NORWEGIAN ENVIRONMENT AGENCY

A Norwegian environmental emission scenario for nets used in fish farms

Adjustment of the EU scenario (2015) to better represent national conditions

Norwegian Environment Agency, 2019

Introduction and strategy

This document describes a national adjustment of the *Scenario document for the calculation of environmental exposure from antifouling active substances from nets used in fish farms* (NO 2015, hereafter referred to as the EU scenario). In the EU scenario, it is recognised that fish farm facilities and environmental conditions vary throughout the EU/EEA Member States. It is emphasised that in cases where it is known or expected that the default parameter values presented therein are not representative for a country, they could be replaced by more appropriate values in accordance with Article 37 of the BPR. Fish farming is a major industry in Norway, and it is important for the Norwegian Environment Agency that the environmental assessment of fish nets antifoulants (PT 21) to be used in Norway is based on a scenario which is realistic for Norwegian fish farming, while at the same time ensuring a sufficient level of protection of the environment.

This document describes an emission scenario for a generic Norwegian fish farm, for which predicted environmental concentrations (PECs) can be calculated in MAMPEC[1]. It has to be emphasised that for specific sites, there could be other requirements or conditions which apply, e.g. through other national or local legislation or permits granted for an individual fish farm. Compliance with such requirements or conditions must be ensured regardless of the result of the risk assessment made as part of the biocidal product evaluations.

Data from a selection of Norwegian fish farms, as well as some general data on marine conditions in Norway, was collected. The collected data were used to evaluate the need for adjustment of the parameter values in the EU scenario and, where appropriate, to determine better suited values. The result is a national scenario which is meant to represent a realistic worst case scenario for PT 21 products used for net antifouling at Norwegian fish farms.

The following strategy was followed:

1. **Selecting the representative fish farms** that form the statistical basis for the revised scenario
2. **Identifying the parameters in need of adjustment** from the values given in the EU scenario
3. **Finding methods for collecting the data** on the relevant parameters
4. **Listing the results** of the data collection and investigation
5. **Presenting the Norwegian scenario** based on the collected data

These different parts of the strategy are described and discussed individually below, in sections 1-5.

[1] Version 3.1: van Hattum *et al.* (2016), https://www.deltares.nl/en/software/mampec/

1. Selecting representative fish farms

1.1. Main principles

All aquaculture facilities in Norway need a permit for production. The Norwegian Directorate of Fisheries manages a register of all aquaculture facilities with a valid permit. This register has been used as a starting point for selecting relevant representative fish farms.

In order to ensure a selection which includes a sufficiently relevant and wide range of Norwegian fish farms, the selection should encompass the following:

- a sufficient representation of the most relevant sizes of fish farms, with regards to the amount produced and the number and sizes of nets
- fish farms both in the southern, western, middle and northern parts of Norway
- fish farms both in pelagic coastal and fjord locations
- a total number of farms sufficiently large to give a solid statistical basis for the adjustment of values

1.2. Selection criteria

In selecting the representative fish farms, the following criteria were chosen:

- Only **marine commercial fish farming** has been considered. Land-based aquaculture differs significantly from marine aquaculture, and should if necessary be dealt with in a separate scenario.
- Fish farms with **salmon, trout and rainbow trout** were selected. Other species of fish, as well as shellfish, are also farmed in aquaculture facilities. However, the three mentioned species are by far the most commonly farmed, with salmon representing 94.5 % of the total tonnage of produced fish in 2017.
- Only fish farms with a **production capacity of > 4000 tonnes** were considered. In the register of the Norwegian Directorate of Fisheries, information is given on the production capacity of each individual site. Currently, this ranges from approximately 100 to 8000 tonnes for marine fish farming of salmon, trout and rainbow trout. As discussed in the EU scenario, there is a move towards larger fish farms (i.e. bigger nets and an increased capacity) – from 1999 to 2011, the number of fish farms were reduced from approximately 1900 to 1000, while at the same time the total production was doubled (Gullestad *et al.*, 2011). In order to capture this trend and to take into account that it is likely to continue, it was therefore considered the most relevant to include the sites in the upper half of the range, i.e. with a production capacity of 4000 tonnes and above. Of a total of approximately 950 fish farms, 240 have a capacity of above 4000 tonnes.

The result was that from approximately 950 salmon, trout and rainbow trout farms in Norway, **232 fish farms** were chosen to form the statistical basis for the revised national scenario.

1.3. Map of the selected sites

The 232 fish farms are distributed across the country and represent both fjord and coastal sites, as shown in figure 1. It was concluded that these 232 facilities together are in conformity with the main principles listed in section 1.1 and that any adjusted parameter values could be based on the data obtained from these facilities.

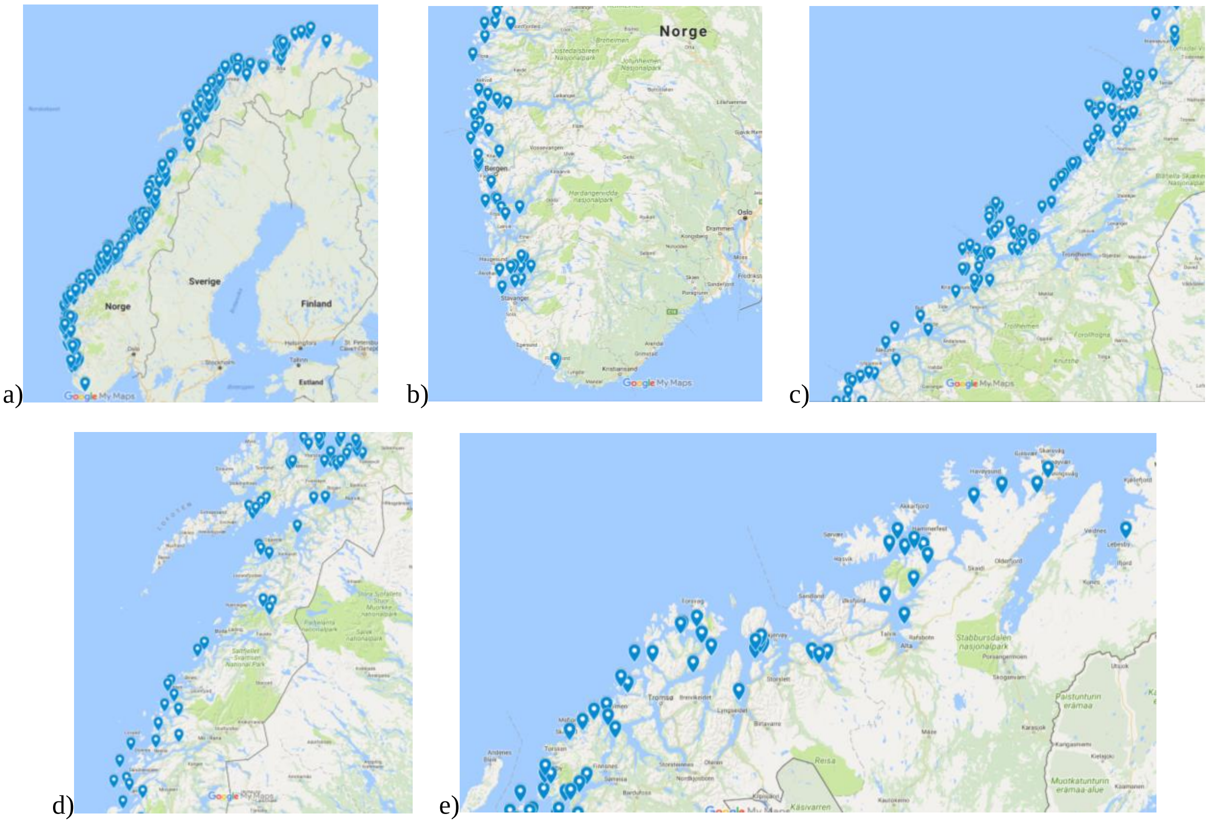


Figure 1*. Geographical representation of the selected sites, in a) Norway as a whole, and shown in more detail in various regions from south to north in b)-e). Google Maps, 2018.*

2. Identifying the parameters in need of adjustment

Data on Norwegian fish farming form a significant part of the basis for the EU scenario. However, concerns have been raised that the model site in the EU scenario might not be fully representative or realistic for Norwegian fish farming. The following parameters from the EU scenario have been considered relevant for adjustment, in order to derive a realistic worst case Norwegian scenario.

Table 1*. Relevance of the parameters for adjustment*

Parameter description	**Relevant to assess need for adjustment?**
E_{local}	
Concentration of a.i. i product, $C_{a.i.}$	No
Number of nets per fish farm, N_{net}	Yes
Coverage of product (L product per kg net), COVERAGE	No
Weight per m^2 of net, W_{net}	No
Area of each net, $AREA_{net}$	Yes
Time net is deployed in the water, $T_{deployment}$	No
Fraction of released a.i. per deployment time, $F_{a.i.}$	No
PEC	
Water characteristics (flow velocity, SPM, POC, DOC, chlorophyll, salinity, temperature, pH)	Yes
Layout of fish farm (length, width, sea depth)	Yes
Sediment parameters (depth mixed sediment layer, sediment density, degradation organic carbon, net sedimentation velocity)	Yes (net sedimentation velocity) / No (all other sediment parameters)

3. Methods for collecting the data

3.1. Data sources

Table 2 gives an overview of the main data sources used and the data collected from each of them.

Table 2. *Main data sources*

Source	Data collected / parameters investigated
The aquaculture register of the Norwegian Directorate of Fisheries [1]	Selection of relevant fish farms
The map tool of the Norwegian Directorate of Fisheries, giving visual information for each fish farm as well as reports on the environmental state in the waters at and around the farms [2]	Number of nets (N_{net}) Net circumference (related to $AREA_{net}$) Fish farm layout (width, length, depth) Flow velocity
The Institute of Marine Research, data from 8 hydrographical stations along the Norwegian coast [3]	Salinity Temperature
Open literature references, cited below in the text	Other water and sediment characteristics

1 https://www.fiskeridir.no/Akvakultur/Registre-og-skjema/Akvakulturregisteret
2 https://kart.fiskeridir.no/
3 http://www.imr.no/forskning/forskningsdata/stasjoner/

3.2. Obtaining data on fish farm areas from the map

For each fish farm, the number of nets (N_{net}) and their circumference, as well as the area of the farm, was obtained from the map of the Norwegian Directorate of Fisheries. The area was defined as the area within the mooring buoys, as shown in figure 2. The length and width was measured using the measurement tool available in the map, and the distances were rounded to the nearest five metres. In order to disregard any seasonal variations in production or temporary rearrangements of the facilities, and for reasons of consistency, data representing the full capacity of a site was recorded. All mooring buoys were included when measuring the distances, regardless of whether nets were present in all frames at the time the image was taken. Similarly, the number of nets, N_{net}, was defined as the maximum number of nets the facility can hold.

The addition of 150 m to the length and width of the facility, in order to obtain the area relevant for PEC calculation, has been kept unchanged in this national scenario. The argumentation given in the EU scenario is still considered valid.

Figure 2. *Example of data obtained from visual inspection of a site. The blue lines show the measurement of the diameter of the nets and the area (length and width) occupied by the nets. The mooring buoys, visible as white dots on the image, were used as outer points for the length/width measurements. The chosen value for number of nets,* N_{net}*, at each site was set to the number representing the production at full capacity. In this image, the area is thus a × b (before adding the additional 150 m to length and width), and* N_{net} *is 8.*

3.3. Obtaining data from environmental reports related to the fish farm permits

Data on depth underneath the fish farm and data on flow velocities are examples of data taken from the environmental reports which are accessible from within the map tool of the Norwegian Directorate of Fisheries. Reports for each fish farm from approximately the last decade are available, which give information e.g. on production capacity, the actual production during the latest production cycle, the area and bathymetric conditions at and surrounding the farm, and some information on the seafloor and sediments, e.g. biological information from sediment samples taken underneath the fish nets.

Depth is usually given as a range. The average depth was recorded – e.g. for a fish farm under which the depth ranges from 40 to 110 metres, the recorded depth would be 75 metres. Information on water currents can either be found as indirect information (based on the type of sediment, which is affected by the current) or as actual current measurements in the environmental reports or in separate reports. In these cases, the flow velocities are given for depths of approximately 5 and 15-25 m below the surface, as an indication of surface current and exchange current, respectively. Since the fish nets will be exposed to a combination of both the surface and exchange current, the average value was recorded.

The reports are related to the permits granted for the operation of the fish farms. A condition for keeping a permit is that an environmental assessment of the site is performed with given time intervals and levels of detail, depending on the site's environmental state (from 1 to 4) given in the latest report. If the environmental state is 1 (very good), a new assessment must be done in 2 years. A state of 2 implies a new assessment in one year. With a state of 3, a new assessment is required after 6 months. If the environmental state is 4 (very poor), the facility cannot operate further before having initiated mitigating measures.

3.4. Obtaining data from other sources

A literature search was carried out to find information on the other parameters. The reports and articles used are cited in section 4.

4. Summary of the collected data

In this section, the collected data are presented and final values are concluded upon for some parameters. However, for the parameters flow velocity and water volume (area and sea depth), results are presented here and finally concluded in section 5.

4.1. Number of nets (N_{net}) and area of the nets ($AREA_{net}$)

A summary of the data on the number of nets in the various size categories is given in table 3. Nets with a diameter between 40 and 60 m are by far the most common. Most of these nets have a diameter of 50 m (corresponding to a circumference of 157 m). This is also in line with information received from the Norwegian fish farming industry, where a circumference of 157 m is often referred to as a standard size. It is expected that more of the smaller nets will be replaced by larger nets during the coming years. Hence, large (size L) nets were identified as relevant for the Norwegian scenario. Further statistics on the number of size L nets at the fish farms is given in table 4.

In the EU scenario, the default value for AREAnet is 5103 m^2. This is based on a net with a circumference of 157 m and a depth of 20 m. However, in Norwegian fish farming, nets with this circumference are often deeper than 20 m. A report from 2011 lists 35 m as a normal depth for a net with a circumference of 157 m (Rosten *et al.*, 2011[2]). The same report informs that circumferences of fish nets range from 90 to 200 m and that depths of the fish nets range from 10 to 60 m. Personal communication with the fish farming industry indicates that nets with a circumference of 157 m and a depth of up to 50 m are not unusual. According to the net supplier and service provider Egersund Net[3], an area of 7770 m^2 is a typical example of a large straight-walled circular net.

Table 3. *Distribution of net sizes*

Net size	XS/S	M	L	XL
Diameter / circumference (m) [a]	-- [b]	< 40 / < 125	40-60 / 125-190	> 60 > 190
Number of nets (counted from all 232 farms)	123	487	1949	17

a) the categories are slightly different from those given in the EU scenario.
b) nets in square cages connected in a steel structure

Table 4. *Data on number of nets per fish farm (N_{net}), on farms with size L nets*

Statistical value	N_{net}
Min	4
10^{th} percentile	8
Mean	10
90^{th} percentile	14
Max	18

Choice of values: $AREA_{net}$: 7770 m^2, N_{net}: 10. Further elaboration on the choice is given in section 5.

[2] Rosten, T.W. *et al*., 2011: *Oppdrett av laks og ørret i lukkede anlegg – forprosjekt*. SINTEF, report no. A21169
[3] https://www.egersundnet.no/products/fish-farming-nets/straight-wall-circular-net

4.2. Flow velocity, area and sea depth of the fish farms

A statistical summary of the data is given in table 5. Given the choice of value for $AREA_{net}$ and N_{net} described above, separate statistics for fish farms with 10 large nets is also presented. Each data column gives independent statistics. The area and water volume columns, for example, give a statistical summary of the recorded water volumes for all the fish farms, and do not correspond exactly to the width, length and depth values in the same row.

Table 5. *Summary of data on flow velocity, sea depth, width, length and water volume*

Statistical value	Flow velocity (cm/s)	Sea depth (m)	Width + 150 (m)	Length + 150 (m)	Area (m²)	Ratio length/width	Water volume (m³)
All fish farms							
Min	2.2	20	180	340	78200	1.0	3375000
10th percentile	3.2	50	240	510	153460	1.5	10159243
Mean	6.1	101	329	693	228045	2.2	23059512
90th percentile	9.1	160	420	900	317350	3.4	40404300
Max	18.0	325	895	1540	1132175	6.3	108842500
n	140 [a]	232	232	232	232	232	232
Fish farms with 10 L nets							
Min	2.2	40	190	450	126900	1.1	8820000
10th percentile	3.5	59	250	510	171000	1.5	11865000
Mean	5.5	103	342	692	235268	2.2	24063307
90th percentile	8.5	160	500	930	325000	3.8	46927125
Max	10.7	310	570	1200	517500	4.7	67275000
n	28 [a]	51	51	51	51	51	51

a) As explained above, actual flow velocity measurements were not available for all fish farms.

Choice of values: See discussion directly below, and conclusion in section 5.

4.3. Discussion on fish farm layout parameters: fictional or real-life model site?

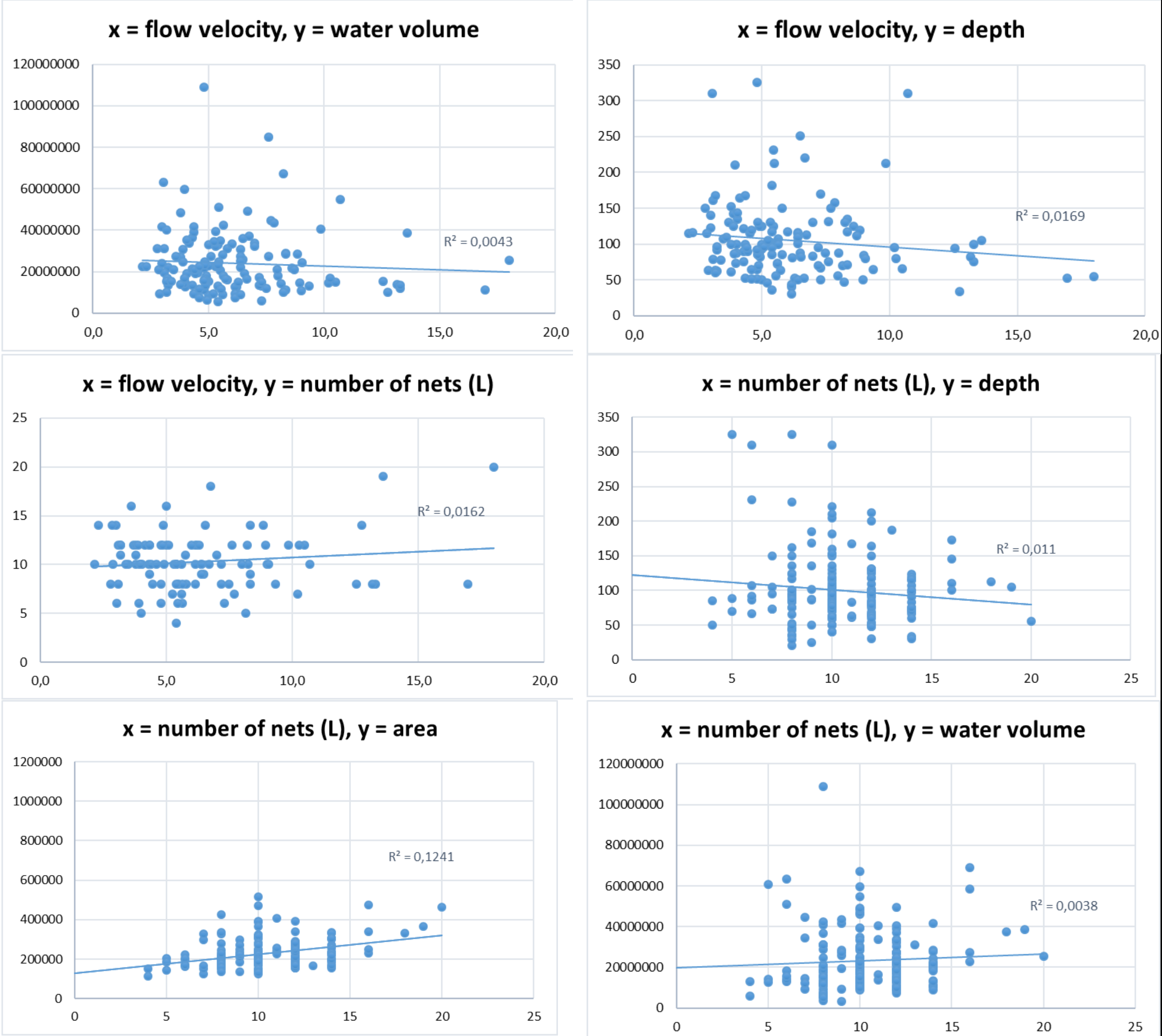
The data presented in sections 4.1 and 4.2 were further investigated in order to determine whether the values for these parameters in the Norwegian scenario should come from the same real-life fish farm in order to constitute a realistic situation, or whether they could be chosen statistically. The underlying assumption was that if there is no clear correlation between the parameter values, it is not necessary to have a scenario that describes an actual currently existing real-life facility.

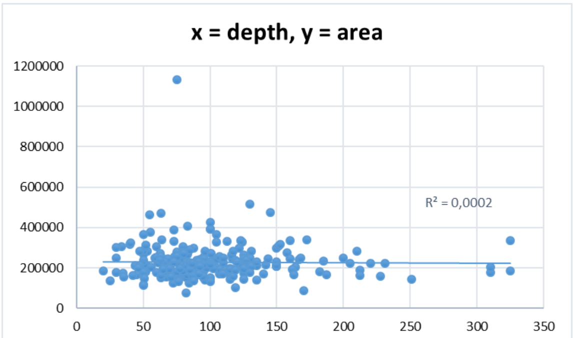
Figure 3 gives a summary of the linear regression performed for different pairs of variables. In general, the correlation between the variables is low.

There is no indication in our data set that the largest sites have a high flow velocity. Most of the sites have flow velocities between 2.5 and 10 cm/s, and many quite large sites have a flow velocity below 5 cm/s. Similarly, it is not necessarily the case that the larger sites are at the highest depths. Several of the sites with ≥ 10 fish nets (size L) have depths of approx. 50 m or less.

The highest correlation identified was between the number of fish nets (size L) and the area (width × length). It could have been expected that this correlation would be higher. An explanation could be that the layout of facilities with the same number of nets can vary with regards to e.g. spacing between parallel lines of nets and the arrangement of the frames / mooring buoys.

In conclusion, due to the lack of correlation between these variables, it was decided to create a fictional model site with statistically determined values. It must however be ensured that the fish farm area is suitable for the N_{net} value of 10 and that the sea depth is realistic for an $AREA_{net}$ of 7770 m^2.





Summary:

Correlation investigated	**R^2**
Water volume and flow velocity	0.0043
Depth and flow velocity	0.0169
Water volume and number of nets (N_{net})	0.0038
Depth and number of nets (N_{net})	0.011
Area and number of nets (N_{net})	0.1241
Depth and area	0.0002
Flow velocity and number of nets (N_{net})	0.0162

***Figure 3**. Correlation between pairs of variables*

4.4. Water characteristics

Salinity and temperature

The Institute of Marine Research has 8 hydrographical stations where the sea salinity and temperature is measured each month at depths of 1, 5, 10, 20, 30, 50, 75, 100, 125, 150, 200, 250, and 300 m (if the location is that deep)[4]. Data from July 2017 to June 2018 were used to find the average yearly temperature and salinity. The yearly average temperature and salinity along the Norwegian coast, from the surface to a maximum of 300 m, is 8.3 °C and 33.7 psu, respectively. If looking at the data sampled from the surface to a maximum of 100 m, which is seen as more relevant in this context, the corresponding numbers are 8.6 °C and 33.2 psu, respectively.

Choice of values: Temperature: 8.6 °C, salinity: 33.2 psu.

Chlorophyll

According to the REVAMP project's Atlas of Chlorophyll-a concentration for the North Sea (Peters *et al.*, 2005[5]), the chlorophyll concentration along the Norwegian coast is on average lower than along the coast of European countries further to the south. According to national quality criteria for seawater in Norway, a chlorophyll content of 3 µg/L (the default value from the EU scenario) would qualify for state II, good quality (states I-V, where I is very good and V is very bad). When chlorophyll concentrations were measured throughout the summer season at a fish farm in a fjord in the middle part of Norway, no indications were found that the fish farm activity affected the chlorophyll levels (Andersen & Sandnes, 2013[6]).

Choice of value: Chlorophyll: 3 µg/L.

SPM (TSM)

The SPM or TSM (total suspended matter) is measured regularly at several locations along the Norwegian coast as part of the monitoring programme ØKOKYST[7]. The SPM/TSM measurements are largely within the range of 0.1 mg/L to 1.5 mg/L. The SPM could however be expected to be higher at fish farms. Not much data on this has been found, but SPM measurements from a fish farm in the western part of Norway show concentrations mainly in the range of 1.25 to 1.5 mg/L (Brager, 2016[8]).

Choice of value: SPM: 1.5 mg/L.

[4] http://www.imr.no/forskning/forskningsdata/stasjoner/

[5] Peters, S.W.M. *et al.*, 2005: *Atlas of Chlorophyll-a concentration for the North Sea based on MERIS imagery of 2003*. Edition 3, 23 May 2005, REVAMP EC-FP5.

[6] Andersen, P.A. & Sandnes, O.K., 2013: *Overvåkning av klorofyll og næringssalter i Indre Follafjord 2010-2012*. Aqua Kompetanse AS, project no. 9-1-13

[7] Monitoring programme for coastal ecosystems, run by the Norwegian Environment Agency: http://www.miljodirektoratet.no/no/Tema/Miljoovervakning/Naturovervaking/Hav-og-kyst/Okoystemovervaking-i-kystvann/

[8] Brager, L.M. *et al.*, 2016: *Temporal variations in suspended particulate waste concentrations at open-water fish farms in Canada and Norway*. Aquacult Environ Interact, Vol. 8, 437-452.

POC and DOC

The POC and DOC concentrations measured at five locations in the Tromsø area between 2001 and 2003, at a depth of 10 cm below the surface, ranged from 1.21 to 1.85 mg/L[9]. The five locations represent sampling sites both close to densely populated, less populated and unpopulated areas, close to industry / fish farms as well as remote areas, and sites in both narrow and open fjords. For one of the locations, POC and DOC measurements were also done between 5 and 60 m and range from 0.1 to 0.3 mg/L (POC, average 0.2) and 1.1 to 1.4 mg/L (DOC, average 1.2).

Choice of values: POC: 0.2 mg/L, DOC: 1.2 mg/L.

4.5. Sediment characteristics

Net sedimentation velocity

The sedimentation of particle disharge from the fish farm is affected by depth, flow velocities, how fast the particles sink towards the bottom and how easily they disintegrate. If the flow velocities are < 5 cm/s, most of the particles will be deposited directly underneath the fish farm, whereas if the flow velocities are > 10 cm/s, the particles are spread over a wider area with little discharge underneath the farm (IMR, 2017[10]). Sedimentation rates and the concentration of particulate matter are expected to be higher underneath the fish farms than at reference locations further away, sometimes twice as high, as shown by the data in table 6, from a publication by Bannister *et al.* (2014[11]). Therefore the default net sedimentation velocity in the EU scenario of 0.1 m/d (i.e. the shipping lane value), is thought to be too low and is doubled.

Table 6. *Sedimentation rates of total particulate matter at a fish farm with 8 size M nets, a water depth of 180 m and an average flow velocity of 4.2 cm/s.*

Month	Distance above bottom [m]	Average sedimentation rate at farm [g/m²/d]	Average sedimentation rate at reference location [g/m²/d]
March 2010	10	7.2	6.1
	80	3.8	2.5
July 2010	10	16.2	-
	80	10.4	-
September 2010	10	26.2	10.5
	80	6.1	3.6
February 2011	10	11.7	9.8
	80	4.2	2.3

Choice of value: Net sedimentation velocity: 0.2 m/d.

[9] Gašparović *et al.*, 2007: *Organic matter characterization in the sea surface microlayers in the subarctic Norwegian fjords region.* Marine Chemistry 105, 1–14.
[10] Institute of Marine Research (Havforskningsinstituttet), 2017: *Risikorapport norsk fiskeoppdrett 2017*.
[11] Bannister, R.J. *et al*, 2014: *Changes in benthic sediment conditions under an Atlantic salmon farm at a deep, well-flushed coastal site*. Aquacult Environ Interact, Vol. 5, 29-44.

5. Final values for the national scenario

When determining the final values for the parameters which have not been concluded earlier in this document, the following aspects were taken into account, in addition to the discussion in section 4.3:

- The scenario should represent a realistic worst case Norwegian fish farm
- When selecting the fish farms, only the 25 % with the highest production capacity were included (possibly selection towards worst case?)
- The full capacity at each facility was recorded (selection towards worst case)
- The average depth underneath each site was recorded (selection towards typical case)
- The chosen values for $AREA_{net}$ of 7770 m^2 and N_{net} of 10 (selection towards typical case)

If only average values had been used for all the parameters, the scenario would represent a typical case fish farm within the selection. Since the selection represents large fish farms, it could be argued that this is sufficiently conservative – provided that the large fish farms represent the worst case farms with regards to environmental impact. However, a large fish farm with at the same time a high flow velocity and deep sea floor might not be sufficiently conservative. Figure 3 above shows that fish farms with 10 large nets or more and at the same time a flow velocity and water volume below the average value, are not uncommon.

Therefore, an average size fish farm at a site with a lower flow velocity and a reduced water volume is considered to be more in line with the goal of creating a realistic worst case scenario. The data given in table 5 were used to find the final values, according to the following description.

For the **flow velocity**, the 10^{th} percentile value from all fish farms is used, i.e. 3.2 cm/s, since there is no correlation between fish farm size or depth and flow velocity.

For the **sea depth**, the 10^{th} percentile value for fish farms with 10 large nets is used, i.e. 60 m (rounded up from 59). This would allow for nets with an area of 7770 m^2, as the depth of these nets is given as 35 m and the Norwegian Food Safety Authority recommends at least 20 m between the bottom of the net and the seafloor[12].

For the **fish farm area** relevant for PEC calculation, the 10^{th} percentile value for fish farms with 10 large nets (171000 m^2) was used as a starting point to determine the length and width. The following equation was used in order to calculate a realistic length and width, using the average ratio between these parameters (2.17, rounded to 2.2 in table 5):

$$Area = width \times length = a \times b$$
$$b = 2.17\ a$$
$$a \times 2.17\ a = 171000\ m^2$$

⇨ Width = 280 m, length = 610 m (rounded to nearest 10)

An investigation of a random selection of the fish farms for which current measurements are available, indicates that there is no clear trend with regards to the orientation of the fish farm relative to the most prominent water flow direction. When the PECs are calculated in MAMPEC, the result will differ substantially if the values for length and width of the area are interchanged. It is therefore considered

[12] The Norwegian Food Safety Authority, 2016: *Etableringsøknader – saksbehandling i tilsynet. Retningslinje til behandling av søknader etter forskrift 17. juni 2008 nr. 823 om etablering og utvidelse av akvakulturanlegg, zoobutikker m.m.* Version 6, ref. 2014/30636, 24.10.2016

the most appropriate to run the calculations twice – once with 280 m and 610 m as the width and length, respectively, and once with 610 m and 280 m as the width and length, respectively – and use the mean PEC from these two runs for the risk assessment.

Table 7 lists the adjusted values for the Norwegian scenario together with the EU scenario values for comparison.

Table 7. *Presentation of the values selected for the Norwegian scenario, compared to the EU scenario values.*

Parameter	Norwegian scenario	EU scenario
E_{local} 1)		
N_{net}	10	10
$AREA_{net}$	7770 m^2	5103 m^2
PEC		
Flow velocity	3.2 cm/s	3.0 cm/s
SPM	1.5 mg/L	5.0 mg/L
POC	0.2 mg/L	0.3 mg/L
DOC	1.2 mg/L	0.2 mg/L
Chlorophyll	3.0 µg/L	3.0 µg/L
Salinity	33.2 psu	34 psu
Temperature	8.6 °C	9.0 °C
pH	8	8
Depth mixed sediment layer	0.1 m	0.1 m
Sediment density	1000 kg/m^3	1000 kg/m^3
Degr. OC in sediment	0	0
Net sedimentation velocity	0.2 m/d	0.1 m/d
Fish farm area (length × width)	280 × 610 m 2)	300 × 450 m
Sea depth	60 m	30 m
Water volume	10 248 000 m^3	4 050 000 m^3
Latitude	60° N	50° N
Cloud coverage	8	5 / n.a. 3)

1) E_{local} Norwegian scenario ≈ 24 900 g/d, E_{local} EU scenario ≈ 16 300 g/d, based on an example product with a copper content of 20 g/L, cf. the calculation example in Appendix 1 of the EU scenario

2) PEC calculations are run twice – a second time with the values for length and width interchanged – and the mean PEC of these two runs is used for risk assessment purposes (see description in the text above).

3) Not available in version 3.0.1.

MAMPEC environment module – open harbour or shipping lane / open sea?

In the EU scenario, the environment module 'open harbour' is used for the fish farm calculations. It is stated that a "modified shipping lane scenario could be used as a refinement option in case such an environment is seen as more representative in an individual country at product assessment". It should be noted that the environment module 'shipping lane' from MAMPEC v.3.0.1 is called 'open sea' in MAMPEC v.3.1 – the latter version has been used when creating the Norwegian fish farm scenario. The fictional model site described above is not likely to be located as close to land as a harbour. It is therefore considered that the hydrodynamics used for the shipping lane / open sea module would be better suited for the Norwegian scenario, when at the same time the parameter values are chosen to reflect the situation underneath a fish farm as correctly as possible. Therefore, for the Norwegian scenario, the open sea module is used as a basis. The parameter values listed in table 7 above are used to replace the default open sea values.

Background concentrations of copper in seawater and sediment

When calculating PECs for copper from the use in fish farms, copper background concentrations in water and sediment of **1.1 µg/L and 16.1 µg/g**, respectively, should be added. This is in line with the EU-agreed background concentrations used for the active substance evaluation for the marina scenarios for antifouling paints on recreational crafts, including the regional Atlantic marina scenario. It is not considered suitable to use the background values for open sea (0,5 µg/L for water and 3,5 µg/g for sediment), since the open sea background concentrations represent areas that are further away from the sources for release of Cu. The background concentrations should be added manually after calculating the steady-state PECs (without background concentrations) in MAMPEC.

PECs for the Norwegian scenario vs. the EU scenario

As an example, PECs for copper (total) calculated using the EU scenario and the Norwegian scenario are shown in the following figure. The basis is an example product with a copper content of 200 g/L, i.e. the same example given in Appendix 1 of the EU scenario. MAMPEC v. 3.1 has been used for the comparison. Background concentrations for copper have been added to the steady-state average PECs calculated in MAMPEC (as described above) to give the resulting PECs shown in the figure.

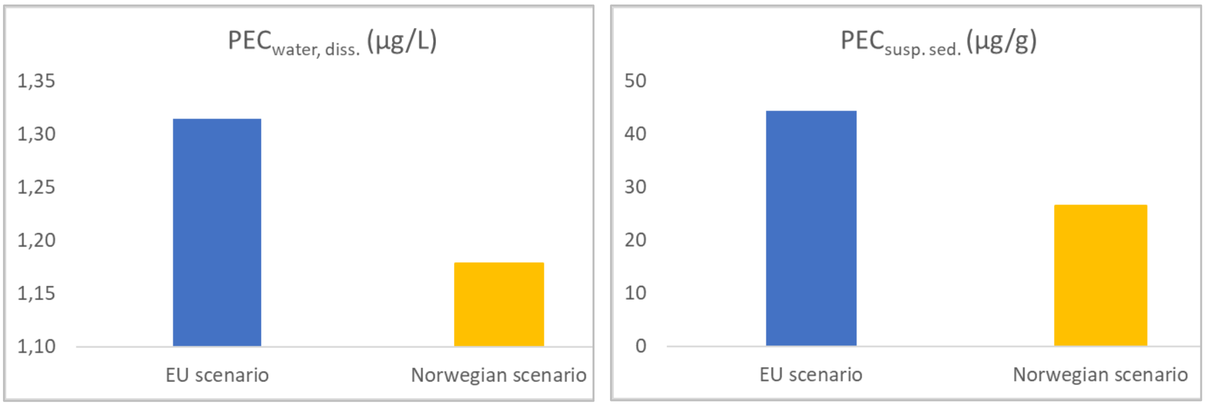


Figure 4. *Comparison between EU scenario and Norwegian scenario: PECs for water and suspended sediment. The calculations were done in MAMPEC v. 3.1. Regarding the EU scenario PEC: The open harbour scenario in v. 3.1 requires you to specify also the surroundings of the open harbour (this was not the case in the previous version 3.0, on which the EU scenario is based). As a simple approach, the length and width of the surrounding area was set to the minimum allowed value of 10 m. The main area (within harbour) was inserted as 300 × 450 m. The PEC value from within the harbour is used for this exercise. For the Norwegian scenario, the PEC is the mean value from two runs where the length and width of the fish farm area have been interchanged – cf. explanation above.*