield Bay Bathing Water in Northern Ireland. http://www.ni-environment.gov.uk/cranfield-bw04to09.pdf. Accessed December 2010.

NISRA. 2010. http://www.nisra.gov.uk/demography/default.asp125.htm . Super Output Area 2001 - 2008. Accessed 1/10/2010.

NISRA, 2011. http://www.ninis.nisra.gov.uk/mapxtreme_towns/PopChangesIntMap/atlas.html. Towns and Villages - Population Changes. Accessed March 2011.

NITB. 2009. Tourism Facts 2009 Northern Ireland. http://www.nitb.com/DocumentPage.aspx?path=2e3c2831-b6cb-4bcd-a276-e0283e5bd203,1b5cd50d-c92b-4284-9b42-a59934eb3da6,82ea8dba-d01e-4eea-a4f6-577cd8878c9c,8feb55ce-8c72-4b33-813b-9a70542acabd

NITB. 2010. Northern Ireland Local Authority Tourism Estimates 2007-2009. http://www.nitb.com/DocumentPage.aspx?path=2e3c2831-b6cb-4bcd-a276-e0283e5bd203,b5d4e565-ef7a-4afe-b31e-ffff177e70cb,7990e2ce-9eca-4f91-a891-edc6e07db308

Norton, T.A. 1990. Introduction. In: The Irish Sea An Environmental Review. Part Three: Exploitable Living resources. Liverpool University press

NPWS. 2004. Carlingford Lough SPA Site Synopsis (Site Code: 004078). www.npws.ie

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

OSPAR. 2008. OSPAR List of Threatened and/or Declining Species and Habitats. Reference Number: 2008-6

Owili, M.A. 2003. Assessment of Impact of Sewage Effluents on Coastal Water Quality in Hafnarfjordur, Iceland. Kenya Marine and Fisheries Research Institute. UNU-Fisheries Training Programme pp. 39.

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

Petrucio, M.M., Mederios, A.O., Rosa, C.A. & A.R. Barbosa. 2005. Trophic state and microorganisms community of major sub-basins of the middle Rio Doce basin, southeast Brazil. Brazilian Archives of Biology and Technology **48(4):** 625-633.

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

Ramsar. 2008. Information Sheet on Ramsar Wetlands (RIS). Produced by JNCC: Version 3.1, 13/06/2008.

Richardson, C.A. & R. Seed. 1990. Predictions of mussel (*Mytilus edulis*) biomass on an offshore platform from single population samples. *Biofouling*, **2**, 289-297.

NRFA. 2010a. http://www.nwl.ac.uk/ih/nrfa/station_summaries/op/RiversAgency1.html. Accessed September 2010.

NRFA. 2010b. http://www.nwl.ac.uk/ih/nrfa/webdata/206001/g.html. Accessed September 2010.

RPS. 2011. Current metering data provided by RPS Consulting Engineers on behalf of Greenore Port Authority.

Seed, R. 1969a. The ecology of *Mytilus edulis* L. (Lamellibranchiata) on exposed rocky shores 2. Growth and mortality. *Oecologia*, **3**, 317-350.

Seed, R. 1969b. The ecology of *Mytilus edulis* L. (Lamellibranchiata) on exposed rocky shores 1. Breeding and settlement. *Oecologia*, **3**, 277-316.

Seed, R., (1993). Invertebrate predators and their role in structuring coastal and estuarine populations of filter feeding bivalves. Berlin: Springer-Verlag.

Seed, R. & Suchanek, T.H. 1992. Population and community ecology of *Mytilus*. Amsterdam: Elsevier Science Publ. [Developments in Aquaculture and Fisheries Science, no. 25.]

Shumway, S.E. 1992. Mussels and public health. Amsterdam: Elsevier Science Publ. [Developments in Aquaculture and Fisheries Science, no. 25]

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

Strathmann, M.F. 1987. *Reproduction and development of marine invertebrates of the Northern Pacific coast.* Seattle: University of Washington Press.

Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, P., McLean, I., Baker, H. & S, Whitehead. 2001. The UK SPA Network: its scope and content. Joint Nature Conservation Committee, Peterborough.

Taylor, J., Charlesworth, M. & M. Service. 1999. Nutrient inputs and trophic status of Carlingford Lough. The Queens University of Belfast and the Department of Agriculture for Northern Ireland.

Thiesen, B.F. 1972. Shell cleaning and deposit feeding in *Mytilus edulis* L. (Bivalvia). *Ophelia*, **10**, 49-55.

Thiesen, B.F. 1973. The growth of *Mytilus edulis* L. (Bivalvia) from Disko and Thule district, Greenland. *Ophelia*, **12**, 59-77.

Thompson, G.B. 1979. Distribution and population dynamics of the limpet *Patella aspera* (Lamarck) in Bantry Bay. *Journal of Experimental Marine Biology and Ecology*, **40**, 115-135.

Thompson, I.S., Richardson, C.A., Seed, R. & Walker, G., (2000). Quantification of mussel (*Mytilus edulis*) growth from power station cooling waters in response to chlorination procedures. *Biofouling*, **16**, 1-15.

UKHO. 2004. Admiralty Chart 2800. UK Hydrographic Office.

Valero, J. 2006. *Ostrea edulis* Growth and mortality depending on hydrodynamic parameters and food availability. *Department of Marine Ecology, Göteborg University*, Strömstad, Sweden. pp. 47.

Wilson, J.H. 1977. The growth of *Mytilus edulis* from Carlingford Lough. *Irish Fisheries Investigations* Series B (Marine), No. 17.

Appendix 1

Discharge Analysis Data 2010

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
Lurganare WWTW Effluent	S27BL	28/01/10	2.12	5			6.4				14.27	2.52	1.6	8	16.79	
Lurganare WWTW Effluent	S27BL	24/02/10	4.38	7			6.4				22.06	1.37	2.7	11	23.43	
Lurganare WWTW Effluent	S27BL	23/03/10	0.3	6			6.9				16.92	0.12	2.7	9	17.04	
Lurganare WWTW Effluent	S27BL	19/04/10	8.07	4			6.8				1.25	0.17	3.5	5	1.42	
Lurganare WWTW Effluent	S27BL	21/05/10	2.82	4			6.8				16.69	0.42	3.3	7	17.12	
Lurganare WWTW Effluent	S27BL	17/06/10	4.16	3			6.9				13.74	0.74	3.1	8	14.47	
Lurganare WWTW Effluent	S27BL	30/07/10	5.03	6			6.1				29.43	0.39	5.1	4	29.82	
Lurganare WWTW Effluent	S27BL	10/08/10	2.8	2			7				11.58	0.14	3	8	11.72	
Lurganare WWTW Effluent	S27BL	06/09/10	6.84	2			6.1				30.3	0.27	6.1	5	30.52	
Lurganare WWTW Effluent	S27BL	08/10/10	0.29	3			6.7				22.33	0.09	2.2	8	22.42	
Lurganare WWTW Effluent	S27BL	04/11/10	2.16	4			6.7				10.99	0.35	1.5	11	11.35	
Lurganare WWTW Effluent	S27BL	01/12/10	0.38	3			6.5				23.06	0.18	3.4	9	23.24	
Mullaghglass 1 WWTW Effluent Combined	S37AN	22/01/10	3.48	7			7.7				3.4	0.13	0.9	15	3.52	
Mullaghglass 1 WWTW Effluent Combined	S37AN	18/02/10	5.3	8			7.4				13.66	0.38	3.4	21	14.04	
Mullaghglass 1 WWTW Effluent Combined	S37AN	16/03/10	0.72	9			6.9				34	0.47	4.8	23	34.42	
Mullaghglass 1 WWTW Effluent Combined	S37AN	13/04/10	2.54	11			7.3				13.77	1.14	2.4	19	14.92	
Mullaghglass 1 WWTW Effluent Combined	S37AN	10/05/10	0.11	2			7				28.3	0.55	4.8	16	28.85	
Mullaghglass 1 WWTW Effluent Combined	S37AN	11/06/10	<0.094	4			7.1				30.1	0.21	4.5	19	30.32	
Mullaghglass 1 WWTW Effluent Combined	S37AN	08/07/10	0.12	3			6.8				36.4	0.75	5.4	19	37.2	
Mullaghglass 1 WWTW Effluent Combined	S37AN	04/08/10	<0.094	4			7.1				25.71	0.43	3.5	9	26.15	
Mullaghglass 1 WWTW Effluent Combined	S37AN	27/09/10	0.13	4			7.2				19.94	1.27	2.6	11	21.21	
Mullaghglass 1 WWTW Effluent Combined	S37AN	29/10/10	0.12	3			7.1				16.01	0.22	1.9	13	16.23	
Mullaghglass 1 WWTW Effluent Combined	S37AN	25/11/10	<0.094	10			7.1				15.39	0.56	2	14	15.95	
Mullaghglass 1 WWTW	S37AN	06/12/10	0.48	4			7.2				8.3	0.48	1.4	13	8.78	

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
Effluent Combined																
Newry WWTW Effluent	S27AC	04/01/10	10.51	14			7				0.4	0.04	<0.153	15	0.44	
Newry WWTW Effluent	S27AC	12/01/10	7.57	17		0.00409	6.9	0.1793	0.001	<0.000080	0.22	<0.003	<0.153	18	0.22	0.04773
Newry WWTW Effluent	S27AC	20/01/10	5.93	8			6.8				0.39	0.03	<0.153	14	0.42	
Newry WWTW Effluent	S27AC	28/01/10	6.15	3			7				4.25	0.01	0.5	<0.100	4.27	
Newry WWTW Effluent	S27AC	05/02/10	3.5	7			6.8				2.75	0.08	0.2	14	2.83	
Newry WWTW Effluent	S27AC	08/02/10	5.64	12		0.00776	6.9	0.1704	0.0012	0.0032	0.11	<0.003	<0.153	22	<0.196	0.0396
Newry WWTW Effluent	S27AC	16/02/10	7.42	12			6.9				0.19	<0.003	<0.153	14	<0.196	
Newry WWTW Effluent	S27AC	24/02/10	7.92	9			6.8				0.15	<0.003	<0.153	19	<0.196	
Newry WWTW Effluent	S27AC	04/03/10	3.16	12			6.9				10.89	0.04	1.5	17	10.93	
Newry WWTW Effluent	S27AC	12/03/10	5.91	11			6.9				0.23	<0.003	<0.153	21	0.23	
Newry WWTW Effluent	S27AC	15/03/10	5.97	9		0.00521	7	0.3499	<0.001	<0.000080	0.23	<0.003	0.2	22	0.23	0.08101
Newry WWTW Effluent	S27AC	23/03/10	11.37	17			6.8				0.33	<0.003	<0.153	22	0.33	
Newry WWTW Effluent	S27AC	08/04/10	6.24	7			7.1				<0.100	0.04	<0.153	14	<0.196	
Newry WWTW Effluent	S27AC	19/04/10	4.52	13			6.6				0.27	0.01	0.2	11	0.27	
Newry WWTW Effluent	S27AC	27/04/10	3.49	3			6.9				5.05	0.14	1	9	5.19	
Newry WWTW Effluent	S27AC	05/05/10	18.67	4			7.1				0.28	0.01	0.5	6	0.29	
Newry WWTW Effluent	S27AC	13/05/10	20.38	5		0.00189	7.1	0.2514	<0.001	0.00017	<0.100	0.01	0.4	11	<0.196	0.01933
Newry WWTW Effluent	S27AC	21/05/10	18.28	3			7				<0.100	0.01	0.7	13	<0.196	
Newry WWTW Effluent	S27AC	24/05/10	15.27	7			7				0.14	0.01	0.6	11	<0.196	
Newry WWTW Effluent	S27AC	01/06/10	11.9	32			7				0.1	<0.003	1.2	14	<0.196	
Newry WWTW Effluent	S27AC	09/06/10	11.83	6			7.2				<0.100	0.02	0.5	7	<0.196	

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
Newry WWTW Effluent	S27AC	14/06/10	13.72	3		<0.001	7.2	0.1511	0.00122		<0.100	0.03	<0.153	5	<0.196	0.01784
Newry WWTW Effluent	S27AC	17/06/10	17.48	3		0.00233	7.4	0.1177	<0.001	<0.000080	0.21	0.03	0.3	8	0.23	0.02032
Newry WWTW Effluent	S27AC	25/06/10	15.71	79			7.1				1.13	0.05	2.2	14	1.18	
Newry WWTW Effluent	S27AC	06/07/10	9.83	6			7.2				3.16	0.04	1.4	13	3.2	
Newry WWTW Effluent	S27AC	22/07/10	4.15	4			7.3			0.0005	5.18	0.04	0.6	6	5.22	
Newry WWTW Effluent	S27AC	02/08/10	3.82	5			7				1.63	0.03	0.6	5	1.66	
Newry WWTW Effluent	S27AC	10/08/10	0.75	10			7.3				19.61	0.46	3.8	18	20.08	
Newry WWTW Effluent	S27AC	18/08/10	22.22	4		0.00157	7.2	0.1787	<0.001	0.0029	<0.100	0.03	0.7	9	<0.196	0.02602
Newry WWTW Effluent	S27AC	23/08/10	21.17	2			7.5				<0.100	0.05	0.3	5	<0.196	
Newry WWTW Effluent	S27AC	26/08/10	16.15	23			7.1				<0.100	0.01	0.4	18	<0.196	
Newry WWTW Effluent	S27AC	03/09/10	25.88	5			7.4				<0.100	0.04	0.3	16	<0.196	
Newry WWTW Effluent	S27AC	06/09/10	25.58	3			7.8				<0.100	0.07	0.3	6	<0.196	
Newry WWTW Effluent	S27AC	14/09/10	7.62	6		0.00138	6.9	0.09967	<0.001	<0.000080	0.26	0.01	<0.153	11	0.28	0.01826
Newry WWTW Effluent	S27AC	22/09/10	7.31	2			6.9				0.38	0.02	<0.153	5	0.41	
Newry WWTW Effluent	S27AC	30/09/10	7.56	6		0.00197	6.8	0.3333	<0.001	<0.000080	<0.100	<0.003	<0.153	13	<0.196	0.03731
Newry WWTW Effluent	S27AC	08/10/10	7.89	6			6.9				<0.100	0.01	<0.153	13	<0.196	
Newry WWTW Effluent	S27AC	11/10/10	5.86	3		0.00474	6.9	0.1592	0.00102	<0.000080	6.67	0.03	0.8	19	6.7	0.02862
Newry WWTW Effluent	S27AC	19/10/10	15.23	5			7.2				<0.100	0.01	0.8	12	<0.196	
Newry WWTW Effluent	S27AC	27/10/10	8.02	11			6.9				<0.100	<0.003	0.2	14	<0.196	
Newry WWTW Effluent	S27AC	04/11/10	11.53	5			7				<0.100	0.01	0.2	9	<0.196	
Newry WWTW Effluent	S27AC	12/11/10	4.39	3			6.6				<0.10	0.01	<0.153	6	<0.196	

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
											0					
Newry WWTW Effluent	S27AC	15/11/10	4.31	3		0.00246	6.8	0.127	0.00137	0.00011	0.24	0.01	0.2	3	0.25	0.03041
Newry WWTW Effluent	S27AC	23/11/10	8.46	5			7.4				0.11	0.01	<0.153	7	<0.196	
Newry WWTW Effluent	S27AC	01/12/10	9.96	3			7				<0.100	<0.003	<0.153	7	<0.196	
Newry WWTW Effluent	S27AC	09/12/10	13.57	10			7				<0.100	0.01	<0.153	13	<0.196	
Newry WWTW Effluent	S27AC	14/12/10	6.33	4		0.0027	6.8	0.2386	0.00193	<0.000080	<0.100	<0.003	<0.153	6	<0.196	0.04198
Newry WWTW Effluent	S27AC	17/12/10	9.85	5			7.6				<0.100	<0.003	0.3	11	<0.196	
Newry WWTW UWWTR Effluent	U27AC	16/01/10	3.58	11			6.9				0.18	0.02	<0.153	23	0.2	
Newry WWTW UWWTR Effluent	U27AC	20/01/10	6.06	6			7.1				0.99	0.23	<0.153	9	1.22	
Newry WWTW UWWTR Effluent	U27AC	05/02/10	10.09	4			7.1				0.39	0.05	<0.153	6	0.45	
Newry WWTW UWWTR Effluent	U27AC	16/02/10	7.55	14			7				0.2	<0.003	<0.153	13	0.2	
Newry WWTW UWWTR Effluent	U27AC	12/03/10	6.61	15			6.7				0.2	<0.003	<0.153	21	0.2	
Newry WWTW UWWTR Effluent	U27AC	23/03/10	8.82	14			6.9				0.38	0.01	0.2	11	0.38	
Newry WWTW UWWTR Effluent	U27AC	08/04/10	5.99	6			7.1				<0.100	0.04	<0.153	18	<0.196	
Newry WWTW UWWTR Effluent	U27AC	19/04/10	4.4	3			6.5				0.25	0.01	0.2	7	0.26	
Newry WWTW UWWTR Effluent	U27AC	05/05/10	20.61	5			6.9				0.28	<0.003	0.5	8	0.28	
Newry WWTW UWWTR Effluent	U27AC	21/05/10	18.45	15			7.1				0.13	0.03	0.9	9	<0.196	
Newry WWTW UWWTR Effluent	U27AC	09/06/10	11.7	7			7.2				<0.100	0.01	0.4	14	<0.196	
Newry WWTW UWWTR Effluent	U27AC	25/06/10	17.08	36			7				0.87	0.05	1.7	12	0.92	

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
Newry WWTW UWWTR Effluent	U27AC	06/07/10	8.96	12			7				1.09	0.01	0.6	10	1.11	
Newry WWTW UWWTR Effluent	U27AC	22/07/10	8.57	7			7.2				<0.100	0.08	0.3	11	<0.196	
Newry WWTW UWWTR Effluent	U27AC	02/08/10	3.84	7			7				1.56	0.03	0.6	8	1.59	
Newry WWTW UWWTR Effluent	U27AC	26/08/10	16.14	18			7.1				<0.100	0.01	0.4	20	<0.196	
Newry WWTW UWWTR Effluent	U27AC	06/09/10	25.46	2			7.8				<0.100	0.06	0.3	6	<0.196	
Newry WWTW UWWTR Effluent	U27AC	22/09/10	7.34	2			6.9				0.11	0.02	<0.153	4	<0.196	
Newry WWTW UWWTR Effluent	U27AC	08/10/10	10.81	3			7.1				<0.100	0.04	<0.153	8	<0.196	
Newry WWTW UWWTR Effluent	U27AC	19/10/10	16.1	6			7.2				0.13	0.03	0.4	15	<0.196	
Newry WWTW UWWTR Effluent	U27AC	12/11/10	4.78	8			6.4				0.13	0.01	<0.153	8	<0.196	
Newry WWTW UWWTR Effluent	U27AC	23/11/10	8.31	5			7.3				0.87	0.09	0.2	8	0.96	
Newry WWTW UWWTR Effluent	U27AC	05/12/10	9.51	6			7				0.16	0.09	<0.153	13	0.25	
Newry WWTW UWWTR Effluent	U27AC	17/12/10	9.81	6			7.6				<0.100	<0.003	<0.153	19	<0.196	
Poyntzpass WWTW Effluent	S27BW	28/01/10	3.69	8			7				13.01	0.84	2.8	9	13.85	
Poyntzpass WWTW Effluent	S27BW	24/02/10	3.98	11			7.5				13.57	0.37	3.4	19	13.94	
Poyntzpass WWTW Effluent	S27BW	23/03/10	0.16	5			6.6				15.17	0.45	2	10	15.63	
Poyntzpass WWTW Effluent	S27BW	19/04/10	0.72	5			6.7				7.47	0.16	2	8	7.63	
Poyntzpass WWTW Effluent	S27BW	21/05/10	0.3	26			6.6				21.71	0.63	3.7	107	22.34	
Poyntzpass WWTW Effluent	S27BW	17/06/10	13.19	9			7.2				0.15	0.04	4.7	7	<0.196	
Poyntzpass WWTW Effluent	S27BW	30/07/10	6.22	18			7.1				4.75	0.03	8.8	17	4.78	
Poyntzpass WWTW Effluent	S27BW	10/08/10	0.17	6			6.7				29.16	0.14	3.4	16	29.3	
Poyntzpass WWTW Effluent	S27BW	06/09/10	0.49	1			6.7				26.35	0.27	3.6	8	26.62	
Poyntzpass WWTW Effluent	S27BW	08/10/10	0.48	15			7.7				13.85	0.29	3	28	14.14	
Poyntzpass WWTW Effluent	S27BW	04/11/10	1.7	10			7.1				5.06	0.16	0.8	8	5.22	

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
Rathfriland MBR WWTW Effluent	S27AM	22/01/10	0.11	1			7.8				5.74	0.04	0.6	1.1	5.79	
Rathfriland MBR WWTW Effluent	S27AM	18/02/10	<0.094	1			7.1				4.41	<0.003	1	0.7	4.41	
Rathfriland MBR WWTW Effluent	S27AM	09/03/10	1	2			6.6				9.53	0.15	2.2	1	9.69	
Rathfriland MBR WWTW Effluent	S27AM	13/04/10	<0.094	2			7.1				3.64	<0.003	0.6	0.2	3.64	
Rathfriland MBR WWTW Effluent	S27AM	10/05/10	0.44	2			7.2				3.51	0.03	2.2	0.8	3.55	
Rathfriland MBR WWTW Effluent	S27AM	11/06/10	<0.094	<0.186			7.2				4.87	0.03	2.4	1.1	4.89	
Rathfriland MBR WWTW Effluent	S27AM	08/07/10	<0.094	2			7.2				4.15	0.03	2.3	1	4.18	
Rathfriland MBR WWTW Effluent	S27AM	04/08/10	<0.094	1			7.2				6.36	0.03	2.7	1.8	6.39	
Rathfriland MBR WWTW Effluent	S27AM	13/10/10	<0.094	1			6.8				8.06	0.03	2.4	0.4	8.08	
Rathfriland MBR WWTW Effluent	S27AM	29/10/10	0.11	1			6.8				6.8	<0.003	1.2	0.3	6.8	
Rathfriland MBR WWTW Effluent	S27AM	25/11/10	0.16	3			6.9				6.77	0.04	1.4	1.7	6.81	
Rathfriland MBR WWTW Effluent	S27AM	06/12/10	0.24	1			7.1				4.81	0.03	1.2	1	4.84	
Rathfriland WWTW UWWTR Effluent	U27AM	22/01/10	0.11	1			7.6				5.19	0.02	1	3	5.21	
Rathfriland WWTW UWWTR Effluent	U27AM	13/04/10	0.18	2			7				4.24	0.03	0.7	<0.100	4.27	
Rathfriland WWTW UWWTR Effluent	U27AM	04/08/10	<0.094	1			7.2				6.18	0.02	3	2	6.2	
Rathfriland WWTW UWWTR Effluent	U27AM	29/10/10	<0.094	16			6.9				4.86	<0.003	1.2	2	4.85	
Warrenpoint WWTW Effluent	S27AD	04/01/10	0.92	4	460.00		7.0				3.01	0.31	0.5	10.0	3.32	
Warrenpoint WWTW Effluent	S27AD	20/01/10	0.57	3	38.86		7.0				3.27	0.14	0.5	7.0	3.41	

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
Warrenpoint WWTW Effluent	S27AD	05/02/10	1.37	8	77.86		7.1				4.14	0.20	0.4	16.0	4.34	
Warrenpoint WWTW Effluent	S27AD	16/02/10	1.22	7	113.00		7.1				6.99	0.36	0.7	13.0	7.35	
Warrenpoint WWTW Effluent	S27AD	04/03/10	5.87	8	728.66		7.1				7.42	0.19	1.8	16.0	7.61	
Warrenpoint WWTW Effluent	S27AD	15/03/10	10.99	9	50.12		7.4				1.62	0.25	2.2	14.0	1.87	
Warrenpoint WWTW Effluent	S27AD	31/03/10	<0.094	5	76.75		6.6				1.96	0.10	<0.153	10.0	2.07	
Warrenpoint WWTW Effluent	S27AD	16/04/10	1.69	11	39.56		7.0				5.32	0.29	0.8	10.0	5.61	
Warrenpoint WWTW Effluent	S27AD	27/04/10	4.36	4	51.46		7.1				3.59	0.42	1.5	6.0	4.01	
Warrenpoint WWTW Effluent	S27AD	13/05/10	2.24	7	41.15		7.0				12.17	0.48	1.3	16.0	12.65	
Warrenpoint WWTW Effluent	S27AD	09/06/10	9.21	7	41.28		7.4				2.50	1.18	0.3	12.0	3.68	
Warrenpoint WWTW Effluent	S27AD	25/06/10	12.57	8	58.27		7.2				<0.100	0.06	2.1	10.0	<0.196	
Warrenpoint WWTW Effluent	S27AD	06/07/10	11.88	16	48.64		7.2				<0.100	0.05	1.0	15.0	<0.196	
Warrenpoint WWTW Effluent	S27AD	22/07/10	1.35	3	38.79		7.1				3.24	0.57	0.3	4.0	3.81	
Warrenpoint WWTW Effluent	S27AD	02/08/10	8.50	7	48.18		7.4				0.54	0.34	1.0	7.0	0.88	
Warrenpoint WWTW Effluent	S27AD	18/08/10	6.87	5	61.78		7.3				2.57	0.48	0.8	10.0	3.05	
Warrenpoint WWTW Effluent	S27AD	03/09/10	6.12	4	44.68		7.2				7.14	0.59	0.4	10.0	7.73	
Warrenpoint WWTW Effluent	S27AD	14/09/10	0.18	3	52.55		7.2				4.18	0.16	0.2	8.0	4.34	
Warrenpoint WWTW Effluent	S27AD	30/09/10	1.73	3	36.83		6.9				6.02	0.43	<0.153	5.0	6.45	
Warrenpoint WWTW Effluent	S27AD	11/10/10	2.80	2	843.50		7.5				5.68	0.37	0.8	14.0	6.05	

Sample Point Description	Site Code	Date	NH_4 mg/l	BOD (ATU) mg/l O2	Cl mg/l	Cu mg/l	pH	Fe mg/l	Pb mg/l	Hg mg/l	NO_3 mg/l	NO_2 mg/l	P (SRP) mg/l	SS mg/l	Total Oxidised N mg/l as N	Zn mg/l
Warrenpoint WWTW Effluent	S27AD	12/11/10	0.97	4	51.74		6.9				4.31	0.18	0.4	9.0	4.49	
Warrenpoint WWTW Effluent	S27AD	23/11/10	2.04	3	108.93		7.1				4.08	0.23	0.7	7.0	4.30	
Warrenpoint WWTW Effluent	S27AD	09/12/10	6.98	11	549.76		7.2				4.42	0.25	0.7	18.0	4.67	
Warrenpoint WWTW Effluent	S27AD	17/12/10	4.74	3	63.35		7.7				4.41	0.22	0.3	6.0	4.63	

NH_4 Ammonium, NO_3 Nitrate, NO_2 Nitrite, P Phosphorus, BOD Biochemical Oxygen Demand, SS Suspended Solids, Cl Chloride, Cu Copper, Fe iron, Pb Lead, Hg Mercury, Zn Zinc

Appendix 2

Shellfish Sampling *E. coli* Results

AQUALAB

Donegal Road
Killybegs
Co. Donegal
Ireland
Tel [illegible]
Fax [illegible]

CERTIFICATE OF ANALYSIS

Account # : Aquafact International Services
Brendan O'Connor
12 Kilkerrin Park
Lisbawn
Co. Galway

Report No	: 10-04993
No. Of Samples	: 2
Acceptance Date	: 20/10/2010
Analysis Date	: 20/10/2010
Date of Issue	: 26/10/2010
Contact	: Brendan O'Connor

Comments
2 x samples Pacific oysters ex [illegible]
Sampled 19/10/10 by [illegible]

SAMPLE NO	SAMPLE TYPE	CLIENT REF	TEST METHOD	TEST DESCRIPTION	RESULT UNITS
10-04993-(01)	Oysters	PO 4	ISO 16649-3	E. coli	<20 MPN/100g
10-04993-(02)	Oysters	PO 3	ISO 16649-3	E. coli	<20 MPN/100g

[illegible]

Authorised by
Quality Manager
[illegible]

[illegible]

AQUALAB

CERTIFICATE OF ANALYSIS

Account # : Aquafact International Services Brendan O'Connor 12 Kilkerrin Park Lisbawn Co. Galway	Report No : 10-04994 No. Of Samples : 7 Acceptance Date : 20/10/2010 Analysis Date : 20/10/2010 Date of Issue : 26/10/2010 Contact : Brendan O'Connor

Comments
[illegible]

SAMPLE NO	SAMPLE TYPE	[illegible]	TEST METHOD	[illegible]	RESULT / UNITS
10-04994-(01)	Mussels	BM 1	ISO 16649-3	E. coli	330 MPN/100g
10-04994-(02)	Mussels	BM 2	ISO 16649-3	E. coli	1,300 MPN/100g
10-04994-(03)	Mussels	BM 3	ISO 16649-3	E. coli	20 MPN/100g
10-04994-(04)	Mussels	BM 4	ISO 16649-3	E. coli	[illegible] MPN/100g
10-04994-(05)	Mussels	BM 5	ISO 16649-3	E. coli	[illegible] MPN/100g
10-04994-(06)	Mussels	BM 6	ISO 16649-3	E. coli	[illegible] MPN/100g
10-04994-(07)	Mussels	BM 7	ISO 16649-3	E. coli	< 20 MPN/100g

[illegible]

Authorised by:

AQUAL

CERTIFICATE OF ANALYSIS

Account #	Aquafact International S[illegible]lan Brendan O'Connor 12 Kilkerrin Park Lisbawn Co. Galway

Report No	: 10-06199
No. Of Samples	: 1
Acceptance Dat[illegible]	[illegible]
Analysis Date	[illegible]
Date of Issue	[illegible]
Contact	: Brendan O'Connor

Comments:
1 x sample pacific oysters ex Carlingford Lough - PD

SAMPLE NO	SAMPLE TYPE	[illegible]	[illegible]	[illegible]	[illegible]
10-06199-(01)	Oysters	PD1	ISO 16649-3	E. col[illegible]	<18 MPN/100g

Authorised By:
Quality Manage[illegible]
Geraldine Fox

Appendix 3

Water Sampling *E. coli* Results

NI Water Analytical Services
Certificate of Analysis

Sampled Date: 20 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1336667 / 2010-10-27
Sample ID: AQUAFT_4W-10-13

<u>Aquaft Private Sample point</u>

2 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	32.0	MPN		
Total coliforms	162.0	MPN		

Sample Reference = W

Sample Comments:

Issued by: **Natasha McMonagle (4W)**
Microbiology Manager
Date: **27-Oct-2010**

[illegible]

Contact No: 028 7 1400[illegible]
NI Water, Gransha Grange
106 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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northern ireland water

Sampled Date: 20 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1399988 / 2010-10-27
Sample ID: AQUAFT 4W-10 13sb00l

Aquaft Private Sample point

12,Kilcrimin Park, Liosbaun, Tuam Road, Galway City, Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	6.0	MPN		
Total coliforms	94.0	MPN		

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Sample Comments:

Issued by: Natasha McMenagle (JW)
Microbiology Manager

Date: 27-Oct-2010

[illegible]

Contact No. 08457 440088
NI Water, Dalvin Grange
10A Irish Street, Altnagelvin
Londonderry
BT47 2LD

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northern ireland water

Sampled Date: 20 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1336659/ 2010-10-27
Sample ID: AQUAFT_4W-10-19

Aquaft Private Sample point

12,Killeen Park, Loobaun, Tuam Road, Galway City, G

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Leve
E. coli	4.0	MPN		
Total coliforms	30.0	MPN		

Sample Reference ... '3

Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager
Date: 27-Oct-2010

Contact No: 08457 440088
NI Water, Belvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date:	20 Oct 2010		
Received Date:	20 Oct 2010	**Certificate Id:**	1?36670/ 2010-10-27
Completed Date:	21 Oct 2010	**Sample ID:**	AQUAFT_4W-10-1330

Aquafi Private Sample point

2 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	2.0	MPN		
Total coliforms	4.0	MPN		

Sample Reference = W4

Sample IlomIT!»t1

Issued by:	**Natasha McMonagle (4W)** **Microbiology Manager**
Date:	**27-Oct-2010**

[illegible]

Contact No: 08457 440088
NI Water, Galvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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northern ireland water

Sampled Date: 20 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1236571 / 2010-10-27
Sample ID: AQUAPT_4W-10-13365

Aqualt Private Sample point

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Lev
E. coli	0.0	MPN		
Total coliforms	10.0	MPN		

Sample Reference = WS

Sample Comments:

Issued by: **Natasha McMonagle (4W)**
Microbiology Manager
27-Oct-2010

[illegible]

Contact No: 08457 440088
NI Water, Gelvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 3LD

[illegible]ervices
[illegible] Analysis

Sampled Date: 20 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate No: 1330672 / 2010-10-27
Sample ID: AQUAFT_4W-10-1330672

Aquafit Private Sample point

15 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	0.0	MPN		
Total coliforms	5.0	MPN		

Sample Reference:

Sample Comments:

Issued by: **Natasha McMonagle (4W)**
Microbiology Manager
27-Oct-2010

Contact No: 08457 440088
NI Water, Gelvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1325673 / 2010-10-27
Sample ID: AQUAFT_4W-10-13[illegible]

Aquafit Private Sample point

12 Kilkeenin Park, Lissbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	0.0	MPN		
Total coliforms	2.0	MPN		

Sample Reference=

Sample Comments:

Issued By: Natasha McMonagle (4W)
Microbiology Manager
27-Oct-2010

[illegible]

Contact No: 08457 440088
NI Water, Gelvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: [illegible] / 2010-10-27
Sample ID: AQUAFT_4W-10-[illegible]

Aquaft Private Sample point

12 [illegible] Park, [illegible], Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	10.0	MPN		
Total coliforms	10.0	MPN		

Sample Reference = W6

Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager

Date: 27-Oct-2010

Contact No: 08457 440088
NI Water, Gelvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1330075 / 2010-10-27
Sample ID: AQUAFT_4W-10-1330075

Aquaft Private Sample point

2 Kilconnon Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and	ethod Reference	Result	Unit	Pass Fail	Fail Leve
E. coli		0.0	MPN		
Total coliforms		0.0	MPN		

Sample Reference

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Issued by: **Natasha McMonagle (4W)**
Microbiology Manager

Date: **27-Oct-2010**

[illegible]

Contact No: 08457 440088
NI Water, Galvin Grange
105 Main Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1386676 / 2010-10-27
Sample ID: AQUAFT_4W 10-1386676

Aquafi Private Sample point

2,Kilkeimm Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	0.0	MPN		
Total coliforms	0.0	MPN		

Sample Reference = W10

Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager

Date: 27-Oct-2010

[illegible]

Contact No: 08457 440088
NI Water, Gransha Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1336677 / 2010-10-07
Sample ID: AQUAFT_4W-10-1336677

Aquaft Private Sample point

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	2.0	MPN		
Total coliforms	4.0	MPN		

Sample Reference = W11

Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager
27-Oct-2010

[illegible]

Contact No: 08457 440088
NI Water, Gavin Grange
108 Ash Street, Altnagelvin
Londonderry
BT47 3LD

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northern ireland water

Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1586078 / 2010.10-27
Sample ID: AQUAFT_4W-10-133687

Aquafi Private Sample point

12 Kilbeerin Park, Lissbaun Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass Fail	Fail Level
E. coli	0,0	MPN		
Total coliforms	18,0	MPN		

Sample Reference = W12

Sample Comments:

Issued by: **Natasha McMonagle (4W)**
Microbiology Manager
27-Oct-2010

[illegible]
Tests marked ' in this report are not included in the UKAS Accreditation Schedule for Analytical Services [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Contact No: 08457 440088
NI Water, Gelvin Grange
105 [illegible] Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: [illegible] 2010-10-27
Sample ID: AQUAFT_4W 10193

Aquafit Private Sample point

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass Fail	Fail Level
E. coli	72.0	MPN		
Total coliforms	[illegible]	MPN		

Sample Reference = R1

Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager

Date: 27-Oct-2010

[illegible]

Contact No: 38457 440088
NI Water, Gelvin Grange
115 Irish Street, Altnagelvin
Londonderry
BT47 2LD

2148

NI Water Analytical Services

Certificate of Analysis

Sampled Date: 19 Oct 2010

Received Date: 20 Oct 2010

Completed Date: 21 Oct 2010

Certificate Id: 1336680 / 2010-10-27

Sample ID: AQUAFT_4W-10-1336680

<u>Aquaft Private Sample point</u>

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	96.0	MPN		
Total coliforms	404.0	MPN		

Sample Reference = R2

Sample Comments:

Issued by: **Natasha McManagle (4W)**
Microbiology Manager

Date: 27-Oct-2010

[illegible]

Contact No: 08457 440088
NI Water, Galvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date:	19 Oct 2010		
Received Date:	20 Oct 2010	**Certificate Id:**	1326651 / 2010-10-27
Completed Date:	21 Oct 2010	**Sample ID:**	AQUAFT_4W-10-1326651

<u>Aquafi Private Sample point</u>

12 Killamin Park, Liosbaun, Tuam Road, Galway City, Co

Parameter and Method Reference	Result	Unit	Pass Fail	Fail Level
E. coli	16.0	MPN		
Total coliforms	66.0	MPN		

Sample Reference = R3

Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager
Date: 27-Oct-2010

[illegible]

Contact No: 028 7 [illegible]
NI Water, Gelvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

Northern Ireland Water

Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1356682/ 2010-10-27
Sample ID: AQUAFT AW-10-1356682

Aquaft Private Sample point

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	[illegible]	MPN		
Total coliforms	[illegible]	MPN		

Sample Referenc [illegible]

Sample Comments:

Issued by: Natasha McMonagle (NW)
Microbiology Manager

Date: 27-Oct-2010

Please note results relate only to the items tested.
[illegible]
[illegible] Belfast, BT14 6TE. [illegible] NI Water, [illegible] Grange, 105 Irish Street, Londonderry, BT47 2LD.
[illegible]
[illegible]

Contact No: 08457 440088
NI Water, Glenn Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Northern Ireland water

Sampled Date: 19 Oct 2010

Received Date: 20 Oct 2010

Completed Date: 21 Oct 2010

Certificate Id: 1326661 / 2010-10-27

Sample ID: AQUAFT_4W-10-1336660

Aquaft Private Sample point

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass-Fail	Fail Level
E. coli	6.0	MPN		
Total coliforms	78.0	MPN		

Sample Reference = R5

Sample Comments:

Issued by: **Natasha McMonagle (4W)**
Microbiology Manager

Date: 27-Oct-2010

[illegible]

Contact No: 08457 440088

NI Water, Gelvin Grange

105 Irish Street, Altnagelvin

Londonderry

BT47 2LD

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northern ireland water

Sampled Date: 19 Oct 2010

Received Date: 20 Oct 2010

Completed Date: 21 Oct 2010

Certificate Id: 1336684 / 2010-10-27

Sample ID: AQUAFT_4W-10-1336684

Aquaft Private Sample point

12 Kilvernin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	0.0	MPN		
Total coliforms	4.0	MPN		

Sample Reference = R

Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager

Date: 27-Oct-2010

[illegible]

Contact No: 08457 440088

NI Water, Gelvin Grange

105 Irish Street, Altnagelvin

Londonderry

BT47 2LD

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northern ireland water

Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id. 1386665 / 2010-10-27
Sample ID: AQUAFT_IW-10-1386665

Aquaft Private Sample poin

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Leve
E. coli	2200.0	MPN		
Total coliforms	241000.0	MPN		

Sample Reference = D1

ple Comments:

Natasha McMonagle (4W
Microbiology Manager
llu 27-Oct-2010

[illegible]

Contact No. 08457 440088
NI Water, Celyn Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

Water Analytical Services
Certificate of Analysis

Sampled Date:	14 Oct 2010		
Received Date:	20 Oct 2010	**Certificate Id:**	1336886 / 2010-10-27
Completed Date:	21 Oct 2010	**Sample ID:**	AQUAFT_4W-10-133088

Aquafi Private Sample point

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail
E. coli		MPN	
Total coliforms		MPN	

Sample Result: [illegible]

Sample Comments:

Issued by: **Natasha McManagle (4W)**
Microbiology Manager
Date: 27-Oct-2010

Please note results apply relate only to the items tested.
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
This certificate shall not be reproduced except in full, without written approval of the laboratory.

Contact No: 08457 440088
NI Water, Gelvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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Sampled Date: 19 Oct 2010
Received Date: 20 Oct 2010
Completed Date: 21 Oct 2010

Certificate Id: 1306667 / 2010-10-27
Sample ID: AQUAFT_4W-10-1306667/

Aquaft Private Sample point

12,Kilcornin Park, Doughiska Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass Fail	Fail Level
E. coli	120.0	MPN		
Total coliforms	1650.0	MPN		

Sample Reference = D3
Sample Comments:

Issued by: Natasha McMonagle (4W)
Microbiology Manager
Date: 27-Oct-2010

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Contact No: 08457 440088
NI Water, Galvin Grange
105 Irish Street, Altnagelvin
Londonderry
BT47 2LD

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I Water Analytical Services

Certificate of Analysis

northern ireland water

Sampled Date: 19 Oct 2010

Received Date: 20 Oct 2010

Completed Date: 21 Oct 2010

Certificate Id: 1536508 / 2010-10-27

Sample ID: AQUAFT_4W 10-1338688

Aquaft Private Sample point

12 Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Gal

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	5300.0	MPN		
Total coliforms	93800.0	MPN		

mple Reference ill

Sample Comments

Issued by: Natasha McMonagle (4W)
Microbiology Manager

Date: 27-Oct-2010

Contact No: 08457 440088

NI Water, Gelvin Grange

105 Dash Street, Altnagelvin

Londonderry

BT47 2LD

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Sampled Date:	19 Oct 2010
Received Date:	20 Oct 2010
Completed Date:	21 Oct 2010

Certificate Id: 1336680 / 2010-10-27
Sample ID: AQUAFT_4W-10-1336680

Aquafit Private Sample point

12,Kilkerrin Park, Liosbaun, Tuam Road, Galway City, Co Galway

Parameter and Method Reference	Result	Unit	Pass/Fail	Fail Level
E. coli	4.0	MPN		
Total coliforms	42.0	MPN		

Sample Reference = D6

Sample Comments:

Issued by: **Natasha McMonagle (4W)**
Microbiology Manager
27-Oct-2010

[illegible]
Tests marked * in this report are not included in the UKAS Accreditation Schedule for [illegible]
Tests marked [illegible] were subcontracted. [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

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