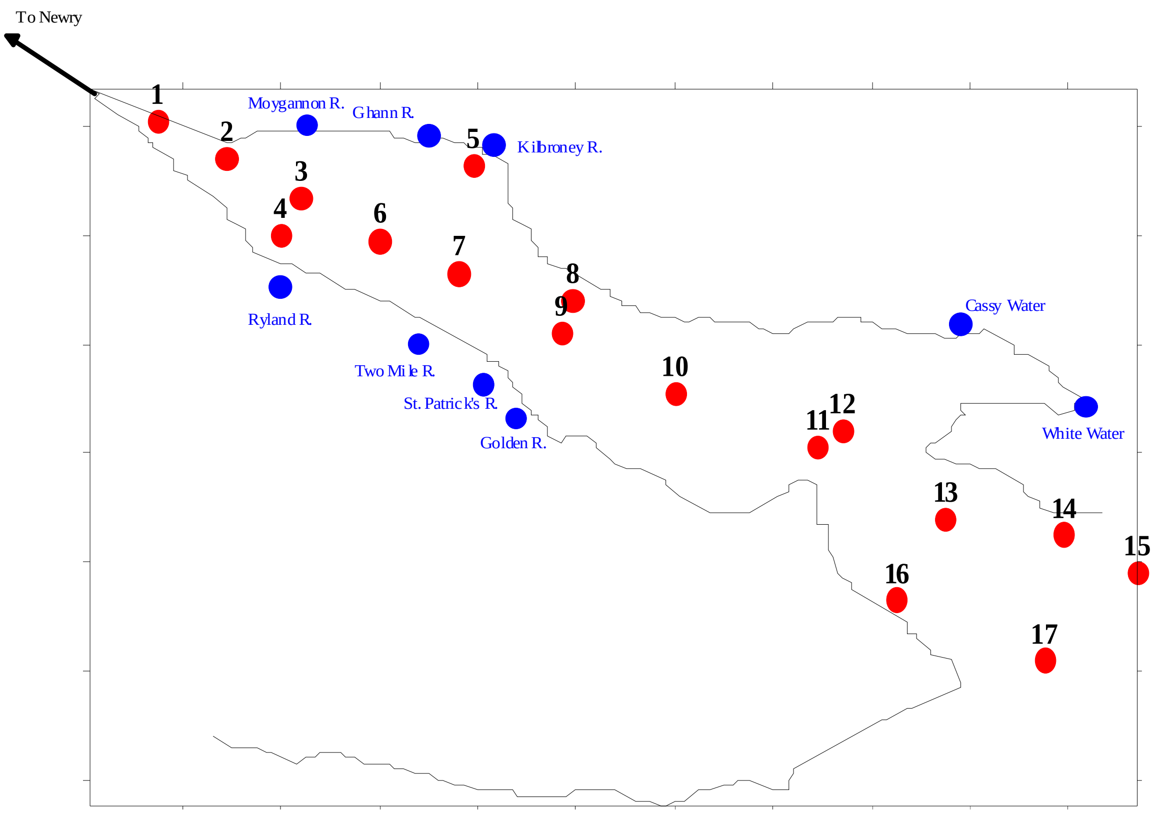
AFBI Historic Monitoring Data

The original work carried by AFBI/QUB in Carlingford was the Trophic Status Report designed to indentify potential issues arising from eutrophication. The work which was undertaken in the period 1997-98 and some of the supporting physical data is summarised below.



Sampling Stations 97-98.

Summary of physical data collected at marine sampling stations within Carlingford Lough 97-98.

Station	Salinity (psu)			Temperature (°C)			Secchi depth (m)		
	min	**mean**	max	min	**mean**	max	Min	**mean**	max
1	26.24	**31.31**	33.85	5.44	**11.98**	18.58	0.20	**0.88**	1.50
2	26.93	**32.28**	34.06	5.40	**11.97**	18.51	0.40	**1.17**	2.25
3	28.94	**32.80**	34.00	5.80	**11.91**	18.40	0.20	**1.57**	3.50
4	30.21	**32.62**	33.79	5.75	**11.78**	18.27	0.25	**1.49**	3.80
5	27.56	**32.52**	33.91	5.77	**11.62**	17.78	0.25	**2.01**	4.00
6	30.80	**33.09**	34.05	5.83	**11.84**	18.52	0.25	**2.00**	4.00
7	31.55	**33.28**	34.36	5.75	**11.77**	18.07	0.75	**2.35**	4.75
8	27.03	**32.99**	34.14	5.70	**11.46**	17.52	0.25	**2.45**	3.75
9	31.67	**33.42**	34.21	5.76	**11.50**	17.75	0.75	**2.55**	4.00
10	32.35	**33.54**	34.33	5.82	**11.49**	17.22	0.75	**3.06**	5.75
11	32.69	**33.76**	34.27	6.07	**11.55**	17.09	0.50	**3.53**	6.25
12	32.90	**33.86**	34.59	6.12	**11.53**	17.07	0.75	**3.80**	7.00
13	33.04	**33.91**	34.37	6.07	**11.37**	16.80	0.50	**3.75**	7.00
14	32.12	**33.99**	34.57	6.14	**11.44**	16.46	0.75	**4.01**	7.00

15	32.26	**33.99**	34.87	5.94	**11.31**	16.48	0.75	**4.24**	7.25
16	32.44	**33.96**	34.72	7.76	**11.65**	16.58	0.75	**4.16**	6.70
17	33.47	**33.99**	34.36	7.88	**11.86**	16.55	0.90	**3.31**	5.50

Temperature

The temperature profile within any sea lough is a function of the mixing of fresh and sea water and solar heating. Because the salinity gradient within Carlingford Lough is narrow, there was little variation between stations.

Stratification

Salinity and temperature data may be used to assess the degree of vertical stratification of the water column. Such stratification has implications for the availability of remineralized nutrients to the surface layer in summer, although in a shallow Lough such as Carlingford, this effect is less crucial. Pingree and Griffiths, 1978 (cf. Jenkinson, 1983) calculated a stratification parameter (S):

$S = \log_{10}(d) / IUI^3$ where, d is depth and IUI^3 is the cube of current speed (Ball *et al,* 1997) quote a maximum current speed near the lough mouth of 0.87 m sec^{-1} and in the inner lough, speeds regularly exceed 0.35 m sec^{-1} around the Rostrevor Narrows. DIFS (1976) quote an average velocity at Narrow Water of 0.39 m sec^{-1} for Spring tides and 0.30 m sec^{-1} for Neap tides).

Where S is >1.5 to 2.0, the water column is considered to be stratified. Based on the above figures, inner and mid sites in Carlingford Lough may be expected to experience some degree of stratification, but the water column at outer sites would be expected to be vertically homogeneous due to high current speeds and turbulent mixing reaching to the seabed. The greatest degree of both thermal and salinity stratification was recorded at the inner to mid sites (where maximum stratification was recorded in the winter months, this will have resulted from the outward movement of a colder, less saline layer of freshwater runoff, moved outwards from the estuary by wind). This finding is also illustrated in the depth plots of salinity and temperature (Appendix 4) which show a general increase in vertical homogeneity on moving seawards.

Secchi depth

Secchi depth measurements are indicative of the depth of light penetration. Within Carlingford Lough, secchi depth increased in the direction of the Irish Sea, from a minimum of 0.20 m at station 1 to a maximum of 7.25 m at station 15 (Table 3.5; Appendix 2) and was lowest during the winter months of October to February (Fig. 3.3c). Low secchi depth measurements recorded at the innermost stations probably reflects the high suspended matter loadings originating from Newry River and resuspension of bed sediments in the shallower water depths from wind, wave and tidal actions. It is likely that some of this suspended load arises from the flood banks that protects the reclaimed land on the far side of the river from the canal (DIFS, 1976). Figure 3.4 illustrates the relationship between secchi depth and suspended particulate matter. At SPM concentrations greater than 50 mg L^{-1}, the secchi depth is less than 1.25 m whereas below SPM concentrations of 50 mg L^{-1}, the secchi depth is variable, indicating that other factors as well as SPM influence secchi depth.

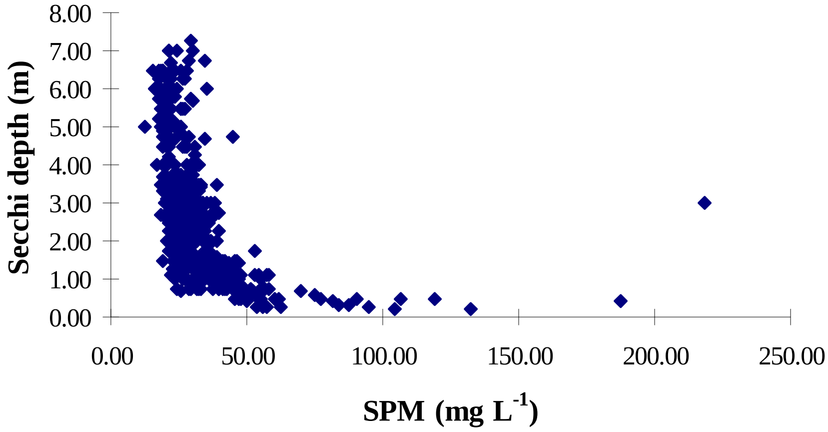


Figure 3.4 Relationship between secchi depth and SPM.

Secchi depth may be used to give an indication of the irradiance, and by comparing this with the water depth, the potential for light to limit primary production may be evaluated. The compensation depth may be approximated from the depth of 1 % of the surface radiation (Tett, 1990) which may be estimated as being three times the depth of the secchi disc visibility (Parsons *et. al.* 1984). As Carlingford Lough is well vertically mixed, the compensation depth shown in Figure 3.5a may be thought of as a minimum value of potential light limitation, since gross production may be achieved below the compensation depth to the critical depth. The average total depths in the inner, mid, and outer lough at low tide are 3.6, 5.8, and 5.7 m. By comparison to Figure 3.5a, the compensation depth during the phytoplankton growing season is larger than the total depth therefore light does not generally limit phytoplankton growth.

Suspended Particulate Matter

Suspended particulate matter loads are a function of freshwater input, tidal range, salinity and wind stress (Dyer, 1972). Concentrations of SPM within Carlingford Lough were shown to decrease on moving seawards, from an average level of 46.76 mg L^{-1} at station 1 to an average of 26.02 mg L^{-1} at station 15 (Table 3.6).

Table 3.6 Summary of suspended particulate matter and organic SPM elemental composition data collected at marine sampling stations within Carlingford Lough.

8 S	SPM (mg L^{-1})			SPM C:N		
tation	min	**mean**	Max	Min	**mean**	max
1	23.60	**46.76**	132.67	5.23	**6.84**	9.31
2	24.30	**44.76**	187.40	3.31	**6.54**	8.95
3	20.28	**36.19**	104.66	4.12	**6.81**	10.31
4	22.80	**35.94**	87.80	3.56	**6.64**	9.66
5	21.43	**31.69**	61.60	5.10	**6.80**	8.60
6	18.86	**39.60**	218.57	4.76	**7.16**	11.14
7	18.29	**30.42**	47.20	4.78	**7.07**	10.90
8	19.42	**29.37**	57.68	4.25	**7.08**	10.64
9	16.86	**28.31**	43.60	3.95	**6.79**	10.02
10	19.00	**27.85**	54.85	4.31	**7.30**	17.88
11	16.10	**29.18**	55.00	4.11	**7.68**	16.18
12	16.20	**27.58**	58.40	3.93	**7.46**	28.63
13	18.25	**26.87**	60.56	4.05	**7.65**	23.21
14	17.15	**27.88**	58.04	4.57	**7.48**	14.50
15	12.29	**26.02**	47.00	2.09	**7.47**	12.64

16	15.43	**26.52**	51.60	1.08	**7.58**	15.11
17	18.85	**26.92**	42.50	1.52	**6.96**	10.93

This pattern may be explained by the influence of high SPM loadings from the Newry River together with the resuspension of sediment in the shallower inner sites from wind, wave and tidal action. Seasonal contour plots of SPM (Appendix 2) show higher levels during winter when river flow and storms are maximal and low levels during the summer when river flow is low. SPM concentrations from this study were generally between 30 mg L^{-1} and 50 mg L^{-1} and are within the range reported by Ball *et al* (1997).

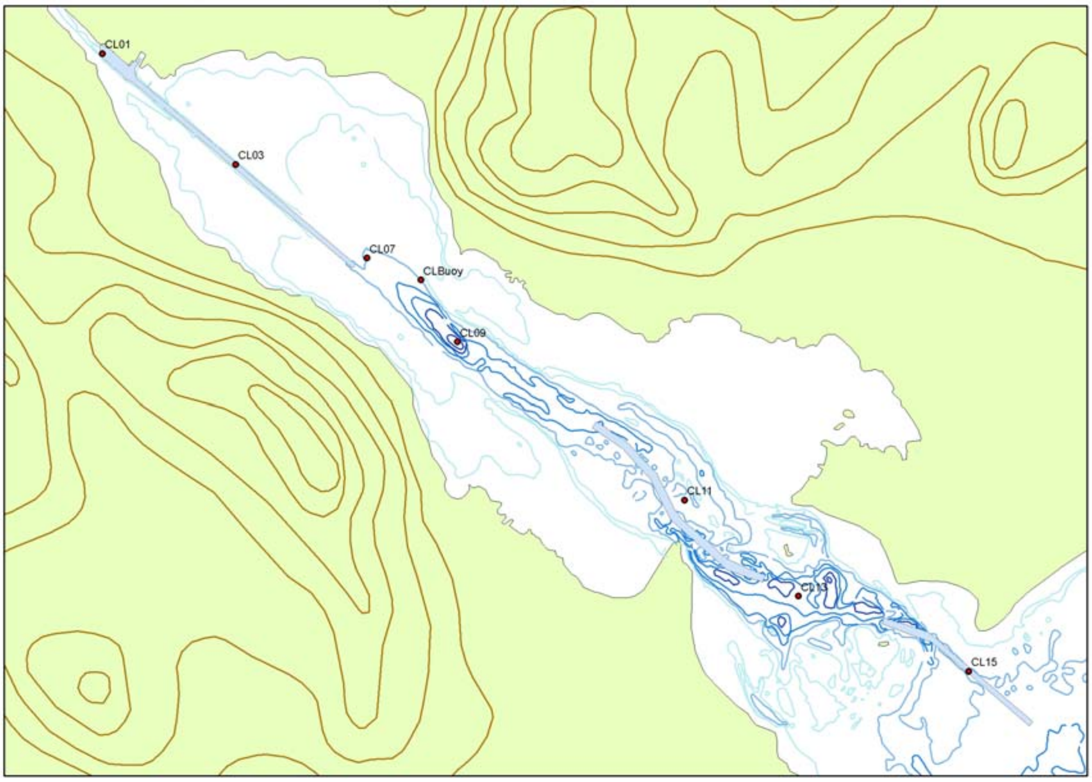
Suspended particulate carbon and nitrogen (SPC and SPN)
The ratio of carbon to nitrogen in the suspended particulate matter can give an indication of the origin of the material. Phytoplankton have C/N ratios of between 3 and 6 approximately, and lithogenic material has a ratio of approximately 10 (Parsons *et. al.* 1984). Figure 3.5b shows that the C/N ratio varied temporally, with higher ratios of between 7 and 10 during the winter and lower ratios which were generally in the 6 – 8 range during the summer. This pattern reflects the higher contribution of lithogenic material in the winter due to higher SPM loads and resuspension of bed sediments arising from storm events and the higher contribution of phytoplankton biomass during the summer. Phytoplankton biomass is the predominant contributor to the SPM in the spring and summer and is probably the main source of food for the shellfisheries within the lough at these times.

From 2004 AFBI in conjunction with the Loughs Agency and EHS have operated continuous monitoring buoys in the Lough. These buoys are equipped with turbidity sensors and AFBI routinely collect spot samples to validate the instruments. During 1996 a more intensive period of sampling was undertaken to gather data to support he SMILE programme to develop shellfish carrying capacity models.

Some of this data is summarised below.

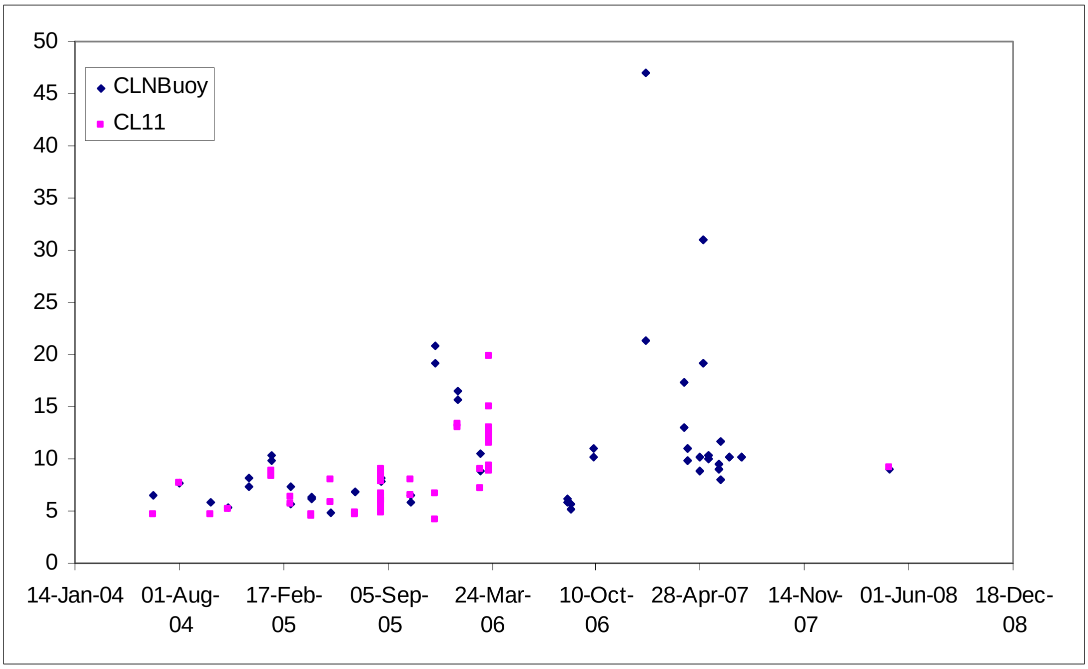
Station	Min	Mean	Max	*n*	SD	Latitude	Longitude
CL03	4.35	**9.88**	17.81	*20*	4.45	054 05.16	006 14.06
CL05	7.41	**8.07**	8.72	*2*	0.92		
CL07		**5.54**		*1*		054 04.40	006 12.25
CL11	4.10	**8.52**	19.85	*51*	3.38	054 02.44	006 07.87
CL13	6.76	**7.37**	7.98	*2*	0.86	054 01.66	006 06.30
CL15	3.85	**6.08**	12.00	*20*	2.02	054 01.05	006 03.95
CL16	3.23	**6.92**	11.68	*9*	2.55	054 01.9	006 05.42
CL17	3.62	**6.81**	14.60	*10*	3.19	054 03.22	006 08.23
CLNBuoy	4.84	**11.17**	47.03	*71*	6.72	054 04.223	006 11.506
CLSBuoy	6.77	**7.55**	8.39	*6*	0.72	054 01.345	006 06.430

Carlingford Lough SPM (mg/L-1) - a preliminary review of AFBI data June 2004 to June 2008



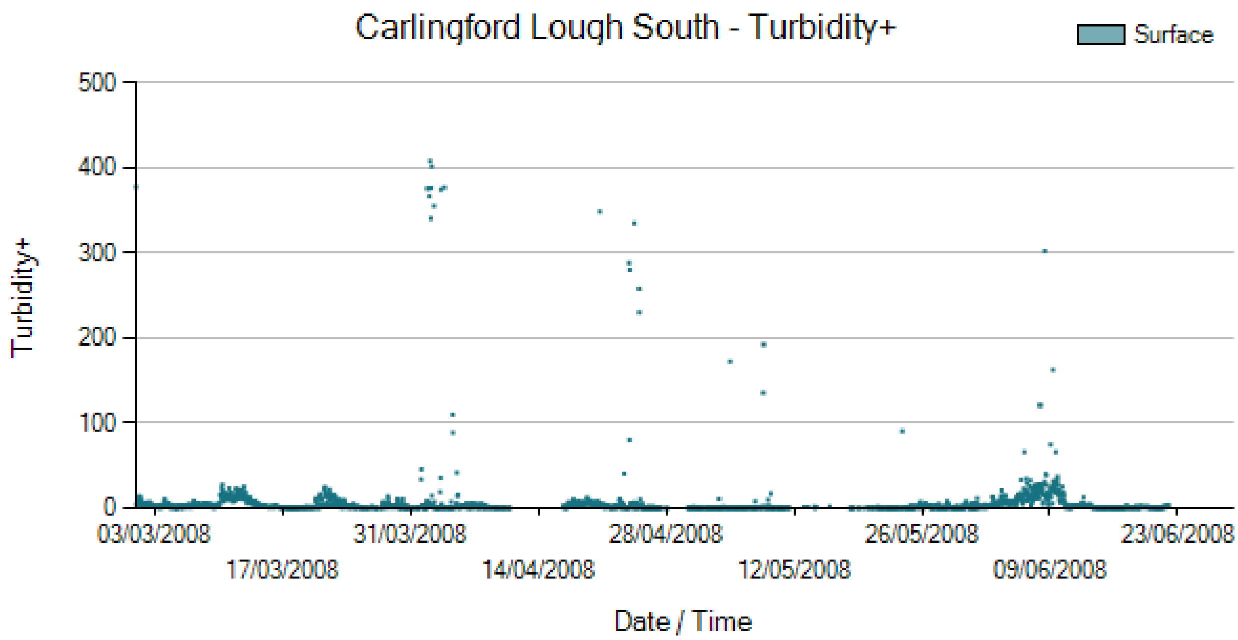
Carlingford Lough Sampling sites – coastal monitoring programme

Looking at two sites in more detail the general trend is of course for higher values in winter and the inner Lough sites to be higher.

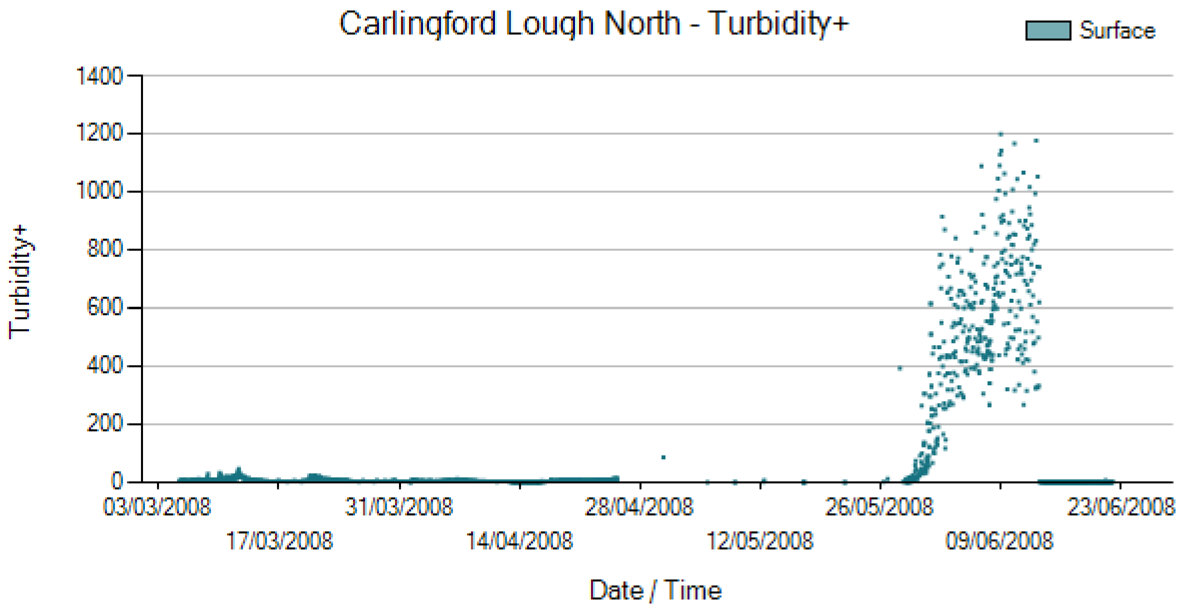


Seasonal data.

A screenshot of the data from the Carlingford South Buoy confirms this pattern of generally low values in the outer Lough and some evidence of a Spring Tide signal can be seen.



Current turbidity readings from the North Buoy are very low and we believe to be reliable. The instrument was replaced on the 13th June due to turbidity wiper malfunction - the high readings from late May to mid June are an artifact of fouling/instrument failure.



There is no doubt that mussel dredging can produce high levels of turbidity. Recent studies by AFBI have found levels close to active dredgers approaching the 600mg/l levels set as a limit for harbour dredging in Belfast Lough and Warrenpoint. Against this it should be note that levels quickly drop to background (<30 mins). It also has to be acknowledged that areas actively mussel dredged support an active mussel fishery so impacts must be considered as low. Inner Carlingford Lough has a much muddier seabed than the outer areas and is prone to resuspension particularly in the winter months hence some of the higher values in the more intensive 97-98 survey campaign.

The Carlingford Lough habitat map (figure 3, below) shows that there is a strong energy regime influencing the habitat distribution throughout the Lough: mud dominates the upper reaches of the lough, except for the main dredged channel which is comprised of sand and muddy sand sediments. The central lough is dominated by the sand habitat with the central channel comprising of coarse sands and gravel. Near the mouth of the lough rock and cobble habitats dominate, influenced by the fast-moving water at the narrow entrance to the lough that suspends any finer sediment. Seawards the seabed is dominated by rock and cobble substrates, interspersed by patches of coarse sand and gravel. Either of the mouth, the substrate is often covered by a fine layer of silt.

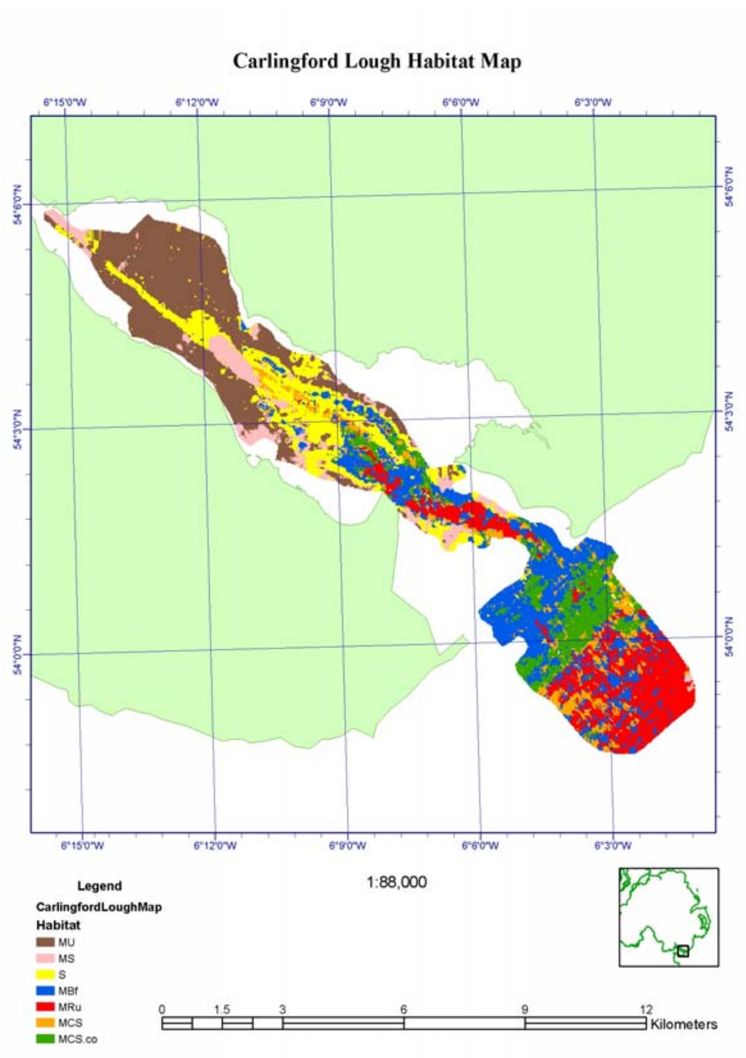


Figure 3. Habitat map for Carlingford Lough.