

Evaluation of Inner Harbor Desalination Far-Field Model

6/1/2026

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Executive Summary

Here we present a scientific opinion on information shared to date with the Corpus Christi Inner Harbor Desalination Far-Field Modeling team. This opinion represents the consensus of thirteen scientists listed above, who have expertise in estuarine science, fisheries and modeling. The purpose of this opinion is to: 1) provide an evaluation of far-field model performance, 2) conduct a preliminary analysis of the results, including potential ecological outcomes, and 3) offer suggestions for improvement of model performance and credibility of results to ensure that the City of Corpus Christi receives the best possible scientific output in support of its decision-making. The modeling effort focused on quantifying the potential impact of brine discharge into the Inner Harbor on the Corpus Christi Bay system, particularly the location and extent of salinity increases. In contrast, our aim is to assess potential ecological outcomes given the modeling results.

Based on the preliminary results presented to date, the modeling exercises have not produced convincing evidence that desalination would not have detrimental ecological effects across the Corpus Christi Bay system.

Key Points:

- Preliminary model results show that desalination discharge will increase stratification and potential for low oxygen events in the Inner Harbor and Corpus Christi Ship Channel to at least 5 miles out from the mouth of Inner Harbor into Corpus Christi Bay, and that it extends the period of stratification from being primarily a summertime phenomenon to one that lasts into fall/early winter.
- The Corpus Christi Ship Channel is a primary pathway for dispersal of early life stages of commercially important fish (redfish, spotted seatrout, black drum) and shellfish (blue crab, brown shrimp, white shrimp) species into the Nueces Bay and shallow regions of upper Corpus Christi Bay, while the Inner Harbor supports a diverse assemblage of recreationally and commercially important fish species.
- Modeling efforts were under severe time constraints, and following the last committee meeting on May 28th, uncertainties about the model setup and ability to accurately predict real-world conditions remain.
- Model code, parameterization and outputs should be made available immediately to facilitate independent peer review, a standard practice in the scientific community. Additional time should also be allocated for interpreting the results in the context of the environmental impacts of the Inner Harbor desalination plant.

Background

We want to start by thanking the City of Corpus Christi staff for allowing HRI and UTMSI to have representation on the committee. We also want to acknowledge the hard work that the modeling team of Spheros Environmental, DSI, and Hazen have put towards model development under the severe time constraints of the project. The purpose of this scientific opinion is to: 1) provide an evaluation of far-field model performance, 2) furnish a preliminary analysis of the results, and 3) offer suggestions for improvement of model performance and credibility of results to ensure that the City of Corpus Christi receives the best possible scientific output in support of its decision-making.

HRI and UTMSI were represented on the City of Corpus Christi's Inner Harbor Desalination Far-Field Modeling Committee by Drs. Michael Wetz and Sharon Herzka, respectively. As part of the Coastal Bend community, these scientists and their colleagues, noted above, recognize the severity of the regional water shortage and the necessity of seawater desalination as a sustainable, drought-proof, long-term freshwater supply solution for residents and industry. Nevertheless, seawater desalination must be performed in a manner that will yield no cumulative negative impact on the bays and estuaries that provide recreational and economic value to the region.

Based on instructions provided by city staff, the role of the HRI and UTMSI representatives was to offer scientific guidance and advice on the Inner Harbor far-field desalination modeling effort (hereafter "IHDM"). It is on record that HRI and UTMSI representatives would engage with their colleagues to evaluate model results in the context of potential impacts on marine life and habitat in Nueces/Corpus Christi Bay, and they were encouraged to do so by city staff and specific members of the far-field committee. This

scientific opinion represents the consensus of thirteen scientists listed above, who have extensive expertise in estuarine science, fisheries, and modeling.

Preliminary report on work to date

Model performance

Model validation is the process of comparing model outputs to real-world observations to assess model accuracy. Following an analysis of data availability, 2023 and 2024 were adopted as “baseline” or “reference” years against which to compare the desalination plant's effects on the environment. The initial results for the reference years were presented on May 7th. Validation statistics improved between the model runs presented on May 7th and May 21st. Specifically, the unreasonably low salinities (underestimated on the order of 10-15 ppt) predicted with the model for Nueces Bay on May 7th improved to within an average of ~1 ppt (Bias = -0.476 ppt and +0.977 ppt for Inner Harbor and Nueces Bay, respectively) of observations by May 28th, a reasonable performance across the two years for which modeling was conducted. Employing river discharge data from a station closer to Nueces Bay than in previous model runs, adding dynamic mixing between the inflow and discharge locations, scaling (adjustment) of salinity at the ocean boundary conditions based on the output of the BAYCAST model relative to HYCOM model for the end of 2024, and addition of discharges from North Beach Power Station, Barney Davis, and American Chrome plants, among others, may have contributed to the improvement in model performance. However, the contribution of specific adjustments to the model cannot be assessed as they were made simultaneously, at least as presented to the committee. Although the model performance in terms of average salinity across the two years improved substantially by May 21st, there were notable deviations for specific periods, such as a ~5 ppt difference for Nueces Bay in spring/summer 2023 in the slides presented on May 28th. This requires further review to determine if there is a systematic reason for the deviation.

In terms of the model's prediction of water temperature, results presented on May 28th show that the model is overestimating average temperature (Bias = +0.92°C and +1.85°C for Inner Harbor and Nueces Bay, respectively). Both salinity and water temperature are determinants of density, vertical gradients of which define stratification strength. If the model overestimates temperature, it will underestimate density and stratification compared to real world data, as warmer waters are less dense than cooler waters.

Prior to the May 28th meeting, committee members posed questions regarding model validation that remain unanswered as of today. In addition, while the selection of 2023 and 2024 was based on data availability to force the model, it should be emphasized that those years do not fully capture the system's natural variability. For example, 2025 was a very dry year, resulting in occasional hypersaline conditions in Nueces Bay. To date, the model has not been validated under such conditions.

In order to be able to conduct a thorough review of the model validation, the committee should be provided with detailed model parametrization and code, boundary-condition forcing dynamics, a list of data sets, and the discharge volumes of all point sources.

Section summary: Modeling efforts were under severe time constraints, and uncertainties in model setup and validation remain. At this time, the scientific experts associated with this statement cannot provide a robust and fully informed assessment of how closely the model reflects reality. Achieving a thorough assessment requires evaluation of the model’s code, parameterization and analysis of the results. As stated by city staff, the full model report, results, and programming code won’t be released until the end of June, 2026. We encourage the City to provide them to the Far-Field Committee immediately for detailed assessment and to facilitate independent peer review, a standard practice in the scientific community. Additional time should be allocated for interpreting the results in the context of the environmental impacts of the Inner Harbor desalination plant.

Model structure and outputs

The following is a list of conditions for which model runs with and without desalination were presented on May 21st and 28th. In parentheses are model forcing that requires additional analysis and verification.

- 2023 and 2024 as reference or “baseline” years
- 30 mgd per day produced by Inner Harbor desalination plant, 50% recovery (*needs to be confirmed; to date, the modelers have also not shared what the salinity of the brine discharge is in the model and this is critical for salinity modeling*)
- Point source discharges into Inner Harbor and Corpus Christi Bay that were incorporated into the model (*list of final sources and volumes needs to be examined and confirmed*)
- Ocean boundary forcing conditions were achieved with a combined approach driven by available data and outputs from the HYCOM model, a large-scale coupled atmospheric-oceanic circulation model that is well-suited to examining large-scale circulation in the Gulf, or from the BAYCAST model, a smaller-scale estuarine/bay hydrodynamic model developed for the Texas Coast (*use of each model’s output and any “corrections” need to be presented and justified in detail*)
- Nueces River inflow was obtained from the Calallen USGS station, but appears to have been underestimated in the model relative to real-world data (*confirmation of the data that were used to account for the inflow is needed*)
- Data from 6 meteorological stations were used to force the model (*location, sources, and time series of measurements used in the model should be provided*)
- Dynamic brine discharge that accounts for the interaction between intake and outflow within Inner Harbor (*the committee has not been presented with any results specific to dynamic mixing/discharge and cannot assess its veracity at this point*)

- Vertical resolution of the model, or “how deep” each cell is within the model, is key to resolving stratification, but was unacceptably low as of May 21st and 50% lower than what the contract with Spheros required. A brief comparison of outputs with higher vertical resolution was presented on May 28th and show differences (increased stratification in Inner Harbor w/ 20 layer vertical resolution vs 10 layer vertical resolution model) *(a more in-depth analysis of this issue needs to be undertaken given its relevance to stratification and the potential for low oxygen events near the bottom)*
- On May 7th, a set of scenarios was provided to the modeling team by the scientific experts on the committee. The scenarios were designed to evaluate the magnitude of the effects of brine discharge under specific environmental conditions (see Appendix A). Due to time constraints, the scenarios were compiled into a single model run, which was considered the “worst-case” scenario, and results were presented on May 21st. Two additional scenarios, a simulation of a high freshwater inflow event and low wind period, were presented on May 28th. However, without modeling results for each of the other requested scenarios, it is impossible to determine the magnitude and direction of the effects of Inner Harbor desalination discharge under specific environmentally relevant conditions, such as severe drought or rising regional temperatures *(all requested scenarios should be tested independently to determine the how the effects of brine discharge are modulated by relevant environmental forcings; this is known as a sensitivity analysis)*

Brief guide to the interpretation of model results

Key parameters for consideration in scientific assessment of the effects of brine discharge are salinity, water temperature, density/stratification, and dissolved oxygen. Salinity, temperature, and dissolved oxygen define the suitability of a habitat for most estuarine life forms including various important fish and shellfish. Any increase in salinity due to brine discharge must be considered in the context of ambient salinity levels, as organisms tend to exhibit physiological responses to salinity and its variation. For example, a species of fish inhabiting 30 ppt may tolerate or adjust (acclimate) to a 3 ppt increase in salinity. However, a 3 ppt increase above a background salinity of 40 ppt could lead to mortality or chronic negative physiological effects, especially on reproduction and larval and juvenile survival.

Stratification is the density-driven layering of water masses with different salinity and temperature values. Saltier water is heavier (has a higher density) and thus tends to sink under weak mixing, which is driven by physical processes such as tides, currents, turbulence, and wind. Warmer water is less dense (has a lower density) and tends to rise toward the surface. Together, salinity and temperature determine the density of the water at different depths. Large density differences between the bottom and surface waters are indicative of the strength of the stratification.

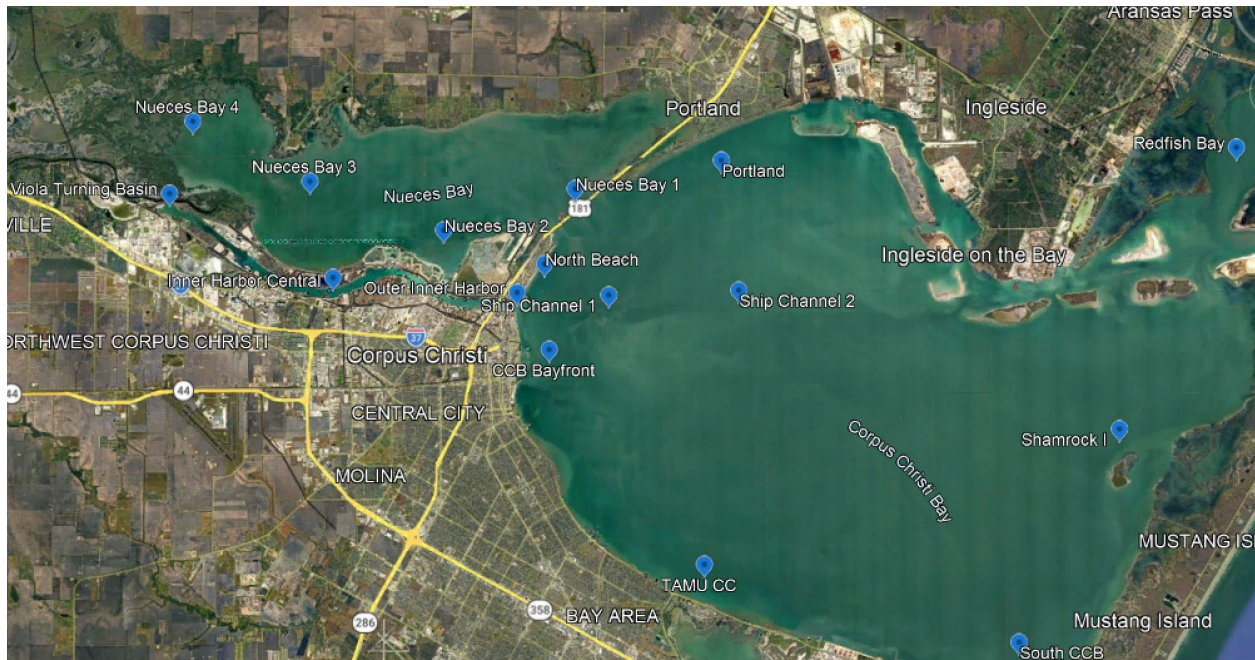
In the absence of brine discharge, and for 2023-2024 specifically, stratification within the Corpus Christi Bay system tends to be more prevalent during the summer due to the warming of surface waters. Mixing due to winter fronts that have high winds and colder temperatures is conducive to the absence of stratification. Higher salinities near the bottom relative to the surface is also conducive to stratification. Because the water discharged after desalination has a high salinity and density, it is expected to sink.

The most appropriate indicator of stratification is the difference in density between bottom and surface waters. Strong and persistent stratification acts as a “cap” on bottom waters, preventing oxygen replenishment and leading to hypoxic (low oxygen) or anoxic (no oxygen) conditions that are harmful to aquatic life. Much prior work has shown that naturally occurring salinity-driven stratification and low-oxygen conditions can occur within 20 cm above the bottom in parts of Corpus Christi Bay. There has long been a concern that discharging brine into the bay system would cause or exacerbate stratification and cause hypoxia or anoxia. Members of the committee repeatedly requested that the dissolved oxygen concentrations be included in the modeling effort, which would require a dedicated effort. However, we were informed that it was outside of the scope of the contract. Hence, the interpretation of potential environmental effects is, unfortunately, limited to assessing whether periods of stratification could be conducive to hypoxia or anoxia.

Section summary: Key parameters for consideration in scientific assessment of the effects of brine discharge are salinity, water temperature, density/stratification, and dissolved oxygen. This study assessed the former three parameters, but did not address effects on dissolved oxygen, an important oversight that limits our ability to fully understand potential impacts from desalination discharge.

Preliminary model results

The committee requested model outputs at the following stations within the Inner Harbor, Nueces Bay and Corpus Christi Bay:



Model results were presented on May 21st and May 28th by Spheros. Note that all the results were considered by Spheros as preliminary and in progress as of the May 21st meeting. The following summarizes model results:

1) Inner Harbor:

- a. In the absence of desalination, the Inner Harbor shows signs of moderate to strong stratification during summer, when surface waters are warmer, and salinities are higher near the bottom.
- b. Within the Inner Harbor, desalination discharge is associated with a salinity increase of up to 2 ppt in the bottom waters. The increase in salinity near the surface is reportedly more limited (< 1 ppt). However, desalination substantially increases stratification and extends it well into the fall and early winter.
- c. Salinity differences are greatest toward the inner reaches of the Inner Harbor (Viola turning basin).

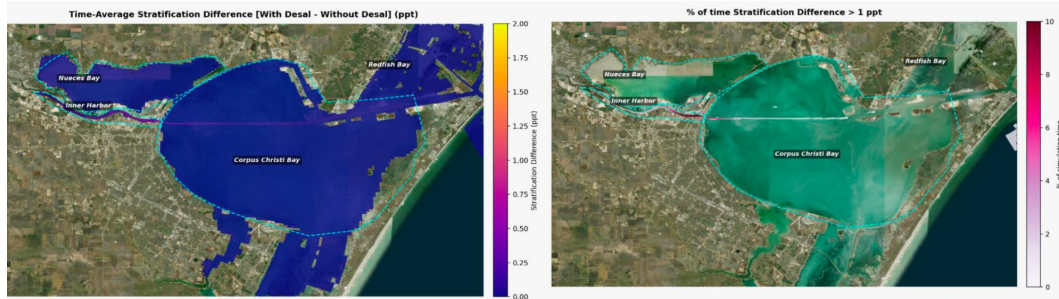
2) Corpus Christi Ship Channel:

- a. The water column is sometimes stratified without desalination. There is weak-to-strong stratification with a seasonal component; stratification is higher in summer and tends to be absent in winter, likely due to colder temperatures and increased wind-driven mixing from frontal passages.
- b. There is a moderate to strong increase in stratification due to desalination discharge, which increases the salinity difference between the surface and bottom layers. Strong stratification due to desalination is observed within the Ship Channel out to at least station Ship Channel 2 in the model domain, ~5 miles from the mouth of the Inner Harbor, suggesting that a high salinity plume of high density is transported from the discharge location along the bottom of the channel. Stratification also increases into fall-early winter with addition of desalination discharge.

- c. Note: the model's limited vertical resolution may obscure differences in salinity and density between the surface and the bottom.
- 3) Corpus Christi Bay Stations (North Beach, CCB Bayfront, TAMUCC, and others)
 - a. Limited to no differences in salinity and density due to desalination.
 - b. Note: the model's limited vertical resolution may obscure differences in salinity and density between the surface and the bottom.
 - 4) Nueces Bay
 - a. Nueces Bay Station 2 is closest to the discharge of the power plant that pumps large volumes of water from IH to Nueces Bay and is therefore more likely to see effects from desalination discharge than other stations. The station shows weak or no stratification in the absence of desalination.
 - b. Vertical salinity differences < 1 ppt (24 h average) indicate a limited increase in salinity due to desalination.
 - c. Limited differences in stratification were observed due to desalination.
 - d. The rest of the Nueces Bay stations show no evidence of increases in salinity, density, or stratification.
 - e. Note: the model's limited vertical resolution may obscure differences in salinity and density between the surface and the bottom.
 - 5) Simulation of a freshwater inflow event using USGS data from May 2021: The results cannot be adequately interpreted without presenting a direct comparison to model outputs in the absence of freshwater inflow. Only results with and without desalination were included in the presentation.
 - 6) Identification of periods of calm wind conditions (which can be conducive to the build-up of stratification due to limited mixing):
 - a. Analysis of meteorological data indicates that these events are rare in the Coastal Bend.
 - b. Analysis of stratification during periods of calm winds (December 2023 and December 2024) indicates a limited difference in salinity and density stratification between bottom and surface waters in the Inner Harbor, Ship Channel, Nueces Bay, and Corpus Christi Bayfront.
 - c. As noted previously, stratification is less likely during the winter. Short periods of calm winds during the winter should be less likely to lead to stratification resulting in hypoxia than during the summer.
 - d. Additional model runs should be conducted in late summer/early fall.

As a side note, maps were presented on May 28th titled “Stratification Changes: Areal extent and duration” (example below). These maps represent average differences in salinities between the bottom and surface waters. Salinities alone do not adequately represent stratification, as stratification in terms of water column mixing is better represented in terms of density differences. Additional analysis of the temporal and spatial distribution of density differences between surface and bottom waters are needed to adequately assess the potential for hypoxia or anoxia with and without desalination.

Stratification Changes: Areal Extent and Duration



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Section Summary: Based on the results presented to date, stratification is naturally present in the Inner Harbor and Ship Channel and will be exacerbated by brine discharge. Desalination discharge increases stratification and consequently the potential for low oxygen events harmful to marine life in the Inner Harbor and Corpus Christi Ship Channel out to at least station Ship Channel 2 in the model domain, ~5 miles from the mouth of the Inner Harbor, and extends the period of stratification from being primarily a summertime phenomenon to one that lasts into fall/early winter.

What does it mean for the environment?

Model results presented indicated that the brine discharge within the Inner Harbor will increase salinities and stratification throughout the Inner Harbor and within the Corpus Christi Ship Channel. This increases the probability of low (hypoxia) or no oxygen (anoxia) events that have negative consequences ranging from evasion of unfavorable conditions for mobile organisms to mass mortality events.

The Corpus Christi Ship Channel is a primary pathway for dispersal of early life stages of commercially important fish (redfish, spotted seatrout, black drum) and shellfish (blue crab, brown shrimp, white shrimp) species into the Nueces Bay and shallow regions of upper Corpus Christi Bay, while the Inner Harbor supports a diverse assemblage of recreationally and commercially important fish species.

Unfortunately, the scientists involved in writing this opinion cannot offer further assessment regarding the potential environmental/fisheries impacts of Inner Harbor desalination until the following standard scientific practices are met:

1. Time is allocated for a thorough analysis of the model validation and its results.

2. An independent, peer-reviewed assessment of the IHDM (its structure, code, assumptions, validation and outputs) is conducted. Peer review is the gold standard for ensuring scientific rigor and validating the work (as noted in the March 5 and 12 Executive Briefs).
3. Model vertical resolution is improved so as to not mask stratification conducive to hypoxia and consequent fish kills.
4. Dissolved oxygen is assessed. The inclusion of dissolved oxygen was recommended by the Far-Field Committee early in the process (in the March 5 and March 12 Executive Briefs). Without dissolved oxygen, the model cannot detect hypoxia caused by stratification, which can lead to serious environmental impacts, including fish kills. The EFDC+ model includes a module that can simulate dissolved oxygen as a state variable (see https://www.epa.gov/sites/default/files/2016-01/documents/efdc_water_quality_manual.pdf). Excluding dissolved oxygen also prevents evaluation of long-term oxygen changes driven by increasing salinity and temperature.
5. The duration of the modeling effort is increased from the current 2 years to span the lifetime of the plant, ~20-30 years, to reflect long-term conditions, variability, and the cumulative effects of discharge and subsequent salinity accumulation.

Section Summary: The Corpus Christi Ship Channel is a primary pathway for dispersal of early life stages of commercially important fish (redfish, spotted seatrout, black drum) and shellfish (blue crab, brown shrimp, white shrimp) species into the Nueces Bay and shallow regions of upper Corpus Christi Bay, while the Inner Harbor supports a diverse assemblage of recreationally and commercially important fish species. Increased stratification along the bottom would increase potential for harmful low oxygen events and habitat compression. Deficiencies and uncertainties in the modeling process prevent us from developing a more robust assessment of environmental impacts from Inner Harbor desalination at this time.

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Appendix A.

5/7/2026 Inner Harbor Desalination Far Field Modeling scenario request

Committee members: Drs. Wetz, Herzka, Stanzel

Definitions/conditions:

2024-2025 (reference conditions) = model forced by data from meteorological and marine stations, inflows, and discharge estimates (winds, rain, inflows, permitted discharges, return flows, tides, etc.) without the addition of the Inner Harbor desalination plant discharge. These will serve as conditions against which scenarios will be compared to examine the temporal and spatial distribution of salinity, temperature, and stratification.

For comparison with reference conditions:

+Desal = addition of Inner Harbor desalination plant brine discharge

Include two levels of intake and discharge to examine the magnitude of the effect on salinity, temperature, and stratification: 1) Plant running at 100% capacity. 2) Plant running at 50% of projected capacity.

+Climate = Two conditions based on regional trends for water temperature and sea level, propagated out to year 2050 (~20 years into life of Inner Harbor desalination plant). 1) +1.2 °C water temperature (0.05°C/year). 2) + 120 mm sea level (5 mm/year).

+CCP = Addition of CC Polymers plant estimated brine discharge (volume and salinity) to Inner Harbor

–Return = Wastewater return flows (from Allison, Oso plants) removed as per the current planned trajectory, given their reuse. *Note that it is assumed that this condition will apply to every scenario given that the reduction in return flows is underway.*

–Wind = simulate low-wind event during summer OR substitute 2024-2025 winds with wind from years in lower 10th percentile of a local climatology for wind speed

–Inflows = assumes no discharge from Nueces River into system

+Flood = replicates inflows from 2021 flood

Scenarios (ranked by priority):

1. 2024-2025 (reference conditions)
2. (Hypothesized worst case): 2024-2025 reference conditions + Desal 100% + Climate (Temperature and sea level) + CCP – Return – Wind – Inflows

3. 2024-2025 + Desal 50% – Return
4. 2024-2025 + Desal 100% – Return
5. 2024-2025 + Desal 100% + CCP – Return
6. 2024-2025 + Desal 100% – Inflows – Return
7. 2024-2025 + Desal 100% – Wind – Return
8. 2024-2025 + Desal 100% + Climate (Sea level) – Return
9. 2024-2025 + Desal 100% + Climate (temperature) – Return
10. 2024-2025 + Desal 100% + Climate (Sea level) + Climate (temperature) – Return
11. 2024-2025 + Desal 100% + Flood - Return

Requested data output:

Time series of temperature, salinity, and stratification at specific locations for each scenario (see map below).

