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The Finest Salmon from SCOTLAND

Nutrient Calculations Report

West Gigha, Isle of Gigha

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1. Introduction

Nutrient enhancement budgets have been calculated which give a representation of the amount of nutrient waste released from salmon farming. These budgets consider the expected total production from the consented biomass and use the intended Feed Conversion Rate (FCR) to determine total feed input throughout the growing cycle. By using the feed manufacturer's value for nutrient content in the feed, and the relative nutrient content in the fish, the amount of particulate and soluble nutrient waste released to the receiving coastal environment can be determined. Most of these nutrients are in a bio-available form as ammonium (NH_4^+).

The nitrogenous component in nutrient loading is particularly important in the marine environment because it is predominantly nitrogen levels which limit primary production. An increase in primary productivity and phytoplankton biomass as a result of nitrogen enrichment has the potential to cause eutrophication in marine waters, providing hydrographic conditions are suitable. To assess the impact of nitrogen loading into the waters surrounding the proposed West Gigha site as a result of fish farming operations and the potential for nutrient enrichment, the Equilibrium Concentration Enhancement (ECE) equation has been used.

The ECE equation was developed by Marine Scotland for the Locational Guidelines for the Authorisation of Marine Fish Farms in Scottish Waters. The equation estimates the enhancement of nitrogen above background levels which occurs as a result of aquaculture, assuming that all the released nitrogen is conserved in the environment and only removed by tidal flushing. The ECE model considers dissolved nitrogen but also emissions of particulate nitrogen and nitrogen which has re-dissolved into the water column from the seabed.

$$ECE = S * M / Q$$

Where:

S = Source Rate (kg N $T_{production}^{-1}$)

M = Total Consented Biomass (T)

Q = Flushing Rate (m^3 yr^{-1})

Source rate is calculated through the budgets discussed above, and biomass is known, but to assess site specific nutrient enrichment, the hydrographic conditions of the loch system must also be considered. In enclosed loch systems, the flushing rate is determined using the volume of the loch and flushing time, which is defined as the number of days it takes for 60 % of the water in a well-mixed system to exchange with the open sea water outside of the loch.

For the purpose of the calculation the flushing rate has been calculated using the mean low water volume and the flushing time both calculated from digitised admiralty charts (the waters surrounding the proposed West Gigha site do not feature in Marine Scotland Science Locational Guidelines for the Authorisation of Marine Fish Farms in Scottish Waters, December 2020).

2. Calculations – West Gigha

The proposed West Gigha site is located in an open water location, therefore a different approach was used to determine flushing rate, based on the Box Model Method. In the Box Model, flushing time is assumed as one day, which is considered appropriate based on the current speeds and distances in the area. The low water volume is calculated for a 10 km^2 box area (Figure 1), based on the SEPA definition in NewDEPOMOD depositional modelling that unconstrained water systems should be limited to a 10 km^2 box.

The bathymetry within the 10 km^2 area was calculated by digitising the Admiralty charts for the area. An average depth for the area was determined to be 51.52 m. This depth was used with the low water area (7,221,071.49 m^2) to calculate the volume of water. Volume and flushing time were then used to calculate an estimated total flush rate (m^3/yr^{-1}), which was then used within the ECE equation to determine potential nutrient loading for the West Gigha Box Model area.

The total volume of the low water area surrounding the West Gigha site (10 km^2) is estimated at 372,029,602.91 m^3, with a flushing time of one day. These values were used to calculate the flushing rate of the waters surrounding the West Gigha site as 135,790,805,061.13 $m^3\,yr^{-1}$.

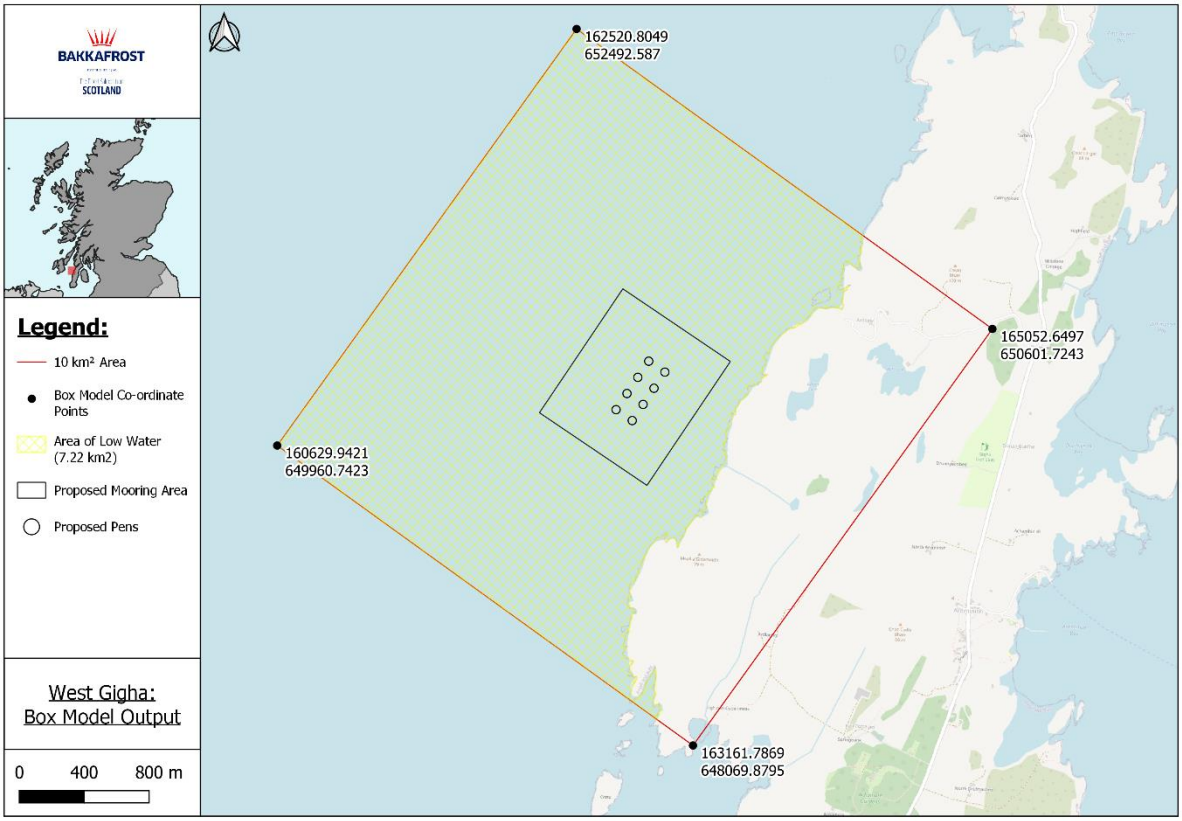

Figure 1. West Gigha site location and specified 10km^2 area.

The estimates of enhancement of nitrogen concentration should be assessed against recognised quality standards. The SEPA Environmental Quality Standard (EQS) for dissolved available inorganic nitrogen is 168 µg/L (Working Arrangement Requirements of Statutory Consultees (Scottish Environment Protection Agency, NatureScot, Marine Scotland Science and the District Salmon Fisheries Boards) and consultation protocol for marine aquaculture planning applications, July 2010) and calculated ECE values should be assessed against this SEPA EQS. In addition, the Oslo & Paris Commission (OSPAR) and UK Technical Advisory Group (TAG) recommends that Cumulative Enhancement values should be added to locally relevant worst case (winter) background concentrations to assess the risk of potential enrichment. OSPAR sets a quality standard criterion for

nutrients at 50 % above background, therefore the calculated cumulative ECE, added to background levels, should not be more than 50 % of locally relevant background winter concentrations.

The ECE for the proposed 3,104 T West Gigha site is 1.31 µg/L (Table 1). This estimated level as a result of the proposed site is only 0.78 % of the SEPA EQS (168 µg/L). The ECE calculation demonstrates that there will be a small increase in the level of nutrients released, therefore the potential for enrichment is minimised and thus it is unlikely that there will be significant effects on water quality as a result of the proposed site.

Table 1. West Gigha proposed nutrient enhancement calculations.

Total Biomass	Budget	Source Rate (kgN T^{-1} production)	Flush Rate (m^3 yr^{-1})	ECE (kg m^{-3})	ECE µg L^{-1}	% ECE of SEPA EQS
3104	Black	66.37	135,790,805,061.128	0.000001517	1.52	0.90
3104	OSPAR	57.63	135,790,805,061.128	0.000001317	1.32	0.78
3104	FRS	48.20	135,790,805,061.128	0.000001102	1.10	0.66
AVERAGE					1.31	0.78

3. Cumulative effects

There are two other BFS sites operating in the waters around Gigha, Druimyeon Bay and East Tarbert Bay, both located off the north-east coast. These sites have not been included in this report or calculations, due to the proposed West Gigha development being located in open water and the large distance between the sites.

4. Conclusion

The total nutrient levels released in the area as a result of the farm are low in relation to the SEPA EQS for dissolved inorganic nitrogen loading, with an average value of 0.78 % of the EQS of 168 µg/L. The level of nitrogenous waste estimated to be released from the proposed West Gigha development can be considered a “worst case scenario” as it has been assumed that all the nitrogen will be dispersed in the surrounding waters, at mean low water spring tidal levels. Additionally, the source rate includes both dissolved and particulate nitrogen; however, the EQS is only set for dissolved available nitrogen, with the result that a higher nitrogen loading has been used for comparisons with the SEPA EQS.

5. Appendices

5.1 Appendix 1: West Gigha Nutrient Calculations

OSPAR Budgets	MSB T	production T/yr	FCR	total feed input T/yr	N discharge T/yr	N kg/yr	kg N/T production
Proposed West Gigha	3104	2709	1.17	3165.13	156.12	156116.53	57.63

FRS budget	MSB T	production T/yr	FCR	total feed input T/yr	feed [N] T	fish [N] T	morts/esc [N]T	solid [N] T	soluble [N] T	Tot waste T/yr	kg N for tot pro	kg N /tonne production	in year kg N/day
Proposed West Gigha	3104	2709	1.17	3165.13	227.89	92.07	3.65	34.18	96.40	130.58	130580.68	48.20	357.76

Black budget	MSB T	production T/yr	FCR	total feed input T/yr	feed [N] T	fish [N] T	morts/esc [N]T	solid [N] T	soluble [N] T	Tot waste T/yr	kg N for tot pro	kg N /tonne production	kg N/day
Proposed West Gigha	3104	2708.95	1.17	3165.13	253.21	68.37	5.06	58.24	121.54	179.78	179779.49	66.37	492.55

Site	MSB T	budget	N discharge(kg/Tpro)	flush rate (m3/yr)	ECE kg m3	ECE ug L	% ECE of UKTAG background level
Proposed West Gigha	3104	Black	66.37	1.35791E+11	0.000001517	1.52	0.90
	3104	OSPAR	57.63	1.35791E+11	0.000001317	1.32	0.78
	3104	FRS	48.20	1.35791E+11	0.000001102	1.10	0.66
Average						**1.31**	**0.78**