Sanitary Survey Review for Strangford Lough

Produced by AQUAFACT International Services Ltd

On behalf of The Food Standards Agency in Northern Ireland

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Aquafact International Services Ltd.
12 Kilkerrin park
Tuam Road
Galway city
www.aquafact.ie

info@aquafact.ie

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Glossary

AFBI	Agri-Food and Biosciences Institute
ANOVA	Analysis Of Variance
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; is the level of water that charted depths displayed on a nautical chart are measured from. Common chart datums are lowest astronomical tide and mean lower low water
CEFAS	Centre for Environmental, Fisheries & Aquaculture Science
CEH	Centre for Ecology & Hydrology
C-Mar	Centre for Marine Resources and Mariculture
CSO	Combined Sewer Overflow
DAERA	Department of Agriculture, Environment and Rural Affairs
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 substrates
Epiflora	Plants living on the surface of marine or freshwater substrates
Fetch	The distance a wave can travel towards land without being blocked

FFT	Flow to Full Treatment
Fouling	Accumulation of unwanted material on solid surfaces, most often in an aquatic environment.
FSA in NI	Food Standards Agency in Northern Ireland
FTU	Formazin Turbidity Unit
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
Hydrodynamic	Forces in or motions of liquids
Hydrography	The description and analysis of the physical conditions, boundaries, flows and related characteristics of water bodies
LAT	Lowest Astronomical Tide
Marpol 73/78	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. Marpol is short for Marine Pollution, 73 for 1973 and 78 for 1978.
MPN	Most Probable Number
MSD	Marine Sanitation Device
NAP	Nitrates Action Programme
ND	Not Detectable
NH_4	Ammonium
NI Water	Northern Ireland Water
NO_2	Nitrite
NO_3	Nitrate
NR	Nature Reserve
NRFA	National River Flow Archive
NRL	National Reference Laboratory
Ordnance Datum	OD
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
Pseudofaeces	Material rejected by suspension or deposit feeders as potential food before entering the gut
PSP	Paralytic Shellfish Poisoning
PSU	Practical Salinity Units
RAMSAR	A term adopted following an international conference, held in 1971 in Ramsar in Iran, to identify wetland sites of international importance, especially as waterfowl habitat.
Regulation (EU) 2017/625	of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SLLP	Strangford Lough and Lecale Partnership
SMILE	Sustainable Mariculture in northern Irish Lough Ecosystems
SOA	Super Output Areas or ward
SPA	Special Protection Area
SPS	Sewage Pumping Station
SS	Suspended Solids
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
WWTW	Waste Water Treatment Works

1. Executive Summary

Under Regulation (EU) 2017/625 and its subsequent Implementing Regulation (EU) 2019/627, 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 determine the extent to which potential sources of pollution may impact on a production area and ultimately inform the sampling plan for the Official Control Microbiological Monitoring Programme, the results of which determine the annual classification for bivalve mollusc production areas. In accordance with the EURL Guide to Good Practice on the microbiological monitoring of bivalve mollusc harvesting areas, a re-evaluation of pollution sources and the sampling plan (primary sanitary survey) should be undertaken if a time trigger (6 years or > since last survey) or change in the environment has occurred. As the sanitary survey for Strangford Lough was completed in 2011 a review of this sanitary survey is required. This report will review any changes to Strangford Lough and assess whether or not the changes are likely to affect the microbiological concentration of the classified production area.

Strangford Lough is a large marine lough located south of Newtownards and northeast of Downpatrick, Northern Ireland. The lough is 24km long, 8km wide and 59m in depth at its deepest point, however much of the lough is less than 20m deep. The main freshwater sources to Strangford Lough are the Comber River in the northwest and the Quoile River in the southwest. The lough connects to the Irish Sea through an inlet known as ‘The Narrows’. The Narrows are relatively deep (30m) and are subjected to strong tidal currents of over 3.6m/s while conversely some sheltered inlets on the western shores have virtually still water. Many islands, reefs and rocks are distributed throughout the lough and the shore is approximately 240km in length and is highly indented. The lough supports populations of blue mussels (*Mytilus edulis*), native oysters (*Ostrea edulis*), pacific oysters (*Crassostrea gigas*) and scallops (*Pecten maximus*), all of which have designated fisheries within the lough.

There has been little to no change to the hydrodynamics or pollution inputs to Strangford Lough. Wind and rainfall patterns have remained consistent. However, the 30-year monthly average rainfall from 1981-2010 was drier than from 1971-2000 for every month. The

estimated population for the catchment remains the same as in 2011. The population of Newtownards decreased by 1.5%, although, the total urban population increased by 0.6% (501 people). Tourism in Northern Ireland has increased significantly since 2011 (+63.5%), but the increase has been less strong in most of the Strangford Lough catchment. Tourism in the two districts that cover most of the catchment Newry /Mourne /Down and Ards/ North Down has increased by 7.4%.

There has been little change to sewage infrastructure in the catchment with p.e. for the catchment reducing slightly. Agriculture remains the dominant landuse in the catchment with 90% of the catchment associated with agricultural activities (non-irrigated arable land, pastures, complex cultivation patterns and agriculture/natural vegetation). The area used for crops and numbers of sheep have decreased, while Cattle, pigs and poultry numbers have increased. The area of land used for farming has also increased.

Statistical analysis was carried out on E. coli data for the active shellfish beds to ascertain if there are any temporal or geographical patterns. The three datasets with up-to-date results were S2 AFFNI 42 Skate Rock for mussels and S7 AFFNI 76 Paddy's Point for oysters and mussels. It was found that S2 AFFNI 42 Skate Rock had significantly lower *E. coli* levels than both S7 AFFNI 76 Paddy's Point oysters and mussels for the years 2016, 2018 and 2019. S2 AFFNI 42 Skate Rock was also found to have significantly lower *E. coli* levels in spring. It was found that at S7 AFFNI 76 Paddy's Point mussel *E. coli* levels were significantly higher in winter than in spring or autumn and for oyster the summer *E. coli* levels were significantly higher than spring or autumn. There was found to be no significant difference between years for any of the three classified harvesting areas with up-to-date results. Therefore, the E. coli levels within the lough have not changed since the 2011 survey.

For these reasons, a new shoreline survey is not required. The RMP locations (Table 7.1) or monthly sampling frequency does not need to be adjusted and no alterations to the production area boundary are required.

Preclassification sampling was carried out between July and October 2020 to classify S24 AFFNI 32 Dunsy Island for mussels. As no suitable RMP exists that would represent this new bed a new one has been chosen for this area (see section 8).

2. Overview of the Fishery/Production Area

2.1. Location/Extent of Growing/Harvesting Area

The shellfish waters in Strangford Lough that are deignated for the protection of shellfish growth and productin by DAERA for cover an area of approximately 14.84km^2. This is made up of three different designated areas Paddy's Point/ Reagh Bay (10.64km^2) is the largest followed by Marlfield Bay (3.42km^2) and Skate Rock (0.78km^2) and can be seen in Figure 2.1 (DAERA-NI, 2019). Currently only pacific oysters and mussels are being harvested in Strangford Lough between S7 Paddy's Point/S6 Reagh Bay and S2 Skate Rock. In previous years scallops, cockles and Native Oysters were harvested.

Figure 2.1: Shellfish designated waters within Strangford Lough (Source: DAERA-NI, 2019).

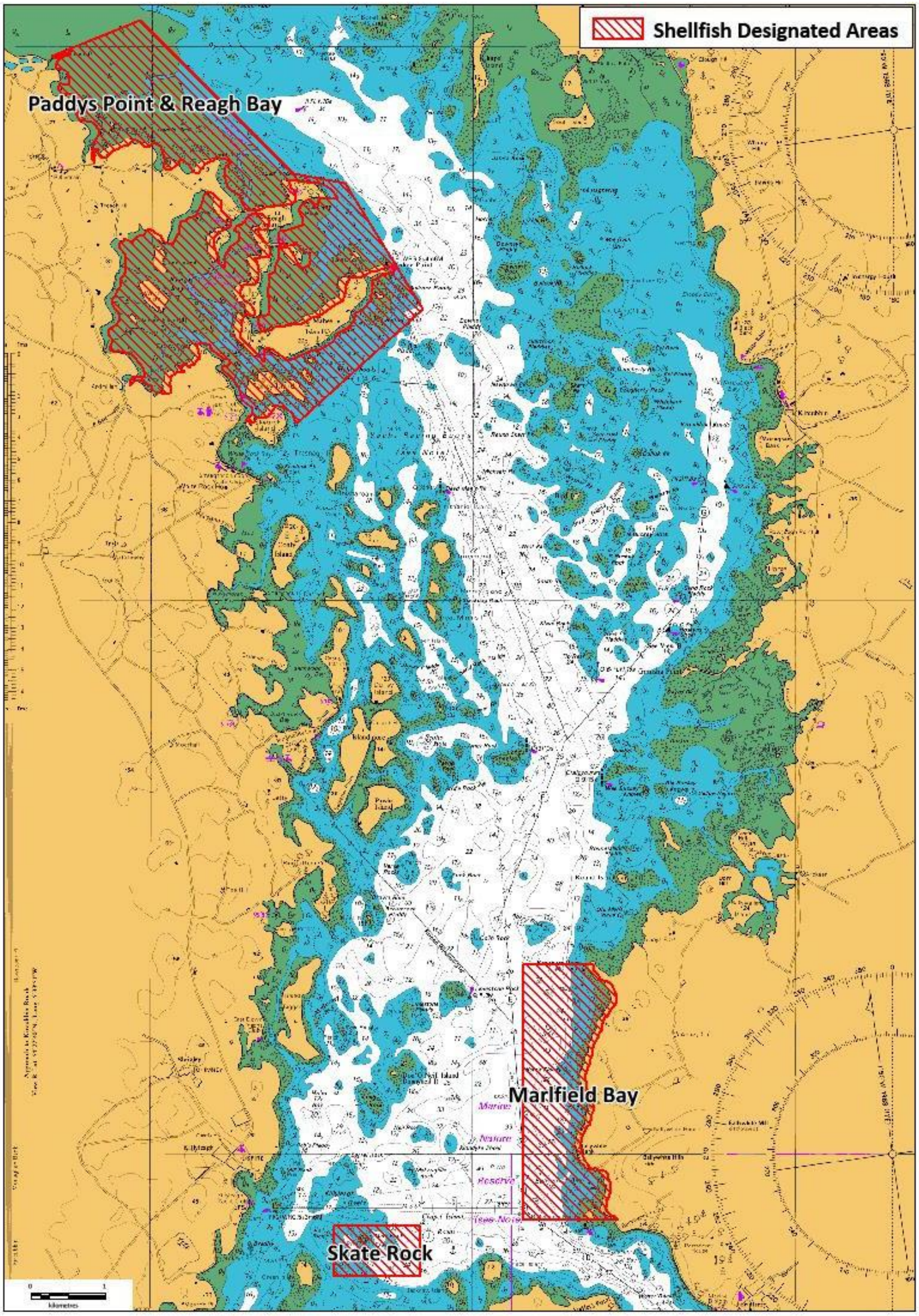
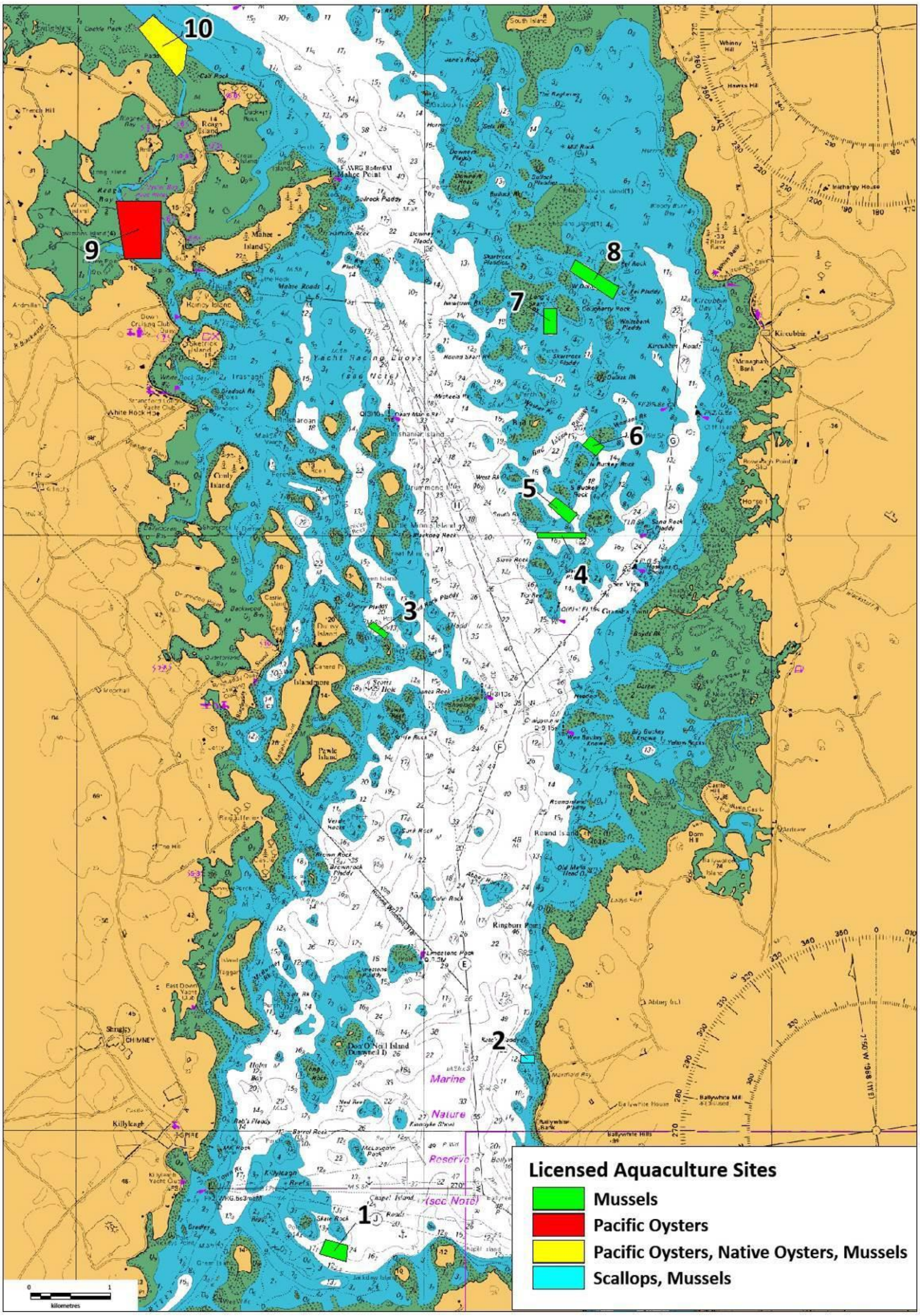


Figure 2.2 shows the current locations of licensed harvesting areas within Strangford Lough. Strangford Lough is currently licensed for mussels, native oysters, Pacific oysters, native clams and scallops covering an area of 0.96km^2. Some sites are licensed for only one species while others are licensed for multiple species. Mussels occupy 0.36km^2, pacific oysters occupy 0.36km^2, scallops and mussels occupy 0.02km^2 and Pacific oysters, native oysters and mussels occupy 0.22km^2. Although the licences exist only three are currently classified and one is in preclassification. Table 2.1 shows the details of each of these sites.

Table 2.1: Details on DAERA licensed sites in Strangford Lough

Map ID	Name	Species	Area KM^2	Active
1	S2 Skate Rock	Mussels	0.06	Yes
2	S23 Marlfield Bay	Scallops, mussels	0.02	No
3	S24 Dunsy Island	Mussels	0.02	Preclassification
4	S22	Mussels	0.04	No
5	S21	Mussels	0.05	No
6	S18 East of Bird Island Passage	Mussels	0.03	No
7	S16 South Dougherty Rock	Mussels	0.05	No
8	S15 West Dougherty Rock	Mussels	0.11	No
9	S6 Reagh Bay	Pacific oysters	0.36	Yes
10	S7 Paddy's Point	Pacific oysters, native oysters, mussels	0.22	Yes

Figure 2.2: Licensed harvesting areas located within Strangford Lough (Source: DAERA).



2.2. Description of the Area

Strangford Lough is a large marine lough located south of Newtownards and northeast of Downpatrick, Northern Ireland (See Figure 2.3). The lough is 24km long, 8km wide and 59m in depth at its deepest point, however much of the lough is less than 20m deep. It covers an area of approximately 150km^2 and has a volume of 1537 x 106m^3. The main freshwater sources to Strangford Lough are the Comber River in the northwest and the Quoile River in the southwest. The lough connects to the Irish Sea through an inlet known as 'The Narrows', approximately 8km in length and less than 1km wide. The Narrows are relatively deep (>10m to 60m) and are subjected to strong tidal currents of over 3.6 m/s while conversely some sheltered inlets on the western shores have virtually still water. Many islands, reefs and rocks are distributed throughout the lough and the shore is approximately 240km in length and is highly indented. The exit channel consists of patches of bedrock and extensive beds of coarse gravel.

Strangford Lough is designated as a Special Area of Conservation (SAC), a Special Protection Area (SPA) and a Ramsar Site. It is a Marine Nature Reserve and contains six marine related Nature Reserves. Strangford Lough contains 4 Annex I habitats, which are the primary reason for the designation of this site: mudflats and sandflats not covered by seawater at low tide, coastal lagoons, large shallow inlets and bays and reefs. It also contains the following Annex I habitats as qualifying features of the site: Annual vegetation of drift lines, Perennial vegetation of stony banks, *Salicornia* and other annuals colonising mud and sand and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*). Also, the common seal, which is an Annex II species is present as a qualifying feature of the site.

Strangford Lough holds 7 bird species of international importance: light-bellied Brent goose, red knot, shelduck, common redshank, black-tailed godwit, whooper swan and mute swan. It also holds populations of 24 nationally important bird species.

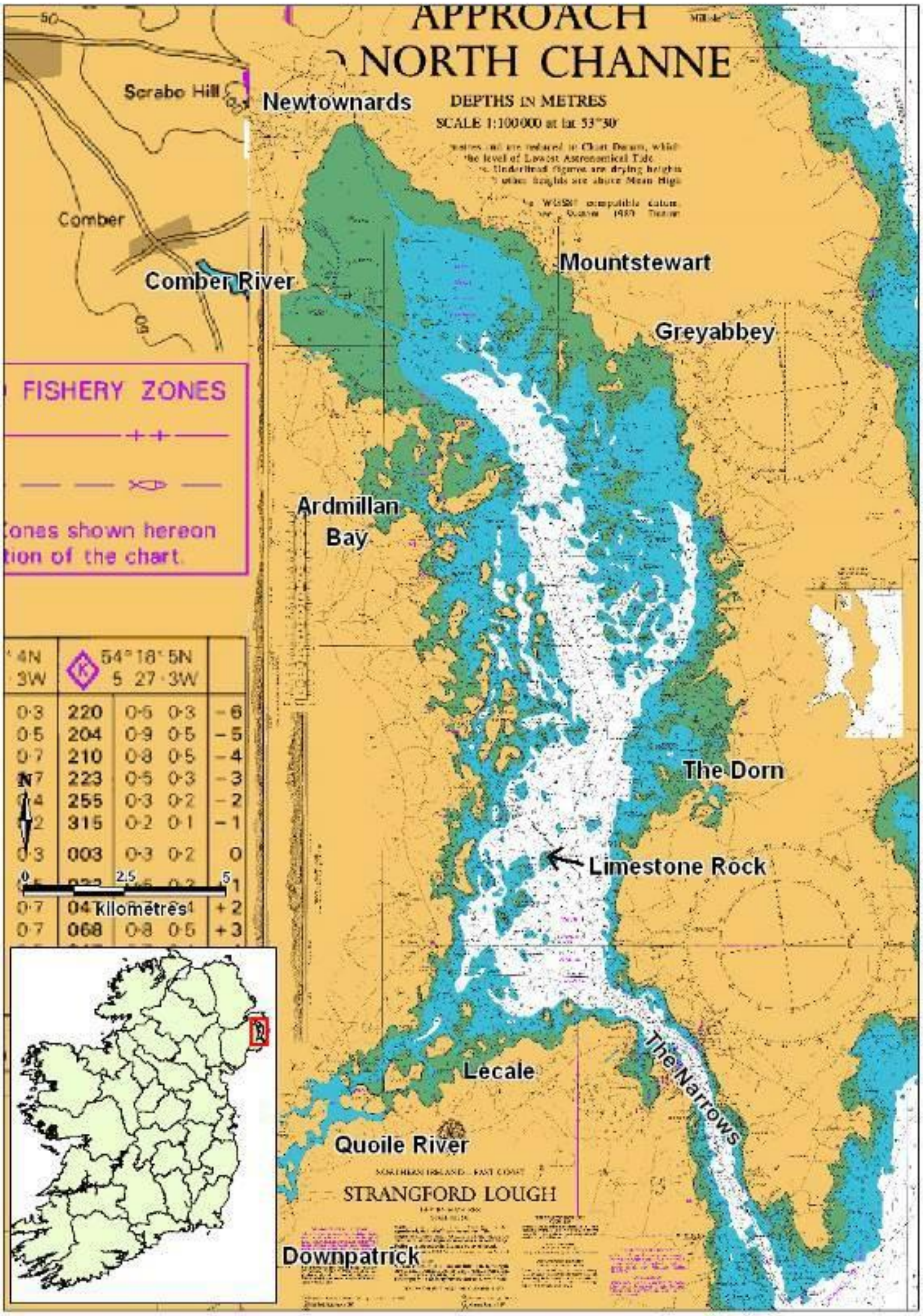
Strangford Lough on the east coast of Northern Ireland is an outstanding example of a large, enclosed fjordic sea lough. Sea water enters the lough through a narrow entrance, expanding into a broad, mostly shallow basin that has a central deep channel (30-60m deep), which carries rapid currents and causes great turbulence in some parts, particularly the Narrows. With a wide range of tidal stream strengths and depths, there is a remarkable marine fauna within Strangford Lough, and it is one of the most diverse sea loughs in the UK. The faunal assemblages present range from the very rich high-energy communities near the mouth, which depend on rapid tidal streams, to communities in extreme shelter where fine muds support burrowing brittlestars, Dublin Bay prawn *Nephrops norvegicus*, and a rich community associated with horse mussels *Modiolus modiolus*.

The intertidal mudflats and sandflats in the north of Strangford Lough represent the largest single continuous area of mud/sandflats in Northern Ireland. There are very extensive areas of muddy sand from Newtownards to Ardmillan Bay in the west and to Greyabbey in the east. The habitat also occurs in the southwest reaches of the lough along the northern shore of Lecale. The northern flats support luxuriant beds of the eel grasses *Zostera noltii* and *Z. angustifolia*. Common eel grass *Z. marina* and tasselled pondweed *Ruppia maritima* are also present, the latter being widespread but quite local in its distribution. Such extensive beds are rare in the British Isles. The green algae *Enteromorpha* spp. and *Ulva lactuca* tend to occur where there is seepage of nutrient-enriched freshwater. Many of the invertebrate species present in muds also occur in muddy sand. However, lugworm *Arenicola marina* and nereid worms are generally dominant, along with bivalve molluscs such as the thin tellin *Macomangulus tenuis*, the softshell clam *Mya arenaria* and the common cockle *Cerastoderma edule*.

The ‘Dorn’ is a silled lagoon on the eastern side of Strangford Lough in Northern Ireland. The Dorn, from the Gaelic word for ‘narrow channel’, refers specifically to the channel which connects several exceptionally sheltered bays to the main area of the lough. Near the mouth, rock barriers or sills hold back water as the tide falls, creating saltwater rapids, unique in Ireland. In the area of the Dorn rapids, abundant growths of sea anemones, sponges and ascidians clothe the rock and boulders. Several of the animals found in the area of the rapids normally occur in relatively deep water. These include the featherstar *Antedon bifida*, purple sun-star *Solaster endeca*, sting winkle *Ocenebra erinacea*, king scallop *Pecten maximus* and light-bulb sea-squirt *Clavelina lepadiformis*. The main trough of the Dorn supports a dense forest of sugar kelp *Laminaria saccharina* and sea-oak *Halidrys siliquosa*. The gravelly-sand bottom has unusually dense colonies of peacock worm *Sabella pavonina* and sand gaper *Mya arenaria*, with occasional native oysters *Ostrea edulis* and *P. maximus*. The channel immediately above the sill has fast tidal streams without turbulence, enabling sponges to grow to exceptional proportions. The sheltered marine ‘ponds’ feeding the Dorn feature beds of common eelgrass *Zostera marina* and the green alga *Codium fragile* ssp. *tomentosoides*.

Reefs in Strangford Lough vary from tide-swept bedrock and large boulders in the main channel of the Narrows, through sand-scoured bedrock and boulders at either end of the channel, to more sheltered bedrock and boulders in the main central portion of the lough and in parts of the intertidal. Beds of horse mussels *Modiolus modiolus* form extensive biogenic reefs within the central portion of the lough. Tide-swept bedrock is restricted to the Strangford Narrows, where rock surfaces are entirely clothed in suspension-feeding species, notably the soft coral dead-men’s fingers *Alcyonium digitatum*, sponges, especially *Pachymatisma johnstonia* and the rock-boring *Cliona celata* (which reaches massive proportions), ascidians, particularly *Dendrodoa grossularia* and *Corella parallelogramma*, and sea-anemones including *Metridium senile*. Very large boulders strew much of the bed of the Narrows and are subject to strong tidal streams. These boulders are clothed with encrusting sponges, such as *Myxilla incrustans* and *Myxilla fimbriata*, with abundant hydroids, especially *Tubularia indivisa*, and sea anemones, including *Sagartia elegans*, *Corynactis viridis* and *Actinothoe sphyrodeta*. Coarse sand scours rock surfaces at the sides and at either end of the Narrows. Here the characteristic species is the bryozoan *Flustra foliacea*. Though most of the intertidal zone is clothed in sediments, glaciated or sea-worn bedrock outcrops are found at many locations. Massive boulders (glacial erratics or the cores of eroded drumlins) occur on the shore and form rocky islands known as ‘pladdies’. Whilst Silurian rocks predominate, there is sandstone at Mountstewart and limestone at Limestone Rock. The fauna and flora associated with these outcrops are dependent on the rock type, the angle of bedding-plane and degree of weathering, the position on the shore, and the degree of exposure to currents and waves. Full development of the climax biotope associated with the *M. modiolus* beds depends on the very sheltered, plankton-rich waters of extremely low turbidity found in the central to northern area. *M. modiolus* rarely occurs in such still waters. The mussels and dead mussel shells provide a hard surface in an otherwise soft-sediment environment on which numerous other species (up to 100) depend. Many mobile suspension-feeders also occur, particularly the scallop *Mimachlamys varia* which is co-dominant with *M. modiolus*. A similar biotope, also dominated by *M. modiolus*, but with brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra* replacing *M. varia* as co-dominant, occurs in the central to south-western area where water movement is slightly greater.

Figure 2.3: Location of Strangford Lough.



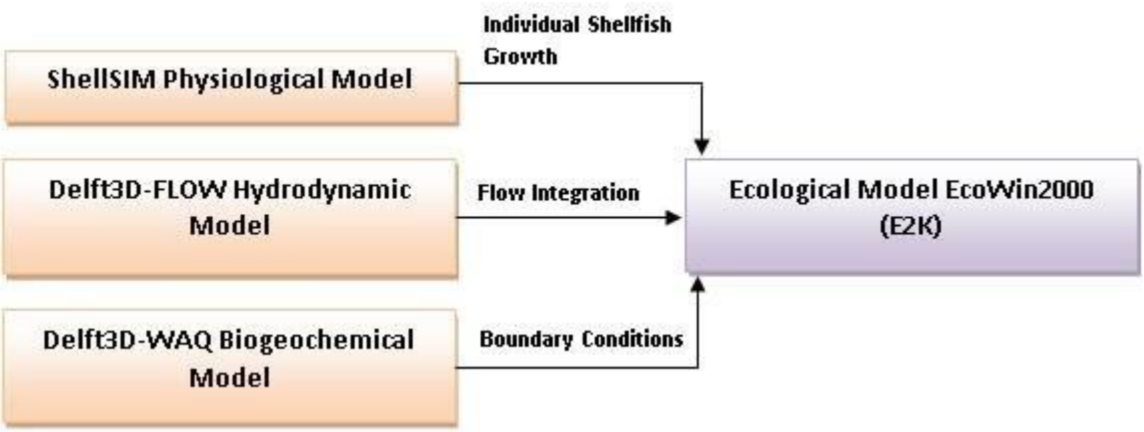
Strangford Lough supports a wide diversity of species, including shellfish. The designated shellfish area within the lough is 14.84km^2 and the licenced shellfish sites cover an area of 0.96km^2. Mussels, Pacific oysters, native oysters and scallops are cultivation in the lough.

3. Hydrography/Hydrodynamics

3.1. Simple/Complex Models

The Sustainable Mariculture in northern Irish Sea Lough Ecosystems (SMILE) project was commissioned by the Department of Agriculture and Rural Development Northern Ireland (DARD) 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). Strangford 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).

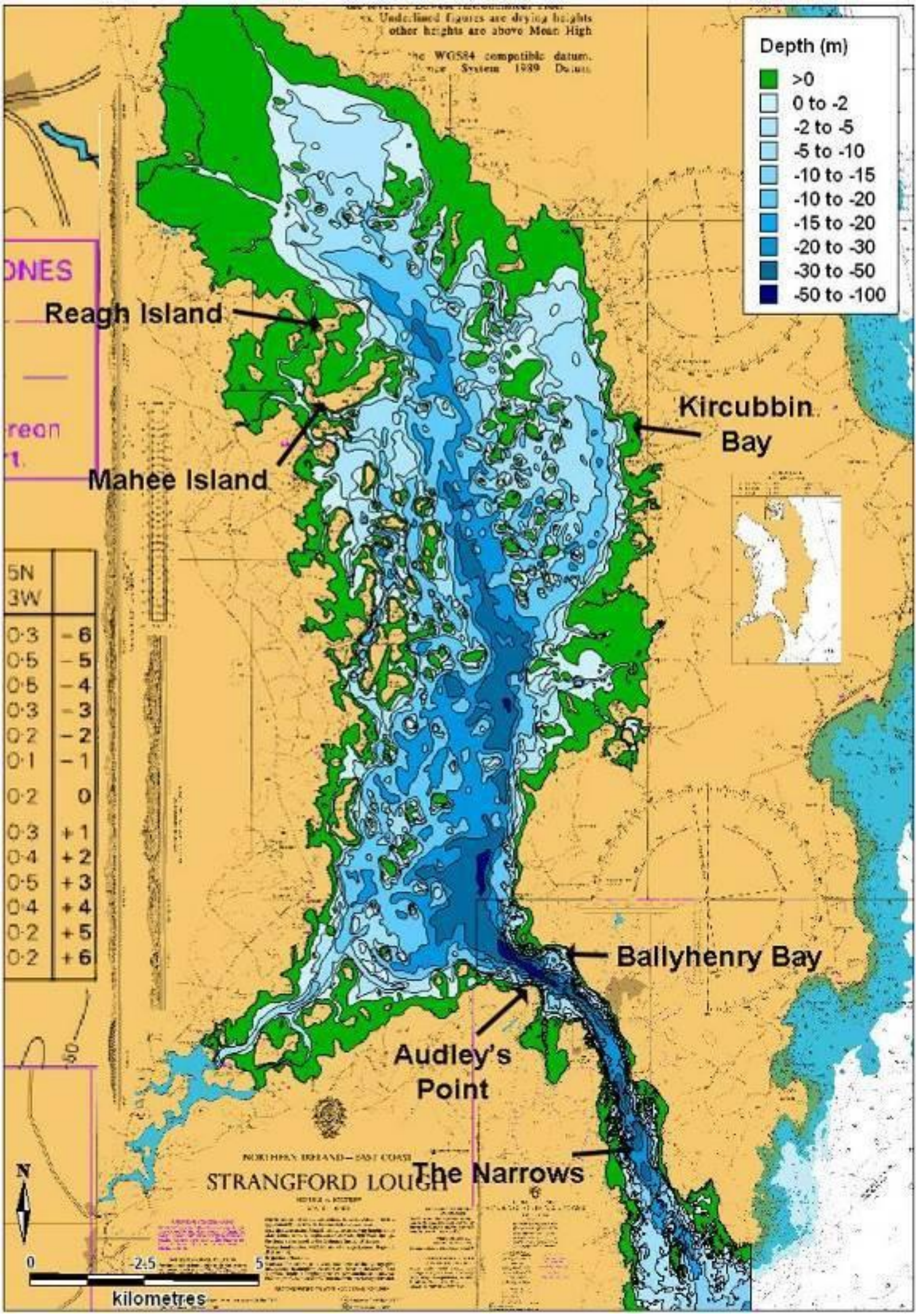


The Delft3D-FLOW hydrodynamic model was used to simulate the tidal, wind and ocean currents within the lough (Ferreira *et al.,* 2008). This model was combined with the Delft3D-WAQ model to stimulate circulation and phytoplankton productivity for periods of up to 1 year and used to generate aggregated 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 upscaled from detailed hydrodynamic models.

3.2. Depth

Depths in Strangford Lough vary from approximately 62m in the inner most part of the Narrows (the narrow channel connecting the lough to the Irish Sea) between Audley's Point and Ballyhenry Bay to very shallow depths of 2-5m along the coastal parts of the lough and in particularly the inner reaches of the lough. Depths greater than 10m predominant in the Narrows and extend up along the centre of the lough before bifurcating into two main channels, one heading northeast to Kircubbin Bay and one northwest to beyond Mahee and Reagh Islands. Deeper pools of water, varying in depths from approximately 30 to 60m are found within this channel. Figure 3.2 shows a bathymetric map of Strangford Lough.

Figure 3.2: Depths in Strangford Lough (modified from The Loughs Agency data).



3.3. Tides & Currents

The tidal cycle in Strangford Lough ranges from a mean high water of 4.5m to a mean low water of 0.3m during spring tides (UKHO, 1988; 2009). The characteristic tidal levels in Strangford Lough can be seen in Table 3.1. These are taken from the Admiralty Chart 2156-0 and 2156-1 (UKHO, 1988; 2009). Levels are presented in metres Chart Datum, which is approximately equal to Lowest Astronomical Tide (LAT). The tidal level locations can be seen in Figure 3.3.

Table 3.1: Strangford Lough tidal characteristics (Source: UKHO, 1988; 2009).

Admiralty Chart 2156-0/2156-1 Levels (m CD)	MHWS	MHWN	MLWN	MLWS	Datum & Remarks
Killard Point	4.5	3.8	1.2	0.5	3.14m below Ordnance Datum (Belfast)
Strangford	3.6	3.1	0.9	0.4	1.84m below Ordnance Datum (Belfast)
Quoile Barrier	3.7	3.2	0.8	0.3	1.86m below Ordnance Datum (Belfast)
Killyleagh	3.8	3.3	-	-	1.86m below Ordnance Datum (Belfast)

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 Strangford Lough (UKHO, 1988; 2009) and information was taken from Brown, (1990). The Narrows are subjected to strong tidal currents of over 3.6 m/s while conversely some sheltered inlets on the western shores have virtually still water.

On a flooding spring tide, tidal flows reaching a mean spring rate of 1.29 m/s enter the Narrows around Killard Point and proceed into the West Channel maintaining their speeds up towards Kilchief Bay. In the East Channel, a mean spring rate of 2.52 m/s enters the Narrows east of Angus Rock. This flow weakens to imperceptible levels as it flows across the Narrows to Kilclief Point. A mean spring rate of 4.01 m/s is seen in the Narrows east of Black Islands, this decreases slightly to 3.34 m/s as the tide flows around Church Point, decreasing to 2.31 m/s around Audley's Point and decreases again to 1.03 m/s as the tide enters the main body of the lough. Mean spring rates of 0.51 m/s to 1.03 m/s are seen between Limestone Rock and Ringburr Point and the tide flows towards the upper reaches of the lough. From here, mean speeds of 1.03 m/s flow northeasterly up the main channel and speeds reduced to 0.51 m/s -0.77 m/s in the upper reaches of the lough. Imperceptible speeds flow in the southwestern region of the lough around Killyleagh and in the northeastern region of the lough towards Kircubbin Bay.

On the ebbing spring tide, the flow reaches a maximum of 0.51 m/s to 0.77 m/s as it leaves the inner reaches of the lough, increasing to 1.03 m/s north of Ringburr Point and decreasing to 0.51 m/s on approaches to Audley's Point. Once in the Narrows, speeds increase to 2.57 m/s around Church Point, increasing to 3.7 m/s east of Black Islands, decreasing to 2.83 m/s east of Kilclief Point and exiting through the East Channel at speeds of 3.91 m/s. There is an imperceptible flow across the Narrows just north of Angus Rock into the East Channel. There is a flow of 1.29 m/s out of Kilclief Bay, increasing to 2.06 m/s as the flow leaves the West Channel.

Outputs from the Delft3D-FLOW hydrodynamic model which was developed during the SMILE Project were provided by the Agri-Food and Biosciences Institute (AFBI). Figures 3.4 to 3.11 show the direction and magnitude of spring and neap tide surface and bottom ebb and flood flow currents.

Tidal movements in Strangford Lough are relatively simple entering in the southeast through the Narrows and moving in a northwesterly direction up through the lough. During a flooding spring tide, maximum velocities are seen in the Narrows between Dogtail Point and Strangford Point (3.2 – 4.1 m/s at the surface and 2.3 – 2.99 m/s at the bottom). At the surface, flows decrease to approximately 2.4 m/s around Ballyhenry Bay (1.8 m/s at the bottom) and decrease further to approximately 0.8 – 1.2 m/s (0.7 – 0.9 m/s at the bottom) as the flow moves around Ballyhenry Point and into the lough proper. This level of flow continues as far north as Ringburr Point. Between Ringburr Point and approximately Gransha Point, the flow is in the region of 0.5 – 1 m/s (0.4 – 0.7 m/s at the bottom) in the centre and eastern part of the channel with flows as low as 0.08 m/s (0.04 m/s at the bottom) in amongst the islands on the western coastline. Flows decrease to approximately 0.4 m/s (0.2-0.3 m/s at the bottom) between Gransha Point and a line drawn between Mahee Point and South Islands. Inside if this line, flows increase slightly and range between 0.4 to 0.7 m/s (0.5m/s at the bottom) in the central channel and in towards the Comber Estuary. Flows are lower (0.02 – 0.3 m/s) in the shallower coastal parts of the inner lough and in towards Newtownards.

On the ebbing tide, flows are highest in the Narrows between Dogtail Point and Strangford Point (3.49 – 4.12 m/s at the surface and 2.5 – 3.1 m/s at the bottom). Surface ebb flows within the lough proper range from 0.05 m/s in the inner reaches of the lough near Newtownards to 0.9 m/s off Ringburr Point. Bottom ebb flows in the same areas range from 0.04 m/s to 0.7 m/s.

The flow pattern described above is the same for neap tides with significantly lower velocities experienced. On a flooding neap tide, maximum bottom and surface speeds are found between Dogtail Point and Strangford Point (1.9 – 2.4 m/s at the surface and 1.4 -1.8 m/s at the bottom). On an ebbing neap tide, again maximum bottom and surface speeds are found between Dogtail Point and Strangford Point (1.9 – 2.3 m/s at the surface and 1.3 -1.7 m/s at the bottom).

Figure 3.3: Tidal streams within Strangford Lough (UKHO, 1988; 2009; Brown, 1990).

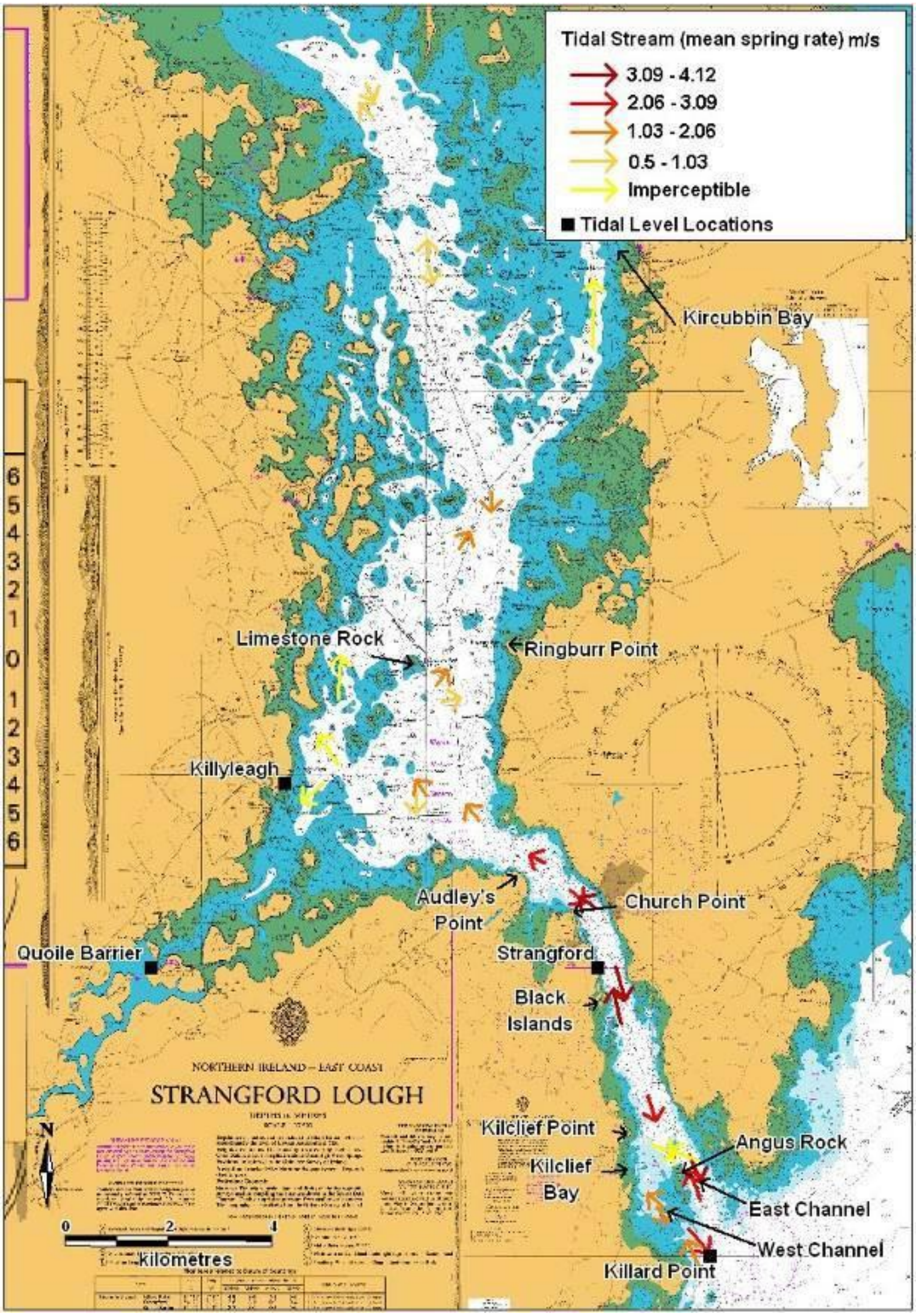


Figure 3.4: Surface current velocities and direction during a spring tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

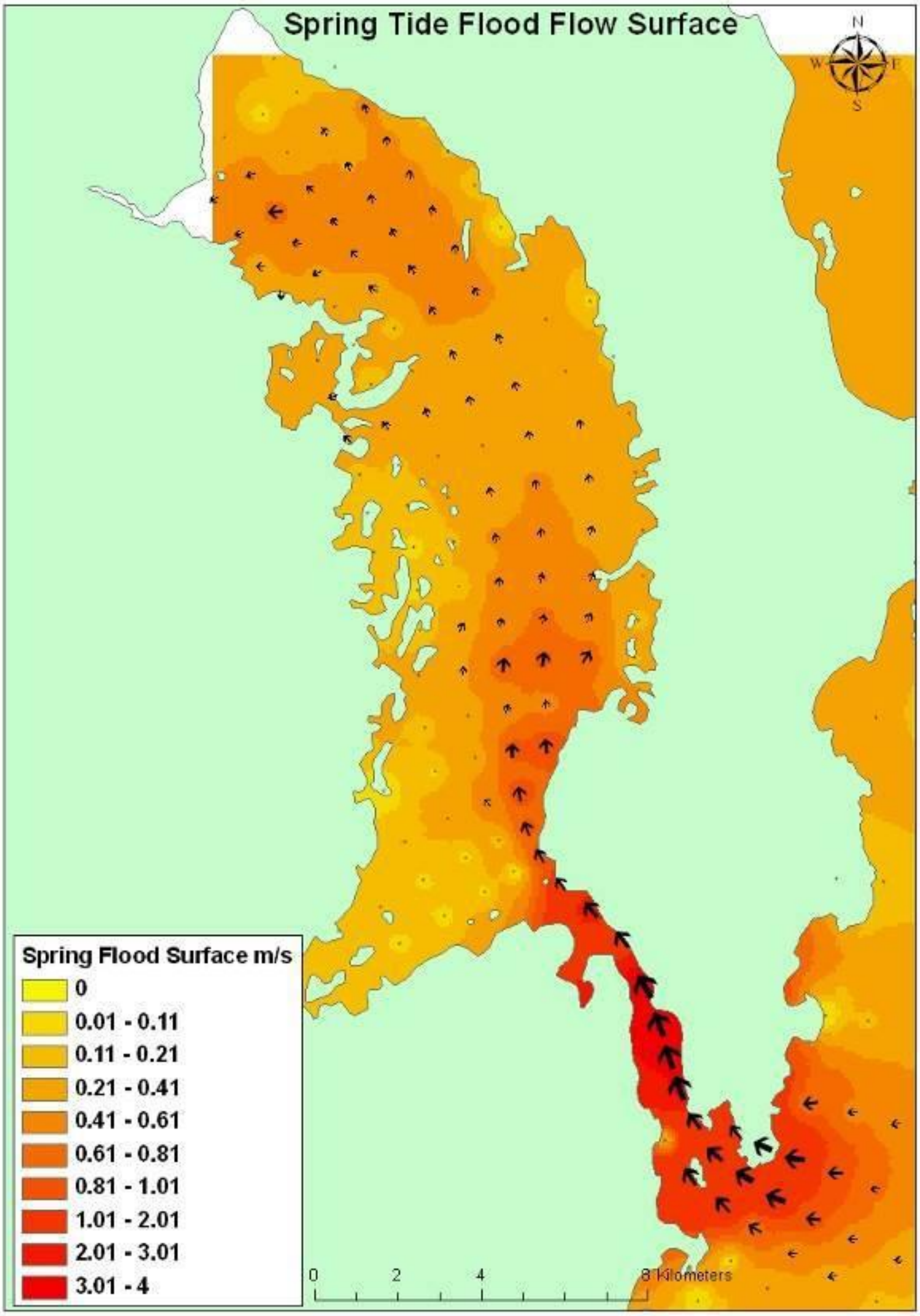


Figure 3.5: Bottom current velocities and direction during a spring tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

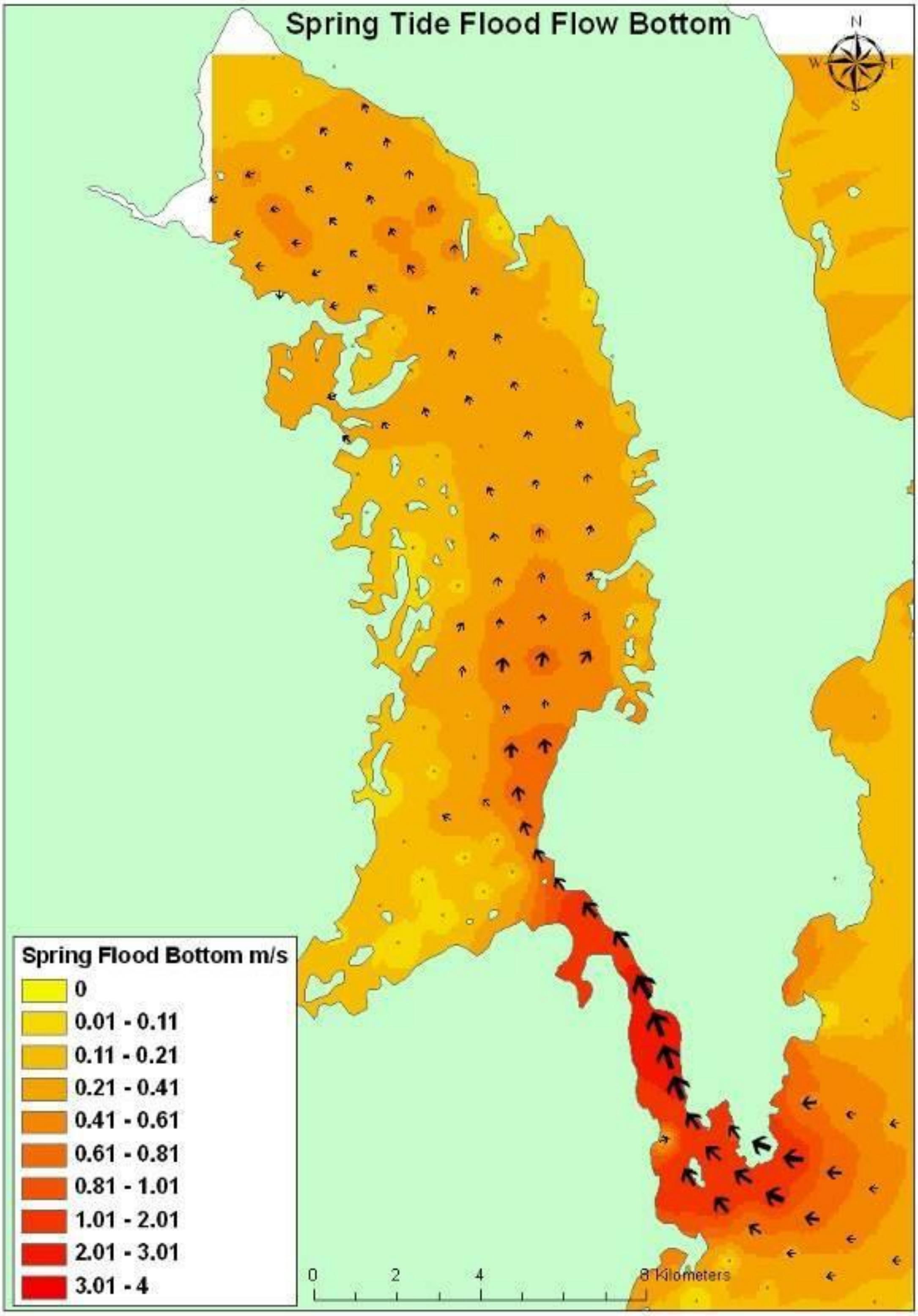


Figure 3.6: Surface current velocities and direction during a spring tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

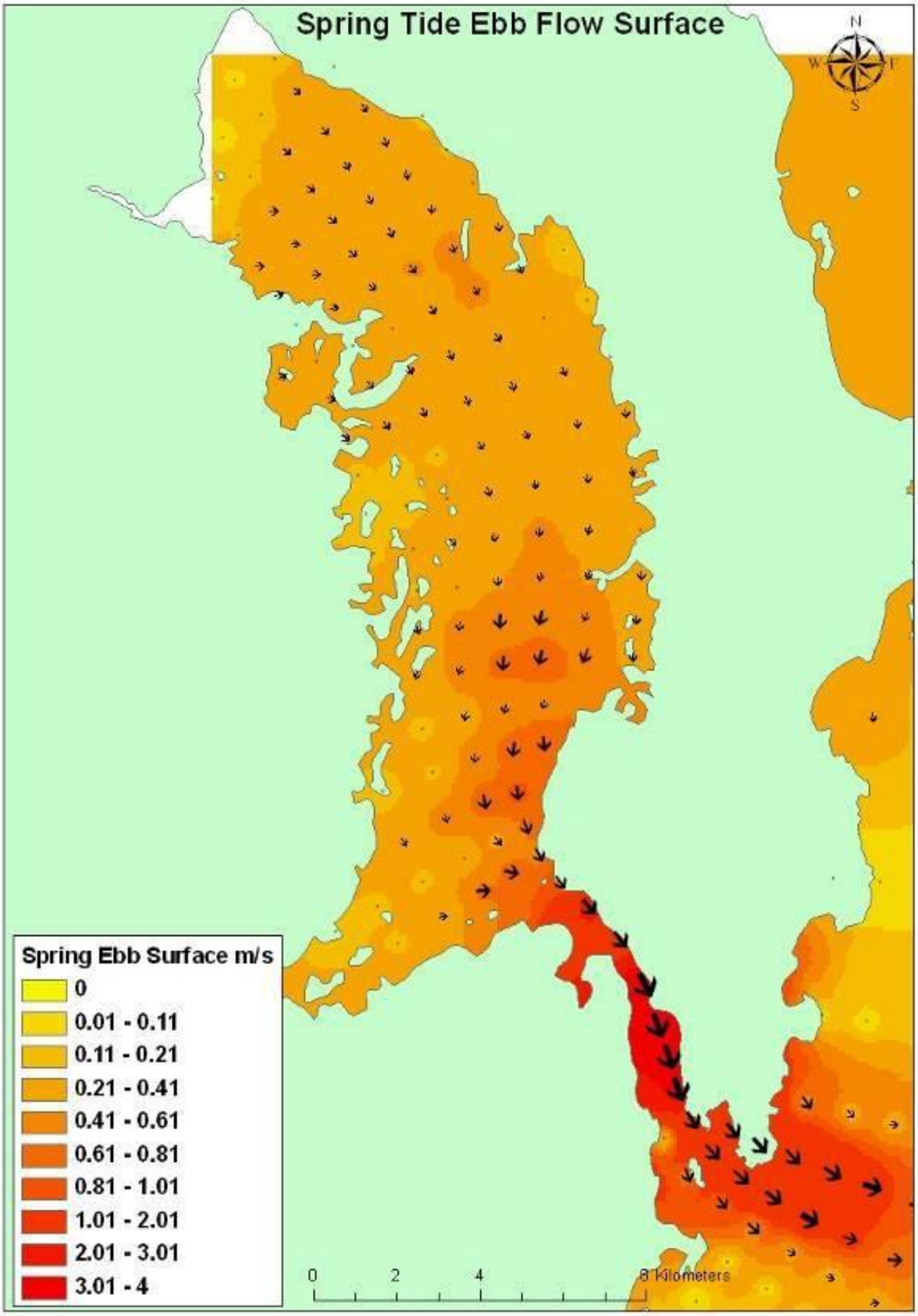


Figure 3.7: Bottom current velocities and direction during a spring tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

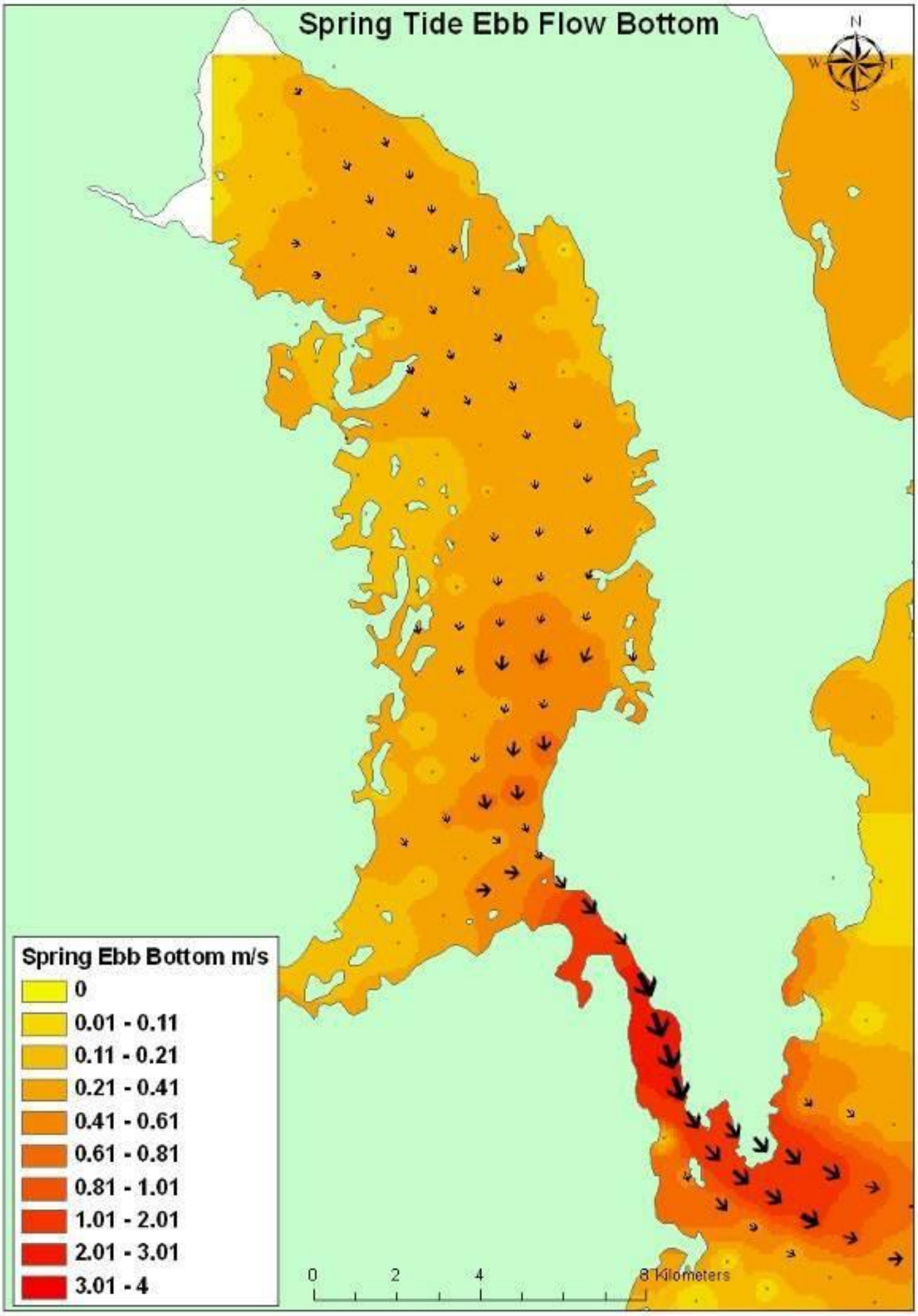


Figure 3.8: Surface current velocities and direction during a neap tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

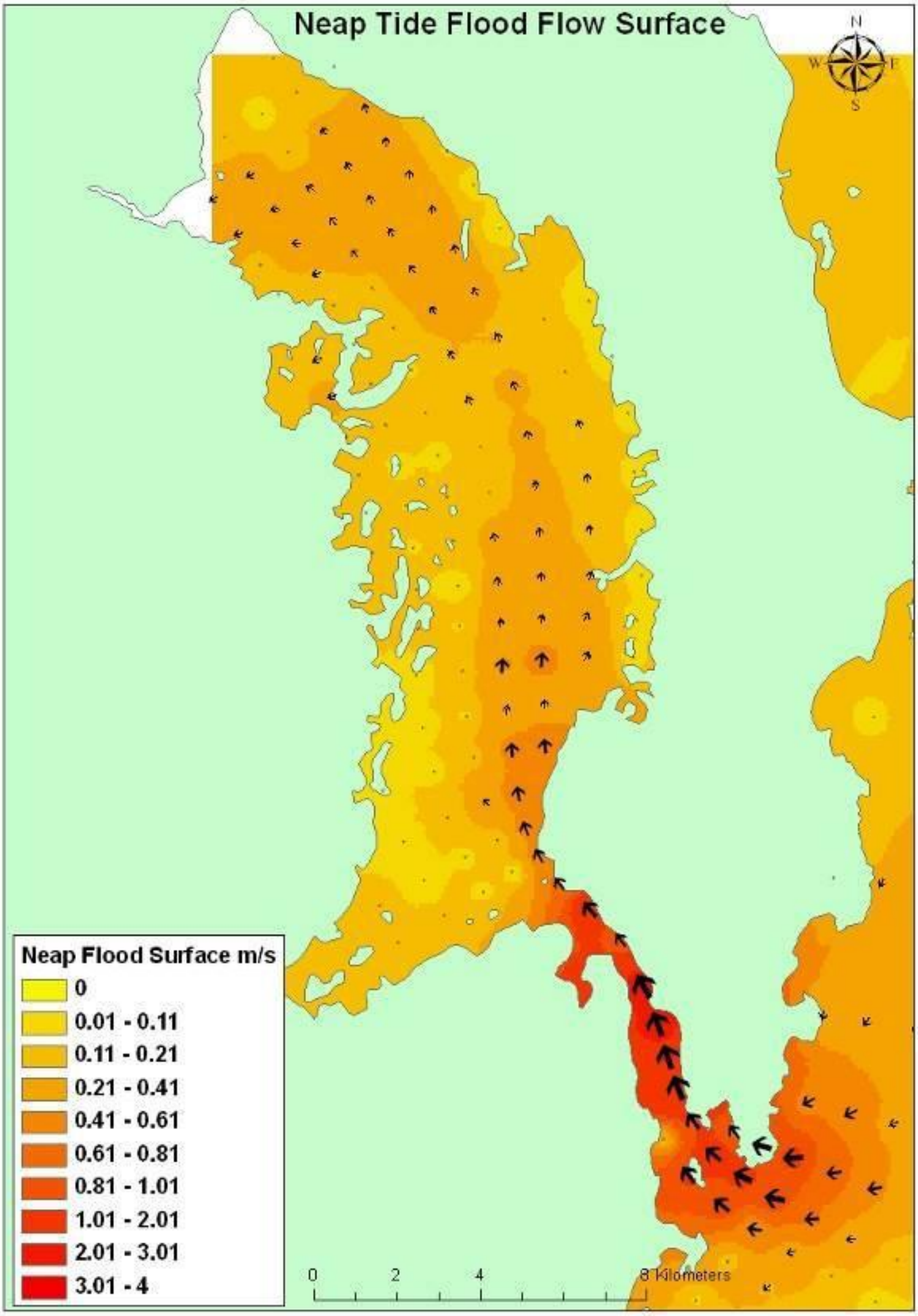


Figure 3.9: Bottom current velocities and direction during a neap tide, flood flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

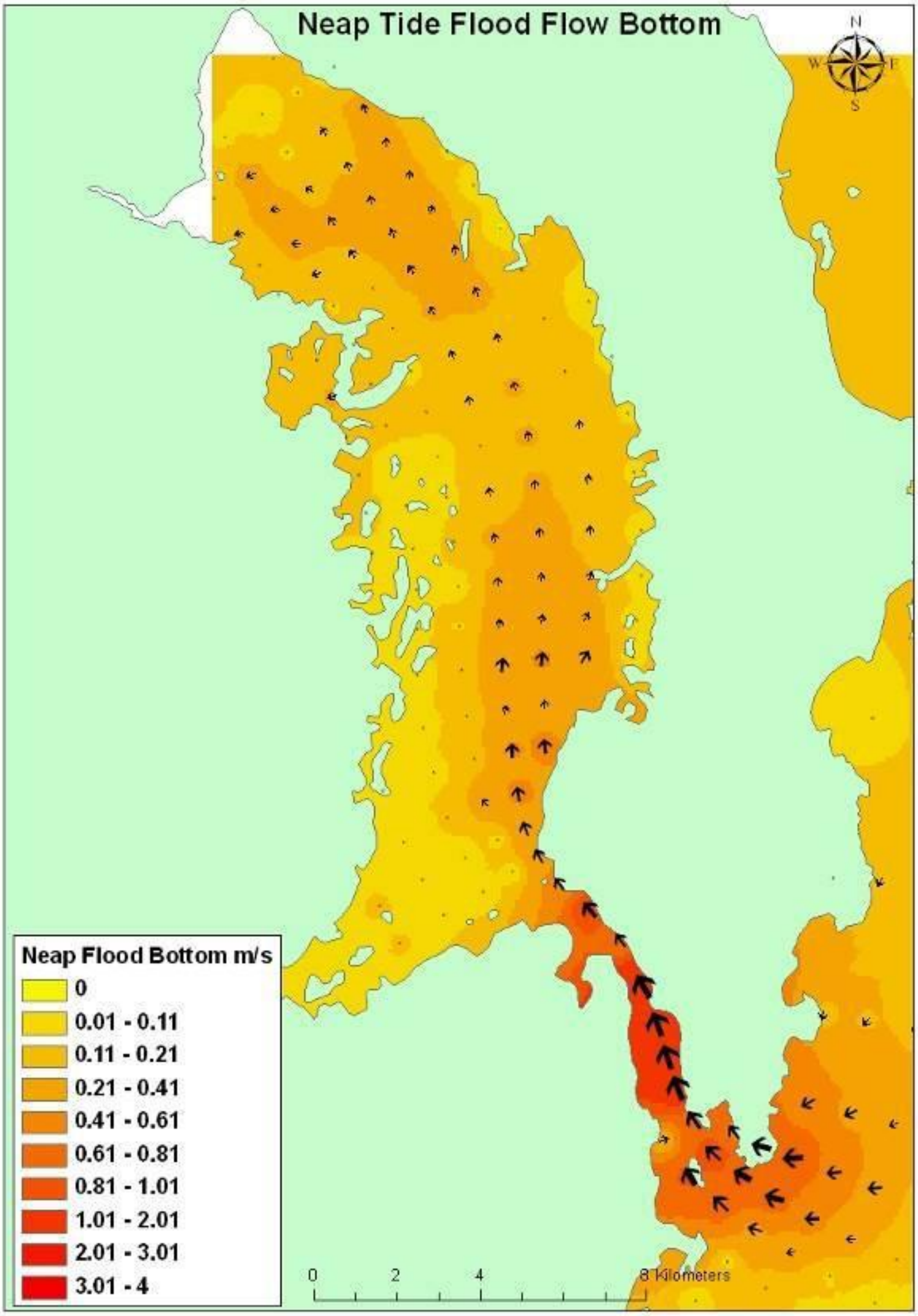


Figure 3.10: Surface current velocities and direction during a neap tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).

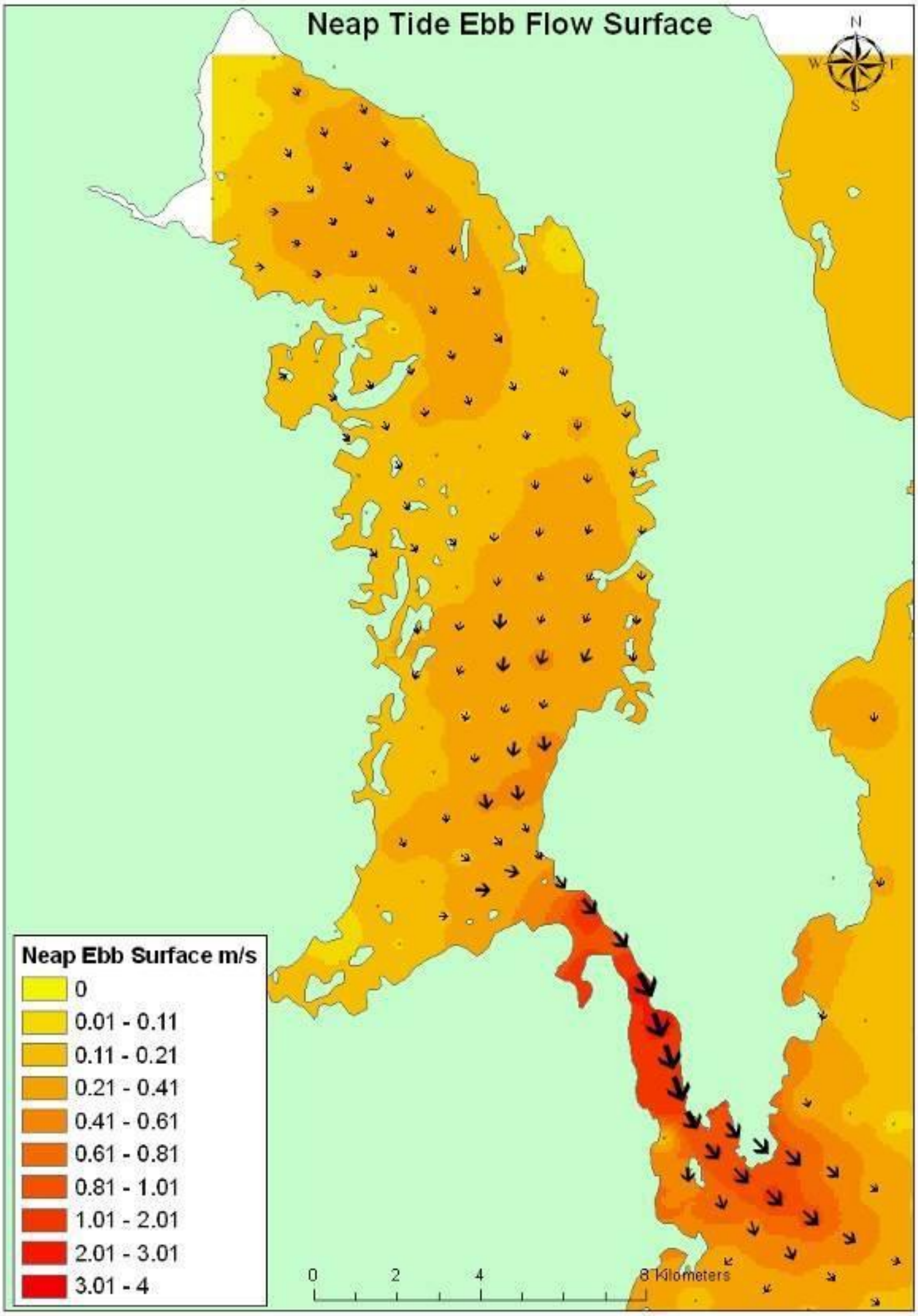
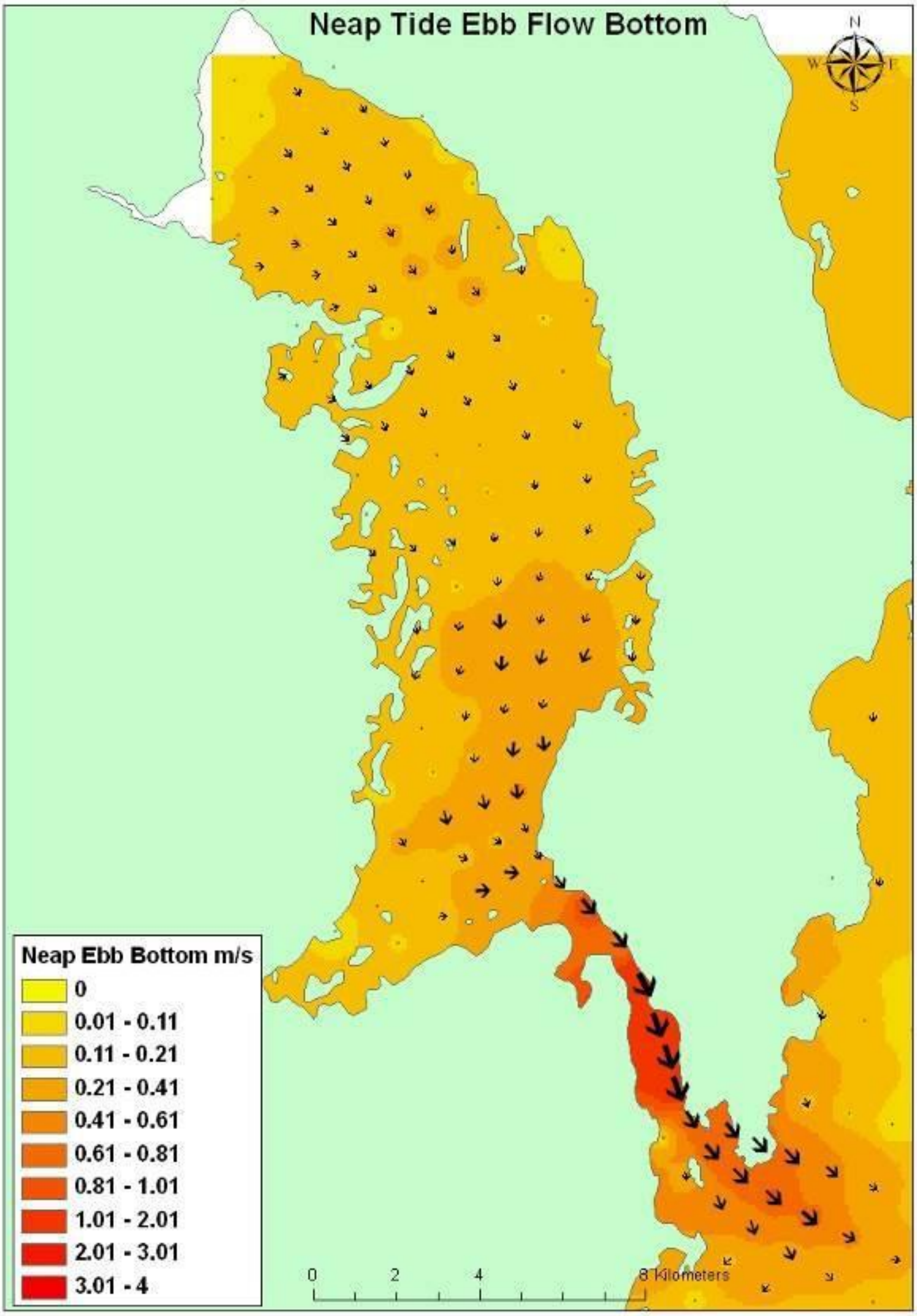


Figure 3.11: Bottom current velocities and direction during a neap tide, ebb flow (Source: AFBI SMILE Deflt3D-Flow Model Data).



3.4. Wind and Waves

Average wind speed data for Northern Ireland from 1971-2000 and 1981-2010 can be seen in Figure 3.12 (Met Office, 2011a; Met Office, 2020a). It can be seen from these maps that there has been little to no change in the wind patterns in the Strangford Lough area. The eastern coast of Northern Ireland is one of the windiest areas. November to February experienced the strongest wind speeds (10-20kn) while July and August experienced the weakest winds (6-15kn). The strongest winds are associated with the passage of deep areas of low pressure close to or across the country. The frequency and strength of these depressions is greatest in the winter half of the year, especially from November to January, and this is when mean speeds and gusts (short duration peak values) are strongest (Met Office, 2011b). Figure 3.13 shows the seasonal averages in wind speed for Northern Ireland from 1971-2000 to 1981-2010, as expected summer experienced the weakest speeds (6-15kn) while winter experienced the strongest (10-20kn).

As Atlantic depressions pass the UK and Ireland the wind typically starts to blow from the south or south west, but later comes from the west or north-west as the depression moves away (Met Office, 2011b). The range of directions between south and north-west accounts for the majority of occasions and the strongest winds nearly always blow from these directions. Therefore, the prevailing wind over Strangford Lough ranges from a southerly all the way around to a northwesterly.

Figure 3.12: Average wind speed data for Northern Ireland from 1971 to 2000 and 1981-2010 (Source: Met Office, 2011a; Met Office, 2020a).

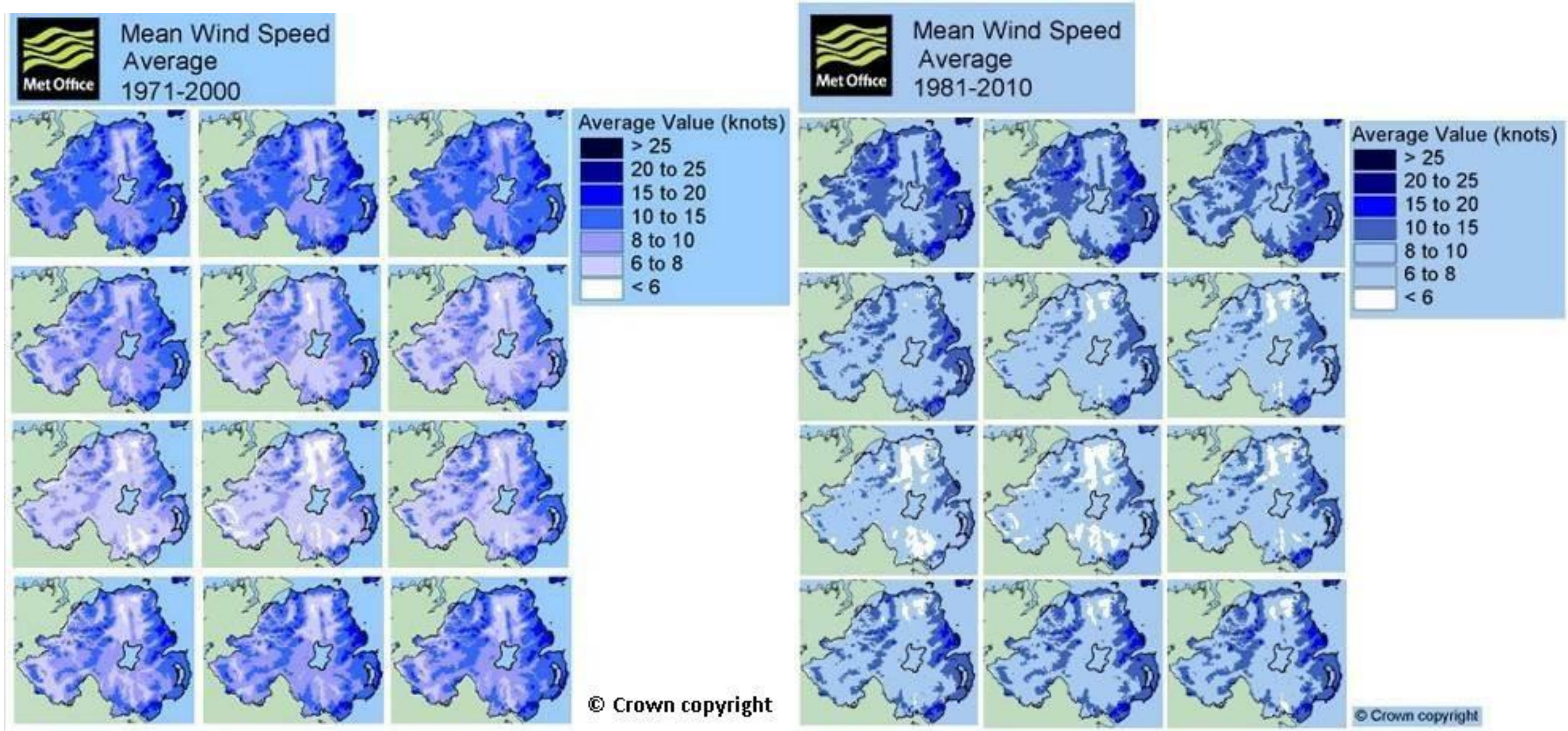
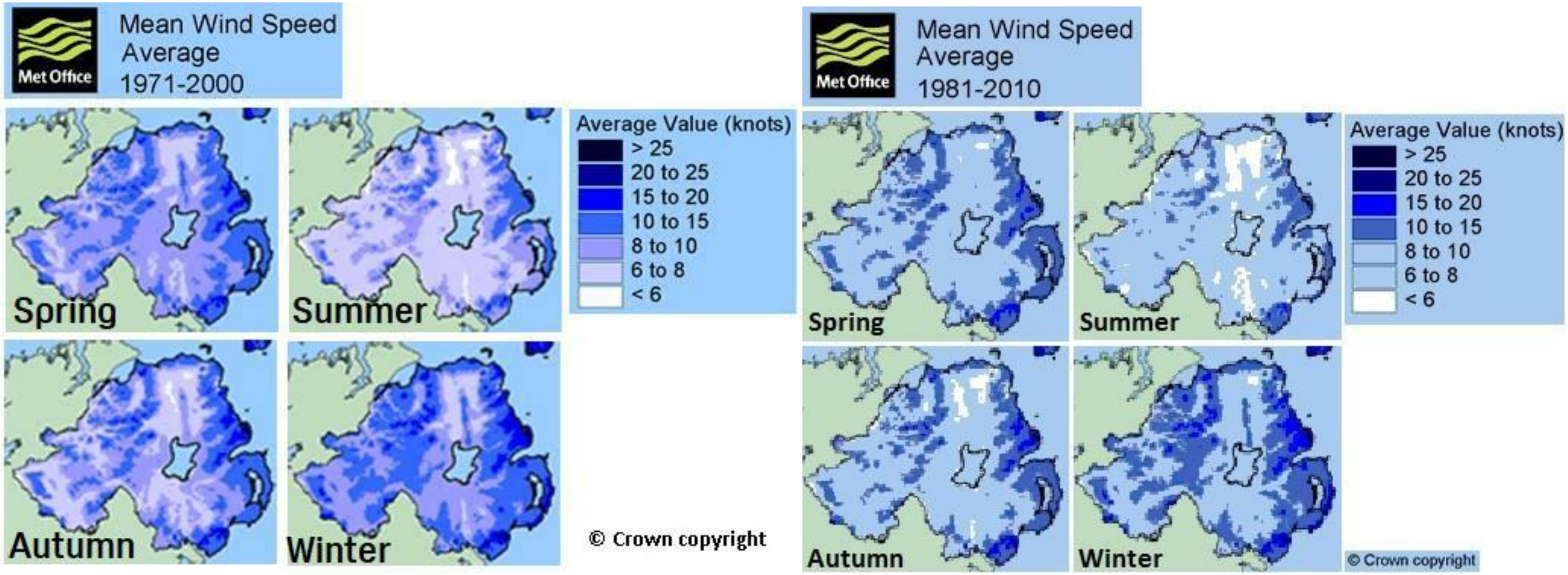


Figure 3.13: Average seasonal wind speed data for Northern Ireland from 1971-2000 and 1981 to 2010 (Source: Met Office, 2011a; Met Office, 2020a).

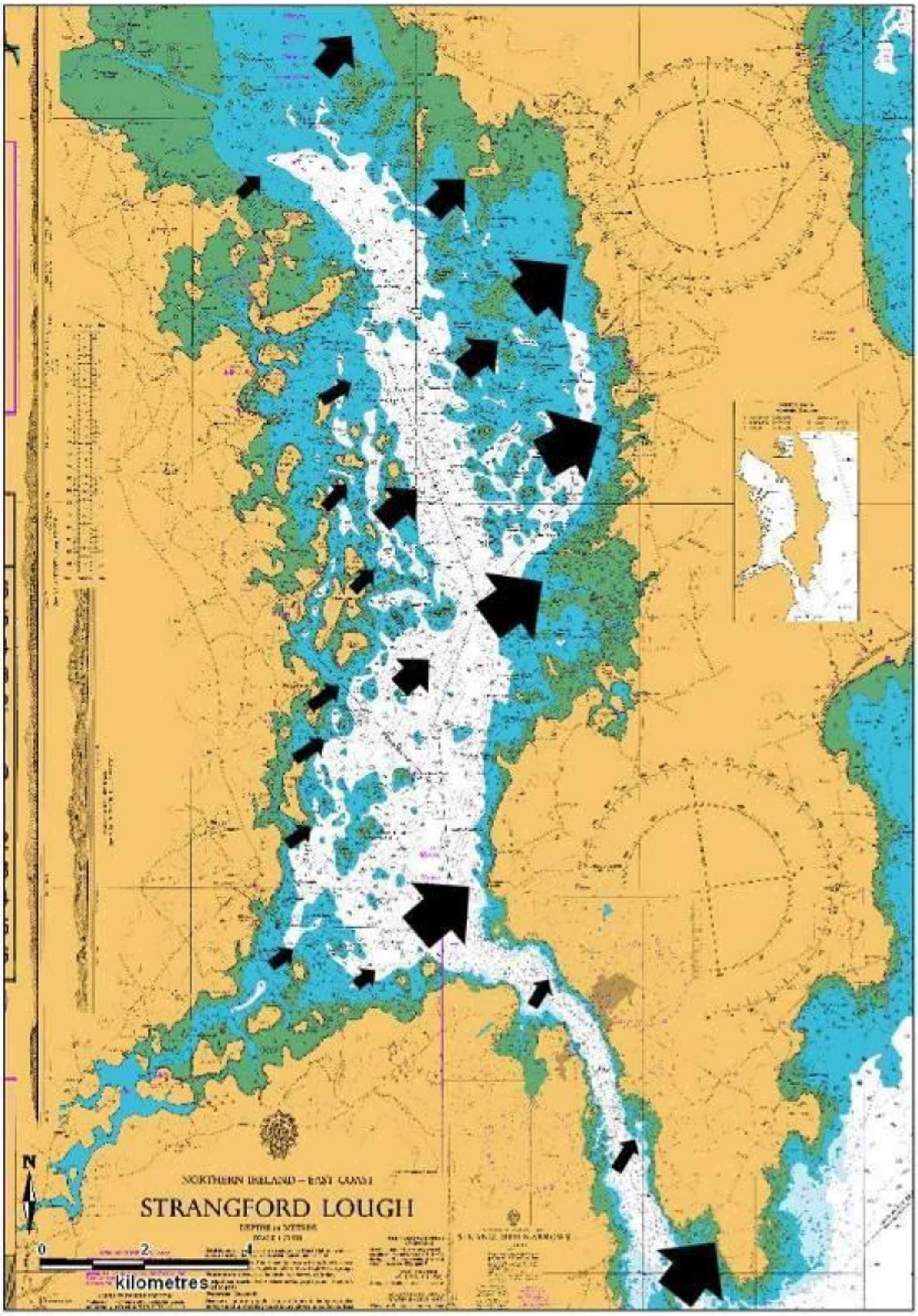


Wind conditions affect the hydrodynamic conditions in Strangford Lough by generating wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Wind waves are produced by the local prevailing wind. They travel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

Especially over the shallow areas of Strangford Lough, wave-induced bottom friction may lead to resuspension of material and entrainment of sediments in the water column. Figure 3.14 shows the pattern of water movement due to wave action in Strangford Lough, the greater energy being shown by the larger arrows.

Figure 3.14: Pattern of water movement in Strangford Lough due to wave action (adapted from Brown, 1990).



3.5. River Discharges

The main freshwater sources to Strangford Lough are the Comber River (through Comber town) in the northwest and the Quoile River (through Downpatrick) in the southwest. The Comber River drains 11% of the total Strangford catchment area and the Quoile River drains 31% (CEFAS, 2005). The Rivers Agency operates 2 hydrometric monitoring stations within the Strangford Lough catchment area: Enler at Comber and Annacloy at Kilmore Bridge. The mean flow at Enler has increased slightly to 0.82 m^3/s in 2019 from 0.78 m^3/s in 2011. Similarly, the mean flow at Annacloyhas increased to 3.6 m^3/s in 2019 from 3.5 m^3/s in 2011 (NRFA [National River Flow Archive], 2020). Figure 3.15 shows all rivers discharging into Strangford Lough or a tributary of Strangford Lough and the two hydrometric monitoring stations within the catchment.

Figure 3.16 and 3.17 shows the averaged and total flow of the Enler River at Comber from 2006 to 2009 and 2015 to 2018 (Data for the Annacloy at Kilmore Bridge was not available). Over the 4-year period of 2006 to 2009, April and May had the least flow (52.7 and 51.9 m^3/s respectively) with January and November having the highest flows (211.1 and 160.5 m^3/s respectively). January 2008 had the highest overall flow (98.85 m^3/s total; 3.19 m^3/s average) and July 2006 had the lowest overall flow (4.52 m^3/s total; 0.15 m^3/s average). Over the 4-year period of 2015 to 20018, June and July had the least flow (27.9 and 36.0 m^3/s respectively) with January and December having the highest flows (218.9 and 226.0 m^3/s respectively). December 2015 had the highest overall flow (102.4 m^3/s total; 3.30 m^3/s average) and July 2006 had the lowest overall flow (3.69 m^3/s total; 0.12 m^3/s average).

Figure 3.15: Rivers and river monitoring stations (Source: NRFA, 2020).

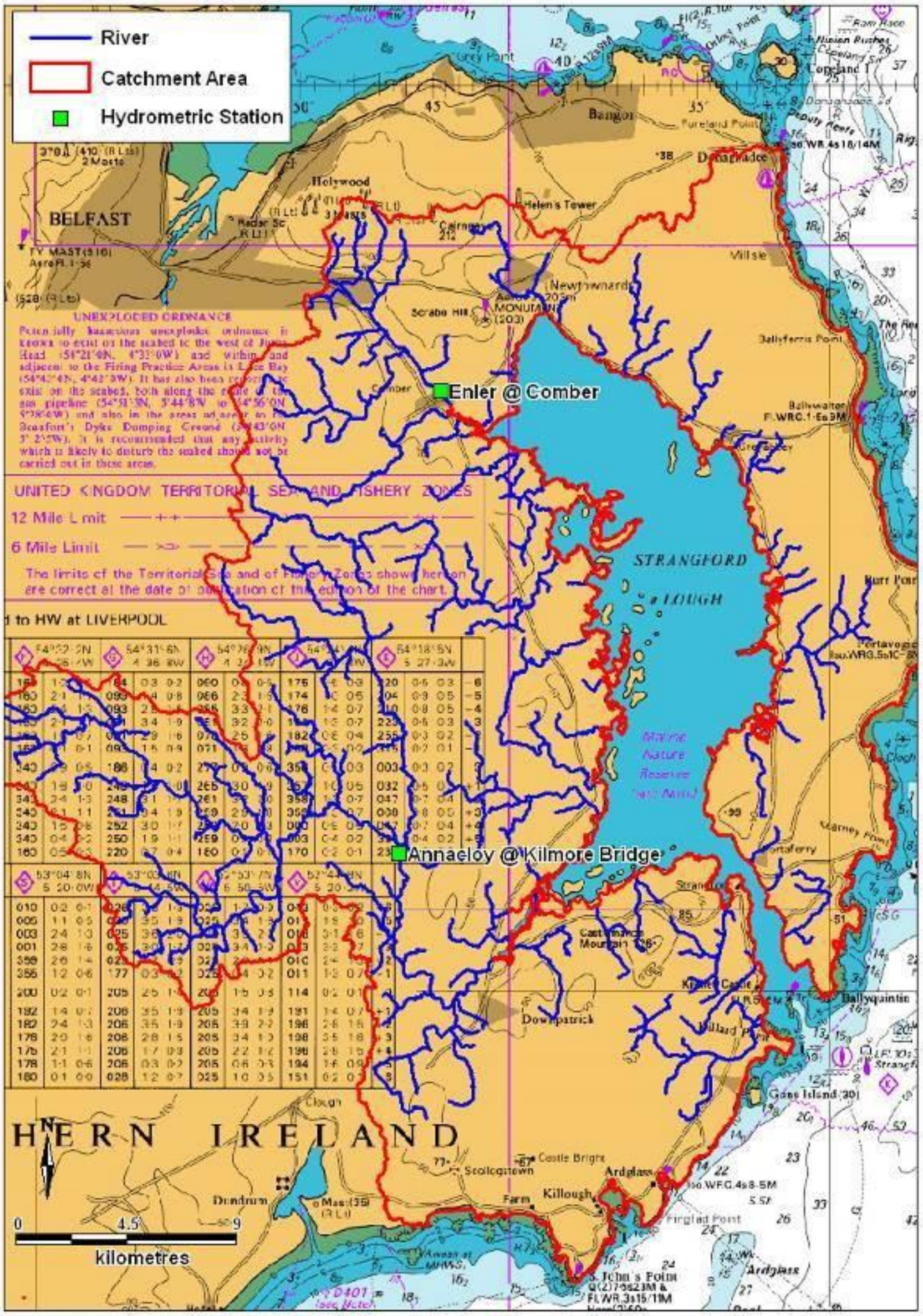
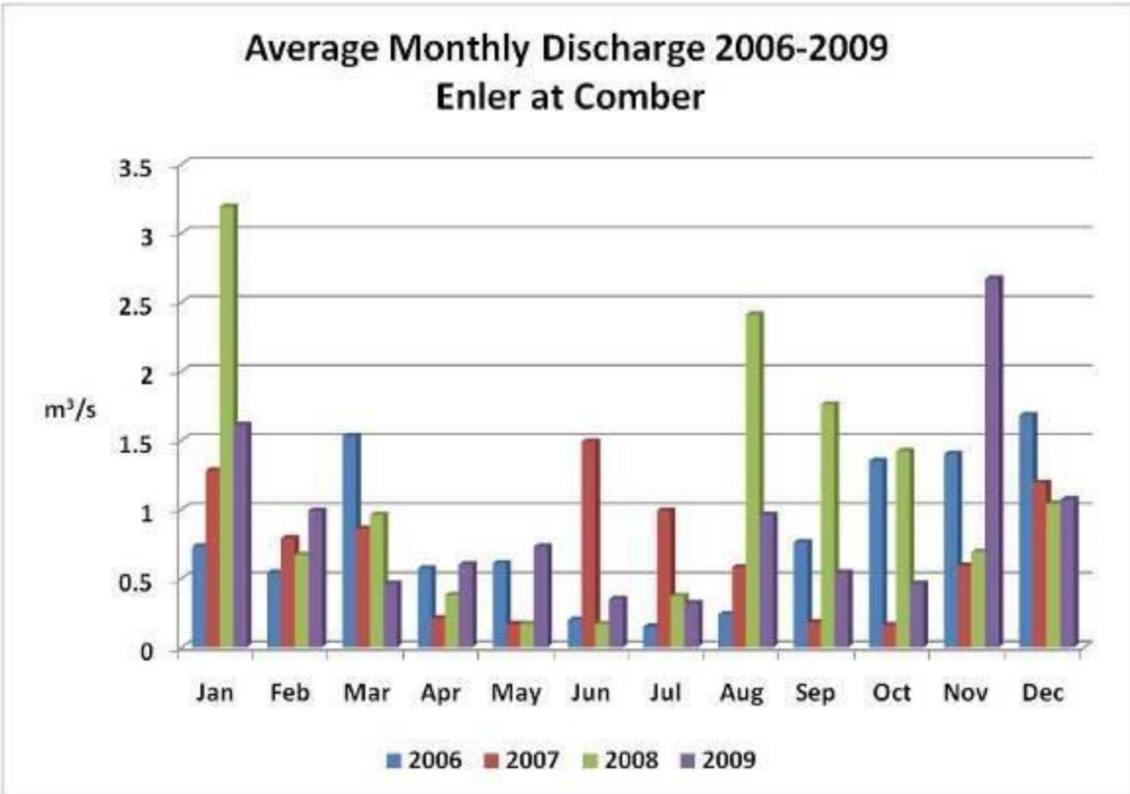


Figure 3.16: Average monthly flow data from the Enler at Comber 2006-2009 and 2015-2018 (Source: NRFA, 2011; NRFA, 2020).



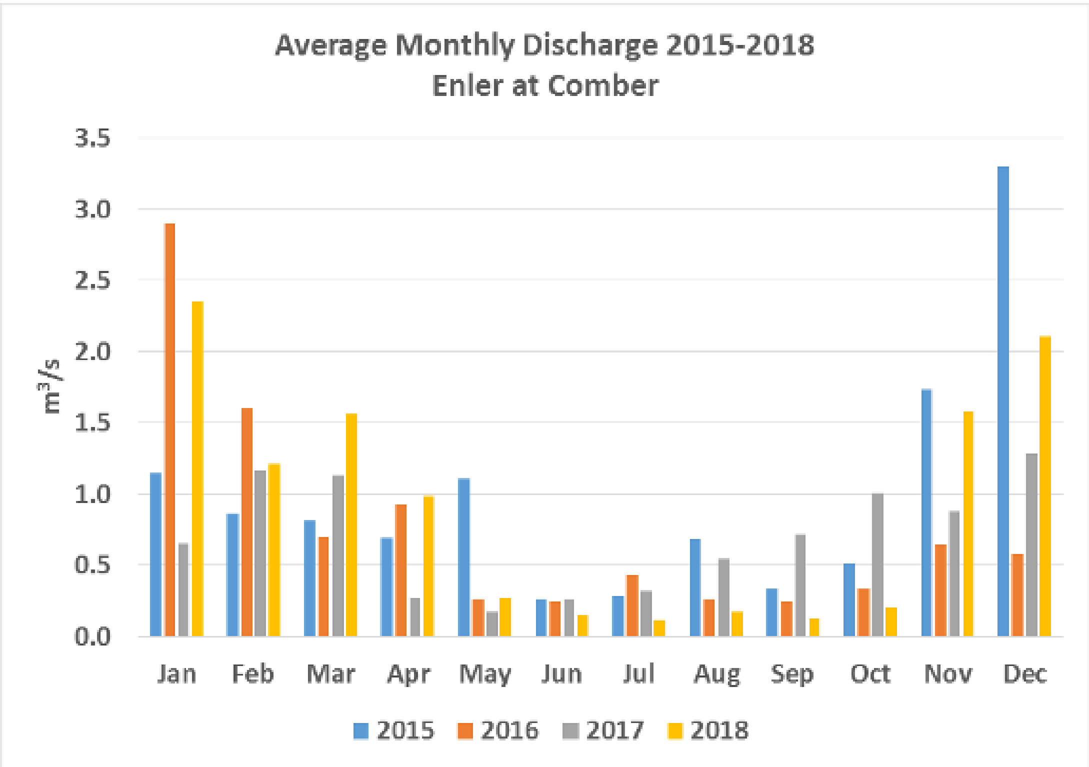
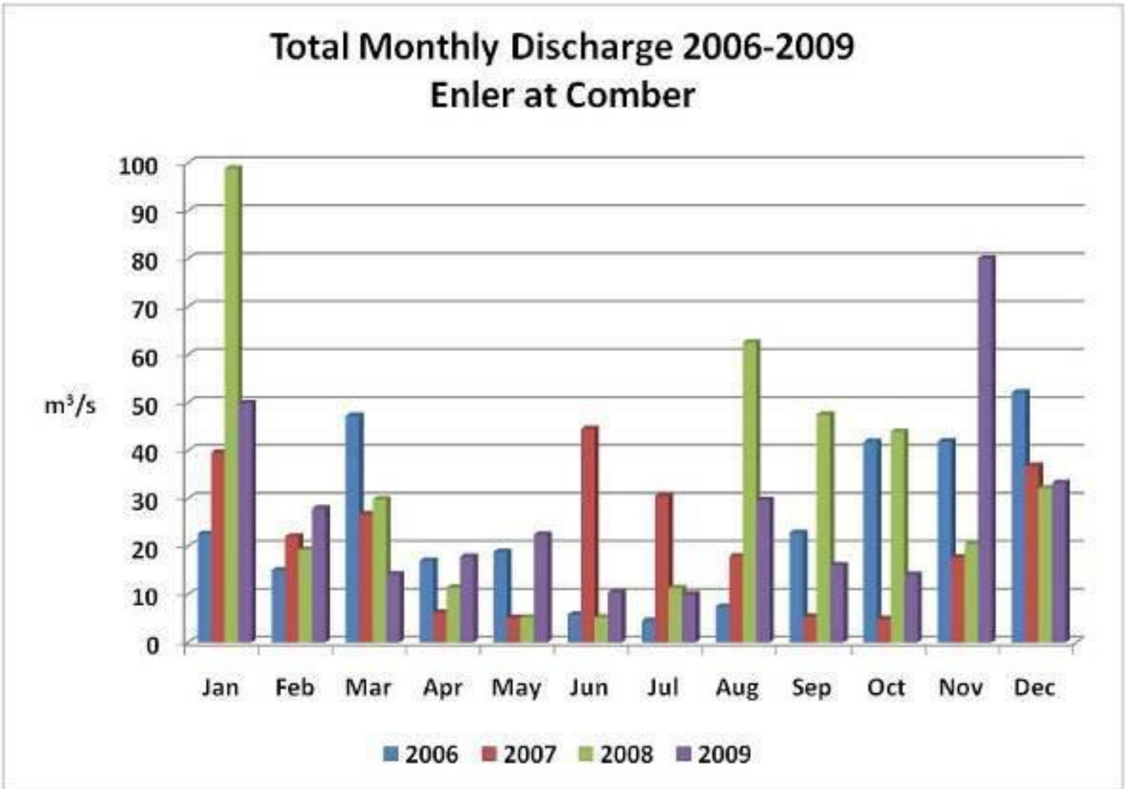
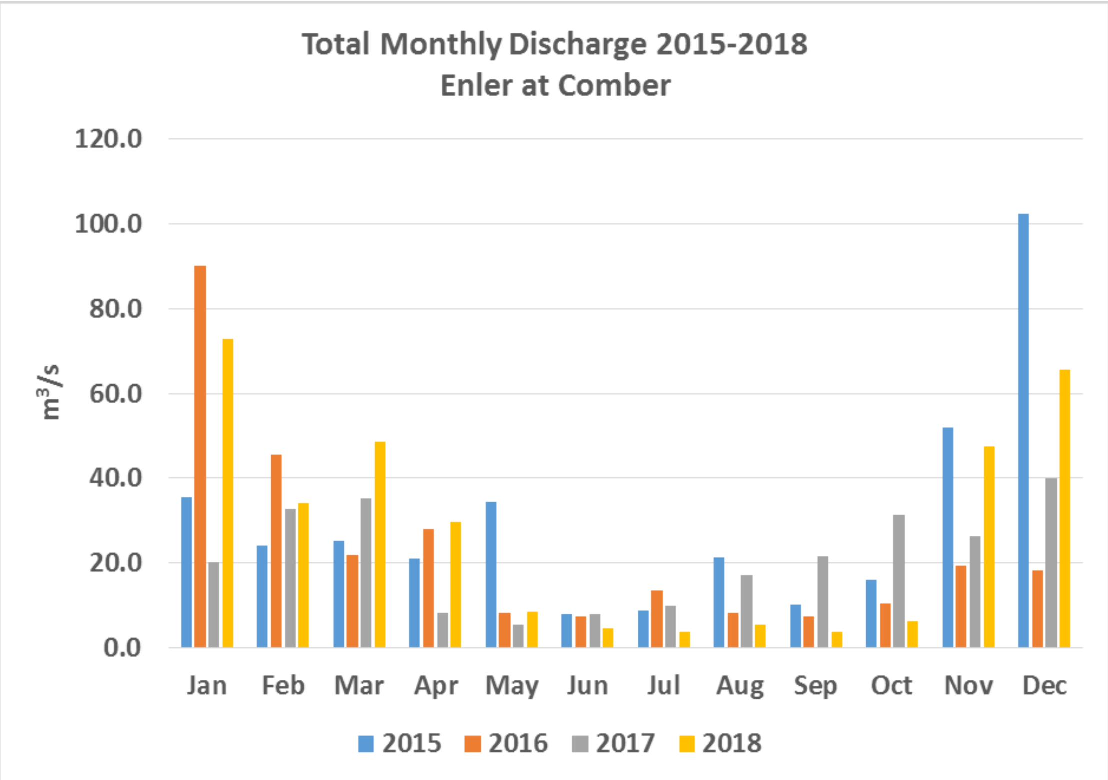


Figure 3.17: Total monthly flow data from the Enler at Comber 2006-2009 and 2015-2018 (Source: NRFA, 2011; NRFA, 2020).





3.6. Rainfall Data

3.6.1. Amount & Time of Year

Figures 3.19 to 3.20 show the average monthly rainfall data for Northern Ireland (Met Office, 2010) from 1971 to 2000 (previous sanitary survey) and 1981 to 2010 (Met Office, 2020a). It can be seen from these maps that the Strangford Lough area is one of the driest in Northern Ireland. Figure 3.18 shows the average rainfall along the Strangford Lough coastline. During the period 1971 to 2000, the average rainfall ranged from 68.1mm in May to 119.1mm in January. During the 1981 to 2010 period the average rainfall ranged from 60mm in May to 92.2 in October. In fact, the average rainfall for all months during the 1981 to 2010 period where lower than the 1971 to 2000 period. Figure 3.21 and 3.22 shows the seasonal averages from 1971 to 2000 and 1981 to 2010 for Northern Ireland. Table 3.2 shows the seasonal rainfall average values. Seasonally, spring and summer were the driest seasons and autumn was the wettest season for both 30-year periods.

Figure 3.18: 30-year average monthly rainfall (mm) along the Strangford Lough coastline (Source: Met Office, 2020a).

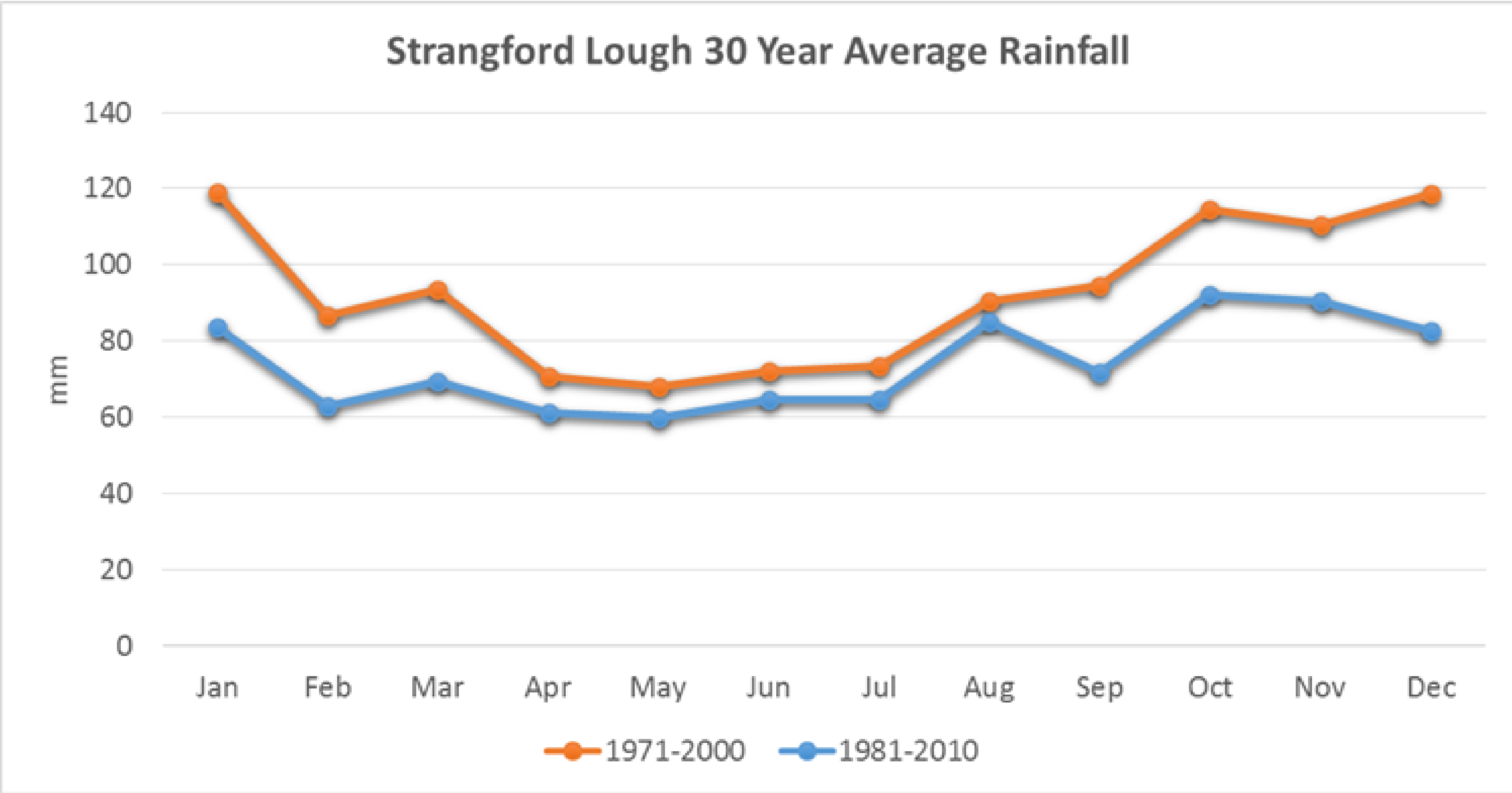


Table 3.2: Seasonal rainfall average values (mm) from 1971-2000 and 1981-2010 (Source: Met Office, 2020a).

Season	Average Rainfall (mm) 1971-2000	Average Rainfall (mm) 1981-2010
Spring	232.2	190.7
Summer	235.9	213.9
Autumn	319.7	254.5
Winter	324.2	229.1

Figure 3.19: Average monthly rainfall (mm) data for January to December from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

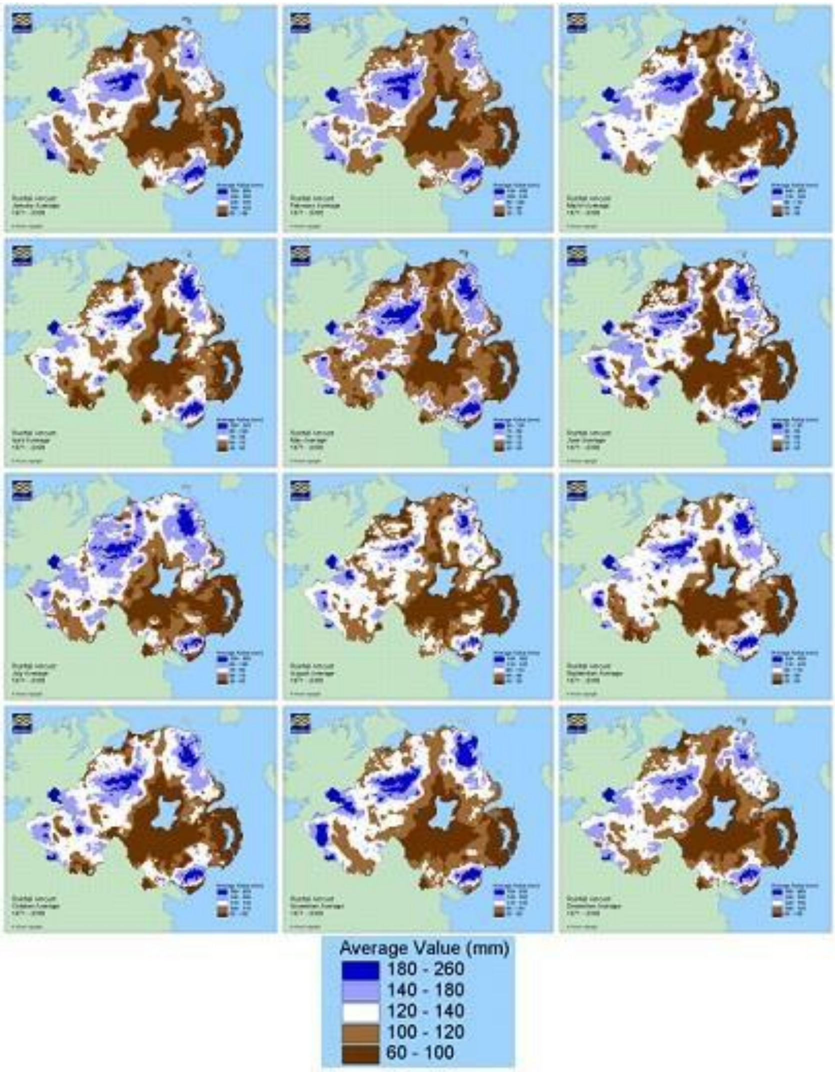


Figure 3.20: Average monthly rainfall (mm) data for January to December from 1981 to 2010 for Northern Ireland (Source: Met Office, 2020a).

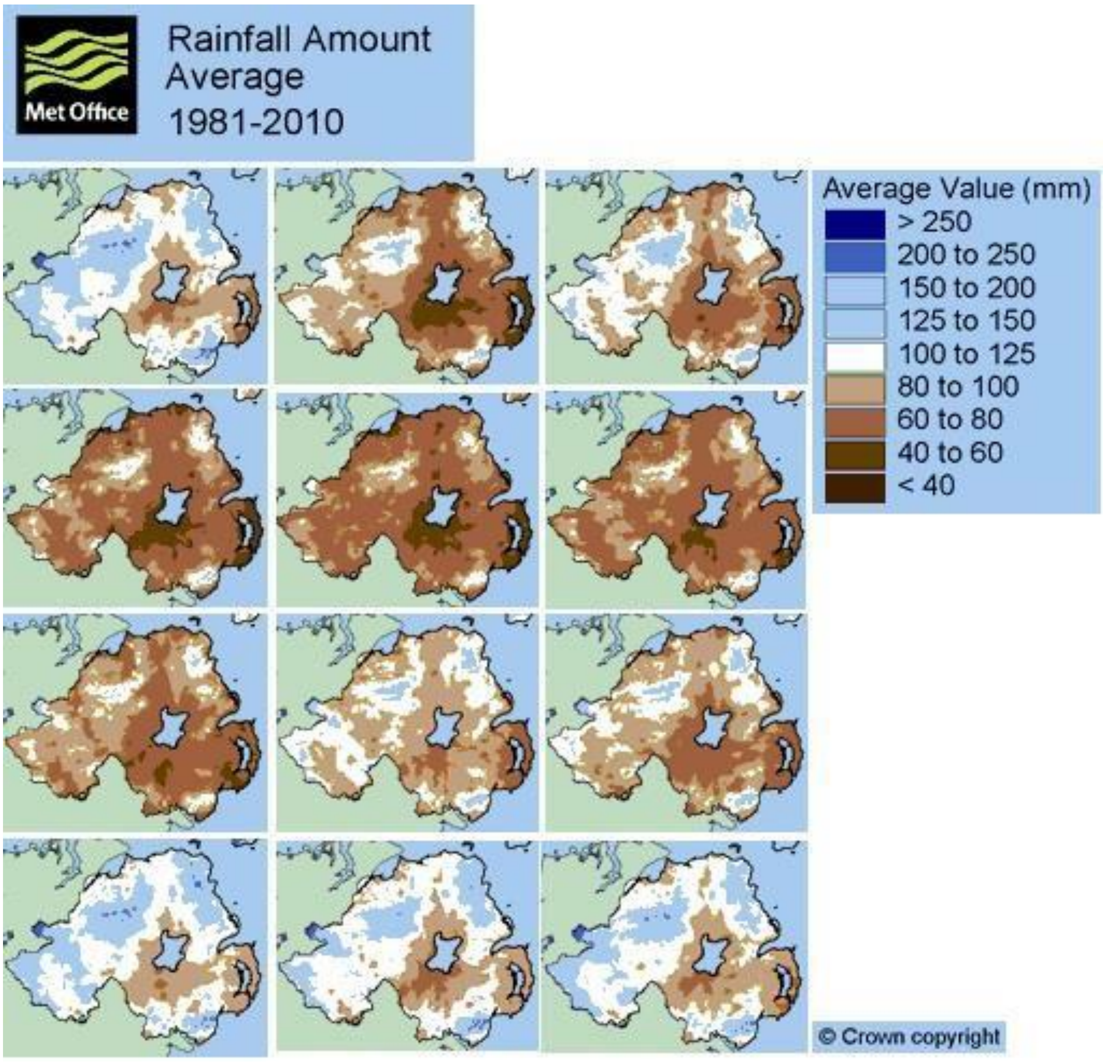


Figure 3.21: Seasonal rainfall averages (mm) from 1971 to 2000 for Northern Ireland (Source: Met Office, 2010).

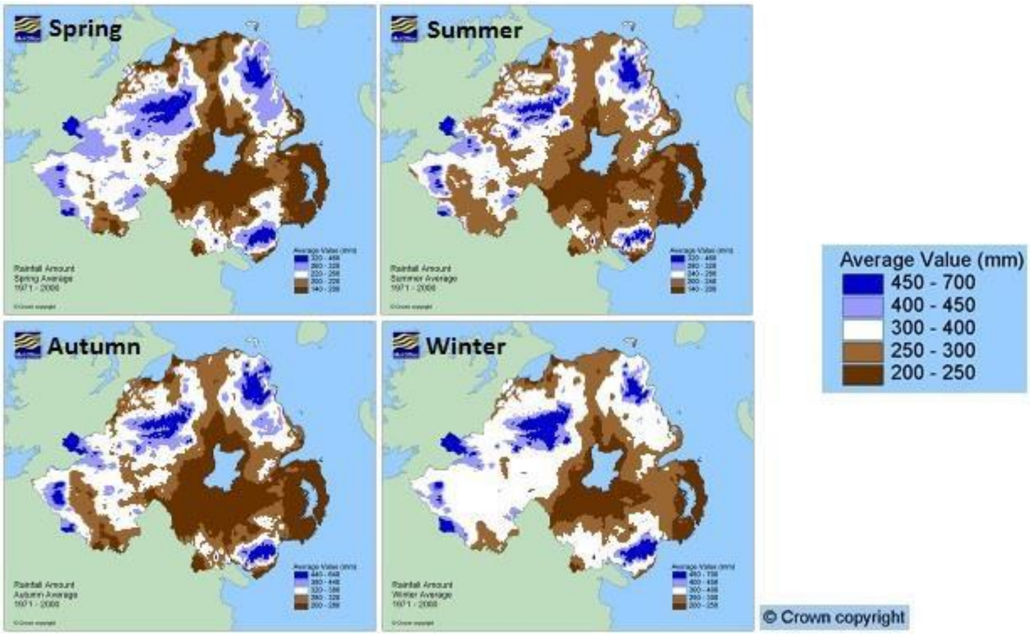


Figure 3.22: Seasonal rainfall averages (mm) from 1981 to 2010 for Northern Ireland (Source: Met Office, 2020a).

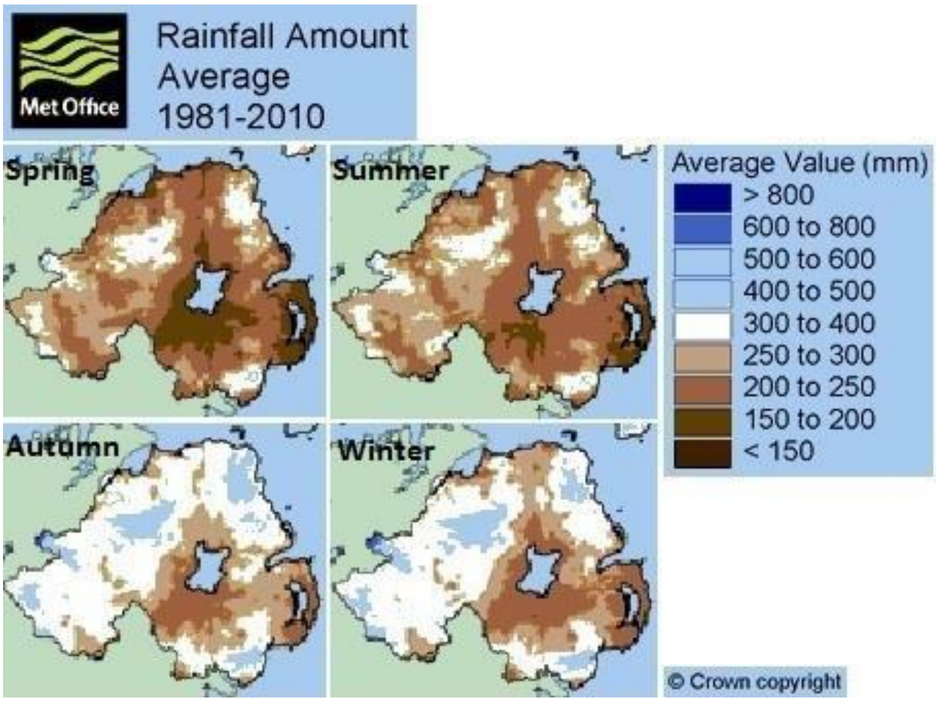


Figure 3.23 shows the 5-year average rainfall values from 2007-2011 (previous sanitary survey) and 2015-2019 for Strangford Lough (Met Office, 2020b). It can be seen that for both 5-year averages February to May is the driest period. In both cases conditions become wetter towards the end of summer. They then drop off somewhat in early autumn before increasing again in late autumn and winter. Figure 3.24 shows 5-year average seasonal rainfall for the Strangford Lough area (Met Office, 2020b). In both 5-year periods summer was the wettest season and spring the driest.

Figure 3.23: 5 Year monthly rainfall averages for Strangford Lough area (Met Office, 2020b).

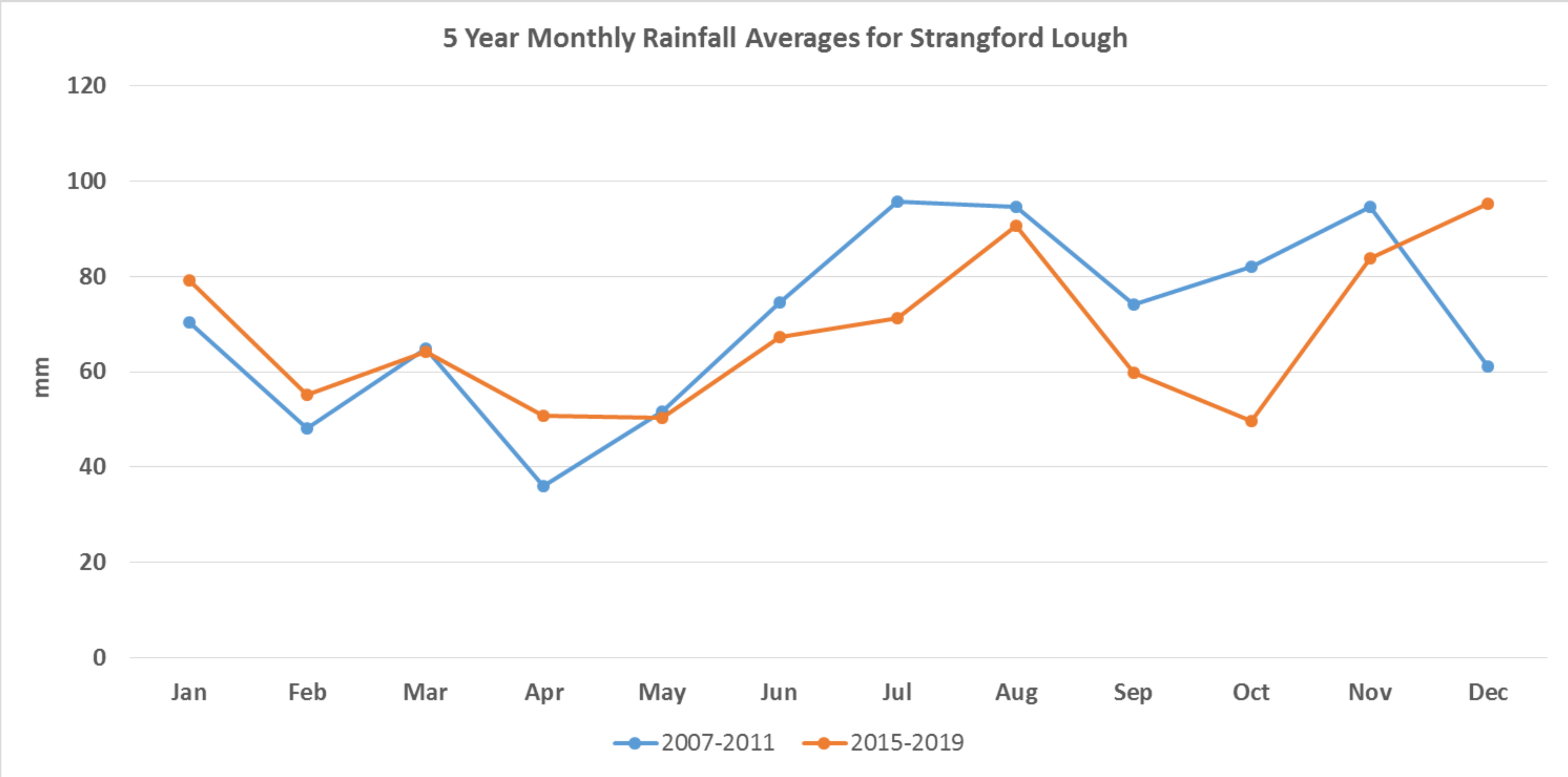
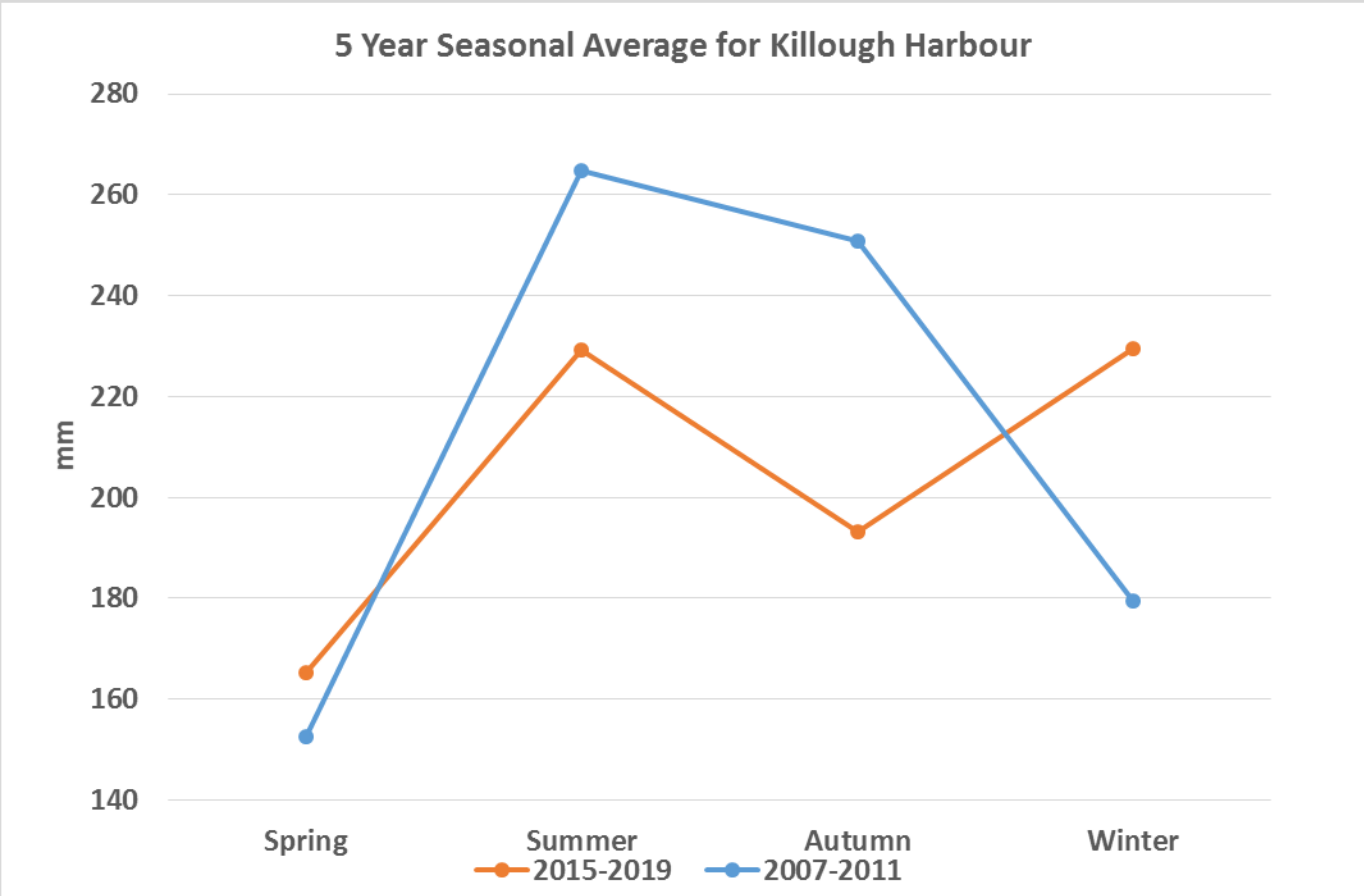


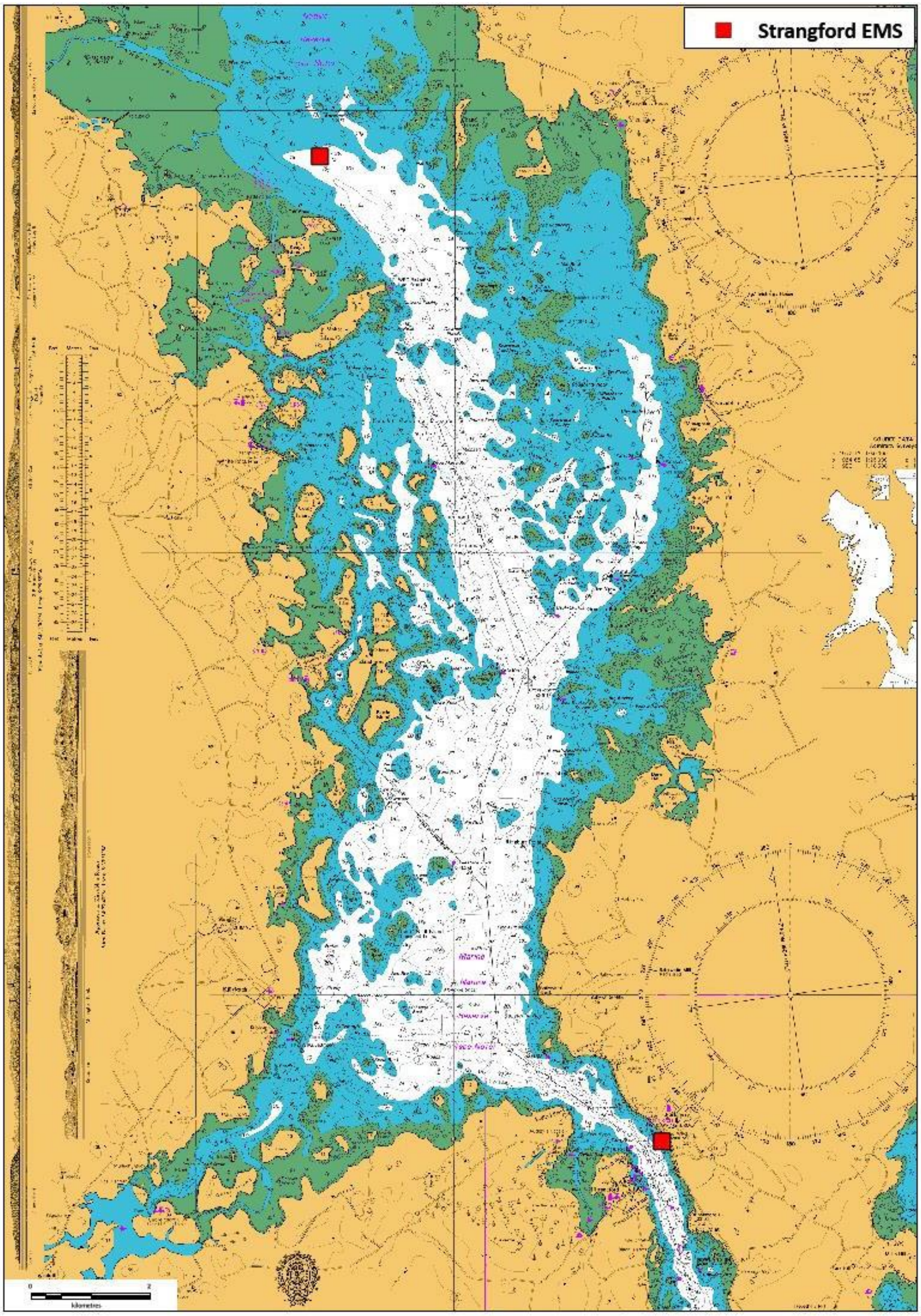
Figure 3.24: 5 Year seasonal rainfall averages for Strangford Lough area (Met Office, 2020b).



3.7. Salinity

Salinity is the saltiness or dissolved salt (sodium chloride, magnesium, calcium sulphates and bicarbonates) content of a body of water. Freshwater typically has a salinity of <0.5 PSU and seawater typically has a salinity of between 30-35 PSU. The Agri-Food & Biosciences Institute (AFBI) collect, manage, and process data on coastal water quality including salinity via a network of remotely moored Environmental Monitoring Stations (EMS) in Strangford Lough. 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 this data with a base station on-land. There are two EMS stations located within Strangford Lough (See Figure 3.25). The Strangford Lough North EMS is located approximately 7.7km southeast of Comber and the Strangford Lough Narrows EMS is located outside Portaferry Marina. Salinity data are collected daily. Surface salinities at the North site ranged from approximately 28 to 34 PSU and from approximately 32 to 35 PSU at the Narrows site. A slight seasonal effect on salinity occurs within the lough, typically with higher salinities in the summer and lower salinities through the autumn and winter.

Figure 3.25: Location of the salinity and turbidity monitoring sites in Strangford Lough.



3.8. Turbidity

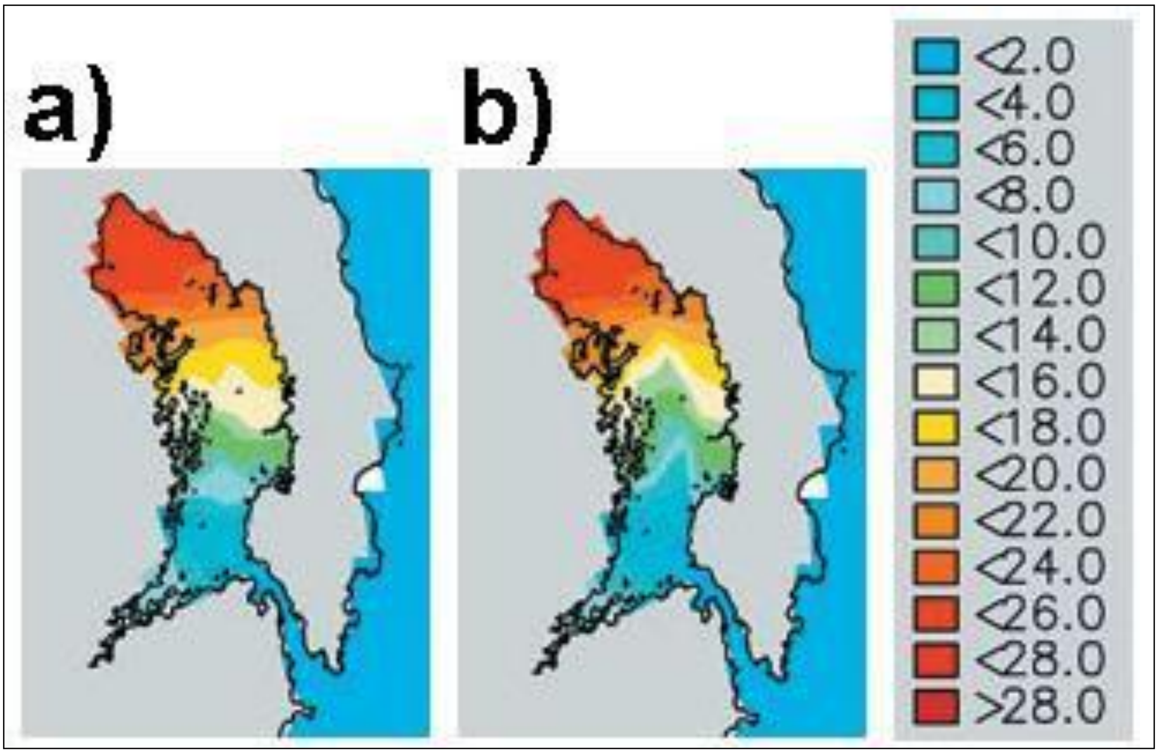
Turbidity is a measure of the degree to which water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity levels are expected to be highest in shallow disturbed waters compared to deeper well flushed areas. Turbidity at the north EMS site (Figure 3.25) ranges from 0 to 1047 NTU with an average of 4.4 NTU. The narrows site ranges from 0 to 2422 NTU with an average of 23.6 NTU.

3.9. Residence Times

Residence time is a measure of the average time a substance spends within a physical system; this substance could be any particle flowing with the water. Residence time are an indicator of how long a pollutant, or a biological organism will reside in a bay/estuary before being forced out of its mouth due either to river discharge or tidal flow. 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 3.26 (Source: Ferreira *et al.,* 2007). These values are calculated from the SMILE Delft3D Model. Strangford 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 3.26: Residence times (days) within Strangford Lough a) near surface and b) near bottom (Source: Ferreira *et al.,* 2007).



3.10. Discussion

The bathymetric and hydrographic characteristics of the Narrows, with greatest depths and strongest currents make it a well-mixed and well flushed area and as a result any contaminants in the Narrows are diluted and dispersed rapidly. Inside the Narrows, in the lough proper, there are strong currents between Ballyhenry Point and Gransha Point and moderate current speeds inside of Gransha Point. Depths in these areas range from shallow (2-5m) to deeper pools from between 30-60m. These areas are considered to be well mixed and well flushed over the course of a tidal cycle. There are three areas in the lough, where depths are shallow and current speeds are weak and as a result these areas may act as sinks for contaminants. These areas are in the southwest of the lough in the area of the Quoile River, along the western shoreline between Ringhaddy and Conly Island and in the northwestern region of the lough inside the Comber River area. These areas also have varying amounts of freshwater input and as a result may be more vulnerable to contamination. Water movement as a result of wave action is towards the eastern shoreline and the prevailing wind direction also results in water movement towards the eastern and northern shoreline, this and the fact that there are strong to moderate current flows in these areas it is likely that these areas will experience varying levels of sediment disturbance and resuspension particularly in the shallower areas.

There has been no significant change in the hydrodynamics of Strangford lough since the 2011 sanitary survey. A slight increase was noted in the flow in both the Comber and Quoile rivers, although weather data did not show any real change in rainfall patterns or amounts. There has been no change in wind patterns.

4. Identification of Pollution Sources

4.1. Desktop Survey

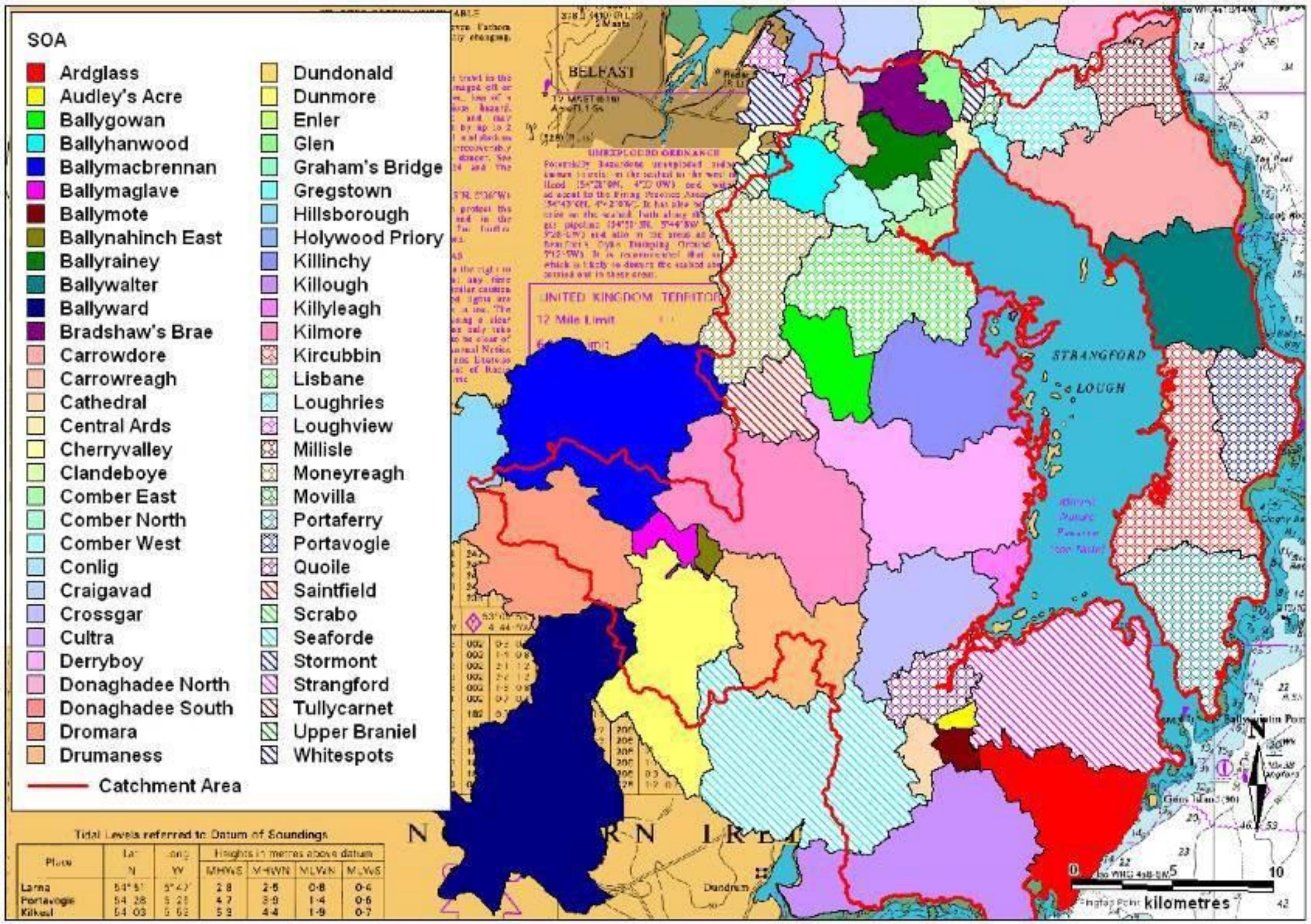
Pollution sources were considered within the catchment area of Strangford Lough (see Figure 4.1). The catchment area covers an area of 771.5km^2 (Roberts *et al.,* 2004) and it is approximately 38.5km east west at its widest point and 42.3km north south at its longest point. The rivers, which drain into Strangford Lough can also be seen in Figure 4.1. The entire catchment area (as shown in Figure 4.1) does not drain into Strangford Lough. Only the pollution sources, flowing into the lough or into a tributary of the lough were considered as part of this survey i.e., sources flowing into the Irish Sea or Dundrum Bay were not considered.

Figure 4.1: Strangford Lough catchment area and rivers used for assessment of the pollution sources (Source: NIEA, 2011).

4.1.1. Human Population

Strangford Lough and its catchment area are located entirely in Co. Down. Population census data for Northern Ireland is given in units of Super Output Areas (SOA). Figure 4.2 shows the SOAs within the Strangford Lough catchment area which drain into Strangford Lough.

Figure 4.2: SOAs within the Strangford Lough Catchment Area.



Data on human populations for 2008 and 2016 for Northern Ireland was obtained from The Northern Ireland Statistics and Research Agency (NISRA) website (NISRA, 2020). Figure 4.3 shows the human population change within the Strangford Lough catchment area from 2008 – 2016 and Table 4.1 shows this data in tabular form.

Population size around the coast of Strangford Lough ranges from 2,139 (-5.6%) people in Audley's Acre SOA to 6,021 (+2.8) people in Cherryvalley SOA. The largest population centres (>5,000 people) in the study area are located around Belfast and Bangor and are Cherryvalley (6,021 people +2.8%), Conlig (5,612 people -0.6%) and Stormont (5,639 people + 3.4%). These population centres are located along the border of the catchment area and only a very small percentage actually lies within the catchment area. The total population of the SOA which overlap Strangford Lough Catchment is 200,586 people up 3.2% from the 2011 sanitary survey. However, much of the SOAs only partially overlap the catchment. Therefore, an effort was made to estimate the population within the catchment based on the percentage of the SOAs within it. Based on this the total population within the Strangford Lough catchment is estimated at approximately 150,000 people which is the same as the estimate from the 2011 sanitary survey.

Figure 4.4 and Table 4.2 shows the 2008 and 2015 population size in the main urban centres within the catchment area (NISRA, 2015). Newtownards (28,039 -1.5%) and Downpatrick (10,847 +1.3%) are the largest population centres, located to the north and south of the lough. Comber (9,078 +1.6%) was the next largest centre located to the northwest of the lough. The remaining coastal centres are all villages/intermediate settlements with populations ranging from 939 (Greyabbey, -9.5%) to 2,928 (Killyleagh, -3.3%).

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. However, it is clear that areas with a higher population will have higher levels of sewage and wastewater entering the Strangford Lough system.

Figure 4.3: Human population change within the Strangford Lough Catchment Area from 2008 - 2016 (Source: NISRA, 2020).

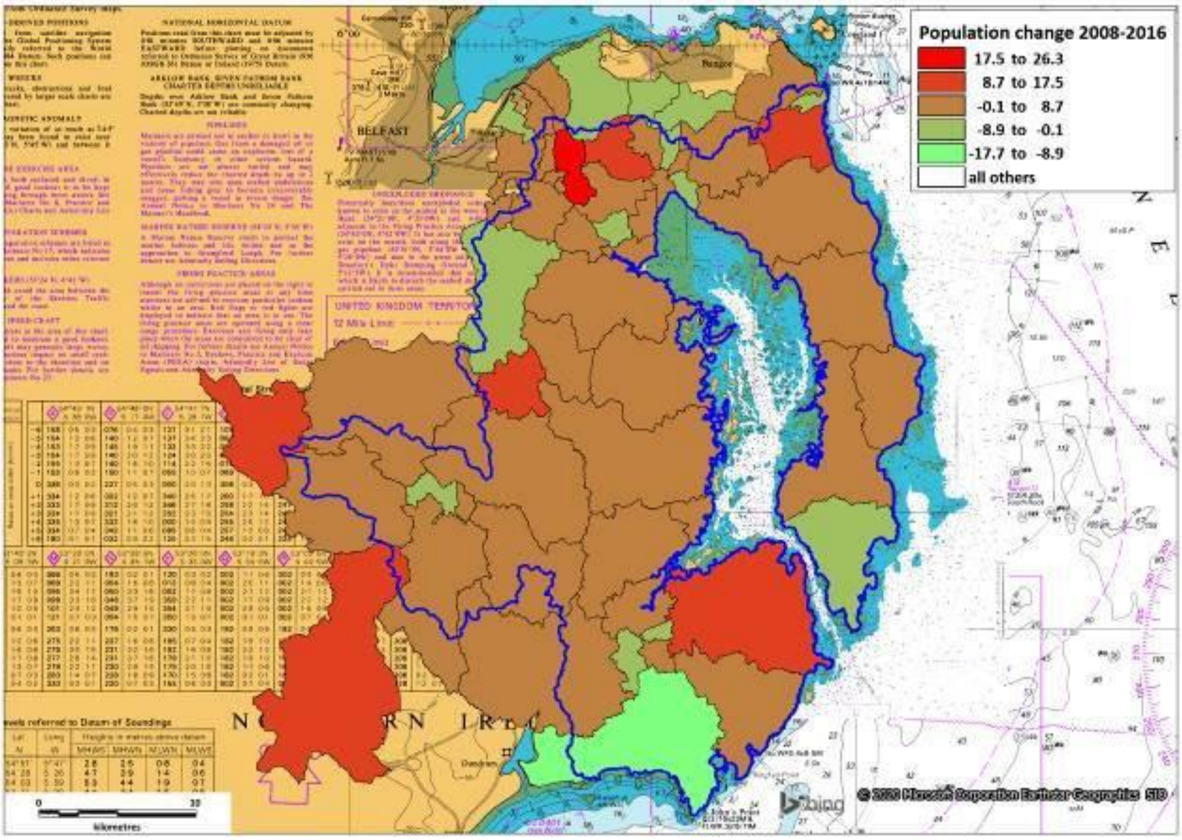


Table 4.1: Human population within the Strangford Lough Catchment Area (Source: NISRA, 2020).

SOA	Pop. 2008	Pop. 2016	% Change
Ballynahinch East	2457	2481	1.0
Holywood Priory	2684	2728	1.6
Cultra	2492	2502	0.4
Craigavad	2613	2573	-1.5
Strangford	2643	2872	8.7
Seaforde	2940	3138	6.7
Killyleagh	2941	3125	6.3
Dunmore	2952	3118	5.6
Ballymote	2844	3080	8.3
Audley's Acre	2266	2139	-5.6
Upper Braniel	2257	2328	3.1
Tullycarnet	2393	2413	0.8
Graham's Bridge	2537	2716	7.1
Enler	2559	2573	0.5
Ballyward	2705	3007	11.2
Central Ards	2763	2933	6.2
Ballyrainey	2387	2433	1.9
Ballymacbrennan	3285	3504	6.7
Saintfield	3258	3557	9.2
Quoile	2667	2819	5.7
Kilmore	3182	3296	3.6
Killough	3687	3035	-17.7
Drumaness	3764	4031	7.1
Derryboy	2997	3170	5.8
Dromara	4575	4640	1.4
Crossgar	3232	3352	3.7
Cathedral	3353	3211	-4.2
Ballymaglave	2935	2830	-3.6
Ardglass	3122	3194	2.3
Moneyreagh	3818	3752	-1.7
Dundonald	3428	3455	0.8
Carrowreagh	4178	5276	26.3
Ballyhanwood	3120	3198	2.5
Whitespots	3070	3006	-2.1
Scrabo	3046	3289	8.0
Portavogie	4563	4762	4.4
Portaferry	3451	3304	-4.3
Movilla	4751	4921	3.6

Millisle	4047	4539	12.2
Loughries	3546	3589	1.2
Lisbane	3062	3285	7.3
Kircubbin	3349	3497	4.4
Killinchy	3065	3131	2.2
Gregstown	4549	4349	-4.4
Glen	2767	2925	5.7
Donaghadee South	3106	2912	-6.2
Donaghadee North	3303	3422	3.6
Comber West	2981	3001	0.7
Comber North	2646	2622	-0.9
Comber East	2870	3023	5.3
Carrowdore	3293	3478	5.6
Bradshaw's Brae	2931	3221	9.9
Ballywalter	4007	4311	7.6
Ballygowan	3625	3739	3.1
Loughview	3388	3343	-1.3
Conlig	5645	5612	-0.6
Clandeboye	4956	4939	-0.3
Hillsborough	3614	3958	9.5
Stormont	5456	5639	3.4
Cherryvalley	5859	6021	2.8

Figure 4.4: Populations of urban centres within the catchment area 2015 (Source: NISRA, 2015).

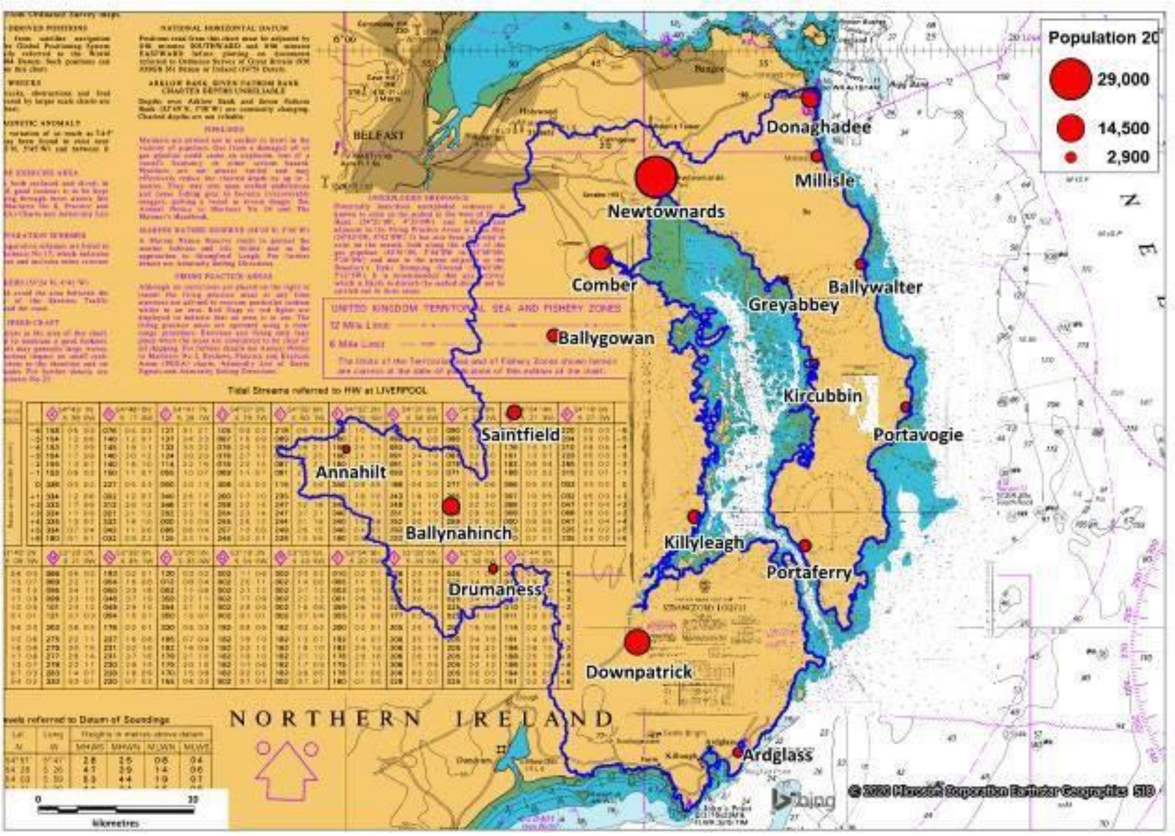


Table 4.2: Change in Populations of urban centres within the catchment area between 2008 and 2015 (Source: NISRA, 2015).

Name	Settlement	Population 2008	Population 2015	Population Change %
Greyabbey	Village	1037	939	-9.5
Kircubbin	Village	1188	1153	-2.9
Portaferry	Village	2514	2514	0.0
Portavogie	Village	2042	2122	3.9
Ballywalter	Village	1647	2027	23.1
Millisle	Village	2089	2318	11.0
Donaghadee	Small Town	6856	6869	0.2
Newtownards	Large Town	28437	28039	-1.5
Comber	Small Town	8933	9078	1.6
Ballygowan	Intermediate Settlement	2828	2957	4.6
Killyleagh	Intermediate Settlement	3028	2928	-3.3
Downpatrick	Medium Town	10737	10874	1.3
Drumaness	Village	1300	1344	3.4
Ballynahinch	Small Town	5633	5715	1.5
Saintfield	Intermediate Settlement	3445	3406	-1.1
Ardglass	Village	1605	1643	2.4
Annahilt	Village	1115	1045	-6.3
Total		**84470**	**84971**	**0.6**

4.1.2. Tourism

In 2018, 2,809,000 tourists visited Northern Ireland compared to 1,918,000 in 2009 (NITB {Northern Ireland Tourist Board}, 2018). This is a 46.5% increase in tourism to Northern Ireland since the last sanitary survey. Of these tourists, 46% were visiting family and friends and 37% were holidaying, 30% of them arrived in between July and September and 25% of them arrived between April and June and 49% stayed with family or friends while 30% stayed in a hotel/guesthouse/B&B. The Strangford Lough Catchment overlaps four Local Government Districts for tourism numbers Newry /Mourne /Down, Ards/North Down, Lisburn/ Castlereagh and Belfast. These four districts received 1,758,568 tourists in 2018, an increase of 63.5% since 2011. However, only a small portion of the Belfast and Lisburn/ Castlereagh districts overlap the catchment. The districts of Newry /Mourne /Down and Ards/ North Down received 345,708 tourists in 2018, an increase of 7.4% on 2011.

There are numerous activities which tourists can partake in along the shores of Strangford Lough, e.g., sailing, kayaking, canoeing, bird watching, diving, cruising, adventure centres, wildlife centres, angling, golf, mountain biking, walking and caravanning. These can be seen in Figure 4.5 below.

Currently sea anglers target mackerel during the summer as well as pollack, coalfish and conger eels (SLLP, 2011a). The majority of sea angling takes place from the shore, rocks and from piers and marinas. Some angling takes place on the lough on privately owned and local charter boats and these anglers may target other species such as cod and ling in deep areas of the lough and on shipwrecks. Sailing and canoeing are among the other water sports on the lough. There are 12 sailing clubs around Strangford Lough, Strangford Lough Yacht Club (Whiterock) being the largest. Boats at these clubs range from dinghies to large cruisers. Competitive sailing takes place throughout the summer and annual regattas and other events are held. Windsurfing (or sail boarding) has become increasingly popular over recent years, particularly at Cunningburn, Kircubbin and Whiterock. The majority of windsurfing on Strangford Lough is affiliated with RYA Clubs and training centres. Little depth of water is required and insulating suits enable enthusiasts to sail throughout the year when weather permits. Typically, up to 50 windsurfers would be afloat during a summer weekend on the lough. There is also some kitesurfing in Strangford Lough, again mainly at the north end, around Cunningburn.

Strangford Lough is Northern Ireland’s first and only Marine Nature Reserve and there are also seven Nature Reserves located around the shores of Strangford Lough. The entire shoreline of the lough is designated as an Area of Outstanding Natural Beauty (AONB).

Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Strangford 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.

In order to identify any significant differences in *E. coli* levels based on seasonality, a one-way analysis of variance (ANOVA) was performed on seasonal *E. coli* results (for the period January 2005 to June 2011) from shellfish flesh taken at a number of beds around the lough (Refer to Section 5.1.2 for more details on the sampling points) and box-plots were created. For this analysis, all shellfish flesh results that returned a less than value (i.e., <X) were given that value (e.g., <20 becomes 20). Box-plots are frequently used to assess and compare sample distributions of microbiological data.

Figures 4.6 to 4.8 show box-plots produced for each shellfish bed after grouping the data by season. These graphs are composed of 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

This analysis revealed that for S2 Skate Rock mussels, spring had significantly lower *E. coli* results that all other seasons. S2 Skate Rock is located at between the mouth of the Quoile River and the Narrows. Based on the modelling of water movement in the lough contamination from the upper part of the lough will not reach S2 Skate Rock. Instead, it will be flushed out to the open ocean. Therefore, the main source of pollution for S2 Skate Rock will be from the Quoile River. This river drains 31% of the Lough’s catchment which has some of the most intensive farming in the area. Spring is the driest season in the catchment. As the highest *E. coli* levels recorded at S2 Skate Rock occur during the wetter seasons it is likely for this licensed area that run off from land is the major source of contamination rather than tourism.

The analysis for S7 Paddy’s Point found that mussel *E. coli* levels were significantly higher in winter than in spring or autumn and for oyster the summer *E. coli* levels were significantly higher than spring or autumn. The boxplots in Figures 4.7 and 4.8 show that for both species *E. coli* levels have been highest in summer and winter. The increase in *E. coli* levels in summer may be from a combination of increased tourism and runoff from farmland towards the end of the summer as rainfall increases. The runoff from farmland in late summer can have particularly high levels of contamination due to accumulation of faecal waste over the driest months from April to June. The high levels recorded in winter are likely due to runoff from land as rainfall and river flows are at their highest.

Figure 4.5: Tourist facilities within the Strangford Lough Catchment Area.

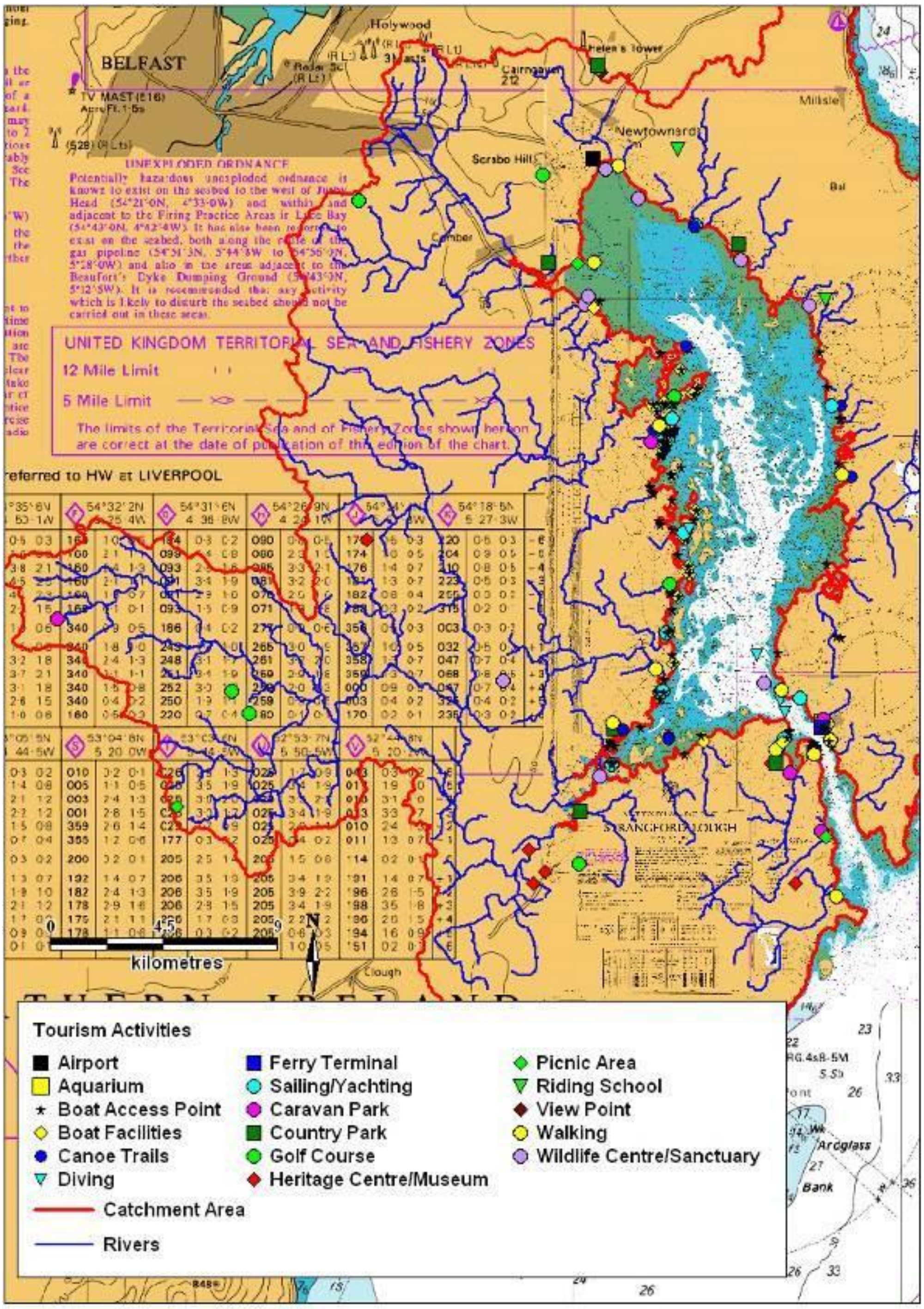


Figure 4.6: Seasonal variation of *E. coli* in mussel flesh from S2 Skate Rock.

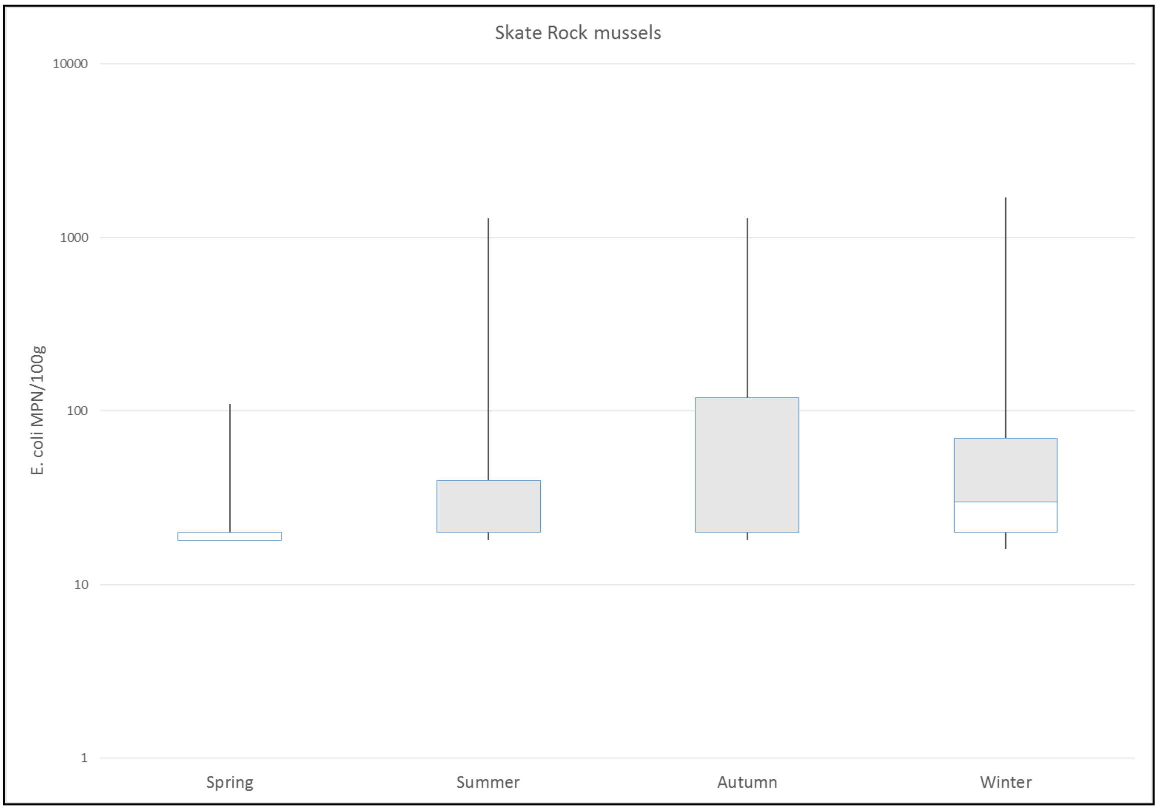


Figure 4.7: Seasonal variation of *E. coli* in mussel flesh from S7 Paddy's Point.

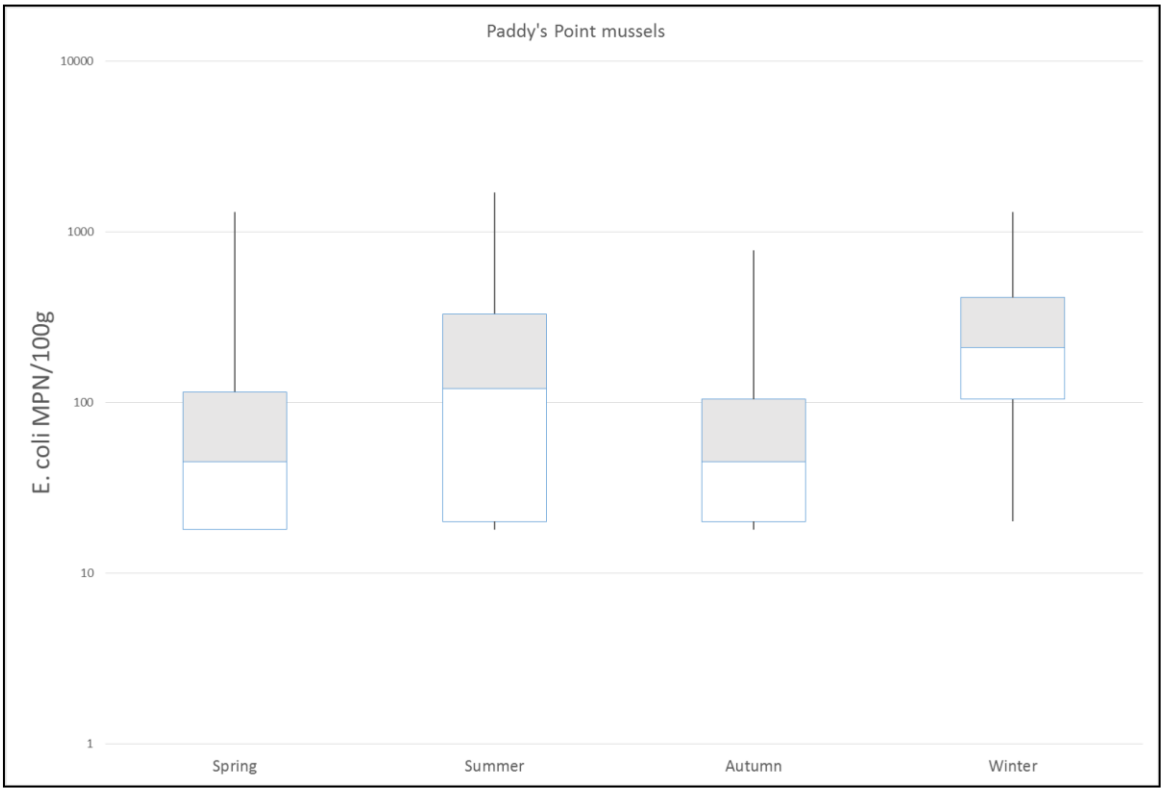
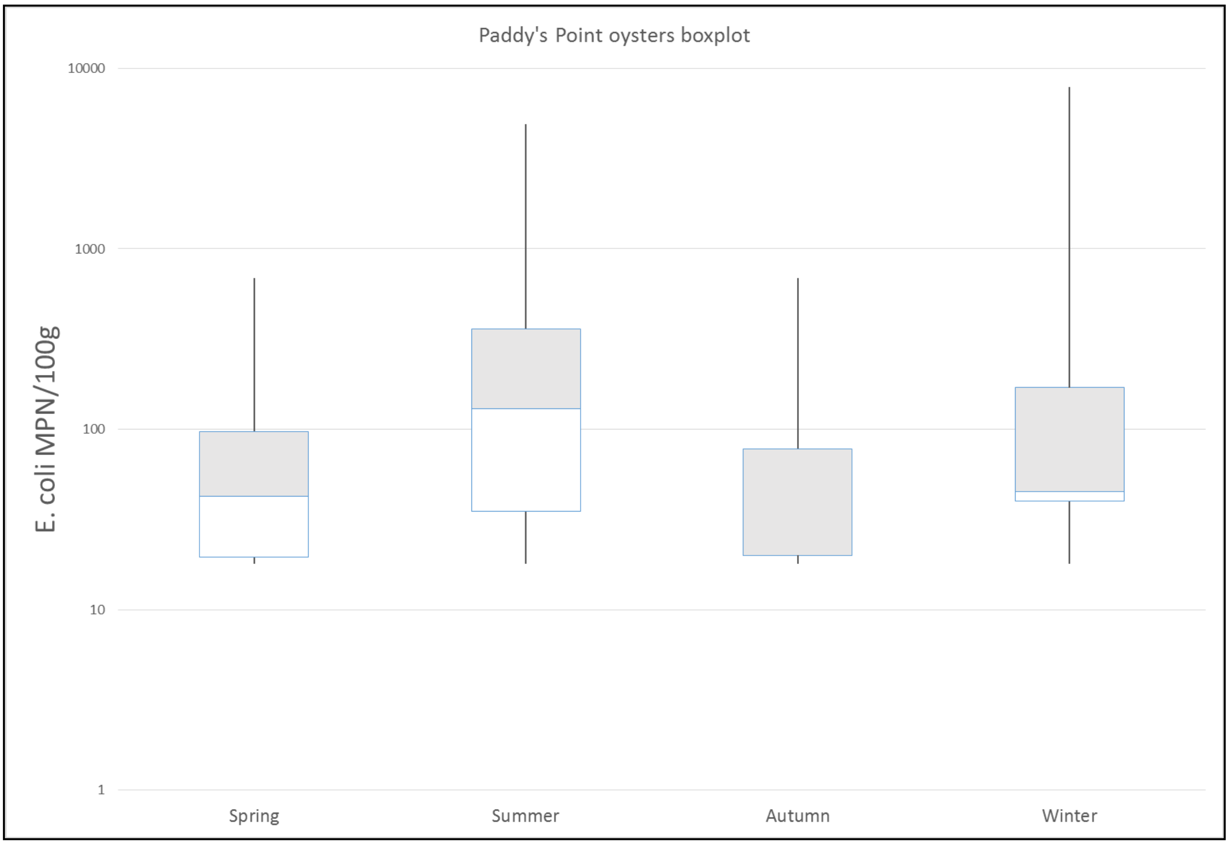


Figure 4.8: Seasonal variation of *E. coli* in oyster flesh from S7 Paddy's Point.



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 4.9 shows all 39 Waste Water Treatment Works within the Strangford Lough catchment area. Table 4.3 shows the coordinates and population equivalents (p.e.) of these plants. There are 39 Waste Water Treatment Works (WWTWs) in the Strangford Lough catchment, serving a population of approximately 106,000 (This is an underestimate as the current p.e. is not available for all facilities). Which is slightly lower than recorded in the 2011 sanitary survey, however, two of the treatment plants were mistakenly included as they are septic tanks. These are now included below with in the septic tank section. The major works are those at Ballyrickard, Downpatrick, Ballynahinch, Killyleagh and Killinchy, these five works together account for 75.2% of the total population equivalent of the catchment. Of the 39 WWTWs 22 are below capacity, 6 are over capacity and 11 had no p.e. information available. The six plants that are over capacity account for 11.5% of the load on the WWTW in the catchment.

Figure 4.9: WWTWs within the Strangford Lough Catchment Area (Source: NI Water).

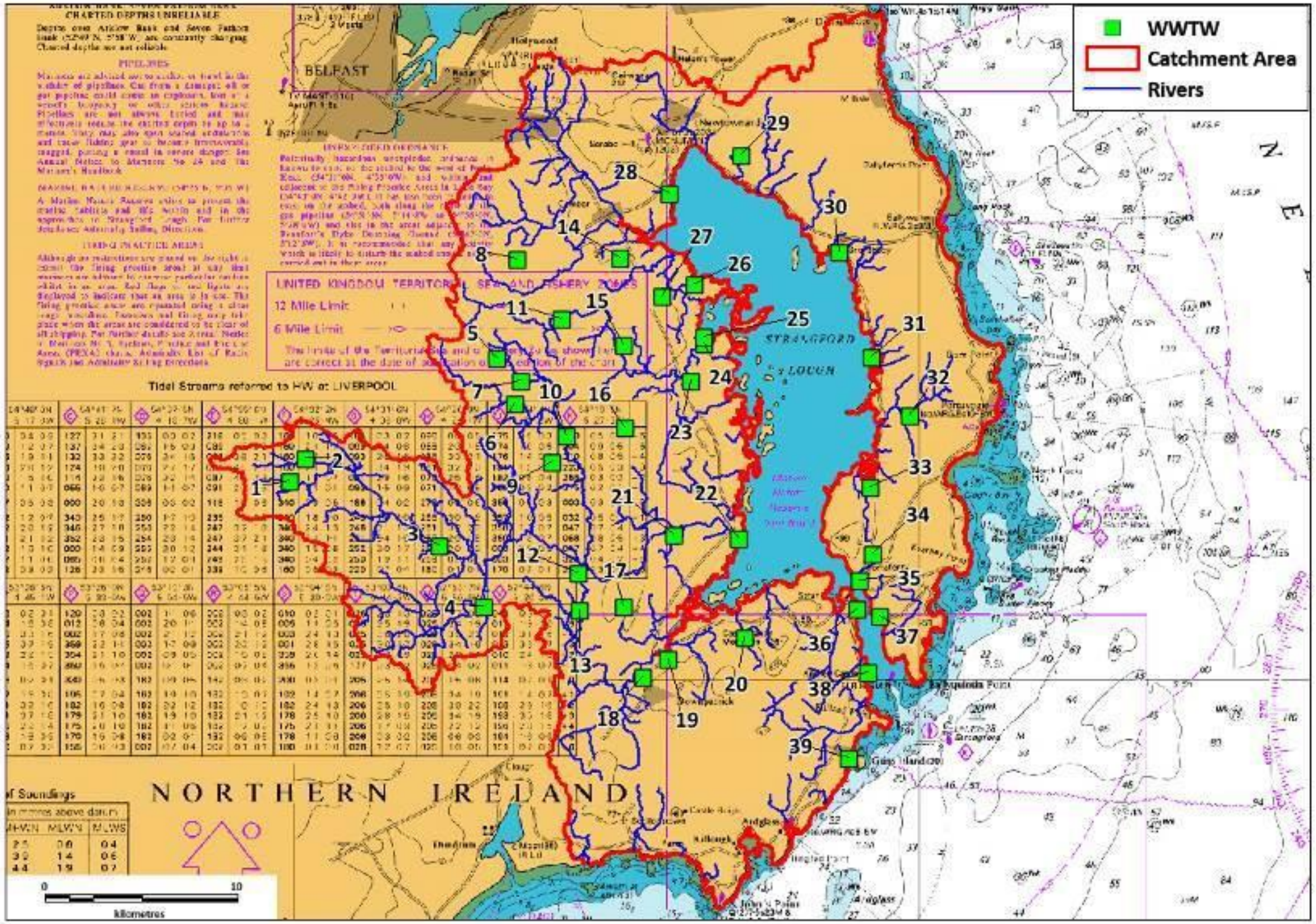


Table 4.3: WWTWs within the Strangford Lough Catchment Area (Source: NI Water).

Map ID	NAME	Easting	Northing	Longitude	Latitude	Current p.e.	Design p.e.	Over capacity
1	Poundburn WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
2	Annahilt Ballycrune WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1750	2214	No
3	Ballynahinch WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	7940	14600	No
4	Drumaness WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	2649	2651	No
5	Lessans WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	18	30	No
6	Saintfield WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	5048	5637	No
7	Glassdrummond Saintfield WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	21	32	No
8	Moneyreagh North WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	2387	2150	Yes
9	Lisowen WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	50	50	No
10	Darragh Cross West WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
11	Ballygowan WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	3372	3000	Yes
12	Kilmore Crossgar WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
13	Annacloy WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	889	1261	No
14	Drumhirk WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	24	33	No
15	Kilmood WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	169	300	No
16	Thorney Glen WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	58	100	No
17	Bells Hill WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	19	30	No
18	Downpatrick WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	17573	27775	No
19	Quoile WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
20	Raholp WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
21	Ballytrim WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	33	25	Yes

22	Killyleagh WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	7226	20000	No
23	Killinchy WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	5877	2271	Yes
24	The Oyster Yard WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	45	150	No
25	Tullynakill road WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	31	36	No
26	Ringneill WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	673	880	No
27	Lisbarnet WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
28	Newtownards Ballyrickard WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	41244	N/A	N/A
29	Loughries WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	280	270	Yes
30	Greyabbey WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1147	2000	No
31	Kircubbin WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1361	3000	No
32	Ballycranbeg WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	275	183	Yes
33	Abbacy Road WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	34	43	No
34	Portaferry WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	3802	5287	No
35	Portaferry Two WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
36	Strangford WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	1236	1800	No
37	Bar Hall WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	22	27	No
38	Kilclief WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	N/A	N/A	N/A
39	Ballyhornan Outfall WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]	911	N/A -	N/A

N/A indicates data was Not Available

4.1.3.1. Continuous Sewage Discharges

Figure 4.10 shows the continuous sewage discharges associated with the WWTWs within the Strangford Lough catchment area. Table 4.4 shows the coordinates for the continuous discharges from WWTW.

All of the WWTW shown in Figure 4.7 above have continuous discharge pipes associated with them, however, coordinates for some discharge pipes were not available (those marked with * in Table 4.4). Assumptions as to the location of their discharge pipes were made based on the plant's location in relation to the nearest water body.

In total, there are 9 direct discharges into Strangford Lough and the remainder discharge into rivers which ultimately discharge into the lough.

https://www.sciencedirect.com/science/article/pii/S120197122100312X

Figure 4.10: Location of Continuous Sewage Discharges within the Strangford Lough Catchment Area (Source: NI Water).

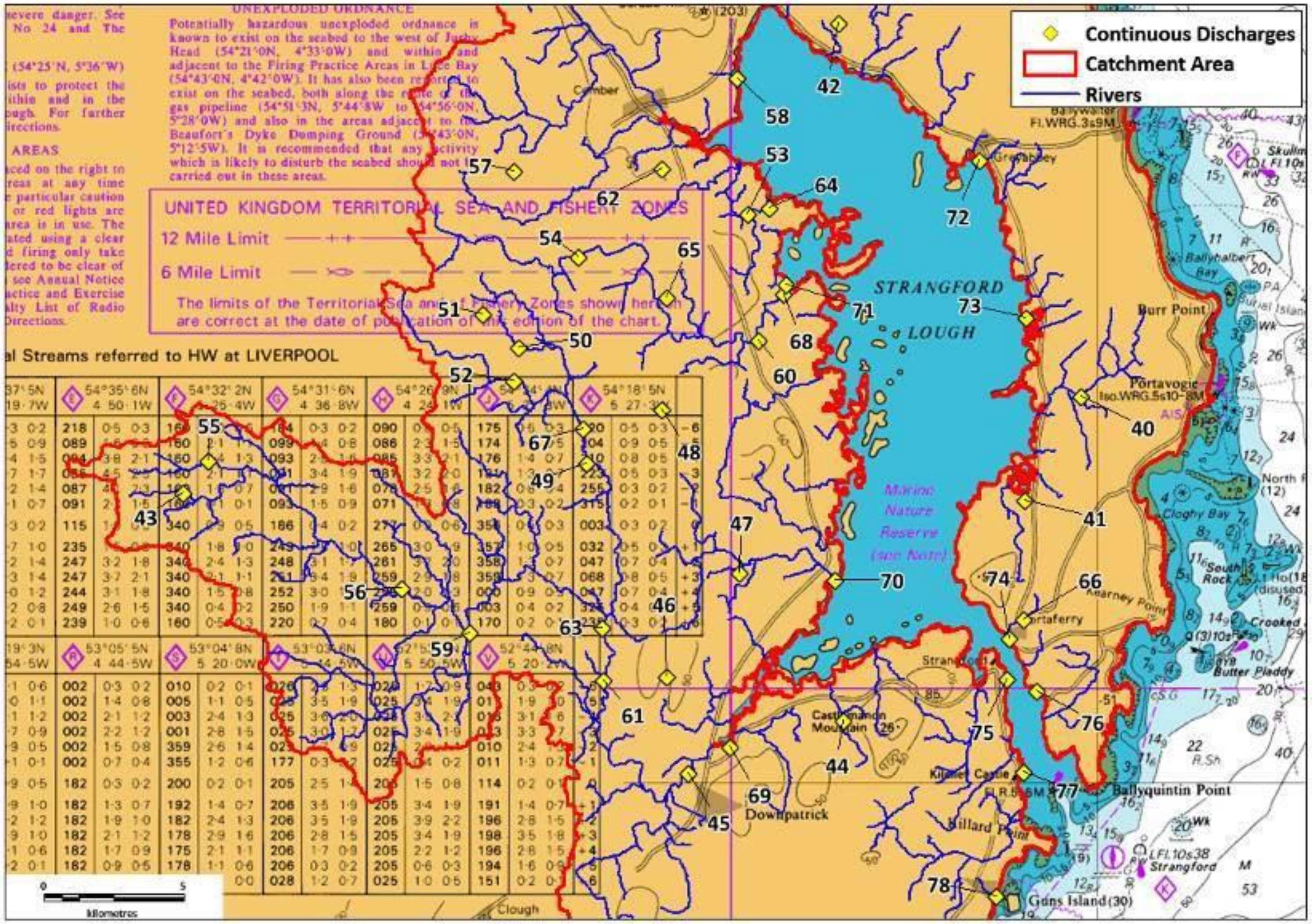


Table 4.4: WWTW Continuous Discharges within the Strangford Lough Catchment Area (Source: NI Water).

Map ID	Plant	Longitude	Latitude	Easting	Northing
40	Ballycranbeg WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
41	Abbacy Road WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
42	Loughries WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
43	Poundburn WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
44	Raholp WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
45	Downpatrick WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
46	Bells Hill WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
47	Ballytrim WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
48	Thorney Glen WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
49	Lisowen WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
50	Glassdrummond Saintfield WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
51	Lessans WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
52	Saintfield WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
53	Lisbarnet WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
54	Ballygowan WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
55	Annahilt Ballycrune WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
56	Ballynahinch WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
57	Moneyreagh North WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
58	Newtownards Ballyrickard WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
59	Drumaness WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
60	Killinchy WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
61	Annacloy WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
62	Drumhirk WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
63	Kilmore Crossgar WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
64	Ringneill WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
65	Kilmood WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
66	Portaferry WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
67	Darragh Cross West WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
68	The Oyster Yard WwTW	[Redacted]	[Redacted]	[Redacted]	[Redacted]
69	Quoile WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
70	Killyleagh WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
71	Tullynakill Road WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
72	Greyabbey WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
73	Kircubbin WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
74	Portaferry Two WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
75	Strangford WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
76	Bar Hall WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
77	Kilclief WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]
78	Ballyhornan WwTW*	[Redacted]	[Redacted]	[Redacted]	[Redacted]

*Rainfall Dependent Sewage Discharges***Error! Reference source not found.** show all rainfall d ependent discharges i.e., overflows, group septic tanks and private sewage treatment respectively, within the catchment area. Table 4.5 documents the Combined Sewer Overflows (CSO) and Sewage Pumping Station (SPS) overflows which discharge into Strangford Lough or a tributary of it and Table 4.6 documents the septic tanks. There are 113 rainfall dependent discharges, 46 group septic tanks and 783 private sewage systems within the Strangford Lough catchment area.

Figure 4.11: All overflow discharges within the Strangford Lough Catchment Area (Source: NI Water).

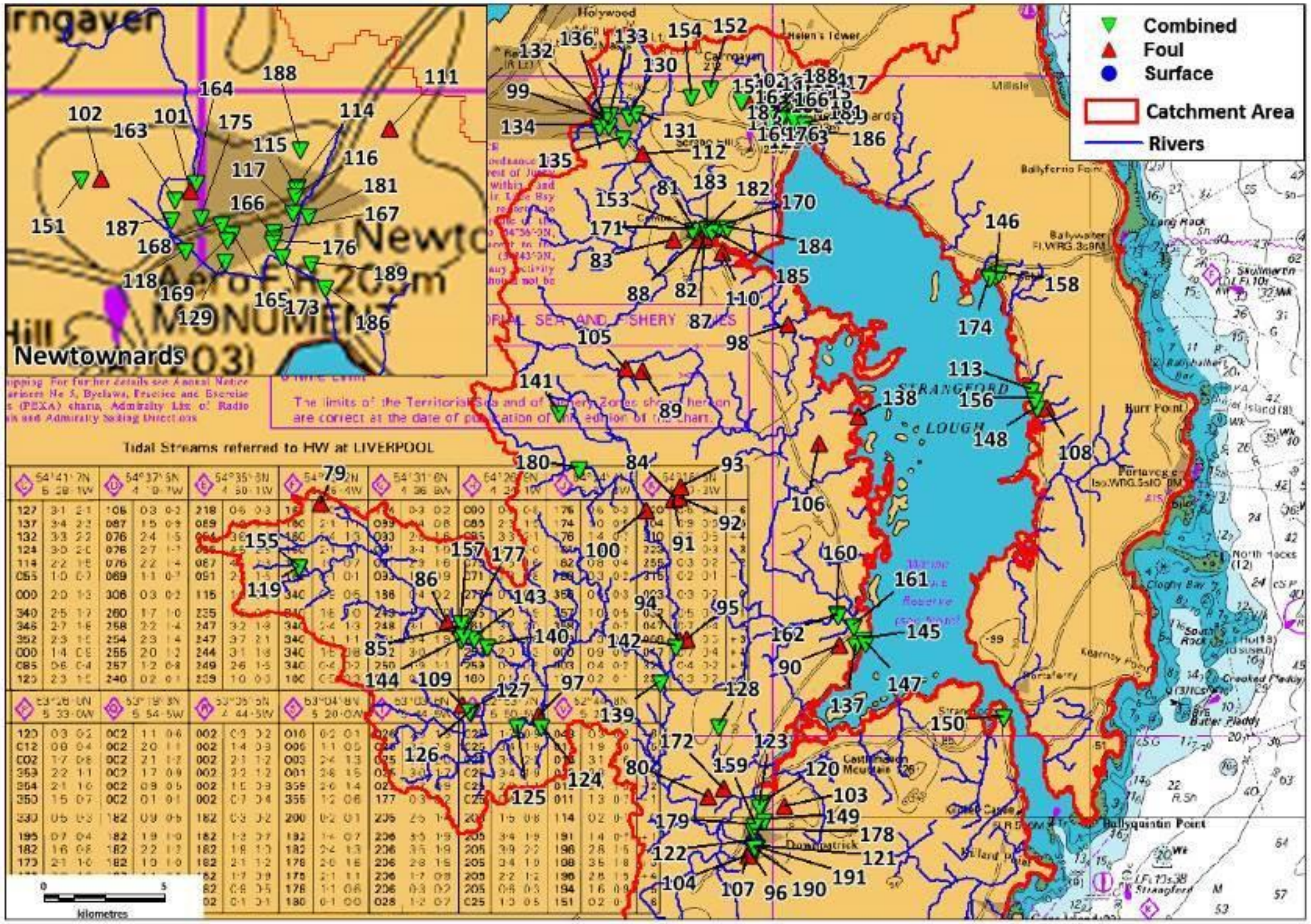


Figure 4.12: All septic tanks within the Strangford Lough Catchment Area (Source: NI Water).

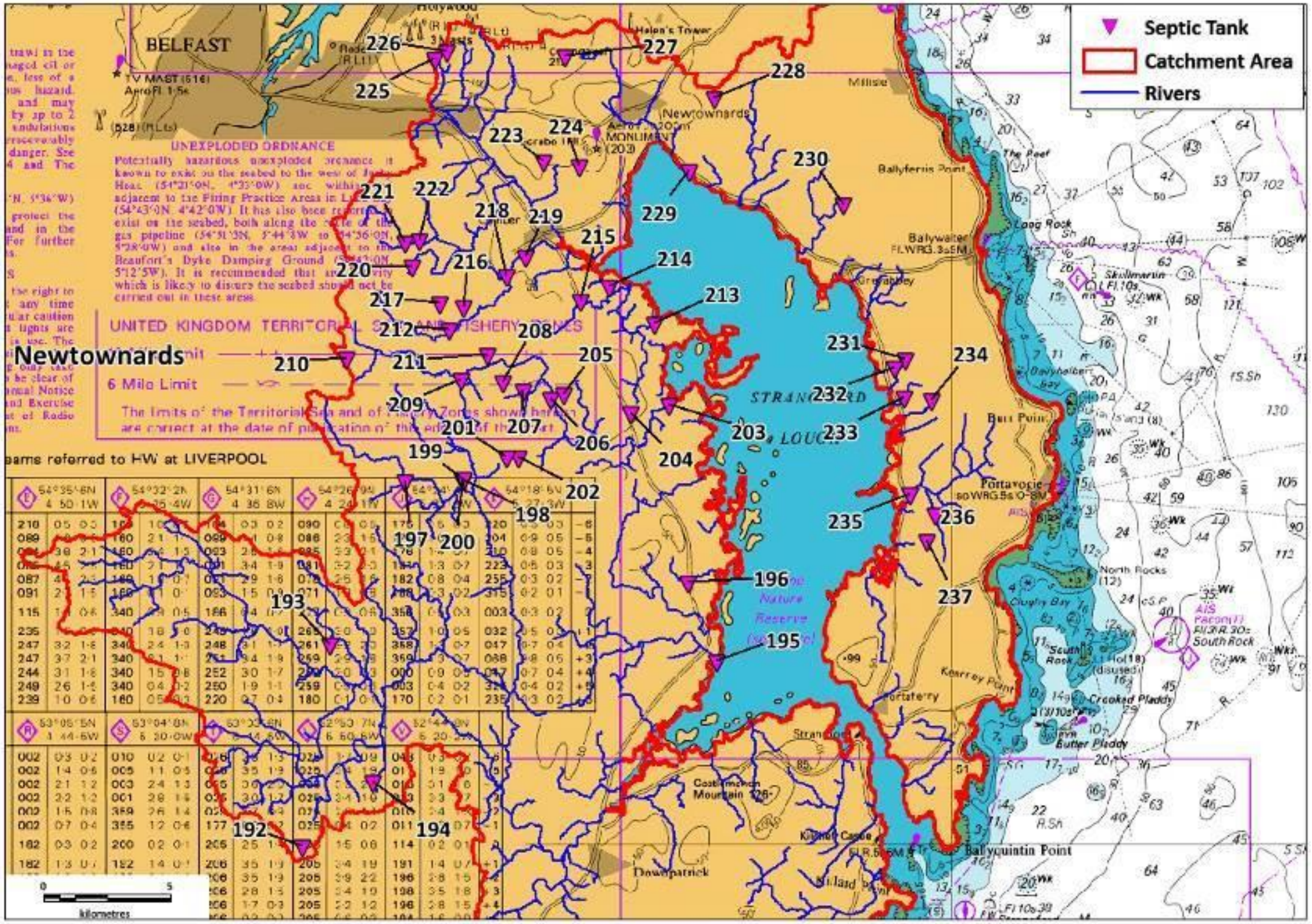


Figure 4.13: All private sewage systems within the Strangford Lough Catchment Area (Source: NI Water).

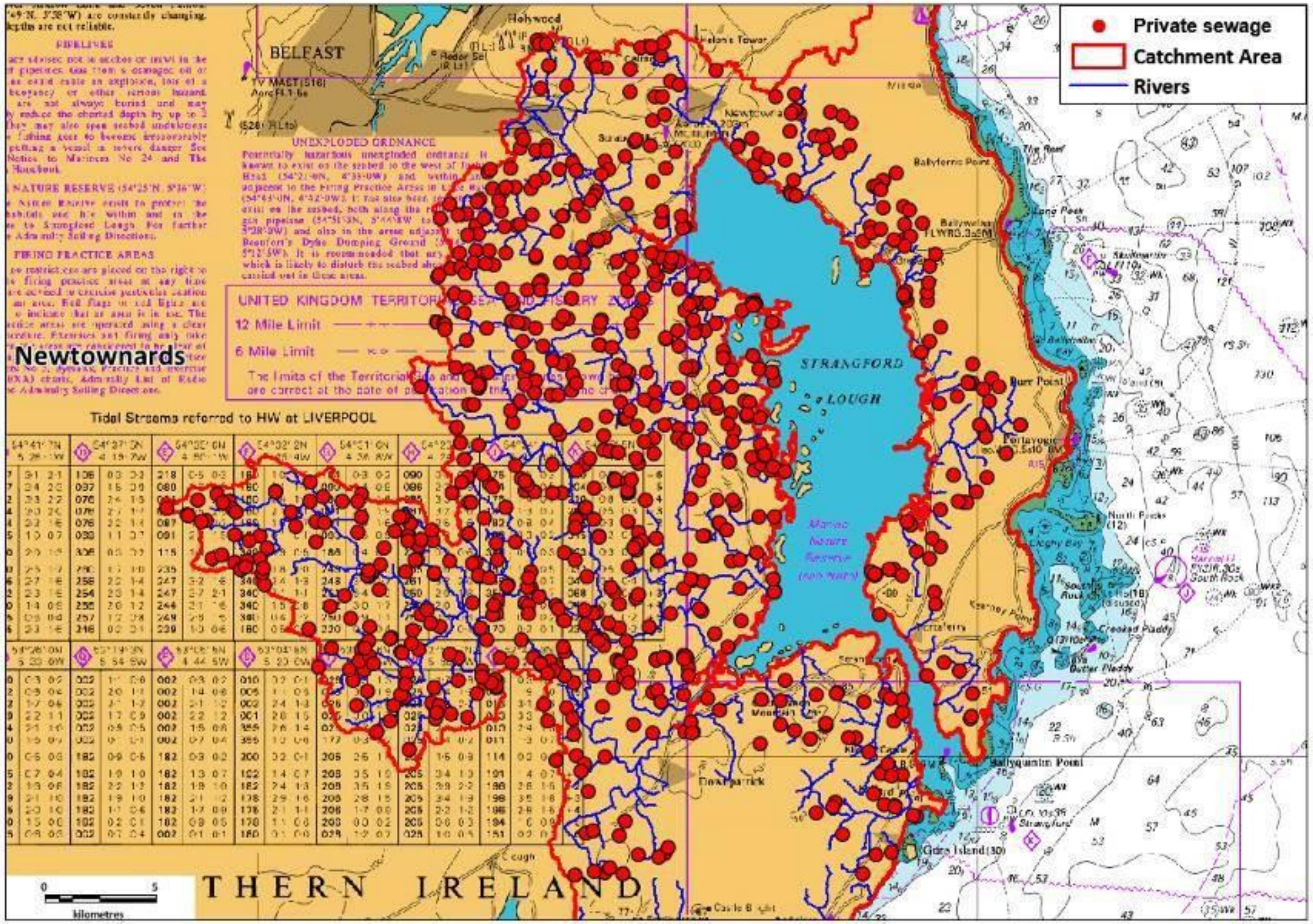


Table 4.5: CSO and WwPS overflows within the Strangford Lough catchment Area (Source: NI Water).

Map ID	Name	Longitude	Latitude	Easting	Northing	Function
79	Annahilt North WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
80	IDB Lands Three WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
81	Upper Crescent WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
82	N/A	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
83	Glen Park WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
84	Oaklands Darragh Cross WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
85	Church View Ballynahinch WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
86	Kinedale WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
87	Hillside WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
88	Carnesure Terrace WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
89	Mossvale WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
90	Annsfield WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
91	Darragh Cross One WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
92	Darragh Cross Two WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
93	Darragh Cross Three WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
94	Lissara Close WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
95	Cochranes WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul

96	Cathedral View WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
97	Drumaness Cumber WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
98	Lisbarnet TPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
99	Leathem Square WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
100	Darragh Cross West WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
101	Glenford Way WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
102	Braeside Newtownards WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
103	Ardenlee WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
104	Ballydugan Road WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
105	Ravara Dale WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
106	Whitecherry Hill WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
107	Ballydugan Road WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
108	Long Island Drive WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
109	Carnglave Manor WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
110	Ardnavally Ballydrain Road WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
111	Wyndell Park WwPS	[Redacted]	[Redacted]	[Redacted]	[Redacted]	Foul
112	N/A	-5.78603	54.57933	343204.4	372372.4	Foul
113	Shore Road 65 CSO	-5.53850	54.49255	359545.0	363247.9	Combined
114	Bangor Road Newtownards CSO	-5.68559	54.59859	349627.2	374725.2	Combined
115	Bangor Road Belvedere CSO	-5.68587	54.59842	349609.7	374705.4	Combined
116	Bangor Road Riverhill CSO	-5.68602	54.59766	349602.6	374621.0	Combined

117	Bangor Road Newtown CSO	-5.68638	54.59599	349585.4	374434.0	Combined
118	Mill Street John CSO	-5.70500	54.59218	348396.0	373971.0	Combined
119	Poundburn 1 CSO	-6.00510	54.42672	329523.0	354963.6	Combined
120	Down Council Strangford Road CSO	-5.70924	54.33933	349038.0	345822.0	Combined
121	Stream Street One CSO	-5.71372	54.32293	348806.0	343988.0	Combined
122	Folly Lane Downpatrick CSO	-5.71523	54.32512	348700.0	344228.2	Surface
123	Malone Park CSO	-5.71203	54.33811	348861.0	345680.0	Combined
124	Greenview CSO	-5.85050	54.36773	339755.9	348693.6	Combined
125	Magheratimpany CSO	-5.86599	54.36745	338750.5	348631.9	Combined
126	Dunmore Road Two CSO	-5.89594	54.37299	336785.7	349189.6	Combined
127	Dunmore Road One CSO	-5.89670	54.37351	336734.2	349246.5	Combined
128	Bells Hill CSO	-5.73792	54.36772	347071.6	348921.7	Combined
129	John Street Police Station CSO	-5.69826	54.59103	348836.0	373857.0	Combined
130	Brooklands Avenue CSO	-5.79443	54.59345	342612.3	373926.7	Combined
131	Brooklands Crescent CSO	-5.78979	54.59479	342907.0	374085.0	Combined
132	Grand Prix Mews CSO	-5.80756	54.59046	341773.9	373567.5	Combined
133	Moat Park Upper Newnards Road CSO	-5.80643	54.59472	341832.0	374044.1	Combined
134	Cumberland Road CSO	-5.81385	54.59002	341368.7	373506.2	Combined
135	Comber Road Enler CSO	-5.79873	54.58551	342361.9	373034.1	Combined

136	Comber Road Shop Centre CSO	-5.81067	54.59271	341564.9	373812.3	Combined
137	Seaview CSO	-5.65017	54.39760	352663.1	352433.4	Combined
138	Whiterock Bay CSO	-5.64903	54.48234	352422.2	361865.9	Foul
139	Teconnaught Road CSO	-5.77525	54.38402	344588.4	350658.6	Combined
140	Carlisle Park CSO	-5.88523	54.39715	337401.0	351899.0	Combined
141	Lessans CSO	-5.83916	54.48417	340094.9	361674.9	Combined
142	Crossgar CSO	-5.76471	54.39716	345226.6	352142.5	Combined
143	Town CSO	-5.89338	54.40049	336860.2	352255.5	Combined
144	Dromore Road CSO	-5.90204	54.40022	336299.0	352208.0	Combined
145	Killyleagh CSO	-5.64583	54.39985	352936.4	352693.2	Combined
146	Greyabbey Square CSO	-5.56118	54.53484	357912.1	367902.4	Combined
147	Net Walk CSO	-5.64402	54.39867	353058.6	352565.5	Combined
148	Boyd Avenue CSO	-5.53486	54.48578	359806.8	362502.9	Combined
149	Saul Street CSO	-5.70865	54.33251	349101.0	345064.0	Combined
150	The Slip CSO	-5.55607	54.37133	358875.0	349718.0	Combined
151	Killysuggan CSO	-5.72339	54.59930	347182.0	374725.0	Combined
152	Ballybarnes Meadow CSO	-5.74321	54.60420	345884.0	375229.1	Combined
153	Pound Bridge CSO	-5.75323	54.55170	345423.0	369365.0	Combined
154	Ballyrogan Park CSO	-5.75486	54.60119	345142.0	374869.9	Combined
155	Poundburn 2 CSO	-6.00508	54.42686	329524.3	354978.9	Combined
156	Kircubbin Green CSO	-5.53639	54.48879	359696.0	362834.1	Combined

157	Downhill Terrace CSO	-5.90180	54.40645	336294.0	352902.0	Combined
158	Main Street Grey Abbey CSO	-5.55951	54.53567	358016.8	367999.0	Combined
159	Meadowlands CSO	-5.71412	54.33097	348751.0	344881.0	Combined
160	Osbourne Drive CSO	-5.66273	54.40964	351803.0	353746.0	Combined
161	St Marys Killyleagh CSO	-5.65212	54.40484	352509.4	353235.4	Combined
162	Shrigley Road CSO	-5.66181	54.40882	351866.0	353657.0	Combined
163	Hartford Link Glenford CSO	-5.70698	54.59730	348250.0	374536.0	Combined
164	Crawsfordsburn Road Newtownards CSO	-5.70329	54.59893	348482.0	374726.0	Combined
165	Lower Mary Street CSO	-5.69707	54.59377	348903.0	374164.0	Combined
166	Frances Street CSO	-5.68981	54.59334	349374.0	374132.0	Combined
167	East Street CSO	-5.68975	54.59408	349375.0	374214.0	Combined
168	West Street Brewery CSO	-5.69879	54.59478	348787.9	374273.8	Combined
169	Mill Street Pound CSO	-5.69794	54.59320	348849.0	374099.0	Combined
170	Crescent Grove CSO	-5.73783	54.55247	346417.0	369482.0	Combined
171	Mill Street Belfast Road CSO	-5.75415	54.55171	345364.0	369364.0	Combined
172	IDB Lands No.2 ERO	-5.73462	54.34424	347370.4	346315.4	Foul
173	New Road Greenwell CSO	-5.68833	54.59148	349476.0	373928.0	Combined
174	Greyabbey Works CSO	-5.56529	54.53392	357650.1	367790.6	Combined
175	William Street Corry CSO	-5.70240	54.59553	348552.0	374349.0	Combined
176	Movilla Street CSO	-5.68999	54.59295	349363.2	374088.4	Combined

177	Antrim Road Factories CSO	-5.90058	54.40133	336390.0	352335.0	Combined
178	Scotch Street Downpatrick CSO	-5.71549	54.32905	348669.1	344665.5	Combined
179	Meadowside Downpatrick CSO	-5.71525	54.33075	348678.1	344854.7	Combined
180	Belfast Road Saintfield CSO	-5.82677	54.46348	340969.0	359397.0	Combined
181	Movilla High CSO	-5.68378	54.59568	349755.0	374405.0	Combined
182	Comber High CSO	-5.74449	54.55277	345985.0	369502.0	Combined
183	Comber Leisure CSO	-5.74516	54.55204	345944.0	369420.0	Combined
184	Copeland Road CSO	-5.73258	54.55251	346756.0	369497.9	Combined
185	Newtown Bridge CSO	-5.74231	54.55114	346132.0	369325.0	Combined
186	Old Shore Ards CSO	-5.68097	54.58839	349962.9	373599.9	Combined
187	Church Street Ards CSO	-5.70764	54.59528	348214.2	374309.7	Combined
188	Bangor Road Whitespots CSO	-5.68515	54.60233	349642.0	375143.0	Combined
189	Upper Greenwell Street CSO	-5.68333	54.59083	349802.0	373866.0	Combined
190	Stream Street Two CSO	-5.71544	54.32230	348696.5	343913.8	Combined
191	Hunters Mill CSO	-5.71520	54.32269	348710.7	343957.7	Combined

Table 4.6: Septic tanks within the Strangford Lough catchment Area (Source: NI Water).

Map ID	Name	Easting	Northing	Longitude	Latitude
192	Drumaroad ST	-5.89740	54.33249	336825.4	344679.8
193	Ballylone Road ST	-5.88112	54.40449	337643.0	352724.0
194	Newcastle Road 58-66 ST	-5.85469	54.35554	339525.3	347328.4
195	Killyleagh Net Walk ST	-5.64426	54.39849	353043.6	352545.0
196	Kirkland Road 6-12 ST	-5.66201	54.42690	351786.0	355668.8
197	The Demesne ST	-5.83511	54.46279	340431.0	359304.0
198	Jacksons Crescent 1-6 ST	-5.79978	54.46321	342720.2	359420.8
199	Jacksons Crescent 7-8 ST	-5.79935	54.46335	342747.3	359437.4
200	Jacksons Crescent 9-10 ST	-5.79885	54.46363	342778.9	359470.3
201	Station Road 155-157 ST	-5.77290	54.47155	344433.5	360404.0
202	Kilcarn Road ST	-5.76527	54.47128	344928.7	360389.7
203	Craigarusky Road 66-68 ST	-5.67405	54.48999	350772.9	362664.3
204	Comber Road 102-106 ST	-5.69702	54.48715	349294.8	362298.9
205	Lisbarnet Road 47-53 ST	-5.73790	54.49399	346621.7	362973.8
206	Moss Road 76-78 ST	-5.74578	54.49207	346117.7	362744.4
207	Drumreagh Road 9-11 ST	-5.76234	54.49526	345033.5	363064.9
208	Moss Road 36-38 ST	-5.77499	54.49804	344204.8	363348.2

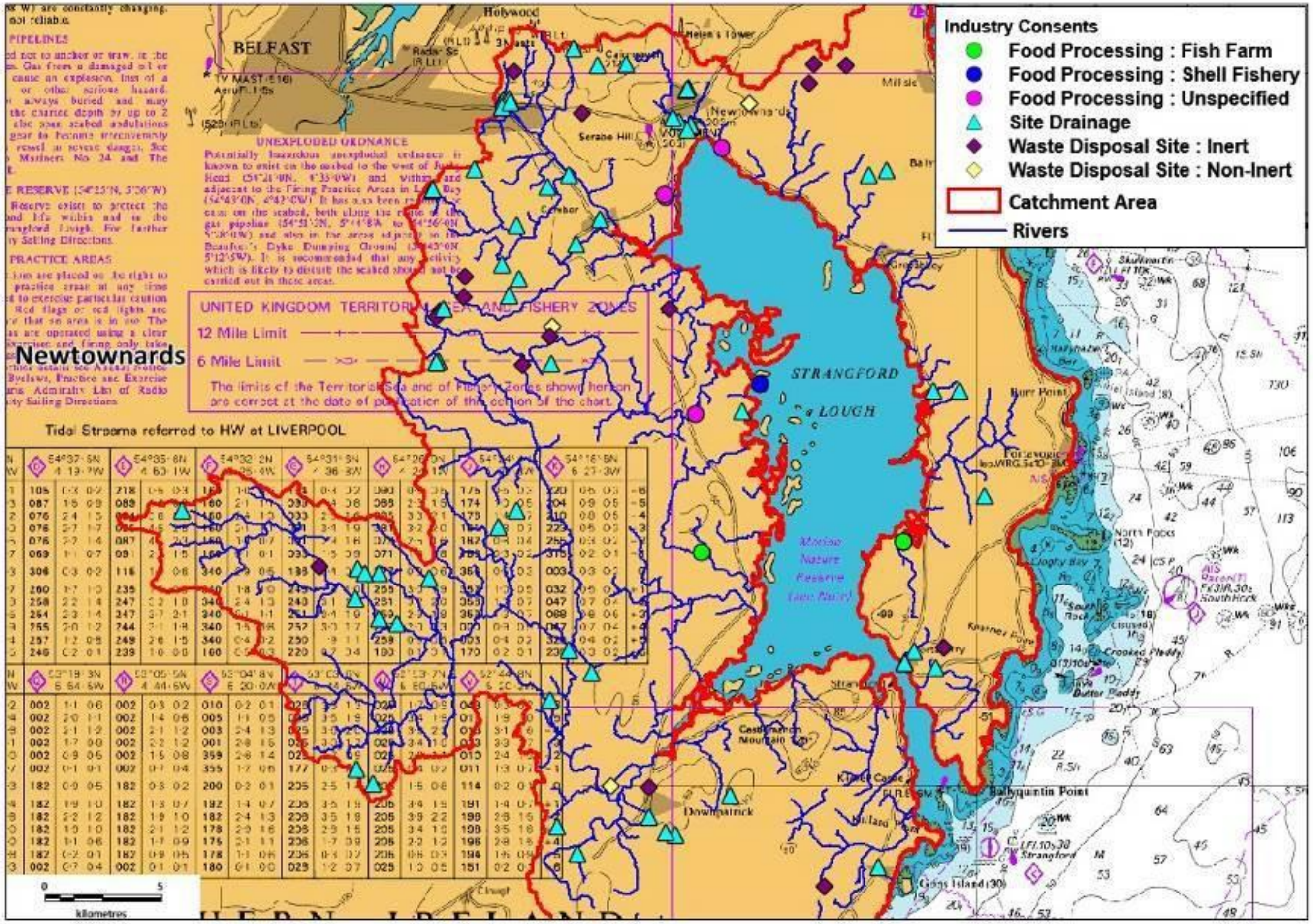
Map ID	Name	Easting	Northing	Longitude	Latitude
209	Ravara Road 9-19 ST	-5.80072	54.49897	342534.3	363399.0
210	Belfast Road 207-209 ST	-5.87045	54.50643	337992.3	364090.4
211	Ballygowan Road 102-104 ST	-5.78465	54.50791	343544.1	364427.0
212	Tullyhubbert Road 75-81 ST	-5.80783	54.51658	342012.9	365344.5
213	Ringneill Road 1-5 ST	-5.68230	54.51873	350132.9	365844.2
214	Ballydrain Road 39-43 ST	-5.71034	54.53194	348269.3	367255.5
215	Killinchy Road 96-100 ST	-5.72738	54.52674	347185.3	366641.2
216	Ballycreely Road ST	-5.79923	54.52484	342541.3	366281.3
217	Moneyreagh Road 139-141 ST	-5.81384	54.52606	341590.9	366387.3
218	Ballygowan Road 41-47 ST	-5.77279	54.53588	344213.5	367563.6
219	Clattering Ford ST	-5.76151	54.54268	344919.6	368344.5
220	Moneyreagh Road 51-55 ST	-5.83084	54.53925	340445.5	367821.2
221	Gransha Road 10-12 ST	-5.83469	54.54791	340166.4	368777.9
222	Gransha Road 26-28 ST	-5.82615	54.54863	340716.4	368874.8
223	Ballyrainey Road 65-67 ST	-5.75012	54.57659	345535.6	372141.2
224	Ballyalton Road ST	-5.72820	54.57473	346959.6	371980.0
225	Ballymiscaw Road 33-37 ST	-5.81683	54.61299	341097.2	376056.1
226	Ballykeel Cottages ST	-5.80955	54.61553	341558.6	376353.4
227	Ballybarnes Road ST	-5.73720	54.61381	346237.5	376310.1
228	Movilla Road 136-140 ST	-5.64616	54.59899	352173.6	374854.9

Map ID	Name	Easting	Northing	Longitude	Latitude
229	Portaferry Road 96-100 ST	-5.66162	54.57302	351270.9	371930.6
230	Carrowdore Road 38-40 ST	-5.56758	54.56117	357396.4	370818.1
231	Inishargy Road 10-12 ST	-5.52910	54.50617	360100.3	364784.5
232	Inishargy Road 2-10 ST	-5.53621	54.50297	359652.6	364412.1
233	Tubber Road 10-16 ST	-5.53035	54.49263	360072.6	363275.5
234	Parsonage Road 110-120 ST	-5.51351	54.49163	361167.2	363202.3
235	Blackstaff ST	-5.52676	54.45814	360440.0	359445.0
236	Lisbane Road 38-40 ST	-5.51103	54.45106	361487.8	358692.9
237	Upper Ballygelagh Road 12-18 ST	-5.51642	54.44158	361175.1	357625.9

4.1.4. Industrial Discharges

shows the industrial discharges within the Strangford Lough catchment area accounted for during the desk-based assessment. In total, there are 93 industrial discharges within the catchment.

Figure 4.14: All industrial discharges within the Strangford Lough Catchment Area (Source: NIEA Water water information request viewer).



4.1.5. Landuse Discharges

Figure 4.15 shows the Corine land use within the Strangford Lough catchment area for 2009 and 2018.

Within the catchment area, landuse proportions have changed somewhat. The dominated landuse type remains pastures and has increased from 66.8% to 70.4%), followed by complex cultivation patterns (down from 15.8% to 10.5%) and agriculture/natural vegetation (down from 4.2% to 1.9%) (See Figure 4.14). Forestry (coniferous, broad-leafed and mixed) has increased from 0.8% of the landuse 1.6%). However, land associated with agricultural activities (non-irrigated arable land, pastures, complex cultivation patterns and agriculture/natural vegetation) remains at 90% of the landuse in the area.

Figure 4.15: Corine land use within the Strangford Lough Catchment Area 2009 (Left) and 2018 (Right) (Source: CLC, 2018).

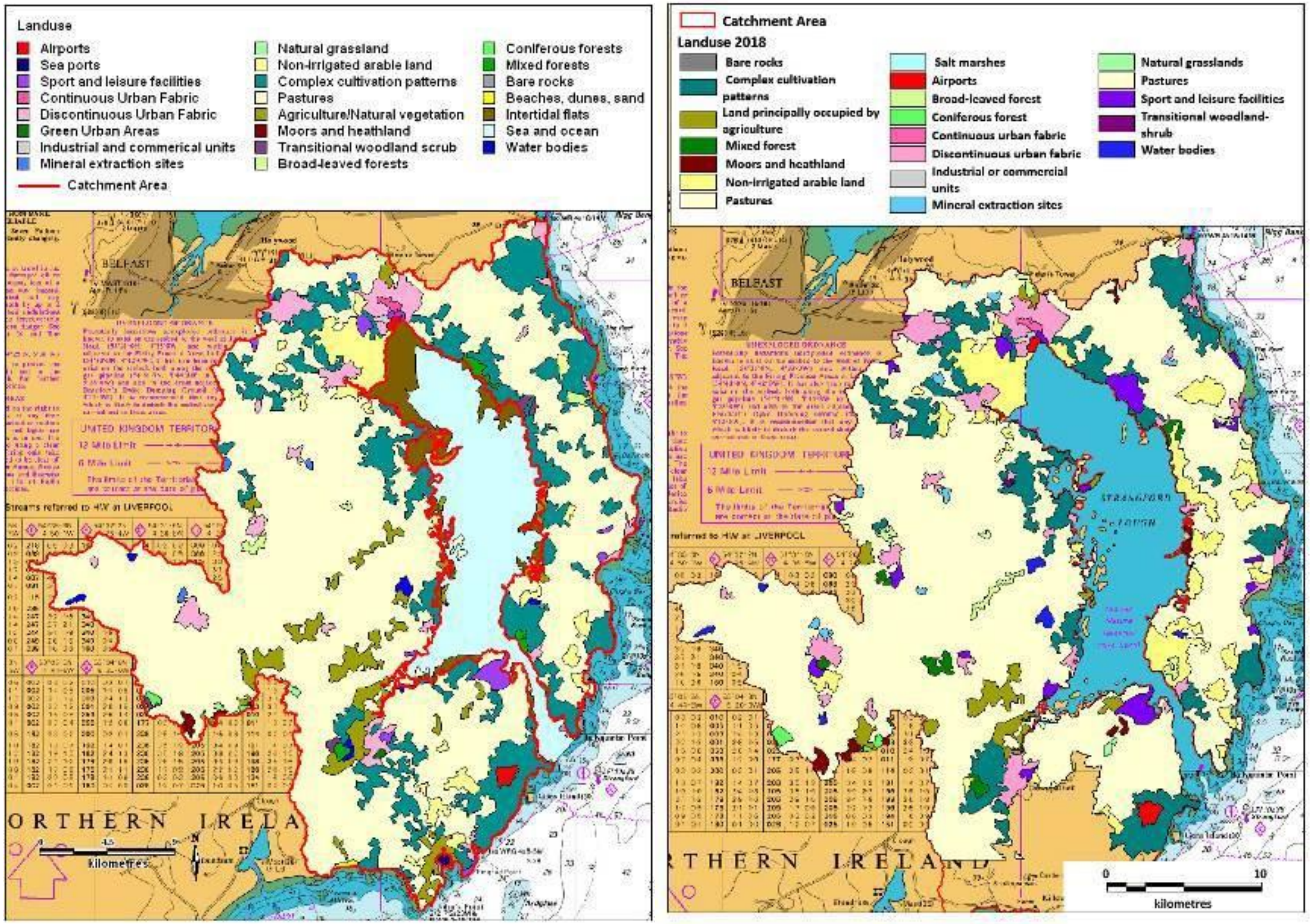
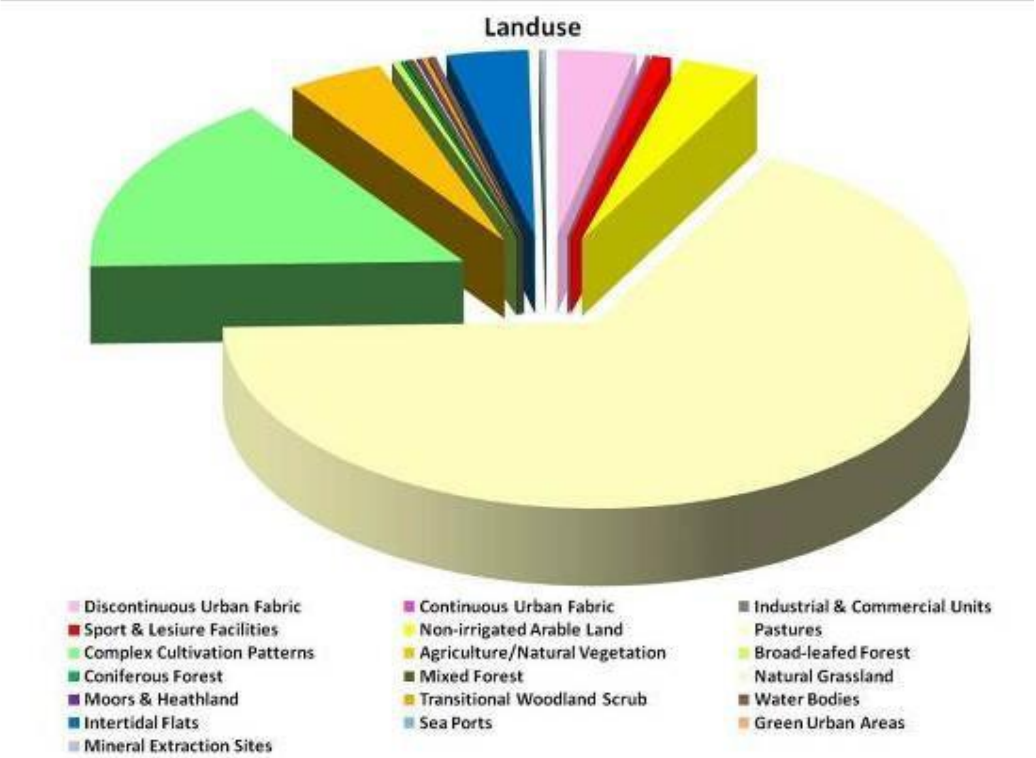
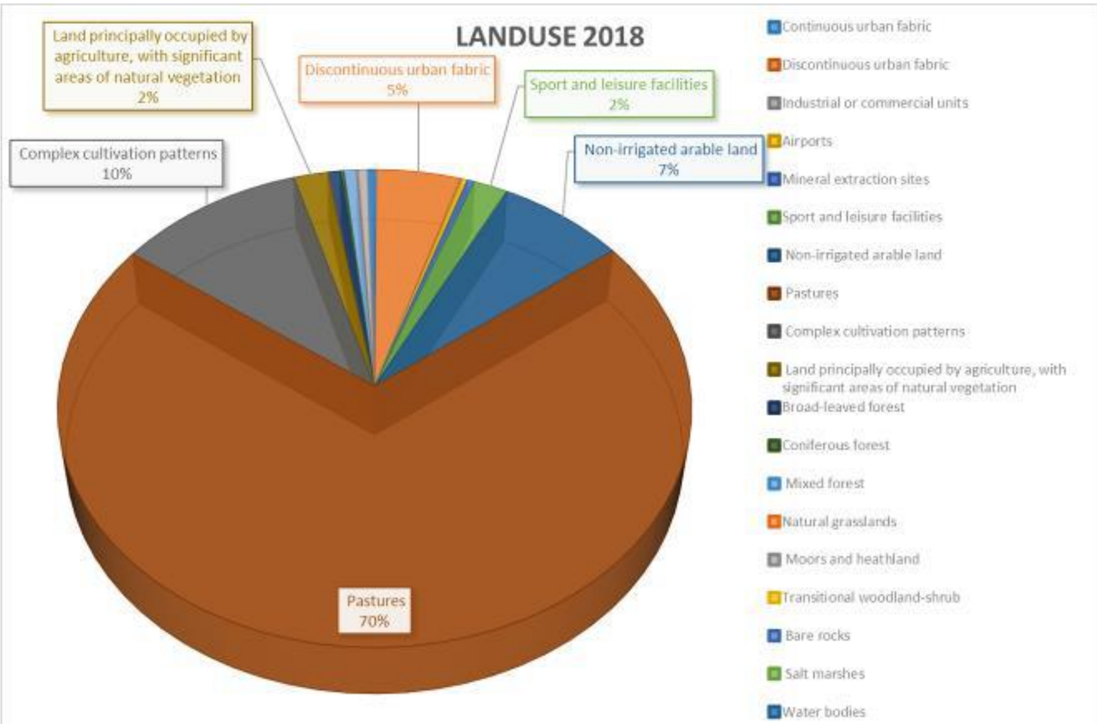


Figure 4.16: Breakdown of landuse within the Strangford Lough Catchment Area 2009 (Top) and 2018 (Bottom).





Agricultural data used in the 2009 sanitary survey were organised by SOA (Super Output Area); however, the 2018 agricultural data are not available in this format. The 2018 data have been organised by wards which are similar to SOA boundaries but vary somewhat. Changes in agricultural data can therefore not be directly compared. However, visual representation of these data can be used to compare the distribution of farming practices in the catchment (Figure 4.17 to Figure 4.24). The highest number of farms and area farmed remain in the southwest of the catchment. The majority of land used for crops is located in divisions next to the shoreline. A large proportion of the farmland in all divisions is used for grasses, with slightly higher proportion in the southwest. High numbers of cattle are present through the catchment with distribution similar to that of 2009. The highest number of sheep are located in the south west of the catchment for both 2009 and 2018. Pigs are mostly farmed in the southern half of the catchment, with the highest numbers present in the areas surrounding Killyleagh and Portaferry. The highest density of poultry framing is in the mid-western area of the catchment.

Although individual divisions cannot be compared due to the change in division type some comparison can be made on a catchment scale. As some of the wards (2018) or SOAs (2009) only partially overlap the catchment an attempt was made to account for this. The percentage of each division within the catchment was estimated in GIS. This percentage was then applied to the agri data to estimate the proportion within the catchment. Based on this area used for crops has decreased by 13.3% (-1,322ha) and sheep numbers have decreased by 0.08% (-840). Cattle numbers have increased by 10,220 (8.9%), pigs by 6,113 (19.8%) and poultry by 303,000 (117.9%). Although these appear to be relatively high increases the area of farmland within the catchment needs to be considered, which has also increased by 6,578ha (10%). When spread across all farmland cattle have increased 0.14 per ha, pigs have increased 0.08 per ha and poultry have increased 4.2 per ha.

Figure 4.17: Number of farms within the Strangford Lough Catchment Area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).

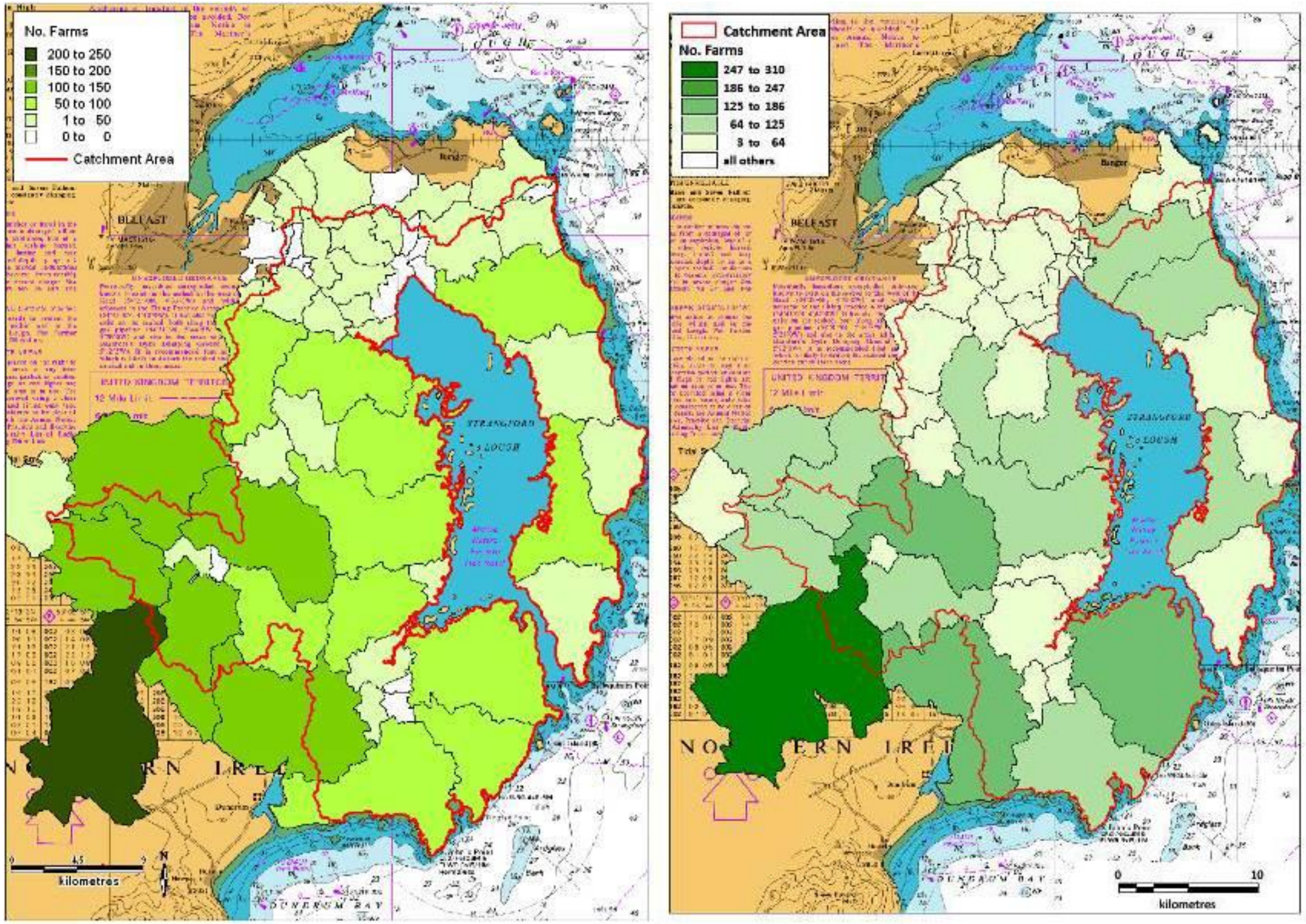


Figure 4.18: Area farmed (ha) within the Strangford Lough Catchment Area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).

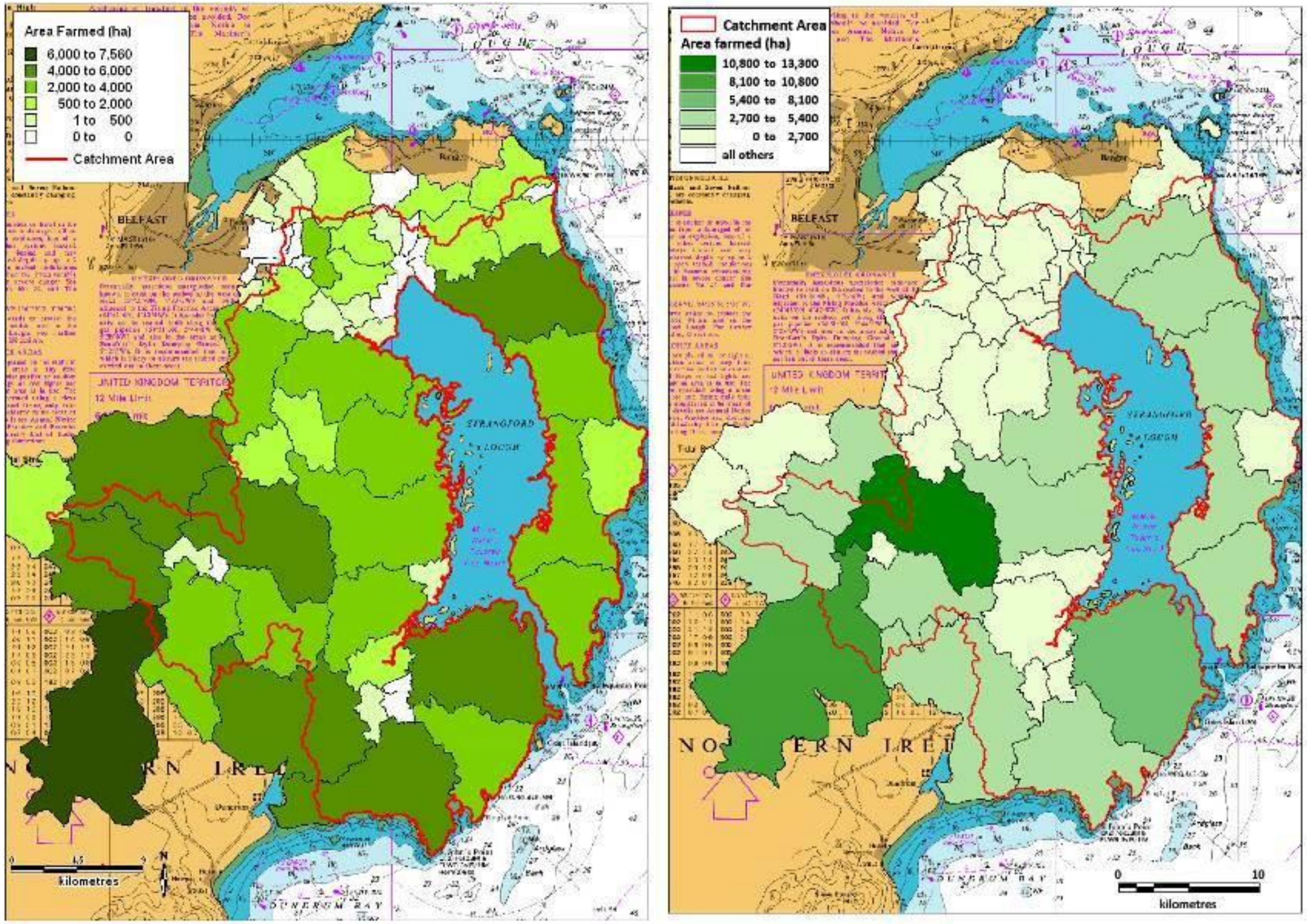
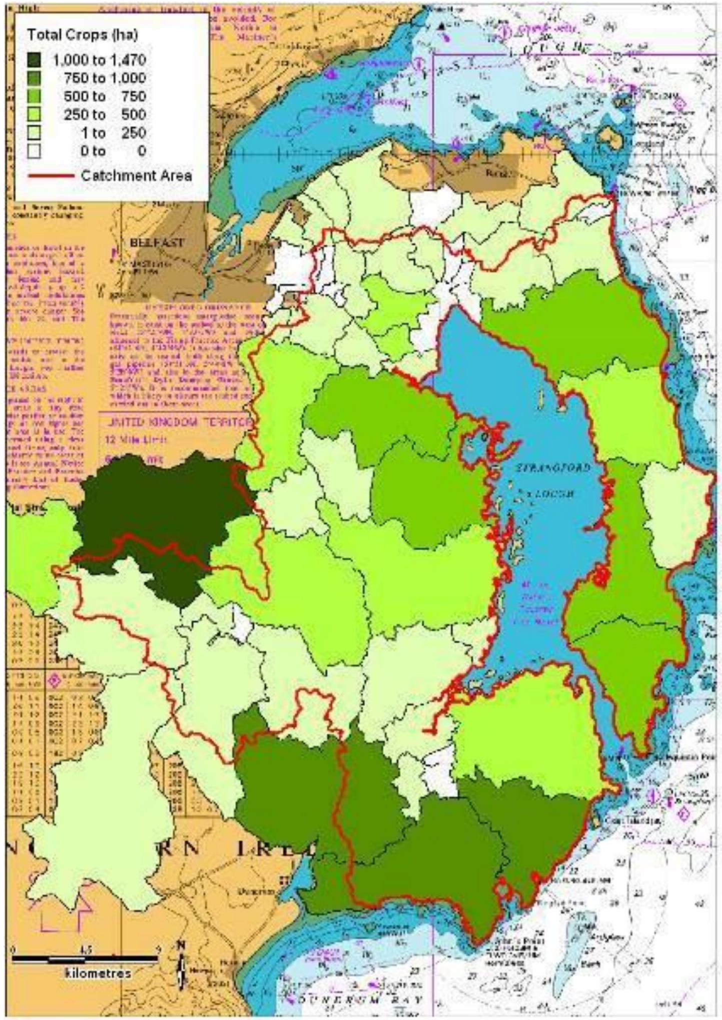


Figure 4.19: Total crops within the Strangford Lough Catchment area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).



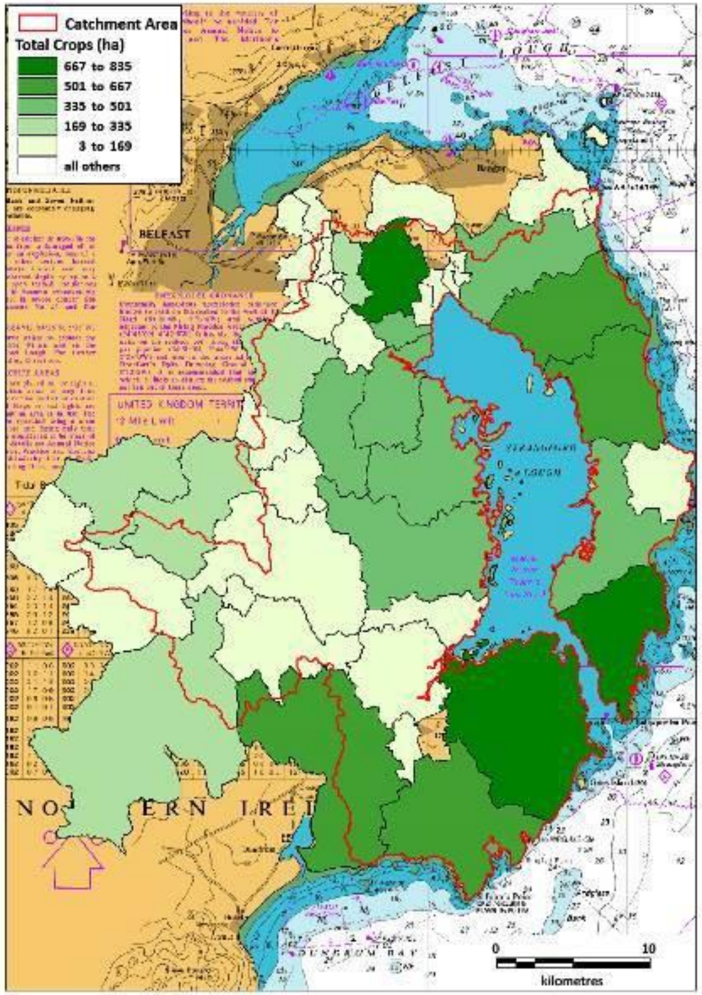


Figure 4.20: Total grass and rough grazing within the Strangford Lough Catchment Area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).

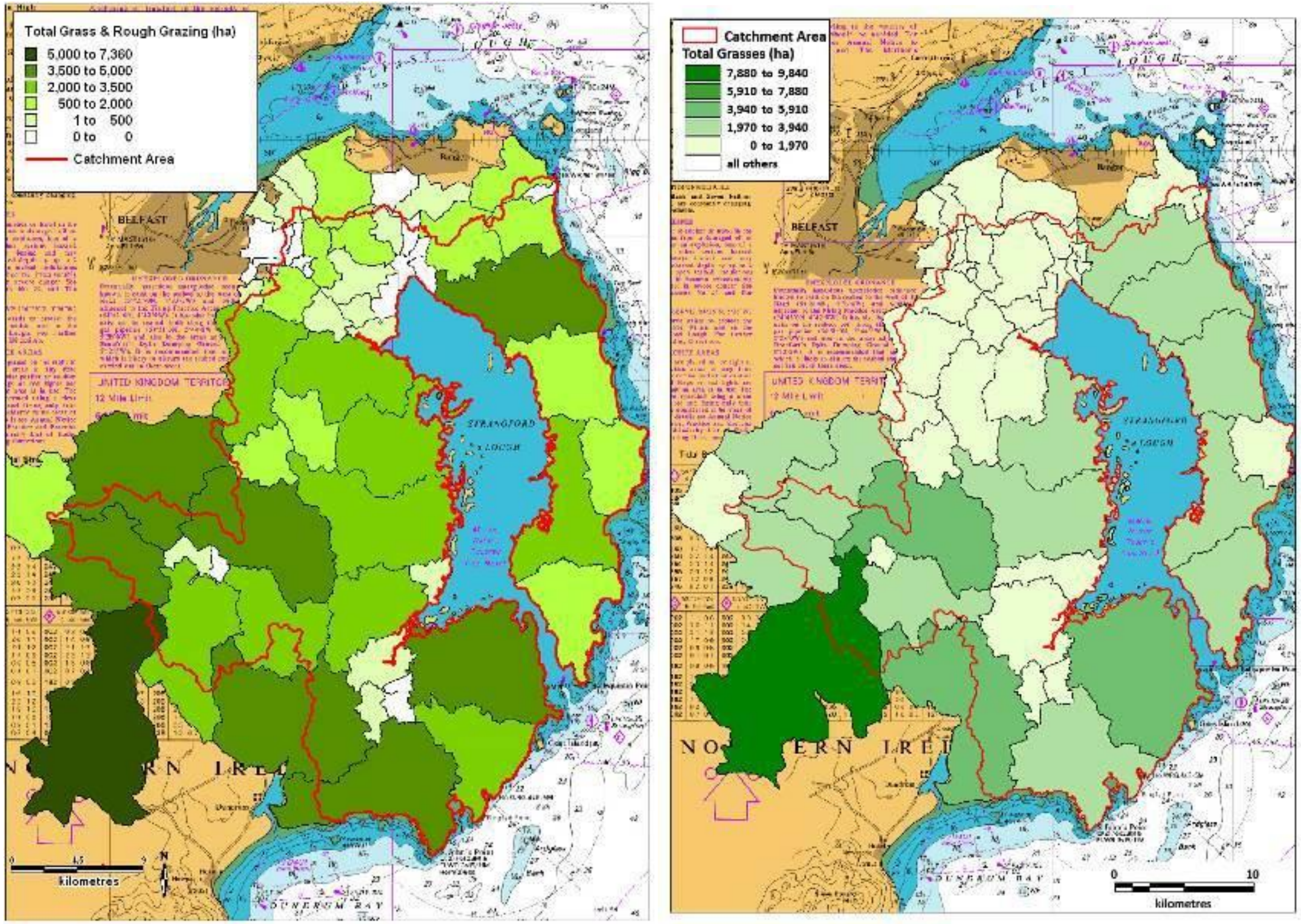


Figure 4.21: Cattle within the Strangford Lough Catchment Area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).

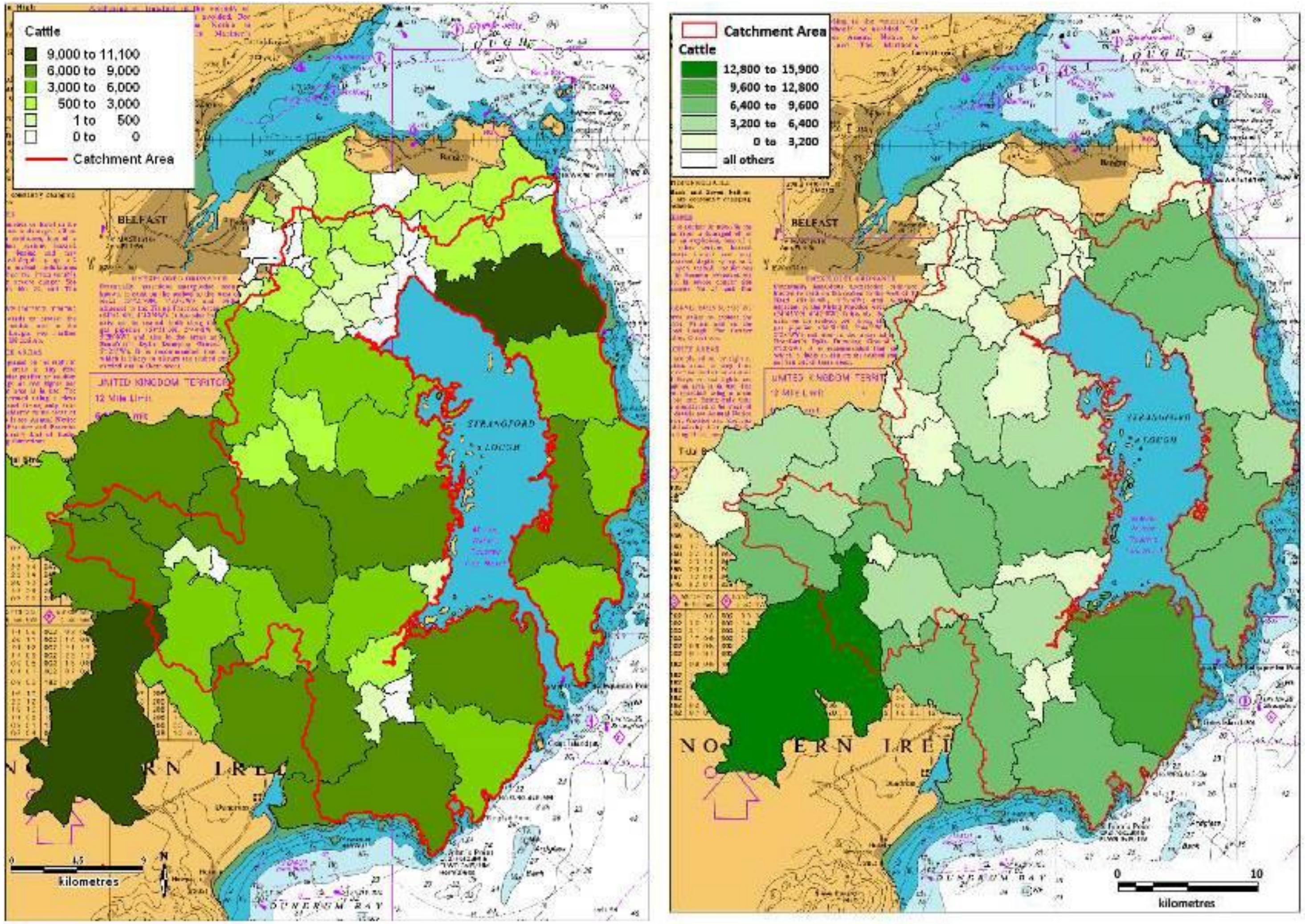


Figure 4.22: Sheep within the Strangford Lough Catchment Area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).

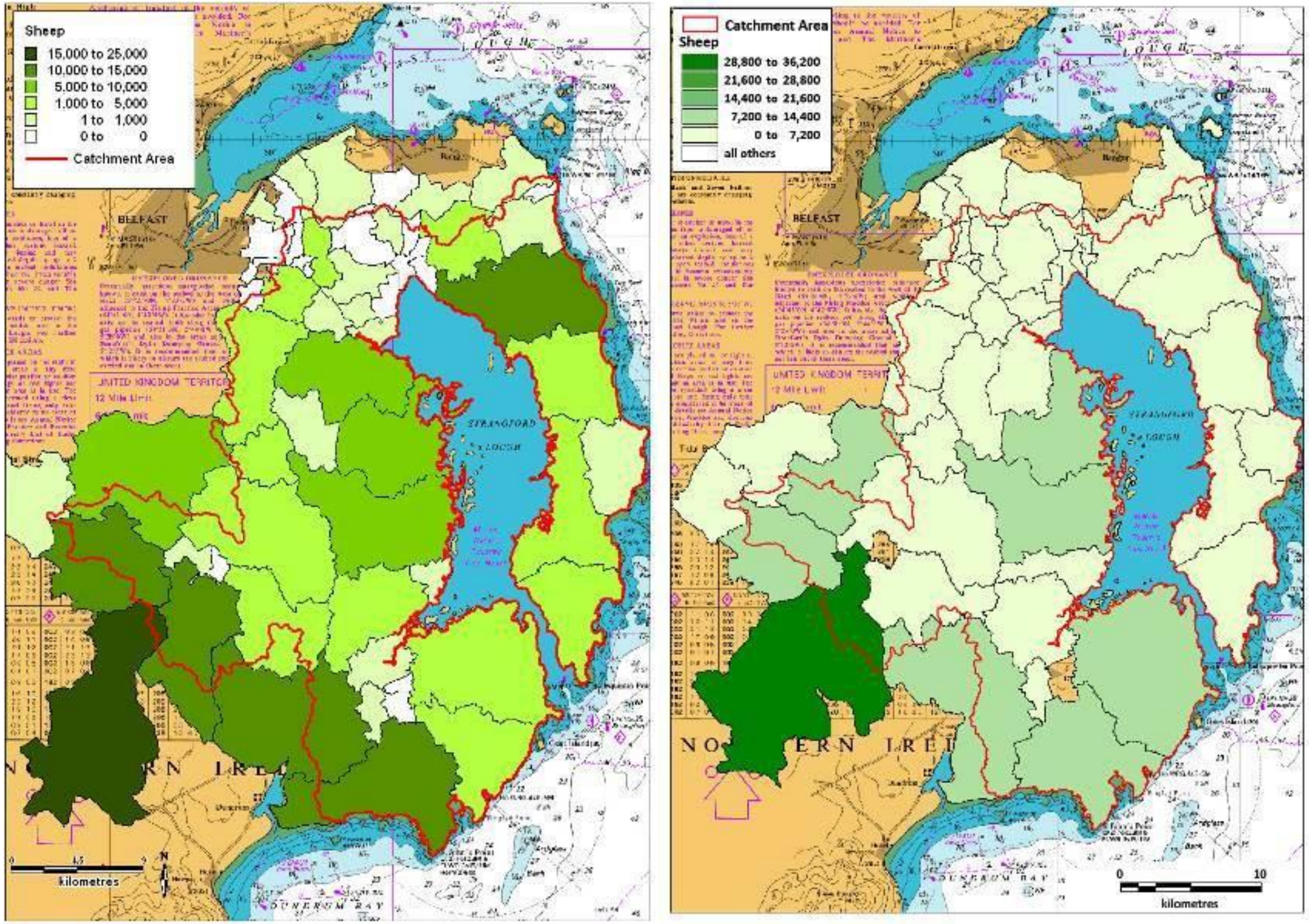


Figure 4.23: Pigs within the Strangford Lough Catchment Area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).

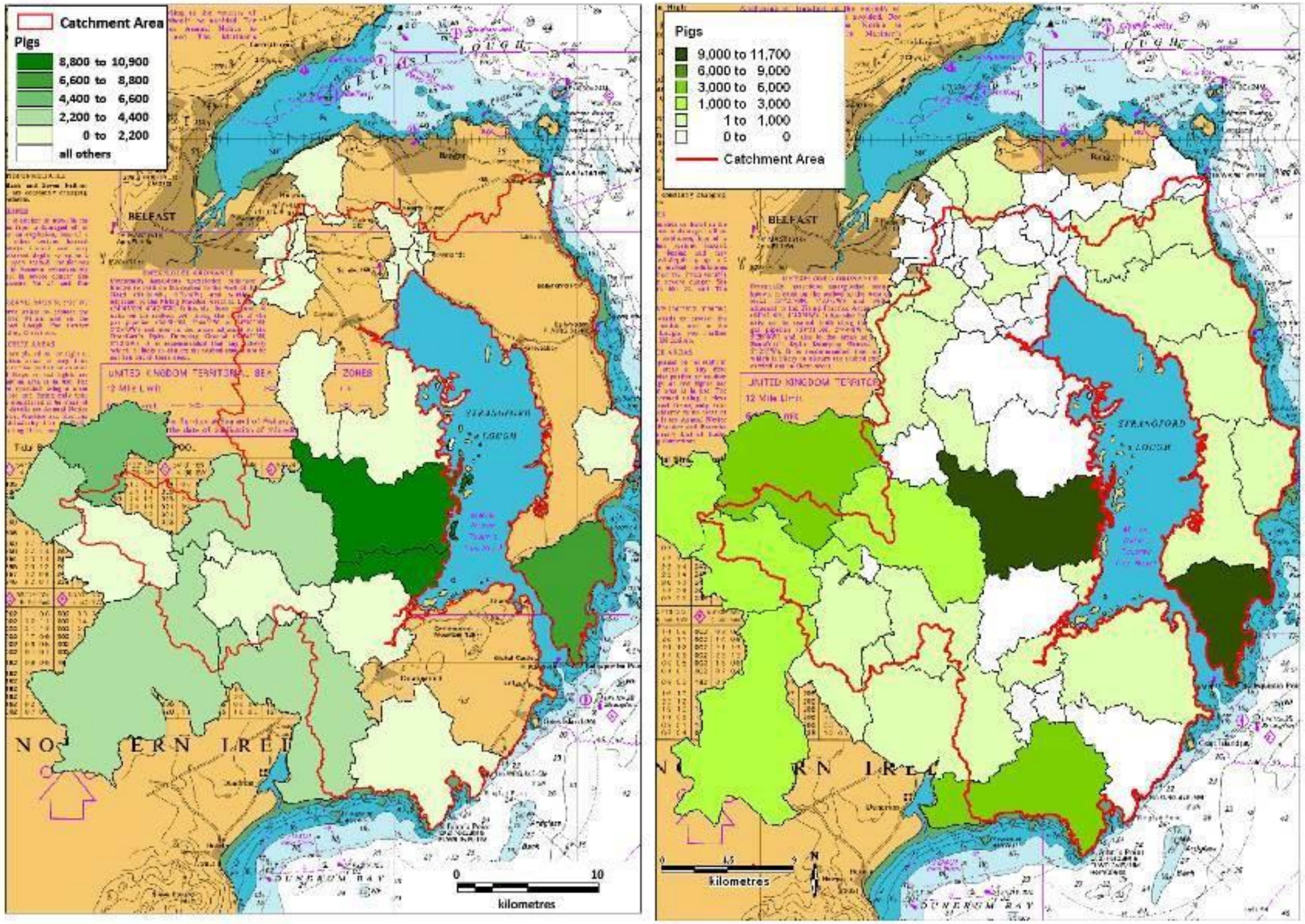
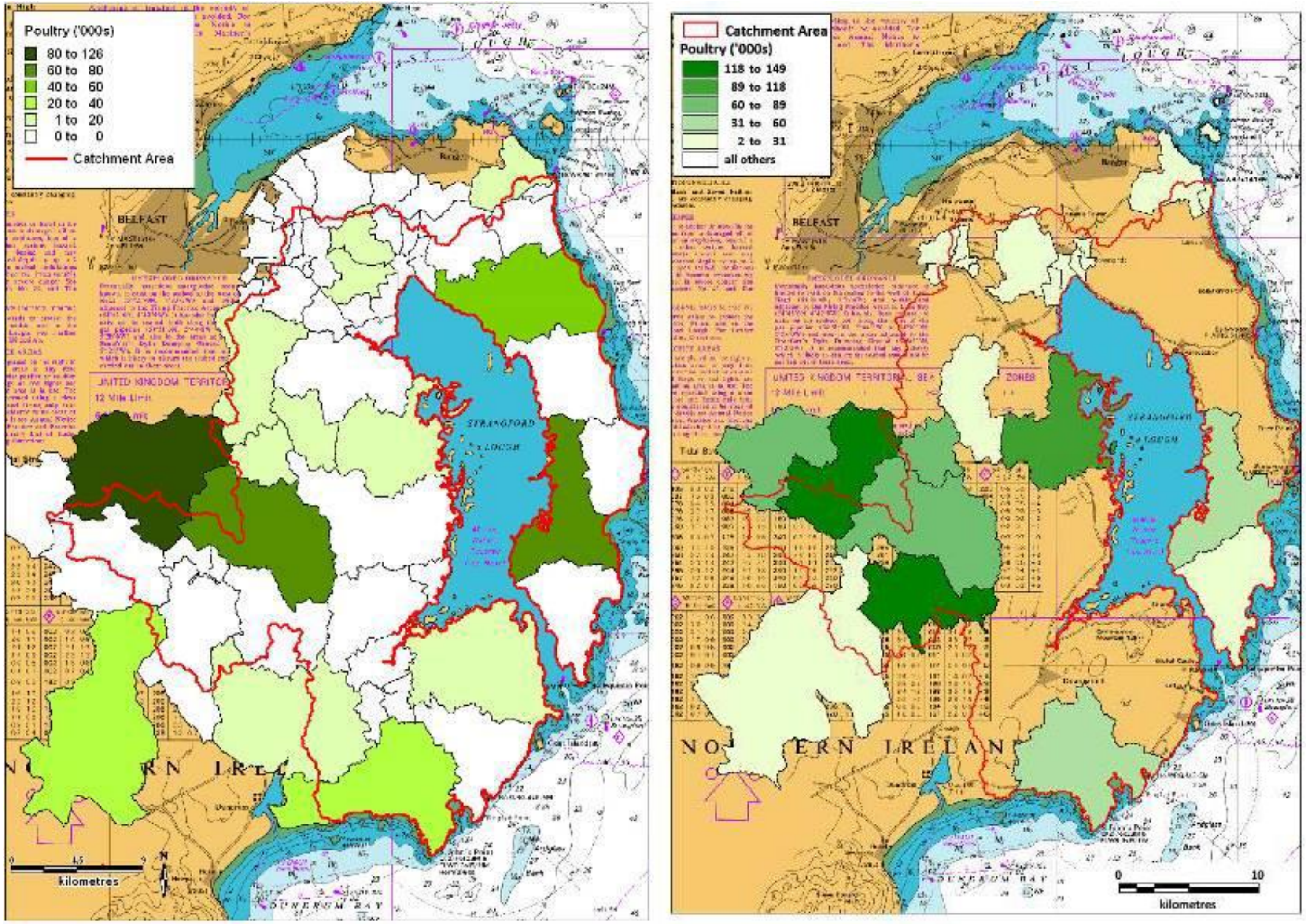


Figure 4.24: Poultry within the Strangford Lough Catchment Area for 2009 (Left) and 2018 (right) (Source: DAERA, 2009 & 2018).



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).

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.

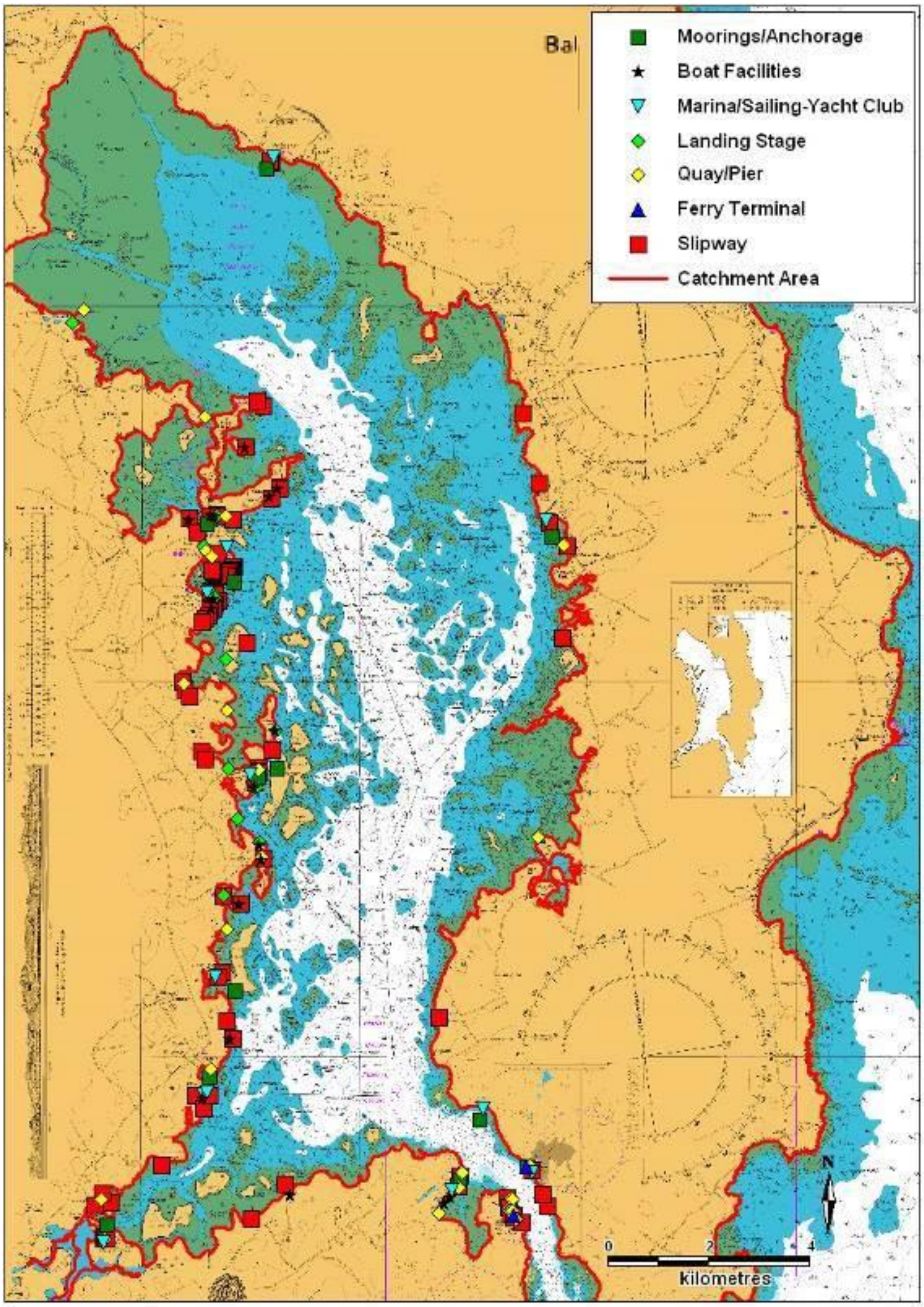
Marpol Annex IV defines sewage as “drainage from medical premises, toilets, urinals, spaces containing live animals and other waste waters when mixed with sewage waste streams”. Although adopted in 1973, the Annex did not come into effect until September 2003, with subsequent amendments entered into 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 4.25 shows all boat facilities and activities in Strangford Lough. Strangford Lough does not have a commercial port. A ferry service does operate between Portaferry and Strangford crossing the Strangford Narrows. It operates year-round with approximately 30 sailings a day. There remains are 12 marinas/yacht or sailing clubs in the lough and 12 mooring/anchorage sites (DAERA-NI, 2021).

While data on sewage discharge levels from shipping activities in Strangford 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 4.25: Location of all boating facilities and activities in Strangford Lough (Source: DAERA-NI, 2021).



4.1.6.2. Birds

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

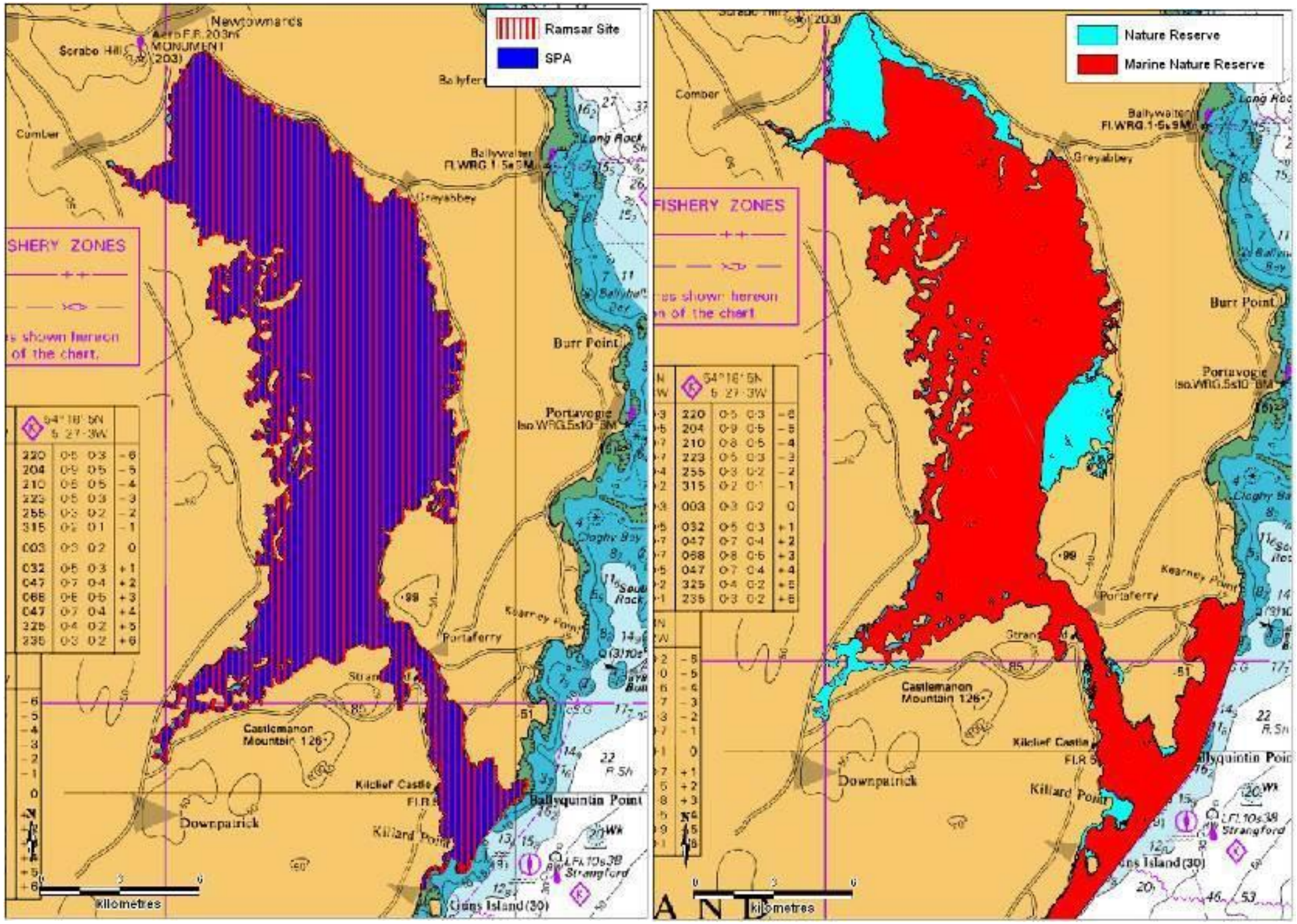
Figure 4.26a shows the locations of the Strangford Lough Special Protection Areas (SPA) and Ramsar Site and Figure 4.26b shows the 6 Nature Reserves (NR) (North Strangford Lough NR, The Dorn NR, Quoile Pondage NR, Granagh Bay NR, Cloghy Rocks NR and Killard NR) and 1 marine nature reserve which is Strangford Lough. The Strangford Lough SPA (Site Code: UK9020111) and the Strangford Lough Ramsar Site (Site Code: 7UK116) encompass the entire lough.

Strangford Lough routinely surveyed by the British Trust for Ornithology (BTO) (Through the WeBS [Wetland Bird Survey] Project). Table 4.7 shows the most recent results from the wetland bird surveys that are carried out each year. There appears to have been a significant decrease in the abundance of wetland birds in the Strangford since the 2011 sanitary survey. The 5-year average has dropped from 80,930 to 57,957 for the most recent 5 year period.

Table 4.7: Total number of water birds in Strangford Lough between 2004/05 and 2018/19 (Source: Frost et al., 2020).

Site Name	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**
Strangford Lough	78,452	83,314	74,420	87,104	81,364	71,818	72,511	78,565
Site Name	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	5 year Mean
Strangford Lough	60,811	65,256	46,204	60,700	62,867	53,703	66,313	57,957

Figure 4.26: Strangford Lough a) SPA and Ramsar Site and b) nature reserve and marine nature reserve.



Bird populations in the Strangford 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 Strangford Lough is higher in the winter months. However, it is highly likely that these levels are low when compared with land-based discharges.

4.1.6.3. Pollution Incidences

Between 2013 and 2017, there were 268 pollution incidents in the Strangford catchment area (NIEA, 2020). This averages out at 54 per year which is significantly lower than the 143 record in 2009. Eighteen were from industrial sources, 37 from farm sources, 95 were sourced from NI Water Ltd, 47 from domestic sources and 71 were from other sources or had no information. Of the 268 incidents, 225 were of low severity, 42 were of medium severity and one was of high severity.

5. Shellfish and Water Sampling

5.1. Historical Data

5.1.1. Shellfish Water Quality

DAERA Water Management Unit monitors a number of shellfish growing waters around the Northern Irish coastline as part of the Water Framework Directive. However, Strangford Lough has not been monitored since 2013.

5.1.2. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and its subsequent Implementing Regulation (EU) 2019/627, the Food Standards Agency of Northern Ireland (FSA in NI), as competent authority, is required to establish the location and fix the boundaries of shellfish harvesting areas.

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.

FSA in NI currently monitors shellfish flesh in Strangford Lough for microbiological contamination on a monthly basis and these results are reviewed annually to determine the classification award. FSA in NI monitors currently both oysters and mussels from within the classified area shown in Figure 5.1. Previously cockles and scallops were monitored.

Strangford Lough has historically always been classified as a mixture of A and B harvesting areas. Table 5.1 summaries this system. Table 5.2 shows the current and historical (back to 2003) classifications within Strangford Lough.

Table 5.1: Classification system for shellfish harvesting areas.

Classification	Permitted Levels	Outcome
A	80% of sample results ≤230 *E.coli*/100g, no results exceeding 700 *E.coli*/100g –	Molluscs can be harvested for direct human consumption provided the end product standard is met.
B	90% of sample results must be less than or equal to 4,600 *E. coli*/100g with none exceeding 46,000 E. *coli*/100g	Molluscs can go for human consumption after: • purification in an approved establishment, or • relaying in a classified Class A relaying area, or • an EC approved heat treatment process.
C	Less than 46,000 *E.coli*/100g flesh	Molluscs must be subject to relaying for a period of at least 2 months or cooked by an approved method.

Figure 5.1: **Locations of FSA in NI shellfish monitoring points for classification purposes.**

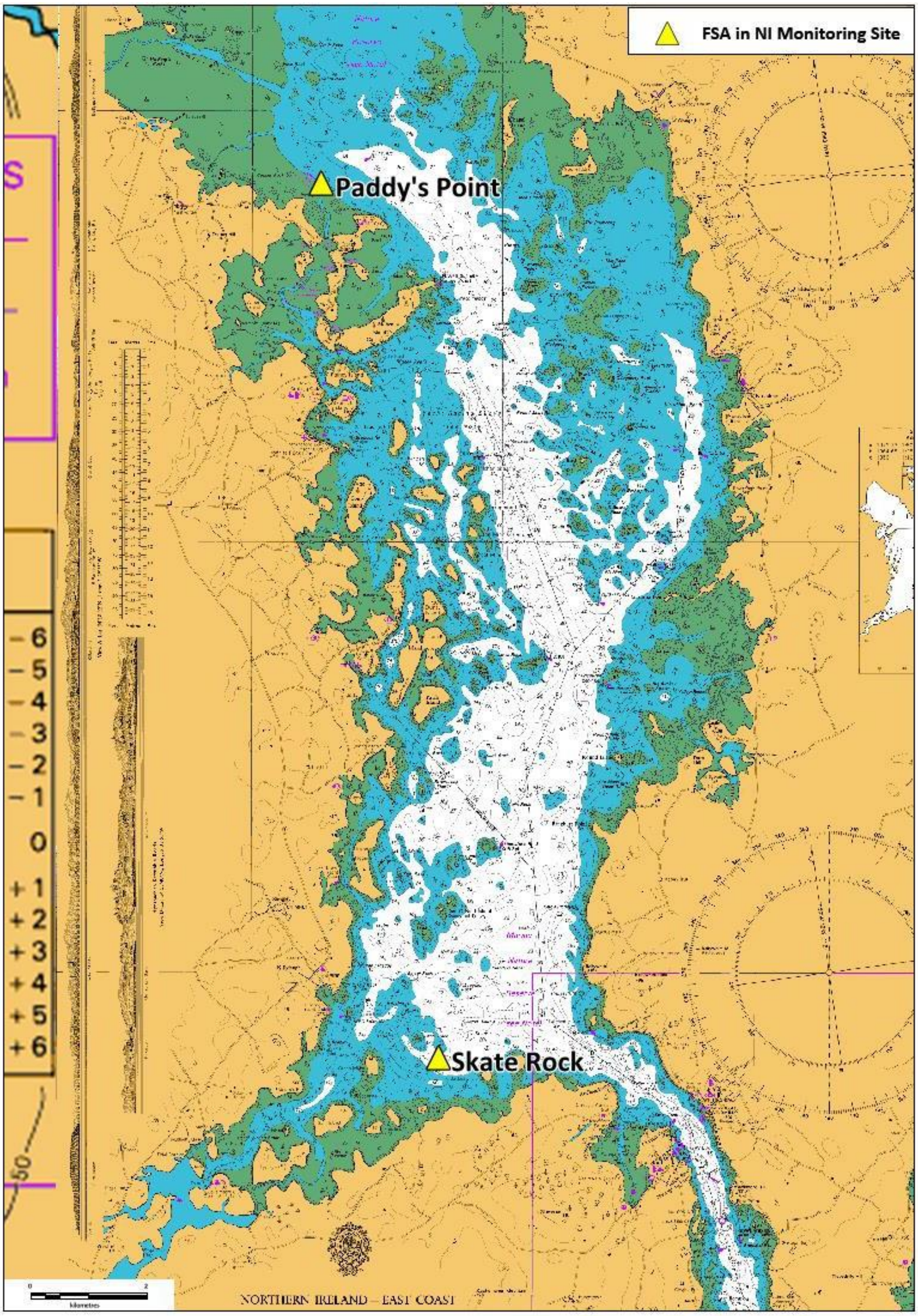


Table 5.2: Current and historical classification of shellfish beds in Strangford Lough (2003 – 2019).

Bed Name	Species	Classification																
		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
The Dorn	Oysters	A*	A*	A	A	A	A	A	A*	A	-	-	-	-	-	-	-	-
Marlfield Bay	Scallops	A	B	A	A	B	B	B	B	B	B	B	B	-	-	-	-	-
Reagh Bay	Oysters	A	A	A	A	A	A	A	A	A	A	-	A*	B	B	B	B	B
Skate Rock	Mussels	B	A	A	A	A	A	B	A	B	A*	A*	A*	A	A*	A	A	A#
Paddy's Point	Oysters	A	B	A	A	A	A	A	-	-	-	A*	A*	B	B	B	B	B
Paddy's Point	Cockles	-	A*	A*	A*	A*	-	-	-	-	-	-	-	-	-	-	-	-
Paddy's Point	Mussels	-	-	-	-	-	-	-	-	-	-	A*	A*	B	B	B	B	B
Ardmillan Bay	Cockles	A*	A	A*	A*	A*	-	-	-	-	-	-	-	-	-	-	-	-
Castle Espie	Cockles	B*	B	B	B	B*	-	-	-	-	-	-	-	-	-	-	-	-

*Provisional Classification - Classifications are described as 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.

A – Seasonal: 1st February 2019 – 30th September 2019 and B - Seasonal: 1st October 2019 – 31st January 2020

Tables 5.3 to 5.7 list the *E. coli* results for mussels and oysters from S6 Reagh Bay, S2 Skate Rock, S7 Paddy's Point and scallops for S23 Marlfield Bay from 2005 to 2019. Figures 5.2 to 5.6 show these data in graphical form.

Table 5.2 above shows the annual classification of all site monitored in Strangford Lough from 2005 to 2019. Three cockle sites have not been classified since 2007 Paddy's Point, Ardmillan Bay and Castle Espie. Classification for the years they were monitored were **provisional A** for Paddy's Point and Ardmillan Bay and **B** for Castle Espie. The Dorn had an **A** or **A provisional** classification from 2003 to 2011; however, it has not been classified since. S23 Marlfield Bay was predominately classified as **B**, however, it has not been classified since 2014. Between 2005 and 2014, the S23 Marlfield Bay scallop harvesting bed had an **A** result 88.2% of the time and a **B** result 11.8% of the time.

S6 Reagh Bay had an **A** classification from 2003 to 2012. Classification for S6 Reagh Bay since 2014 has been based on the S7 Paddy's Point Classification. In 2014, it was classified as **provisional A** since then it has been **B**. Up until monitoring stopped in 2012 there had been one instance of a **C** result for the S6 Reagh Bay oyster harvesting bed which occurred in May 2005 (9,100 MPN/100g) and one instance of a B result and it occurred in April 2005 (2,200 MPN/100g). All other results were **A.**

S2 Skate Rock had a **B** classification on three occasions (2003, 2009 & 2011) and an **A** classification from 2004 – 2008, 2010, 2015, 2017 and 2018. Since 2005, the S2 Skate Rock mussel harvesting bed had an **A** result 94.4% of the time and a **B** result 5.6% of the time. *E. coli* counts during these **B** periods ranging from 310-1,700 MPN/100g.

S7 Paddy's Point has been monitored for mussels and oysters since 2013. Classification for both mussels and oysters was **provisional A** for 2013 – 2014 and B for 2015 – 2019. Since 2013, S7 Paddy's Point mussels have had an **A** result 75.6% of the time and a **B** 24.4% of the time (See Figure 5.9). *E. coli* counts during these **B** periods ranging from 270-1,700 MPN/100g. S7 Paddy's Point was declassified for mussels in on 01/01/2020. Since 2013, S7 Paddy's Point oysters have had an **A** result 81.9% of the time, a **B** 15.7% of the time and a **C** 2.4% of the time. *E. coli* counts during these **B** periods ranged from 330-990

MPN/100g. There were only two occasions in which **C** results were recorded December 2014 (7,900 MPN/100g) and August 2015 (4,900 MPN/100g).

Table 5.3: *E. coli* results from scallops from S23 Marlfield Bay from 2005 to June 2014 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category
27-Jan-05	20	A
21-Feb-05	20	A
07-Mar-05	40	A
21-Apr-05	500	B
03-May-05	50	A
29-Jun-05	110	A
18-Jul-05	130	A
15-Aug-05	70	A
08-Sep-05	40	A
12-Oct-05	90	A
28-Nov-05	20	A
14-Dec-05	40	A
25-Jan-06	500	B
22-Feb-06	320	B
21-Mar-06		A
10-Apr-06	220	A
08-May-06	ND	A
12-Jun-06	40	A
17-Jul-06	110	A
07-Aug-06	310	B
04-Sep-06	70	A
16-Oct-06	110	A
27-Nov-06	140	A
08-Jan-07	310	B
05-Feb-07	ND	A
02-Apr-07	500	B
05-Jun-07	40	A
03-Jul-07	20	A
28-Aug-07	220	A
18-Sep-07	310	B
15-Oct-07	20	A

Date	*E. coli* (MPN/100g)	Category
01-Apr-08	110	A
21-May-08	20	A
09-Jun-08	20	A
21-Jul-08	20	A
05-Aug-08	1300	B
08-Sep-08	110	A
06-Oct-08	<20	A
04-Nov-08	40	A
02-Dec-08	20	A
06-Jan-09	160	A
17-Feb-09	70	A
03-Mar-09	20	A
07-Apr-09	20	A
05-May-09	<20	A
02-Jun-09	20	A
06-Jul-09	20	A
03-Aug-09	20	A
01-Sep-09	700	B
06-Oct-09	500	B
03-Nov-09	200	A
30-Nov-09	20	A
11-Jan-10	<20	A
08-Feb-10	<20	A
08-Mar-10	<20	A
13-Apr-10	200	A
11-May-10	<20	A
08-Jun-10	<20	A
06-Jul-10	230	A
03-Aug-10	350	B

Date	*E. coli* (MPN/100g)	Category
07-Sep-10	130	A
12-Oct-10	<20	A
09-Nov-10	40	A
10-Jan-11	<20	A
01-Feb-11	<20	A
07-Mar-11	20	A
05-Apr-11	<20	A
10-May-11	<20	A
14-Jun-11	<20	A
16-Jan-12	20	A
13-Feb-12	490	B
12-Mar-12	50	A
02-Apr-12	<20	A
22-May-12	20	A
11-Jun-12	1300	B
23-Jul-12	20	A
20-Aug-12	490	B
18-Sep-12	<20	A
23-Oct-12	230	A
04-Dec-12	<20	A
10-Dec-12	20	A
14-Jan-13	130	A
11-Feb-13	20	A
08-Apr-13	<20	A
16-Apr-13	50	A
07-May-13	<20	A
10-Jun-13	<20	A
08-Jul-13	<20	A
06-Aug-13	170	A
02-Sep-13	<20	A
01-Oct-13	110	A
05-Nov-13	80	A
02-Jul-14	20	A

Figure 5.2: ***E*. coli results from scallops at S23 Marlfield Bay from 2005-June 2014 (Source: FSA in NI).**

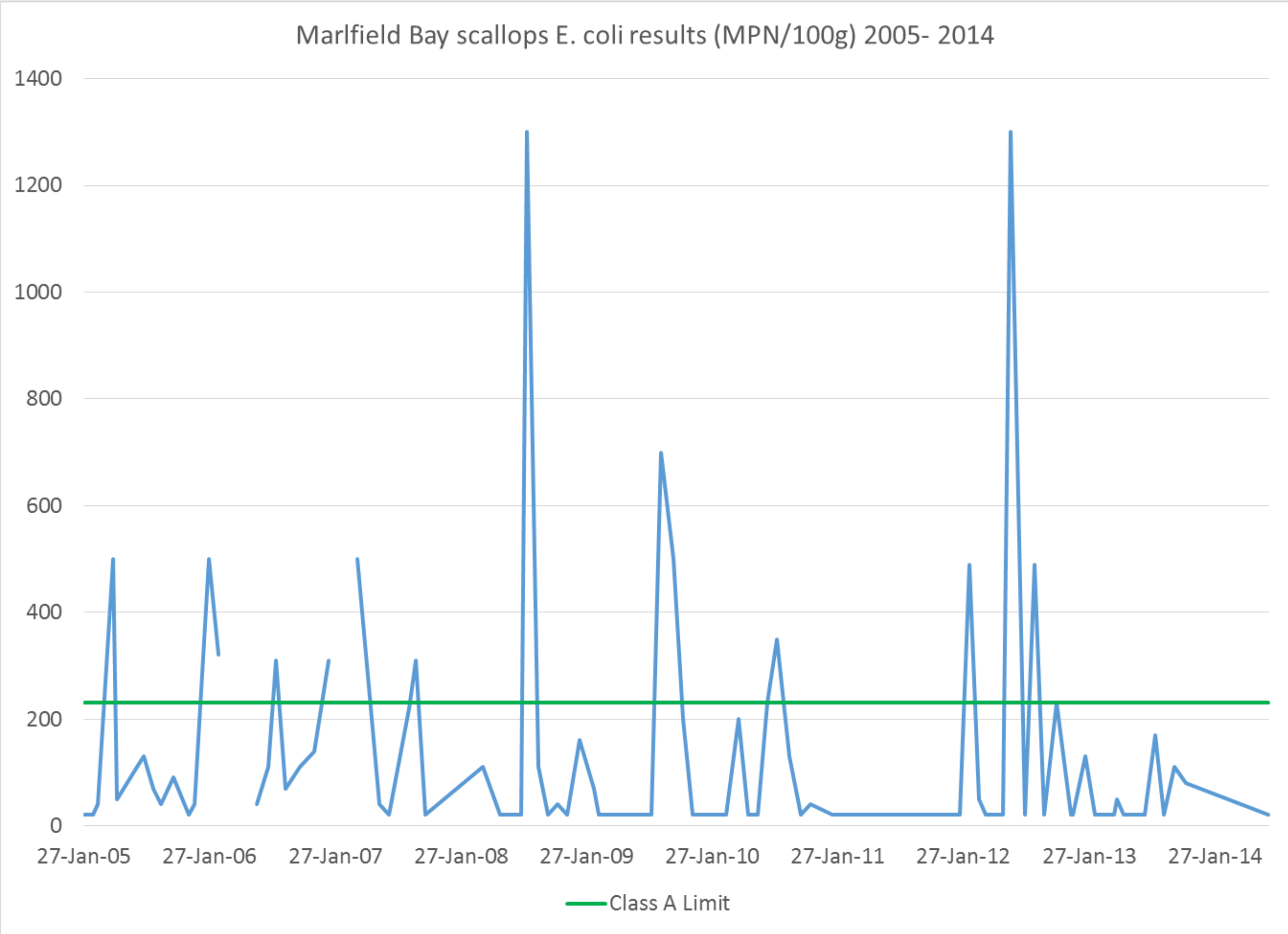


Table 5.4: *E. coli* results from oysters from S6 Reagh Bay from 2005 to June 2012 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category
26-Jan-05	70	A
23-Feb-05	220	A
09-Mar-05	110	A
18-Apr-05	2200	B
03-May-05	9100	C
17-May-05	40	A
28-Jun-05	90	A
28-Jul-05	ND	A
15-Aug-05	<20	A
07-Sep-05	ND	A
11-Oct-05	70	A
29-Nov-05	40	A
13-Dec-05	220	A
25-Jan-06	20	A
22-Feb-06	ND	A
21-Mar-06	ND	A
12-Apr-06	ND	A
09-May-06	220	A
13-Jun-06	20	A
18-Jul-06	ND	A
08-Aug-06	ND	A
19-Sep-06	<20	A
18-Oct-06	<20	A
29-Nov-06	ND	A
12-Dec-06	160	A
09-Jan-07	20	A
06-Feb-07	50	A
06-Mar-07	70	A
02-Apr-07	20	A
17-Apr-07	ND	A

Date	*E. coli* (MPN/100g)	Category
23-May-07	<20	A
20-Jun-07	40	A
18-Jul-07	20	A
29-Aug-07	40	A
19-Sep-07	<20	A
16-Oct-07	<20	A
28-Nov-07	<20	A
19-Dec-07	<20	A
22-Jan-08	<20	A
19-Feb-08	<20	A
19-Mar-08	20	A
23-Apr-08	<20	A
20-May-08	<20	A
24-Jun-08	<20	A
08-Jul-08	70	A
18-Aug-08	70	A
23-Sep-08	<20	A
20-Oct-08	<20	A
18-Nov-08	<20	A
16-Dec-08	<20	A
21-Jan-09	<20	A
18-Feb-09	<20	A
18-Mar-09	<20	A
21-Apr-09	<20	A
19-May-09	<20	A
16-Jun-09	<20	A
27-Jul-09	40	A
18-Aug-09	20	A
15-Sep-09	40	A
10-Oct-09	40	A
17-Nov-09	40	A
17-Dec-09	<20	A

Date	*E. coli* (MPN/100g)	Category
26-Jan-10	80	A
24-Feb-10	<20	A
24-Mar-10	20	A
27-Apr-10	<20	A
25-May-10	<20	A
29-Jun-10	110	A
20-Jul-10	<20	A
23-Aug-10	20	A
27-Sep-10	<20	A
25-Oct-10	<20	A
23-Nov-10	<20	A
26-Jan-11	<20	A
16-Feb-11	<20	A
24-Mar-11	<20	A
20-Apr-11	20	A
24-May-11	<20	A
21-Jun-11	50	A
17-Jan-12	200	A

Figure 5.3: *E. coli* levels from oysters at S6 Reagh Bay from 2005 to June 2012 (Source: FSA in NI).

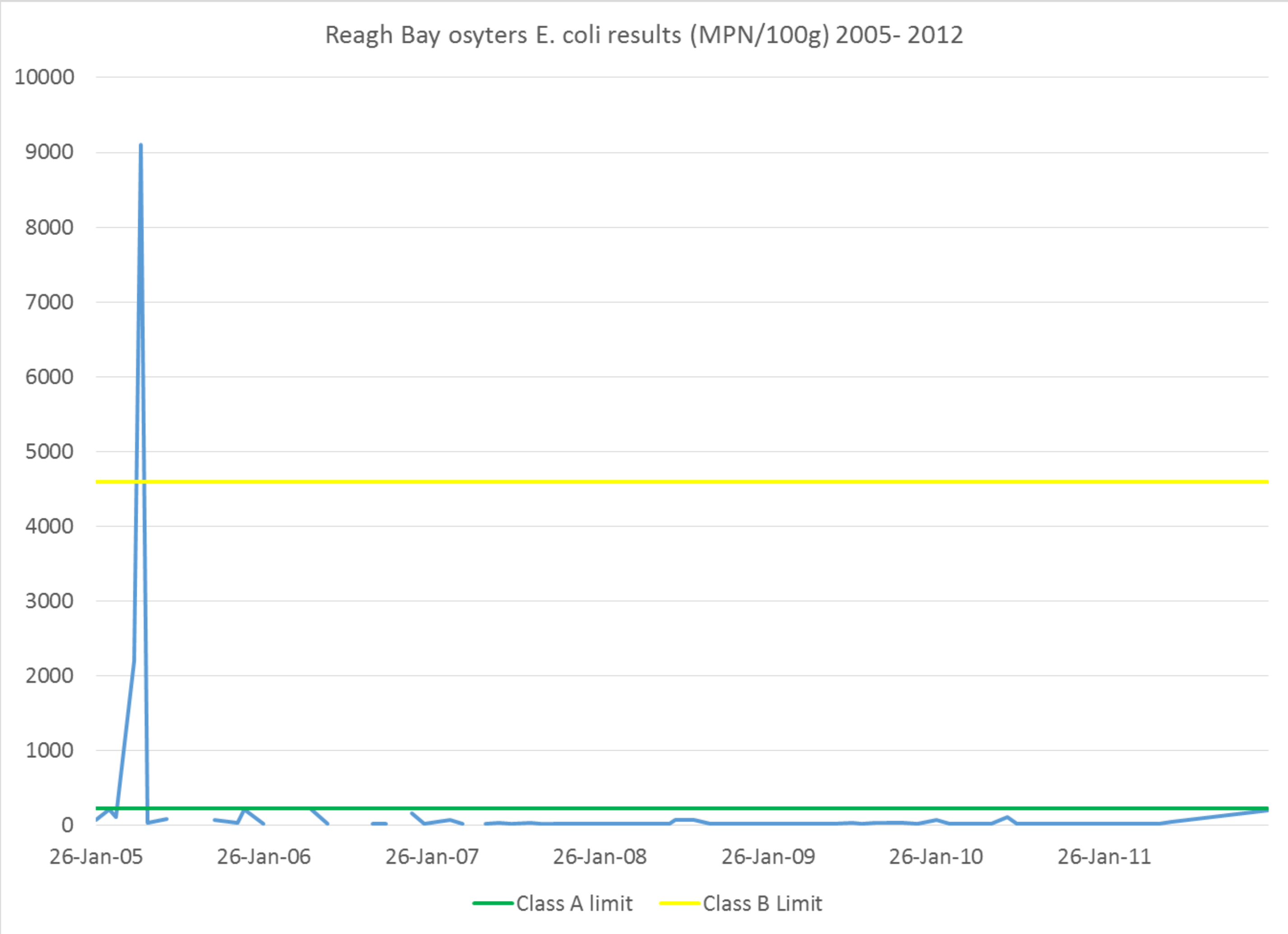


Table 5.5: *E. coli* results from mussels from S2 Skate Rock from 2005 to 2019 (Source: FSA in NI)

Date	*E. coli* (MPN/100g)	Category
25-Jan-05	50	A
27-Jan-05	70	A
21-Feb-05	20	A
07-Mar-05	20	A
21-Apr-05	110	A
03-May-05	110	A
29-Jun-05	ND	A
18-Jul-05	50	A
15-Aug-05	40	A
08-Sep-05	ND	A
12-Oct-05	50	A
28-Nov-05	70	A
14-Dec-05	70	A
23-Jan-06	110	A
20-Feb-06	20	A
21-Mar-06	20	A
10-Apr-06	50	A
08-May-06	70	A
12-Jun-06	20	A
17-Jul-06	20	A
07-Aug-06	20	A
04-Sep-06	ND	A
16-Oct-06	20	A
27-Nov-06	20	A
11-Dec-06	40	A
08-Jan-07	40	A
05-Feb-07	ND	A
05-Mar-07	40	A
02-Apr-07	20	A
05-Jun-07	40	A
03-Jul-07	750	B
13-Aug-07	40	A
18-Sep-07	310	B
15-Oct-07	<20	A
03-Dec-07	<20	A

Date	*E. coli* (MPN/100g)	Category
08-Jan-08	110	A
05-Feb-08	40	A
03-Mar-08	<20	A
07-Apr-08	<20	A
07-May-08	<20	A
09-Jun-08	20	A
21-Jul-08	20	A
05-Aug-08	1300	B
08-Sep-08	1300	B
06-Oct-08	20	A
04-Nov-08	<20	A
02-Dec-08	70	A
06-Jan-09	<20	A
17-Feb-09	200	A
03-Mar-09	<20	A
07-Apr-09	<20	A
05-May-09	<20	A
02-Jun-09	40	A
06-Jul-09	70	A
07-Jul-09	<20	A
02-Aug-09	<20	A
01-Sep-09	70	A
06-Oct-09	220	A
03-Nov-09	220	A
30-Nov-09	<20	A
11-Jan-10	<20	A
08-Feb-10	20	A
08-Mar-10	<20	A
13-Apr-10	<20	A
11-May-10	<20	A
08-Jun-10	<20	A
06-Jul-10	330	B
03-Aug-10	460	B
21-Sep-10	20	A
12-Oct-10	<20	A

Date	*E. coli* (MPN/100g)	Category
09-Nov-10	80	A
10-Jan-11	<20	A
01-Feb-11	20	A
07-Mar-11	<20	A
05-Apr-11	<20	A
09-May-11	50	A
14-Jun-11	<20	A
16-Jan-12	50	A
13-Feb-12	110	A
12-Mar-12	40	A
02-Apr-12	<20	A
22-May-12	<20	A
11-Jun-12	1100	B
23-Jul-12	20	A
20-Aug-12	<20	A
18-Sep-12	130	A
23-Oct-12	<20	A
04-Dec-12	200	A
14-Jan-13	50	A
11-Feb-13	20	A
19-Mar-13	<20	A
08-Apr-13	<20	A
07-May-13	<20	A
10-Jun-13	<20	A
08-Jul-13	20	A
06-Aug-13	<20	A
02-Sep-13	<20	A
01-Oct-13	<20	A
05-Nov-13	<20	A
02-Dec-13	<20	A
08-Jan-14	110	A
18-Feb-14	170	A
02-Apr-14	<20	A
06-May-14	<20	A
02-Jun-14	20	A

Date	*E. coli* (MPN/100g)	Category
02-Jul-14	<18	A
02-Jul-14	<18	A
29-Jul-14	<18	A
26-Aug-14	130	A
22-Sep-14	18	A
27-Oct-14	45	A
24-Nov-14	<18	A
30-Dec-14	40	A
26-Jan-15	<18	A
03-Mar-15	<18	A
31-Mar-15	20	A
21-Apr-15	<18	A
27-May-15	<18	A
22-Jun-15	<18	A
21-Jul-15	<18	A
25-Aug-15	20	A
22-Sep-15	78	A
20-Oct-15	20	A
16-Nov-15	780	B
14-Dec-15	170	A
11-Jan-16	170	A
16-Feb-16	<18	A
15-Mar-16	<18	A
11-Apr-16	20	A
09-May-16	45	A
06-Jun-16	<18	A
04-Jul-16	<18	A
01-Aug-16	20	A
31-Aug-16	220	A
19-Sep-16	130	A
24-Oct-16	<18	A
21-Nov-16	<18	A
03-Jan-17	<16	A
16-Jan-17	20	A
13-Feb-17	<18	A

5 Date	*E. coli* (MPN/100g)	Category
13-Mar-17	<18	A
03-Apr-17	20	A
02-May-17	<18	A
30-May-17	<18	A
26-Jun-17	20	A
24-Jul-17	<18	A
21-Aug-17	20	A
18-Sep-17	<18	A
10-Oct-17	1300	B
06-Nov-17	<18	A
11-Dec-17	<18	A
08-Jan-18	<18	A
05-Feb-18	<18	A
05-Mar-18	<18	A
04-Apr-18	<18	A
09-May-18	<18	A
05-Jun-18	<18	A
03-Jul-18	20	A
30-Jul-18	20	A
28-Aug-18	110	A
24-Sep-18	110	A
16-Oct-18	130	A
13-Nov-18	<18	A
10-Dec-18	1700	B
07-Jan-19	40	A
29-Jan-19	<18	A
12-Feb-19	<18	A
12-Mar-19	<18	A
08-Apr-19	18	A
08-May-19	20	A
03-Jun-19	20	A
26-Jun-19	20	A
23-Jul-19	130	A
19-Aug-19	<18	A
16-Sep-19	<18	A
14-Oct-19	170	A
18-Nov-19	20	A
10-Dec-19	<18	A

Figure 5.4: *E. coli* levels in S2 Skate Rock mussels from 2005 to 2019 (Source: FSA in NI).

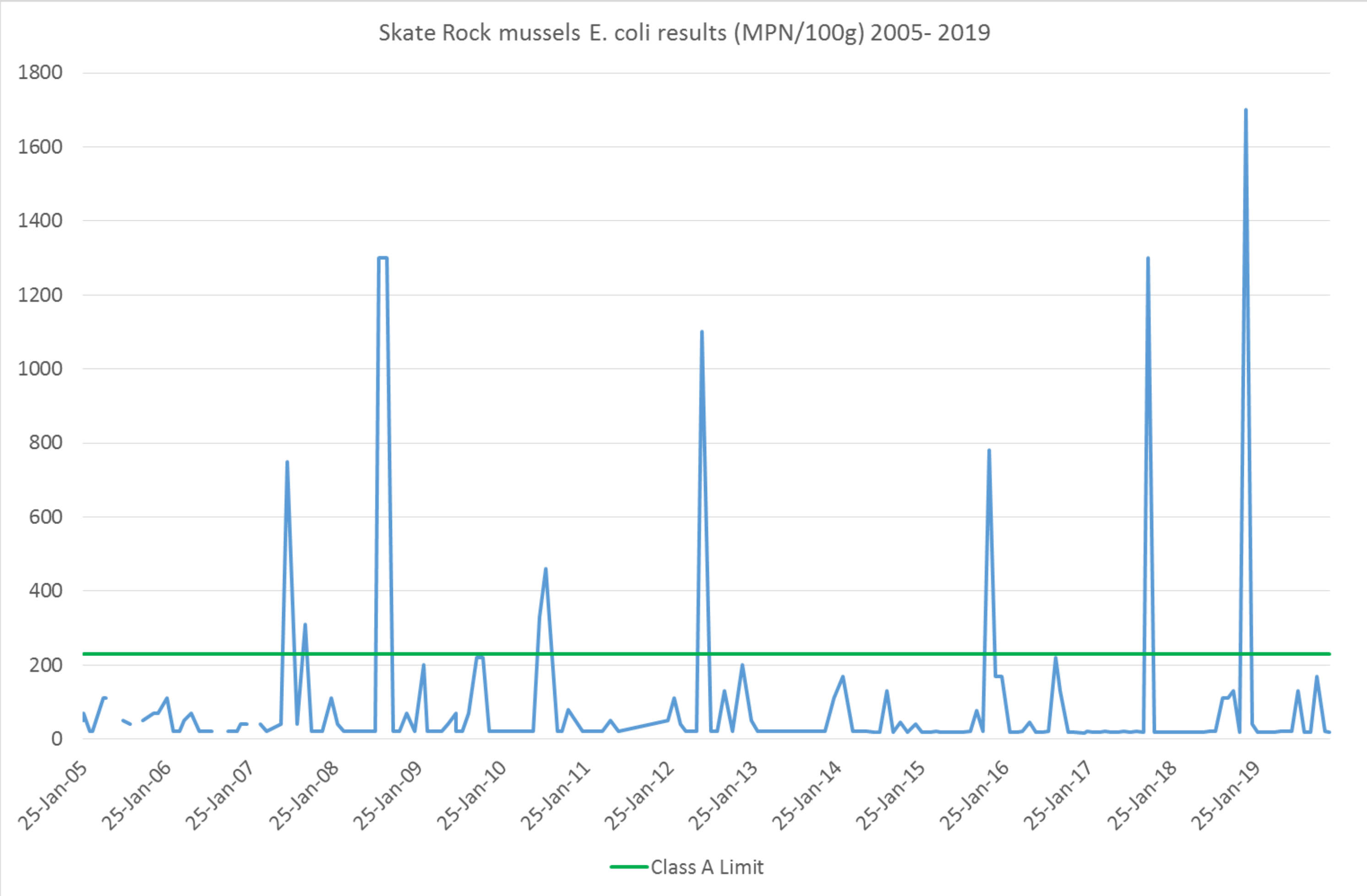


Table 5.6: *E. coli* results from mussels from S7 Paddy's Point site from 2013 to June 2019 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category
09-Jul-13	80	A
06-Aug-13	110	A
02-Sep-13	<20	A
30-Sep-13	<20	A
05-Nov-13	70	A
03-Dec-13	<20	A
19-Feb-14	1300	B
03-Mar-14	<20	A
01-Apr-14	50	A
06-May-14	<20	A
02-Jun-14	<18	A
02-Jul-14	<18	A
30-Jul-14	20	A
26-Aug-14	20	A
22-Sep-14	20	A
27-Oct-14	78	A
26-Nov-14	45	A
30-Dec-14	780	B
26-Jan-15	78	A
09-Mar-15	40	A
31-Mar-15	78	A
21-Apr-15	<18	A
26-May-15	<18	A
22-Jun-15	<18	A
20-Jul-15	130	A
24-Aug-15	1700	B
21-Sep-15	20	A
19-Oct-15	18	A
17-Nov-18	780	B
15-Dec-15	330	B
12-Jan-16	270	B
15-Feb-16	270	B
14-Mar-16	<18	A
12-Apr-16	130	A
10-May-16	110	A

Date	*E. coli* (MPN/100g)	Category
07-Jun-16	18	A
05-Jul-16	330	B
02-Aug-16	110	A
31-Aug-16	330	B
20-Sep-16	78	A
25-Oct-16	170	A
21-Nov-16	170	A
20-Dec-16	130	A
24-Jan-17	45	A
14-Feb-17	170	A
14-Mar-17	78	A
04-Apr-17	<18	A
02-May-17	<18	A
30-May-17	20	A
27-Jun-17	490	B
24-Jul-17	780	B
22-Aug-17	45	A
19-Sep-17	78	A
09-Oct-17	20	A
07-Nov-17	130	A
12-Dec-17	690	B
09-Jan-18	20	A
06-Mar-18	1300	B
05-Apr-18	330	B
09-May-18	<18	A
05-Jun-18	110	A
02-Jul-18	130	A
31-Jul-18	780	B
29-Aug-18	130	A
25-Sep-18	<18	A
16-Oct-18	45	A
12-Nov-18	310	B
11-Dec-18	490	B
08-Jan-19	210	A
11-Feb-19	130	A

Date	*E. coli* (MPN/100g)	Category
11-Mar-19	450	B
08-Apr-19	130	A
07-May-19	78	A
05-Jun-19	170	A
24-Jun-19	170	A
22-Jul-19	<18	A
19-Aug-19	690	B
17-Sep-19	40	A

Figure 5.5: *E. coli* levels in mussels from S7 Paddy's Point from 2013 - 2019 (Source: FSA in NI).

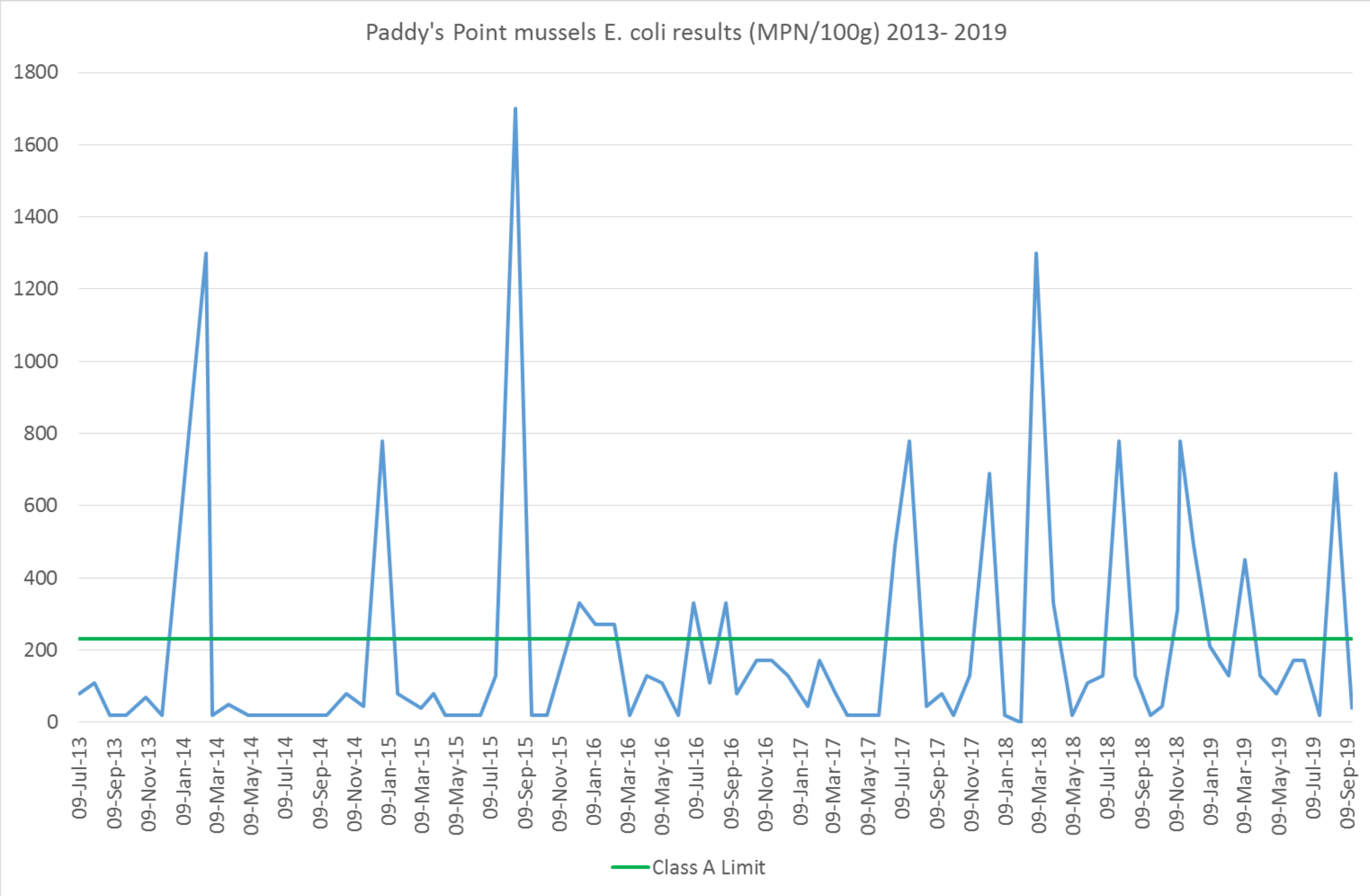


Table 5.7: *E. coli* results from oysters from S7 Paddy's Point site from 2013 to June 2019 (Source: FSA in NI).

Date	*E. coli* (MPN/100g)	Category
09-Jul-13	<20	A
06-Aug-13	80	A
02-Sep-13	20	A
30-Sep-13	<20	A
05-Nov-13	<20	A
03-Dec-13	40	A
19-Feb-14	330	B
03-Mar-14	<20	A
01-Apr-14	<20	A
06-May-14	<20	A
02-Jun-14	<18	A
02-Jul-14	20	A
30-Jul-14	<18	A
26-Aug-14	78	A
22-Sep-14	<18	A
27-Oct-14	20	A
26-Nov-14	170	A
30-Dec-14	7900	C
13-Jan-15	45	A
26-Jan-15	<18	A
09-Mar-15	45	A
31-Mar-15	78	A
21-Apr-15	<18	A
26-May-15	<18	A
22-Jun-15	330	B
20-Jul-15	<18	A
24-Aug-15	4900	C
21-Sep-15	45	A
19-Oct-15	40	A
17-Nov-15	690	B
15-Dec-15	330	B
12-Jan-16	40	A
15-Feb-16	170	A
14-Mar-16	20	A
12-Apr-16	110	A

Date	*E. coli* (MPN/100g)	Category
10-May-16	93	A
07-Jun-16	45	A
05-Jul-16	490	B
02-Aug-16	40	A
31-Aug-16	130	A
20-Sep-16	<18	A
25-Oct-16	<18	A
21-Nov-16	20	A
20-Dec-16	40	A
24-Jan-17	45	A
14-Feb-17	<18	A
14-Mar-17	40	A
04-Apr-17	<18	A
02-May-17	<18	A
30-May-17	170	A
27-Jun-17	20	A
24-Jul-17	780	B
22-Aug-17	490	B
19-Sep-17	20	A
09-Oct-17	<18	A
07-Nov-17	45	A
12-Dec-17	330	B
09-Jan-18	170	A
06-Feb-18	<18	A
06-Mar-18	690	B
05-Apr-18	140	A
09-May-18	<18	A
05-Jun-18	78	A
02-Jul-18	130	A
31-Jul-18	690	B
29-Aug-18	330	B
25-Sep-18	20	A
16-Oct-18	92	A
12-Nov-18	330	B
11-Dec-18	78	A

Date	*E. coli* (MPN/100g)	Category
08-Jan-19	20	A
11-Feb-19	45	A
11-Mar-19	130	A
08-Apr-19	78	A
07-May-19	68	A
05-Jun-19	210	A
24-Jun-19	450	B
22-Jul-19	130	A
19-Aug-19	330	B
17-Sep-19	78	A
15-Oct-19	220	A
19-Nov-19	78	A
16-Dec-19	68	A

Figure 5.6: *E. coli* levels in mussels from S7 Paddy's Point from 2013 - 2019 (Source: FSA in NI).

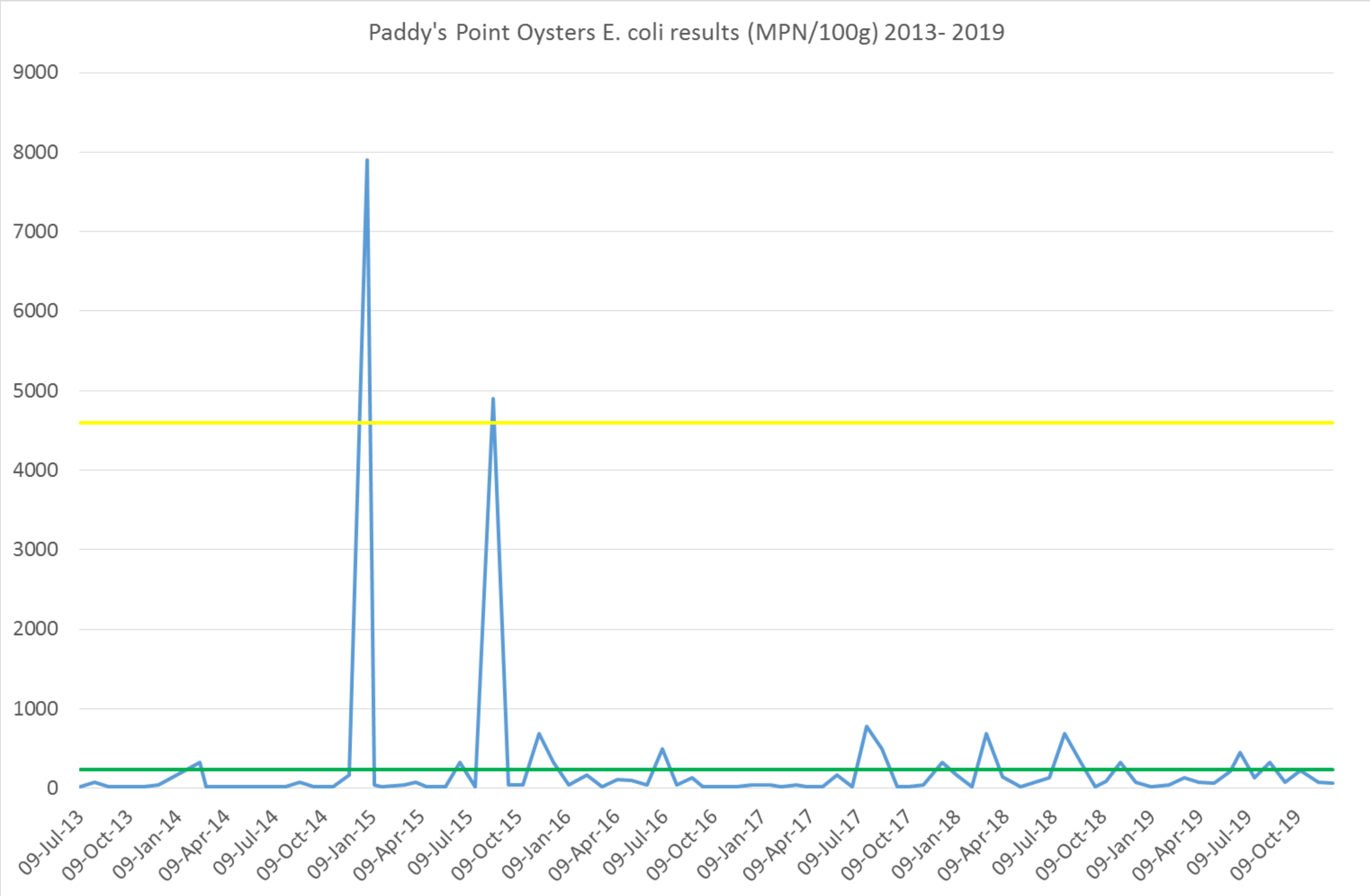


Table 5.8 shows the summary statistics for the *E. coli* historical data (2005 to 2019) from the 5 shellfish beds classified over the period.

The geometric mean of *E. coli* levels was highest for mussels at S7 Paddy's Point (87 MPN/100g), followed by oysters at S7 Paddy's Point (70 MPN/100g) and scallops at S23 Marlfield Bay (58 MPN/100g). The lowest geometric mean was for oysters at S6 Reagh Bay and mussels S2 Skate Rock (36 MPN/100g).

Table 5.8: Summary statistics of historical *E. coli* data monitored from shellfish beds in Strangford Lough.

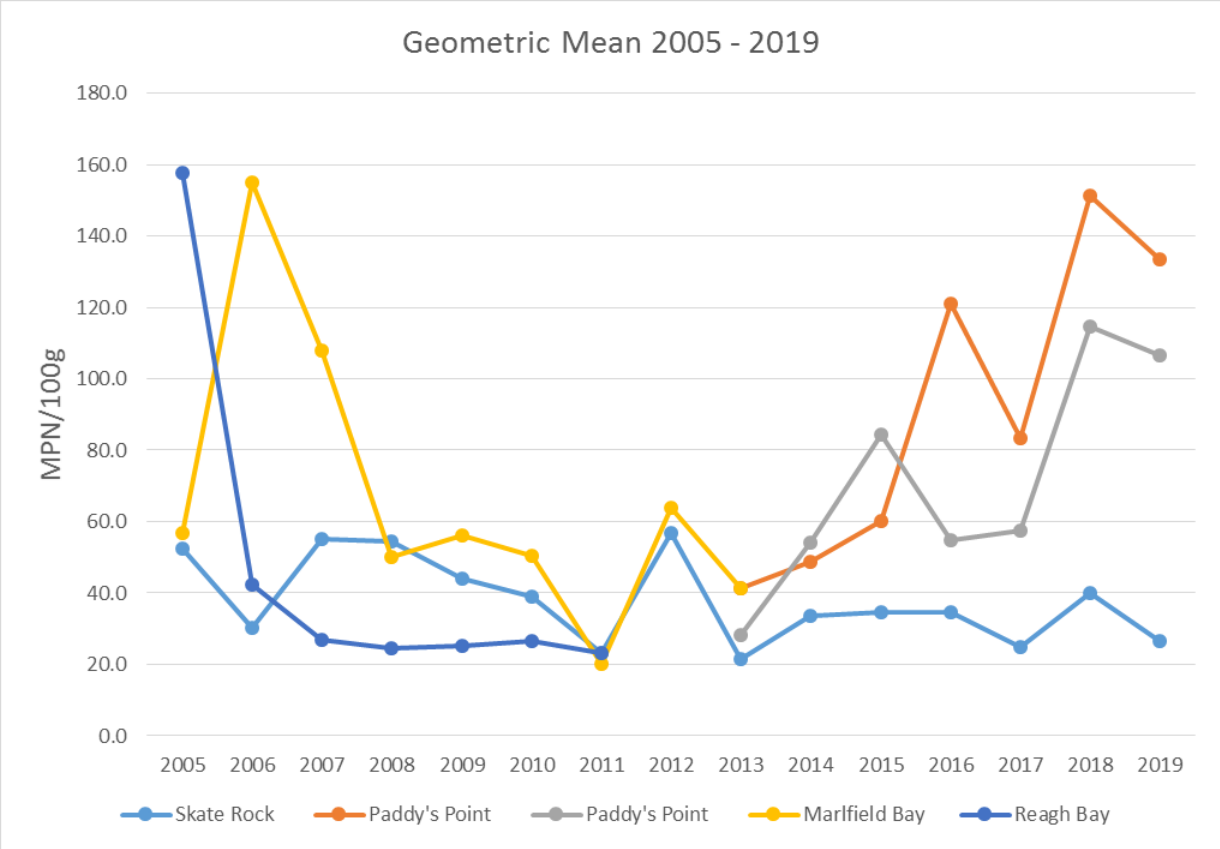
Site	Species	Date 1st Sample	Date last Sample	Min *E. coli* (MPN/100g)	Max *E. coli* (MPN/100g)	Median *E. coli* (MPN/100g)	Geometric Mean *E. coli* (MPN/100g)
S23 Marlfield Bay	Scallops	27/01/05	02/07/14	20	1300	40	58
S6 Reagh Bay	Oysters	26/01/05	17/02/12	20	9100	20	36
S2 Skate Rock	Mussels	25/01/05	10/12/19	16	1700	20	36
S7 Paddy's Point	Mussels	09/07/13	17/09/19	18	1700	78	87
S7 Paddy's Point	Oysters	09/07/13	16/12/19	18	7900	45	70

Table 5.9 shows the variations of the annual geometric means of *E. coli* for the shellfish beds monitored in Strangford Lough. Figure 5.7 shows the trend in geometric mean from 2005 to June 2019 for all 5 shellfish beds. The geometric mean for mussels at S2 Skate Rock ranged from 21.6 – 56.9 MPN/100g. The geometric mean for mussels at S7 Paddy's Point ranged from 41.3 – 151.1 MPN/100g and for oysters at the same location ranged from 28.3 – 114.5 MPN/100g. The geometric mean for oysters at S6 Reagh Bay ranged from 23.3 – 157.7 MPN/100g (No monitoring has taken place at this location since 2011). The geometric mean for scallops at S23 Marlfield Bay ranged from 20 – 155 MPN/100g (No monitoring has taken place at this location since 2013).

Table 5.9: Variation of annual geometric means of *E. coli* from shellfish beds monitored in Strangford Lough.

Site	Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
S2 Skate Rock	mussels	52.5	30.3	55.2	54.4	44.2	38.9	23.3	56.9	21.6	33.5	34.5	34.6	25.0	39.9	26.6
S7 Paddy's Point	mussels	-	-	-	-	-	-	-	-	41.3	48.8	60.1	121.0	83.3	151.1	133.4
S7 Paddy's Point	Oysters	-	-	-	-	-	-	-	-	28.3	54.2	84.4	54.9	57.4	114.5	106.6
S23 Marlfield Bay	Scallops	56.9	155.0	107.8	50.2	56.3	50.4	20.0	63.9	41.5	-	-	-	-	-	-
S6 Reagh Bay	Oysters	157.7	42.2	26.9	24.6	25.2	26.5	23.3	-	-	-	-	-	-	-	-

Figure 5.7: Trend in geometric mean of *E. coli* levels from 2005 to June 2019 for all 5 beds.



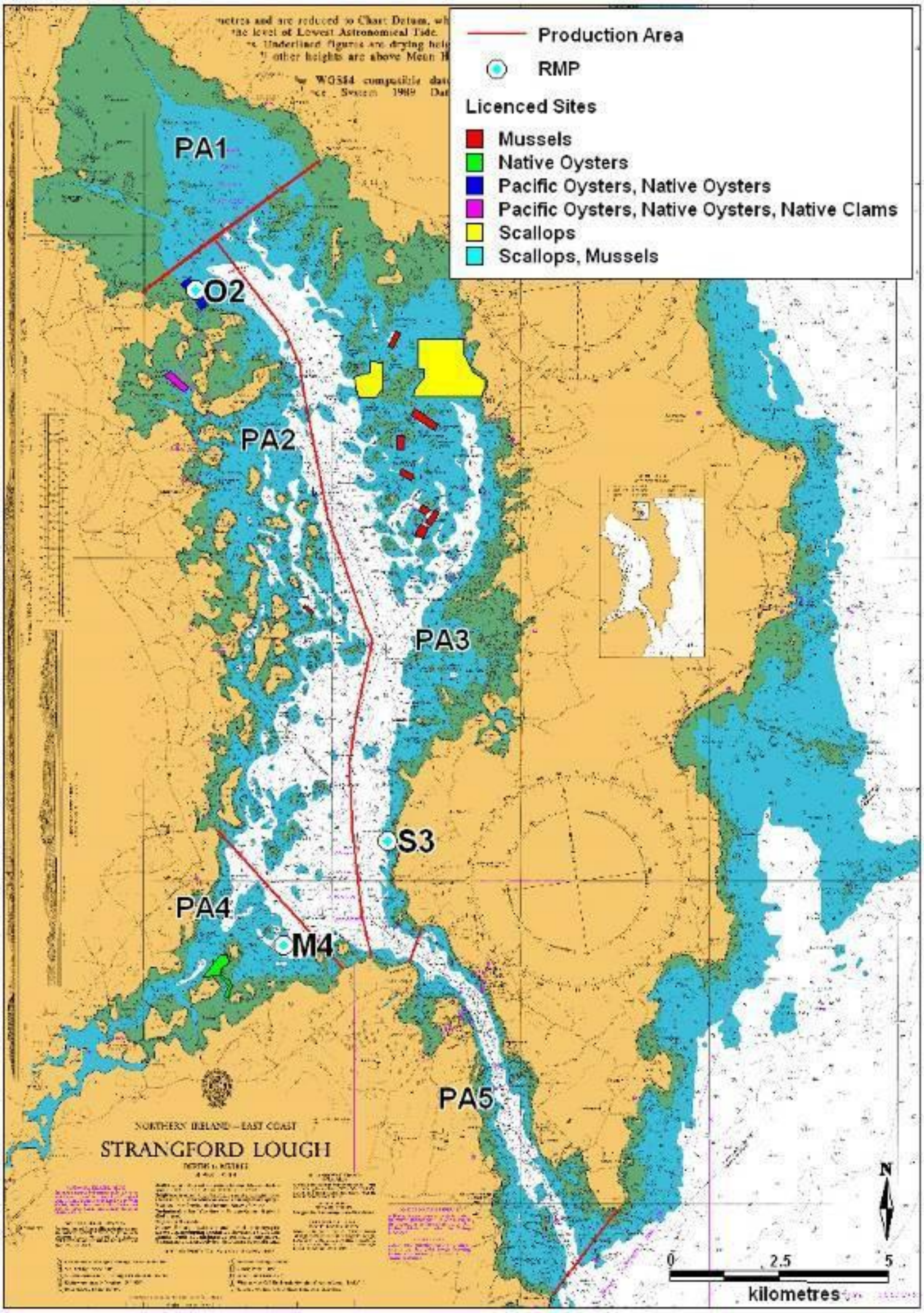
In order to identify any significant differences in *E. coli* levels based on location, a one-way analysis of variance (ANOVA) was performed on all *E. coli* results from shellfish flesh from the various harvesting beds (3 classified beds with up to date results available). For this analysis, all shellfish flesh results that returned a less than value (i.e., <X) were given that value (e.g., <20 becomes 20). All beds had ≥6 results per year and all were included in this analysis. This analysis revealed that there was a significant difference between the three licensed areas in 2016, 2018 and 2019. A two tailed t-test was used to compare each of the licensed areas to each other within these years. The t-tests found that S2 Skate Rock mussels has significantly lower *E. coli* results than S7 Paddy's Point Mussels in all three and lower than S7 Paddy's Point oysters in 2019. There was found to be no significant difference betweenS7 Paddy's Point mussel and oyster results in any year. A one-way ANOVA was also carried out to look for differences between years for each harvesting bed and species. There was found to be no significant difference between years for any of the three licensed harvesting areas.

A one-way ANOVA was also carried out on the seasonal *E. coli* counts for each harvesting location and species. This analysis revealed that for S2 Skate Rock spring has a significantly lower *E. coli* levels than other seasons, there was no significant difference between the other seasons. The analysis showed that for mussels at S7 Paddy's Point, winter results were significantly higher than both spring and autumn. The analysis for oysters at S7 Paddy's Point showed that summer was significantly higher than both spring and autumn. Refer to Section 4.1.2 'Tourism' for further details on the seasonal data.

6. Production Areas for Monitoring

The 2011 sanitary survey proposed production areas 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. These five production areas and RMPs can be seen in Figure 6.1.

Figure 6.1: Production Areas and RMPs from 2011 sanitary survey.



7. Discussion/Conclusion

The monthly and seasonal wind patterns for the Strangford Lough catchment area have remained constant over time. The eastern coast of Northern Ireland remains the windiest area. November to February experienced the strongest wind speeds, while July and August experienced the weakest winds. The rainfall patterns for the catchment area have also remained the same with February to May being the driest period, with rainfall increasing through summer to the wettest period between October and January. However, the 30 year monthly average rainfall from 1981-2010 was drier than from 1971-2000 for every month.

The total population of the SOA which overlap Strangford Lough Catchment is 200,586 people up 3.2% from the 2011 sanitary survey. However, much of the SOAs only partially overlap the catchment. Therefore, an effort was made to estimate the population within the catchment based on the percentage of the SOAs within it. Based on this, the total population within the Strangford Lough catchment is estimated at approximately 150,000 people which is the same as the estimate from the 2011 sanitary survey. Newtownards (28,039 -1.5%) and Downpatrick (10,847 +1.3%) are the largest population centres, located to the north and south of the lough. Comber (9078 +1.6%) was the next largest centre located to the northwest of the lough. The remaining coastal centres are all villages/intermediate settlements with populations ranging from 939 (Greyabbey, -9.5%) to 2,928 (Killyleagh, -3.3%). The population in urban centres overall increase slightly by 0.6% (501 people).

Tourism in Northern Ireland since the 2011 sanitary survey has increased significantly by 46%. The Strangford Lough Catchment overlaps four Local Government Districts for tourism numbers Newry /Mourne /Down, Ards/North Down, Lisburn/ Castlereagh and Belfast. These four districts received 1,758,568 tourists in 2018 which is an increase of 63.5% since 2011. However, only a small portion of the Belfast and Lisburn/ Castlereagh districts overlap the catchment. The districts of Newry /Mourne /Down and Ards/ North Down received 345,708 tourists in 2018 which is an increase of 7.4% on 2011.

Statistical analysis was carried out on *E. coli* data for the active shellfish beds to ascertain if there are any seasonal patterns. The *E. coli* levels for S2 Skate Rock were found to be significantly lower in spring than in the other seasons. There was no significant difference between the *E. coli* levels in summer, autumn, or winter. As such is appears that increased tourism in the summer do not affect the E. coli levels at S2 Skate Rock. The analysis for S7 Paddy's Point found that mussel *E. coli* levels were significantly higher in winter than in spring or autumn and for oyster the summer *E. coli* levels were significantly higher than spring or autumn.

The increase in *E. coli* levels in summer may be from a combination of increased tourism and runoff from farmland towards the end of the summer as rainfall increases. The runoff from farmland in late summer can have particularly high levels of contamination due to accumulation of faecal waste over the driest months from April to June. The high levels recorded in winter are likely due to runoff from land as rainfall and river flows are at their highest.

There has been little change to sewage infrastructure in the catchment with p.e. for the catchment reducing slightly. However, this reduction is due to two septic tanks mistakenly being listed as treatment plants. In effect, there has been no change to the load on treatment plants.

The 2011 survey only listed industrial discharges along the shoreline. All industrial discharges within the catchment have now been identified. In total 93 discharges have been identified with most relating to site drainage or waste disposal sites.

Agriculture remains dominant, with landuse associated with agricultural activities (non-irrigated arable land, pastures, complex cultivation patterns and agriculture/natural vegetation) accounting for 90% of the landuse in the catchment. Due to a change in the reporting boundaries for the agri-census between 2009 and 2018 farming densities could not be compared directly. As some of the wards (2018) or SOAs (2009) only partially overlap the catchment an attempt was made to account for this. The percentage of each division within the catchment was estimated in GIS. This percentage was then applied to the agri data to estimate the proportion within the catchment. Based on this, the area used for crops has decreased by 13.3% (-1322ha) and sheep numbers have decreased by 0.08% (-840). Cattle numbers have increased by 10,220 (8.9%), pigs by 6,113 (19.8%) and poultry by 303,000 (117.9%). Although these appear to be relatively high increases the area of farmland within the catchment needs to be considered, which has also increased by 6,578ha (10%). When spread across all farmland cattle have increased 0.14 per ha, pigs have increased 0.08 per ha and poultry have increased 4.2 per ha.

There remains no commercial port in Strangford Lough and there does not appear to be any change in boating facilities within the lough. The available data for wetland birds show a significant decrease since the 2011 survey, with the 5-year mean dropping from 80,930 to 57,957 for the most resent 5 year period. Reported pollution incidences in the catchment have also decreased with an average of 54 incidences per year from 2013 to 2017 compared to 143 incidences in 2009.

There are currently only three areas classified for shellfish within the lough – S2 Skate Rock for mussels, S7 Paddy's Point and S6 Reagh Bay for Oysters. S7 Paddy's Point was de-classified for mussels on the 01/01/20. S6 Reagh Bay is no longer sampled directly for *E. coli* and instead it is classified based on official control microbiological results from its RMP, S7 Paddy's Point. S2 Skate Rock has been classified since 2005 and S7 Paddy's Point has been classified for oysters since 2013. Statistical analysis was carried on *E. coli* results for S2 Skate Rock (mussels) and S7 Paddy's Point (oysters and mussels) as these were the only sites with up-to-date results. It was found that *E. coli* levels at S2 Skate Rock were significantly lower than S7 Paddy's Point in 2016, 2018 and 2019. This is to be expected as S2 Skate Rock is located in Production Area 4 and has a much shorter residence time than S7 Paddy's Point located in the northern end of Production Area 2. There was found to be no significant difference between years for any of the three licensed harvesting areas with up-to-date results. Therefore, the *E. coli* levels within the lough have not changed since the 2011 survey.

For these reasons, a new shoreline survey is not required. The RMP locations (Table 7.1) or monthly sampling frequency does not need to be adjusted and no alterations to the production area boundary are required. The Marlfield Bay RMP has been discontinued as the area has been declassified for scallops since 2014.

Table 7.1: Strangford Lough RMPS coordinates.

RMP	Licence	Longitude	Latitude	Easting	Northing
O2	S7 Paddy's Point	-5.649774	54.522289	352,225.4	366,310.6
M4	S2 Skate Rock	-5.61827	54.3869	354774.6	351313.6

8. Preclassification of S24 AFFNI 23 area

Preclassification sampling was carried out between July and October 2020 to classify S24 Dunsy Island for mussels. The sampling results can be seen below (Table 8.1). Due to the declassification of S7 Paddy's Point for mussels, a new RMP will be needed for S24 Dunsy Island. The RMP at S7 Paddy's Point is not suitable as it is now only sampled for oysters and results are much lower than the preclassification results for Dunsy Island. A new RMP for S24 Dunsy Island will be required and can be seen in Figure 8.1 and coordinates are shown in Table 8.2. This RMP should be sampled monthly with a minimum of 15 mussels per sample for submission to the laboratory for *E. coli* analysis.

Table 8.1: Dunsy preclassification sampling.

Date	*E. coli* (MPN/100g)	Category
20-Jul-20	330	B
28-Jul-20	690	B
04-Aug-20	2300	B
11-Aug-20	45	A
17-Aug-20	2200	B
25-Aug-20	780	B
01-Sep-20	450	B
09-Sep-20	690	B
15-Sep-20	2300	B
18-Oct-20	20	A

Figure 8.1: S24 Dunsy Island RMP location.

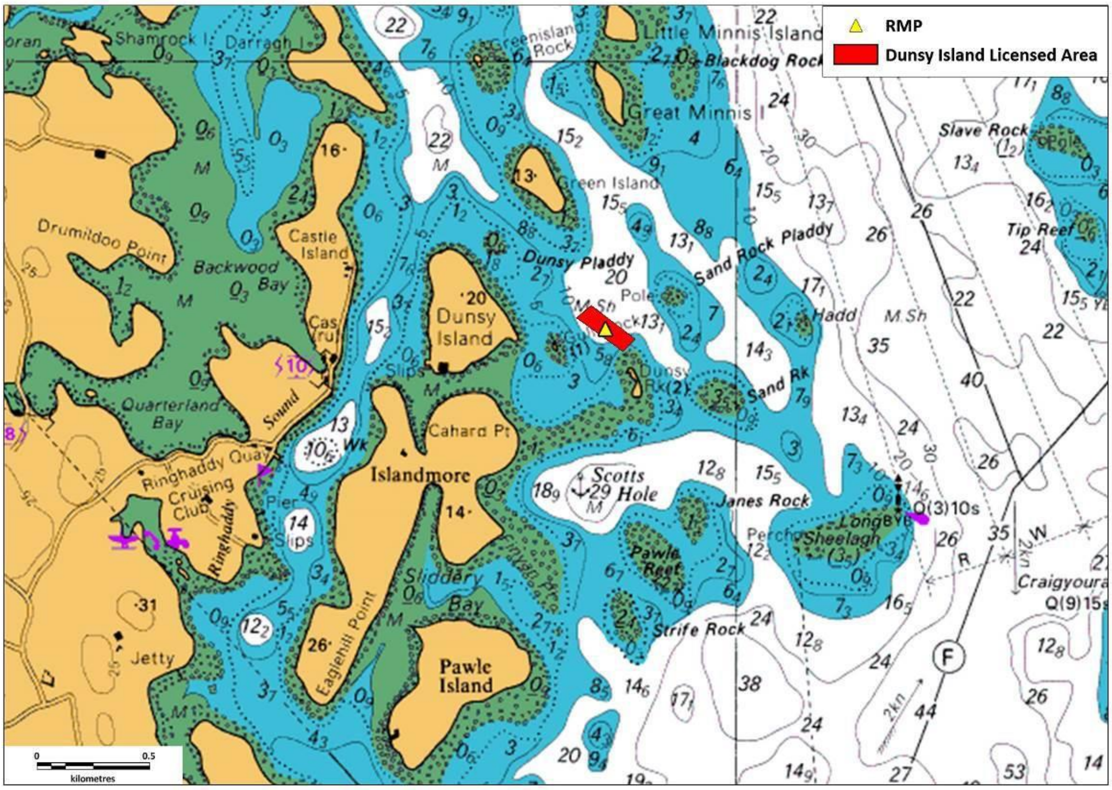


Table 8.2: S24 Dunsy Island RMP coordinates.

RMP	Licence	Longitude	Latitude	Easting	Northing
S24	Dunsy Island	-5.610001	54.456248	355,049.9	359,047.9

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Appendix 1

Statistical Analysis

S2 Skate Rock mussels v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2005	11	19.02435	1.729487	0.059078
2006	11	16.47247	1.497497	0.069774
2007	9	15.78619	1.754022	0.305364
2008	12	20.99345	1.749455	0.465434
2009	13	21.56282	1.658678	0.185377
2010	11	17.66977	1.606343	0.268956
2011	6	8.318667	1.386444	0.024749
2012	11	19.43903	1.767184	0.312921
2013	12	16.25198	1.354332	0.012375
2014	13	20.03156	1.540889	0.131061
2015	12	18.66245	1.555204	0.271529
2016	12	18.67438	1.556198	0.17971
2017	14	19.86363	1.418831	0.238795
2018	13	21.03434	1.618026	0.349657
2019	14	20.2032	1.443086	0.104212

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.921196	14	0.208657	1.025683	0.43063	1.754437
Within Groups	32.34569	159	0.203432			
Total	35.26689	173				

S7 Paddy’s Point mussels v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2013	6	9.77172	1.62862	0.11664
2014	12	20.4435	1.70362	0.41195
2015	11	19.7131	1.7921	0.40342
2016	13	27.1519	2.08861	0.16703
2017	13	25.0962	1.93048	0.34933
2018	13	28.4256	2.18658	0.41803
2019	10	21.3076	2.13076	0.20928

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.93103	6	0.48851	1.55917	0.17186	2.22927
Within Groups	22.245	71	0.31331			
Total	25.1761	77				

S7 Paddy's Point oysters v year

Anova: single factor

Summary

Groups	Count	Sum	Average	Variance
2013	6	8.81015	1.46836	0.06
2014	12	20.9955	1.74962	0.64013
2015	13	25.1831	1.93716	0.55277
2016	13	22.7629	1.75099	0.18875
2017	13	23.0343	1.77187	0.35828
2018	13	26.8616	2.06627	0.29207
2019	13	26.4328	2.03329	0.13263

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.34179	6	0.3903	1.1571	0.33824	2.22044
Within Groups	25.6355	76	0.33731			
Total	27.9773	82				

S2 Skate Rock mussels v S7 Paddy's Point oysters v S7 Paddy's Point mussels 2013

ANOVA: single factor

Summary

Groups	Count	Sum	Average	Variance
SR 2013	12	16.252	1.35433	0.01237
PPM 2013	6	9.77172	1.62862	0.11664
PPO 2013	6	8.81015	1.46836	0.06

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.30324	2	0.15162	3.1237	0.06492	3.4668
Within Groups	1.0193	21	0.04854			
Total	1.32253	23				

S2 Skate Rock mussels v S7 Paddy's Point oysters v S7 Paddy's Point mussels 2014

ANOVA: single factor

Summary

Groups	Count	Sum	Average	Variance
SR 2014	13	20.0316	1.54089	0.13106
PPM 2014	12	20.4435	1.70362	0.41195
PPO 2014	12	20.9955	1.74962	0.64013

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.30359	2	0.1518			
Within Groups	13.1456	34	0.38664	0.39261	0.67831	3.2759
Total	13.4492	36				

S2 Skate Rock mussels v S7 Paddy’s Point oysters v S7 Paddy’s Point mussels 2015

ANOVA: single factor

Summary

Groups	Count	Sum	Average	Variance
SR 2015	12	18.6625	1.5552	0.27153
PPM 2015	11	19.7131	1.7921	0.40342
PPO 2015	13	25.1831	1.93716	0.55277

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.92156	2	0.46078	1.11362	0.3404	3.28492
Within Groups	13.6543	33	0.41377			
Total	14.5759	35				

S2 Skate Rock mussels v S7 Paddy’s Point oysters v S7 Paddy’s Point mussels 2016

ANOVA: single factor

Summary

Groups	Count	Sum	Average	Variance
SR 2016	12	18.6744	1.5562	0.17971
PPM 2016	13	27.1519	2.08861	0.16703
PPO 2016	13	22.7629	1.75099	0.18875

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.82639	2	0.9132	5.11701	0.01123	3.26742
Within Groups	6.2462	35	0.17846			
Total	8.07259	37				

S2 Skate Rock mussels v S7 Paddy's Point mussels 2016

t-Test: Two-Sample Assuming Equal Variances

Factor	SR 2016	PPM 2016
Mean	1.5562	2.08861
Variance	0.17971	0.16703
Observations	12	13
Pooled Variance	0.17309	
Hypothesized Mean Difference	0	
df	23	
t Stat	-3.1967	
P(T<=t) one-tail	0.00201	
t Critical one-tail	1.71387	
P(T<=t) two-tail	0.00401	
t Critical two-tail	2.06866	

S2 Skate Rock mussels v S7 Paddy's Point oysters 2016

t-Test: Two-Sample Assuming Unequal Variances

Factor	SR 2016	PPO 2016
Mean	1.58142	1.75099
Variance	0.18928	0.18875
Observations	11	13
Hypothesized Mean Difference	0	
df	21	
t Stat	-0.952	
P(T<=t) one-tail	0.17597	
t Critical one-tail	1.72074	
P(T<=t) two-tail	0.35193	
t Critical two-tail	2.07961	

S7 Paddy's Point mussels v S7 Paddy's Point oysters 2016

t-Test: Two-Sample Assuming Unequal Variances

Factor	PPM 2016	PPO 2016
Mean	2.08861	1.75099
Variance	0.16703	0.18875
Observations	13	13
Hypothesized Mean Difference	0	
df	24	
t Stat	2.04083	
P(T<=t) one-tail	0.02621	
t Critical one-tail	1.71088	
P(T<=t) two-tail	0.05241	
t Critical two-tail	2.0639	

S2 Skate Rock mussels v S7 Paddy’s Point oysters v S7 Paddy’s Point mussels 2017

ANOVA: single factor

Summary

Groups	Count	Sum	Average	Variance
SR 2017	14	19.8636	1.41883	0.23879
PPM 2017	13	25.0962	1.93048	0.34933
PPO 2017	13	23.0343	1.77187	0.35828

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.86448	2	0.93224	2.97466	0.06339	3.25192
Within Groups	11.5956	37	0.31339			
Total	13.4601	39				

S2 Skate Rock mussels v S7 Paddy’s Point oysters v S7 Paddy’sPoint mussels 2018

ANOVA: single factor

Summary

Groups	Count	Sum	Average	Variance
SR 2018	13	21.0343	1.61803	0.34966
PPM 2018	13	28.4256	2.18658	0.41803
PPO 2018	13	26.8616	2.06627	0.29207

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.33419	2	1.1671	3.30386	0.04816	3.25945
Within Groups	12.7171	36	0.35325			
Total	15.0513	38				

S2 Skate Rock mussels v S7 Paddy's Point mussels 2018

t-Test: Two-Sample Assuming Unequal Variances

Factor	SR 2018	PPM 2018
Mean	1.61803	2.18658
Variance	0.34966	0.41803
Observations	13	13
Hypothesized Mean Difference	0	
df	24	
t Stat	-2.3397	
P(T<=t) one-tail	0.01398	
t Critical one-tail	1.71088	
P(T<=t) two-tail	0.02795	
t Critical two-tail	2.0639	

S2 Skate Rock mussels v S7 Paddy's Point oysterss 2018

t-Test: Two-Sample Assuming Equal Variances

Factor	SR 2018	PPO 2018
Mean	1.61803	2.06627
Variance	0.34966	0.29207
Observations	13	13
Pooled Variance	0.32086	
Hypothesized Mean Difference	0	
df	24	
t Stat	-2.0175	
P(T<=t) one-tail	0.02748	
t Critical one-tail	1.71088	
P(T<=t) two-tail	0.05496	
t Critical two-tail	2.0639	

S7 Paddy’s Point mussels v S7 Paddy’s Point oysterss 2018

t-Test: Two-Sample Assuming Equal Variances

Factor	PPM 2018	PPO 2018
Mean	2.18658	2.06627
Variance	0.41803	0.29207
Observations	13	13
Pooled Variance	0.35505	
Hypothesized Mean Difference	0	
df	24	
t Stat	0.51477	
P(T<=t) one-tail	0.30571	
t Critical one-tail	1.71088	
P(T<=t) two-tail	0.61142	
t Critical two-tail	2.0639	

S2 Skate Rock mussels v S7 Paddy's Point oysters v S7 Paddy's Point mussels 2019

ANOVA: single factor

Summary

Groups	Count	Sum	Average	Variance
SR 2019	14	20.2032	1.44309	0.10421
PPM 2019	10	21.3076	2.13076	0.20928
PPO 2019	13	26.4328	2.03329	0.13263

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.5362	2	1.7681	12.4467	0.0000879	3.2759
Within Groups	4.82981	34	0.14205			
Total	8.36601	36				

S2 Skate Rock mussels v S7 Paddy's Point mussels 2019

t-Test: Two-Sample Assuming Unequal Variances

Factor	SR 2019	PPM 2019
Mean	1.44309	2.13076
Variance	0.10421	0.20928
Observations	14	10
Hypothesized Mean Difference	0	
df	15	
t Stat	-4.0826	
P(T<=t) one-tail	0.00049	
t Critical one-tail	1.75305	
P(T<=t) two-tail	0.00098	
t Critical two-tail	2.13145	

S2 Skate Rock mussels v S7 Paddy’s Point oysters 2019

t-Test: Two-Sample Assuming Unequal Variances

Factor	SR 2019	PPO 2019
Mean	1.44309	2.03329
Variance	0.10421	0.13263
Observations	14	13
Hypothesized Mean Difference	0	
df	24	
t Stat	-4.4431	
P(T<=t) one-tail	8.6E-05	
t Critical one-tail	1.71088	
P(T<=t) two-tail	0.00017	
t Critical two-tail	2.0639	

S7 Paddy’s Point mussels v S7 Paddy’s Point oysters 2019

t-Test: Two-Sample Assuming Equal Variances

Factor	PPM 2019	PPO 2019
Mean	2.13076	2.03329
Variance	0.20928	0.13263
Observations	10	13
Pooled Variance	0.16548	
Hypothesized Mean Difference	0	
df	21	
t Stat	0.56967	
P(T<=t) one-tail	0.28747	
t Critical one-tail	1.72074	
P(T<=t) two-tail	0.57495	
t Critical two-tail	2.07961	

S2 Skate Rock mussels v season

Anova: single Factor

Summary

Groups	Count	Sum	Average	Variance
Winter	42	68.74143	1.636701	0.188438
Spring	45	62.6459	1.392131	0.038868
Summer	48	76.04804	1.584334	0.25818
Autumn	39	66.55294	1.706486	0.298767

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.343151	3	0.78105	4.032912	0.0084	2.657762
Within Groups	32.92374	170	0.193669			
Total	35.26689	173				

S2 Skate Rock mussels winter v spring

t-Test: Two-Sample Assuming Unequal Variances

Factor	Winter	Spring
Mean	1.636701	1.392131
Variance	0.188438	0.038868
Observations	42	45
Hypothesized Mean Difference	0	
df	56	
t Stat	3.343577	
P(T<=t) one-tail	0.00074	
t Critical one-tail	1.672522	
P(T<=t) two-tail	0.00148	
t Critical two-tail	2.003241	

S2 Skate Rock mussels winter v summer

t-Test: Two-Sample Assuming Unequal Variances

Factor	Winter	Summer
Mean	1.636701	1.584334
Variance	0.188438	0.25818
Observations	42	48
Hypothesized Mean Difference	0	
df	88	
t Stat	0.527226	
P(T<=t) one-tail	0.299682	
t Critical one-tail	1.662354	
P(T<=t) two-tail	0.599363	
t Critical two-tail	1.98729	

S2 Skate Rock mussels winter v autumn

t-Test: Two-Sample Assuming Unequal Variances

Factor	Winter	Autumn
Mean	1.636701	1.706486
Variance	0.188438	0.298767
Observations	42	39
Hypothesized Mean Difference	0	
df	72	
t Stat	-0.63317	
P(T<=t) one-tail	0.264313	
t Critical one-tail	1.666294	
P(T<=t) two-tail	0.528627	
t Critical two-tail	1.993464	

S2 Skate Rock mussels spring v summer

t-Test: Two-Sample Assuming Unequal Variances

Factor	Spring	Summer
Mean	1.392131	1.584334
Variance	0.038868	0.25818
Observations	45	48
Hypothesized Mean Difference	0	
df	62	
t Stat	-2.43266	
P(T<=t) one-tail	0.008944	
t Critical one-tail	1.669804	
P(T<=t) two-tail	0.017887	
t Critical two-tail	1.998972	

S2 Skate Rock mussels spring v autumn

t-Test: Two-Sample Assuming Unequal Variances

Factor	Spring	Autumn
Mean	1.392131	1.706486
Variance	0.038868	0.298767
Observations	45	39
Hypothesized Mean Difference	0	
df	47	
t Stat	-3.40477	
P(T<=t) one-tail	0.000682	
t Critical one-tail	1.677927	
P(T<=t) two-tail	0.001364	
t Critical two-tail	2.011741	

S2 Skate Rock mussels summer v autumn

t-Test: Two-Sample Assuming Unequal Variances

Factor	Summer	Autumn
Mean	1.584334	1.706486
Variance	0.25818	0.298767
Observations	48	39
Hypothesized Mean Difference	0	
df	79	
t Stat	-1.06972	
P(T<=t) one-tail	0.144002	
t Critical one-tail	1.664371	
P(T<=t) two-tail	0.288003	
t Critical two-tail	1.99045	

S7 Paddy’s Point mussels v season

Anova: single Factor

Summary

Groups	Count	Sum	Average	Variance
Winter	15	33.9199	2.261327	0.290819
Spring	20	35.22056	1.761028	0.294391
Summer	24	49.14945	2.047894	0.372776
Autumn	19	33.61972	1.769459	0.217801

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.01691	3	1.005637	3.3583	0.023243	2.72828
Within Groups	22.15916	74	0.299448			
Total	25.17607	77				

S7 Paddy’s Point mussels winter v spring

t-Test: Two-Sample Assuming Unequal Variances

Factor	Winter	Spring
Mean	2.261327	1.761028
Variance	0.290819	0.294391
Observations	15	20
Hypothesized Mean Difference	0	
df	30	
t Stat	2.708972	
P(T<=t) one-tail	0.005522	
t Critical one-tail	1.697261	
P(T<=t) two-tail	0.011043	
t Critical two-tail	2.042272	

S7 Paddy's Point mussels winter v summer

t-Test: Two-Sample Assuming Unequal Variances

Factor	Winter	Summer
Mean	2.261327	2.047894
Variance	0.290819	0.372776
Observations	15	24
Hypothesized Mean Difference	0	
df	33	
t Stat	1.142149	
P(T<=t) one-tail	0.130806	
t Critical one-tail	1.69236	
P(T<=t) two-tail	0.261612	
t Critical two-tail	2.034515	

S7 Paddy's Point mussels winter v autumn

t-Test: Two-Sample Assuming Equal Variances

Factor	Winter	Autumn
Mean	2.261327	1.769459
Variance	0.290819	0.217801
Observations	15	19
Pooled Variance	0.249747	
Hypothesized Mean Difference	0	
df	32	
t Stat	2.849585	
P(T<=t) one-tail	0.003798	
t Critical one-tail	1.693889	
P(T<=t) two-tail	0.007595	
t Critical two-tail	2.036933	

S7 Paddy's Point mussels spring v summer

t-Test: Two-Sample Assuming Unequal Variances

Factor	Spring	Summer
Mean	1.761028	2.047894
Variance	0.294391	0.372776
Observations	20	24
Hypothesized Mean Difference	0	
df	42	
t Stat	-1.64931	
P(T<=t) one-tail	0.053272	
t Critical one-tail	1.681952	
P(T<=t) two-tail	0.106545	
t Critical two-tail	2.018082	

S7 Paddy's Point mussels spring v autumn

t-Test: Two-Sample Assuming Equal Variances

Factor	Spring	Autumn
Mean	1.761028	1.769459
Variance	0.294391	0.217801
Observations	20	19
Pooled Variance	0.257131	
Hypothesized Mean Difference	0	
df	37	
t Stat	-0.0519	
P(T<=t) one-tail	0.479445	
t Critical one-tail	1.687094	
P(T<=t) two-tail	0.958889	
t Critical two-tail	2.026192	

S7 Paddy's Point mussels summer v autumn

t-Test: Two-Sample Assuming Equal Variances

Factor	Summer	Autumn
Mean	2.047894	1.769459
Variance	0.372776	0.217801
Observations	24	19
Pooled Variance	0.304738	
Hypothesized Mean Difference	0	
df	41	
t Stat	1.64251	
P(T<=t) one-tail	0.054067	
t Critical one-tail	1.682878	
P(T<=t) two-tail	0.108133	
t Critical two-tail	2.019541	

S7 Paddy’s Point oysters v season

Anova: single Factor

Summary

Groups	Count	Sum	Average	Variance
Winter	18	34.64474	1.924708	0.427402
Spring	20	33.94971	1.697485	0.195612
Summer	24	50.47653	2.103189	0.420653
Autumn	21	35.00928	1.667109	0.225827

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.803235	3	0.934412	2.93233	0.038554	2.720265
Within Groups	25.17402	79	0.318658			
Total	27.97725	82				

S7 Paddy’s Point oysters winter v spring

t-Test: Two-Sample Assuming Equal Variances

Factor	Winter	Spring
Mean	1.924708	1.697485
Variance	0.427402	0.195612
Observations	18	20
Pooled Variance	0.305068	
Hypothesized Mean Difference	0	
df	36	
t Stat	1.266229	
P(T<=t) one-tail	0.106782	
t Critical one-tail	1.688298	
P(T<=t) two-tail	0.213564	
t Critical two-tail	2.028094	

S7 Paddy's Point oysters winter v summer

t-Test: Two-Sample Assuming Equal Variances

Factor	Winter	Summer
Mean	1.924708	2.103189
Variance	0.427402	0.420653
Observations	18	24
Pooled Variance	0.423521	
Hypothesized Mean Difference	0	
df	40	
t Stat	-0.87957	
P(T<=t) one-tail	0.192172	
t Critical one-tail	1.683851	
P(T<=t) two-tail	0.384344	
t Critical two-tail	2.021075	

S7 Paddy's Point oysters winter v autumn

t-Test: Two-Sample Assuming Equal Variances

Factor	Winter	Autumn
Mean	1.924708	1.667109
Variance	0.427402	0.225827
Observations	18	21
Pooled Variance	0.318442	
Hypothesized Mean Difference	0	
df	37	
t Stat	1.421159	
P(T<=t) one-tail	0.081822	
t Critical one-tail	1.687094	
P(T<=t) two-tail	0.163644	
t Critical two-tail	2.026192	

S7 Paddy's Point oysters spring v summer

t-Test: Two-Sample Assuming Equal Variances

Factor	Spring	Summer
Mean	1.697485	2.103189
Variance	0.195612	0.420653
Observations	20	24
Pooled Variance	0.318849	
Hypothesized Mean Difference	0	
df	42	
t Stat	-2.37307	
P(T<=t) one-tail	0.011147	
t Critical one-tail	1.681952	
P(T<=t) two-tail	0.022294	
t Critical two-tail	2.018082	

S7 Paddy's Point oysters spring v autumn

t-Test: Two-Sample Assuming Unequal Variances

Factor	Spring	Autumn
Mean	1.697485	1.667109
Variance	0.195612	0.225827
Observations	20	21
Hypothesized Mean Difference	0	
df	39	
t Stat	0.211983	
P(T<=t) one-tail	0.416612	
t Critical one-tail	1.684875	
P(T<=t) two-tail	0.833224	
t Critical two-tail	2.022691	

S7 Paddy's Point oysters summer v autumn

t-Test: Two-Sample Assuming Equal Variances

Factor	Summer	Autumn
Mean	2.103189	1.667109
Variance	0.420653	0.225827
Observations	24	21
Pooled Variance	0.330036	
Hypothesized Mean Difference	0	
df	43	
t Stat	2.540356	
P(T<=t) one-tail	0.007384	
t Critical one-tail	1.681071	
P(T<=t) two-tail	0.014767	
t Critical two-tail	2.016692	