Equilibrium Enhancement Calculations (ECE) – Mullach Mor

The methodology to assess the level of change follows the UKTAG procedure to assess coastal waters using the winter mean of Dissolved Inorganic Nitrogen (DIN) (UKTAG, 2008). Assessment levels define a level of natural variability in the water plus a 'slight' disturbance (defined as background level, increased by 50 %). UKTAG uses this methodology to define reference conditions for the Water Framework Directive (Water Framework Directive 2024).

The proximity to locational guidelines waterbodies has been assessed and not considered to be a risk (SEPA, 2025), however an Open Water ECE calculation will be done to ensure nutrient enhancement levels from Mullach Mor are acceptable.

The ECE models predict the relative levels of nutrient enhancement. The results of the models are scaled 0-5 to give a nutrient enhancement index (Table 1). Areas with higher ECE values are considered to be the most environmentally sensitive to further fish farming development due to high predicted levels of nutrient enhancement.

Table 1. Index of nutrient enhancement, derived from predicted levels of equilibrium concentration enhancement (ECE) for nitrogen.

Predicted ECE for nitrogenous nutrients arising from fish farming (µmol L^{-1})	Nutrient Enhancement Index
> 10.0	5
3.0 – 10.0	4
1.0 – 3.0	3
0.3 – 1.0	2
< 0.3	1
0	0

The standard 'open water' model has been adopted to calculate the ECE for the proposed site. The simple model estimates the level of enhancement of dissolved nitrogen above background levels. The model uses current data from hydrographic surveys to calculate the rate of water exchange and estimates the enhancement of dissolved nitrogen above background levels due to farming activity, following Gillibrand (2006). Data inputs to the open water ECE model are shown in Table 2.

Table 2. Data inputs to the Open Water ECE model for the proposed biomass at the proposed site. Velocity data from ADCP deployment ID446 were used.

Site name:	Mullach Mor
Mean "along-shore" Flow (m/s):	0.022
Mean "across-shore" flow (m/s):	0.002
Standard deviation of "along-shore" flow (m/s):	0.154
Standard deviation of "across-shore" flow (m/s):	0.051
Water depth or mixed layer depth (m):	34
Site biomass (tonnes)	2650
Nutrient source rate (kgN/day):	349.9452055
Nutrient decay rate (s-1):	0

The ECE value for the proposed farm based on a maximum standing biomass of up to 2,650 tonnes was calculated as 0.000005234 kgN m^{-3} or 0.373 µmol L^{-1} (**Error! Reference source not found.**) and therefore the Nutrient Enhancement Index = 2. The calculated percentage value of the background is very low and hence does not exceed the 50% trigger specified in UKTAG procedures. The nutrient contributions from the site are therefore assessed as not having a significant impact on the water column.

Table 3. Results from the nutrient ECE modelling.

Zone B volume (m3):	109,578,434.56
Exchange rate (s-1):	0.000007062
Flushing time (hours):	39.33405394
ECE (kgm3):	0.000005234
ECE (umol/l):	0.373858271

Table 4 presents Open Water ECE model outputs for a range of scenarios. Current data collected at the existing Rum site was used for the Rum only input, and current data collected at the proposed Mullach Mor site was used for all other calculations. The first scenario in Table 4 assesses the existing Rum site operating alone at its current consented biomass. Two additional combined-site scenarios were assessed for Rum and Mullach Mor: one at the current consented/sought biomass across both sites (total 5,500 T), and one with an additional 350 T. In each case, the resulting ECE values correspond to a Nutrient Enhancement Index of 2, consistent with the Mullach Mor-only outcome. This confirms that nutrient inputs from the proposed site, in combination with the existing site, are not expected to have a significant effect on the water column.

Table 4. Data inputs and results to the Open Water ECE model for several scenarios.

	Rum	**Rum & Mullach Mor (1)**	**Rum & Mullach Mor (2)**
Mean "along-shore" Flow (m/s):	0.042	0.022	0.022
Mean "across-shore" flow (m/s):	0.004	0.002	0.002
Standard deviation of "along-shore" flow (m/s):	0.206	0.154	0.154
Standard deviation of "across-shore" flow (m/s):	0.065	0.051	0.051
Water depth or mixed layer depth (m):	52.75	34.00	34.00
Site biomass (tonnes)	2,850	5,500	5,850
Nutrient source rate (kgN/day):	376.3561644	726.3013699	772.5205479
Nutrient decay rate (s-1):	0	0	0
Zone B volume (m3):	289,839,998.52	109,578,434.56	109,578,434.56
Exchange rate (s-1):	0.000010071	0.000007062	0.000007062
Flushing time (hours):	27.583209630	39.334053940	39.334053940
ECE (kgm3):	0.000001492	0.000010863	0.000011554
ECE (umol/l):	**0.106597948**	**0.775932261**	**0.825309768**

References

Gillibrand, P.A., 2006. Improving Assimilative Capacity Modelling for Scottish Coastal Waters: II. A Model of Physical Exchange for Open Water Sites. Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, Oban, Marine Physics Report No. 168, June 2006, 16 pp.

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