Methodology

This document describes how the physical disturbance, harmful physical disturbance, and physical loss layers were created.

Physical disturbance and loss

Human activity pressure layers used to create the physical disturbance (including harmful disturbance) and loss were either originally in polygon format or transformed from raster to polygons. The polygon component layers were then merged into a single layer representing total disturbance and loss with the ArcGIS tool Union, resulting in layers where all overlapping, and single, pressures created separate features/polygons. Finally, subbasin and coastal WFD water type information was added, and the area (km^2 and m^2) calculated for each feature.

Component layers for physical disturbance and loss

Here each component layer is described in detail. A summary can be viewed in table 1.

Pressure	**Original format**	**Loss extent (m)**	**Harmful disturbance extent (m)**	**Disturbance extent (m)**	**Data source**	**Year**
Anchorage sites	Polygon	-	Original site polygon	200	Väylävirasto	status 2023
Aquaculture	Point	20	20	100	YLVA	status 2023
Bridges	Line	5	10	50	Väylävirasto (digiroad)	status 2023
Cables	Line	1	-	-	Traficom	status 2021
Dredging	Point & Polygon	Dredged area	10/50/100	50/250/500	Vesty, EPO ELY, Väylävirasto	2017-2022
Disposal sites for dredged material	Point & Polygon	Polygon area or 100 m for points	100	500	Vesty, Väylävirasto	2017-2022
Embankments	Point	5	2	10	Vesty, Metsähallitus	status 2018-2019 (MH) & 2023
Harbours	Polygon	Polygon area	10	50	NLS	status 2023
Land claim	Point	100	2	10	Vesty	status 2022
Leisure boating	Line & point	-	Up to 1 km	Up to 1 km	Väylävirasto, Metsähallitus	status 2018-2019 (MH) & 2023

Marinas & Piers	Line & point	5-20	2-10	10-50	Väylävirasto, Metsähallitus	status 2018-2019 (MH) & 2023
Pipelines	Line	10	-	-	Traficom	status 2023
Sand and gravel extraction	Polygon	Polygon area	100	500	Metsähallitus	status 2023
Ship traffic	Raster	-	Highest density quantile	Highest and second to highest density quantile	HELCOM	2017-2020 mean
Wind power turbines	Point	30	20	100	NLS	status 2023

Table 1. A summary of each component layer for physical disturbance, harmful physical disturbance, and physical loss.

Anchorage sites

Polygon anchorage sites were downloaded from the Väylävirasto map service. The data represents the anchorage site status of 2023. A 200 m buffer was created around each site to represent physical disturbance, though harmful physical disturbance was regarded to be present only at the original, unbuffered, polygons.

Aquaculture

Aquaculture site coordinates were downloaded from the Finnish nature protection report service YLVA. The data represents the aquaculture site status of 2023. Each site was given a 20 m buffer to represent loss, a 20 m buffer around the loss buffer to represent harmful physical disturbance, and a 100 m buffer around the loss buffer to represent physical disturbance.

Bridges

Bridges in line format were extracted from the Väylävirasto dataset Digiroad, which represents the status in 2023. To represent physical loss, 5 m polygon buffers were created around the line data. Physical disturbance and harmful physical disturbance was estimated by creating 50 m and 10 m buffers around the loss polygons, respectively.

Cables

The cables spatial data (line format) was downloaded from the Traficom map service and depicts underwater cables, including telecommunication and electricity cables. The data

represents the status in 2021. To depict physical loss caused by cables, the data was given a 1 m polygon buffer.

Dredging

The dredging data, composed of point data downloaded from the Environmental Administration database Vesty and received from EPO ELY Centre, as well as polygon data downloaded from the Väylävirasto map service, included information on both dredged area (m^2) and amount (m^3), with both having “no data” entries. The point data was gathered by Titta Lahtinen from the VAR ELY Centre. Dredging sites from the years 2017-2021 were selected for the analysis.

For point data, the spatial area dredged was estimated using the m^2 attribute by creating buffers with sizes corresponding to each dredging sites m^2 value. In cases where m^2 information did not exist, m^3 was used to estimate the area. Sites were given a class from 1-3 based on m^3 and whether the site was originally point or polygon. Specifically, all points classified as small-scale dredging that do not require a permit (< 500m^3) were grouped into class 1, 500 – 100 000 m^3 points and polygons became class 2, and points and polygons with m^3 > 100 000 class 3. For each class, the median m^2 (excluding null values) within the class was calculated and this was value was used as m^2 estimates for the sites within each class that were missing m^2 values. These estimates, as well as the Vaylavirasto polygons, were used to represent physical loss from dredging.

To estimate the extent and intensity of physical disturbance, the loss features were used as input in the ArcGIS Cost Distance tool, which, as described in the tool’s description, “Calculates the least accumulative cost distance for each cell from or to the least-cost source over a cost surface.” Each class was used as a separate input. The Finnish marine area, represented as a raster with value 1 for each cell, and land areas as no data, was used as a cost raster. This method enables the consideration of the blocking effects of land areas when calculating the disturbance extent. Class 1 features were given a maximum distance (of effect) of 50 m, class 2: 250 m, and class 3: 500 m. Finally, the values of the cost distance output were reversed, to represent a linear decreasing intensity from the source feature, and each cost distance output (classes 1-3) were normalized (0-1) and merged into a single raster, with overlapping cells receiving the higher of the overlapping values. Harmful physical disturbance was regarded to be 20% of the physical disturbance distance.

Deposit sites for dredged material

The physical disturbance and loss caused by deposit sites for dredged material data was composed of point data downloaded from the environmental administration database Vesty, as well as polygon data downloaded from the Väylävirasto map service. The point data was gathered by Titta Lahtinen from the VAR ELY Centre. Sites from the years 2017-2021 were selected for the analysis.

To represent loss, the polygon data was used as is, and the point data was given a 100 m polygon buffer. To represent physical disturbance, the loss polygons were given an extra 500 m buffer, and a 100 m buffer for harmful physical disturbance.

Embankments

The physical disturbance and loss from embankment dataset is based on point spatial data extracted from the Environmental Administration database Vesty and aerial photo mapping from Metsähallitus (also point data). The Vesty data includes entries up to 2023, the Metsähallitus mapping used images from mainly 2018-2019. The data includes breakwaters, embankments, and other erosion protection constructions. The points were merged into a single layer and given a 5 m polygon buffer to estimate physical loss. To estimate physical disturbance and harmful physical disturbance, the 10 m and 2 m buffers, respectively, were created around the loss polygons.

Harbours

Harbour polygon data was downloaded from SYKE's internal spatial data database. The data is part of the National Land Survey of Finland (NLS) topographic database and represents the harbour status in 2023. For physical loss the polygon data was used as is, for physical disturbance and harmful physical disturbance, 50 m and 10 m buffers respectively.

Land claim

Land claim is based on point data downloaded from the Environmental Administration database Vesty. The data depicts the land claim status in 2022. To represent physical

loss, 100 m polygon buffers were created around the point data. Physical disturbance and harmful physical disturbance was estimated by creating 10 m and 2 m buffers around the loss polygons, respectively.

Leisure boating

Physical disturbance to seabed was estimated using pier line data downloaded from Väylävirasto map service, and Marina sites point data produced by Metsähallitus via aerial image interpretation (produced in 2020, aerial images primarily from 2018-2019). The pier data was transformed into point data (centre of line) and used as input in the ArcGIS Kernel density tool. Each pier within 100 m of a marina was given a Kernel density population value of 3, with others piers receiving a value of 1, to account for the presumed higher traffic at marinas compared to private piers. Kernel density search radius was set at 1 km. The output was then weighted according to depth (Source: VELMU):

0-10 m= 1 (100%)
10-15 m= 0,5 (50%)
15-20 m= 0,25 (25%)
20-25 m= 0,1 (10%)
25m < = 0 (0%)

Finally, the raster was classified into three classes according to natural breaks, and the two highest classes were selected to represent physical disturbance and the highest class harmful physical disturbance.

Marinas and piers

Pier data in line format was downloaded from the Väylävirasto map service (represent status in 2023) and supplemented with pier and marina point data from Metsähallitus aerial photo mapping (photos primarily from 2018-2019). To represent physical loss, the point received either 20 m or 5 m buffers, depending on if they were classified by Metsähallitus as large or small. As line length already represents pier size, all lines received a 5 m loss buffer. To represent physical disturbance, points classified as small and all lines received 10 m buffers, while large piers received 50 m buffers. For harmful physical disturbance small piers and all lines received 2 m buffers and large piers received 10 m buffers.

Pipelines

The pipelines spatial data (line format) represents the status in 2023 and was downloaded from the Traficom map service. The data depicts pipelines, including gas, water, and sewage pipelines. To depict physical loss caused by cables, the data was given a 10 m polygon buffer.

Sand and gravel extraction

Metsähallitus produced sand and gravel extraction site polygon data was downloaded from SYKE's internal spatial data database and sites designated as active in 2023 according to Metsähallitus' kaivannaiset.fi site were selected. For loss, the polygons were used as were, for physical disturbance 500 m buffers were created and for harmful physical disturbance 100 m buffers.

Ship traffic

HELCOM AIS based mean ship traffic density raster data, all ship types, from 2017–2020 was used to estimate physical disturbance caused by shipping. The mean density value for the time period was calculated and weighted according to depth (Source: VELMU):

0-10 m= 1 (100%)
10-15 m= 0,5 (50%)
15-20 m= 0,25 (25%)
20-25 m= 0,1 (10%)
25m < = 0 (0%)

Lastly, the raster was log transformed and divided into three quantiles, of which the middle quantile was regarded to cause physical disturbance, and the highest quantile harmful physical disturbance.

Wind power turbines

Wind power turbine site point data that represents the status in 2023 was downloaded from SYKE's internal spatial data database. The data is part of the National Land Survey

of Finland (NLS) topographic database. For the analysis, the offshore wind power sites at Tahkoluoto and the wind power sites on artificial island at Ajos wind park were selected. To represent physical loss, 30 m buffers were created around the points, and 100 m and 20 m buffers were created around the loss buffers to represent physical disturbance and harmful physical disturbance, respectively.