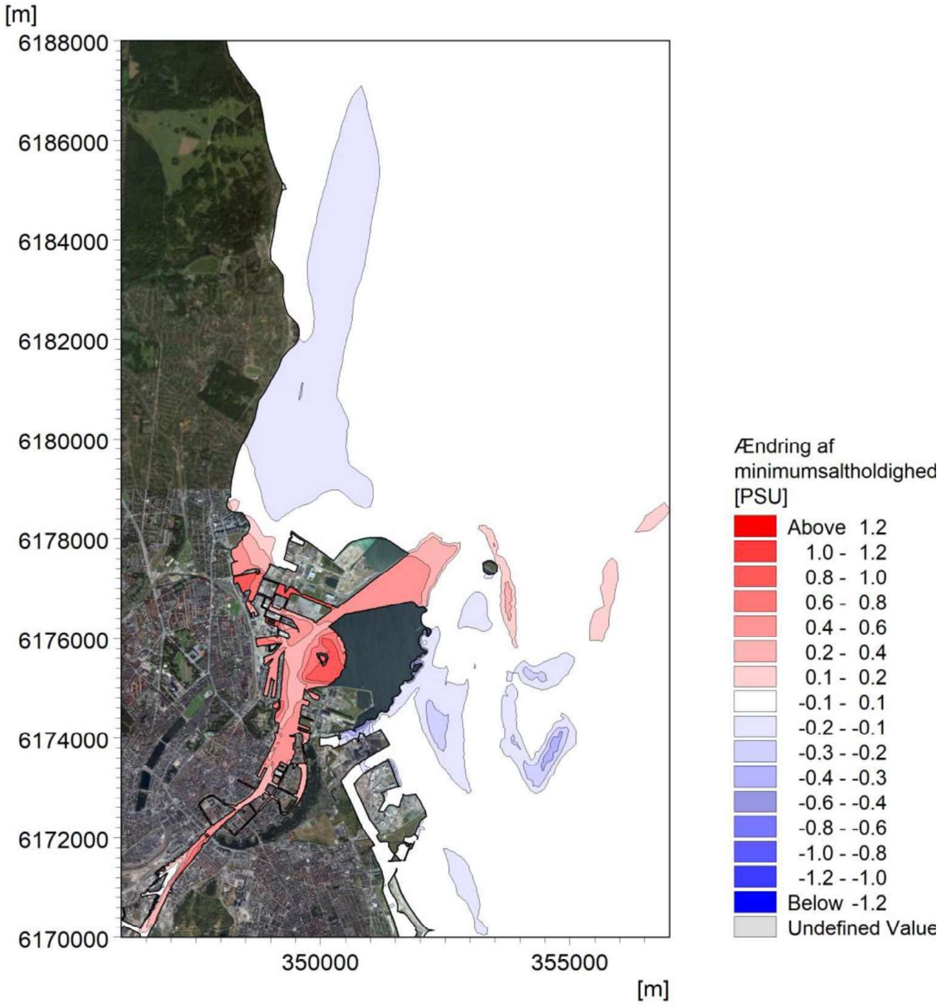


Figure 6-85 Calculated change of minimum salinity for Main Proposal 2.

6.1.5 Assessment of changed wave conditions

To assess the impact of the two main proposals on wave conditions locally and along the surrounding coasts, a full year of waves has been simulated in Øresund so that all seasonal variations are represented. It has been chosen to model the year 2018, as this year is modelled in detail for the hydrodynamic conditions, and the analysis therefore creates an overall picture of the conditions.

The assessment of the changes in wave conditions is made as a comparative analysis. At first, the existing conditions are modelled (baseline) and subsequently compared to the future conditions based on the two main proposals. Any changes have been identified, quantified, and commented on.

Since there are sandy beaches both to the north of the project area (Charlottenlund, Hellerup and Svanemøllen) and to the south of the project area (Amager Beach), any impacts are of interest, as changes in wave fields, and especially the incoming wave directions, can cause changes of the littoral transport conditions.

Figure 6-86 and Figure 6-103 show the locations of the points where wave data have been extracted and analysed on a map with Main Proposal 1 (layout without coastal landscape) and Main Proposal 2 (coastal layout) marked, respectively. Points 1 to 3 are north of the project area, and in particular, points 1 and 2 must not be affected, as this will impact the northern beaches (Svanemøllen and Hellerup). Points 4 to 8 are next to the project area and Prøvestenen. In these points, the coast is protected by hard constructions such as sheet pile walls and rubble mound protection, so any changes will not have significant consequences. Points 9 and 10 are located off Amager Beach, and changes in wave conditions will thus have an impact on this beach.

In addition to the 10 points, two points have been analysed in the entrance between Nordhavn and Lynetteholm. The wave conditions in the funnel between Nordhavn and Lynetteholm will depend on how the protection along the northern edge of Lynetteholm is carried out. This analysis is based on the assumption that the north side of Lynetteholm is carried out correspondingly to Nordhavn as a sheet wall reflecting the amost all of the wave energy. If the perimeter is constructed to absorb parts of the wave energy in the funnel, the wave heights will be smaller than those found here.

6.1.5.1 Main proposal 1 - layout without coastal landscape

Main Proposal 1 is characterised by a convex design of the eastern perimeter. The design is made to lead the current from Kongedybet around the reclamation in a natural connection with the tip of the Nordhavn reclamation.

Figure 6-86 Analysed points in the wave analysis of Main Proposal 1.

Figure 6-87 and Figure 6-88 show waves, for the outer (ydre) and the inner (indre) points in the funnel for the present situation and for Main Proposal 1, respectively. For both the outer and inner points, it can be seen that the reflecting boundaries lead to intensification and amplification of the waves. In addition, the effect of Lynetteholm is seen as a shadow effect for southern and south-eastern wave directions so that virtually all the waves in the funnel will come from an east-northeast direction. In the outermost part of the funnel, the waves will refract around the corner of Lynetteholm, and the period during which the waves exceed 25 cm is much the same as in the current scenario. Figure 6-88 shows that Lynetteholm, despite the intensification of wave height, will act as shelter, thus causing the waves to exceed 25 cm less often. For Main Proposal 1, the significant wave height only exceeds 25 cm for 18% of the time, compared to 28% of the time with the present conditions.

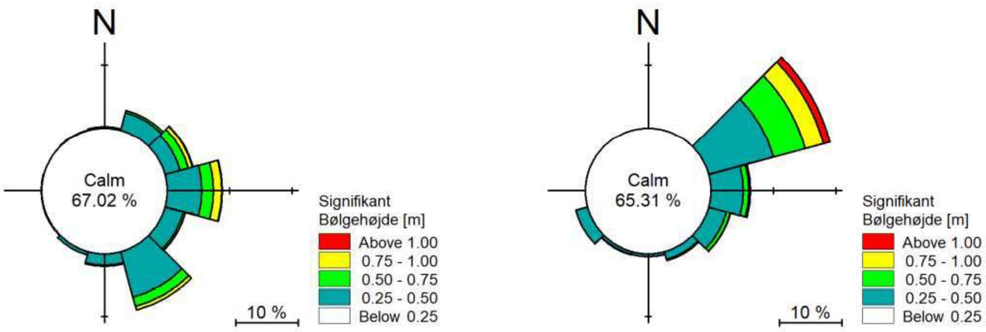


Figure 6-87 Outer funnel, wave roses for the present conditions and Main Proposal 1.

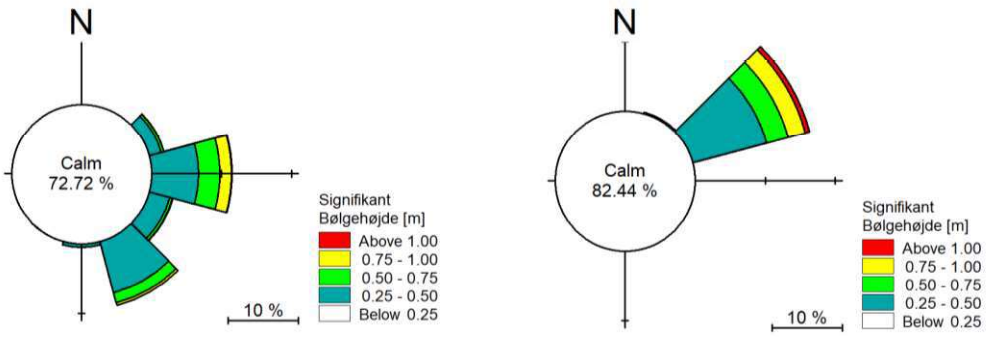


Figure 6-88 Inner funnel, wave roses for the present conditions and Main Proposal 1.

Figure 6-89 to Figure 6-91 show wave heights and wave direction (coming from) for points 1 to 3 before and after the Main Proposal 1 reclamation of Lynetteholm. The wave directions are divided into 30-degree segments. The three figures show no significant changes. The dominant wave direction is directly east with some wave incidence from the north/northeast and for the Nordhavn point also from the southeast.

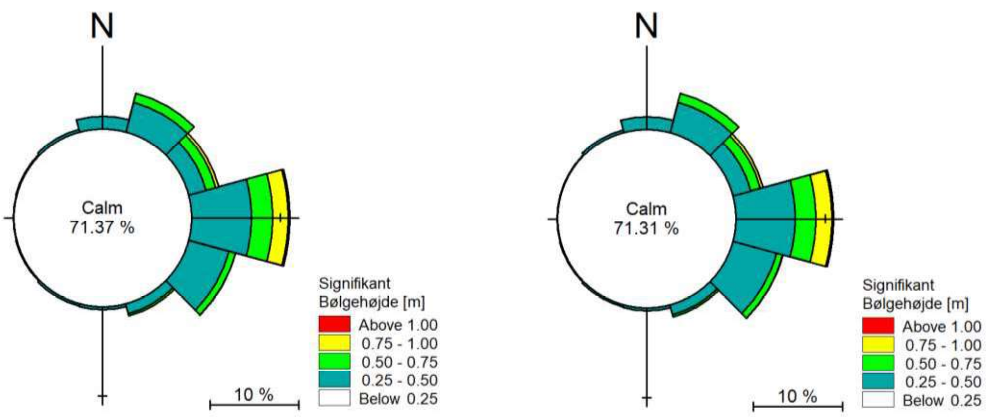


Figure 6-89 Waves roses for the present conditions (left) and Main Proposal 1 (right) for point 1, Charlottenlund.

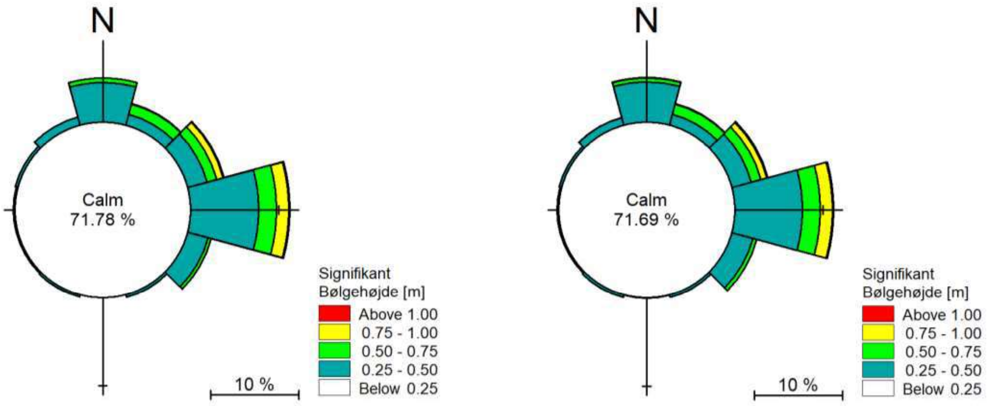


Figure 6-90 Waves roses for the present conditions (left) and Main Proposal 1 (right) for point 2, Hellerup.

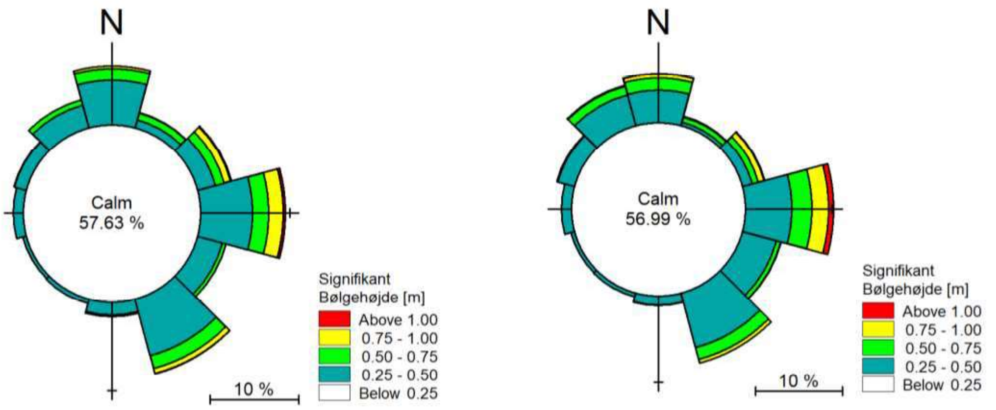


Figure 6-91 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 3, Nordhavn.

Figure 6-92 and Figure 6-93 show the wave condition off Lynetteholm before and after the Main Proposal 1 reclamation. For the two points, there is only an smal effect in the waves from the south, as Lynetteholm creates a shadow effect for this direction. However, the southern waves are already very small, so the effects will also be minor.

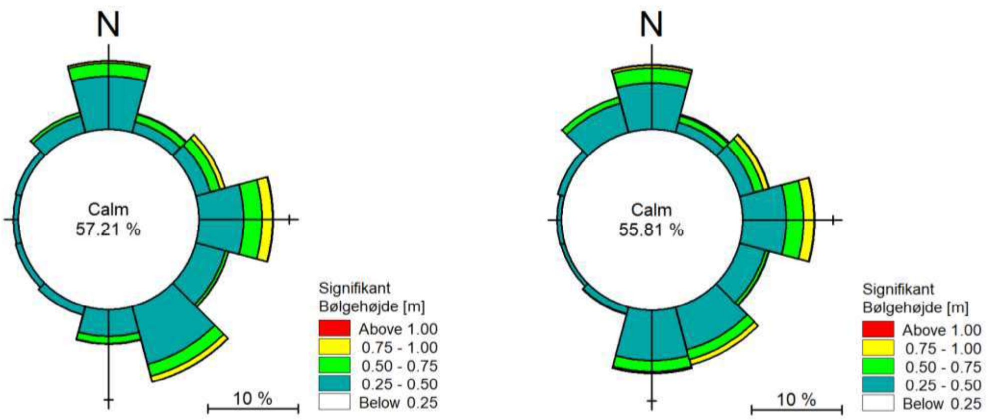


Figure 6-92 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 4, Lynetteholm North.

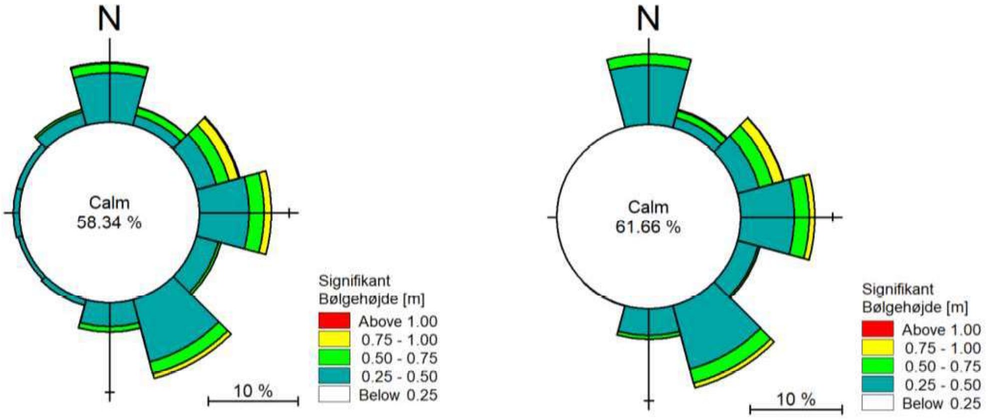


Figure 6-93 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 5, Central Lynetteholm.

Figure 6-94 to Figure 6-96 show the wave conditions south of Lynetteholm. As there is a shadow effect from the north, the waves from the north are seen to occur more rarely and become smaller. There are no visible effects for waves coming from eastern and southern directions.

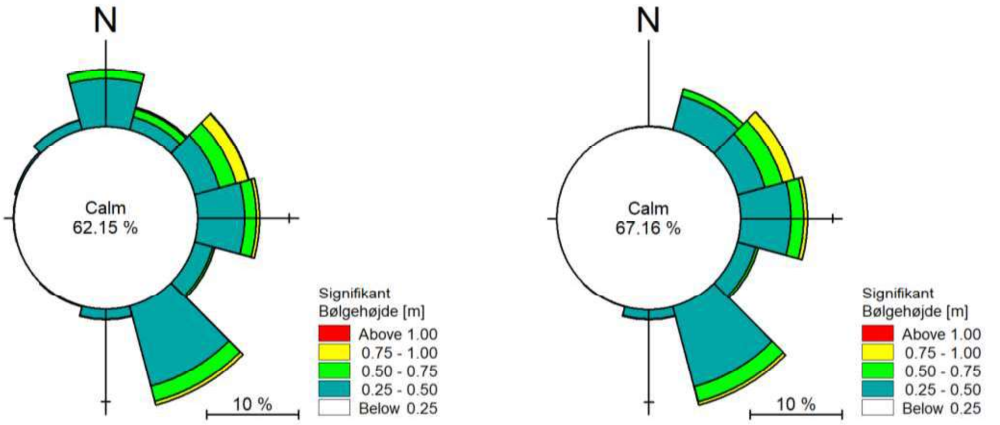


Figure 6-94 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 6, Lynetteholm South.

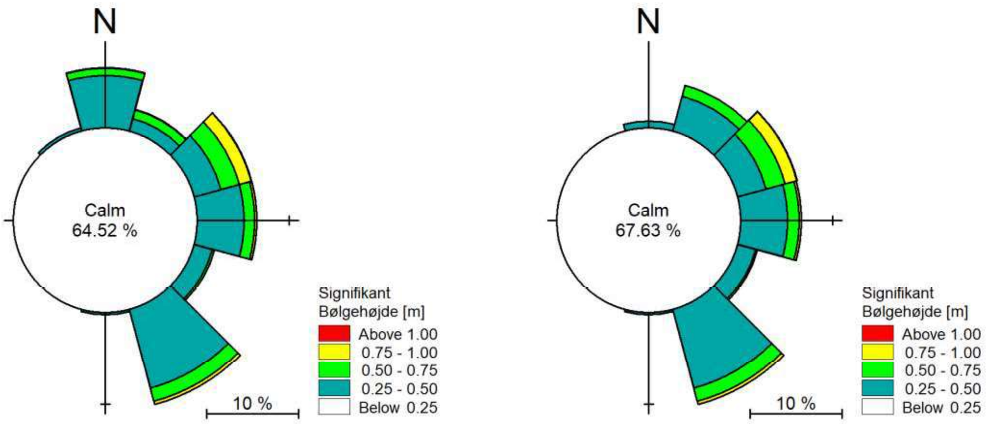


Figure 6-95 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 7, Prøvestenen North.

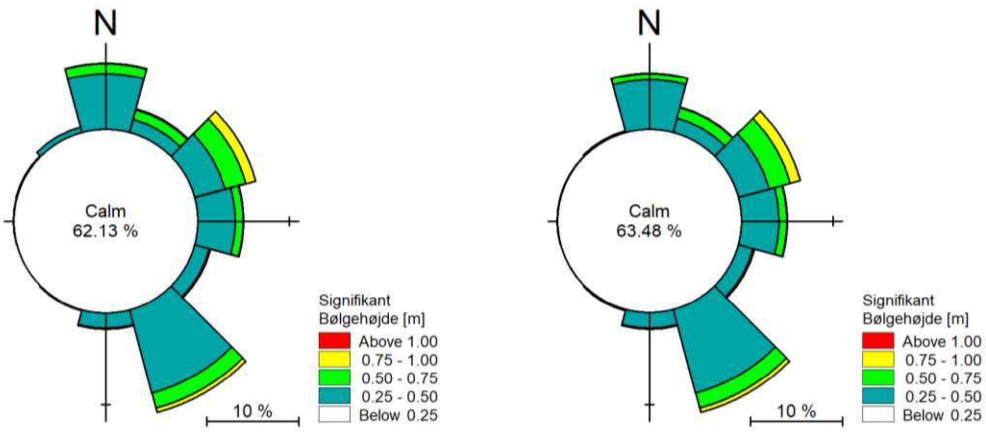


Figure 6-96 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 8, Prøvestenen South.

Figure 6-97 and Figure 6-98 show the critical points off Amager Beach. The figures show that the shadow effect has decreased so that off the beach, there is no visible effect of Lynetteholm.

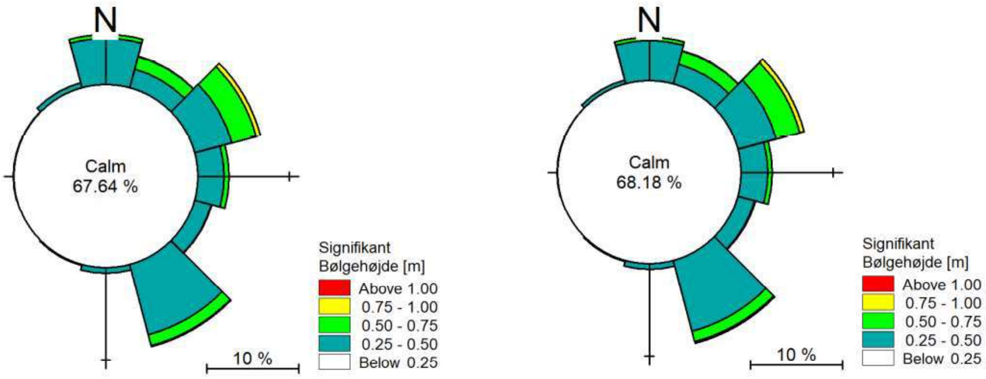


Figure 6-97 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 9, Amager Beach North.

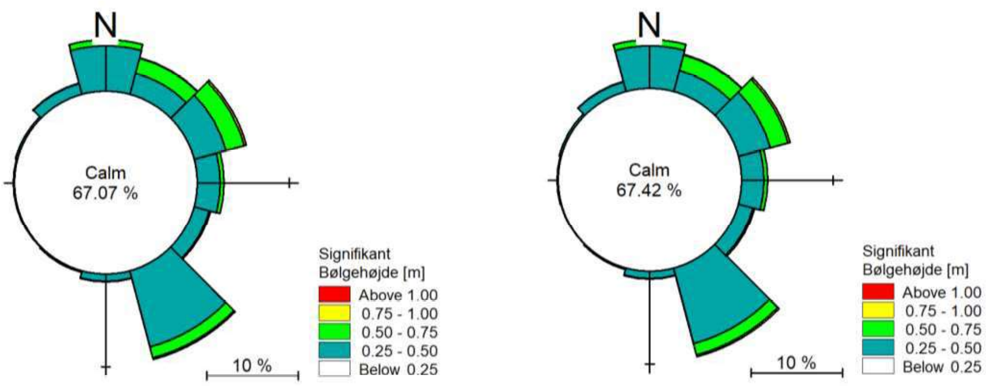


Figure 6-98 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 10, Amager Beach South.

Figure 6-99 to Figure 6-101 show the contours of the changes in wave height caused by the project. Figure 6-99 shows changes in the mean wave height, which are concentrated around the eastern corner of the Nordhavn reclamation, where wave heights are generally more significant and around Lynetteholm, where wave heights are lower on average.

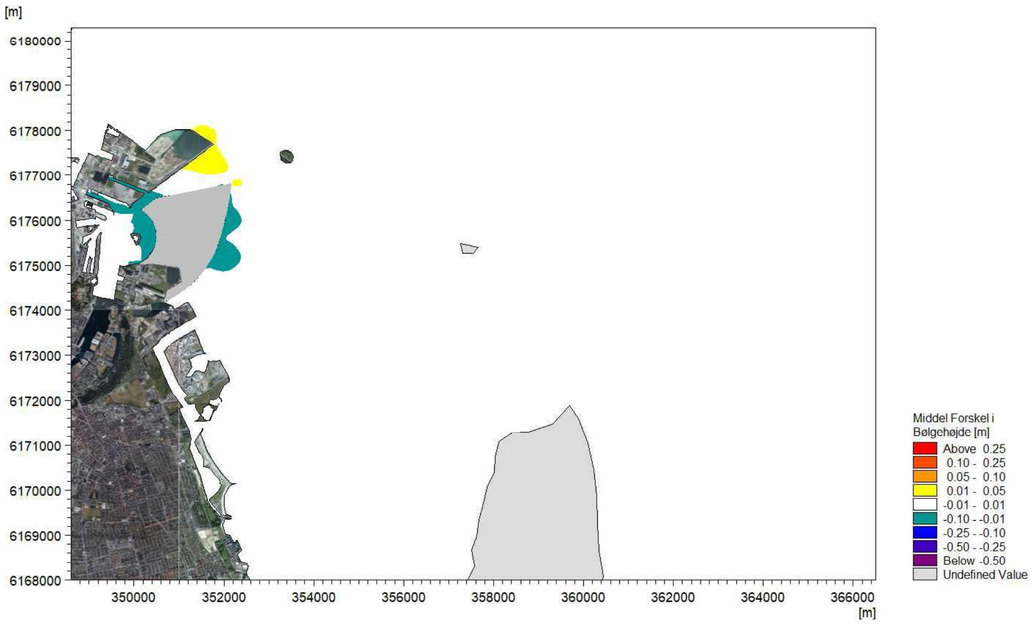


Figure 6-99 Changes in the average annual wave height caused by Main Proposal 1.

Figure 6-100 shows the maximum decrease in the significant wave height created by the Main Proposal 1 reclamation. The most significant reduction of wave heights occurs between Lynetteholm and Trekroner. Today, the waves on the Øresund side have unhindered access and will be completely cut off in the future. In addition, the shadow effect from the reclamation appears both north and south of Lynetteholm, where there is a decrease in significant wave height of up to 50 cm. In addition, reductions of between 1 and 10 cm occur between Amager and Saltholm.

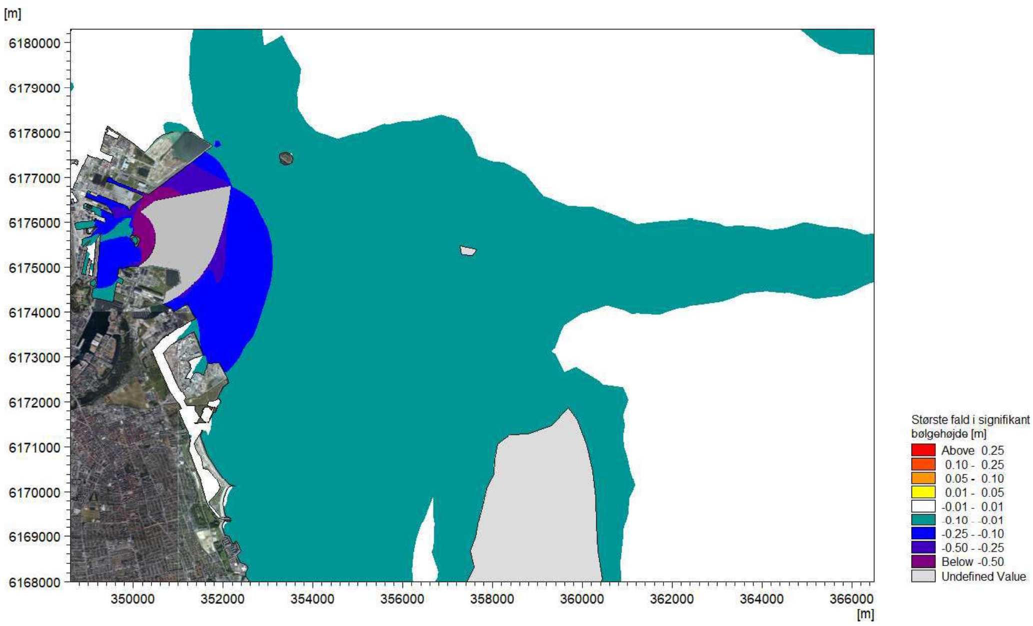


Figure 6-100 Maximum reduction in significant wave height.

Figure 6-101 shows the maximum increase in wave heights created by the Main Proposal 1 reclamation. Here is an apparent intensification of the waves in the entrance between Lynetteholmen and Nordhavn of more than 25 cm. In addition, significant increases are seen north of Nordhavn's eastern corner.

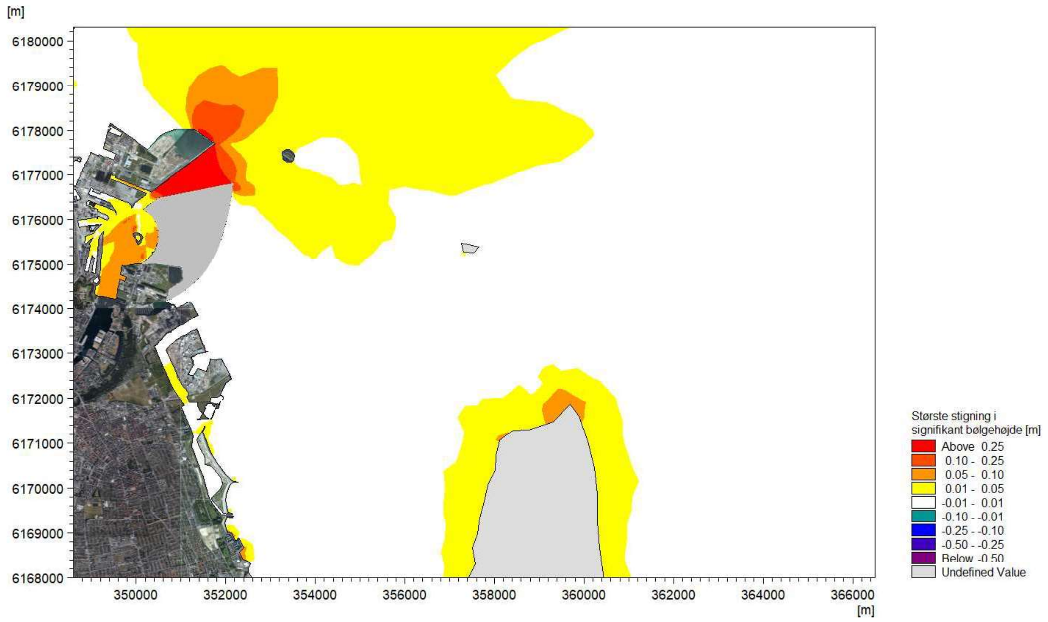


Figure 6-101 Maximum increase in significant wave height.

Figure 6-102 shows the main directions of the incoming waves for the baseline and Main Proposal 1, respectively, of the Lynetteholm reclamation. The main direction indicates the mean direction of the incoming wave energy. As concluded based on the wave roses presented above, changes in size and direction from Nordhavn to Prøvestenen are seen, but neither north of Nordhavn nor off Amager beach, where the sandy beaches are sensitive to changes in the incoming wave conditions.

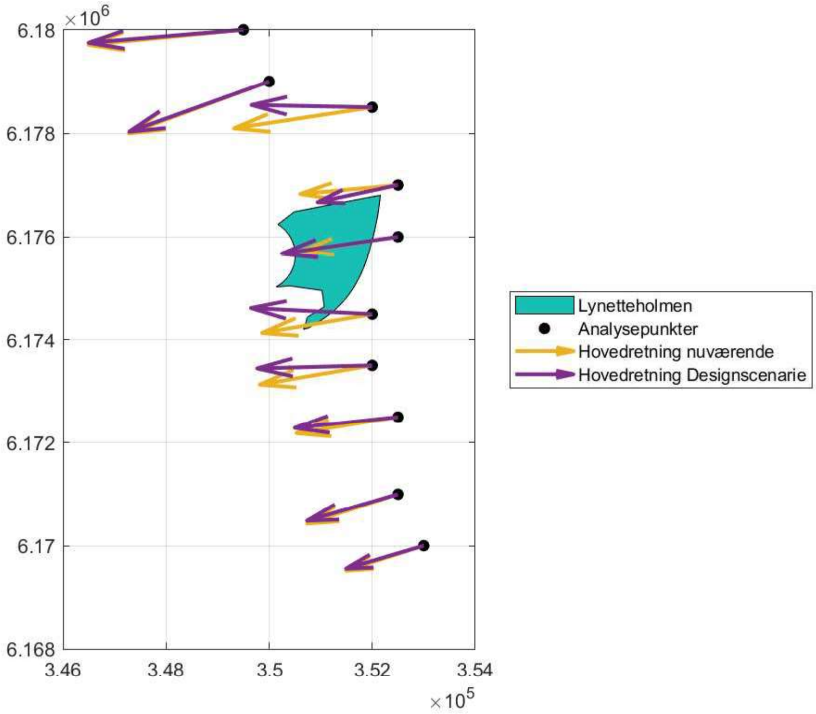


Figure 6-102 Main directions for incoming waves in analysis points with the present conditions and a Main Proposal 1 reclamation.

The highest waves are also unchanged at the critical locations (points 1, 2, 9 and 10). Off Lynetteholm, the waves are seen to be marginally reduced, also due to the previously mentioned shadow effect.

Table 6-1 shows the calculated changes in mean wave directions and the most significant waves, expressed as $H_{s,12\ timer}$ indicating the wave height, which is exceeded annually for only 12 hours. This wave height is often used to estimate the closure depth out to which there will be a wave-driven current and thus in which part of the coastal profile there will be a significant littoral transport.

In the funnel (points T1 and T2), the medium wave directions are seen to be markedly changed. Furthermore, the highest waves have significantly intensified.

For the critical points (1, 2, 9 and 10), the mean wave direction changes are seen to be less than 1° and thus irrelevant for the littoral transport. Off Lynetteholm, the medium wave direction over the simulation period is seen moving about 9 ° to the north. This is confirmed by the wave roses shown in Figure 6-92 and Figure 6-93. For the points south of Lynetteholm, there is a shift towards the south in the medium wave directions. This is due to the aforementioned shadow effect visible in Figure 6-94, Figure 6-95 and Figure 6-96.

The highest waves are also unchanged at the critical locations (points 1, 2, 9 and 10). Off Lynetteholm, the waves are seen to be marginally reduced, also due to the previously mentioned shadow effect.

Table 6-1 Average wave directions and 12 hours of significant wave heights at the selected points.

Point	Location	Depth [m]	Average wave direction [°]			$H_{s,12\ hours}$ [m]	
			Baseline	H1	Change	Baseline	H1
T1	Outer funnel	13,30	110.96	129.98	-19,0	1,02	1,20
T2	Inner funnel	10,98	124.33	88.97	35,4	0,97	1,16
1	Charlottenlund	5,49	106,18	106,86	-0,7	1,03	1,03
2	Hellerup	7,01	100,36	100,82	-0,5	1,04	1,04
3	Nordhavn	10,51	113,76	116,87	-3,1	1,10	1,14
4	Lynetteholm N	7,28	119,19	114,51	4,7	0,98	1,00
5	Lynetteholm C	6,52	116,49	107,32	9,2	0,98	0,97
6	Lynetteholm S	7,98	105,39	111,89	-6,5	0,98	0,95
7	Benzinøen N	14,48	104,02	109,06	-5,0	0,95	0,94
8	Benzinøen S	13,31	107,51	108,44	-0,9	0,93	0,93
9	Amager Beach N	4,39	104,40	105,20	-0,8	0,84	0,84
10	Amager Beach S	4,42	108,25	109,02	-0,8	0,80	0,80

Based on the wave analysis, it can be concluded that the Main Proposal 1 reclamation of Lynetteholm will have no significant effect on the incoming waves in the area north and south of the reclamation, where the coast consists of sandy beaches with a dynamic character. Thus, there will be no changes in the littoral drift along the beaches and accordingly no changes in the natural extent or shape of the coasts.

6.1.5.2 Main Proposal 2 - coastal layout

For Main Proposal 2, the same10 points along the coast off Copenhagen, from Charlottenlund in the north to Amager Beach in the south, have been analysed. Due to sandy beaches, the two ends of this stretch are classified as dynamic coastlines and are therefore sensitive to changes in the main direction of incoming wave energy. The middle points (points 2 to 7) are located off a non-dynamic coast due to a structure with hard constructions and thus not equally sensitive to changes in wave conditions.

In addition to the external points, the wave conditions in the future entrance along the Nordhavn have been analysed in two points.

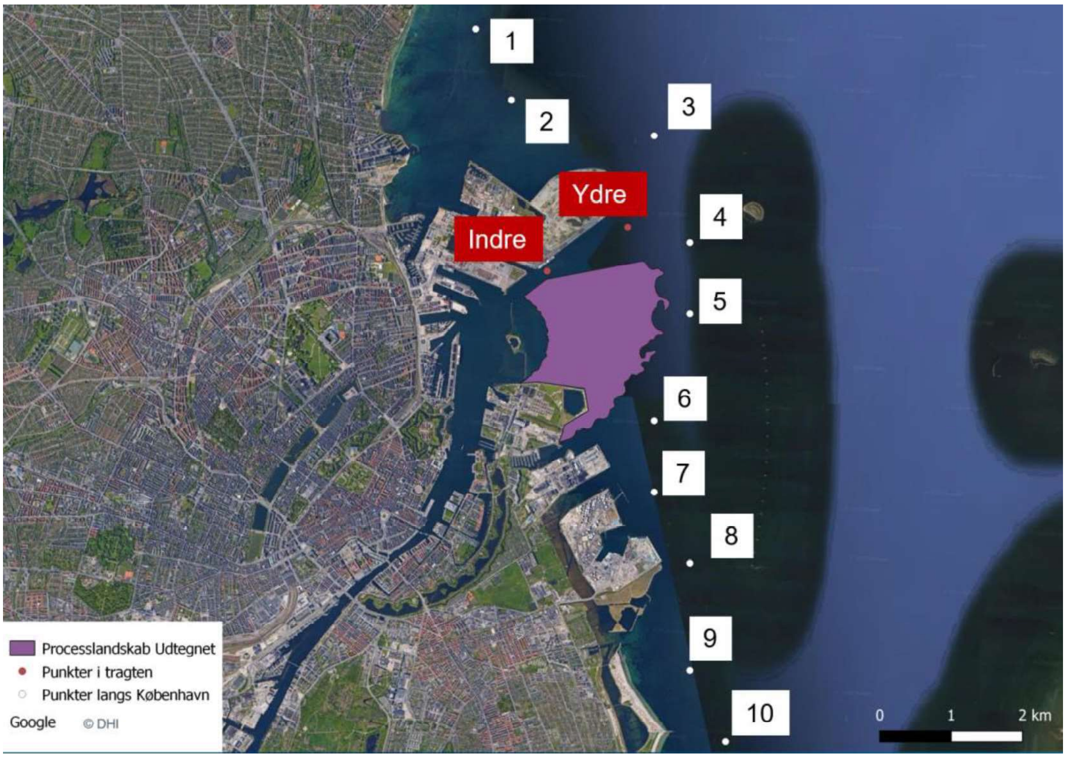


Figure 6-103 Analysed points in the wave analysis carried out for Main Proposal 2.

Figure 6-104 shows the wave climate of the outer point of the harbour entrance. There will be a clear intensification of the waves in the direction from the entrance to the northeast and a distinct shelter from both south and north.

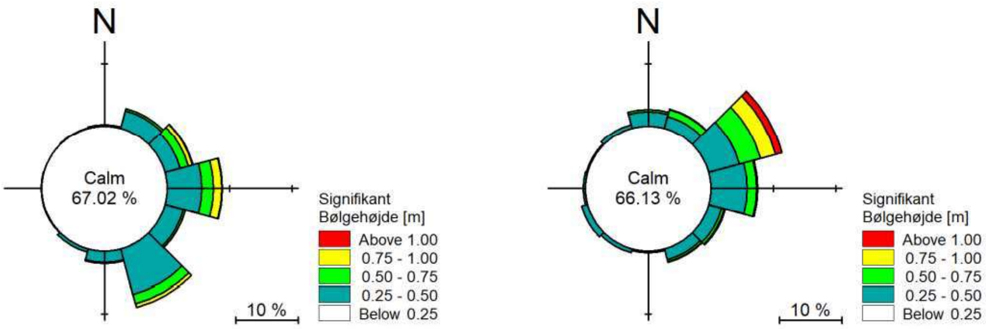


Figure 6-104 Outer funnel, wave roses for baseline and Main Proposal 2.

Figure 6-105 shows the inner point of the funnel-shaped entrance. Here, both intensification and shelter effects from Lynetteholm are reinforced. Figure 6-105 shows that Lynetteholm, despite the intensification of the wave height, will act as a shelter much of the time, thus causing the waves to less often exceed 25cm. With the Main Proposal 2 reclamation, the wave height exceeds 25 cm for 20% of the time compared to 28% of the present conditions.

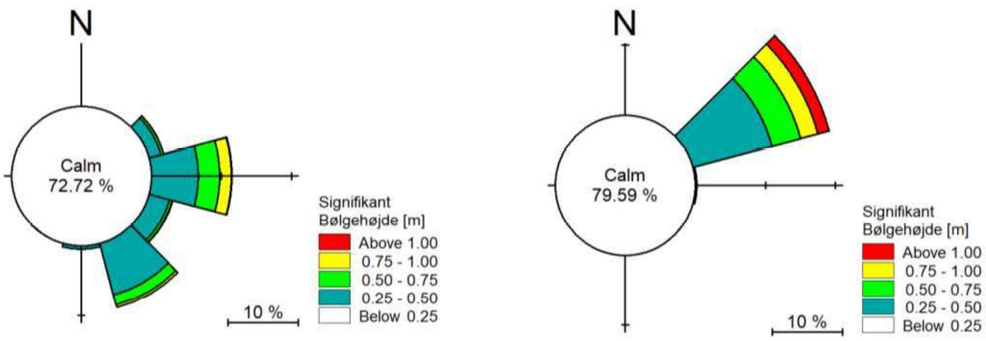


Figure 6-105 Inner funnel, wave roses for baseline and Main Proposal 2.

Figure 6-106 and Figure 6-107 show the wave conditions off Charlottenlund and Hellerup. In both of these points, no change in the general wave climate is observed. The dominant wave direction is directly east with some wave incidence from the north/northeast.

Figure 6-108 shows the wave climate on the east side of the new Nordhavn reclamation. Here a slight shelter effect of Lynetteholm can be seen during periods of incoming waves from the south, but in addition, conditions here are also unchanged. The wave climate is similar to the previous one, in this case with some wave incidence from the southeast.

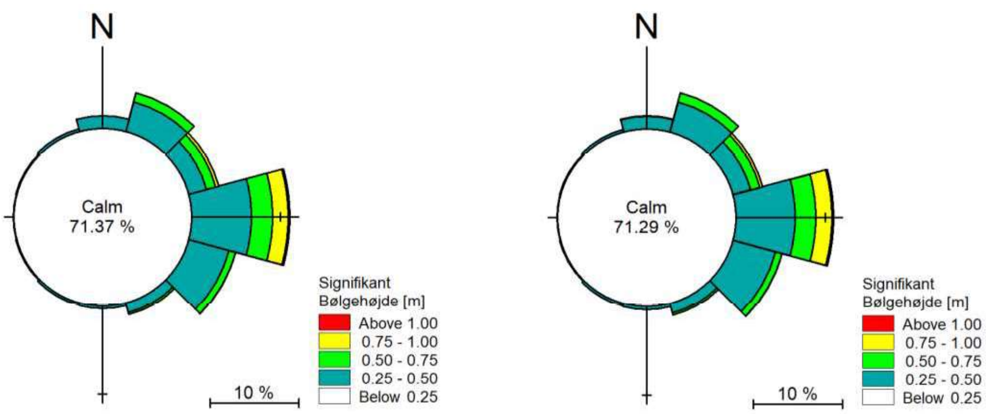


Figure 6-106 Wave roses for baseline (left) and Main Proposal 2 (right) for point 1, Charlottenlund.

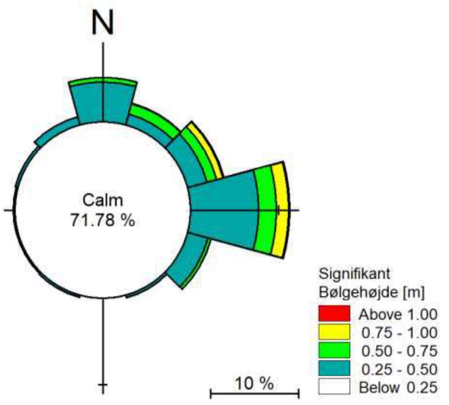


Figure 6-107 Wave roses for baseline (left) and Main Proposal 2 (right) for point 2, Hellerup.

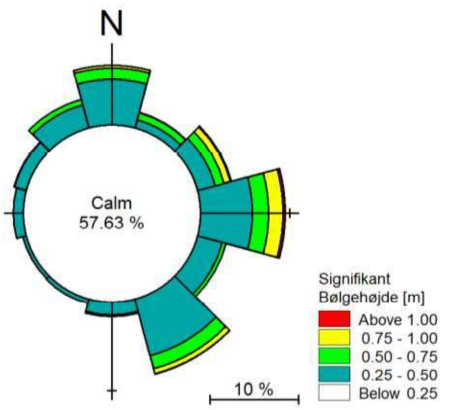


Figure 6-108 Wave roses for baseline (left) and Main Proposal 2 (right) for point 3, Nordhavn.

Figure 6-109 and Figure 6-110 show the wave conditions off Lynetteholm for baseline and Main Proposal 2. As with Main Proposal 1, there is a slight impact on the waves from the south, as Lynetteholm creates a shadow effect. However, the southern waves are already very small; thus, the consequences will also be minor.

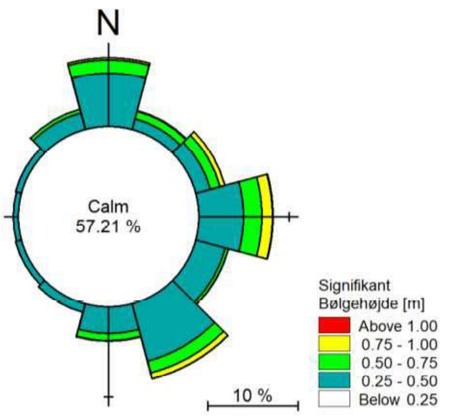


Figure 6-109 Wave roses for baseline (left) and Main Proposal 2 (right) for point 4, Lynetteholm North.

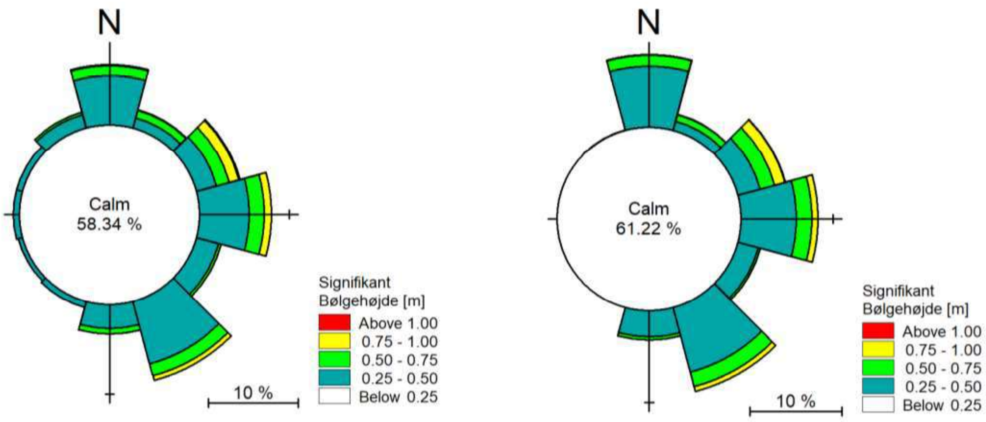


Figure 6-110 Wave roses for baseline (left) and Main Proposal 2 (right) for point 5, Central Lynetteholm.

Figure 6-111 to Figure 6-113 shows the wave conditions south of the reclamation. The implementation of Main Proposal 2 will not significantly alter the effect of Lynetteholm in these points, compared to the impacts of Main Proposal 1. There's a shadow effect from the north. Thus, fewer and smaller waves come from the north. There are no visible effects for waves coming from westerly and southerly directions.

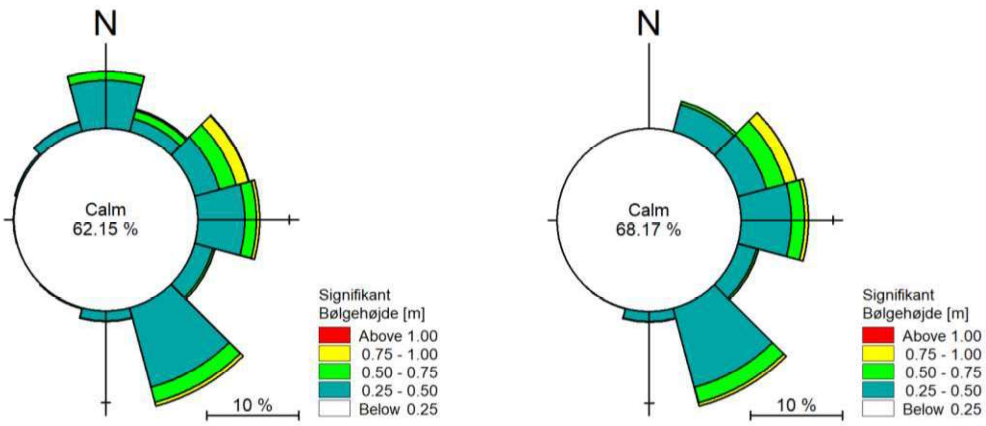


Figure 6-111 Wave roses for baseline (left) and Main Proposal 2 (right) for point 6, Lynetteholm South.

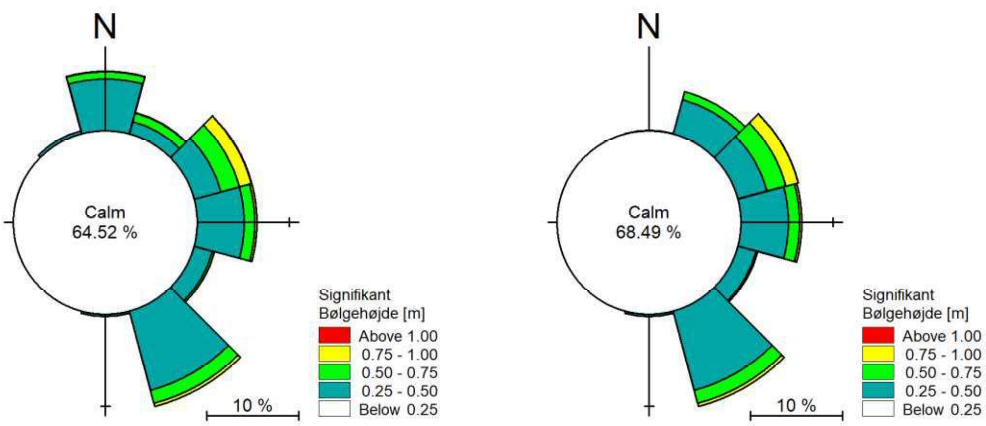


Figure 6-112 Wave roses for baseline (left) and Main Proposal 2 (right) for point 7, Prøvestenen North.

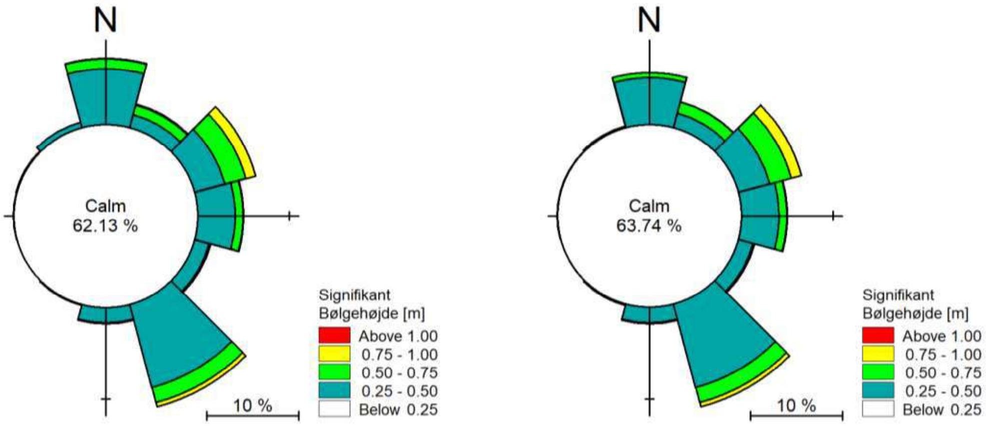


Figure 6-113 Wave roses for baseline (left) and Main Proposal 2 (right) for point 8, Prøvestenen South.

Figure 6-114 and Figure 6-115 show the critical points off Amager Beach. The figures show that the shadow effect has been reduced so that off the beach, there is no visible effect of Lynetteholm.

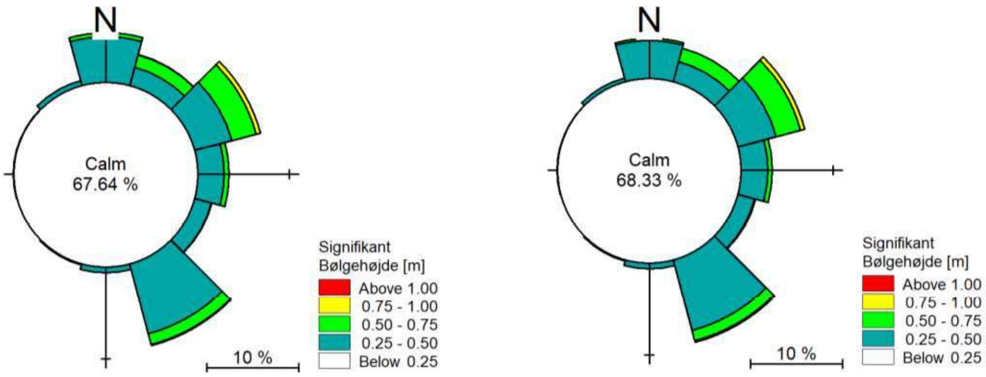


Figure 6-114 Wave roses for baseline (left) and Main Proposal 2 (right) for point 9, Amager Beach North.

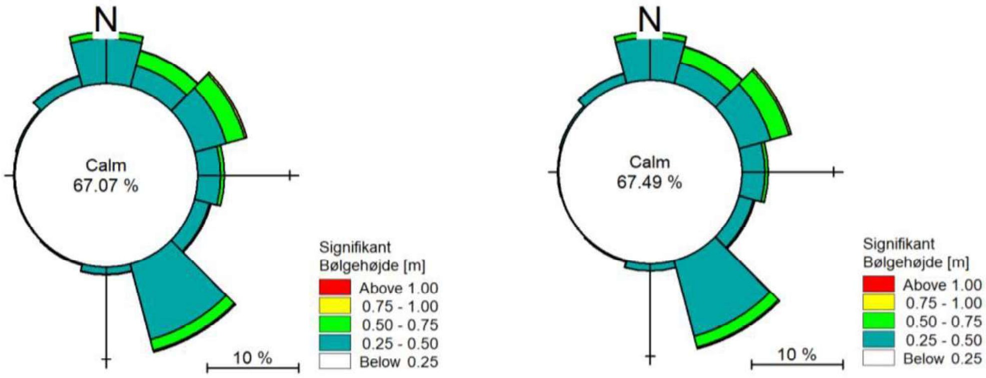


Figure 6-115 Wave roses for baseline (left) and Main Proposal 2 (right) for point 10, Amager Beach North.

Figure 6-116 to Figure 6-118 show the contours of the changes in wave height caused by the project. There are no significant differences between these figures for Main Proposal 1 and Main Proposal 2.

Figure 6-116 shows changes in the mean wave height, which are concentrated around the eastern corner of the Nordhavn reclamation, where wave heights are generally greater and around Lynetteholmen, where wave heights on average are lower.

Figure 6-117shows the maximum decrease in the significant wave height created by the Main Proposal 2 reclamation. The most significant drop in wave heights is found between Lynetteholm and Trekroner. Today, the waves have unhindered access and will be shielded entirely in the future. In addition, the shadow effect from the reclamation appears both north and south of Lynetteholm, where there is a decrease in significant wave height of up to 50 cm. In addition, reductions of between 1 and 10 cm occur between Amager and Saltholm.

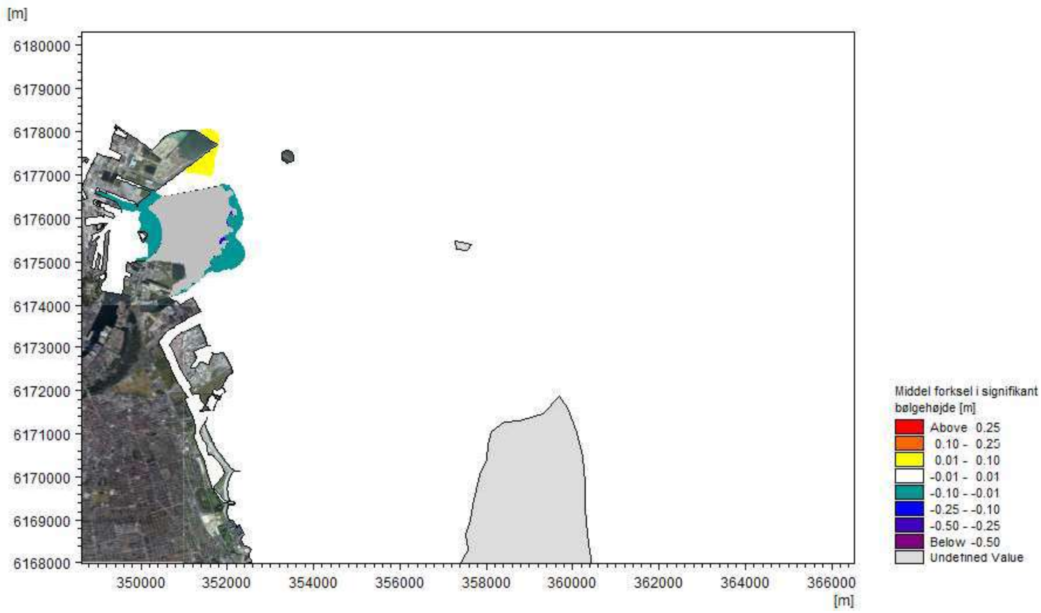


Figure 6-116 Changes in the annual wave height by Main Proposal 2.

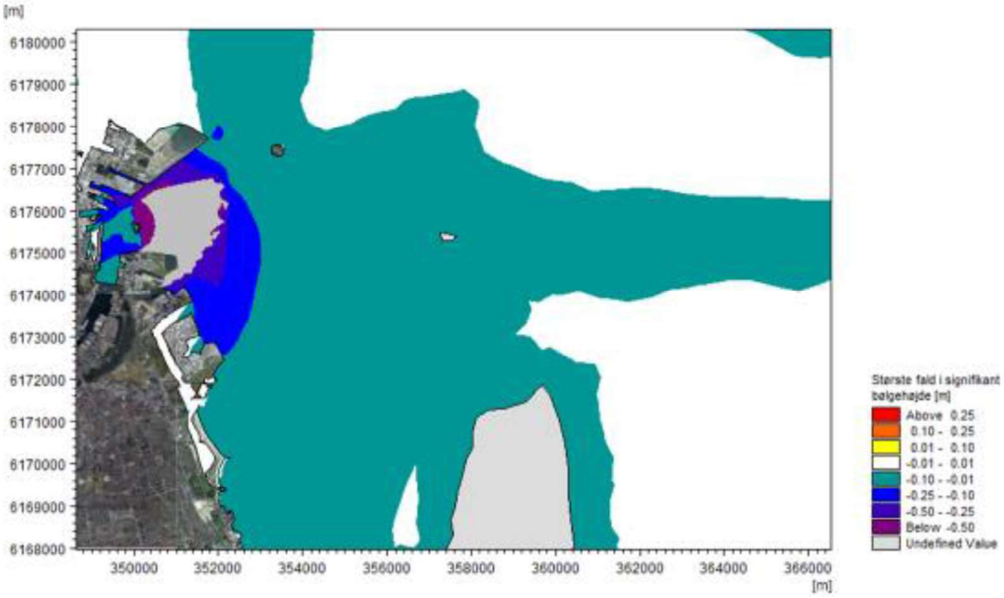


Figure 6-117 Maximum reduction in significant wave height.

Figure 6-118 shows the maximum increase in wave heights created by the Main Proposal 2 reclamation. Here an apparent intensification of the waves in the funnel between Nordhavn and Lynetteholm can be seen.

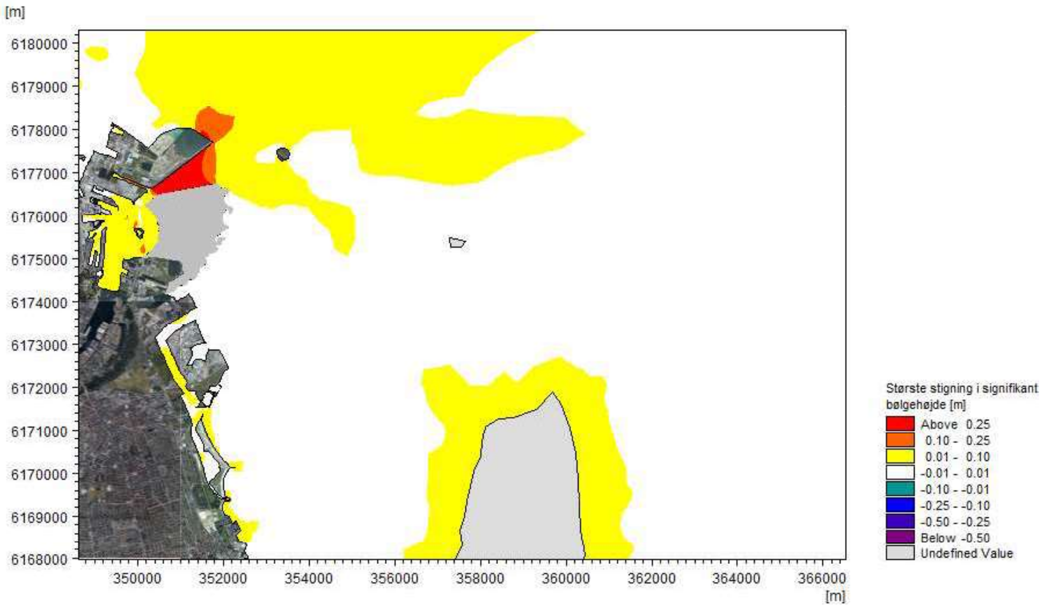


Figure 6-118 Maximum increase of significant wave height.

Figure 6-119 shows the main directions of the incoming waves for baseline and Main Proposal 2 reclamation of Lynetteholm. The main direction indicates the mean direction of the incoming wave energy comes on average. There are no significant differences between the results for Main Proposal 1 and Main Proposal 2. As concluded based on the waves presented above, changes in magnitude and direction from Nordhavn to Prøvestenen are seen, but neither north of Nordhavn nor off Amager beach, where the sandy beaches are dynamically sensitive to changes in the wave conditions.

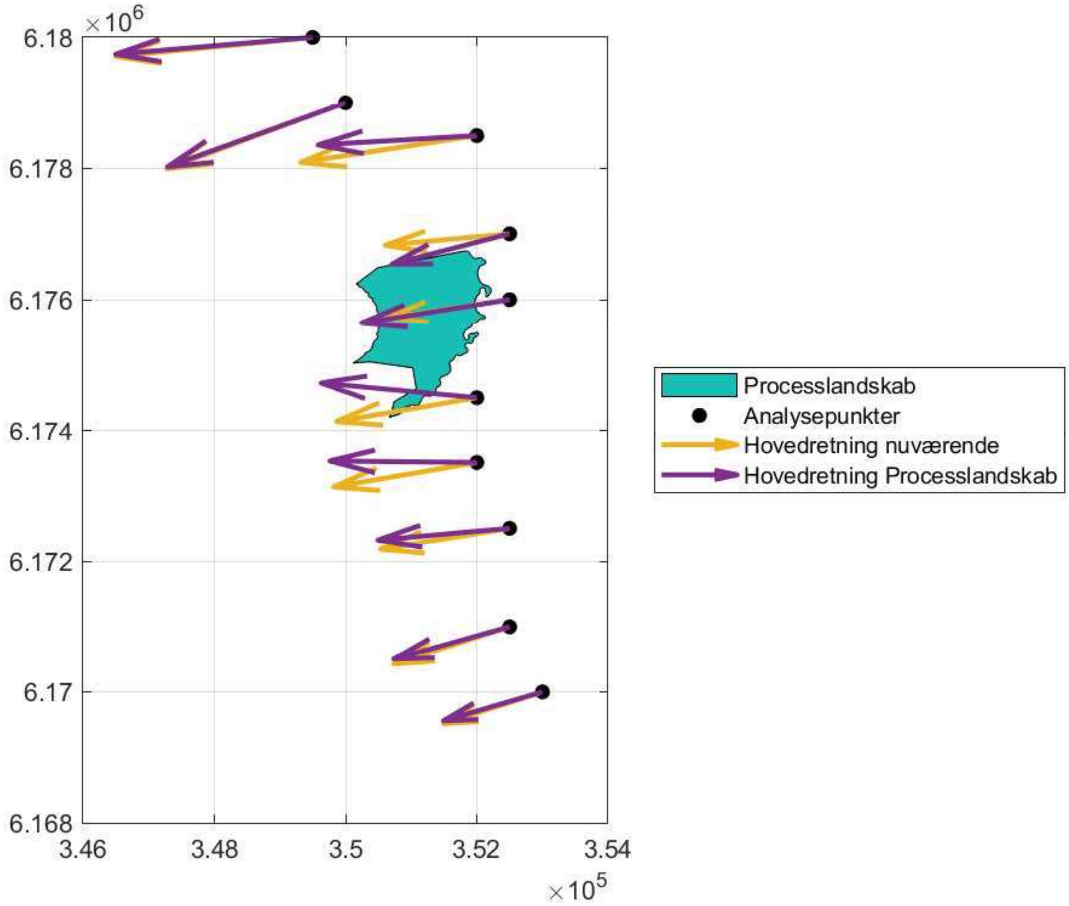


Figure 6-119 Main directions for incoming waves in analysis points with the present conditions and a Main Proposal 2 reclamation.

Table 6-2 shows the calculated changes of mean wave directions and of the largest waves, expressed by $H_{s,12\ timer}$, stating the wave height, which is exceeded annually for only 12 hours. This wave height is often used to estimate the closure depth out to which there will be a wave-driven current and thus in which part of the coastal profile there will be a significant littoral transport. The results given here are virtually identical to those found for Main Proposal 1.

In the inner point of the funnel (T2), the medium wave directions are seen to be markedly changed; at the far end of the funnel, the mean direction change is small compared to the change caused by the implementation of Main Proposal 1. Innermost in the funnel at point T2, the wave heights have intensified further compared to Main Proposal 1. For the outer point T1, the intensification is less for Main Proposal 2.

The highest waves are also unchanged for the critical points (1, 2, 9 and 10). Off Lynetteholm, they are seen to be marginally reduced due to the aforementioned shadow effect.

Table 6-2 Average wave directions and 12 hours of significant wave heights at the selected points.

Point	Location	Depth [m]	Average wave direction [°]			$H_{s,12\ hours}$ [m]	
			Baseline	H2	Change	Baseline	H2
T1	Outer funnel	13,30	110,96	112,95	-2.0	1,02	1,19
T2	Inner funnel	10,98	124,33	99,68	24.7	0,97	1,30
1	Charlottenlund	5,49	106,18	106,73	-0,6	1,03	1,03
2	Hellerup	7,01	100,36	100,75	-0,4	1,04	1,04
3	Nordhavn	10,51	113,76	114,54	-0,8	1,10	1,14
4	Lynetteholm N	7,28	119,19	110,16	9,0	0,98	0,99
5	Lynetteholm C	6,52	116,49	106,13	10,4	0,98	0,97
6	Lynetteholm S	7,98	105,39	115,91	-10,5	0,98	0,94
7	Benzinøen N	14,48	104,02	110,71	-6,7	0,95	0,94
8	Benzinøen S	13,31	107,51	108,75	-1,2	0,93	0,93
9	Amager Beach N	4,39	104,40	105,59	-1,2	0,84	0,84
10	Amager Beach S	4,42	108,25	106,73	1,5	0,80	0,80

Based on the wave analysis, it can be concluded that the Main Proposal 2 reclamation of Lynetteholm will have no significant effect on the incoming waves in the area north and south of the reclamation, where the coast consists of sandy beaches with a dynamic character. Thus, there will be no changes in the littoral drift along the beaches and thus no changes in the natural extent and shape of the coasts.

6.1.6 The impact of the project on flow conditions in Øresund and havneløbet (the inner harbour)

To estimate the impact of the two main proposals on the water and salt flow in Øresund, a hydraulic calculation is carried out for the existing conditions (Baseline) and for reclamations of Lynetteholm with and without a coastal landscape along the eastern perimeter. The blocking calculations have been completed for a full calendar year so that all seasonal variations are included.

The blocking effect of the Lynetteholm reclamation is calculated relative to the reference situation (Baseline) and is estimated as the absolute relative difference given by:

$$dq = \frac{\sum(|Q_L| - |Q_B|)}{\sum|Q_B|}$$

Where Q relates to either the water flow or the salt transport through a predefined vertical cross-section. Q_B refers to baseline, while Q_L refers to the reclamation of Lynetteholm with or without a coastal landscape. The idea of using the numerical value of both sizes is to eliminate the effect of a phase difference and get a sign of the blockage. A negative blocking factor indicates that there is a weakening (blockage), while positive values indicate an increase in the flow.

To assess Lynetteholm's impact on the water and salt balance in Øresund and the havneløbet (the inner harbour), a number of cross-sections have been defined, through which the flow of water and salt transport is calculated, see Figure 6-120. The cross-sections are selected so that an impact on the transport can be estimated through the havneløbet (the inner harbour) and through the entire Øresund as well as in the cross-section west (Drogden) and east (Flinterenden) of Peberholm. Finally, the blockage is calculated for the outer part of Kronløbet, defined by the cross-section between the northern tip of the Nordhavn reclamation and the Middelgrundsfortet.

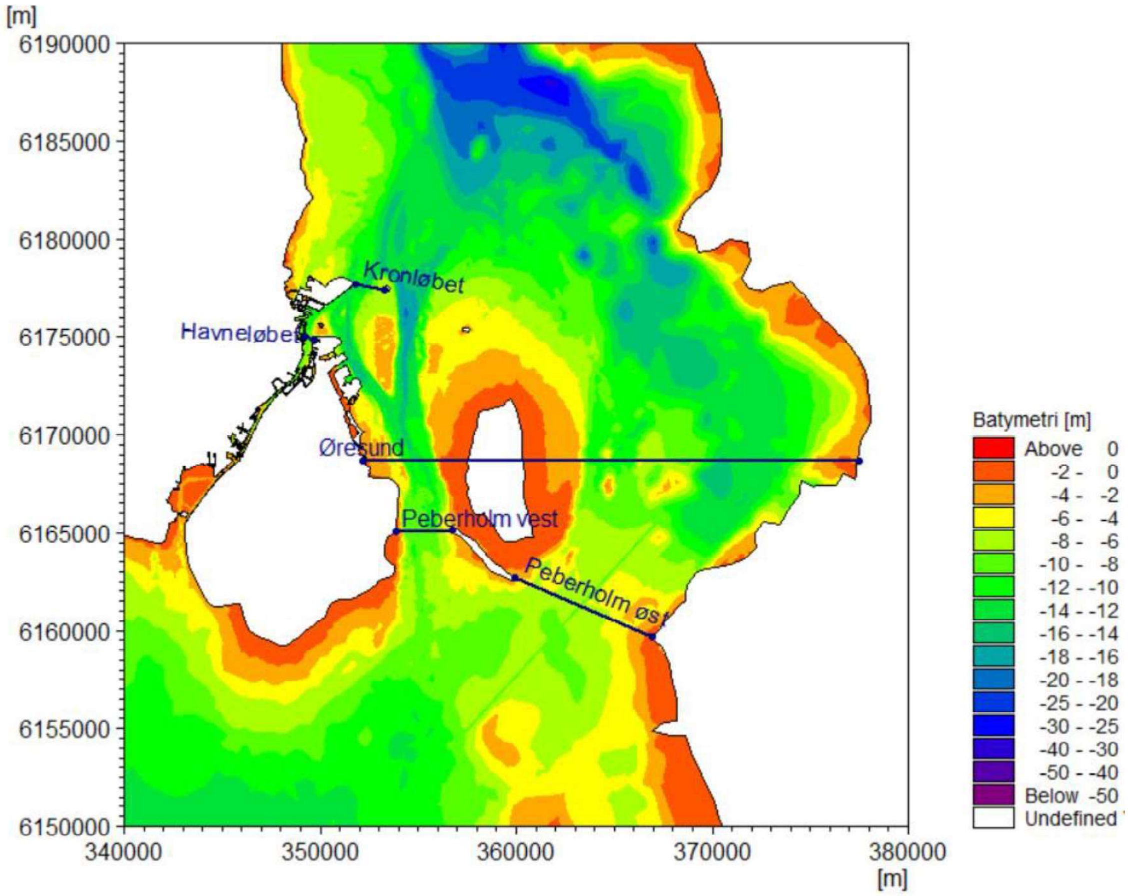


Figure 6-120 Cross-section through which the water flow and salt transport are calculated for present and future conditions.

6.1.6.1 The water flows

The water flows calculated by the model in the five predefined cross-sections are shown in Figure 6-121 through Figure 6-125. The water flows are defined so that positive values indicate outflows from the Baltic Sea, while negative values indicate inflows into the Baltic Sea. Based on the modelled (gross) water flows, it has been found that the flow is distributed by approximately 0.15% in the havneløbet (the inner harbour), 37% in the area west of Peberholm (Drogden) and 63% in the area east of Peberholm (Flinterenden).

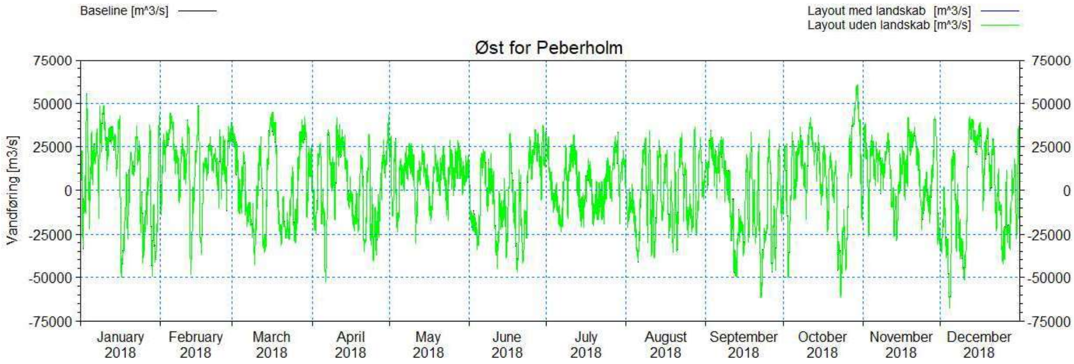


Figure 6-121 Cross-sectional water flow east of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

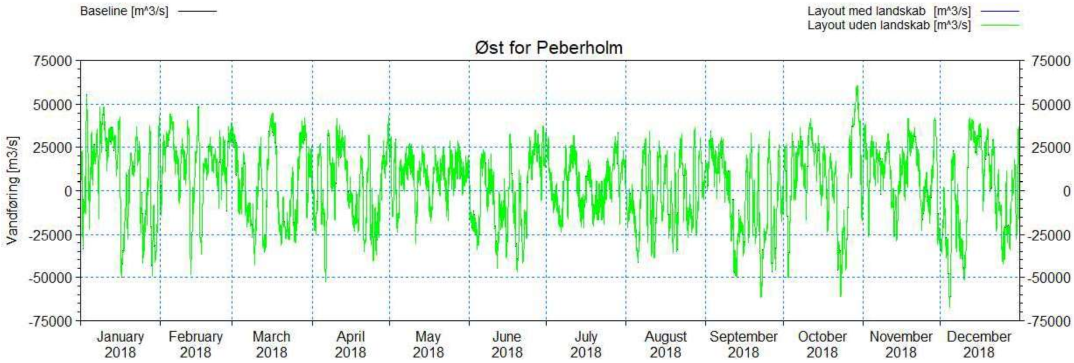


Figure 6-122 Cross-sectional water flow west of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

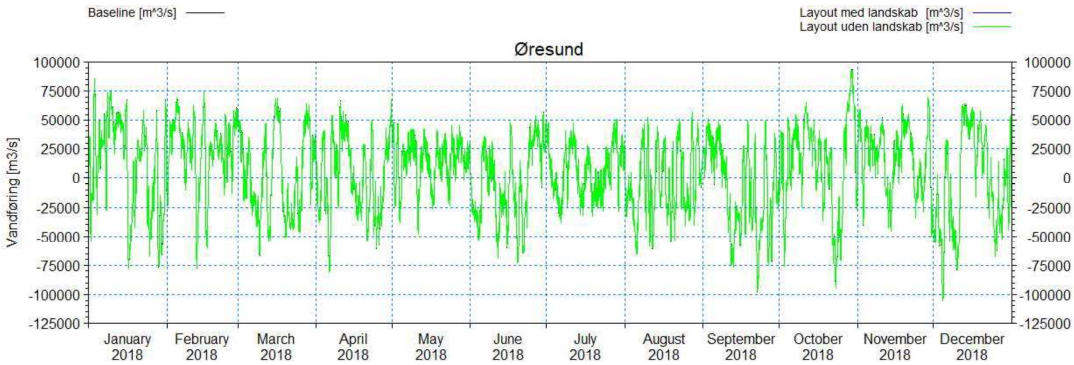


Figure 6-123 Cross-sectional water flow through Øresund with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

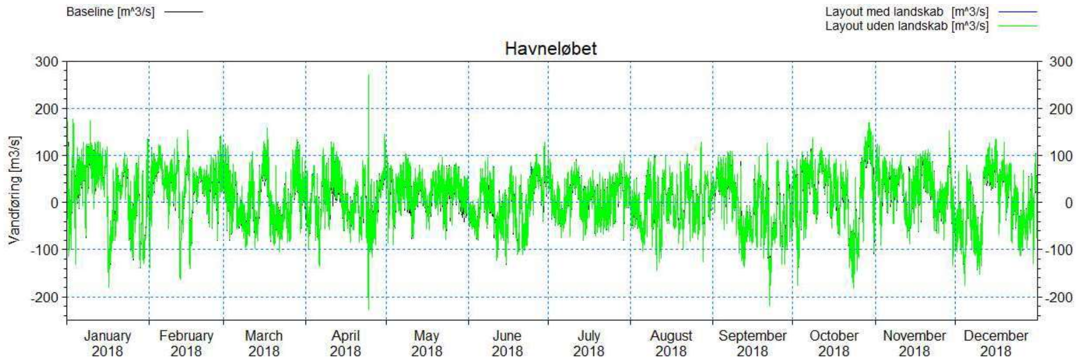


Figure 6-124 Cross-sectional water flow through the havneløbet (the inner harbour) with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

Except for the water flow in Kronløbet (the area between the tip of Nordhavn and Middelgrundsfortet), it is difficult to identify differences in the water flow based on the plots. The change in the water flow in Kronløbet is caused by the fact that as a result of the reclamation and closure of Kongedybet, part of the water is pressed east around Middelgrunden and through Hollænderdybet.

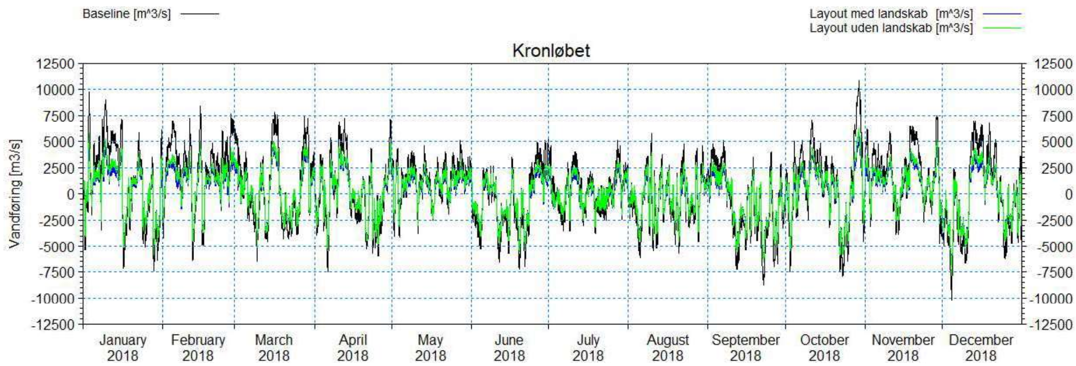


Figure 6-125 Water flow in Kronløbet (the cross-section between the Nordhavn tip and Middelgrundsfortet with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

Table 6-3 shows the annual mean gross water flow (calculated without sign) for baseline and with a Lynetteholm reclamation without a coastal landscape. It can be seen that the reclamation leads to increased dynamics in the havneløbet (the inner harbour) with an increase in the gross water flow of around 2.4%. The reclamation-blockage of Kongedybet causes a considerable reduction of the gross water flow in Kronløbet of up to 31 %. West of Peberholm, the gross water flow weakens by about 0.9%, while east of Peberholm, it is increased by 0.21%. For the entire Øresund cross-section, there is a reduction of 0.19% of the annual mean gross water flow.

Table 6-3 Annual mean gross water flow and its impact on existing conditions and after reclamation without coastal landscape (Main Proposal 1).

Cross-section	Baseline [m^3/s]	After reclamation [m^3/s]	Change [%]
Havneløbet (the inner harbour)	44,1	45,2	2,43
Kronløbet	2.774	1.914	-31,0
West of Peberholm	10.898	10.801	-0,891
East of Peberholm	18.789	18.829	0,211
Øresund	29.568	29.513	-0,186

Table 6-4 shows the annual mean gross water flow (calculated without sign) for baseline and for a Lynetteholm reclamation with a coastal landscape, respectively. It can be seen that the reclamation leads to increased dynamics in the havneløbet (the inner harbour) with an increase in the gross water flow of around 2.4%. The reclamation-blockage of Kongedybet results in a considerable reduction of the gross water flow in the Kronløbet of up to 39 %, as the uneven course of the coastal landscape creates more resistance and blockage. West of Peberholm, the gross water flow weakens by about 1.2%, while east of Peberholm it is reinforced by 0.29%. For the total Øresund cross-section, a reduction of the annual mean gross water flow of 0.24% has been found. Thus, Main Proposal 2 has a slightly more substantial impact on flow conditions in Øresund and locally than Main Proposal 1.

Table 6-4 Annual mean gross water flow and its impact on existing conditions and after reclamation with coastal landscape (Main Proposal 2).

Cross-section	Baseline [m^3/s]	After reclamation [m^3/s]	Change [%]
Havneløbet (the inner harbour)	44,1	45,1	2,37
Kronløbet	2.774	1.715	-38,2
West of Peberholm	10.898	10.768	-1,192
East of Peberholm	18.789	18.845	0,294
Øresund	29.568	29.496	-0,244

6.1.6.2 Accumulated water flow

The freshwater supply from the rivers flowing into the Baltic Sea results in a net outflow from the Baltic Sea through the five cross-sections for one year.

Figure 6-126 Cross-sectional flow west of Peberholm with the existing conditions (black curve) reclamation without landscape (green curve) and reclamation with landscape (blue curve).

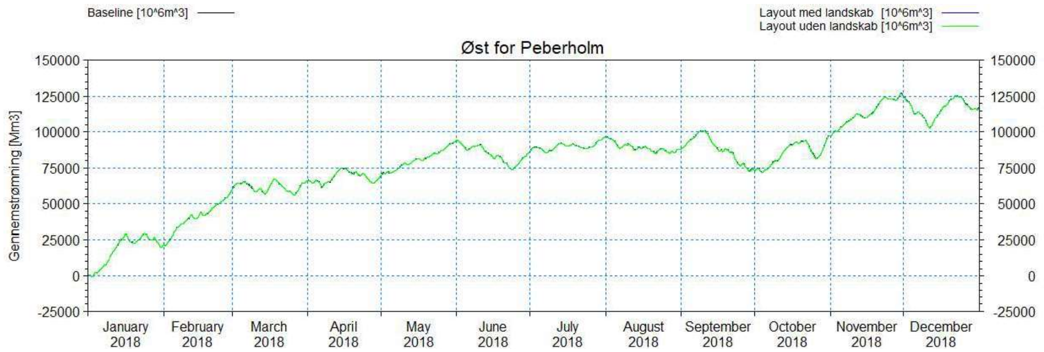


Figure 6-127 Cross-sectional flow east of Peberholm with the existing conditions (black curve) reclamation without landscape (green curve) and reclamation with landscape (blue curve).

Figure 6-128 Cross-sectional flow through Øresund with the existing conditions (black curve) reclamation without landscape (green curve) and reclamation with landscape (blue curve).

Except for the water flow in the havneløbet (the inner harbour) and Kronløbet (the cross-section between the tip of Nordhavn and Middelgrundsfortet), it is difficult to identify differences in the calculated accumulated water flow from the recorded plots. The changed flow of Kronløbet is a result of the expansion and closure of Kongedybet, part of the water is pressed eastwards around Middelgrunden and through Hollænderdybet.

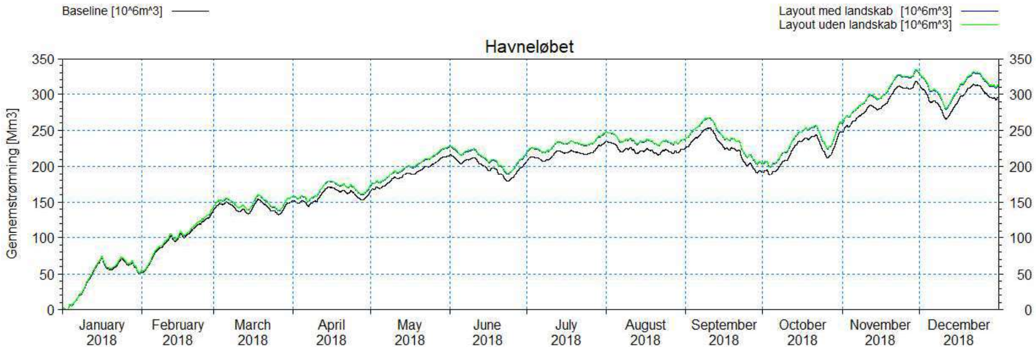


Figure 6-129 Cross-sectional flow through the havneløbet (the inner harbour) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

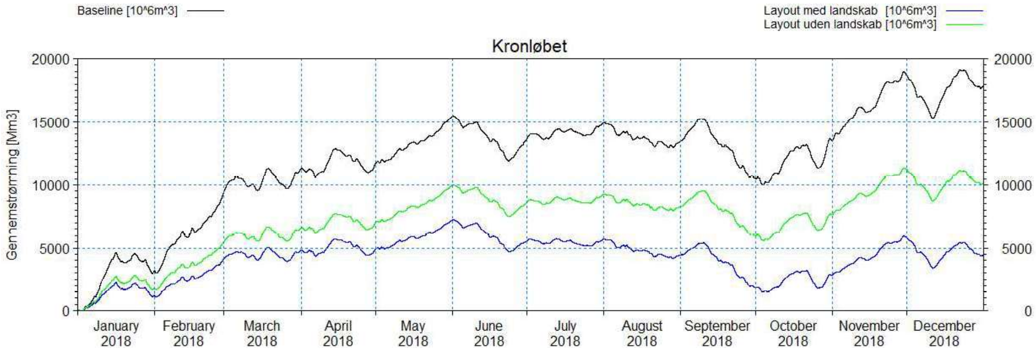


Figure 6-130 Flow in Kronløbet (cross-section between the tip of Nordhavn and Middelgrundsfortet with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

The accumulated water flows (flow-through) can be converted into a depth-averaged net flow, which is done in Table 6-5 for baseline and for a Lynetteholm reclamation without a coastal landscape. The corresponding figures are shown in Table 6-6 for a Lynetteholm reclamation with a coastal landscape along the eastern perimeter. This indicates that the reclamation creates an increased net water flow in the havneløbet (the inner harbour) of around 5-6 %. The risk of affecting the Natura 2000 site in Kalveboderne with, for example, polluted harbour sediment will be reduced due to net water flow being directed out of the Baltic Sea. However, the risk will continue in connection with storm surge events from the north. Net water flow in Kronløbet is reduced by 43% after a reclamation without a coastal landscape and by 75% with a coastal landscape. The reduction is a natural consequence of the closure of Kongedybet. The design of a coastal landscape with protrusions and bays also increases friction due to the formation of eddies, which is why the impact is more significant for Main Proposal 2. In the other three cross-sections, the effect is relatively limited.

Table 6-5 Net water flow and its impact on existing conditions and after reclamation without a coastal landscape (Main Proposal 1).

Cross-section	Baseline [m^3/s]	After reclamation [m^3/s]	Change [%]
Havneløbet (the inner harbour)	9,36	9,90	5,77
Kronløbet	561,8	318,2	-43,4
West of Peberholm	1.843	1.840	-0,16
East of Peberholm	3.693	3.690	-0,08
Øresund	5.539	5.534	-0,09

Table 6-6 Net water flow and its impact on existing conditions and after reclamation with a coastal landscape (Main Proposal 2).

Cross-section	Baseline [m^3/s]	After reclamation [m^3/s]	Change [%]
Havneløbet (the inner harbour)	9,36	9,86	5,34
Kronløbet	561,8	137,7	-75,5
West of Peberholm	1.843	1.833	-0,59
East of Peberholm	3.693	3.694	0,03
Øresund	5.539	5.530	-0,16

6.1.6.3 Blocking factors for water flow

The blocking factors are calculated based on the changed accumulated gross flow relative to the accumulated baseline gross water flow, thus indicating a measure of how much the dynamics of the system will change. Calculations must be done over an extended period to stabilise and contain only effects from a slight seasonal variation to estimate the blocking factors. The temporal variation of the blocking factors in the five defined cross-sections is shown in Figure 6-131 to Figure 6-135.

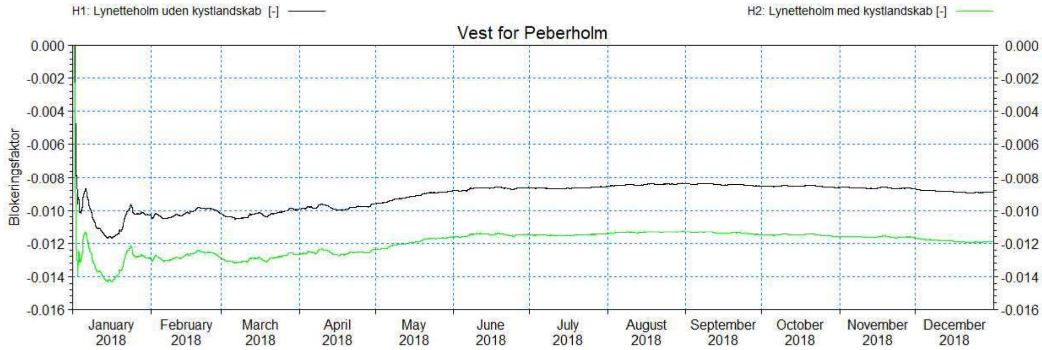


Figure 6-131 Blocking factors for water flow in the cross-section west of Peberholm. Black curve: Main proposal 1, green curve: Main proposal 2.

The plots show that it is necessary to calculate a period of at least 5 months to obtain a stable estimate of blocking factors related to water flow. The slight variation that occurs in the following 7 months is an expression of a seasonal variation. A negative blocking factor is an expression of a weakened dynamic, while a positive blocking factor is an expression of an enhanced dynamic.

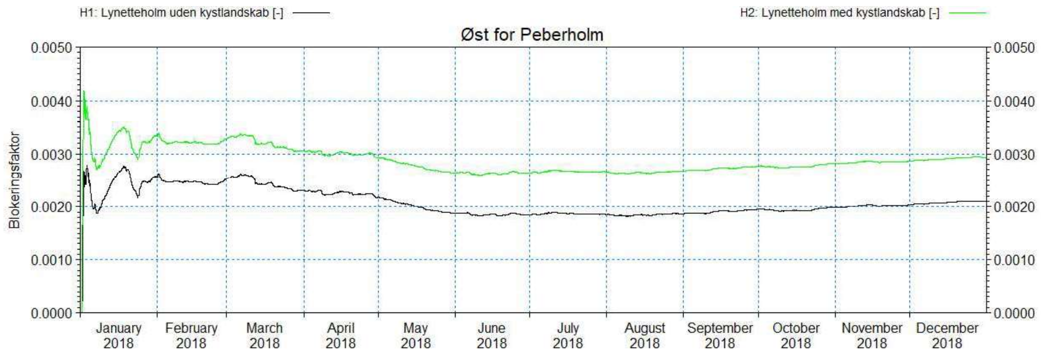


Figure 6-132 Blocking factors for water flow in the cross-section east of Peberholm. Black curve: Main proposal 1, green curve: Main proposal 2.

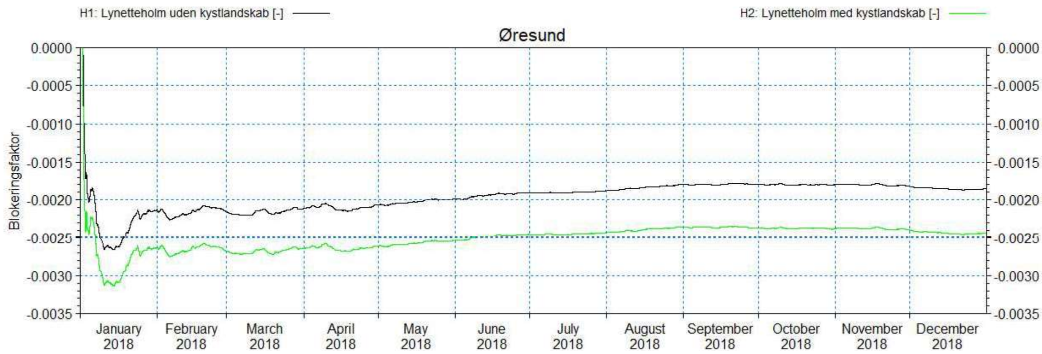


Figure 6-133 Blocking factors for water flow in the Øresund cross-section. Black curve: Main proposal 1, green curve: Main proposal 2.

The blocking factors show that the Lynetteholm reclamation with and without a coastal landscape will lead to a slight redistribution of current through Øresund and thus that slightly larger amounts of water are directed through Flinterenden east of Peberholm and slightly smaller amounts of water through Drogden west of Peberholm. The impact on Kronløbet has only local importance, and the impact on the havneløbet (the inner harbour) could be changed, if so desired, with a change in configuration of the settings of the sluice gates in Sydhavnen. If the sluice gates are maintained in their current setting, it will lead to slightly increased dynamics and flow in the direction away from the Baltic Sea. In the cross-section between the tip of Nordhavn and Middelgrundsfortet, there is a significant blockage due to the blockage of Kongedybet. Instead, the water is pressed eastwards around Middelgrunden and through Hollænderdybet.

Throughout Øresund, a blocking factor of -0.19% has been found for Main Proposal 1 at the end of the year, thus representing the conditions for an entire season. For Main Proposal 2, the effect is slightly more significant; here the blockage factor is -0.24% at the end of the year. The upper and lower values of the blocking factors are given in Table 6-7 for Main Proposal 1 and in Table 6-8 for Main Proposal 2. The values were found based on the calculated blockage in the period June-December 2018. The sign in the last column indicates whether there is a weakened or increased dynamic.

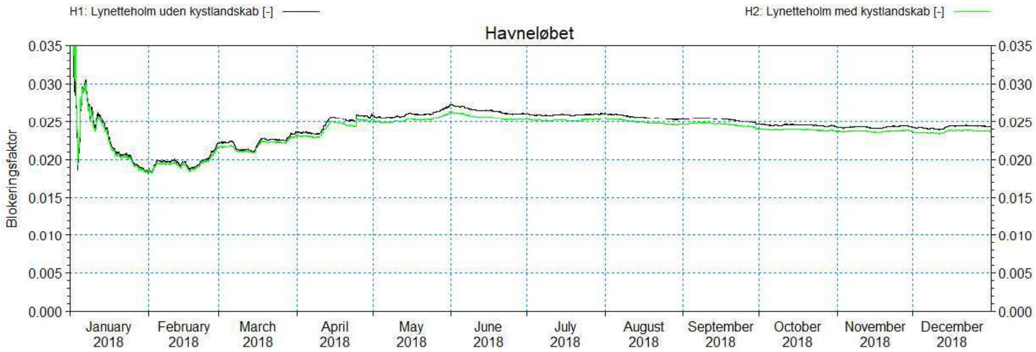


Figure 6-134 Blocking factors for water flow in the havneløbet (the inner harbour). Black curve: Main Proposal 1, green curve: Main Proposal 2.

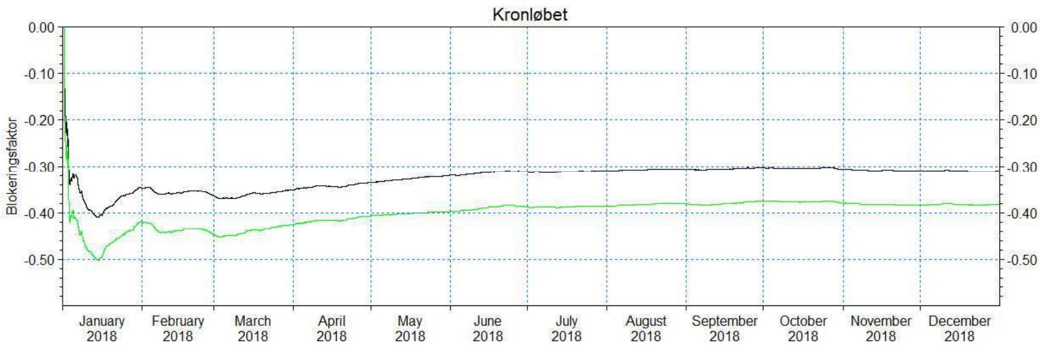


Figure 6-135 Blocking factors for water flow in the cross-section in Kronløbet (the cross-section between the tip of Nordhavn and Middelgrundsfortet). Black curve: Main Proposal 1, green curve: Main Proposal 2.

Table 6-7 Main Proposal 1: Estimated blocking factors for water flow in selected cross-sections. Positive values indicate an increased dynamic, while negative values reflect a weakened dynamic.

Cross-section	Blocking factor Lower value [%]	Blocking factor upper value [%]	Sign
Havneløbet (the inner harbour)	2,39	2,73	+
Kronløbet	30,2	32,0	-
West of Peberholm	0,84	0,89	-
East of Peberholm	0,18	0,21	+
Øresund	0,18	0,20	-

Table 6-8 Main Proposal 2: Estimated blocking factors for water flow in selected cross-sections. Positive values indicate an increased dynamic, while negative values reflect a weakened dynamic.

Cross-section	Blocking factor lower value [%]	Blocking factor upper value [%]	Sign
Havneløbet (the inner harbour)	2,34	2,64	+
Kronløbet	37,4	39,7	-
West of Peberholm	1,13	1,20	-
East of Peberholm	0,26	0,29	+
Øresund	0,23	0,25	-

In connection with the Øresund Link, a zero solution was required, in which compensation excavations attempted to produce conditions that resulted in a blocking factor of zero. In these calculations, the blocking requirement was set at less than 0.1% with an uncertainty spread estimated at +/- 0.25% within an uncertainty limited to a 95% confidence interval, Ref. /1/. The uncertainty accepted by the zero solution is thus more significant or of the same size as the estimated blockages that Lynetteholm's two main proposals give rise to.

The Lynetteholm reclamation causes the closure of Kongedybet. The current sailing route to Prøvestenen will therefore be closed, and instead the sailing route to Prøvestenen will be through Hollænderdybet via Svælget south of Middelgrunden. Opening this route requires additional excavation in the area south of Middelgrunden. An excavation that to a lesser extent will counteract the blocking effect of the reclamation on the transport of water and salt through Drogden and Øresund.

Climate effects and sea level rises will affect baseline conditions over time. Thus, over time, there can be no question of a zero solution. A raised water level (increased water depth) will affect the gross water flow and gradually increase the dynamic exchange between the

Kattegat and the Baltic Sea. Therefore, to maintain a true zero solution over time, friction through Øresund must be increased in other ways, such as a reclamation such as Lynetteholmen.

6.1.6.4 Translating blocking targets for water transport into a measurable physical quantity

It can be difficult to relate the blocking factor to a measurable or tangible physical quantity and thus also to understand the actual consequence of the blockage. As mentioned above, a zero solution may be a slightly farfetched term, as climate effects will gradually lead to sea-level rise in the sea around Denmark. To clarify when a blocking effect is important as well as to quantify the effect using a more understandable size, calculations have been carried out assuming that the mean water level has increased by 2 cm. These calculations are used to quantify the importance of a sea-level rise for the baseline situation, i.e. without a Lynetteholm reclamation, and compare this situation with the two main proposals with and without a weak sea level rise.

Figure 6-136 shows the calculated blocking factor for each of the two main proposals and baseline conditions in the defined section west of Peberholm with and without a sea-level rise of 2 cm. The plots show that a sea-level rise of 2 cm will lead to a blockage of +0.002 (increased flow). Likewise, the change is of the same size when assessing the effect of Lynetteholm and a sea-level rise of 2 cm. The extrapolated effect is therefore found to be that the blocking factor in the cross-section in question will be approximately zero after a sea-level rise of about 8 cm with Main Proposal 1 and approximately 12 cm for Main Proposal 2.

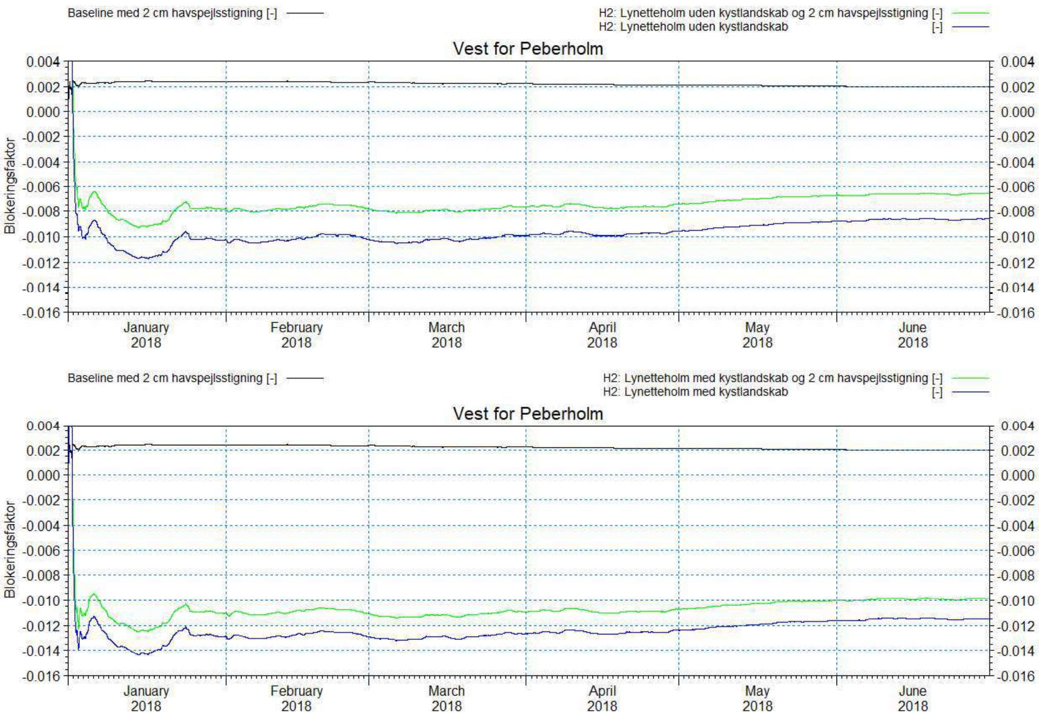


Figure 6-136 Effect of the project and a sea rise on the blocking in the cross-section west of Peberholm. Top: Main Proposal 1, bottom: Main Proposal 2.

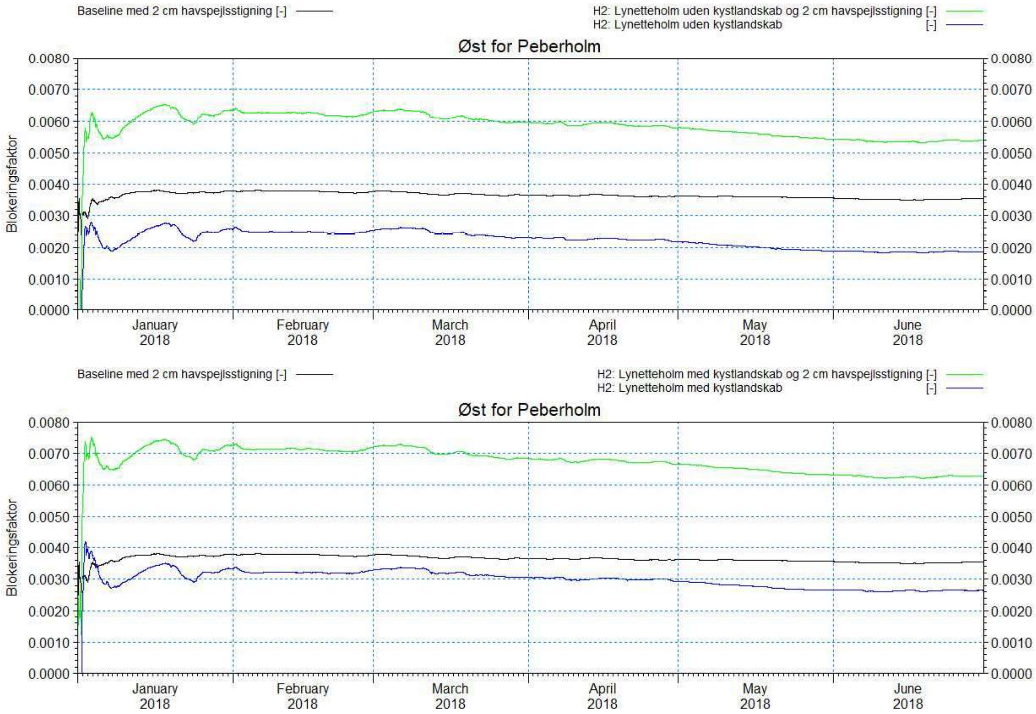


Figure 6-137 Effect of the project and a sea rise on the blocking in the cross-section east of Peberholm. Top: Main Proposal 1, bottom: Main Proposal 2.

The corresponding blocking effects are shown in Figure 6-137 for the cross-section east of Peberholm. It can be seen that the blocking effect of a 2 cm sea-level rise in that cross-section is more significant than the impact of the project. However, both will lead to increased dynamics and not an actual blockage since the sign of the blockage is positive.

Figure 6-138 shows blocking effects for an entire Øresund cross-section and thus reveals how the exchange of water between the Baltic Sea and the Kattegat is affected. The curves show that less than a 2 cm sea-level rise is required to cancel the blocking impact of the project on both main proposals. At the current rate of mean sea level rise compensated for effects of land rebounding (1.55 mm/year, ref. /6/ and /7/), the blocking effect is therefore expected to be equalised after a 10-year period – not least as an acceleration in the increase rate is expected in future, due to thermal expansion and increased ice melting at the poles.

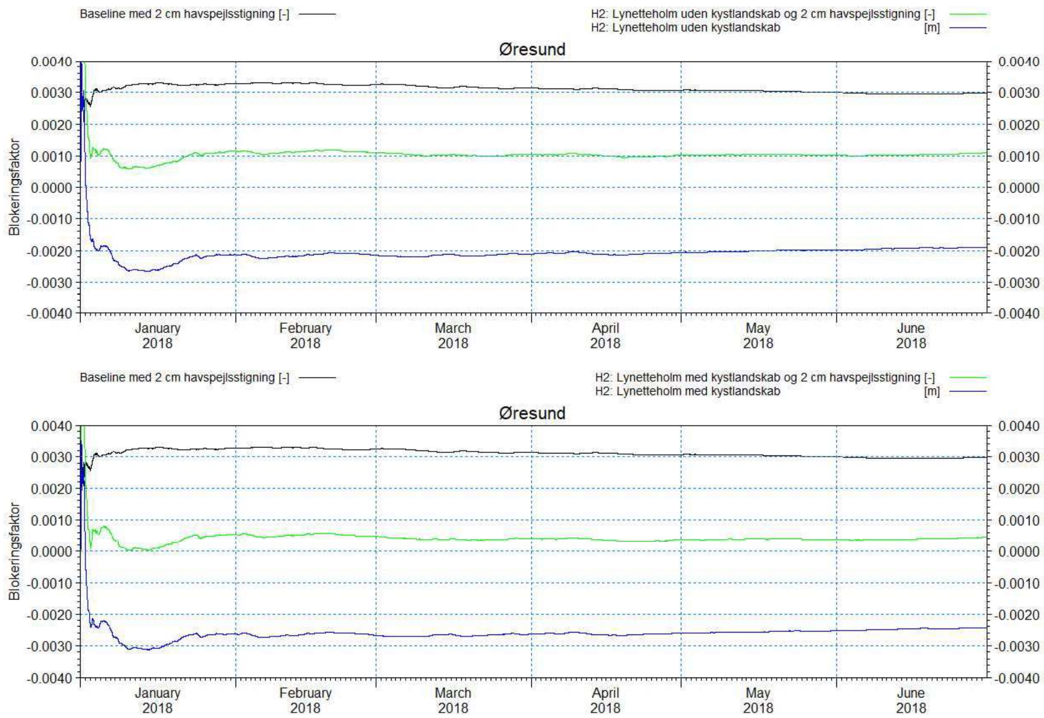


Figure 6-138 The effect of the project and the water level increase on the blocking in the Øresund cross-section. Top: Main Proposal 1, bottom: Main Proposal 2.

The impact of the project and the importance of a 2 cm sea-level rise for blocking in the havneløbet (the inner harbour) are shown in the curves Figure 6-139. It can be seen that the impact of the project is expected to be similar to the effect of an effective sea-level rise of 5 cm for both main proposals. The sluice gates in Sydhavnen largely regulate the flow in the havneløbet (the inner harbour); it will therefore be possible to control the effect by changing their setting.

The closure of Kongedybet by the reclamation will significantly reduce the flow dynamics in the cross-section between the Nordhavn tip and Middelgrundsfortet. Figure 6-140 shows that the effects of sea-level rises will not be able to compensate for the local blocking effect. However, as the effect is only local and not decisive for the overall dynamics of Øresund, it is not critical, but merely a derivative consequence of the closure of Kongedybet.

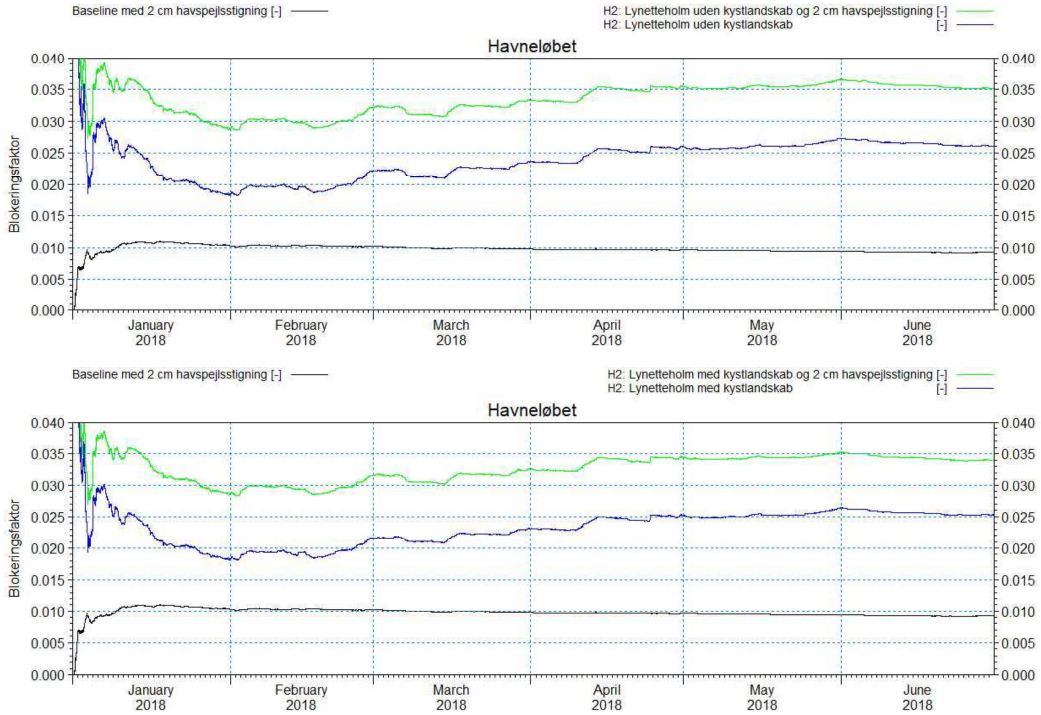


Figure 6-139 The effect of the project and the water level increase on the blocking in the havneløbet (the inner harbour). Top: Main Proposal 1, bottom: Main Proposal 2.

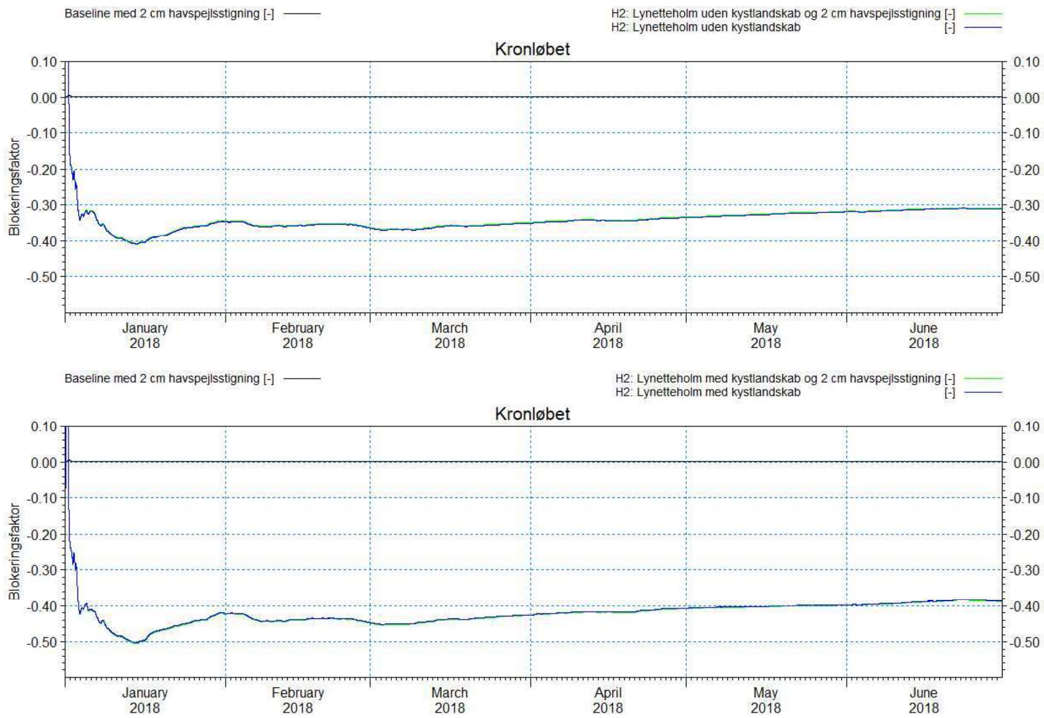


Figure 6-140 The effect of the project and the water level increase on the blocking in the cross-section between the Nordhavn tip and Middelgrundsfortet. Top: Main Proposal 1, bottom: Main Proposal 2.

6.1.6.5 Salt transport

The salt fluxes calculated by the model in the five predefined cross-sections are shown in Figure 6-141 through Figure 6-145. The salt fluxes are defined so that positive values indicate outflows from the Baltic Sea, while negative values indicate inflows into the Baltic Sea. As there is a net run-off of water from the Baltic Sea, the salt balance in the Baltic Sea is to a limited extent maintained through a density-driven vertical flow circulation, where the heavier salty bottom water in the deeper trenches has a net current direction directed towards the Drogden threshold, while the shallow brackish water from the Baltic Sea flows to the surface. However, the largest supply occurs in connection with strong southbound currents of long duration, where the layering is broken, and the salt supply across the Drogden threshold takes place over the entire water column. In cross-sections with limited water depth such as the havneløbet (the inner harbour) and Kronløbet and with current conditions that create a relatively good mix, there will therefore be a tendency for a net outflow of salt from the Baltic Sea. In the three large cross-sections, Øresund, west and east of Peberholm, there will be a tendency to maintain the status quo.

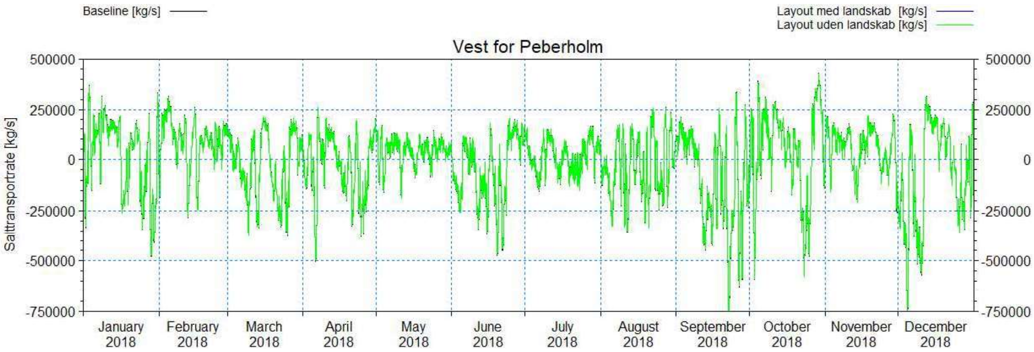


Figure 6-141 Transport of salt in the cross-section west of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

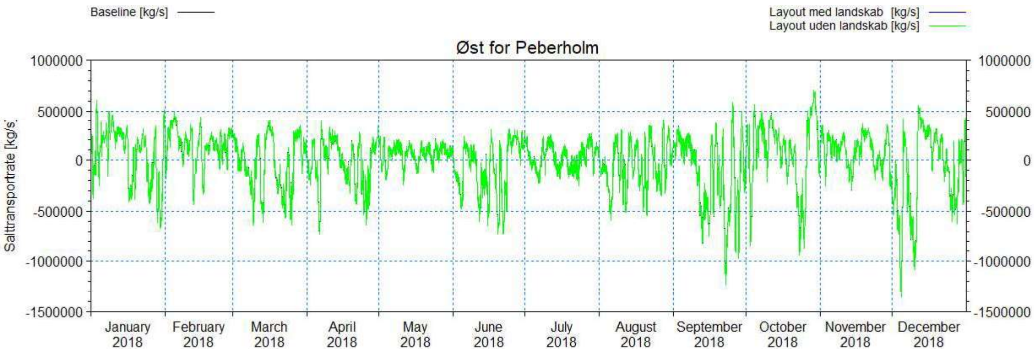


Figure 6-142 Transport of salt in the cross-section east of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

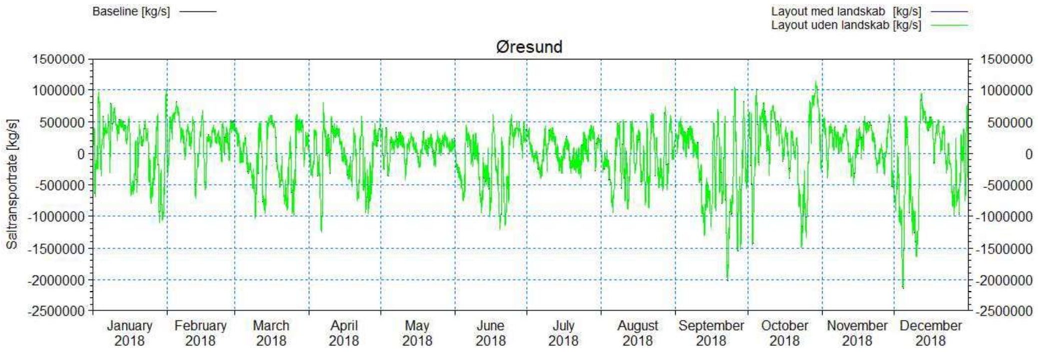


Figure 6-143 Transport of salt in the cross-section through Øresund with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

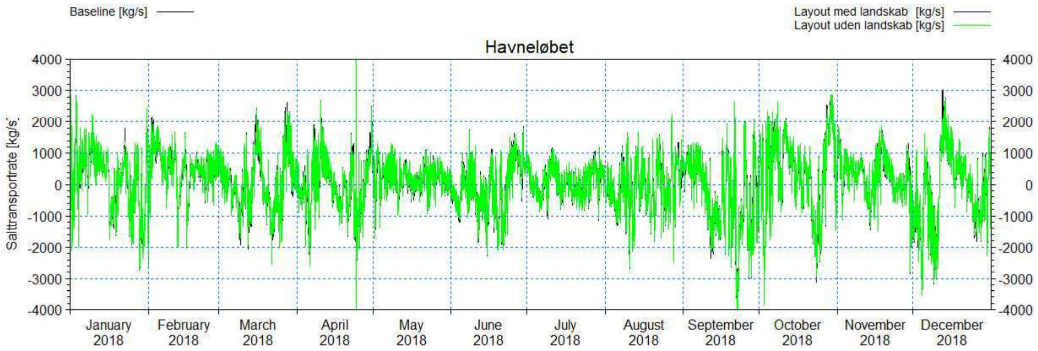


Figure 6-144 Transport of salt in the cross-section through the havneløbet (the inner harbour) with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

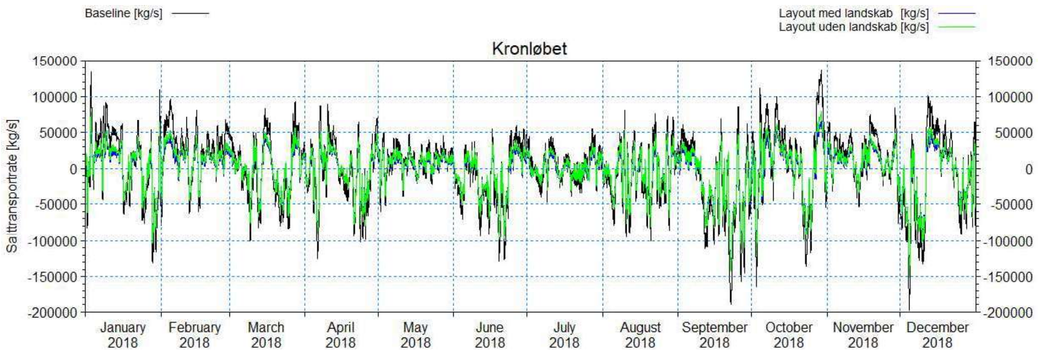


Figure 6-145 Transport of salt in Kronløbet (the cross-section between the Nordhavn tip and Middelgrundsfortet) with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

It is primarily in Kronløbet there is an effect on the salt flux. Again, the reduction is linked to the closure of Kongedybet.

6.1.6.6 Accumulated transport of salt

The freshwater supply from the rivers with estuaries in the Baltic Sea results in a net outflow of water from the Baltic Sea. Therefore, the salt balance is maintained in the event of saltwater intrusion, where isolated incidents add large amounts of salt to the Baltic Sea. Another important mechanism is the vertical circulation in the Sound, where heavy bottom currents directed towards the Drogden threshold create a high level of salinity in the deeper channels, which can be driven into the Baltic Sea during periods of prolonged southbound current. Overall, these incidents ensure an import of salt, which over a year will compensate for the loss created by the net outflow of brackish water from the Baltic Sea. In a year like 2018, when there were no extreme high-water incidents, there were no violent saltwater intrusions. A loss of salt from the Baltic Sea in 2018 is therefore expected. However, the plots show that in the second half of September and the beginning of December, there are flow conditions where a relatively large amount of salt flows into the Baltic Sea via Øresund. The two events mean that the year ends with a modest net salt supply to the Baltic Sea.

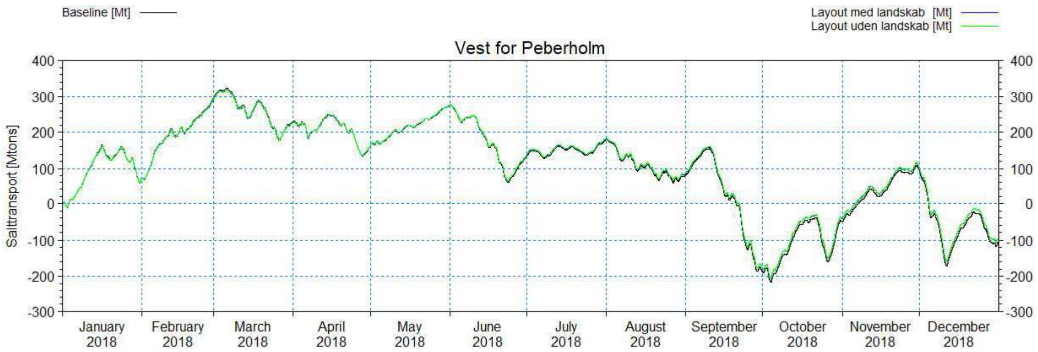


Figure 6-146 Accumulated transport of salt in the cross-section west of Peberholm with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

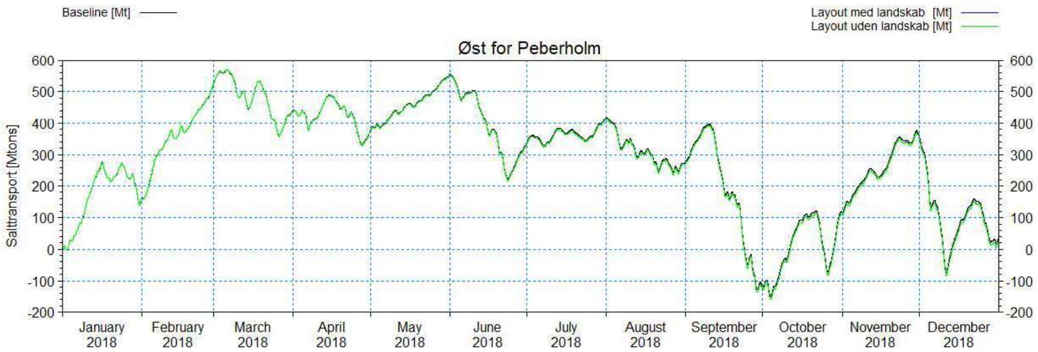


Figure 6-147 Accumulated transport of salt in the cross-section east of Peberholm with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

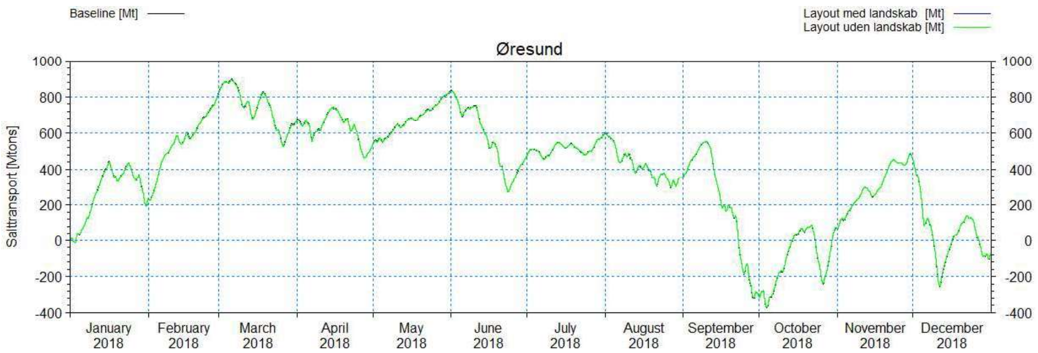


Figure 6-148 Accumulated transport of salt in the cross-section through Øresund with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

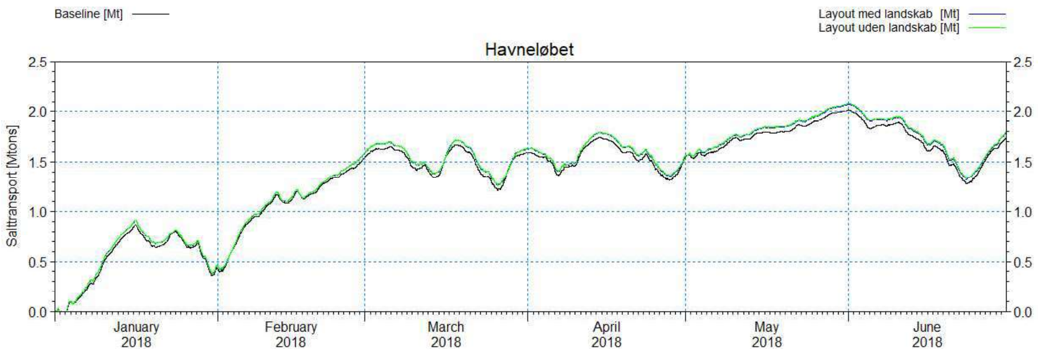


Figure 6-149 Accumulated transport of salt in the cross-section through the havneløbet (the inner harbour) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

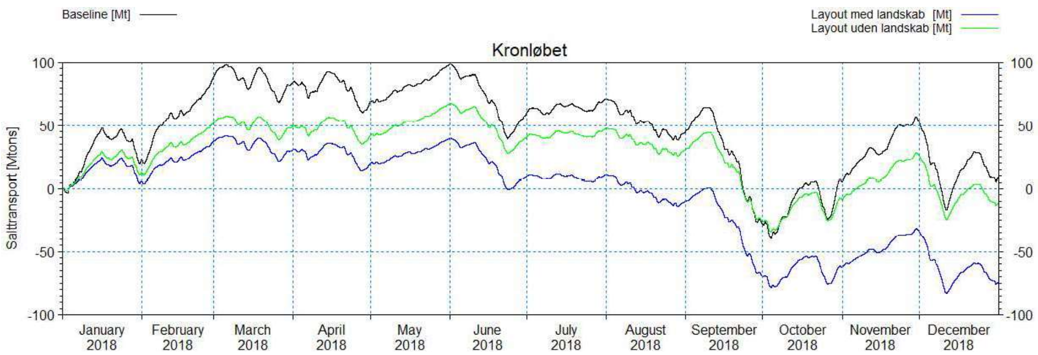


Figure 6-150 Accumulated transport of salt in Kronløbet (the cross-section between the tip of Nordhavn and Middelgrundsfortet) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve).

Figure 6-147 identifies periods with a loss of salt from the Baltic Sea, periods with a balance and periods with an input. To illustrate the conditions during these periods, a salt profile has been extracted along the track indicated in Figure 6-151.

Salt profiles from each of the three types of periods are shown in Figure 6-152 to Figure 6-154. In August, the net transport of salt is almost in balance. During this period, there is a stratification and large variations in salinity at the surface and bottom. In mid-September, there is a significant supply of salt. In this situation, there is more vigorous mixing while at the same time the salinity is higher, as shown in Figure 6-153. In November, there is a period of loss of salt (runoff from the Baltic Sea). During this period, there is almost complete mixing while the salinity is low.

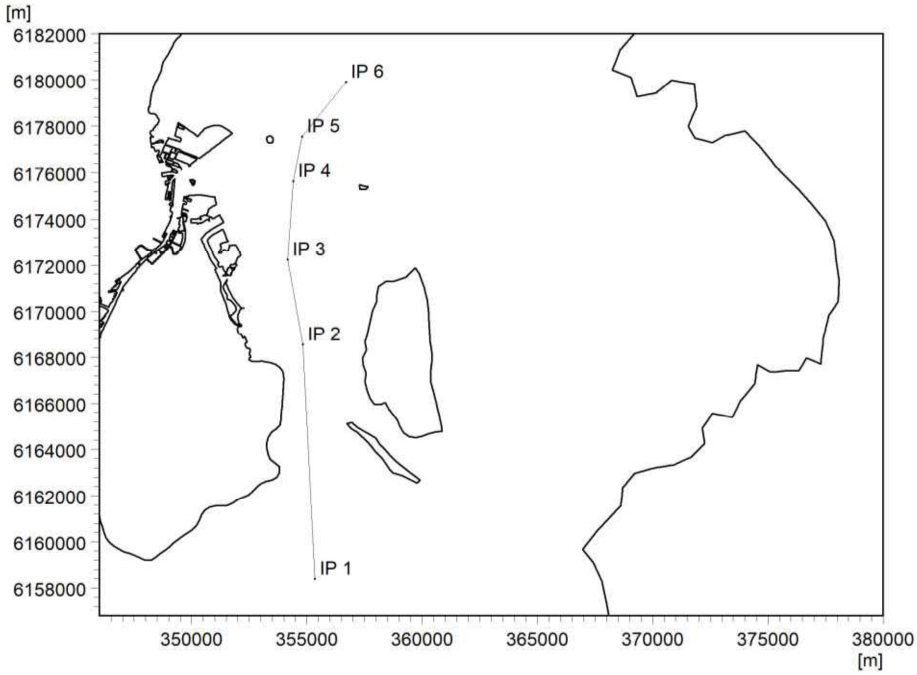


Figure 6-151 The profile's course from the start of the Drogden shipping lane and further up north past the project area.

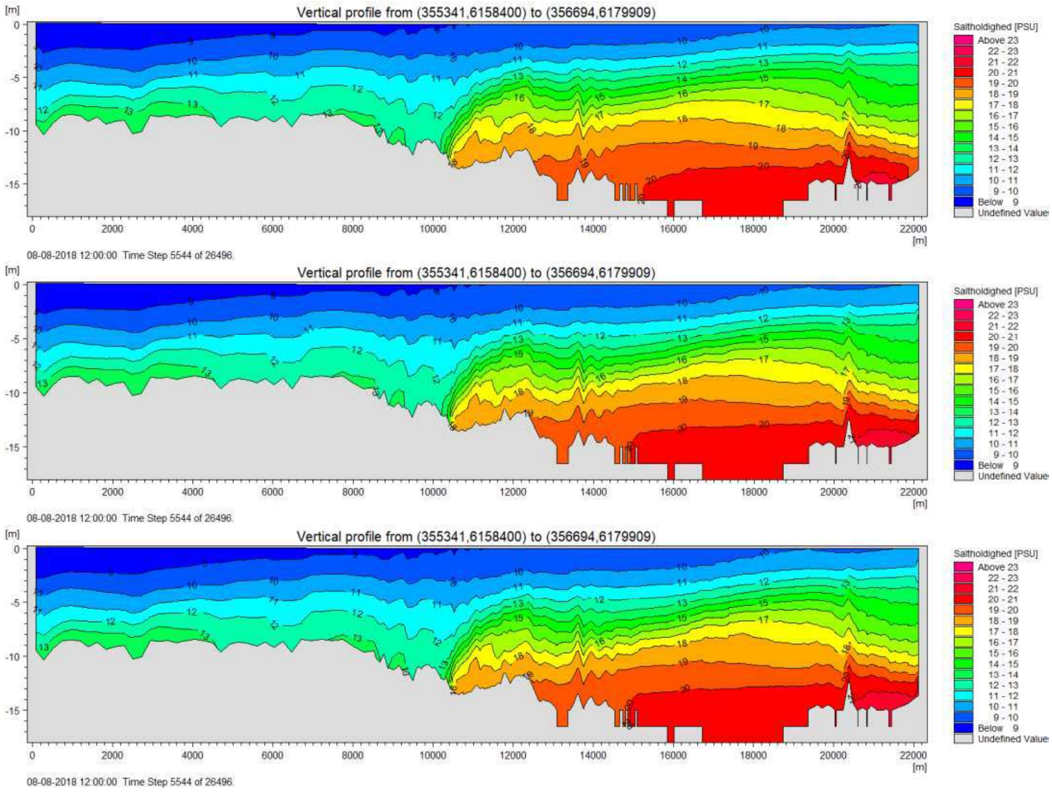


Figure 6-152 Vertical profile of salinity during a period of balance. Top: baseline, middle: Main Proposal 1 and bottom: Main Proposal 2.

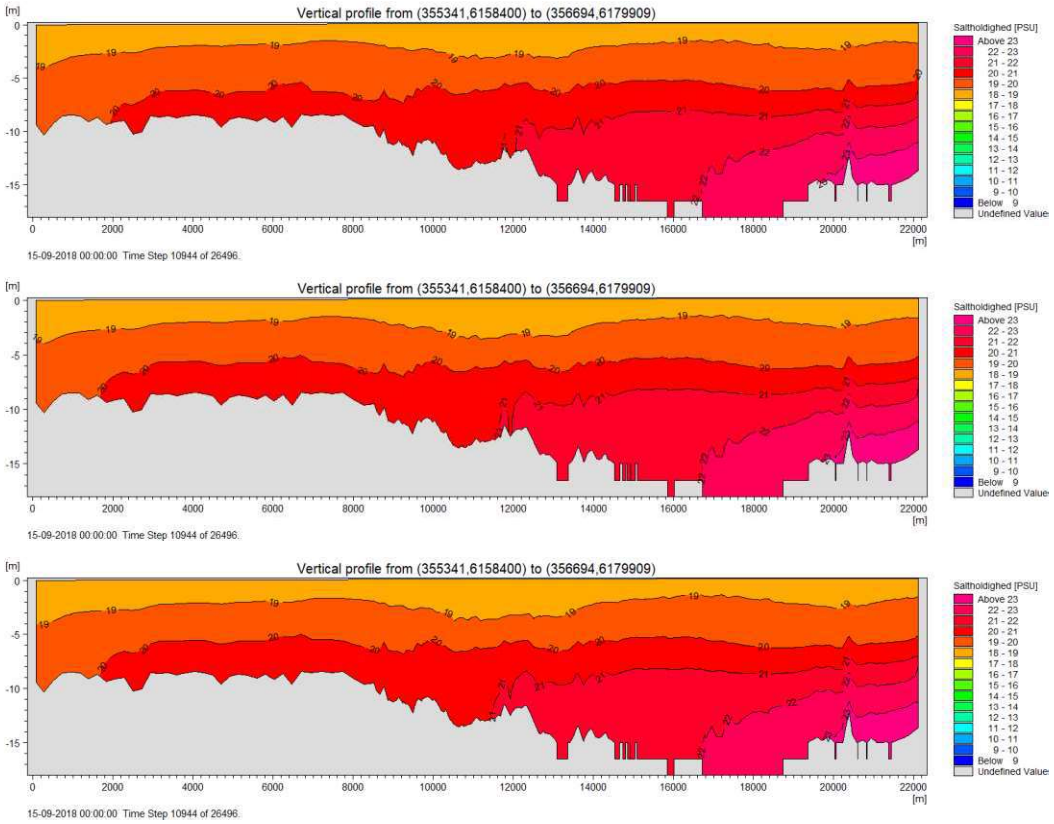


Figure 6-153 Vertical profile of salinity during a period of saltwater intrusion. Top: baseline, middle: Main Proposal 1 and bottom: Main Proposal 2.

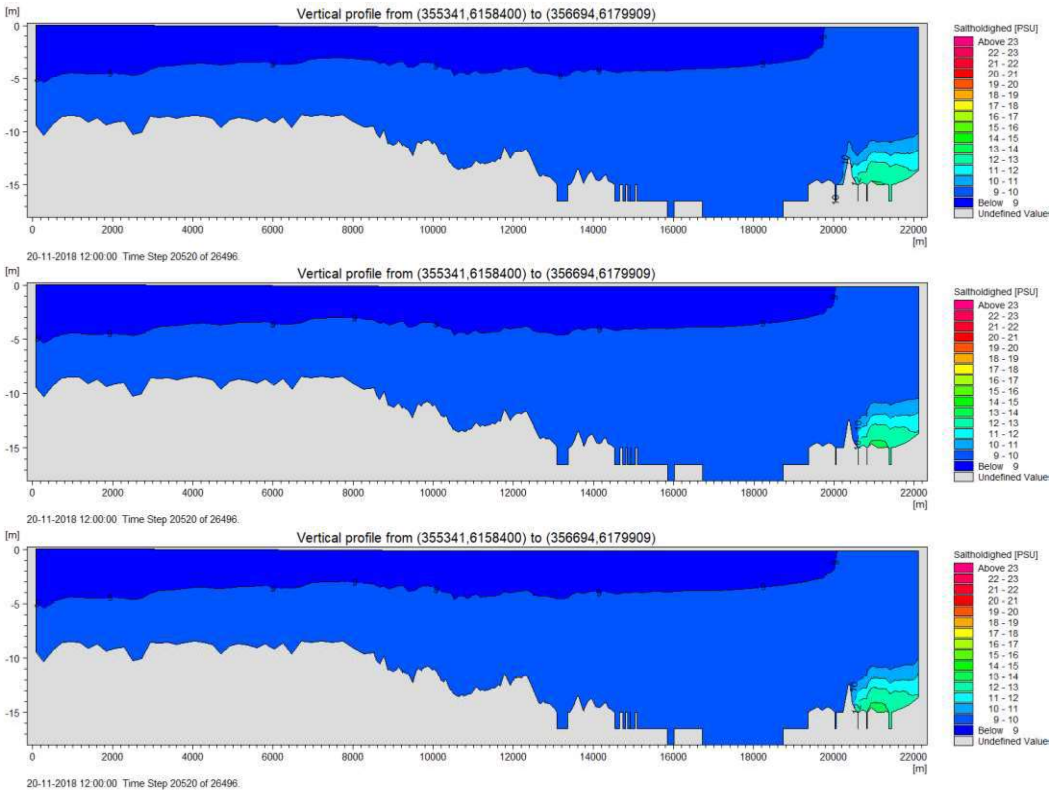


Figure 6-154 Vertical profile of salinity during a period of loss of salt. Top: baseline, middle: Main Proposal 1 and bottom: Main Proposal 2.

Over time, the net transport of salt will stabilise around zero, corresponding to maintaining the existing salinity levels in the Baltic Sea. The net transports and changes in Table 6-9 and Table 6-10 may therefore be difficult to relate to. Basically, a loss of salt from the Baltic Sea through the havneløbet (the inner harbour) is to be expected due to good vertical mixing and relatively low water depths. The net transport of salt through Kronløbet is significantly reduced as a result of the closure of Kongedybet. The cross-section west of Peberholm imports salt into the Baltic Sea, while salt is released from the Baltic Sea via the cross-section east of Peberholm. Overall, a little less salt will be imported in 2018 with a reclamation, but the difference is minimal.

Table 6-9 Net transport of salt and its impact on existing conditions and a Main Proposal 1 reclamation.

Cross-section	Baseline [Mtons]	Main Proposal 1 [Mtons]	Change [Mtons]	Change [%]
havneløbet (the inner harbour)	1,86	1,91	0,05	2,5
Kronløbet	6,75	-13,1	-19,9	-294
West of Peberholm	-110	-99,5	10,8	-9,8
East of Peberholm	26,4	16,9	-9,6	-36,3
Øresund	-85,3	-84,1	1,2	1,4

Table 6-10 Net transport of salt and its impact on existing conditions and a Main Proposal 2 reclamation.

Cross-section	Baseline [Mtons]	Main Proposal 2 [Mtons]	Change [Mtons]	Change [%]
havneløbet (the inner harbour)	1,86	1,89	0,03	1,6
Kronløbet	6,75	-76,1	-82,8	-1.227
West of Peberholm	-110	-99,7	10,6	9,6
East of Peberholm	26,4	16,9	-9,6	-36,3
Øresund	-85,3	-84,3	1,0	1,2

6.1.6.7 Blocking factors for salt transport

The blocking factors are calculated based on the changed accumulated gross salt transport relative to the accumulated baseline gross total transport, thus indicating a measure of how much the dynamics of the system change as a result of the Lynetteholm reclamation. To estimate the blocking factors, a model of a more extended period is needed so that the blocking factor stabilises and contains only a slight seasonal variation. The temporal variation of the blocking factors in the five defined cross-sections is shown in Figure 6-155 to Figure 6-159.

The plots show that it is necessary to calculate a period of at least 5 months to obtain a stable estimate of blocking factors related to salt transport. The slight variation that occurs in the following 7 months reflects a seasonal variation. A negative blocking factor expresses a weakened dynamic, while a positive blocking factor is an expression of a reinforced dynamic in that cross-section.

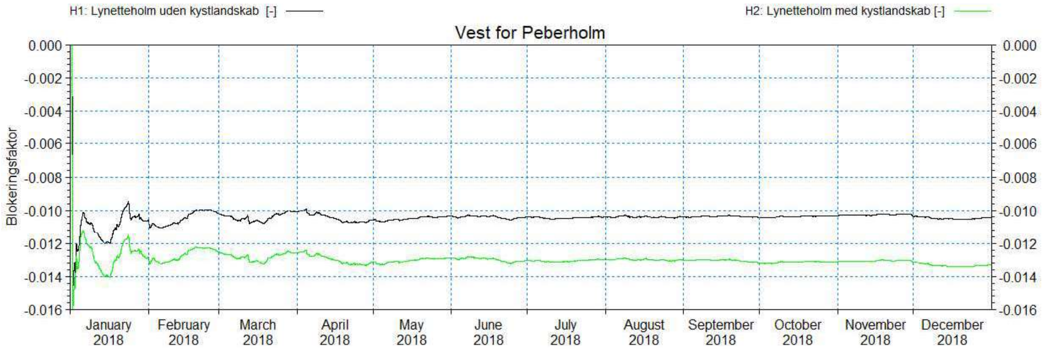


Figure 6-155 Blocking factors for salt transport in the cross-section west of Peberholm. Black curve: Main Proposal 1, green curve: Main Proposal 2.

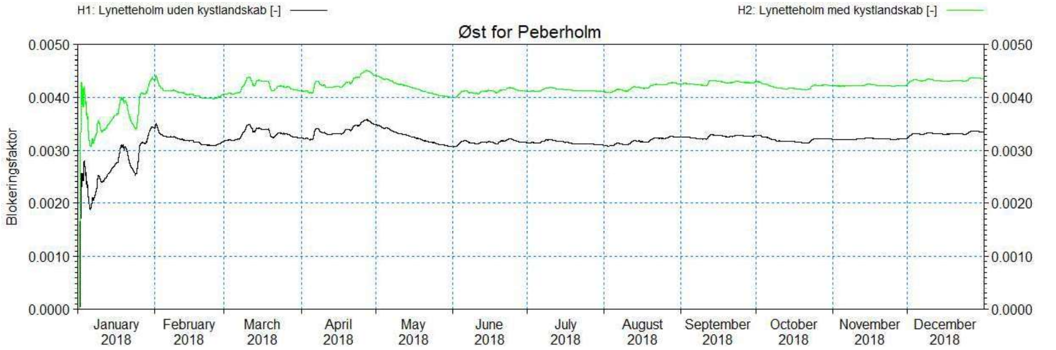


Figure 6-156 Blocking factors for salt transport in the cross-section east of Peberholm. Black curve: Main Proposal 1, green curve: Main Proposal 2.

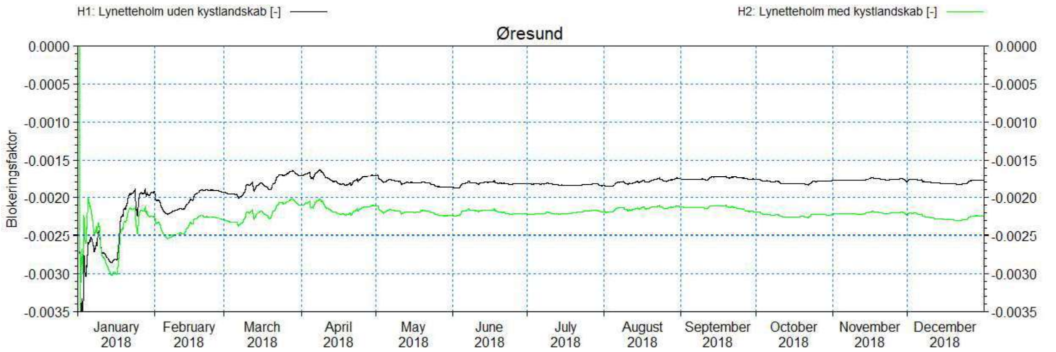


Figure 6-157 Blocking factors for salt transport in the Øresund cross-section. Black curve: Main Proposal 1, green curve: Main Proposal 2.

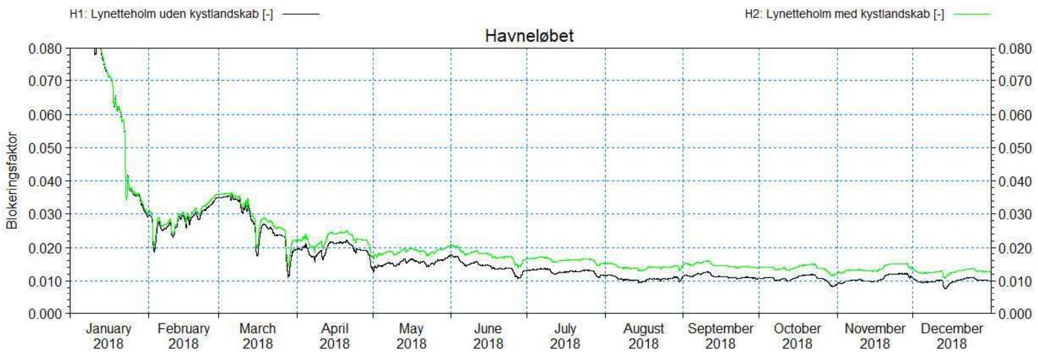


Figure 6-158 Blocking factors for salt transport in the havneløbet (the inner harbour). Black curve: Main Proposal 1, green curve: Main Proposal 2.

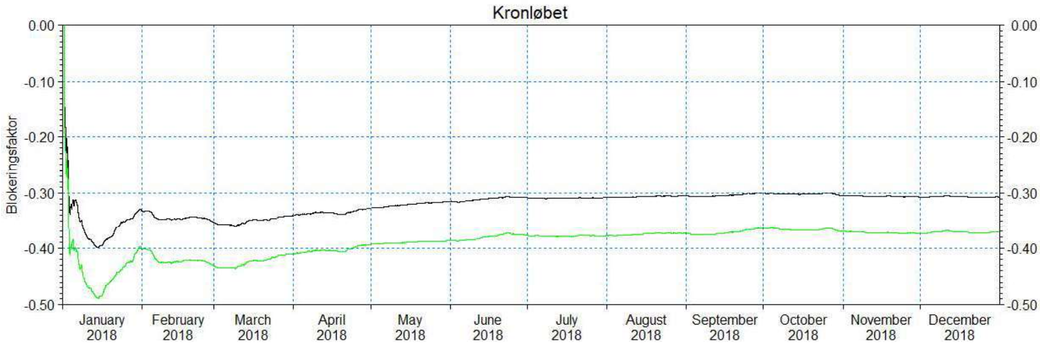


Figure 6-159 Blocking factors for salt transport in Kronløbet (the cross-section between the Nordhavn tip and Middelgrundsfortet). Black curve: Main Proposal 1, green curve: Main Proposal 2.

Table 6-11 Main Proposal 1: Estimated blocking factors for salt transport in selected cross-sections.

Positive values indicate an increased dynamic, while negative values reflect a weakened dynamic.

Cross-section	Blocking factor lower value [%]	Blocking factor upper value [%]	Sign
havneløbet (the inner harbour)	0,76	1,36	+
Kronløbet	30,0	31,0	-
West of Peberholm	1,02	1,05	-
East of Peberholm	0,31	0,34	+
Øresund	0,172	0,186	-

The blocking factors calculated for each of the two main proposals show that the Lynetteholm reclamation will lead to a slight redistribution of the current and the salt transport through Øresund and so that the dynamics are slightly increased in Flinterenden east of Peberholm and slightly weakened in Drogden west of Peberholm. The impact on

Kronløbet is only of local importance and relates to the closure of Kongedybet. Throughout Øresund, a blockage factor of salt of - 0.18% has been found for Main Proposal 1 at the end of the year, thus representing effects from a full seasonal variation. For Main Proposal 2, there is a slightly more substantial impact. Here a blockage factor of salt of -0.22% has been estimated by the end of the year. The upper and lower values of the blocking factors are stated in Table 6-11 and Table 6-12 for each of the main proposals. The values listed in the tables are found based on the calculated blockage in the period July-December 2018. The sign in the last column indicates whether there is a weakened or increased dynamic.

Table 6-12 Main Proposal 2: Estimated blocking factors for salt transport in selected cross-sections. Positive values indicate an increased dynamic, while negative values reflect a weakened dynamic.

Cross section	Blocking factor lower value [%]	Blocking factor upper value [%]	Sign
havneløbet (the inner harbour)	2,39	2,73	+
Kronløbet	30,2	32,0	-
West of Peberholm	1,28	1,34	-
East of Peberholm	0,41	0,44	+
Øresund	0,210	0,229	-

In connection with the Øresund Link, a zero solution was required, whereby compensation excavations an attempt was made to produce conditions resulting in a zero-blocking factor for both water and salt. In these calculations, the blocking requirement was set at less than 0.1% with an uncertainty spread estimated at +/- 0.25% within an uncertainty limited to a 95% confidence interval, Ref. /1/. The uncertainty accepted by the zero solution is thus higher than the estimated blockage than the Lynetteholm reclamation for salt transport through Øresund.

6.1.6.8 Translating blocking targets for salt transport into a measurable physical quantity

It can be difficult to relate the blocking target to a measurable or tangible physical quantity and thus also to understand the real consequence of the blockage. As mentioned above, a zero solution is a slightly far-fetched concept, as climate effects will gradually lead to sea-level rise of the sea around Denmark. To clarify when a blocking effect is important as well as to quantify the effect using a more relatable quantity, calculations have been carried out assuming that the mean sea level has increased by 2 cm. These calculations are used to quantify the importance of a sea-level rise for the baseline situation, i.e. without a Lynetteholm reclamation, and compare this situation with the two main proposals with and without a weak sea level rise.

Figure 6-160 shows the calculated blocking factor for each of the two main proposals and baseline conditions with and without a sea-level rise of 2 cm in the defined section west of Peberholm. The plots show that a sea-level rise of 2 cm leads to a blockage of +0.0015 (increased salt transport). Likewise, the change is of the same size when assessing the effect of Lynetteholm and a sea-level rise of 2 cm. An extrapolation of the effect will thus show that the blocking factor in the cross-section in question will be approximately zero after a sea-level rise of about 14 cm with Main Proposal 1 and about 17 cm for Main Proposal 2.

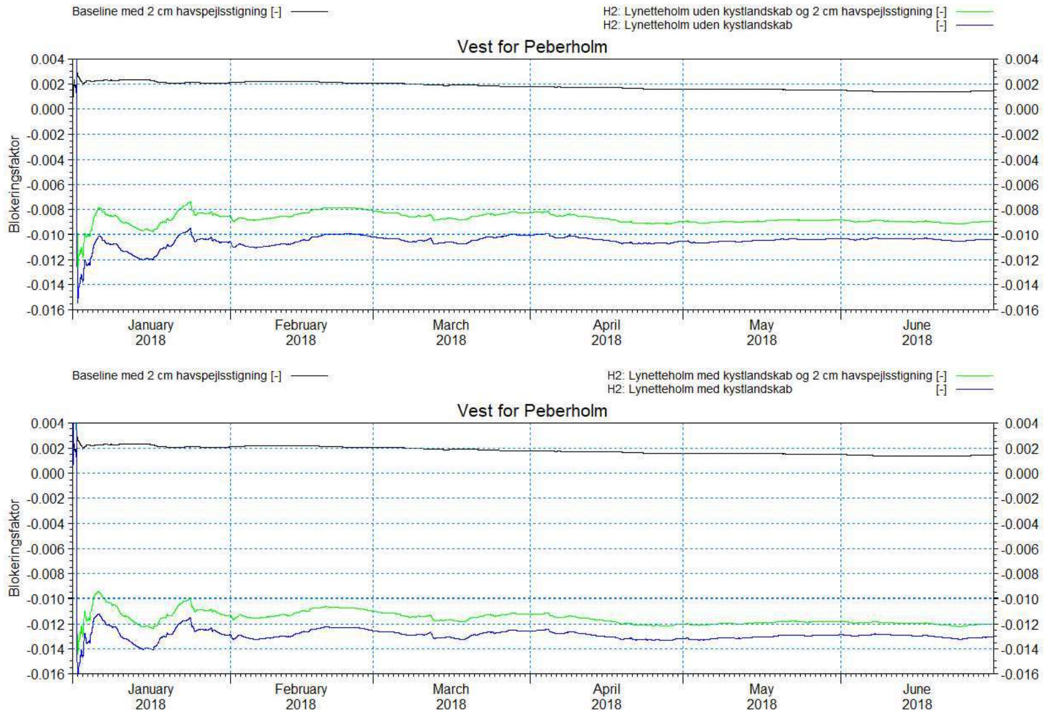


Figure 6-160 Effect of the project and a sea-level rise on the blocking in the cross-section west of Peberholm. Top: Main proposal 1, bottom: Main Proposal 2.

The corresponding blocking effects are shown in Figure 6-161 for the cross-section east of Peberholm. It can be seen that the blocking effect of a 2 cm sea-level rise in that cross-section is almost of the same size as the impact of the project. However, both lead to an increased dynamic and not an actual blockage since the sign of the blockage is positive.

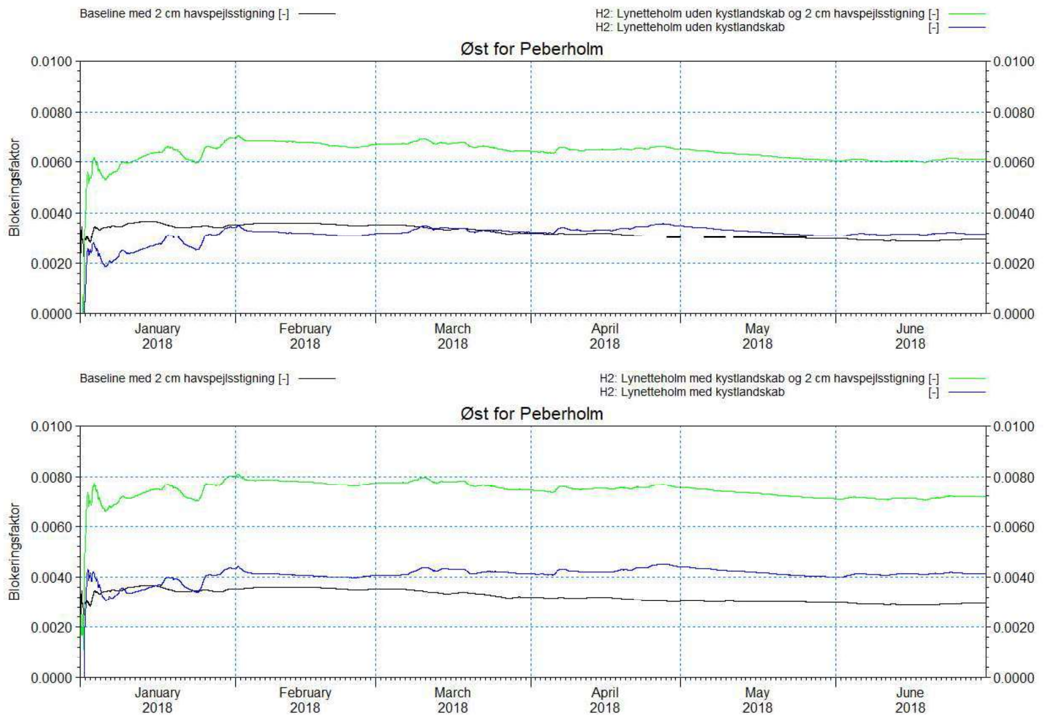


Figure 6-161 The effect of the project and of a sea-level rise on the blocking in the cross-section east of Peberholm. Top: Main Proposal 1, bottom: Main Proposal 2.

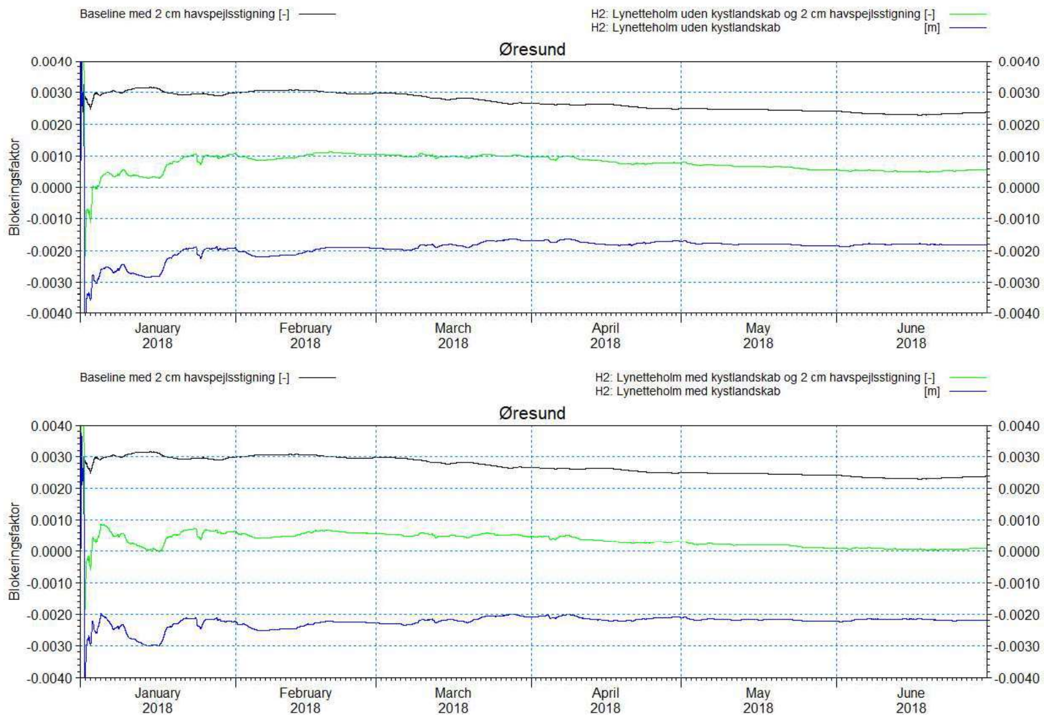


Figure 6-162 The effect of the project and of a sea-level rise on the blocking in the Øresund cross-section. Top: Main Proposal 1, bottom: Main Proposal 2.

Figure 6-162 indicates blocking effects for a complete Øresund cross-section and thus reveals how the exchange of salt between the Baltic Sea and the Kattegat is affected. The curves show that a sea-level rise of about 4 cm is required to cancel the blocking impact of the project on both main proposals. At the current rate of mean sea level rise compensated for effects of land rebounding (1.55 mm/year, ref. /6/ and /7/), the blocking effect is therefore expected to be equalised after a 25-year period. In practice, it is to be expected to happen earlier, as there is an acceleration in the rate of increase due to thermal expansion and increased melting at the poles.

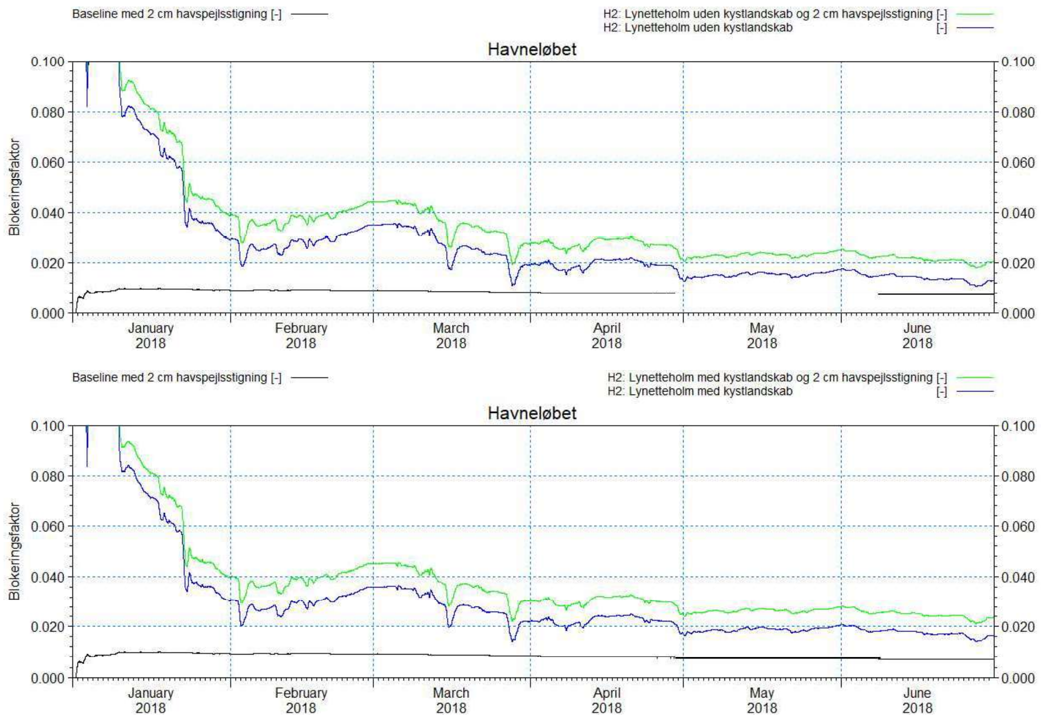


Figure 6-163 Impact of the project and of a sea-level rise on the blocking of the havneløbet (the inner harbour). Top: Main Proposal 1, bottom: Main Proposal 2.

The impact of the project and the importance of a 2 cm sea-level rise for blocking in the havneløbet (the inner harbour) are shown in the curves in Figure 6-163. It can be seen that the impact of the project is expected to be similar to the effect of an effective sea-level rise of 4 cm for Main Proposal 1 and 5 cm for Main Proposal 2. The sluice gates in Sydhavnen largely regulate the flow in the havneløbet (the inner harbour), and it will therefore be possible to control the effect by changing their settings.

The closure of Kongedybet significantly reduces the flow dynamics in the cross-section between the Nordhavn tip and the Middelgrundsfortet. Figure 6-164 shows that effects from sea-level rise will in no way be able to compensate for the local blocking effect. However, as the effect is only local and not decisive for the overall dynamics of Øresund, it is not critical, but merely a derivative consequence of the closure of Kongedybet.

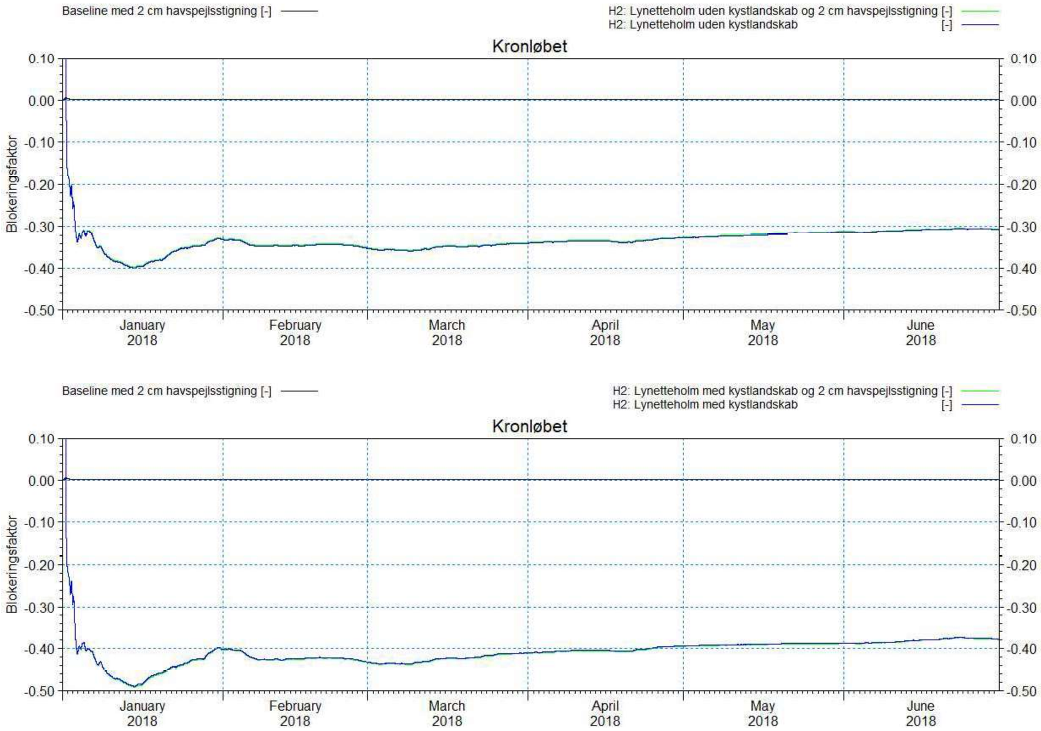


Figure 6-164 Effects of the project and of a sea-level rise on the blockage in the cross-section between the Nordhavn tip and Middelgrundsfortet. Top: Main Proposal 1, bottom: Main Proposal 2.

From: Nanna Zangrando Vestergaard <>
Sent: 03-11-2021 15:40:27 (UTC +01)
To: Mikkel Zwergius Christensen <mizw@tbst.dk>; Jan Albrecht <JAA@tbst.dk>; Gert Agger <GEAG@tbst.dk>; 'Michael Lundgaard' <MLU@byoghavn.dk>; 'Richard.Kristoffersson@Naturvardsverket.se' <Richard.Kristoffersson@Naturvardsverket.se>; 'Egon.Enocksson@naturvardsverket.se' <Egon.Enocksson@naturvardsverket.se>; Sif Zimmermann <sizi@mst.dk>
Cc: Jakob Møldrup Petersen <JMP@tbst.dk>; Henrik Bengtsson <henrik.bengtsson@sgi.se>; Öberg Jörgen <jorgen.oberg@smhi.se>; Malin Hemmingsson <malin.hemmingsson@havochvatten.se>; Per Danielsson <per.danielsson@sgi.se>; Lindqvist Carl <carl.lindqvist@lansstyrelsen.se>; Bo Brahtz Christensen <bbc@dhigroup.com>; Hans Vasehus <hva@byoghavn.dk>; Christina Lea Hoff Johansen <chlej@mst.dk>
Subject: 7. ESPOO-samrådsmøde Lynetteholm

Kære alle

Vedhæftet er materiale til 7. Espoo samrådsmøde.

Dagsorden for mødet:

1. Velkomst
2. Referat fra 6. samrådsmøde (vedlagt)
3. Status på 3. partsgranskning (materiale fremsendt til Havs- och Vattenmyndigheten)
4. Alternativer til klapning (notat om blødbund til klapning vedlagt)
5. Turbidity Management group (beskrivelse af overvågningsprogram og turbidity management group vedlagt)
6. Øvrig orientering
7. Aftaler om den videre proces

Vi ses den 12. november.

Venlig hilsen

Nanna Zangrando Vestergaard
Fuldmægtig
Plan og Klima

Trafikstyrelsen
Danish Civil Aviation and Railway Authority
Carsten Niebuhrs Gade 43
DK-1577 København V

Tlf.: +45 4178 0043
Tlf.: +45 7221 8800
nave@tbst.dk
www.tbst.dk

UDVIKLINGSSELSKABET BY OG HAVN I/S

LYNETTEHOLM

BLØDBUND TIL KLAPNING

ADRESSE COWI A/S
Parallelvej 2
2800 Kongens Lyngby

TLF +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.dk

Dato	Version	Kommentarer
29/10-2021	2.0	Opdateret iht. kommentarer fra By og Havn
14/10-2021	1.0	Første udgave

PROJEKTNR.	DOKUMENTNR.
A125503	HP-GEO-TN-016

VERSION	UDGIVELSESDATO	BESKRIVELSE	UDARBEJDET	KONTROLLERET	GODKENDT
2.0	29-10-2021	Anden udgave	MWNN	MPLN/MRM	HHP

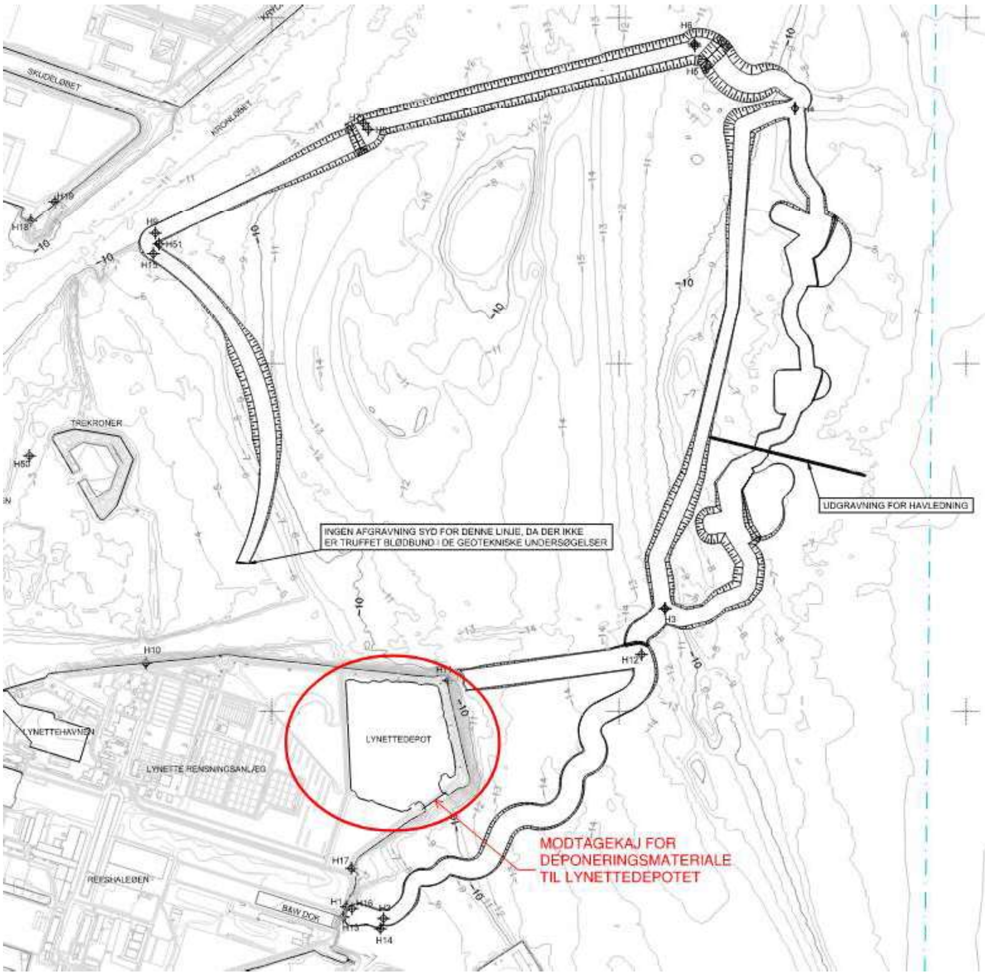
INDHOLD

1 Indledning

I forbindelse med etablering af Lynetteholms perimeter skal der udskiftes blødbund under perimeterkonstruktionerne for sikring af konstruktionernes stabilitet og for at minimere sætninger.

Blødbunden består af postglaciale aflejringer, hovedsageligt gytje men kan også være tørv og gytjeholdig ler.

Bundudskiftning foretages ved at opgrave blødbund fra havbund til overside af faste aflejringer og efterfølgende tilbagefylde afgravningen med marint sand. Bundudskiftningen foretages under fodaftrykket for hele perimeterkonstruktionen, jf. Figur 1-1.



Figur 1-1 Oversigtsplan over området for bundudskiftning for Lynetteholms perimeter. Placering af Lynettedepotet er markeret med rød ring.

Den afgravede blødbund skal deponeres eller klappes afhængig af forureningsgraden af det opgravede materiale.