

NOOS Activity

Exchange of computed water, salt, and heat transports across selected transects



Project Aims	<p>Transports across certain transects constitute a measure of the current hydrodynamic situation. The knowledge of computed transports is also of great value to assess the dispersion of pollutants or the development of ecological parameters.</p> <p>The exchange of transport data between operational forecaster and users will serve several purposes:</p> <ol style="list-style-type: none"> 1. Data from different models could be used for a better characterization of the current hydrodynamic situation. 2. Data from different models can be used for a model intercomparison. 3. Data from other models than the own could be used for forcing one's own model at its open boundaries. 4. Predicted model data can be compared with transports derived from measurements (if available).
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How to compute the transports?

- 1 Define transects (given in Figures 1 & 2 and Table 1 & 2) for your grid taking into account the grid type (e.g. Arakawa C). All transects should start or end at the coast. As the discretisation of topography is different in every model, please check if the transects start/end at the coast. In case of connected transects, please be sure that you do not have any overlapping grid points or gaps in the transects.
- 2 For every grid cell (grid box) on the transect, calculate the normal component of water, salt, and heat transports. The direction of positive transports is given by the arrows in figures 1 & 2.

Note: For most members, the transects will be either parallel or orthogonal to their grid axis. In that case the normal velocity will be in the x- or y-direction. In case of the 'oblique' transects, normal velocities could be computed explicitly for each grid cell (e.g. done by IMR) or alternating u- and v-velocities should be used on the transect.

Calculate normal components of:

water transport [m³/s]:

$$tr_n = u_n * dx * h$$

with u_n normal component of velocity
 dx grid spacing
 h layer thickness at position of normal velocity

heat transport [J/s = W]:

$$q_n = tr_n * c_p * \rho * T$$

with c_p heat capacity of ocean = 4.190*10³ J/kg/K
 ρ density of water (~1026 kg/m³)
 T temperature in K

salt transport [kg/s]:

$$st_n = tr_n * S * 10^{-3} * \rho$$

with S salinity (= g salt per 1 kg sea water)

- 3 Calculate tidal mean values of normal transports for each grid cell. The integration period is 24.8 hours in order to take into account the diurnal inequality. The integration interval should be centred around midday.

e.g. $\overline{tr_n} = \int_P tr_n dt$

..... ..

with dt time increment
 P 2 tidal periods (~24.8 h)

- 4 Calculate inflow and outflow by summing up all negative and positive transports of grid cells on the transect. In a first step use your own model layers.

$$tr_{n\ pos} = \sum_T tr_{n\ pos} \quad tr_{n\ neg} = \sum_T tr_{n\ neg}$$

$$q_{n\ pos} = \sum_T q_{n\ pos} \quad q_{n\ neg} = \sum_T q_{n\ neg}$$

$$st_{n\ pos} = \sum_T st_{n\ pos} \quad st_{n\ neg} = \sum_T st_{n\ neg}$$

- 5 Calculate net transports:

$$tr_{n\ net} = tr_{n\ pos} + tr_{n\ neg}$$

$$q_{n\ net} = q_{n\ pos} + q_{n\ neg}$$

$$st_{n\ net} = st_{n\ pos} + st_{n\ neg}$$

- 6 Calculate vertically integrated transports by integrating positive, negative and net transports using your own model layer data.
- 7 Calculate transports for 'NOOS layers'. The NOOS layers are fixed levels in the z-coordinate system with mean (undisturbed) water level as reference level 0. The first layer includes the variable surface fluctuation ζ .

Definition of 'NOOS layers':	layer 1	ζ -10m	(or ζ – bottom)
	layer 2	10-20m	(or 10m – bottom)
	layer 3	20-30m	(or 20m – bottom)
	layer 4	30-40m	(or 30m – bottom)
	layer 5	40-50m	(....)
	layer 6	50-75m	(....)
	layer 7	75-100m	(....)
	layer 8	100-150m	(....)
	layer 9	150-200m	(....)
	layer 10	200-800m	(....)

Note: In the bottom layer the lower level is the maximum depth of the transect which is normally less than the lower level of the layer. Different models may have different numbers of NOOS levels.

- 8 For every day, write a file 'tr_yyyymmdd_inst' (e.g. tr_20040213_bsh) containing all transports for all transects.

with yyyy year
 mm month
 dd day
 inst institution

Format description:

Write for all 29 transects in:

first line:

```
write(iweg, '(a10,a12,i3,a17,i3)')date(1:10),  
+ ' Transect:',itr,' No. of layers:',ktra(itr)
```

with date = yyyy.mm.dd
 itr = no. of transect
 ktra(itr) = number of layers for each transect

Output in second line: vertically integrated transports (= total mean transport)

```
write(itweg, '(9e12.4E2)')(water(i3),i3=1,3),  
+ (heat(i3),i3=1,3),(salt(i3),i3=1,3)
```

with i3=1: net water, heat and salt transport
 i3=2: positive water, heat and salt transport
 i3=3: negative water, heat and salt transport

Output in next 1 to ktra(itr) lines: transports for each NOOS layer

```
do k=1,ktra(itr)  
write(itweg, '(9e12.4E2)')(water_k(i3,k),i3=1,3),  
+ (heat_k(i3,k),i3=1,3),(salt_k(i3,k),i3=1,3)  
enddo
```

with i3=1: net water, heat and salt transport for layer k
 i3=2: positive water, heat and salt transport for layer k
 i3=3: negative water, heat and salt transport for layer k

Example of BSH model output for transects 3 to 5:
(from file 'tr_20040213_bsh'):

```
2004.02.13 Transect: 3 No. of layers: 0
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
2004.02.13 Transect: 4 No. of layers: 8
0.2867E+06 0.4486E+06 -0.1619E+06 0.3398E+15 0.5379E+15 -0.1980E+15 0.4498E+07 0.1374E+08 -0.9245E+07
0.2916E+05 0.5846E+05 -0.2930E+05 0.3450E+14 0.7010E+14 -0.3560E+14 0.4767E+06 0.1872E+07 -0.1395E+07
0.4890E+05 0.6632E+05 -0.1742E+05 0.5830E+14 0.7952E+14 -0.2123E+14 0.1208E+07 0.2112E+07 -0.9041E+06
0.4769E+05 0.6177E+05 -0.1407E+05 0.5689E+14 0.7401E+14 -0.1712E+14 0.1200E+07 0.1885E+07 -0.6853E+06
0.4166E+05 0.5461E+05 -0.1295E+05 0.4968E+14 0.6543E+14 -0.1575E+14 0.1023E+07 0.1657E+07 -0.6349E+06
0.4166E+05 0.5461E+05 -0.1295E+05 0.4968E+14 0.6543E+14 -0.1575E+14 0.1023E+07 0.1657E+07 -0.6349E+06
0.4662E+05 0.6940E+05 -0.2277E+05 0.5519E+14 0.8325E+14 -0.2806E+14 0.5477E+06 0.2093E+07 -0.1545E+07
0.4662E+05 0.6940E+05 -0.2277E+05 0.5519E+14 0.8325E+14 -0.2806E+14 0.5477E+06 0.2093E+07 -0.1545E+07
-0.1562E+05 0.1409E+05 -0.2971E+05 -0.1961E+14 0.1687E+14 -0.3647E+14 -0.1527E+07 0.3734E+06 -0.1901E+07
2004.02.13 Transect: 5 No. of layers: 10
-0.3488E+06 0.1117E+06 -0.4605E+06 -0.4223E+15 0.1339E+15 -0.5562E+15 -0.1483E+08 0.3272E+07 -0.1810E+08
-0.4635E+04 0.4191E+04 -0.8826E+04 -0.5684E+13 0.4988E+13 -0.1067E+14 -0.3058E+06 0.9567E+05 -0.4015E+06
0.5756E+03 0.6099E+04 -0.5523E+04 0.5684E+12 0.7264E+13 -0.6695E+13 -0.1244E+06 0.1482E+06 -0.2727E+06
0.2156E+03 0.7438E+04 -0.7223E+04 0.1435E+12 0.8868E+13 -0.8725E+13 -0.1319E+06 0.1882E+06 -0.3200E+06
-0.6515E+02 0.7838E+04 -0.7903E+04 -0.1842E+12 0.9346E+13 -0.9530E+13 -0.1330E+06 0.1966E+06 -0.3296E+06
-0.6515E+02 0.7838E+04 -0.7903E+04 -0.1842E+12 0.9346E+13 -0.9530E+13 -0.1330E+06 0.1966E+06 -0.3296E+06
-0.9927E+04 0.2391E+05 -0.3383E+05 -0.1216E+14 0.2870E+14 -0.4086E+14 -0.6338E+06 0.7263E+06 -0.1360E+07
-0.9927E+04 0.2391E+05 -0.3383E+05 -0.1216E+14 0.2870E+14 -0.4086E+14 -0.6338E+06 0.7263E+06 -0.1360E+07
-0.7026E+05 0.3045E+05 -0.1007E+06 -0.8510E+14 0.3665E+14 -0.1217E+15 -0.2962E+07 0.9943E+06 -0.3956E+07
-0.1200E+06 0.0000E+00 -0.1200E+06 -0.1449E+15 0.0000E+00 -0.1449E+15 -0.4679E+07 0.0000E+00 -0.4679E+07
-0.1348E+06 0.0000E+00 -0.1348E+06 -0.1626E+15 0.0000E+00 -0.1626E+15 -0.5094E+07 0.0000E+00 -0.5094E+07
```

9 Compress your daily output file (e.g. using gzip) and put the *.gz-file on your ftp server.

Transports computed by the BSH model can be found on the anonymous ftp server: <ftp.bsh.de>

in directory: `outgoing/opmodel/v4/transports`

10 Please send an email to stephan.dick@bsh.de

with URL (and password?) of your data

APENDIX A

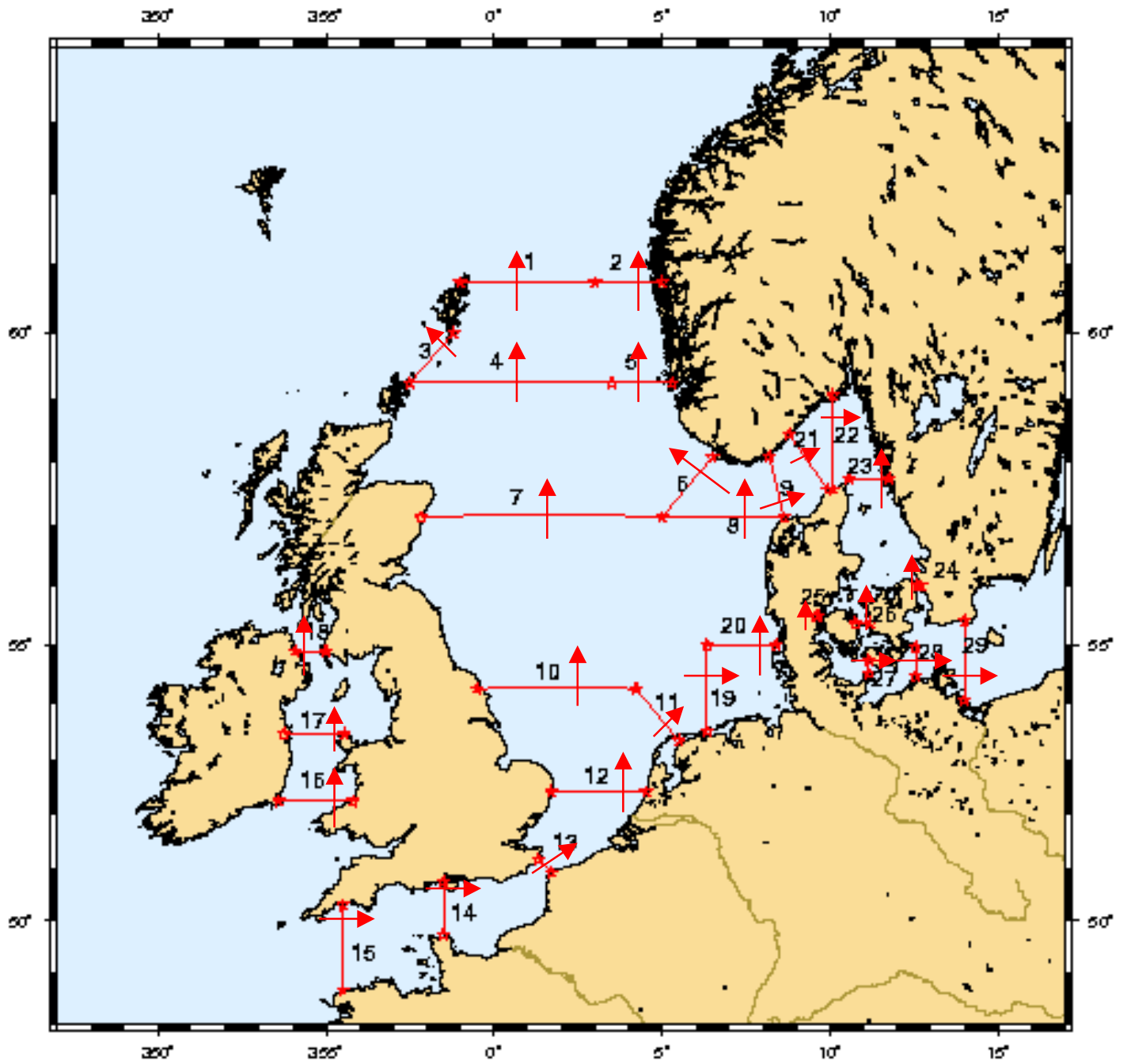


Fig. 1: Position of NOOS transects

→ Direction of positive transports

NOOS transects

No.	Transect	From		To		Measurements available?
		Latitude	Longitude	Latitude	Longitude	
1	Shetland N	60°41' N	0°55' W	60°41' N	3°00' E	Transect 'Feie-Shetland' (N)
2	Sognesjoen	60°41' N	3°00' E	60°41' N	6°00' E	Transect 'Feie-Shetland' (N)
3	Shetland S	59°55' N	1°15' W	59°17' N	2°30' W	
4	Orkney	59°17' N	2°30' W	59°17' N	3°20' E	Transect 'Utsira' (N)
5	Utsira	59°17' N	3°20' E	59°17' N	6°30' E	Transect 'Utsira' (N)
6	Lista	58°10' N	6°32' E	57°08' N	5°00' E	Station 'Lista' (N)
7	Aberdeen	57°08' N	2°15' W	57°08' N	5°00' E	Transect 'Hansthalm-Aberdeen' (N)
8	Hansthalm W	57°08' N	5°00' E	57°08' N	8°40' E	Transect 'Hansthalm-Aberdeen' (N)
9	Okso	57°08' N	8°38' E	58°07' N	8°10' E	Transect 'Oksoe-Hansthalm' (N)
10	Flamborough Hd.	54°15' N	0°35' W	54°15' N	4°14' E	
11	Terschelling	54°15' N	4°14' E	53°15' N	5°30' E	Transect 'Terschelling' (NL)
12	Noordwijk	52°25' N	1°40' E	52°25' N	4°35' E	Transect 'Noordwijk' (NL)
13	Dover Strait	51°10' N	1°20' E	50°55' N	1°42' E	
14	Cherbourg	50°40' N	1°25' W	49°45' N	1°25' W	
15	Plymouth	50°25' N	4°25' W	48°35' N	4°25' W	
16	Rosslare	52°17' N	6°10' W	52°17' N	5°00' W	
17	Dublin-Holyhead	53°27' N	6°20' W	53°27' N	4°35' W	
18	Larne	54°53' N	5°30' W	54°53' N	5°00' W	
19	Rottumerplaat	53°15' N	06°20' E	55°00' N	06°20' E	Transect 'Rottumerplaat' (NL), Station 'NSB II' + 'Ems' (D)
20	Sylt	55°00' N	06°20' E	55°00' N	08°40' E	Station 'NSB II' (D)
21	Torungen-Hirtshals	57°33' N	9°58' E	58°30' N	8°45' E	Transect 'Torungen-Hirtshals' (NL)
22	Skagerrak	57°33' N	10°05' E	59°10' N	10°05' E	FerryBox transect R2 (NL)
23	Kategatt	57°45' N	10°30' E	57°45' N	11°50' E	Station 'Läsö Rende' (DK)
24	Oresund	56°01' N	12°34' E	56°01' N	12°44' E	Station 'Drogden' (DK)
25	Little Belt	55°32' N	9°42' E	55°32' N	9°48' E	
26	Great Belt	55°22' N	10°45' E	55°22' N	11°14' E	Station 'W26' (DK)
27	Fehmarn Belt	54°30' N	11°09' E	54°45' N	11°09' E	Station 'Fehmarn Belt' (D)
28	Darss Sill	54°26' N	12°33' E	54°58' N	12°33' E	Station 'Darsser Schwelle' (D)
29	Arkona Basin	54°00' N	14°00' E	55°30' N	14°00' E	Station 'Arkona Becken' + Station 'Oder Bank' (D)

Table 1

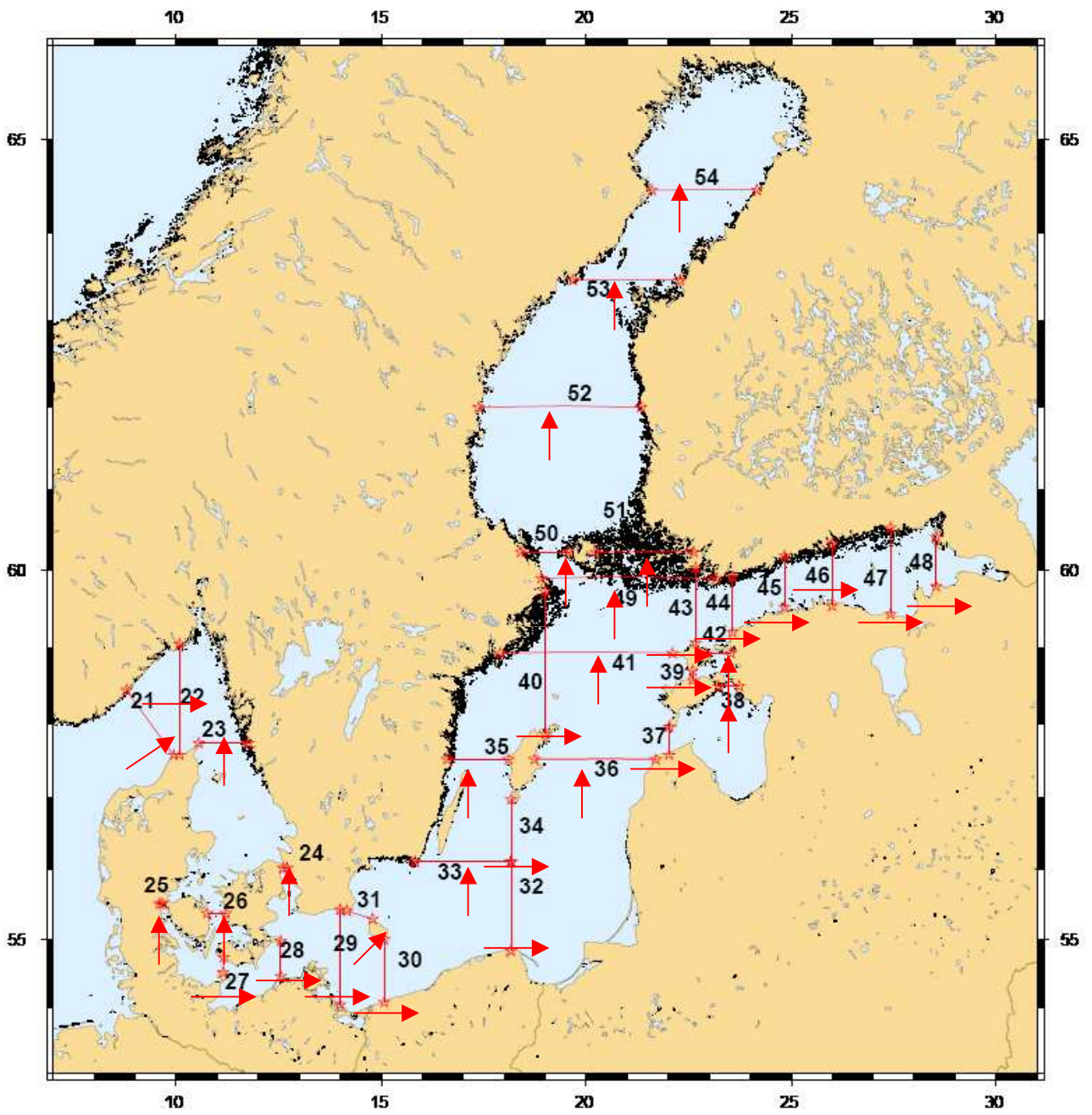


Fig. 2

Position of BOOS transects



Direction of positive transports

BOOS transects

No.	Transect	From		To		Measurements available?
		Latitude	Longitude	Latitude	Longitude	
22	Skagerrak	57°33' N	10°05' E	59°10' N	10°05' E	FerryBox transect R2 (NL)
23	Kategatt	57°45' N	10°30' E	57°45' N	11°50' E	Station 'Läsö Rende' (DK)
24	Oresund	56°01' N	12°34' E	56°01' N	12°44' E	Station 'Drogden' (DK)
25	Little Belt	55°32' N	9°42' E	55°32' N	9°48' E	
26	Great Belt	55°22' N	10°45' E	55°22' N	11°14' E	Station 'W26' (DK)
27	Fehmarn Belt	54°30' N	11°09' E	54°45' N	11°09' E	Station 'Fehmarn Belt' (D)
28	Darss Sill	54°26' N	12°33' E	54°58' N	12°33' E	Station 'Darsser Schwelle' (D)
29	Arkona Basin	54°00' N	14°00' E	55°30' N	14°00' E	Station 'Arkona Becken' + Station 'Oder Bank' (D)
30	Bornholm S	55°00' N	15°04' E	54°05' N	15°04' E	
31	Bornholm N	55°17' N	14°47' E	55°24' N	14°10' E	
32	Slupsk Sill	54°50' N	18°10' E	56°06' N	18°10' E	
33	Middlebank	56°06' N	18°10' E	56°06' N	15°50' E	
34	Gotland S	56°06' N	18°10' E	56°58' N	18°10' E	
35	Gotland W	57°31' N	16°36' E	57°31' N	18°06' E	
36	Gotland E	57°31' N	18°44' E	57°31' N	21°42' E	
37	Gulf of Riga W	57°35' N	22°01' E	57°58' N	22°01' E	
38	Gulf of Riga N	58°30' N	23°14' E	58°30' N	23°44' E	
39	Saaremaa N	58°35' N	22°36' E	58°42' N	22°36' E	
40	Gotland N	57°52' N	19°00' E	59°44' N	19°00' E	
41	Stockholm W	58°56' N	17°54' E	58°56' N	22°06' E	
42	Hiiumaa E	58°56' N	22°55' E	58°56' N	23°32' E	
43	Hiiumaa - Hanko	59°04' N	22°40' E	60°02' N	22°40' E	
44	Gulf of Finland W	59°12' N	23°34' E	59°55' N	23°34' E	
45	Tallinn - Helsinki	59°32' N	24°50' E	60°11' N	24°50' E	
46	Vergi - Porvoo	59°33' N	26°00' E	60°20' N	26°00' E	
47	Ontika - Hamina	59°27' N	27°25' E	60°32' N	27°25' E	
48	Neva Bight	59°48' N	28°32' E	60°25' N	28°32' E	
49	Baltic Proper N	59°54' N	18°54' E	59°54' N	23°10' E	
50	Aland W	60°14' N	18°24' E	60°14' N	19°34' E	
51	Aland E	60°14' N	20°13' E	60°14' N	22°37' E	
52	Bothnian Sea	62°00' N	17°22' E	62°00' N	21°20' E	
53	Kvarken	63°28' N	19°40' E	63°28' N	22°17' E	
54	Bothnian Bay	64°28' N	21°36' E	64°28' N	24°10' E	

Table 2