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Interpretation of Sea Lice Connectivity Patterns among Scottish Farm Management Areas

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Executive Summary

Climatological ("average year") flow fields from the Scottish Shelf Model (SSM) have been used to estimate the degree of connectivity between Scottish finfish aquaculture Farm Management Areas (FMA) using off-line particle tracking simulations of virtual organisms ("particles") representing the infective phases of sea lice. The analysis carried out in this document is based on presence-absence of connections between FMAs as well as connection probabilities above a defined threshold. A weighting (relative to the consented biomass of farms within each FMA) was also applied to the probabilities to give a more realistic scenario.

FMAs within the Clyde Sea are relatively well inter-connected, although there are two somewhat distinct clusters: the FMAs in the inner Clyde Sea and those around Arran, which can export particles to the southwest side of the Mull of Kintyre. Not all FMAs are very well represented in the Clyde Sea by the SSM. A higher resolution Clyde model has been recently developed and it will be possible to resolve this area in more detail in the future.

FMAs on the west side of the Mull of Kintyre connect extensively towards the north, generally all the way to Loch Sunart and including the west side of Mull in the case of the more northerly FMAs, although only 50% of these FMAs are consented to stock biomass at the time of the analysis. The south Firth of Lorne has a very wide connectivity range, from the north of Skye to the south of the Mull of Kintyre, including some weak connectivity with the east side of North Uist and Harris only in the presence/absence analysis. The area between the Firth of Lorne and Loch Sunart is well inter-connected. These FMAs and those to the north of them can export particles for a considerable distance northwards, up to and beyond Skye. There is also export to the Outer Hebrides with variable probability levels. FMAs on the mainland opposite

Skye generally connect towards the north, strongly up to Loch Gairloch but more weakly beyond.

In the Outer Hebrides, the northwestern FMAs are interconnected but not linked to any others and there is some connectivity along the west coast FMAs. The east coast ones are quite well inter-connected. There is some potential for connectivity (export) to the mainland, mostly at low probabilities.

A similar pattern to those opposite Skye is observed for more northerly FMAs (northwest mainland), where the pattern of connection is also towards the north and results in potential export of particles from the most northerly ones to Orkney FMAs. The geographically-close FMAs on that coast (Loch Broom and Eddrachillis Bay areas) display very similar patterns.

Orkney is reasonably self-contained, although there is some potential connectivity (import) from the northernmost mainland FMAs. All Orkney FMAs are reasonably inter-connected, with three out of four consented to stock biomass.

Shetland is self-contained in terms of connectivity (i.e. no import from/ export to other areas). All east coast FMAs are quite well inter-connected. The southern west coast FMAs are also well inter-connected, while the more northerly FMAs tend to link with those downstream, along the prevailing clockwise flow.

Note that the patterns described above correspond to current average oceanographic conditions. The potential effect of extreme events, interannual variability and future climate, which may also influence connectivity patterns, is beyond the scope of this analysis.

Introduction

Degrees of connectivity between FMAs, as defined in the Code of Good Practice for Scottish Finfish Aquaculture (CoGP; http://thecodeofgoodpractice.co.uk/), which have been put in place by industry primarily to control sea lice (*Lepeophtheirus Salmonis*), have been estimated based on average year flow fields (no storms or flow fields specific to any given year) from the Scottish Shelf Model (SSM). The analysis then interprets the proportion of Lagrangian particles representing sea lice released from each individual FMA which reached any other FMA (including self-recruitment). The analysis consists of

an overview of general patterns and then has been divided into eight geographical areas with the nomenclature of the FMAs using Sxx for Shetland, Oxx for Orkney, Mxx for the Mainland, Wxx for the Western Isles, and with xx being the FMA number within each given region.

Methodology

The connectivity analysis is based on output from a coupled bio-physical model. Details about the hydrodynamic model, forcings, model integration, the biological model, particle releases, and the connectivity analysis can be found in Rabe et al. (2020).

The physical model is a hydrodynamic model of Scottish shelf waters and was developed using the open-source, three-dimensional FVCOM (Finite Volume Community Ocean Model) (Chen et al. 2003, Wolf et al. 2016a, Price et al. 2016 a-d). The advantages of this model are an unstructured grid (good resolution within sea lochs for example) and flexibility due to its modular structure (includes modules such as particle-tracking) as examples. The widest domain covers the whole Scottish shelf with resolutions between 1 km at the coast to 10 km offshore, and smaller sub-models have higher resolutions (down to 15 m in places). The model was validated against numerous data sets and met very stringent validation criteria. In this analysis we use climatological flow fields from a one year climatology run, which represents an average year.

The biological model consists of offline particle-tracking simulations of virtual organisms representing the infective phases of sea lice. Particles were released within each of the 86 FMA on a 2 km x 2 km grid at 3 m depth (100 particles from each release point) and retained within the surface layer (transported by passive horizontal advection). Horizontal diffusion was implemented as well. The pelagic sea lice larval duration is temperature-dependent and therefore varied between approx. 18 days in winter, 15 days in spring and autumn, and 10 days in summer. Four runs were performed in total, starting on the first of January, April, July and October.

The connectivity analysis carried out within the Scottish Shelf Model project (Wolf et al. (2016b http://marinedata.scotland.gov.uk/sites/default/files/SMFS%20Vol%207%20No%208.pdf presented two levels of output: one was based on the proportion of particles (representing sea lice, short-persistence (ISAV) and long-persistence (IPNV) viruses) originating from specific finfish Farm Management Areas (FMA) that reach other FMAs

(allowing for self-recruitment) within the relevant infective period; the other was the binary presence-absence of any degree of connectivity between pairs of FMAs within the relevant infective period, i.e. if there were any impacts from each origin area into any destination area.

The analysis below only focusses on sea lice and is carried out at three levels. The initial analysis (i) examines presence/absence linkages, as the more extreme form of connectivity which does not qualify the strength of those connectivity patterns. The probability analysis (ii) quantifies the proportion of particles released from each FMA that reach any other FMA (including the origin FMA) and uses a threshold $>10^{-5}$ C (0.001%) to refine the degree of connectivity to a biologically-relevant level. An analysis (iii) incorporating weighting based on farmed salmon biomass per FMA uses the same threshold. This threshold was chosen based on discussions with Marine Scotland Science colleagues and values in the literature (Adams et al. 2016, Salama et al. 2018). The weights were calculated based on the sum of the consented site salmon biomasses in the area (using the SEPA CAR licenses 23/02/2017) (Appendix 1, Table 1). We also take into account the number of particles released within each FMA to get a weighting per particle and then normalize the weighting to get normalised scores between zero and one (details in Rabe et al., 2020).

Particles were released at regular spacing, on a 2 km x 2 km mesh, within each FMA. This results in a small number of release locations (but always ≥1) for the smaller FMAs. The number of particle release points per FMA is presented in Table 1 in Appendix 1. There is a total of 977 release points for 86 FMAs with the number of particle release locations ranging between 1 and 91. Note that the regularly spaced matrix of release positions over the study area, cropped by the outline of each FMA, may result in some particle release positions that may not be fully representative of the circulation within a given FMA. This may be particularly relevant in the case of small FMAs with low numbers of release locations in more geographically constrained areas such as long, narrow sea lochs and requires a cautionary interpretation of any specific connectivity patterns, particularly in such cases. At each release location, 100 identical particles representing sea lice are released, to reach numerical stability by accounting for random effects (diffusion). The maximum amount of release locations of 91 occurs at around Shapinsay, O2, followed by lower Loch Linnhe, M36 (69), Loch Fyne, M42 (40), and around Gigha, M46 (35). Two sites in Shetland dominate the Shetland Islands and numbers are generally low in the Outer Hebrides, where FMAs are quite small. The minimum is 1 single particle release location from 16 (small) FMAs.

The original analysis of Wolf et al. (2016b) had been presented separately for each of the four seasons. To provide a more concise integrated summary, in the three different analyses we describe below all seasons have been collapsed into a combined dataset. Therefore, in the presence/absence analysis the connectivity scores range between 0 (no connectivity) and four (at least one particle originating from FMA *a* reaching FMA *b* each of the four seasons). The probability analysis then presents the percentages for those collapsed patterns on a log scale with percentages > 10^{-5} C presented. The weighted analysis is presented in percentages on a log scale (details in Rabe et al., 2020).

For the geographical analysis of connectivity patterns, we initially examined the connectivity matrices for the full set of FMAs and then broke up the analysis into a number of reasonably discrete geographical areas, which appeared relatively internally consistent in terms of connectivity and were also geographically justifiable.

The analysis below is presented in the general order of circulation along the Scottish coast, which is clockwise south-west to south-east. Note that the same analysis has been performed for particles representing ISAV and IPNV and those results, not presented here, can be made available if interested.

Results

Clyde Sea

Note that the northwest channel around Bute (Figure 1) is closed in the model.

Loch Fyne (M42) is connected to the Kyles of Bute (M45) (low probability and weighting) and both sides of Arran (M47 and 48) (Figure 2).

Loch Striven (M43) has only one release point and is not consented to stock biomass. It connects to itself, the east of Arran, and the Kyles of Bute with probabilities of over 10%.

M45 (Kyles of Bute) connects to all Clyde FMAs except to the west side of Arran. From the west side of Arran (M47) it self-recruits and connects with Loch Fyne and the east side of Arran (at higher probability and weighting) but it also gets flushed out of the

Clyde and connects to the FMAs on the west side of the Mull of Kintyre with lower probability and weighting (M46, M49).

The east side of Arran (M48) connects with Loch Fyne and the Kyles of Bute but mostly to itself and the west side of Arran at highest weighting and probability, and to the southwest on the Mull of Kintyre at lower probability and weighting.

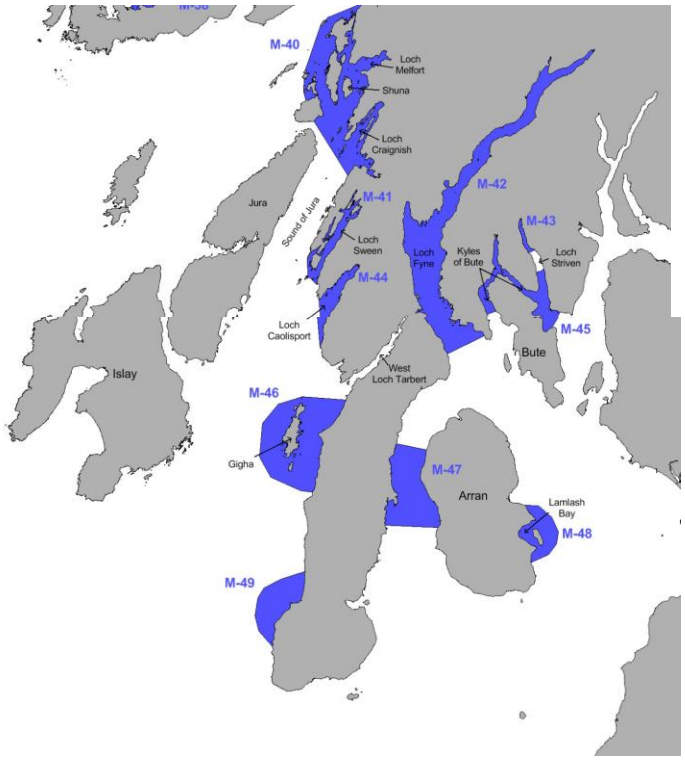


Figure 1: FMAs in the Clyde Sea.

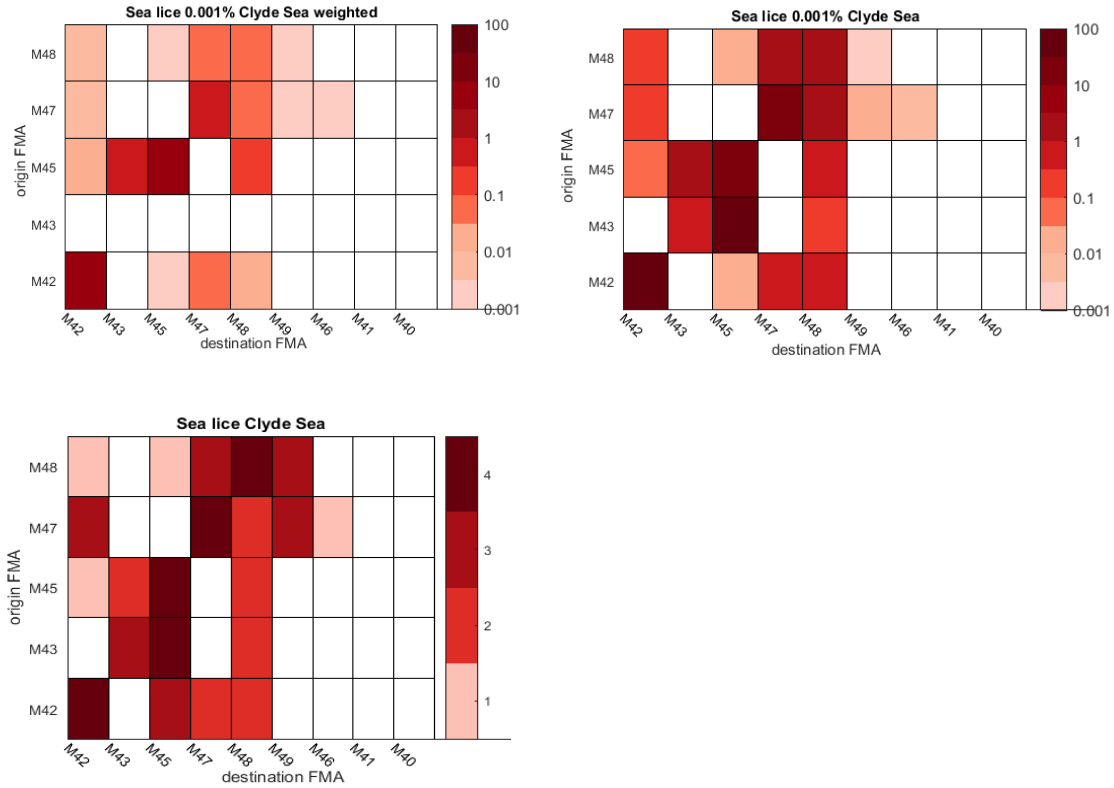


Figure 2: Sea lice weighted connectivity probability (top panel), unweighted connectivity probability (middle panel), and presence/absence connectivity (lower panel) between FMAs in the Clyde Sea.

South Argyll and West Bute

All FMAs on the west side of the Mull of Kintyre (from M49 (Figuere 1) in the south to M41 (Figure 3) in the north) show a similar pattern (Figure 4), with interconnectivity between all of them and with connectivity as far north as Loch Sunart (M34). Towards more northerly FMAs, there is some connection to the west side of Mull, too.

Out of the four Mull of Kintrye FMAs, only M46 (around Gigha) is consented to stock biomass at the time of analysis, with highest weighted probability to itself and the south-west of the Mull of Kintrye.

M40 (south Firth of Lorne) is similar to the above but has a very wide connectivity range, from the north of Skye (higher probability to M25, M27, and M29, west Skye) to the south of the Mull of Kintyre, including some weak connectivity with the east side of North Uist and Harris, less than the threshold for two out of three target FMAs. The weighted probability is only higher to Outer Loch Linnhe (M36). The FMA on the south

of Mull (Loch Spelve, M39; Figure 3) only has two release locations well into the loch so its connectivity is probably underestimated. It connects with the Firth of Lorne, Outer Loch Linnhe, the Sound of Mull and Loch Sunart, with fainter connections to FMAs further south and on the west side of Mull. The weighted probability is highest to M40 (Loch Melford) and M36 (Outer Loch Linnhe).

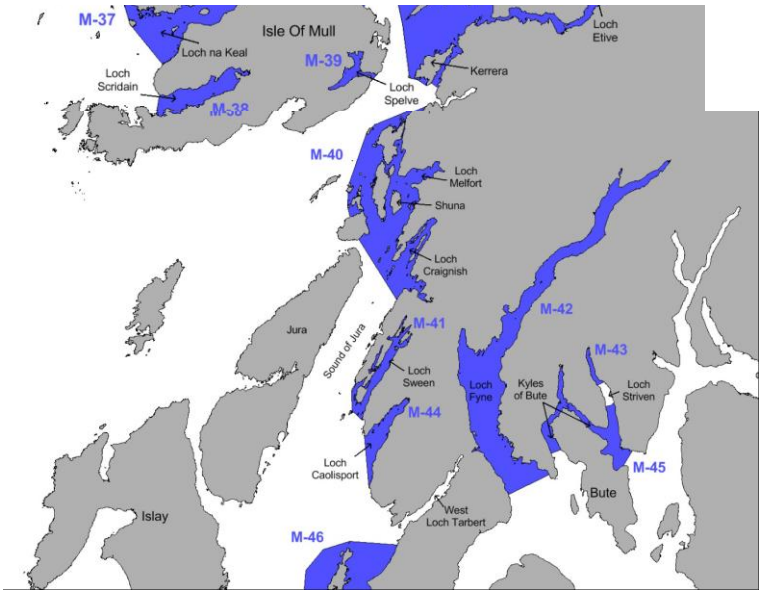


Figure 3: FMAs in south Argyll and west Bute.

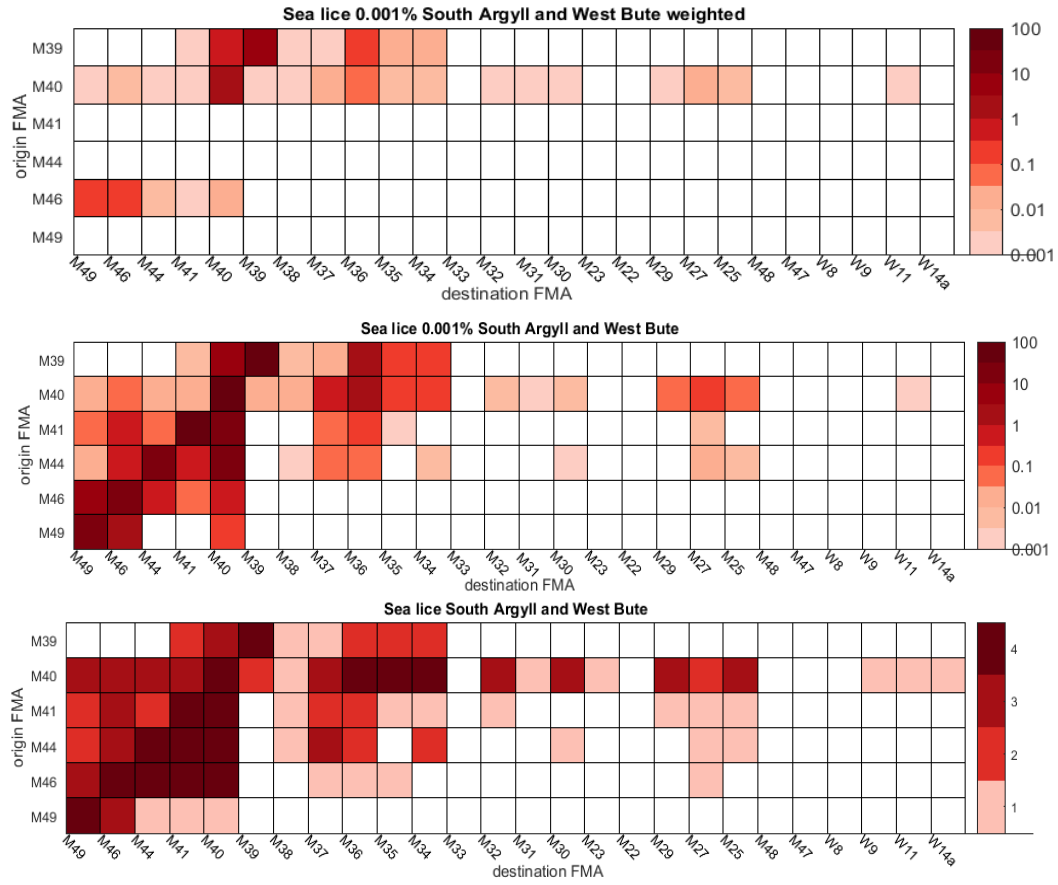


Figure 4: Sea lice weighted connectivity probability (top panel), unweighted connectivity probability (middle panel), and presence/absence connectivity (lower panel) between FMAs from south Argyll and west Bute.

Skye, Mull and mainland in-between

The Upper Loch Linnhe FMA (M33; Fig. 5) connects with Loch Sunart, Sound of Mull, Outer Loch Linnhe, Firth of Lorne, the north of Skye and Loch Spelve FMAs (Figure 6) with highest weighted probability only to Outer Loch Linnhe.

For the FMAs from the north side of Ardnamurchan (M32) to the north of Skye (M24), there is connectivity towards the north. Most Skye FMAs (M24-M28) connect all the way to Enard Bay (M9), while M29, Loch Slapin/Eishort, just connects with the FMAs on Skye to the north.

FMAs M30-M32, on the mainland between Mull and Skye, connect to the north, on both sides of Skye, but not beyond Loch Ewe (M15), although only M31 is .

The Sound of Mull and Lower Loch Linnhe FMAs (M35 and M36) behave in a similar way to those further north, although they do not connect that far north and connect further south (southern areas of Mull and Firth of Lorne). Loch Sunart (M34) and the west side of Mull FMAs (M37 and M38) behave similarly, connecting to the north all the way to Skye (except the northeast FMAs there). M34, Loch Sunart, has a high weighted probability.

In general, most of the FMAs in this grouping also connect with the north-eastern Outer Hebrides ones (weakly to the north of South Uist) with low probabilities except for origins M24, M25, M34, M35, M37 to W6, W8-W12 with higher probabilities. When the weighting is applied, M26 and 28 show high connections to M16, M17, M18, LB and M9, and M34 and M35 stand out. The exceptions to this pattern are the FMAs on the east side of Skye and Upper Loch Linnhe. The southwest side of Mull (M38) is not consented to stock biomass, as is M32 (Loch Moidart). Sea lice connectivity is largely restricted to northern North Uist, Lewis and Harris and weaker connections to the south.

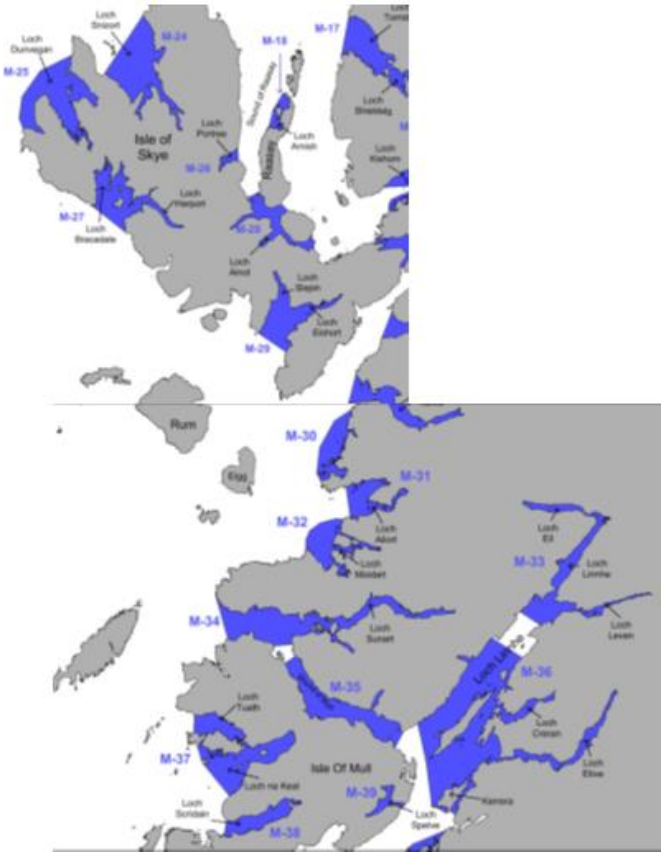
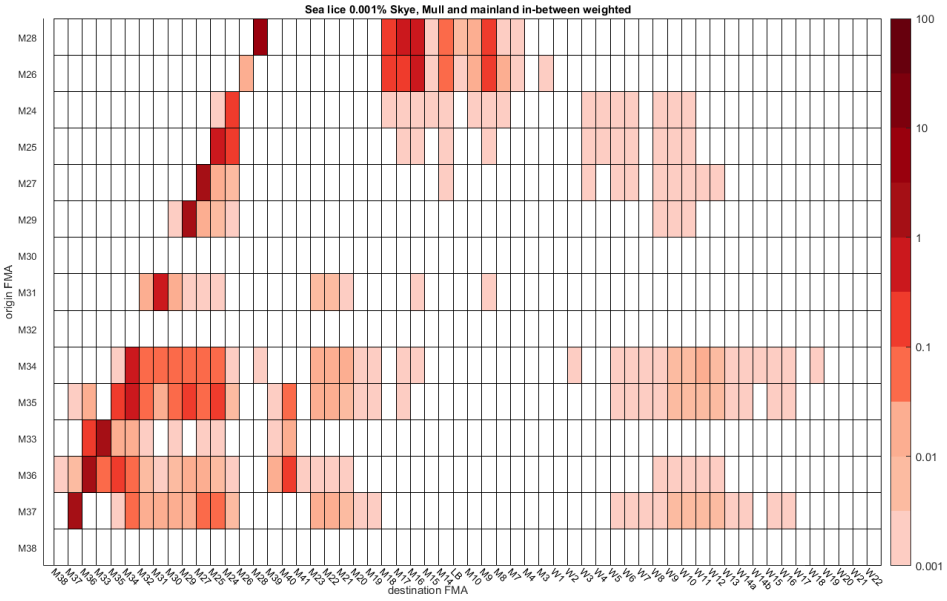
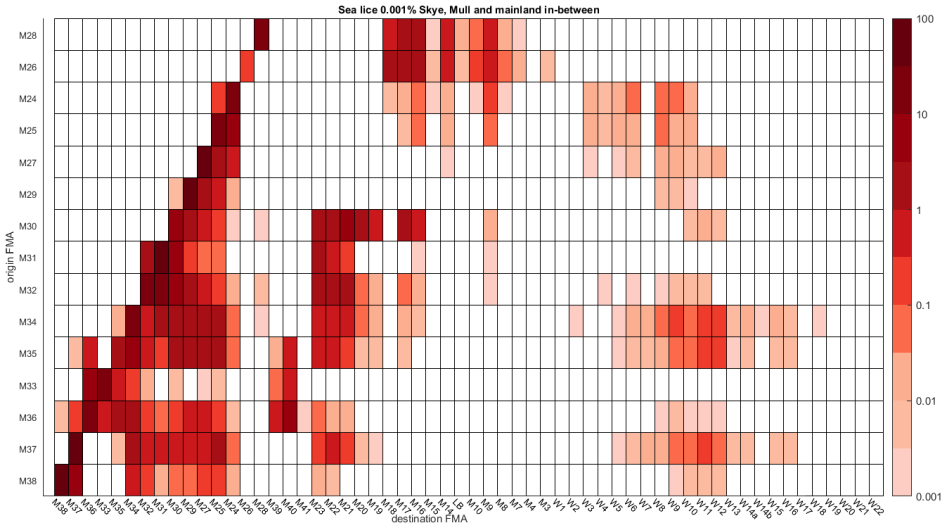


Figure 5: FMAs in the northern Firth of Lorne, Mull and mainland areas between Mull and Skye.


Sea lice 0.001% Skye, Mull and mainland in-between weighted
origin FMA
destination FMA
M28
M26
M24
M25
M27
M29
M30
M31
M32
M34
M35
M33
M36
M37
M38
100
10
1
0.1
0.01
0.001


Sea lice 0.001% Skye, Mull and mainland in-between
origin FMA
destination FMA
M28
M26
M24
M25
M27
M29
M30
M31
M32
M34
M35
M33
M36
M37
M38
100
10
1
0.1
0.01
0.001

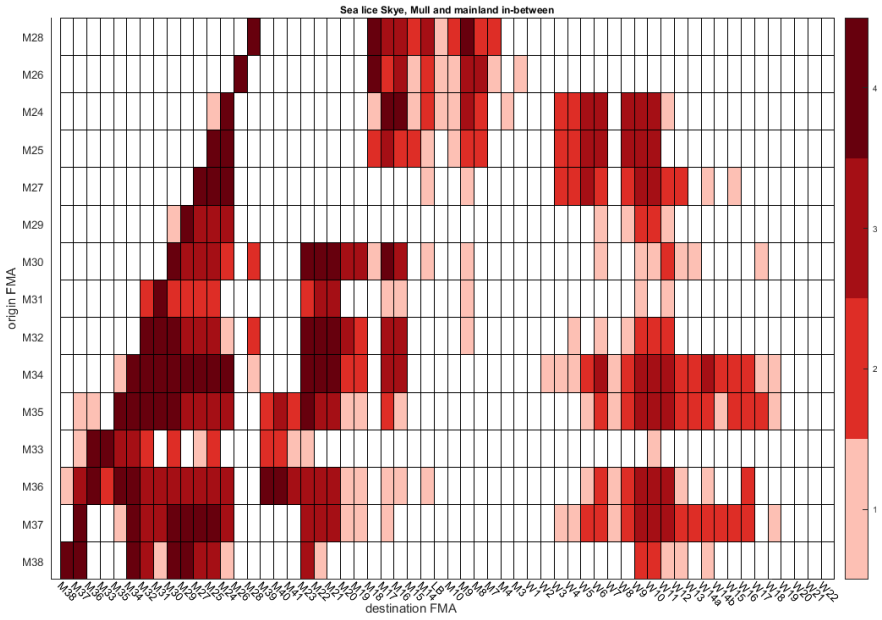


Figure 6: Sea lice weighted connectivity probability (top panel), unweighted connectivity probability (middle panel), and presence/absence connectivity (lower panel) between FMAs for Skye, Mull and mainland FMAs in-between.

Mainland coast east of Skye

Loch Nevis (M23; Figure 7) is the most connected of these FMAs (Figure 8), with one connection with the Outer Hebrides (W10) for all three analysis and all FMAs on Skye (except M26), and M24 for unweighted and weighted probability. The rest of these FMAs do not connect with the Outer Hebrides. The strongest connections range from Loch Gairloch (M16) in the north to Loch Hourn (M22) with high weighting for all connections (except M18). A difference between binary presence/absence and the probability analyses can be seen for M14, M10, and M9 which are reached by sea lice particles during more than one season (dark red), but the probability is either low (M9) or even below the threshold (M10 from M23) with low weighting for all of these.

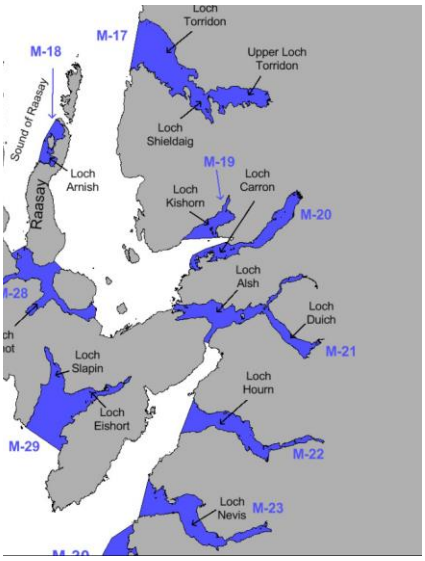


Figure 7: FMAs on the mainland coast east of Skye.

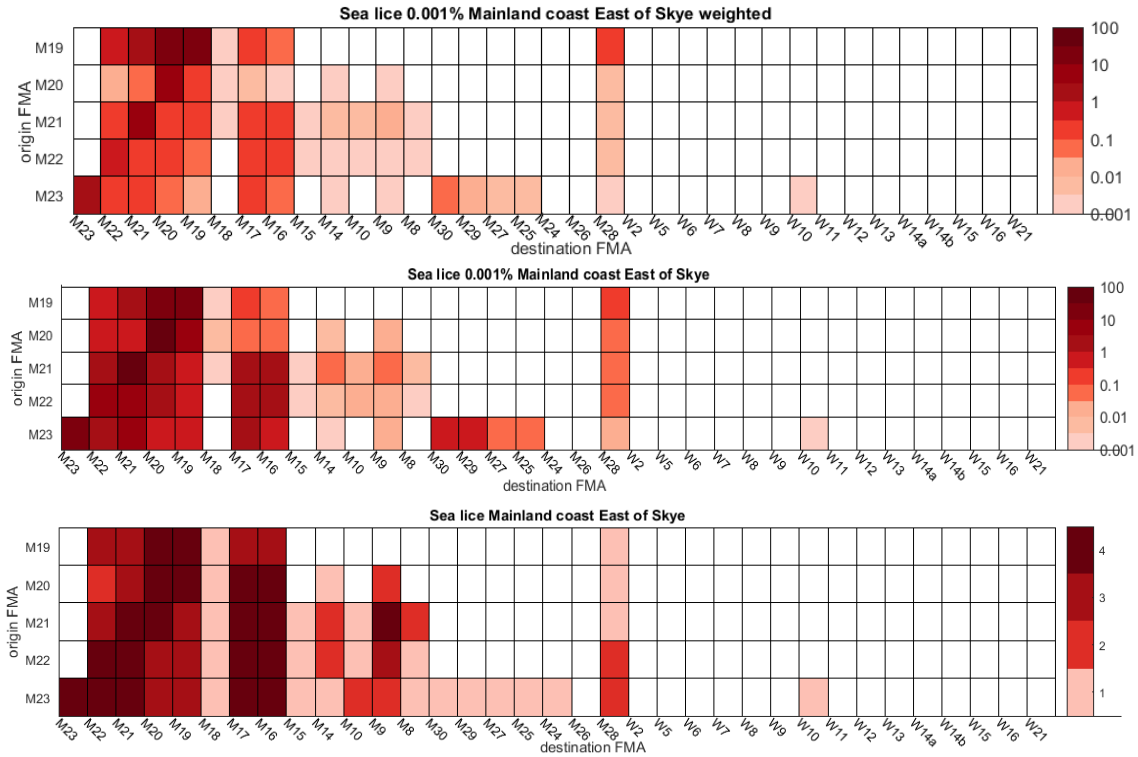


Figure 8: Sea lice weighted connectivity probability (top panel), unweighted connectivity probability (middle panel), and presence/absence connectivity (lower panel) between FMAs for the mainland coast east of Skye.

Outer Hebrides

The northwestern FMAs (Fig. 9; W1-W2) are interconnected for sea lice particles (Figure 10) at high probability (and lower weighted probability), but not linked to any others. W7 (West Loch Tarbert, slightly further south along the west coast) connects with the two downstream FMAs.

W11 (northern tip of North Uist) connects more strongly to all FMAs along the west coast but with some connectivity along the east coast FMAs especially W5-W10 at higher probability but lower weighted probability.

W3 and W4 (northeastern most FMAs) have some connection with other FMAs further south on that coast with weightings. W5 to W10 (excluding W7) (east coast of Lewis and Harris) connect quite extensively with higher weighted probability along the east coast of Lewis and Harris (W3 to W10), with weaker connections and low probability (and below the threshold for some FMAs) towards the south (all the way to the northern part of Benbecula) and the northwest coast of the mainland (Enard Bay, M9) and Loch Snizort (M24) (below weighted threshold). W10 is not consented to stock biomass.

W13 (Loch Euphoirt) has only two release points (one of them positioned well into the loch) and is more strongly self-recruiting than other adjacent FMAs, probably for that reason. Given the generally limited connectivity patterns, this FMA was relatively more connected than what may have been expected from the small number and location of the release points with high weighted probability to W7 and W12.

W14a and W12 are quite similar to each other, connecting with most FMAs in the Western Isles except W1, W3, W4, W21 and W22 with higher probability (and weighted probability) for W8-W15.

W14b has only one release point and is to the west of W14a. It predominantly self-recruits and connects to W14a and W15, with higher probability but is not consented to stock biomass at the time of analysis.

For W15-W18 (Benbecula to north side of South Uist), the FMAs are self-recruiting and are strongly connected with higher probability with their adjacent neighbours and beyond, with a slight pattern of higher probability towards the north. Weighted probabilities roughly match the unweighted probability patterns. W19 is much less

connected lice but there are only two release positions here and positioned well into the loch and it is not consented to stock biomass. W20 is quite well connected with other FMAs further north (to W12) and south (W21, W22), with lower probability north of W16 and less weighted probability. Unweighted and weighted connection probabilities are high for W16-W22. W21 and W22 are reasonably well connected to each other with high weighted probability and there is some connectivity to the north at low probability or below the threshold (more for W21 than W22).

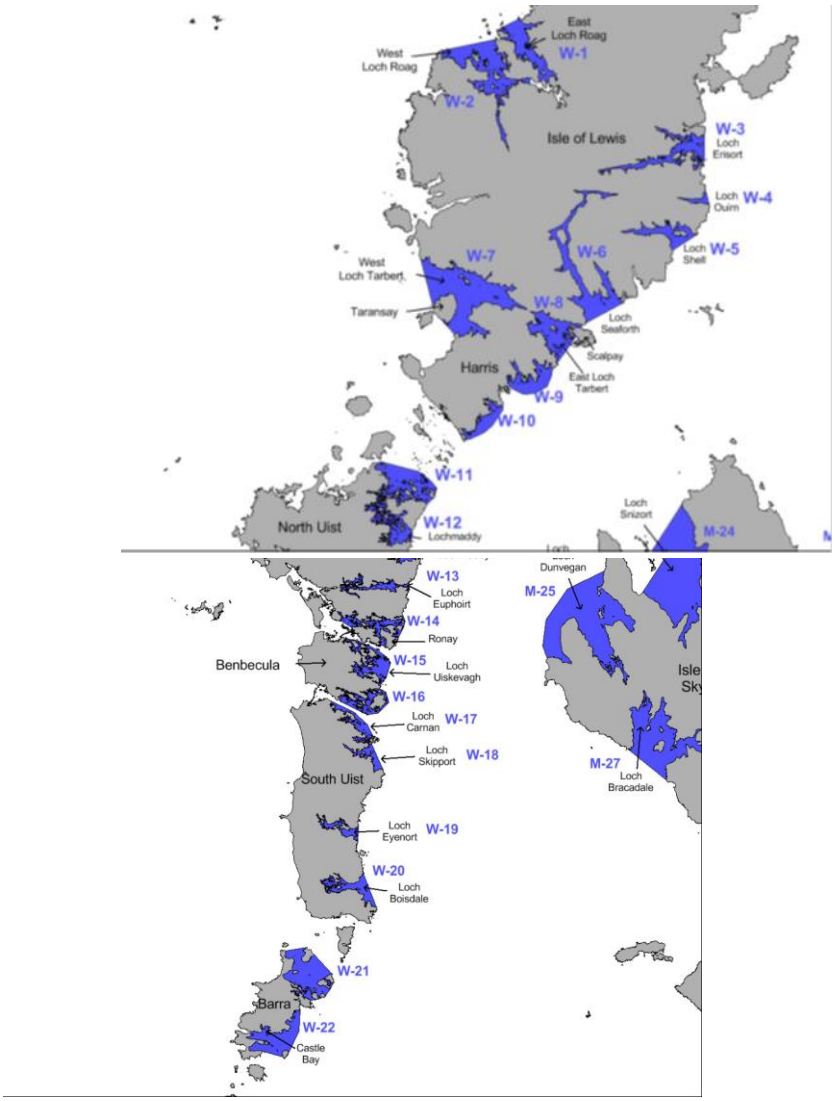
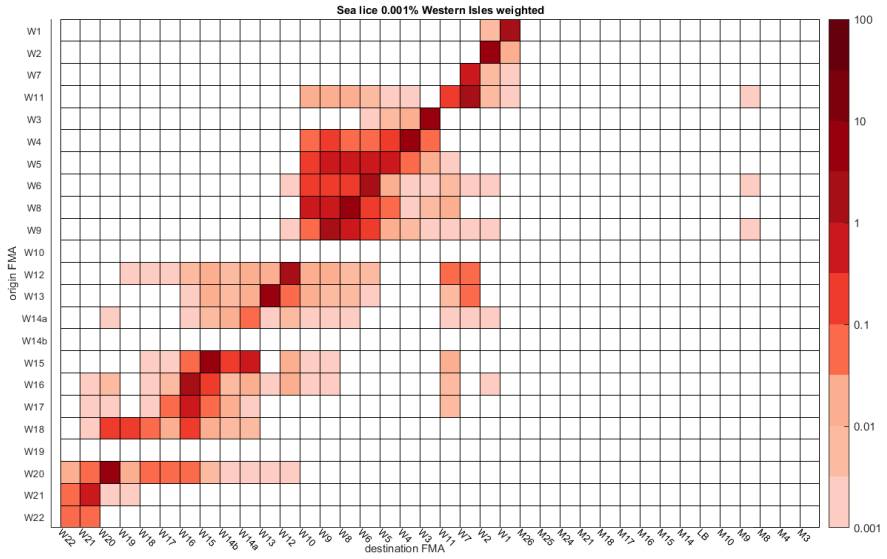
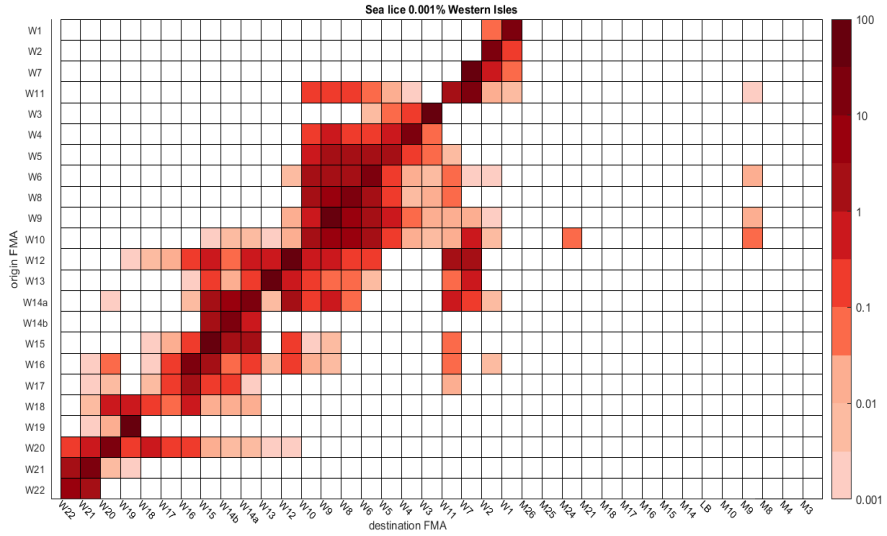


Figure 9: FMAs in the Outer Hebrides.


Sea lice 0.001% Western Isles weighted
origin FMA
destination FMA
W1
W2
W7
W11
W3
W4
W5
W6
W8
W9
W10
W12
W13
W14a
W14b
W15
W16
W17
W18
W19
W20
W21
W22
M3
M4
M8
M9
M10
LB
M14
M15
M16
M17
M18
M21
M24
M25
M26
100
10
1
0.1
0.01
0.001


Sea lice 0.001% Western Isles
origin FMA
destination FMA
W1
W2
W7
W11
W3
W4
W5
W6
W8
W9
W10
W12
W13
W14a
W14b
W15
W16
W17
W18
W19
W20
W21
W22
M3
M4
M8
M9
M10
LB
M14
M15
M16
M17
M18
M21
M24
M25
M26
100
10
1
0.1
0.01
0.001

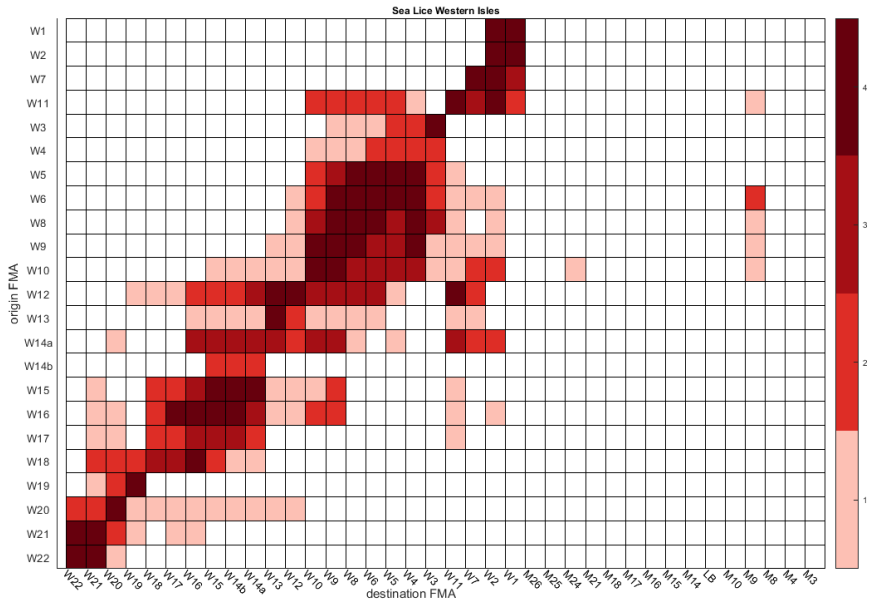


Figure 10: Sea lice weighted connectivity probability (top panel), unweighted connectivity probability (middle panel), and presence/absence connectivity (lower panel) between FMAs in the Outer Hebrides

Northwest Mainland

M18 (Loch Arnish, northeast off Skye; Figure 11) connects (Figure 12) with the north (all the way to the top of the mainland FMAs, although only stronger consistent connections with higher probabilities up to north of Enard Bay). This FMA is not consented to stock biomass. For FMAs from Loch Torridon (M17) northwards, the connections are strong (connecting to all FMAs pretty much all the way to the top, M1) with lower probability to M5, M6 and with high weighted probability to M9 (Enard Bay), M2, M14, M8 and M3. M5 to M7 are close geographically and strongly inter-connected at reasonably high probability. Between M1 (from the northwest mainland) and M5 (and also M8) there is some connection with Orkney. Probabilities are only higher from M1 and M2 and weighted probability is low to Orkney. There are two bigger clusters of geographically-close FMAs: those in the Loch Broom area (inc. Gruinard Bay and Summer Isles, M10, LB, M14) and from M4 to M8, around Eddrachillis Bay, although connectivity is not restricted to these regions. The pattern for presence/absence connectivity looks quite a bit different from the pattern using weighted probabilities. Connections exist for all seasons but at lower probability than the presence/absence would suggest. The weighted probability looks different again with few FMA connections at weighted probability above 0.1%.

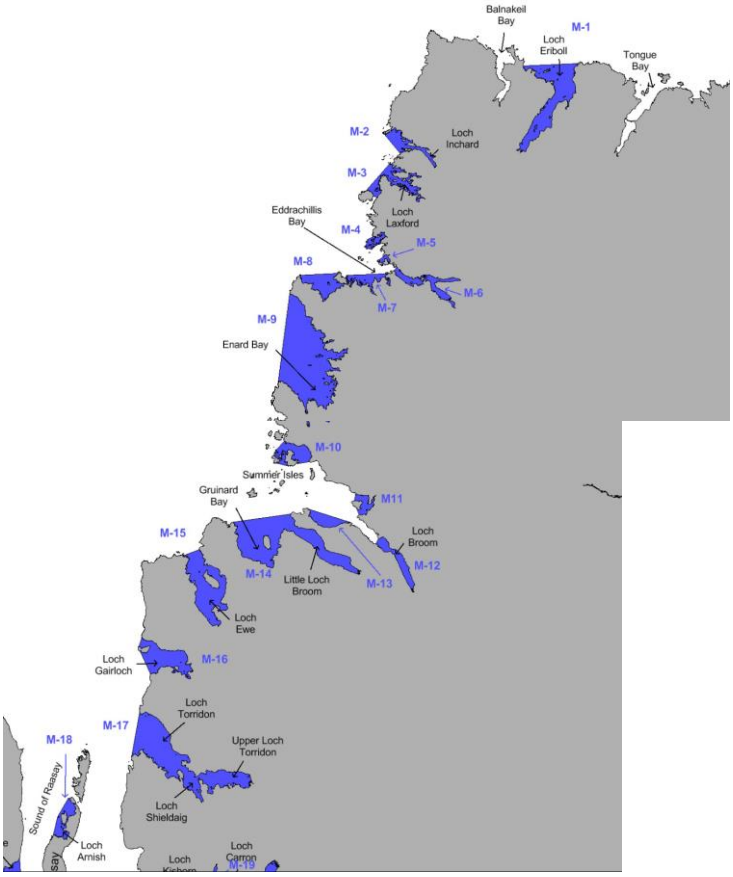
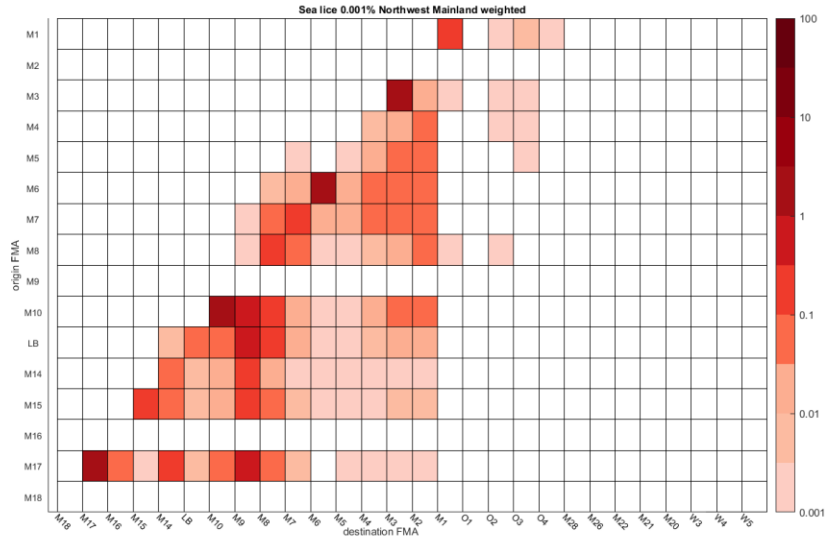
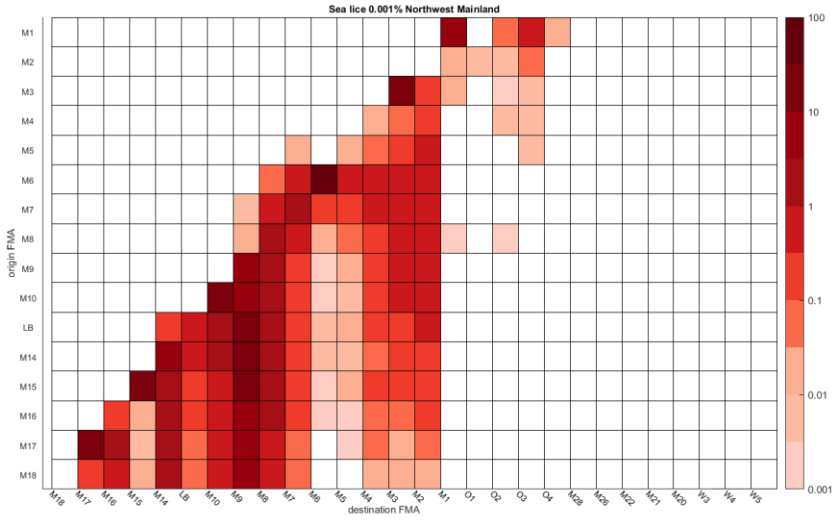


Figure 11: FMAs on the northwest mainland.


Sea lice 0.001% Northwest Mainland weighted
origin FMA
destination FMA
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
LB
M14
M15
M16
M17
M18
O1
O2
O3
O4
M28
M26
M22
M21
M20
W3
W4
W5
100
10
1
0.1
0.01
0.001


Sea lice 0.001% Northwest Mainland
origin FMA
destination FMA
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
LB
M14
M15
M16
M17
M18
O1
O2
O3
O4
M28
M26
M22
M21
M20
W3
W4
W5
100
10
1
0.1
0.01
0.001

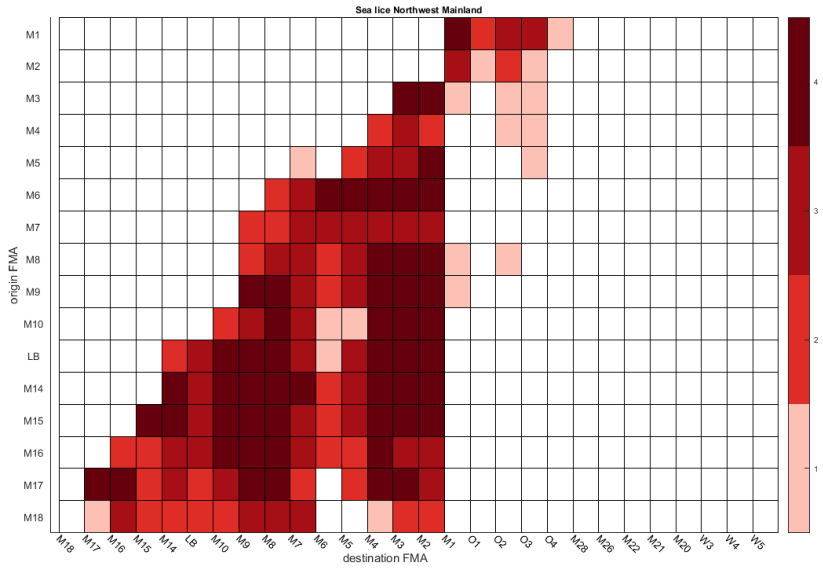


Figure 12: Sea lice weighted connectivity probability (top panel), unweighted connectivity probability (middle panel), and presence/absence connectivity (lower panel) between FMAs for the northwest mainland.

Orkney

All FMAs (Figure 13) are well interconnected (Figure 14) with variable probability (below the threshold only from O4 to O1) (O4 is not consented to stock biomass). Highest weighted probabilities exist from O3 to O2, O3, and O4. O2 is the largest FMA with the most particles released but this is not reflected in the weighted probability due to the lower biomass.

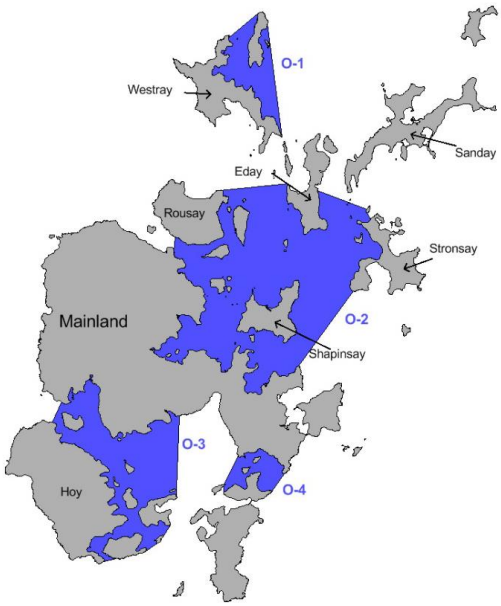


Figure 13: FMAs in Orkney.

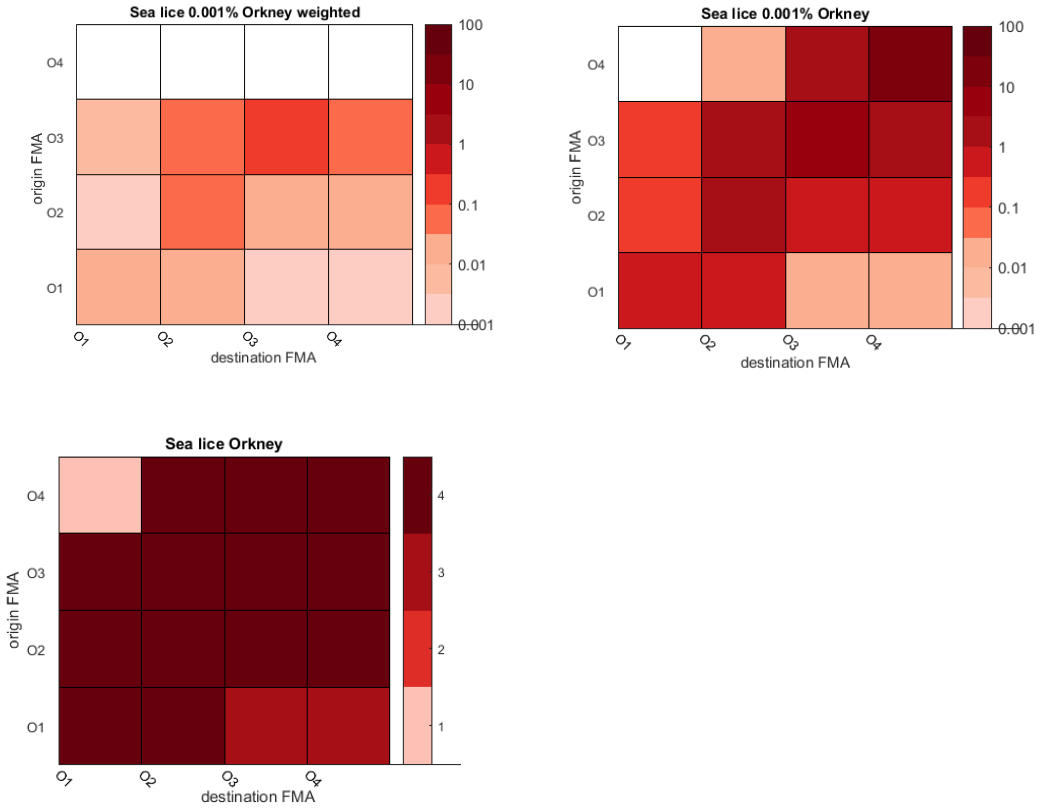


Figure 14: Sea lice weighted connectivity probability (top left panel), unweighted connectivity probability (top right panel), and presence/absence connectivity (lower panel) between FMAs in Orkney.

Shetland

Figure 15 shows the location of FMAs in Shetland, where the prevailing circulation pattern is clockwise. All east coast FMAs are reasonably well inter-connected at reasonably high unweighted and weighted probability (Figure 16) with S1 not consented to stock biomass. In the west S8a, S8b, S10 and S11 are almost all connected to all FMAs except to S5, S6, S9 and S16 in the binary presence/absence connectivity. Probabilities are variable, with highest weighted probability from S10 and S11. Sea lice particles from S7 connect to the downstream FMAs all the way to S5. Sea lice particles stay inshore and are not reaching the more offshore S6. Those further south link with the downstream FMAs and others further south. More northerly FMAs tend to link with those downstream, including the more northerly FMAs on the east side.

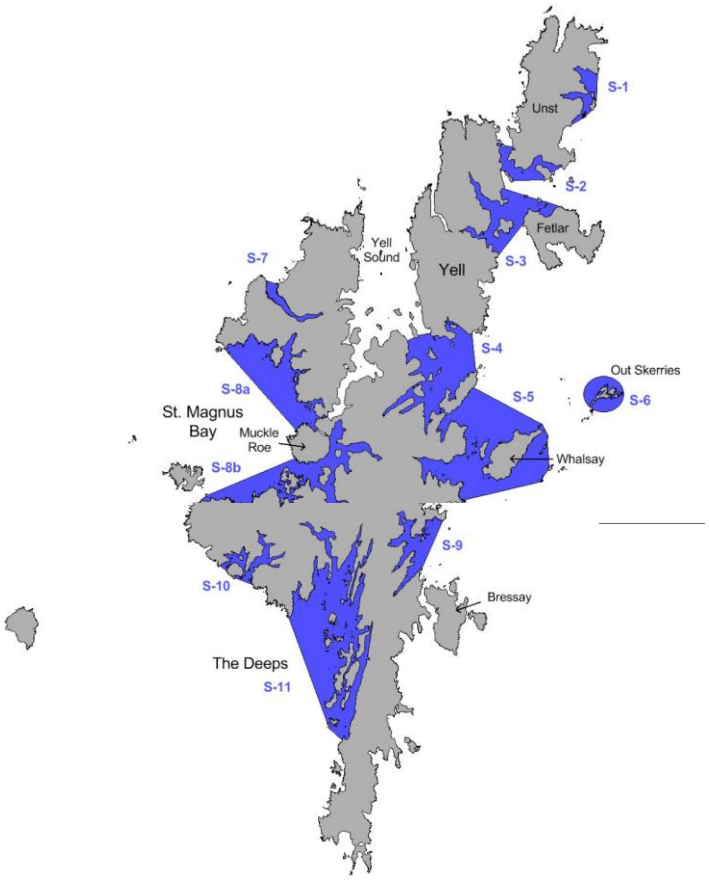


Figure 15: FMAs in Shetland.

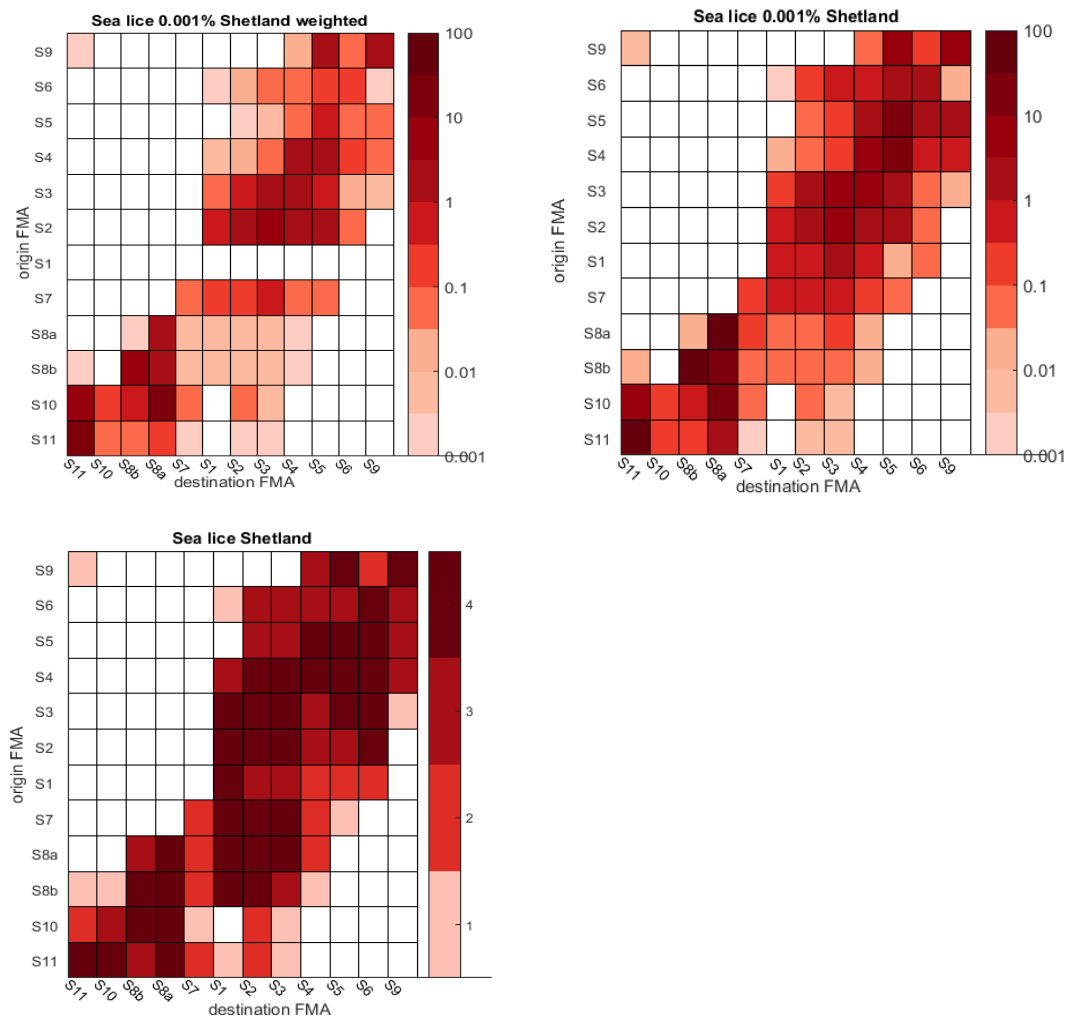


Figure 16: Sea lice weighted connectivity probability (top left panel), unweighted connectivity probability (top right panel), and presence/absence connectivity (lower panel) between FMAs in Shetland.

Conclusions

Output from a coupled bio-physical model has been used to evaluate average sea lice connectivity patterns between Scottish FMAs. Distinct geographical regions are usually well-connected and show a general transport of particles to regions further north, according to the residual circulation pattern. The Skye, Mull and mainland in-between region acts as a major exporter of particles, connecting to the Outer Hebrides and the mainland further north. The Outer Hebrides show interconnectivity along the east coast with some export towards the mainland. Shetland is self-contained while Orkney is self-contained plus import of particles from the northeast mainland.

In the future it would be feasible and may be desirable to carry out further simulations in areas of specific interest and/or where the number or positioning of particle release locations may have been inadequate for a proper connectivity analysis.

This connectivity analysis can be applied by regulators and industry to investigate spatial management structures to control diseases and parasites and, therefore, help with sustainable expansion of the Scottish aquaculture industry.

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Appendix 1

Table 1

Number of release points and consented biomass [t] per FMA, with FMAs not consented to stock marked in blue

	FMA	Release points	Consented biomass [t]
1	'S1'	1	0
2	'S2'	2	10353
3	'S3'	8	12914
4	'S4'	13	15534
5	'S5'	23	6736
6	'S6'	3	1275
7	'S7'	1	2633
8	'S8a'	15	4046
9	'S8b'	11	7366
10	'S9'	3	3685
11	'S10'	1	4638
12	'S11'	25	30664
13	'O1'	12	2585
14	'O2'	91	10296
15	'O3'	37	6422
16	'O4'	4	0
17	'M1'	11	1395
18	'M2'	3	0
19	'M3'	5	1250
20	'M4'	1	1250
21	'M5'	1	1250
22	'M6'	2	600
23	'M7'	2	1050
24	'M8'	3	1000
25	'M9'	27	0
26	'M10'	4	1850
27	'LB'	7	1860
28	'M14'	14	662
29	'M15'	9	1028
30	'M16'	6	0
31	'M17'	16	7035
32	'M18'	3	0
33	'M19'	1	5213

34	'M20'	7	2687
35	'M21'	9	6625
36	'M22'	8	3850
37	'M23'	12	4480
38	'M24'	22	2195
39	'M25'	22	5323
40	'M26'	2	2022
41	'M27'	21	2000
42	'M28'	5	5550
43	'M29'	13	1550
44	'M30'	10	0
45	'M31'	9	300
46	'M32'	10	0
47	'M33'	24	6124
48	'M34'	29	7178
49	'M35'	20	6756
50	'M36'	69	14888
51	'M37'	22	5429
52	'M38'	8	0
53	'M39'	2	1050
54	'M40'	41	12733
55	'M41'	6	0
56	'M42'	40	11755
57	'M43'	1	0
58	'M44'	6	0
59	'M45'	5	5621
60	'M46'	35	3099
61	'M47'	24	5000
62	'M48'	8	1154
63	'M49'	13	0
64	'W1'	7	5213
65	'W2'	9	5197
66	'W3'	6	4150
67	'W4'	1	2885
68	'W5'	2	3402
69	'W6'	10	3810
70	'W7'	18	1725
71	'W8'	6	8424
72	'W9'	5	2301
73	'W10'	2	0
74	'W11'	7	3850

75	'W12'	4	670
76	'W13'	2	1139
77	'W14a'	3	50
78	'W14b'	1	0
79	'W15'	3	3156
80	'W16'	3	1104
81	'W17'	1	1274
82	'W18'	1	1710
83	'W19'	2	0
84	'W20'	3	2400
85	'W21'	9	2150
86	'W22'	4	450