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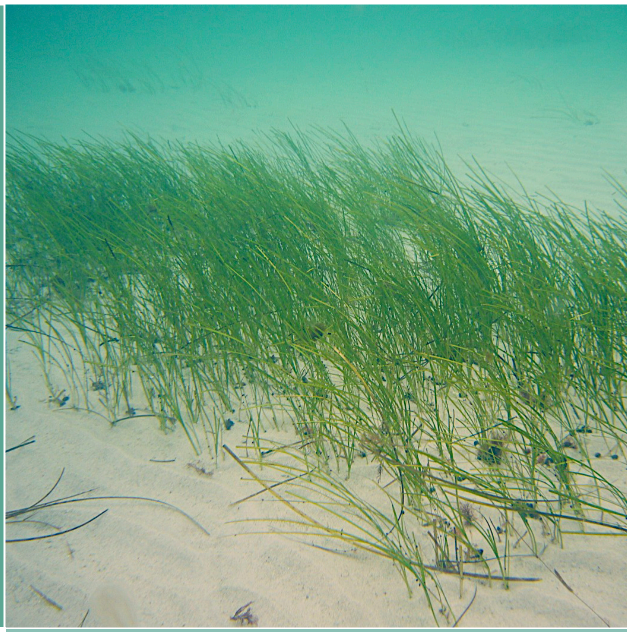

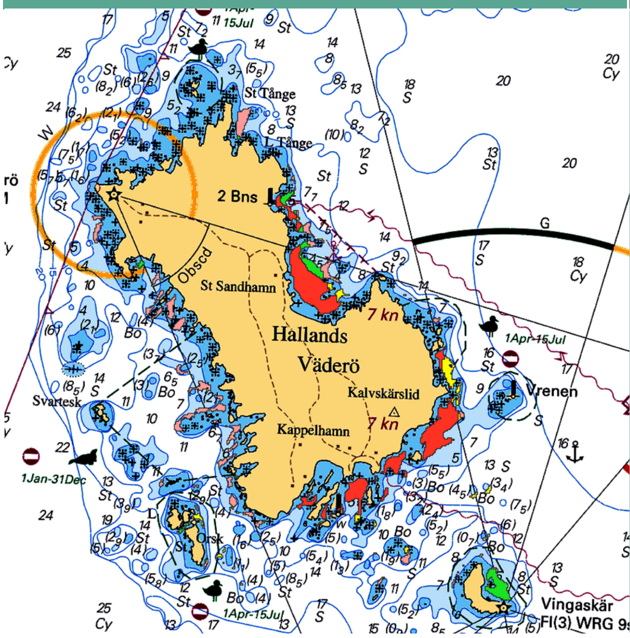

County Administrative Board of Skåne
(Länsstyrelsen Skåne)
Report 2020:14
June 2020

NIRAS project: 32400606

Analysis of areas suitable for eel-grass establish-ment/remediation.

PREPARED FOR LÄNSSTYRELSEN SKÅNE, REFERENCE NUMBER 424-4094-2020
DATE: 25 JUNE 2020
ISBN: 978-91-7675-193-0

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1a. Sammanfattning (Summary in Swedish)

Som en del i Interreg-projektet "Building With Nature", har Länsstyrelsen i Skåne initierat detta projekt. Projektet syftar till att öka kunskapen kring förutsättningarna för ålgräsängar längs den skånska kusten, främst för deras dämpande effekter på kusterosion. En omfattande analys innefattande flera geodata-lager gjordes med syfte att:

- Identifiera lokaler soma är lämpliga/direkt olämpliga för restaurering eller återetablering av ålgräs.
- Rangordna dessa områden efter lämplighet.
- Producera geodata för dessa områden.

Analyserna innefattade utvalda geodata-lager för Skånes kustvatten gällande vattendjup, bottenströmmar, bottensubstrat och vågexponering. Data modellerades för att kunna rangordna lämplighetsgraden för ålgräsetablering. Modellen genererade en lämplighets-rangordning från klass 1 till 4, där klass 1 syftade till den mest lämpliga. Ett detaljerat geodatalager som visar rangordnade områden längs hela Skånes kustlinje skapades.

Modellerade data åskådliggörs i kartsektioner av Skånes kustlinje och kompletteras med tillgängliga övervakningsdata från fältundersökningar. Intressanta lokaler/områden markeras i kartorna.

Modellen visar att de mest lämpliga områdena för artificiell ålgräsplantering (klass-1-områden, röd färg) var mest omfattande i den södra halvan av Öresund. I andra områden längs kustlinjen, representerade klass-1-områden en relativt liten del av kustområdena inom det stipulerade djupintervallet (2-4m). Mer utbredda var klass-2- och klass-4-områden, vilka är mer exponerade.

Jämförelser av rangordnade områden med tillgängliga övervakningsdata visade att väldigt få klass-1-områden, där fältdata fanns tillgängligt, saknade ålgräs. Generellt visade fältundersökningarna på rikliga ålgräsförekomster i klass-1-områden. Vidare sågs även riklig förekomst i stora delar av övriga rangordnade områden (2-4). Detta tyder på att naturligt förekommande ålgräs kan tolerera relativt hög exponeringsgrad av vågor och strömmar. Dock saknades fältdata för många rangordnade områden, varför ytterligare fältundersökningar vore av nytta.

För att fastställa potentiella områden som är lämpliga för ålgräsplantering/restaurering, föreslås inriktning på följande typer av områden:

- Klass-1-områden (mest lämpliga) där fältdata visar på låg eller ingen täckningsgrad av ålgräs.
- Klass-1-områden (mest lämpliga) där data från fältundersökningar saknas. Kompletterande undersökningar behövs i dessa områden för att fastställa om livskraftiga ålgräsbestånd redan förekommer.
- Klass-3-områden där ålgräsförekomst har konstaterats historiskt. Detta kräver studier av äldre undersökningar som visat på förekomster längre tillbaka i tid. Återetablering i denna typ av områden skulle kunna behöva någon form av artificiell reducering av exponeringsgraden.
- Klass-3-områden där kusterosion kan bedömas utgöra ett hot i framtiden. Återetablering i dessa områden kommer säkerligen att kräva någon form av artificiellt erosionsskydd för nyplanterat ålgräs.

1b. Summary

As a step in the Interreg project "Building With Nature" (BwN), the County Administrative Board of Skåne, Sweden has initiated this project which aims to increase knowledge concerning conditions for eelgrass meadows along the coast of Skåne, primarily regarding their wave dampening abilities to mitigate coastal erosion processes. A comprehensive analysis involving several sets of geodata was performed to:

- Identify locations suitable/apparently unsuitable for restoration or establishment of eelgrass meadows
- Categorize locations for their suitability
- Produce geodata of these locations

The analysis incorporated selected geodata sets of coastal waters of Skåne concerning water depth, bottom currents, bottom composition and wave exposure. Data were modelled to rank suitability for eelgrass reestablishment. This model generated suitability rankings of 1-4, rank 1 being most suitable. A detailed geodata set showing ranked areas along the coastline of Skåne was generated.

Modelled data are presented in this report in map sections of the coastline of Skåne and supplemented with availabale monitoring data from field surveys. Locations of interest are highlighted in each map section.

The modelled data suggest that areas most suitable for artificial eelgrass establishment (class-1-areas, red colour) were most abundant in the southern half of Öresund. In other areas along the coastline of Skåne, class-1-areas represent a relatively small proportion of the coastal areas within the stipulated depth range (2-4m). More widespread were class-2- and class-4-areas which are more exposed to waves.

When comparing ranked areas with available eelgrass monitoring data, very few class-1-areas, where monitoring have been performed, lacked eelgrass. In general, surveys showed abundant eelgrass in class-1-areas and furthermore, vital eelgrass meadows occurred frequently in all the classed areas. This implies that naturally occurring eelgrass kan tolerate relatively high exposure from waves and currents. However, many of the ranked areas lacked monitoring data and these areas are yet to explore.

To establish potential areas for eelgrass remediation, focus on the following types of areas are suggested:

- Class-1-areas (most suitable), where monitoring data indicates no or sparse eelgrass coverage.
- Class-1-areas (most suitable), where monitoring data is lacking. Complementary monitoring is needed in these areas to establish if natural and vital eelgrass habitats already exist.
- Class-3-areas where elgrass habitats have existed historically. This requires studies of older monitoring data showing vital habitats back in time. Re-establishment in this type of area could require some degree of artificial measures to reduce exposure factors.
- Class-3-areas where coastal erosion is assessed to pose a threat in the future. Re-establishment in this type of area will almost certainly require some degree of artificial measures to reduce exposure factors for the newly planted eelgrass.

2. Background

The County Administrative Board of Skåne, Sweden is since 2016 a member of the Interreg project "Building With Nature" (BwN). The purpose of this project is to, with the help of natural barriers, make coastlines, estuaries and basins more adaptable and resistant to climate changes. The project is implemented in the Netherlands, Norway, Germany, Belgium, Denmark, Great Britain and Sweden. The County Administrative Board of Skåne is coordinator in Sweden. One of the tasks within this project for the County Administrative Board of Skåne is to identify locations along the coast of Skåne which are suitable for restoration and establishment of eelgrass meadows.

2.1 Purpose

The purpose of this project is to increase knowledge concerning conditions for eelgrass meadows along the coast of Skåne, primarily with respect to their wave dampening abilities to mitigate coastal erosion processes.

2.2 The Project

On basis of available data, this project aims to:

- Identify locations suitable/apparently unsuitable for restoration or establishment of eelgrass meadows
- Categorize locations for their suitability
- Produce geodata of these locations

The County Administrative Board of Skåne has provided geodata and reports of concern as follows:

Reports:

- Ålgräs i Skåne 2016 - Fältinventering och satellitbildstolkning -Lst Skåne (field work and data analysis by Toxicon AB) (monitoring data for eelgrass coverage along coast of Skåne)
- Marin inventering och modellering i Skåne län 2016 -Aqua Biota (water depth, wave exposure)
- Regional handlingsplan för grön infrastruktur nulägesbeskrivning 2018-2019 -Lst Skåne
- Ålgräskartering Fortuna 2019 - Drönarkartering verifierad med undervattensvideo – Medins (monitoring data for eelgrass coverage Fortuna, Hesingborg)
- Marinbiologisk kontroll - ålgräsinventering Skåne 2019 – Clinton Marine Survey (monitoring data for eelgrass coverage att several locations)

Geodata:

- Sjöfartsverket Sjökort skärgårdskort (nautical chart)
- Marin inventering och modellering i Skåne län 2016 -Aqua Biota (water depth, wave exposure)
- Sveriges geologiska undersökning, SGU, Maringeologi 1:25 000; Bottenmaterial, Bottenströmexponering, Erosions/ackumulationsförhållanden, Tunt ytlager av bottenmaterial, Ytsubstrat (bottom composition)
- Kartering av vegetation och blåmusselbankar längs Helsingborgs- och Landskronas kust 2017 (eelgrasss coverage Öresund)
- Ålgräs i Skåne 2016 - Fältinventering och satellitbildstolkning -Lst Skåne (eelgrass coverage Skåne)

3. Parameters

3.1 Depth

The ideal depth of eelgrass restoration along the Swedish west coast is 1,5-2,5 m (Moksnes et al, 2016). However this recommendation mainly concerns archipelagos with relatively sheltered areas and higher turbidities. Along the relatively open coastline of Skåne the conditions are somewhat different with a higher exposure to waves and currents and generally much lower turbidities. A lower turbidity allows better growth capacity (due to increased light penetration) at greater depths than in sheltered locations with higher turbidity, and exposure from waves decreases with increasing depths. Therefore it's realistic to consider a slightly deeper depth-interval to potentially suitable areas. Acceptable depths in this analysis was set to 2-4 m depth.

3.2 Bottom Currents

Currents is one of several factors that can predict bottom conditions, i e which fractions of the sediment that are able to stay put at the bottom. Strong currents tend to transport finer sediment particles away leaving a coarser sediment structure on the bottom. As eelgrass replanting requires finer sediments the exposure of strong bottom currents can be unfavorable. Geodata showing bottom current exposure (SGU) is categorized as follows:

- Low
- Low-moderate
- Moderate-high
- High

Comparisons of geodata (SGU) showing bottom currents with actual eelgrass coverage in natural occurring populations (Lst Skåne, 2017) show that bottom currents are tolerable up to even the highest exposure-class for bottom currents. However, when restoring eelgrass meadows, newly planted eelgrass is more sensitive to sediment transportation than naturally occurring eelgrass. Bottom current exposure-class of "high" has therefore been considered unfavorable when extracting suitable areas for eelgrass restoration.

3.3 Bottom Composition

One of the most crucial factors for eelgrass restoration, along with light penetration, is the bottom composition. The substrate is a kind of "result" of the summarized exposure on the sediment, where high exposure of waves and currents leave only coarser sediment fractions. Geodata (SGU) showing bottom composition (SGU) is categorized as follows:

- silt
- fine sand
- mixed sand, gravel, stones
- stones and boulders
- bedrock

Comparisons of geodata (SGU) showing bottom substrate with actual eelgrass coverage in natural occurring populations (Lst Skåne, 2017) show that eelgrass is generally abundant in areas with both sandy and mixed bottoms. However, in the case of eelgrass restoration, sandy sediments are preferred. Sandy sediments are indicating lower exposure to waves and currents compared to mixed bottoms. Additionally, sandy sediments are required when actually planting eelgrass plants. Therefore, silty and sandy sediments have been given priority over mixed sediments when ranking suitability for eelgrass remediation. "Stones and boulders" and "bedrock" areas have been excluded.

3.4 Wave Exposure

Wave exposure is another crucial factor in shallow waters along the generally open coastline of Skåne. Generally, this coastline is very exposed to wind and therefore wave exposure. Geodata showing wave exposure (Aqua biota , 2016) is categorized as follows:

- ultra sheltered
- extremely sheltered
- very sheltered
- sheltered
- moderately exposed
- exposed
- very exposed

Naturally occurring eelgrass exists in areas with quite high wave exposure in Skåne, but as mentioned earlier, newly planted eelgrass plants are more susceptable to exposure compared to naturally occurring plants. Therefore, wave exposure classes up to “moderately exposed” has been given priority over “exposed” when ranking suitability for eelgrass remediation. Class “very exposed” has been excluded.

3.5 Ranking of Parameters

In order to make the most ecologically relevant suitability ranking based on the available geodata, one must evaluate each parameter individually as a first step. Some parameters will be given a mandatory criterium, while others will be assigned two levels of priority (Fig 1.)

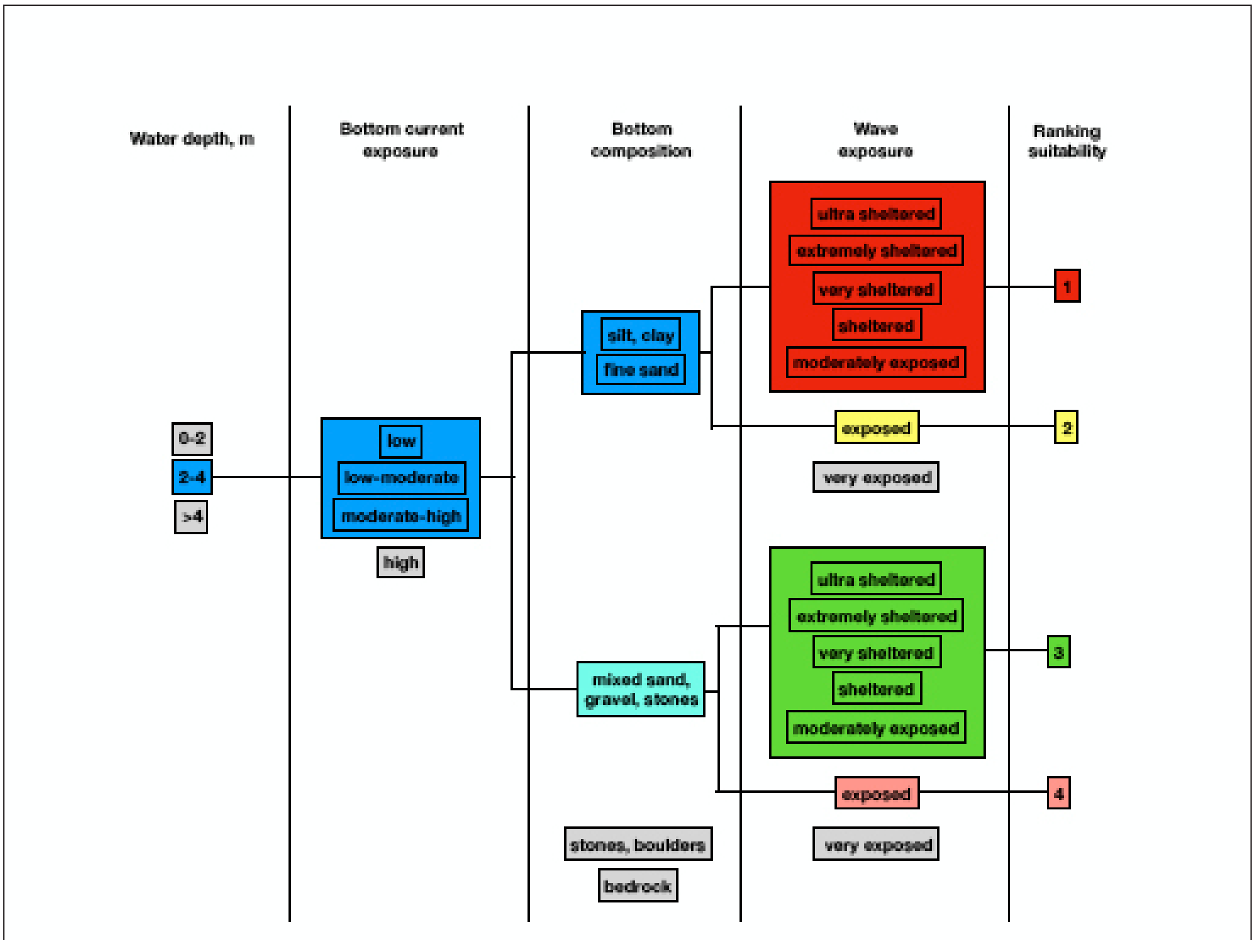

FIGURE 1. Flow chart showing parameters included in suitability ranking of areas.

A water depth range of 2-4 m is, in this model, considered a mandatory criterium. Therefore all other depths are excluded. Bottom current exposure is also set to a mandatory range of "low" up to "moderate-high". Areas with a bottom current exposure of "high" are excluded.

In the next step bottom composition data is ranked in two levels, where areas with finer sediment fractions (silt, clay and fine sand) are ranked as more favourable than areas with coarser sediment structures (mixed (sand, gravel and stones)). Areas with stones, boulders and bedrock are excluded as they are not suitable for eelgrass establishment. This ranking process generates two categories: fine sediment areas and coarse sediment areas.

In the last step of ranking the two categories are further ranked with respect to wave exposure. Each category is separated into areas with wave exposure of "ultra sheltered" up to "moderately exposed" and into a less favourable category with a wave exposure of "exposed". This ranking process renders 4 categories ranging from 1 to 4 with respect to suitablity för eealgrass establishment (Fig 1.).

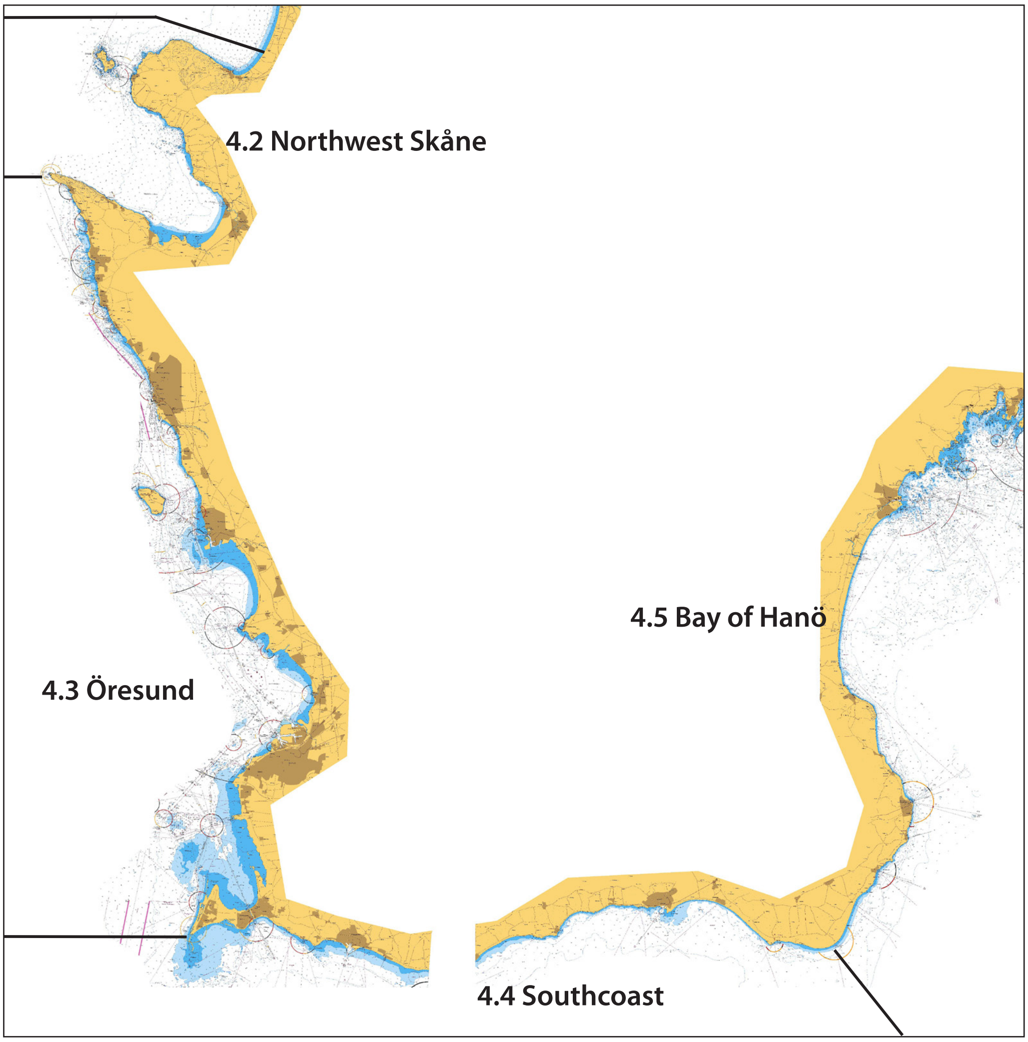

FIGURE 2. Overview map of Skåne with the 4 main areas.

4. Results

4.1 General considerations

When analysing geodata that are modelled from actual measurements, some level of caution is necessary. With the benefit of covering large areas with respect to a certain parameter comes a risk of small scale deviations from actual conditions at a specific locations. Furthermore, when combining several modelled parameters, this risk increases.

Other considerations to account for is human impact in some areas. Maritime activities in harbour areas, dredging activities in channels and dumping of dredge materials also affect suitablity för eelgrass establishment.

The results from the analysis of geodata will be presented with a review of the entire coast range starting in the northwestern parts of Skåne and ending in the northeastern archipelago adjacent to the county of Blekinge. The coastline is divided in 4 main areas (Fig. 2). The main areas are then divided into smaller coast sections for improved visibility of the rankings. Each sub-area will be presented with a map and commented in text. Local deviations/ exceptions will be adressed when appropriate. Note that ranked areas within harbour basins will not be discussed or highlighted in this report as they occur in a type of area that already have been designated mainly for maritime purposes.

4.2 Northwest Skåne

The area is, in general, quite exposed to the open sea of Kattegatt (Fig. 3). Impacts from human activities are limited as no larger cities are situated in the area. Smaller harbours mainly with recreational vessels and local fisheries can affect limited parts of the coastline. Several minor streams flow inte the coast area as well as Rönne river, a larger river.

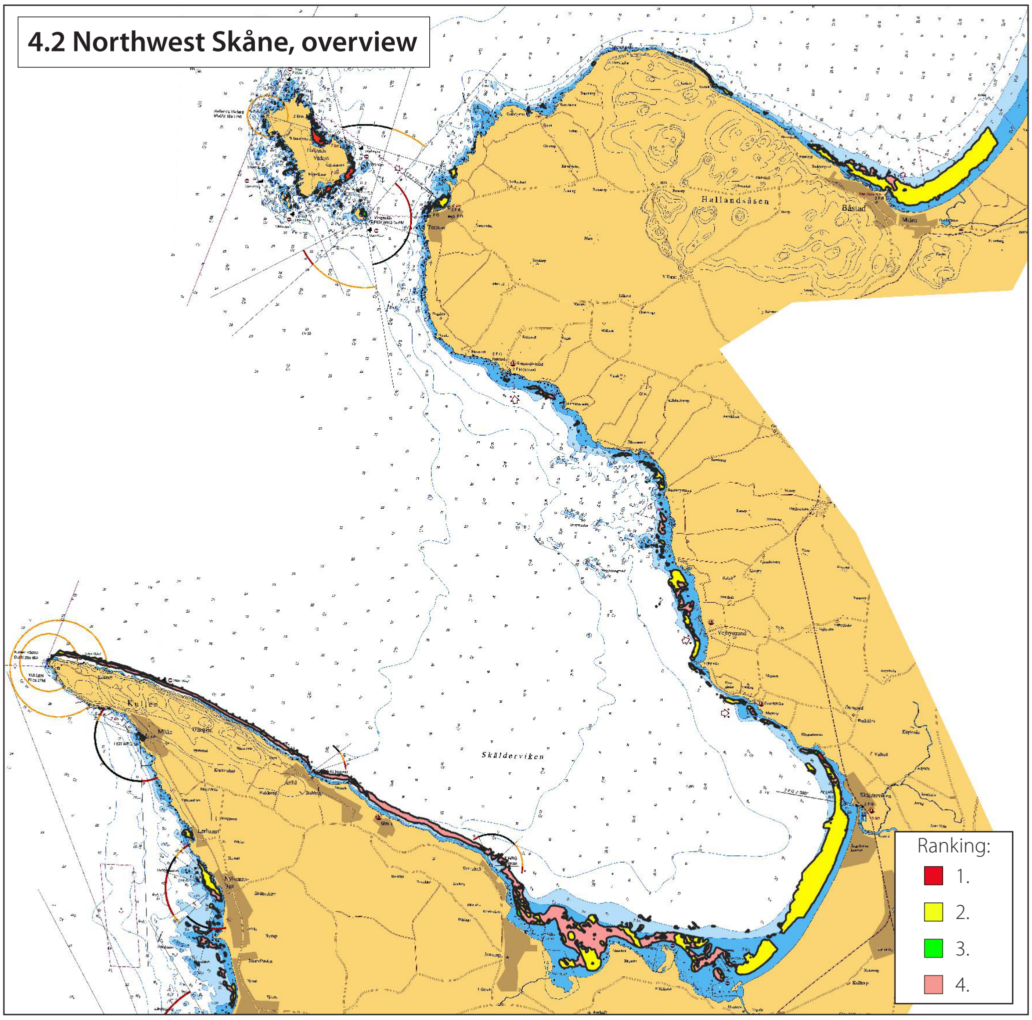

FIGURE 3. Northwest Skåne, overview map. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure)..

4.2.1 Northwest Skåne, area 1

Several class-1-areas (rank 1/best suitability, red areas) were found along the eastern side of the island of Hallands Väderö (area A and B, Fig. 4). In these areas eelgrass meadows were

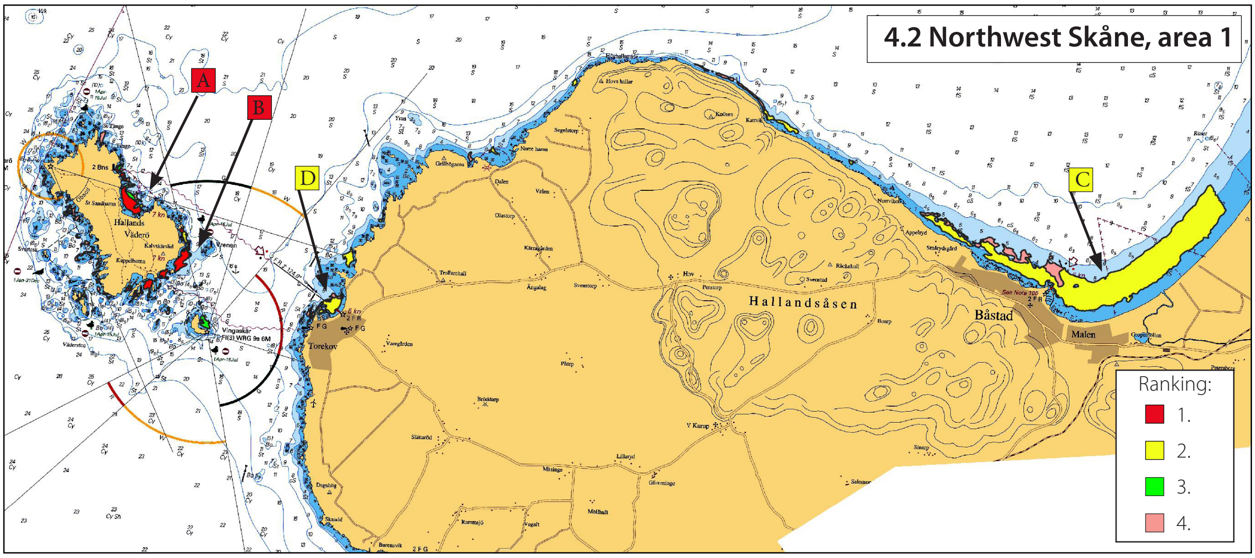

FIGURE 4. Northwest Skåne from Båstad to Rammsjöstrand. Plotted areas are ranked for suitability (1 as the highest and 4 as the lowest) for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A, B and C are described in the text.

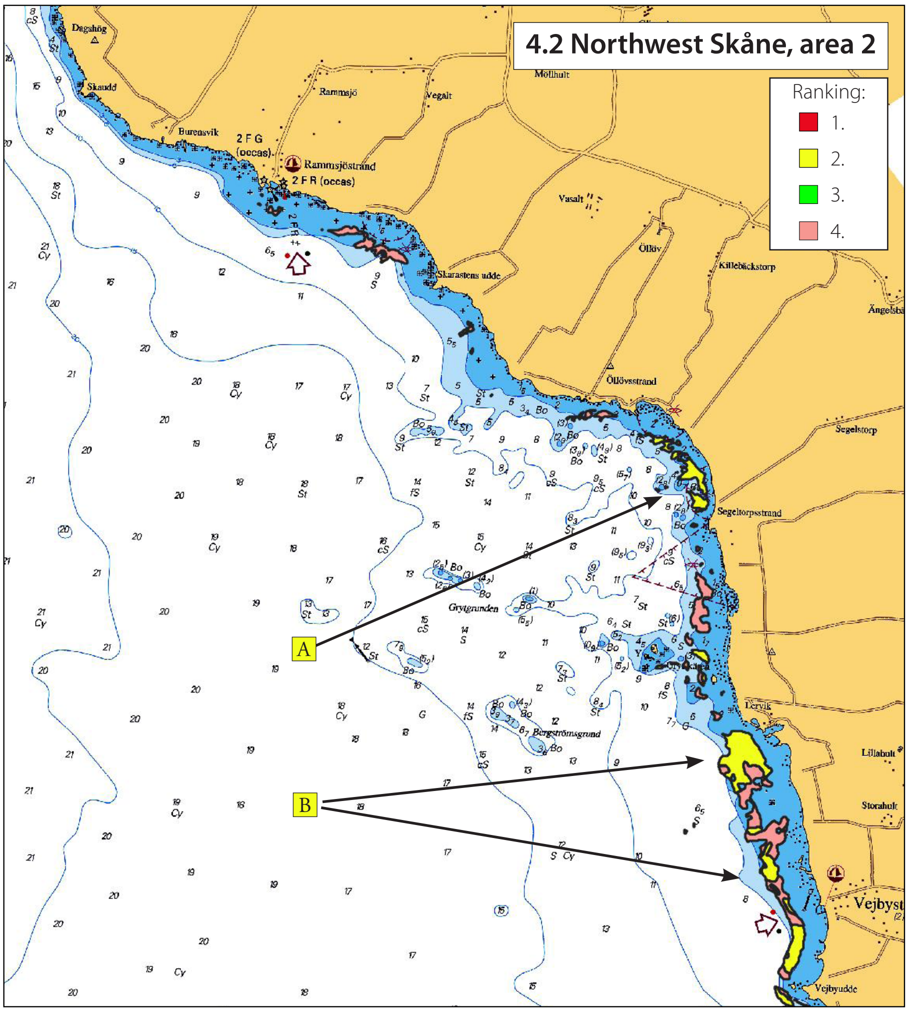

FIGURE 5. Northwest Skåne from Rammsjöstrand to Vejbystrand. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A and B are described in the text.

found in 2016 (Lst Skåne, 2017), but interestingly very little eealgrass in the northern of these areas (area A, Fig 4).

A larger class-2-area (rank 2/second best suitability, yellow areas) was found around and east of Båstad (area C, Fig. 4) with higher wave exposure. Sparse eelgrass were found here in 2016 (Lst Skåne, 2017) indicating that conditions are not ideal in this area. Smaller areas north of Torekov (area D, Fig. 4) were also ranked as class 2, but monitoring has not been done here.

4.2.2 Northwest Skåne, area 2

No class-1-areas were found along this stretch of coast. Several class-2-areas were found, however, in sandy areas (area A-B, Fig. 5). 3 transects were investigated in area B in 2016 (Lst Skåne, 2017), but these transects were not situated in the sandy areas.

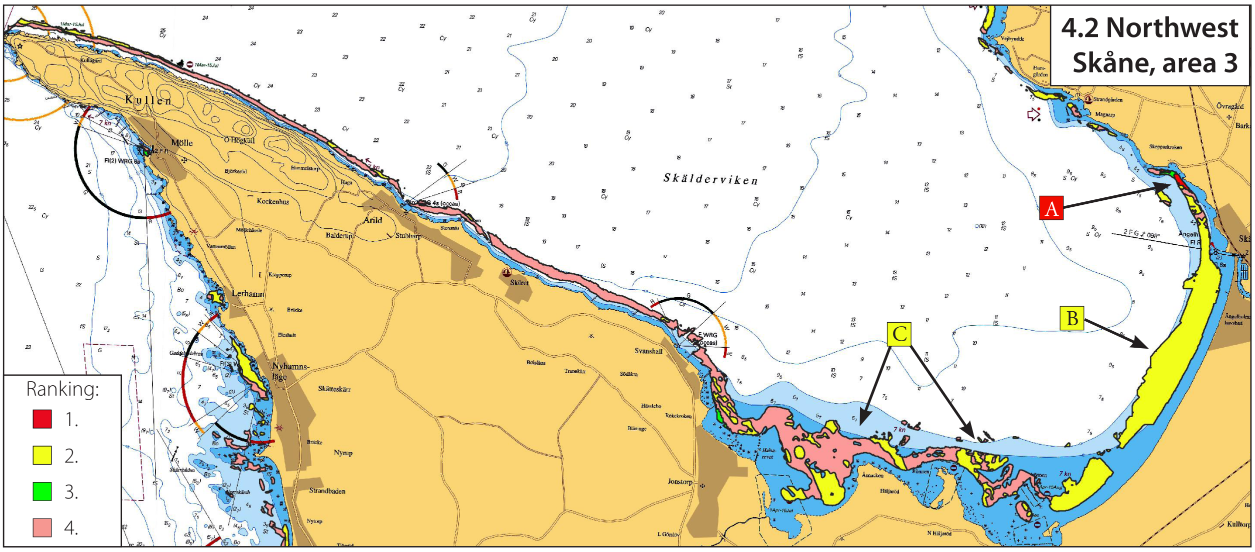

FIGURE 6. Northwest Skåne fråm Vejbystrand to Kullen lighthouse. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A, B and C are described in the text.

4.2.3 Northwest Skåne, area 3

One class-1-area was found along this stretch of coast (area A, Fig. 6). Several class-2-areas were found in sandy areas, especially along the long stretch between Rönne river and Vege river (area B, Fig. 6). Eelgrass has not been monitored in this area. In the shallow and flat southeast area eelgrass has been found (Lst Skåne, 2017) but mainly at depths less than 2 meters (area C, Fig. 6). Further west towards Kullen lighthouse a band of class-4-area was found with small, scattered class-2-areas along the coast.

4.3 Öresund

The area is diverse with a rocky coastline in the north and large, relatively shallow bays in the southern parts. Large rivers flow into Öresund primarily in the southern half of the sound. Several large cities are situated along the coast, affecting the environment in several ways. Commercial vessel traffic is intense in Öresund and is mainly restricted to fairways and harbours.

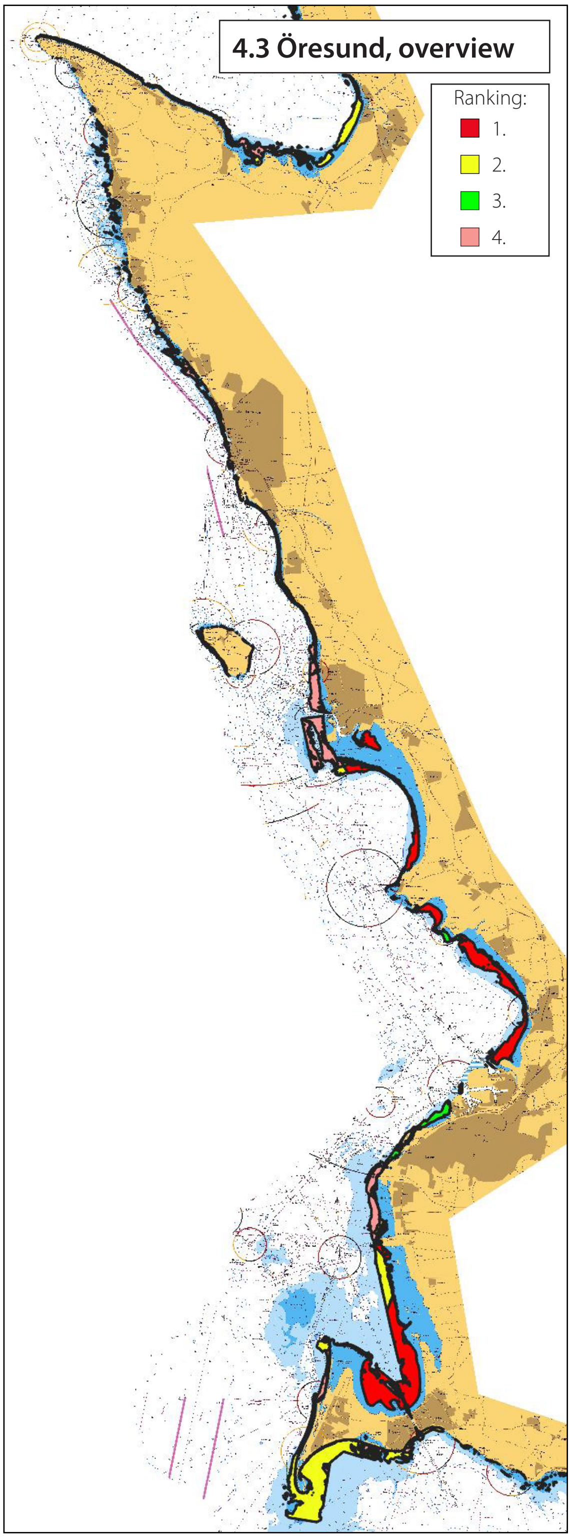

FIGURE 6. Öresund, overview map. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure).

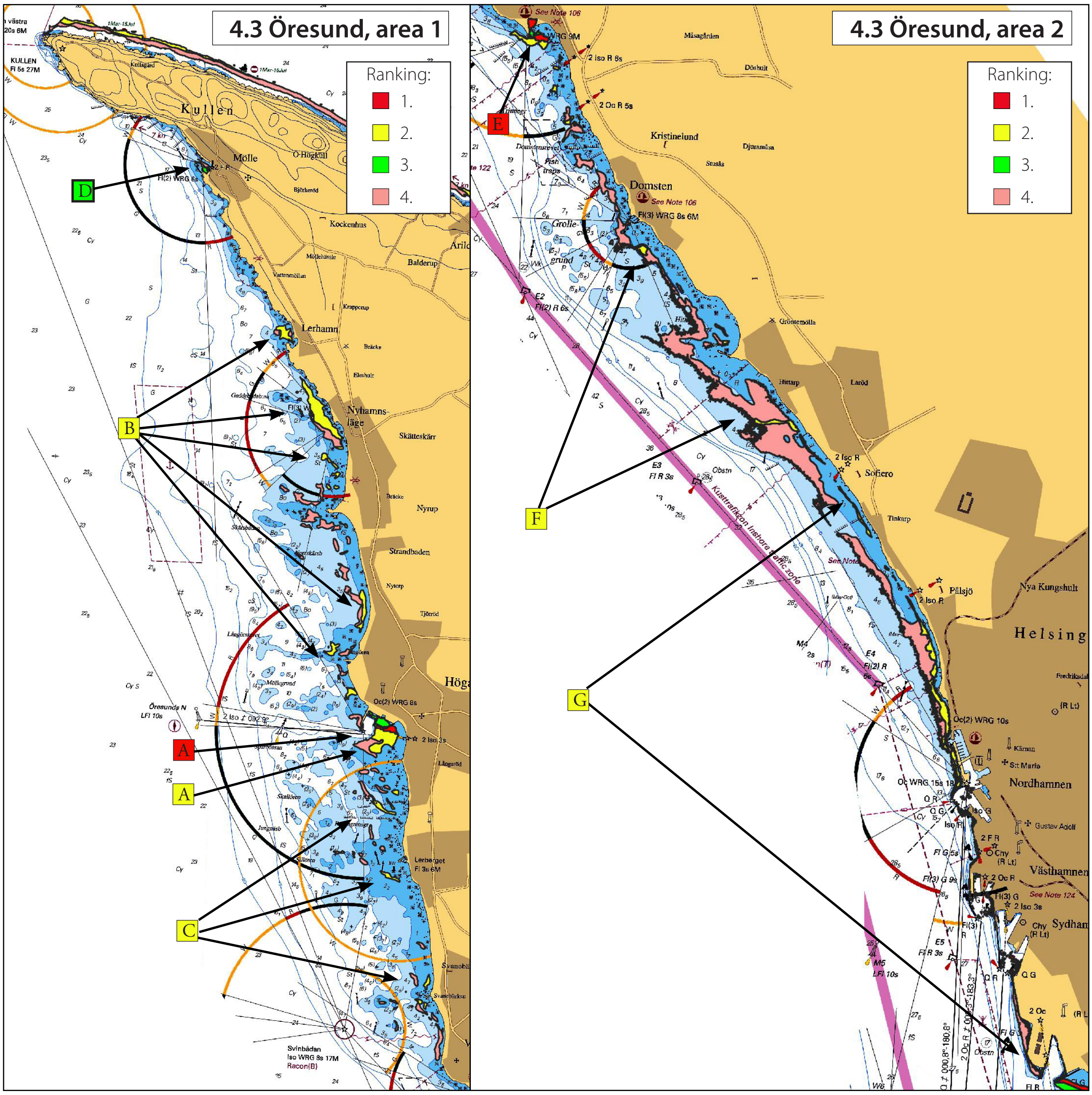

FIGURE 6. Öresund from Kullen lighthouse to Svanebäck (area 1), and Svanebäck to Kopparverkshamnen, Helsingborg (area 2). Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-F are described in the text.

4.3.1 Öresund, area 1

Only one class-1-area was found along this stretch of coast, south of Höganäs harbour (area A, Fig. 6). This area is well monitored within a coastal monitoring program since 1997 (ÖVF, 2020) and contains a well established eelgrass meadow both in the class-1-area and the adjacent class-2-area. However, coverage of eelgrass has varied over time and seems to be affected mainly by wind conditions/wave exposure (i. e. stormy weather).

North of Höganäs scattered class-2-areas were found including one larger area north of Nyhamns läge (area B, Fig. 6). No eelgrass monitoring data was available in this area. South of Höganäs a few scattered class-2-areas were found (area C, Fig. 6). Monitoring of eelgrass in this area (Lst Skåne, 2017) outside Lerberget showed no eelgrass.

A small area with eelgrass was detected just north of Mölle harbour in 2016 (Lst Skåne, 2017). This area was ranked as a class-3-area (green) in this study (area D, Fig. 6), and this could be the northernmost eelgrass meadow in Öresund.

4.3.2 Öresund, area 2

Only one class-1-area was found along this stretch of coast, south of Viken harbour (area E, Fig. 6), but no eelgrass occurred here in video monitoring from 2016 (Lst Skåne, 2017).

Along the coastline from Viken down to Hittarp scattered class-2-areas were found (area F, Fig. 6), but no eelgrass occurred here in previous monitorings (Lst Skåne, 2017 and La-Hbg, 2017).

South of Hittarp scattered class-2-areas were found (area G, Fig. 6), and in this area vital eelgrass meadows occurred in previous monitorings (Lst Skåne, 2017 and La-Hbg, 2017), even in areas with lower ranking (class 3-4) and areas that have been denoted as "not suitable" (i. e. not ranked). These unranked areas generally have a bottom composition with "stones and boulders" according to geodata from SGU or have water depths shallower than 2 m. Possibilities are that a small scale "patchiness" of bottom composition were not shown in marine geological geodata in this area. This stretch of the coast is, nevertheless, not ideal for artificial establishment of eelgrass.

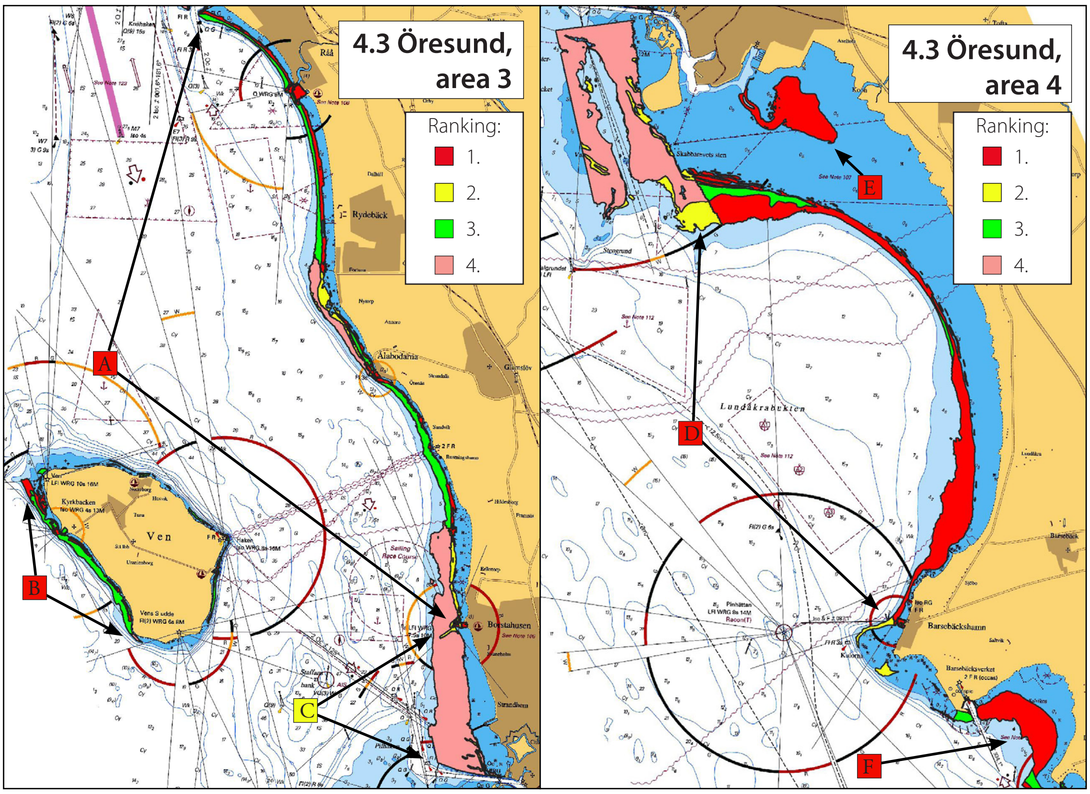

FIGURE 7. Öresund from Kopparverkshamnen, Helsingborg to Landskrona harbour inlet including Ven island (area 3), and Landskrona to Vikhög (area 4). Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-F are described in the text.

4.3.3 Öresund, area 3

A more or less continous class-1-area followed the coastline from Kopparverkshamnen to Borstahusen, with a few interruptions with class-2-areas (area A, Fig. 7). Vital eelgrass meadows have been documented throughout this stretch of coast (Lst Skåne, 2017 and La-Hbg, 2017). Also around Ven island, mainly on the west side, class-1-areas were found, mixed with class-3-areas (area B, Fig. 7). Eelgrass has also been documented around Ven mostly in the western parts (Lst Skåne, 2017 and La-Hbg, 2017).

South of Borstahusen a few scatterd class-2-areas were shown in a relatively widespred class-4-area (area C, Fg. 7). Sparse, but continous, eelgrass occurrences have been documented in this area (Lst Skåne, 2017 and La-Hbg, 2017).

4.3.4 Öresund, area 4

A continous class-1-area followed the coastline from Skabbrevet, south of Landskrona to Barsebäckshamn (area D, Fig. 7). In addition a class-1-area was shown near the estuary of the river of Saxån (area E, Fig. 7) and in the south at Salviken (area F, Fig.7).

In all of area 4, with the exception of area E which has not been monitored, vital and widespread eelgrass habitats have been documented in several surveys (Lst Skåne, 2017; La-Hbg, 2017 and ÖVF 2020), even in the northern parts where class-4-areas were dominating.

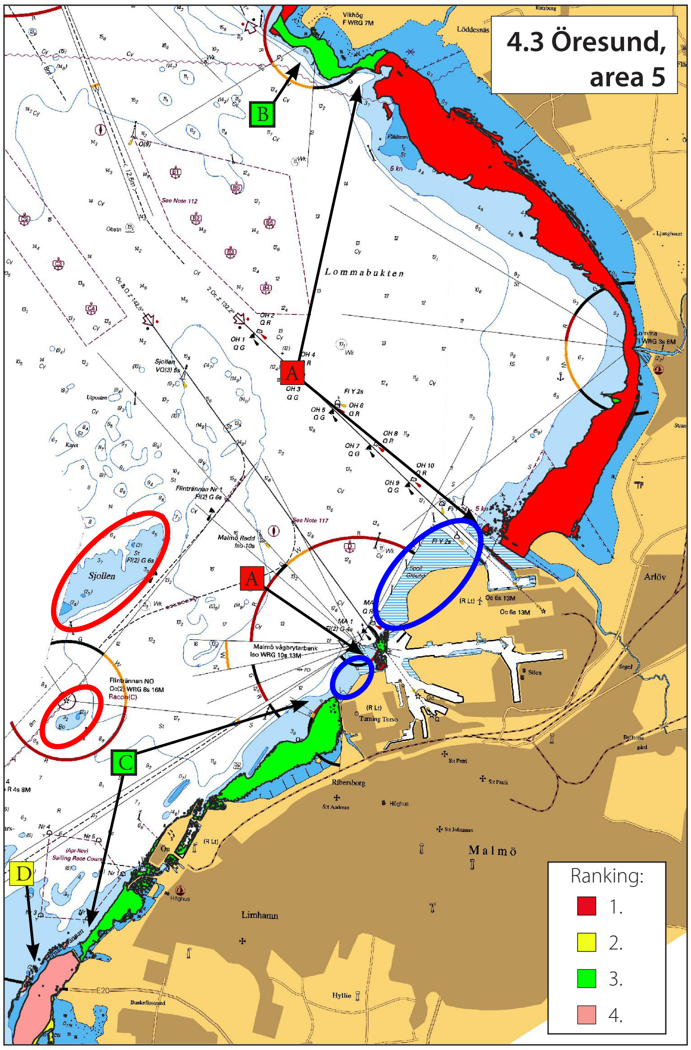

FIGURE 8. Öresund from Vikhög to Lernacken. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-F are described in the text. Red and blue ovals mark areas not included in the analysis model.

4.3.5 Öresund, area 5

A continous class-1-area followed the coastline from Vikhög to Spillepeng, Malmö and in addition, a very small area was located just south of the harbour inlet (area A, Fig. 8). Further south areas of class 3 (area C, Fig. 8) and class 4 (area D, Fig. 8) were observed.

Some areas along this stretch of coast were not included when data was analysed. These include off shore shallows (red ovals, Fig. 8) not covered by bottom composition data (SGU). Additionally, areas with "artifical substrate" (blue ovals, Fig. 8) were not included either.

Monitoring data of eelgrass coverage show that all areas with ranking class 1-4 in this area contain vital eelgrass habitats (Lst Skåne, 2017; Kävlingeåns och Höje å Vattenråd, 2019 and Malmö Stad, 2019). Eelgrass habitats have also been found on offshore shallows (Lst Skåne, 2017).

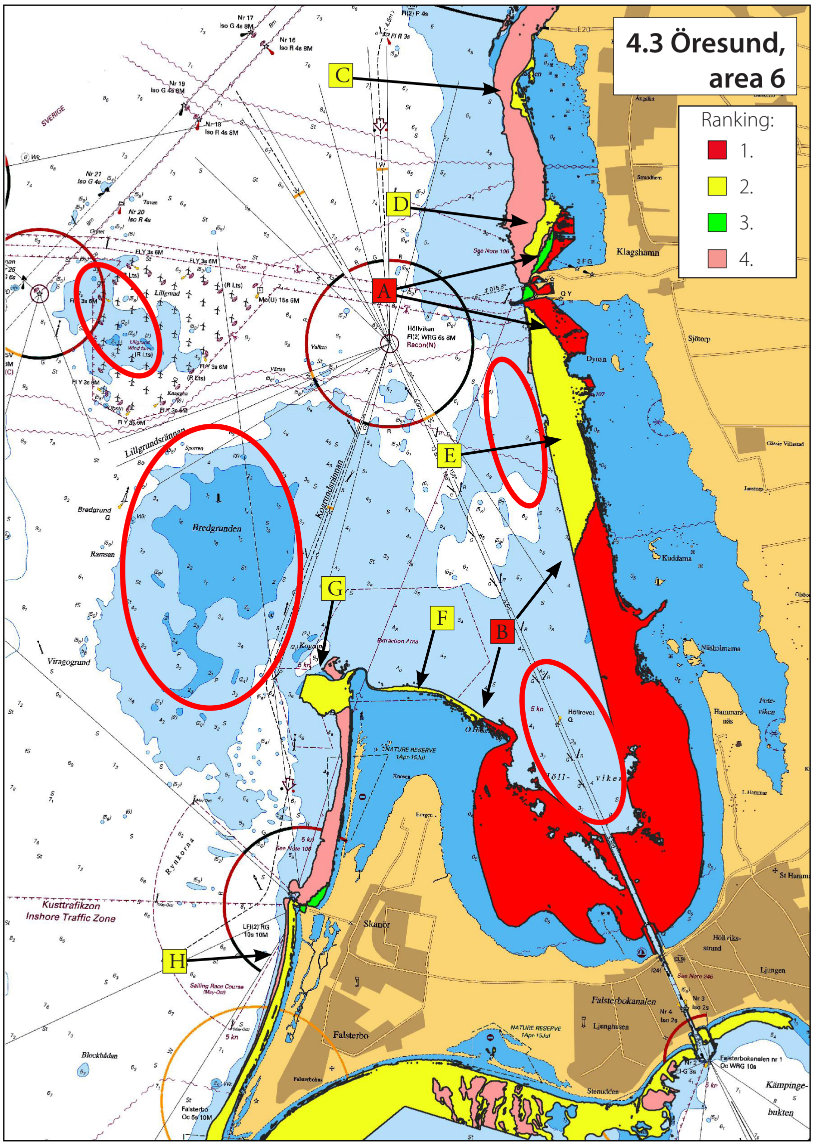

FIGURE 9. Öresund from Lernacken to Falsterbo. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-F are described in the text. Red ovals mark areas not included in the analysis model.

4.3.6 Öresund, area 6

A class-1-area was found around the inlet of Klagshamn harbour (ara A, Fig. 9), and a larger class-1-area consisting of almost the intire bay of Höllviken (area B, Fig.9). Smaller class-2-areas wore found north of Klagshamn (areas C and D, Fig. 9), and a larger area south of Klagshamn (area E, Fig. 9). Additionally smaller areas were found north and west of the Falsterbo peninsula (areas F-H,Fig. 9). There were several areas along this stretch of coast that were not included in the data-analysis (red ovals, Fig. 9), due to missing data concerning bottom composition.

Vast areas of vital eelgrass habitats have been documented from the Öresund bridge in the north to the northern tip of Falsterbo peninsula (Lst Skåne, 2017; Malmö Stad, 2019), including in areas not analysed (red ovals, Fig, 9). Coverage decreased towards the northern tip of Falsterbo peninsula, and was absent in the most northwestern parts (area G, Fig. 9). West of Falsterbo peninsula no monitoring has been performed.

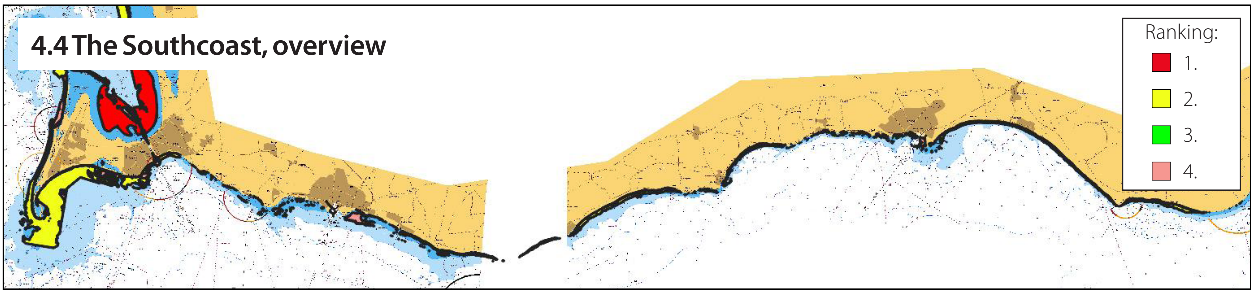

FIGURE 10. The Southcoast, overview map. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure).

4.4 The Southcoast

This stretch of coast is, in general, quite exposed to the open sea of the southern Baltic Sea (Fig. 10). Impacts from human activities are limited as only two larger cities are situated in the area, but both of these cities have substantional ferry traffic. Smaller harbours mainly with recreational vessels and local fisheries can affect limited parts of the rest of the coastline. Relatively few smaller rivers flow into the coast area.

4.4.1 The Southcoast, area 1

Only a couple of very small class-1-areas were found outside the southern tip of Falsterbo peninsula (area A, Fig 11). The westernmost part of the Southcoast consisted of a large class-2-area extending to the Falsterbo channel (area B, Fig 11). East of this stretch scattered class-2-areas were found all the way to Böste (area C, Fig. 11). There were two areas along this stretch of coast that were not included in the data-analysis (red ovals, Fig. 11), due to missing data concerning bottom composition.

Monitoring data of eelgrass have showed patchy and limited areas of vital eelgrss meadows (Lst Skåne, 2017). In the westernmost parts, the eelgrass was mainly confined to areas below 3 m of depth. To the east of Falsterbo canal patchy eelgrass meadows, and in parts with high coverage, have been observed (Lst Skåne, 2017). East of Trelleborg coverages declined.

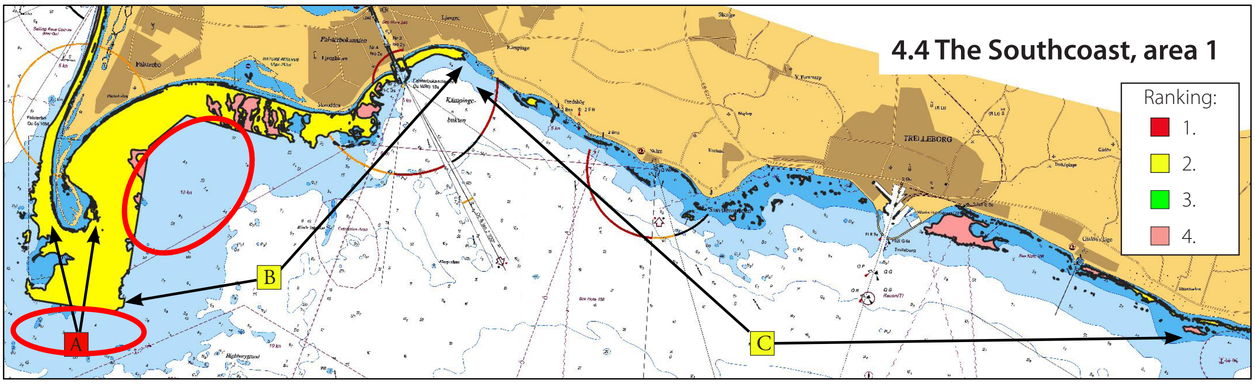

FIGURE 11. The Southcoast from Falsterbo to Böste. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-C are described in the text. Red ovals mark areas not included in the analysis model.

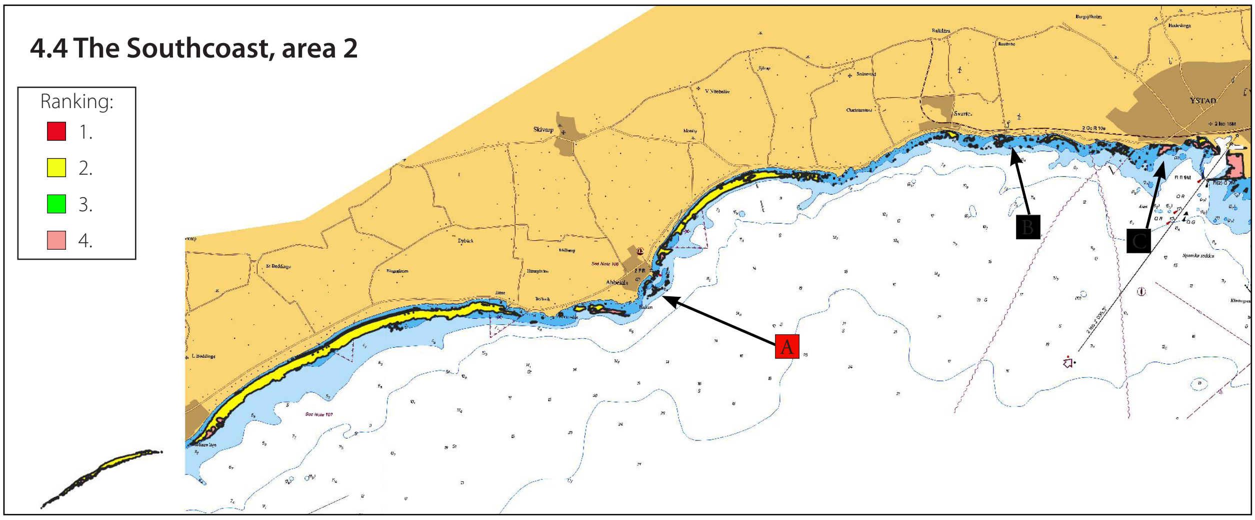

FIGURE 12. The Southcoast from Böste to Ystad. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-C are described in the text.

4.4.2 The Southcoast, area 2

Only very small class-1-areas were found south of Abbekås harbour (area A, Fig 12) and a few even smaller areas west of Ystad harbour (not highlighted in chart). Class-2-areas were found along the coastline between "capes" with more coarse bottom structures.

Only limited monitoring data was available in this area. No eealgrass was found otside Svarte (area B, Fig. 12)(KF, 2019) and west of Ystad harbour (area C, Fig. 12)(Lst Skåne, 2017), however in 2004 small areas with eelgrass was found here (Lst Skåne, 2004).

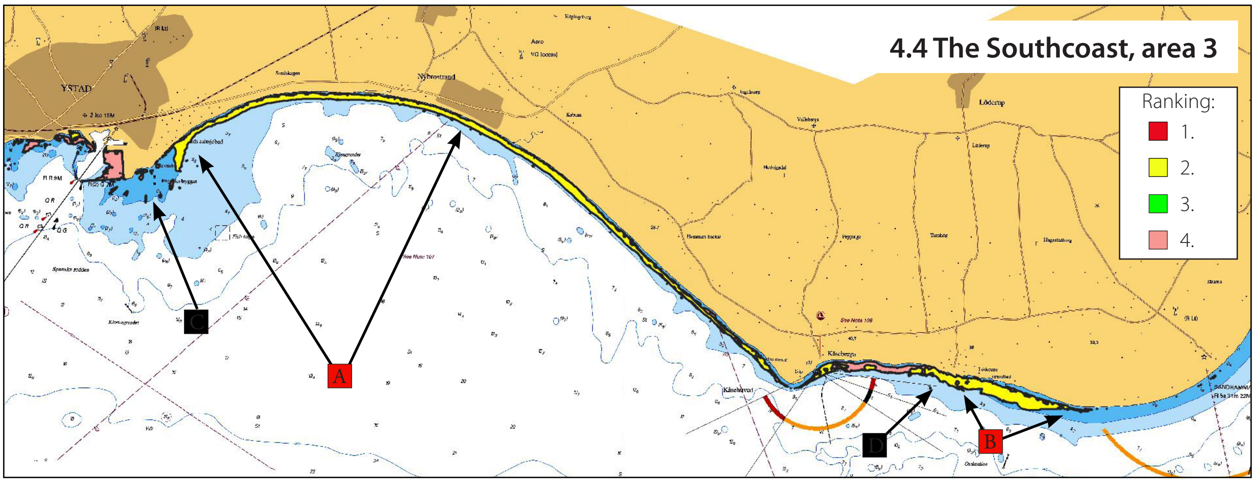

FIGURE 13. The Southcoast from Ystad to Sandhammaren. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-D are described in the text.

4.4.3 The Southcoast, area 3

Only very small scattered class-1-areas were found east of Ystad and in the eastern part of the coastline (not visible, but in area A-B, Fig 13). These areas were situated along the inner fringe of the widespread class-2-areas along this stretch of the coast.

Limited monitoring has been performed along this stretch of coast but east of Ystad harbour, vital eelgrass meadows have been observed, but in an area with coarse bottom substrate (stones and boulders) (area C, Fig. 13)(Lst Skåne, 2017; SVF, 2019 and KF, 2019). No eelgrass was found outside Löderup (area D, Fig.13)(KF, 2019).

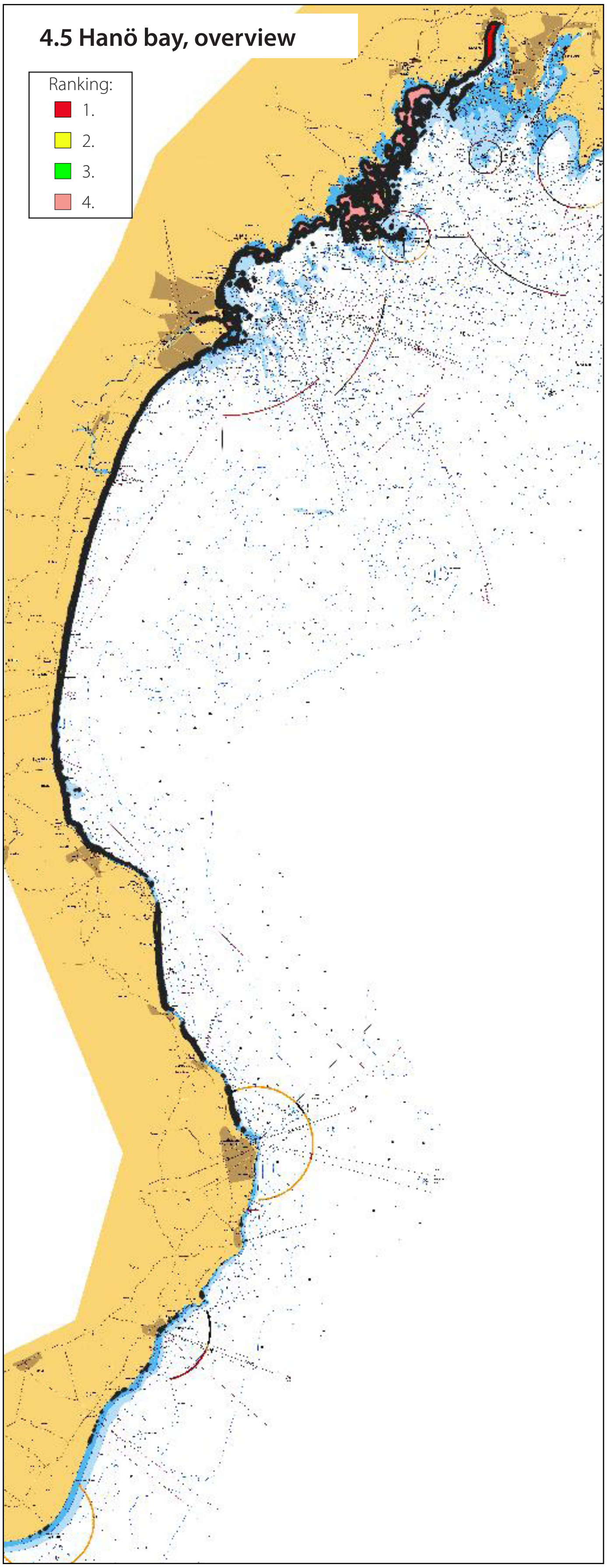

FIGURE 14. Hanö Bay, overview map. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure).

4.5 Hanö Bay

This stretch of coast is, in general, quite exposed to the open sea of the southern Baltic Sea (Fig. 14). Impacts from human activities are limited as only two larger cities are situated in the area. Smaller harbours mainly with recreational vessels and local fisheries can affect limited parts of the coastline. Relatively few smaller rivers flow into the coast area, except for the large Helge å river flowing into Hanö Bay south of Åhus.

4.5.1 Hanö Bay, area 1

One very small class-1-area was found along this stretch of coast (area A, Fig 15), and a small class-2-area at the north end (area B, Fig 15). Other class-1- and class-2-areas were found scattared along the coastline but were to small to be of interrest.

Monitoring data from south of Skillinge showed a small eelgrass meadow (area C, Fig. 15) (Lst Skåne, 2017).

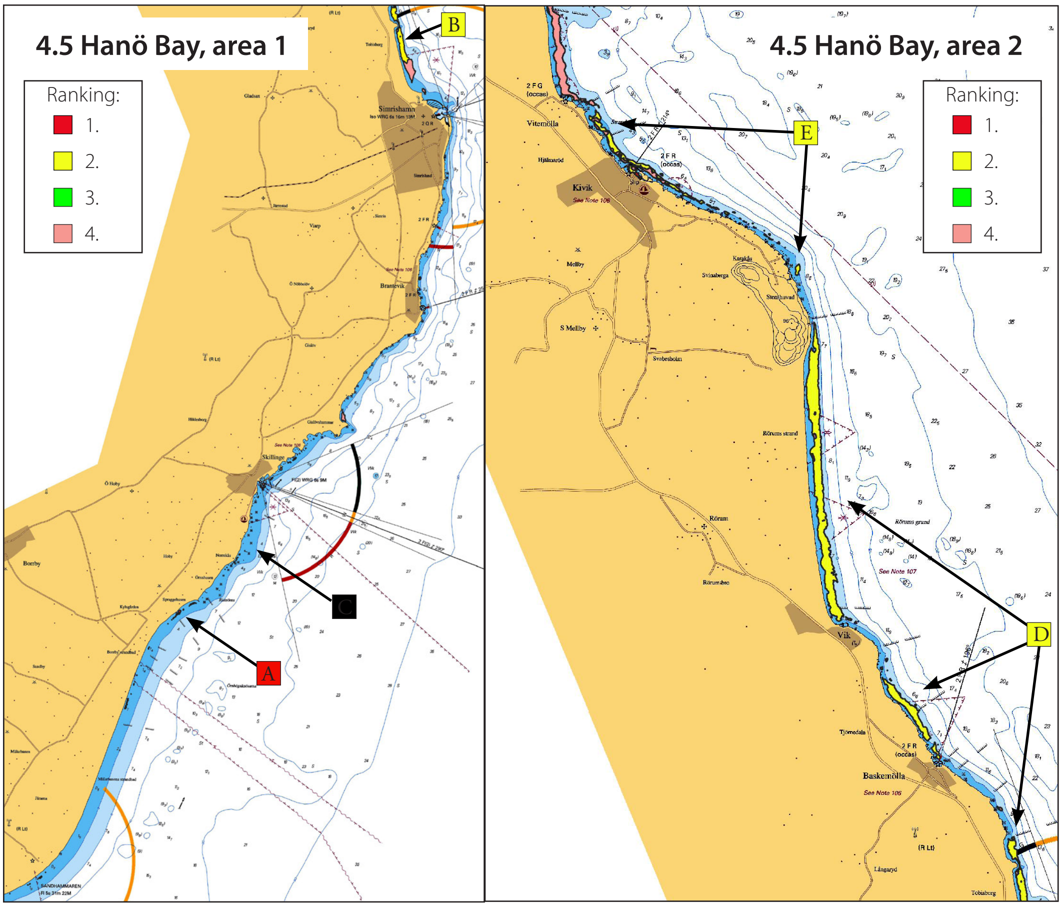

FIGURE 15. Hanö Bay from Sandhammaren to Simrishamn (area 1), and Simrishamn to Kivik (area 2). Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted areas A-F are described in the text.

4.5.2 Hanö Bay, area 2

No class-1-area occurred, but relatively extensive class-2-areas in the southern and middle part of this stretch of coast (area D, Fig 15). North of Stenshuvud smaller, scattered class-2-areas were shown (area E, Fig. 15).

No monitoring data from this part of the coastline was available.

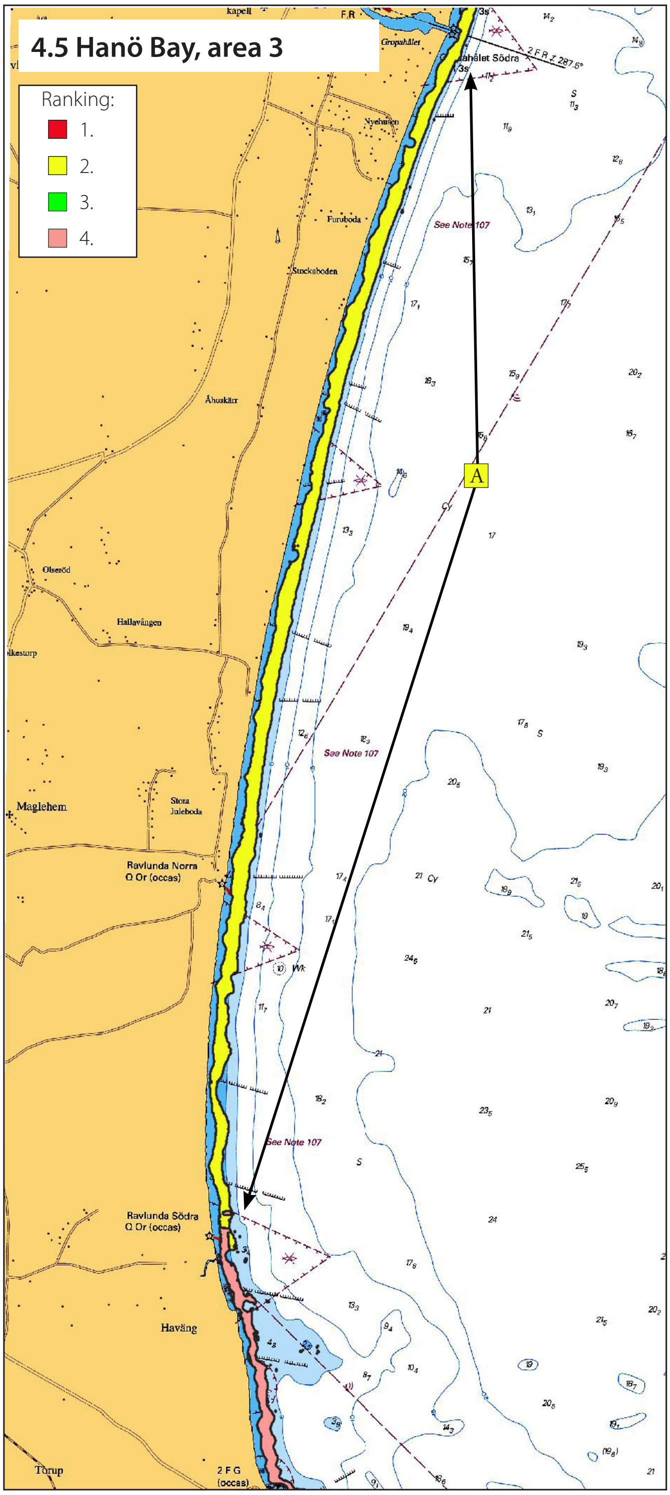

FIGURE 16. Hanö Bay from Kivik to Yngsjö. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted area A is described in the text.

4.5.3 Hanö Bay, area 3

No class-1-area occurred, but an extensive class-2-area ranged from Ravlunda up to Yngsjö on this stretch of coast (area A, Fig 16).

No monitoring data from this part of the coastline was available.

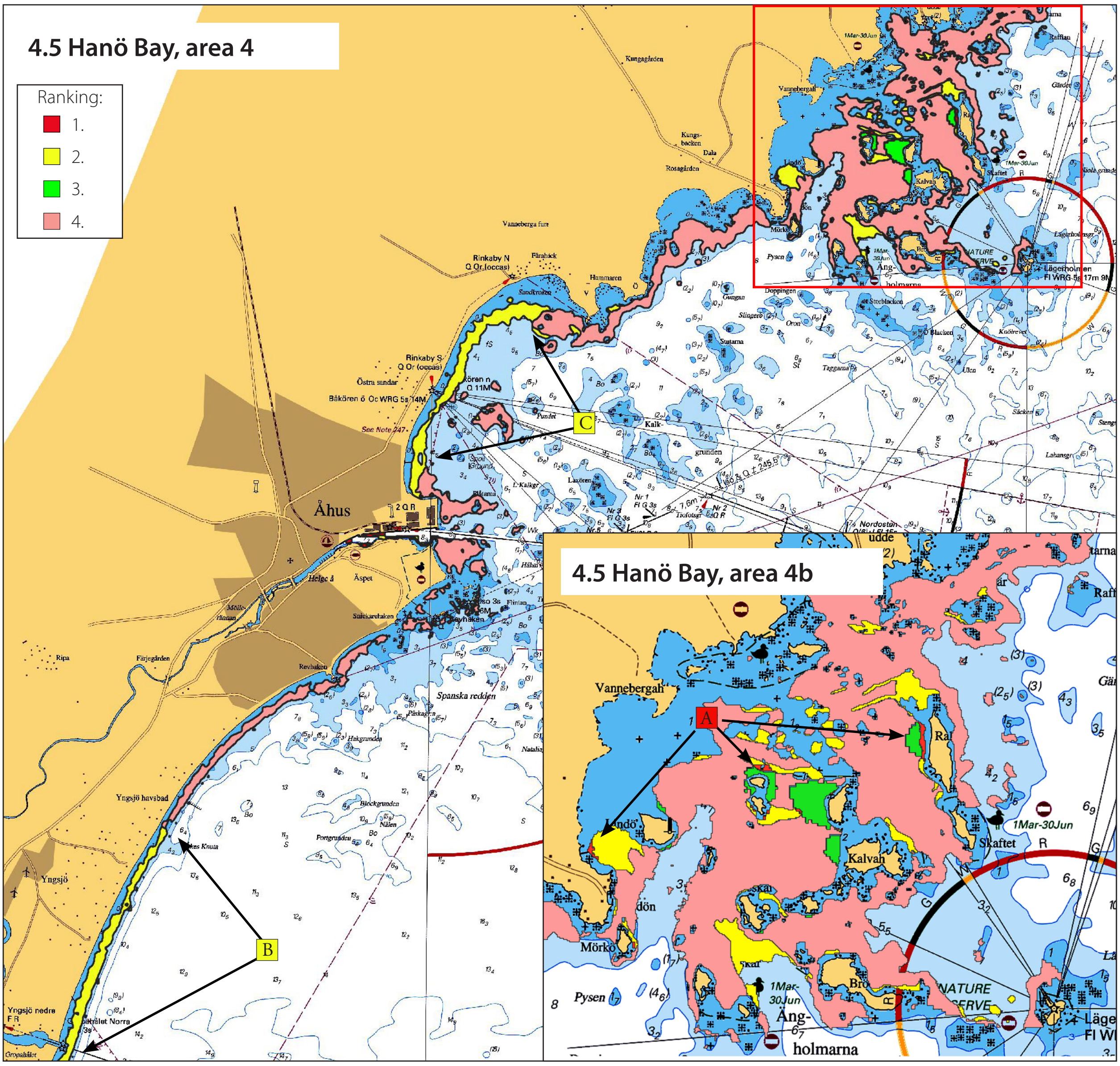

FIGURE 17. Hanö Bay from Yngsjö to Tosteberga. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted area A is described in the text. Area marked with red rectangle is highlighted in area 4b.

4.5.4 Hanö Bay, area 4

A couple of class-1-areas occurred in the northern part of this stretch of coast (area A, Fig 17). Class-2-areas were found along bays north of Yngsjö and just north of Åhus (area B and C, Fig. 17). Additionaly, scattered class-2-areas were found in the archipelago in the north (area 4b, Fig.17).

Monitoring data from Yngsjö up to just south of Åhus was not available, but from Åhus and further north up to Tosteberga eelgrass was found in scattered locations also in class-3 and class-4-areas (Lst Skåne, 2017).

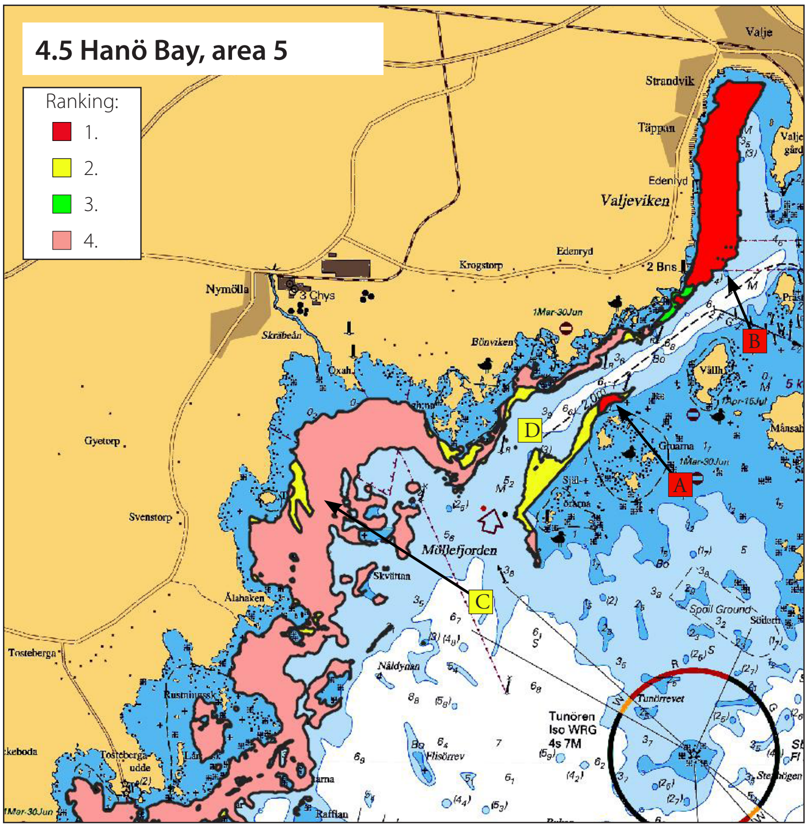

FIGURE 18. Hanö Bay from Tosteberga to Valje. Plotted areas are ranked (1 as the highest and 4 as the lowest) for suitability for eelgrass establishment (based on depth, bottom current exposure, bottom composition and wave exposure). Highlighted area A-D is described in the text.

4.5.5 Hanö Bay, area 5

A small class-1-area was found outside the inlet to Valjeviken (area A, Fig 18), and a large class-1-area along the western shore of Valjeviken (area B, Fig. 18). This area, however, consists of soft bottoms with dense populatons of other macrophytes such as *Potamogeton* spp. This area is also much more turbide compared to other parts of the coastline. Class-2-areas was found north of Ålahaken and around the inlet to Valjeviken (area C and D, Fig. 18).

Monitoring data is available from a couple of locations ranging från Ålahaken up to Valjeviken (just south of area B). Moderate coverage was found at these locations (Lst, Skåne 2016).

5. Conclusions

5.1 General reflections on the results

When summarizing the results of the analysis of geodata, the results suggest that areas most suitable for artificial eelgrass establishment (class-1-areas, red colour) are most abundant in the southern half of Öresund. In other areas along the coastline of Skåne, the class-1-areas represent a relatively small proportion of the coastal areas within the stipulated depth range (2-4m). More widespread were class-2- and class-4-areas which are more exposed to waves.

When comparing ranked areas with available eelgrass monitoring data, it was obvious that very few class-1-areas, where monitoring has been performed, lacked eelgrass. In general, surveys showed abundant eelgrass in class-1-areas and furthermore, vital eelgrass meadows occurred frequently in all the classed areas, which implies that naturally occurring eelgrass kan tolerate relatively high exposure from waves and currents. However, many of the ranked areas lacked monitoring data and these areas are yet to be explored.

5.2 Model shortcomings

An analysis of several geodata sets, such as this "suitability ranking model", will include restrictions/generalizations from each dataset in the analysis. The divisions and classifications for each parameter will affect the overall result of such a model. Geodata do not, to different extents, take small scale patchiness into account. Each dataset has a minimum resolution which will limit the size of the surfaces that will be included in the dataset. If a dataset is based on digital modelling, the assumptions of this model dictate the result of this specific parameter. This is mainly concerning exposure data where confirming field data is harder to obtain.

As mentioned earlier (see section 5.1) eelgrass monitoring data have showed vital eelgrass meadows in lower rank areas. Apart from natural resilience to exposure, these occurrences of eelgrass can also be an effect of "micro-patches" of finer (sandy) sediments within an area that have been catogorized as a "coarse sediment"-area (gravel, stones and boulders) in geodata for bottom composition. Generally, when this could be the case, this applies to small patches of eelgrass.

5.3 Model benefits

A recurrent problem in eelgrass monitoring is that it is very cost intensive when covering large areas. The same problem refers to mapping suitable areas for eelgrass reestablishment. Analysis of geodata is very cost-effective in this respect and gives a good basis to map areas of interest concerning eelgrass remediation. Of course, detailed surveys of each selected area of interst must follow to assure best results possible.

5.4 Interpretations/suggestions

Eelgrass habitats along the coast of Skåne are abundant, and there has bben no marked decline in distribution in the last decades as has been documented in other areas, such as the northern swedish West Coast (Moksnes et al, 2016). One could argue, somewhat generalized, that eelgrass in Skåne occurs wherever it is possible for it to grow, and that there is little need to artificially establish new habitats. However, eelgrass habitats have the ability to stabilize sediments and to dampen wave exposure, which would be beneficial in increasing our protection of coastlines. As we are facing climate changes with increased erosive actions, due to strong winds and altered weather patterns, the need for coastal protection increases.

Data from this analysis of geodata suggest that naturally occurring eelgrass tolerates moderate to high exposure and can occur in areas with relatively coarse sediments. This implicates that if it's possible to overcome the threshhold of reestablished eelgrass being more sensitive to exposure, one could increase abundance of eelgrass habitats in Skåne. This would mean that if exposure factors can be reduced artificially, fully established eelgrass habitats, yet artificially introduced, may be realistic in the future, even in suboptimal areas.

To establish potential areas for eelgrass remediation, focus on the following types of areas are suggested:

- Class-1-areas (most suitable), where monitoring data indicates no or sparse eelgrass coverage.
- Class-1-areas (most suitable), where monitoring data is lacking. Complementary monitoring is needed in these areas to establish if natural and vital eelgrass habitats already existis.
- Class-3-areas where elgrass habitats have existed historically. This requires studies of older monitoring data showing vital habitats back in time. Re-establishment in this type of area could require some degree of artificial measures to reduce exposure factors.
- Class-3-areas where coastal erosion is assessed to pose a threat in the future. Re-establishment in this type of area will almost certainly require some degree of artificial measures to reduce exposure factors for the newly planted eelgrass.

This suitability model for remediation of eelgrass habitats constitutes a basis for further detailed selections of suitable areas along the coastline of Skåne. It takes multiple factors into consideration in a wide spatial range, as well as detailed suitability information in a smaller scale.

6. References

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7. Appendix

7.1 Suitability model

Suitability model

Categories of suitable areas for re-establishment of eel grass, ranking 1-4 have been identified. The categories are produced as polygons, ESRI shapefiles (coordinate SWEREF99TM (EPSG:3006)).

Table 1. Categories 1-4

Category	1	2	3	4
Depth	2-4 m	2-4 m	2-4 m	2-4 m
Bottom current exposure	• Low • Low to moderate • Moderate to high • Unclassified	• Low • Low to moderate • Moderate to high • Unclassified	• Low • Low to moderate • Moderate to high • Unclassified	• Low • Low to moderate • Moderate to high • Unclassified
Bottom substrate	Sand, mud	Sand, mud	Gravel, stone, sand	Gravel, stone, sand
Wave exposure	• Ultra sheltered • Extremely sheltered • Very sheltered • Sheltered • Moderately exposed	• Exposed	• Ultra sheltered • Extremely sheltered • Very sheltered • Sheltered • Moderately exposed	• Exposed

Raster analysis

Selected datasets have been filtered by preferred criteria. All layers have been transformed to common scale (georeferenced units 10 x10 m), equally weighted relative to one another and combined.

Dataset

Following layers of datasets have been combined:

- Depth
- Bottom substrate
- Bottom current exposure
- Wave exposure

Preferred criteria

Depth

Preferred criteria: 2-4 meters

Dataset is produced by AquaBiota Water Research within the EU LIFE+ project "Innovative approaches for marine biodiversity monitoring and assessment of conservation status of nature values in the Baltic Sea (MARMONI)”. The project has been financed by the EU LIFE financial instrument of the European Community and the Swedish Agency for Marine and Water Management (SwAM).” license: Creative Commons Zero (CC0).

Bottom current exposure

Dataset is produced by SGU (Geological Survey of Sweden). Product marine geology 1:25 000

Preferred criteria bottom current:

- Low bottom current exposure
- Low to moderate bottom current exposure
- Moderate to high bottom current exposure
- Unclassified with regard to bottom current exposure

Bottom substrate

Dataset is produced by SGU (Geological Survey of Sweden). Product marine geology 1:25 000

Preferred criteria bottom substrate:

- alt.1 sand and mud
- alt 2. Mixed coarse (gravel, stone and sand)

Wave exposure

Dataset is produced by AquaBiota Water Research within the EU LIFE+ project "Innovative approaches for marine biodiversity monitoring and assessment of conservation status of nature values in the Baltic Sea (MARMONI)”. The project has been financed by the EU LIFE financial instrument of the European Community and the Swedish Agency for Marine and Water Management (SwAM).” license: Creative Commons Zero (CC0).

Data can be found in report ”Marin inventering och modellering i Skåne län”, (2016:09, Länsstyrelsen Skåne)

Preferred criteria for wave exposure:

Alt. 1

- Ultra sheltered
- Extremely sheltered
- Very sheltered
- Sheltered
- Moderately exposed

Alt. 2

- Exposed