Characterization of the near-bottom temperature, salinity, and sound speed scape in the Salish Sea 2020-2025

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by

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List of Acronyms

AMAR: Autonomous Multichannel Acoustic Recorder

ºC: Degrees in Celsius

CTD: Conductivity, Temperature, Depth

m: meter

m/s: Meters per second

PSU: Practical Salinity Units, 1 gram of salt per kilogram of water

SD: Standard Deviation

SOG: Strait of Georgia

ABSTRACT

Taves, R., Burnham, R., Vagle, S. 2026. Characterization of the near-bottom temperature, salinity, and sound speed scape in the Salish Sea 2020-2025. Can. Tech. Rep. Fish. Aquat. Sci. 3809: xi + 48 p. https://doi.org/10.60825/mv2p-8p98

Sound speed measurements were made at ten locations in the Salish Sea. These sites were located along the west coast of Vancouver Island at Swiftsure Bank, and in the Strait of Juan de Fuca, Haro Strait, Boundary Pass, Swanson Channel, and the Strait of Georgia. The sound speed was determined using RBR Concerto[3] CTDs, utilizing sampled temperature, salinity, and pressure. All CTD measurements were taken within 1 meter of the ocean floor. The data analysis used monthly and seasonal averages from 2020 to 2025 to determine local and regional patterns. At Swiftsure Bank and in the Strait of Juan de Fuca, seasonal highs and lows occurred in winter and summer, respectively. Sound speeds were higher at Swiftsure Bank compared to sites in the Strait of Juan de Fuca due to having, on average, warmer near-bottom water temperatures. The locations within the Gulf Islands and more eastern locations, showed seasonal high sound speed values in the fall and lows in the spring, with values demonstrating a greater range in the minimum and maximum extents than those found in the Strait of Juan de Fuca. Distinct differences between the sites in the Strait of Georgia were noted, but overall, they all demonstrated similar seasonal trends to those observed in Haro Strait and Boundary Pass. Sound speed and temperature anomalies were observed through the study area in late 2023 into spring 2024. This persisted into spring 2025 in the Strait of Georgia. This resulted from an El Niño noted for the Pacific northwest during this period.

RÉSUMÉ

Taves, R., Burnham, R., Vagle, S. 2026. Characterization of the near-bottom temperature, salinity, and sound speed scape in the Salish Sea 2020-2025. Can. Tech. Rep. Fish. Aquat. Sci. 3809: xi + 48 p. https://doi.org/10.60825/mv2p-8p98

Des mesures de vitesse du son ont été effectuées a dix emplacements dans la mer des Salish. Les sites de surveillance étaient situés le long de la côte ouest de l'île de Vancouver au banc Swiftsure, dans le détroit de Juan de Fuca, le détroit de Haro, le passage Boundary, le canal Swanson et le détroit de Géorgie. La vitesse du son a été déterminée à l'aide de CTD RBR Concerto, à partir des mesures de température, de salinité et de pression. Toutes les mesures CTD ont été prises à moins d'un mètre du fond marin. L'analyse des données a utilisé des moyennes mensuelles et saisonnières de 2020 à 2025 pour déterminée les tendances locales et régionales. Au banc Swiftsure et dans le détroit de Juan de Fuca, les valeurs maximales et minimales saisonnières ont été observées en hiver et en été, respectivement. Les vitesses du son étaient plus élevées au banc Swiftsure que dans les sites du détroit de Juan de Fuca, en raison de températures en moyenne plus chaudes prés de fond marin. Les sites situés dans les îles Gulf et les sites plus à l'est ont présenté des valeurs maximales de vitesse du son en automne et des valeurs minimales au printemps, avec des écarts entre les valeurs minimales et maximales plus importants que ceux observés dans le détroit de Juan de Fuca. Des différences marquées ont été observées entre les sites du détroit de Géorgie, mais dans l'ensemble, ils ont tous présente des tendances saisonnières similaires a celles observées dans le détroit de Haro et le passage Boundary. Des anomalies de la vitesse du son et de la température ont été observées dans toute la zone d'étude de la fin de 2023 au printemps 2024. Ces anomalies ont persisté jusqu'au printemps 2025 dans le détroit de Géorgie. Ce phénomène étaient attribuables à un épisode El Niño observé dans le nord-ouest du Pacifique au cours de cette période.

1. EXECUTIVE SUMMARY

Underwater sound speed is determined by water temperature, conductivity/salinity, and pressure; changes to any one or more of these properties could alter local sound propagation. This is important to understand when trying to characterize a soundscape, describe changes in the sound field, understand habitat use of marine organisms that vocalize where detection ranges are calculated, and use of acoustics by marine organisms that rely on sound for communication, navigation, and predator-prey interactions.

Ten bottom stationed acoustics moorings were deployed in the Salish Sea, equipped with oceanographic loggers. Of these instruments, measures of temperature, conductivity/salinity, and pressure were taken using RBR Concerto CTDs, positioned on the mooring within 1 meter of the ocean floor. These data were sampled at 30-second intervals throughout the deployment. The raw data were processed and assessed for quality assurance and control. As the conductivity/salinity data has the potential to spike, and the sensor be subject to biofouling, extra steps were taken to clean and remove these spikes from the data prior to analysis. Once cleaned, the data were averaged to 10-minute values for further analyses. From this, for each location, daily and monthly sound speed, temperature, and salinity values were calculated and analyzed. The data were examined for spatiotemporal trends in the Salish Sea. Preliminary grouping was by those sites that were in the same region, with these areas defined by the Victoria and Boundary Pass sills. Analysis of the data confirmed similarities between proximal locations, allowing them to also be grouped by similarities in oceanographic properties and trends. These groups were: (1) Swiftsure Bank and Strait of Juan de Fuca, (2) Haro Strait, Boundary Pass, and Swanson Channel, and (3) Strait of Georgia.

At Swiftsure Bank and the Strait of Juan de Fuca, sound speed and temperature maximums and salinity minimums were observed in the late fall to early spring during the downwelling season. Notably, the sound speeds at Swiftsure Bank were faster due to higher temperatures compared to sites in the Strait of Juan de Fuca. However, the sound speed of Haro Strait, Boundary Pass, and Swanson Channel was observed to have a different trend. The sound speeds were overall faster in this region compared to the Strait of Juan de Fuca and Swiftsure Bank. The seasonal maximums of sound speed and temperature were observed in the late summer/early fall and minimums in the late winter/early spring. In the Strait of Georgia (SOG), the sound speed fields differed between the three mooring locations. Whereas the observations at the northern and southeastern site were similar, measures from the southern location showed fewer seasonal fluctuations compared to the other sites.

In 2023, elevated sound speeds were observed at all mooring sites from the summer to the following spring 2024, likely due to mixing of warmer than usual sea surface waters to the near-bottom waters. These were attributed to an El Niño present more widely in the Pacific northwest. Similar anomalies were observed again in late 2025 at all mooring sites, prior to El Niño conditions again noted in spring 2026.

2. INTRODUCTION

The Salish Sea is the collective name for the waters around southern Vancouver Island and northern Washington State. At its western extent the Strait of Juan de Fuca opens to Swiftsure and La Perouse Banks, and the influence of the Pacific Ocean (Figure 1). The eastern portion of the Salish Sea is characterised with inlets and more protected waterways in and between the Gulf Islands. Monitoring the oceanographic conditions within this region helps to establish trends and assess for variation and trends due to changes in climate and weather patterns. In the work presented here, the oceanographic measures are used to characterise the sound speeds, to aid with the interpretation of passive acoustic recordings made concomitant to the oceanographic measures, and to be able to predict future changes based on the variation seen in the ocean climatologies.

First, we summarise the known oceanographic characteristics of the region through literature review, broadly separated into three major oceanographic basins: the Strait of Juan de Fuca, Haro Strait, and the Strait of Georgia. Then, we consider how measures taken at 10 locations throughout the Salish Sea (Figure 1) might confirm this spatial grouping, add to the existing literature, and help form a 'sound speed scape' to be used alongside soundscape data. Changes to the marine soundscapes can have profound impacts on marine organisms which rely on sound for communication, navigation, and predator-prey interactions. Changes in oceanographic properties may interact with existing and future anthropogenic pressures, including altering the propagation of sound and alter the potential for acoustic disturbance for marine life. In altering sound transmission, these changes can also impact properties of the soundscape captured in recordings, and the range over which sound sources can be detected and characterized. This may include characterizing the presence of marine species through vocalizations through calculations of the detection range over which calls are being recorded.

Oceanographic measures of water temperature, conductivity/salinity and pressure help determine the propagation pathways and sound speeds of underwater sound sources. Spatiotemporal trends of these oceanic variables and water mass movements within the three basins are described. The measures made as part of this work are compared to the known existing patterns.

2.1 Juan de Fuca

Juan de Fuca Strait is a channel-like basin with depths of up to 250 m (Davenne and Masson 2001) and is the main site of exchange of water between the open Pacific Ocean and the western extent of the Salish Sea study area. Conditions in the strait are modulated by seasonal upwelling and downwelling events, and estuarine exchange (Masson and Cummins 2004; Cummins 2026). In the western part of the strait, the strength and direction of prevailing winds is the strongest influence. During the winter, the Aleutian low-pressure system brings predominantly south-southwesterly winds to the region, transporting water to the coastline, resulting in downwelling. This pushes surface waters downward, creating warmer, fresher, and oxygenated waters through the water column (Masson and Cummins 2004). In the summer, the North Pacific high-pressure system brings weak, northwesterly winds that transport surface waters away from the coast, allowing for upwelling. This forces colder, more saline, oxygen poor waters towards the surface. The mid- and eastern extent of the strait are more strongly modulated by estuarine flow. In the spring/summer, inflow from rivers in the Strait of Georgia and Puget Sound bring warm, fresh water from the east to the surface waters of the strait (Thomson et al. 2007). A return flow then transports western waters towards the east creating more saline properties to the mid and lower portions of the water column during the summer (Thomson et al. 2007). In the winter, as the estuarine flow is weakened, this reciprocal flow is disrupted by transient wind events that mix the water column (Thomson et al. 2007).

2.2 Haro Strait

Moving eastward from Juan de Fuca Strait, water is predominantly exchanged through Haro Strait and Boundary Pass. Its flow is dictated by the Gulf Islands and other land masses (Davenne and Masson 2001, Masson 2006). Deeper water flows are restricted by sills that define the subregions of the Salish Sea, namely the Victoria Sill and the Boundary Pass Sill (Figure 1). This bathymetry allows for intense tidal mixing in the region, resulting in vertical mixing of the water column (Griffen and LeBlond 1990). Transport over the sills is facilitated by neap tides at the beginning and end of estuarine dominant flow. Deep water renewal events from Haro Strait to Boundary Pass develop in the spring and the fall, with tidal mixing also noted (Masson 2002).

1.3 Strait of Georgia

The Strait of Georgia is a semi-enclosed, estuarine basin that is approximately 200 km long and 28 km wide, with depths reaching over 400 m (Davenne and Masson 2001). Water from the open ocean is transported through two main passages, either through Johnstone Strait to the north (Masson 2001) or Juan de Fuca Strait to the west (Waldichuk 1957). Surface outflow from the Fraser River freshet and stream inputs in the Strait of Georgia travels seaward, resulting in a deepwater return flow from the Strait of Juan de Fuca (Thomson et al. 2007). Tidal action creates monthly deepwater renewal resulting in cold, and more oxygenated water in the winter and warm, lower oxygen water in the summer (Masson 2002).

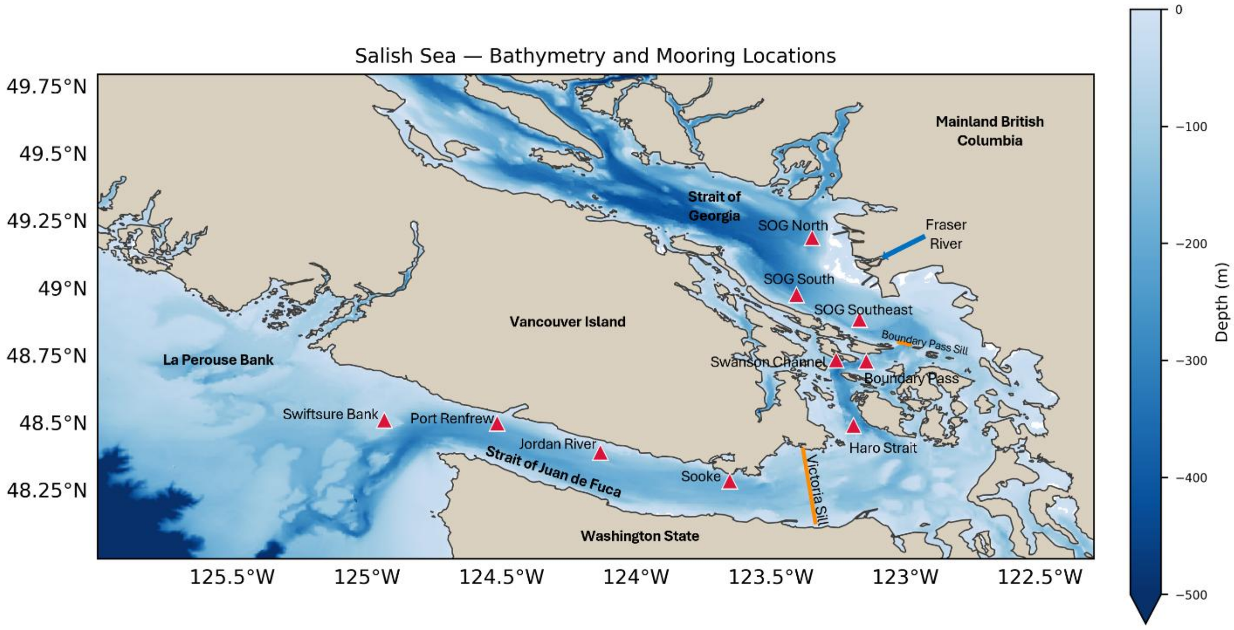

Figure 1: Salish Sea bathymetry, mooring locations, and sill locations. The mooring locations are represented by red triangles. The Victoria and Boundary Pass sills are shown as orange lines and are labelled. The blue arrow represents the mouth of the Fraser River.

3. METHODS

3. Mooring Locations, Instruments, and Data Processing

3.1 Mooring Locations

Ten acoustic moorings with oceanographic sensors were deployed within the Salish Sea (Figure 1). The first deployments on Swiftsure Bank, and in the Strait of Juan def Fuca, Haro Strait and Boundary Pass were made in early 2018, with subsequent deployments in 2020 and 2023 in Swanson Channel and the Strait of Georgia (Table 1). Data from each of the deployment locations was first compared to neighbouring locations, and then to those within the same basin using the three oceanic basins derived from previous studies and review of the literature (see Introduction). There were four moorings deployed in the Juan de Fuca basin: Swiftsure Bank, Port Renfrew, Jordan River, and Sooke. Within the Haro Strait Basin were moorings in Haro Strait, Boundary Pass, and Swanson Channel. In addition, the Strait of Georgia had three moorings deployed, one in the southeast (SOG Southeast), South (SOG South), and North (SOG North).

Table 1: Initial mooring deployment dates (YYYY/MM/DD), dates of first CTD deployment, water depth, and CTD depth.

Mooring	Deployment Date	CTD deployment date	Water depth (m)	CTD depth (m)
Swiftsure Bank	2018/04/15	2020/06/22	75	74
Port Renfrew	2018/04/16	2020/06/22	165	164
Jordan River	2018/04/16	2020/05/14	120	119
Sooke	2018/04/15	2020/05/14	160	159
Haro Strait	2018/04/14	2020/07/17	230	229
Boundary Pass	2018/04/14	2020/05/12	180	179
Swanson Channel	2019/08/18	2020/05/12	70	69
SOG Southeast	2023/07/04	2023/07/04	130	129
SOG South	2020/08/09	2020/08/09	240	239
SOG North	2020/08/09	2020/08/09	190	189

3.2 Instrument Details

The mooring frame, and its configuration, was specifically designed and constructed for both acoustic and oceanographic instrumentation (Figure 2). The major design criterion was that the mooring be quiet and robust enough for prolonged periods of deployment. A JASCO Applied Sciences Ltd Autonomous Acoustic Recorder (AMAR) Generation 4 (G4) was mounted with a GeoSpectrum Technologies Inc (GTI) M36-100 omnidirectional hydrophone for passive acoustic recording. For oceanographic measures, an RBR Concerto CTD was mounted to the mooring at least 15 centimeters away from surrounding metal components. The CTDs were factory calibrated by RBR Ltd after one year of continuous sampling. The instrument was used to sample pressure, temperature, and conductivity every 30 seconds. These variables were used to calculate depth, salinity, and sound speed. Any gaps in data resulted from instrument failure during deployment or removal of data during the quality control process.

3.3 Data Processing

The RBR Concerto CTDs data were averaged from 30-second sampling intervals to 10-minute values for temperature, pressure, depth, conductivity, salinity, and density. Upon retrieval the raw data was subject to a process of quality assessment and control. The salinity and density variables were inspected for likely erroneous data points using the despike function in Pyoceans' python-ctd module (Fernandes 2025). This was used to identify points that deviate strongly from the local means, calculated using measures from the preceding 10-minute interval (300-data points), and flagging them for further scrutiny. The function used a two-pass filter within a specified point window size, where the first pass cleaned what it considered as moderate noise and the second pass eliminated large data spikes around the point average. The first pass used a standard deviation of 2 and the second pass a standard deviation of 1 from the preceding 300-point data window. Data points that were detected and highlighted as being too far removed from the mean level of neighbouring data points were removed. These values were not replaced in the data stream by smoothing or interpolating from other proximal data points.

At times, manual identification of poor data points was required. The process used to determine outliers described would not identify, for example, values that were altered due to decreased instrument sensitivity or a long-term change in the accuracy of the measurements due to biofouling. The moored CTDs did not have any physical or chemical antifouling elements to aid in reducing biofouling. As such, manual analysis of the data and comparison of raw temperature and conductivity values, which typically have a high linear correlation in the upper 2000 m of the water column (Zheng et al. 2018), helped identify periods when biofouling may have impacted the accuracy of the measurements made, represented by strong deviations between the variables. This was supported by photographs taken of the instrumentation on recovery to document the marine growth or fouling around the sensors of each instrument.

Sound speed was calculated using the Python Gibbs SeaWater Oceanographic Package of the Thermodynamic Equation of Seawater -2010, which requires absolute salinity, conservative temperature, and pressure (McDougall et al. 2010). These variables were acquired from the processed RBR Concerto[3] CTDs data. Sound speed typically ranges from 1450 to 1570 m/s in seawater, and is controlled by temperature, salinity, and pressure. It has been approximated that sound speed increases by 4.5 m/s per 1 °C increase in temperature, 1.3 m/s per 1 PSU increase in salinity, and 1.7 m/s per 100m increase in pressure (Mackenzie 1981, Dushaw et al. 2009, Dushaw et al. 2016).

The measurements taken by the CTD at each mooring location were considered through time, as well as compared to neighbouring mooring locations, in particular those within the same basin. The oceanographic measures, and sound speeds were considered as daily, monthly, and seasonal averages calculated from 2020 to 2025. Seasons were defined as winter (December to February), spring (March to May), summer (June to August), and fall (October to November). All measures were taken at or within 1 meter of the ocean floor, Figure 2, which should be kept in mind during the analysis and interpretation.

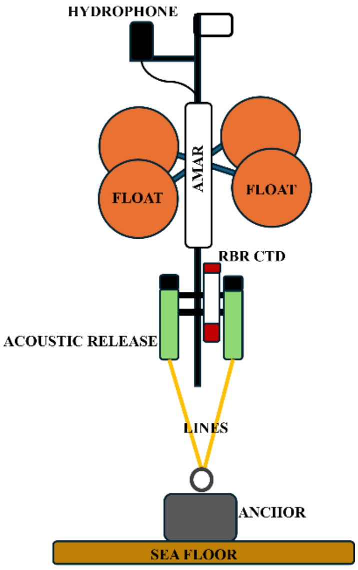

Figure 2: Schematic of a passive acoustic mooring. The distance from seafloor to RBR CTD is approximately 1m and seafloor to hydrophone is approximately 2m.

4. RESULTS

The measures made at each location within each of the three basins of the Salish Sea showed congruence, and so the data from each of the 10 moorings locations were described and considered in context with measures made at neighbouring locations within the same basin. Swiftsure Bank and the data from moorings in the Strait of Juan de Fuca were considered together, Haro Strait, Boundary Pass, and Swanson Channel were seen to be similar, and finally the three Strait of Georgia locations were examined together and compared. This similarity of measures between locations within the basins, and differences seen at locations between basins, reinforced the use of the basin-level data analysis and so the basins as described previously were continued to be used to be able to discuss patterns of oceanographic properties on a more seasonal level, as well as measures taken at each mooring.

4.1 Swiftsure Bank and Strait of Juan de Fuca

The winter at Swiftsure Bank showed the greatest sound speeds, warmest temperatures, and freshest waters of 1483.0 ± 1.0 m/s, 8.8 ± 0.4 ºC, and 32.2 ± 0.1 PSU, respectively (Figure 3, Table A1-A3). Moving from winter to spring, temperatures decreased, salinity increased, and overall sound speed values decreased. Temperature and sound speed minimums and salinity maximums were observed in the summer months, where values reached 7.2 ± 0.2 ºC, 1478.6 ± 0.6 m/s, and 33.6 ± 0.1 PSU. Another transition period occurred in the fall, where the sound speed and temperature increased and the salinity decreased until values typical for winter were reached.

Figure 3: Swiftsure Bank 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

Conditions at Port Renfrew demonstrated a seasonal trend of higher sound speeds, warmer temperatures, and more saline values in the winter, and opposing properties in the summer (Figure 4). Sound speed in the winter averaged 1482.0 ± 1 m/s, elevated by the warm average temperatures and low salinity values when compared seasonally (7.9 ± 0.4ºC and 33.3 ± 0.4 PSU, respectively). The spring transition periods showed average sound speeds of 1480.1 ± 0.6 m/s, with decreasing temperatures, averaging 7.1 ± 0.2 ºC alongside increasing salinity, averaging 33.8 ± 0.01 PSU (Table A3-A6). The sound speed was at its lowest during the summer, averaging 1478.9 ± 0.7 m/s. Concurrently, temperatures approached their lowest values while salinity values approach their highest at 6.7 ± 0.2 ºC and 33.9 ± 0.03 PSU, respectively. During the fall, values of temperature increased and salinity decreased until reaching temperature maximums and salinity minimums typical for winter (Figure 4). Compared to Swiftsure Bank, the conditions at Port Renfrew were cooler and more saline, most notably from fall to spring, resulting in lower sound speeds.

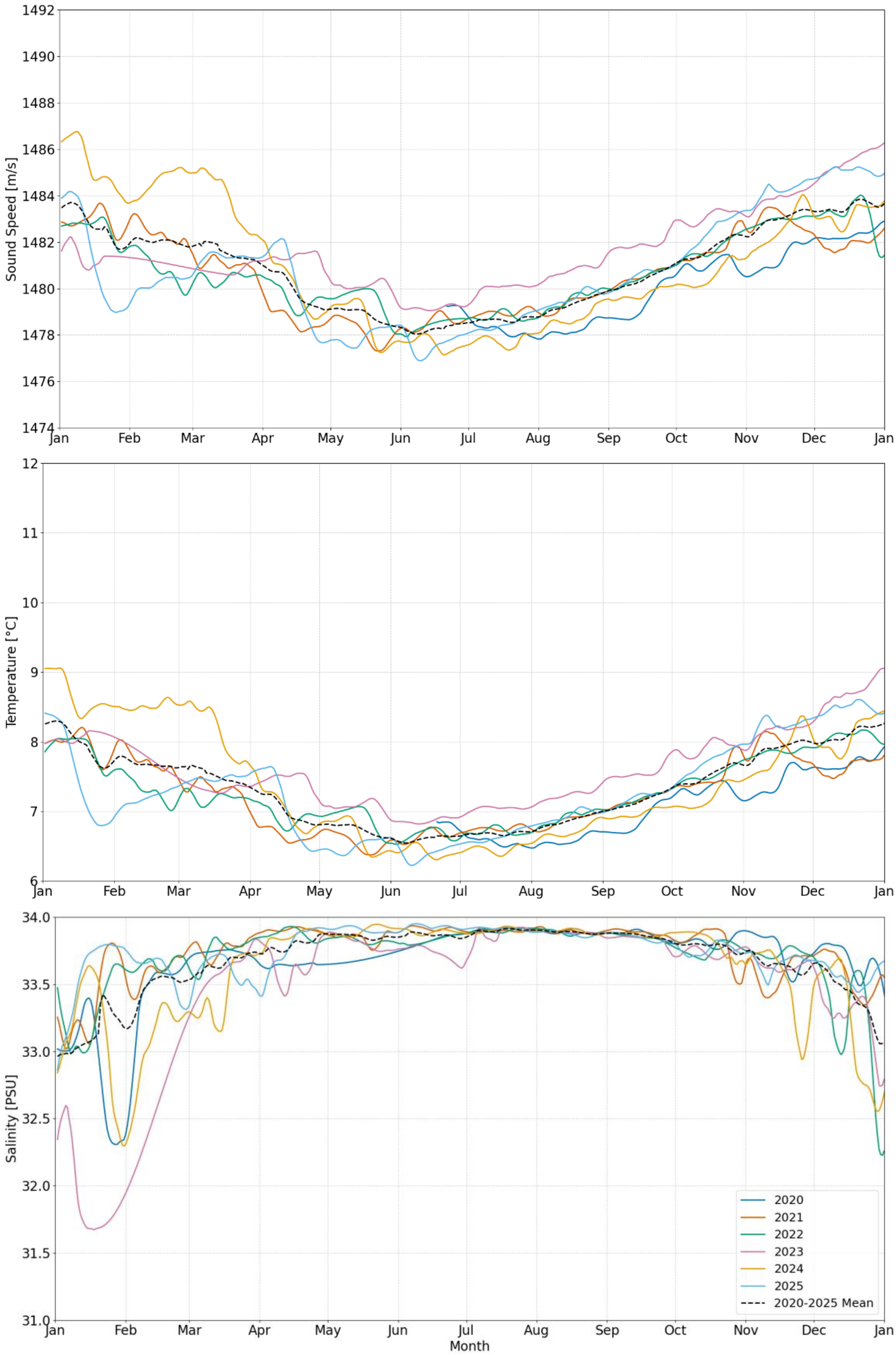

Figure 4: Port Renfrew 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

Sound speed values were seen to vary much less in the eastern extent of Juan de Fuca Strait. At Jordan River, the winter average sound speed was 1482.0 ± 1 m/s and decreased during the spring time transition periods to 1479.6 ± 0.7 m/s (Figure 5, Table A7). The lowest values were observed in the summer with a seasonal average of 1478.5 ± 0.6 m/s, with some monthly values in June and July as slow as 1477.0 m/s. The winter had the highest observed temperature and freshest salinity values of the year at 8.1 ± 0.4 ºC and 32.7 ± 0.2 PSU, respectively (Table A8 and A9). The spring shifted towards cooler and more saline waters with seasonal average temperature minimums of 7.0 ± 0.2 ºC and salinity maximums of 33.6 ± 0.1 PSU in the summer. In the fall, the temperature rose (average of 7.9 ± 0.3 ºC) and the salinity fell (to average 33.5 ± 0.1 PSU) slightly until maximums and minimums are reached again in the winter (Figure 5). Compared to neighbouring mooring at Port Renfrew, Jordan River was marginally warmer but up to 1.0 PSU fresher through the fall to the spring, leading to reduced sound speeds. In the summer months, the water properties are relatively similar in addition to the sound speed.

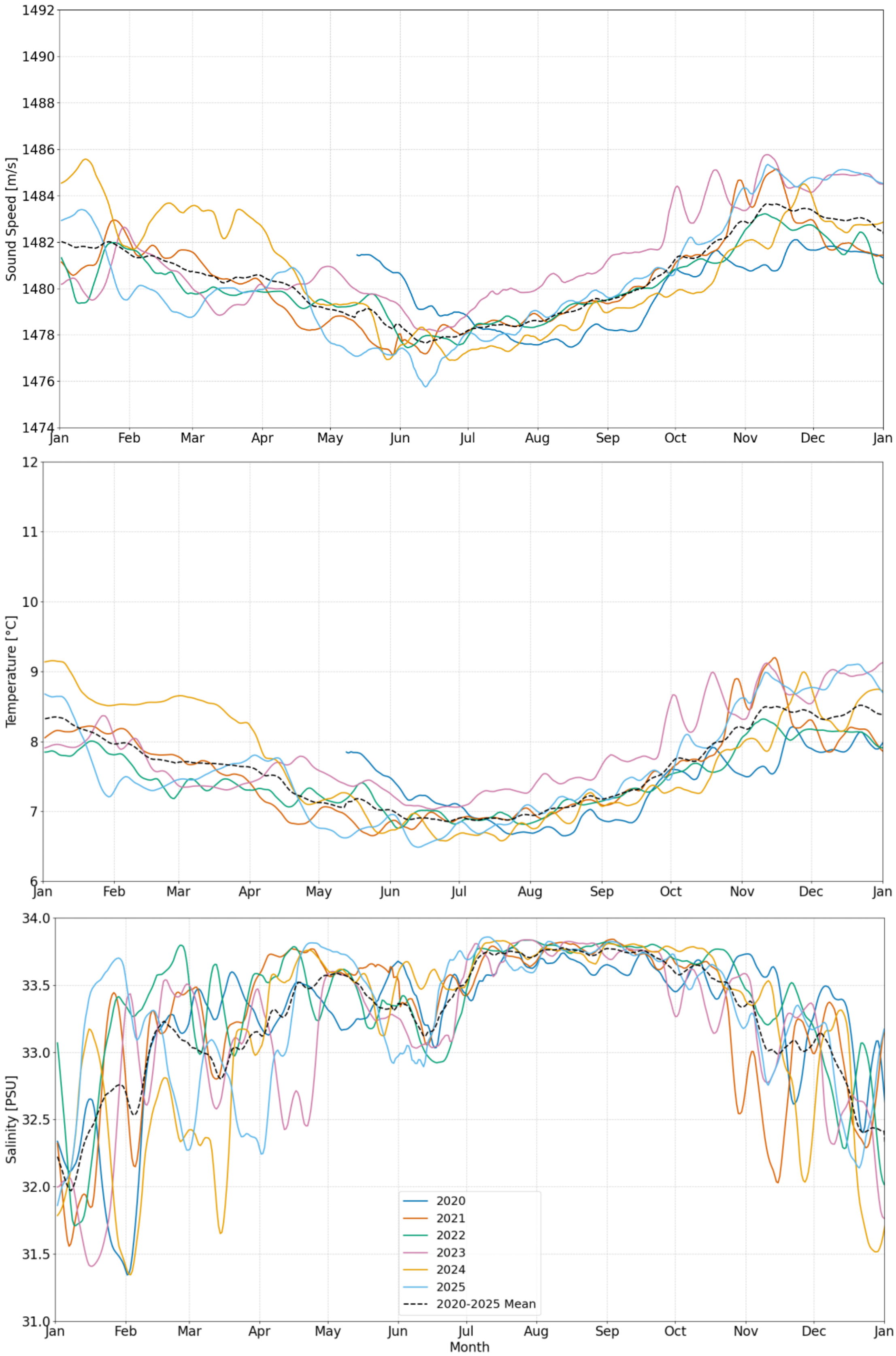

Figure 5: Jordan River 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

At the Sooke mooring, the seasonal sound speed was relatively stable and varied ± 3.5 m/s throughout the year (Figure 6, Table A10). The late fall and winter had some of the highest speeds, averaging 1482.0 ± 1 m/s and 1483.0 ± 1 m/s, respectively. The spring was found to be a period of transition where sound speed decreased to a low in the summer at 1479.3 ± 0.7 m/s. In the early fall, speeds began to rise again until maximum sound speeds were attained in November with a monthly average of 1483.0 ± 1 m/s. These speeds were observed until the following February, when they began to decrease. In the winter, the temperature was its warmest and the salinity the freshest averaging 8.1 ± 0.4 ºC and 33.1 ± 0.2 PSU (Table A11 and A12). During the spring, temperatures began to cool and water became more saline, and by the summer seasonal average temperature and salinity values were 6.9 ± 0.2 ºC and 33.8 ± 0.1 PSU, respectively. At the Sooke mooring, the temperature was very similar to that of Jordan River, which was warmer than Port Renfrew but colder than Swiftsure Bank. The water was marginally more saline compared to Jordan River, but saltier than Swiftsure Bank and fresher than Port Renfrew. The sound speed at Sooke was overall faster compared to the sites in the Strait of Juan de Fuca, and during the summer, faster than Swiftsure Bank.

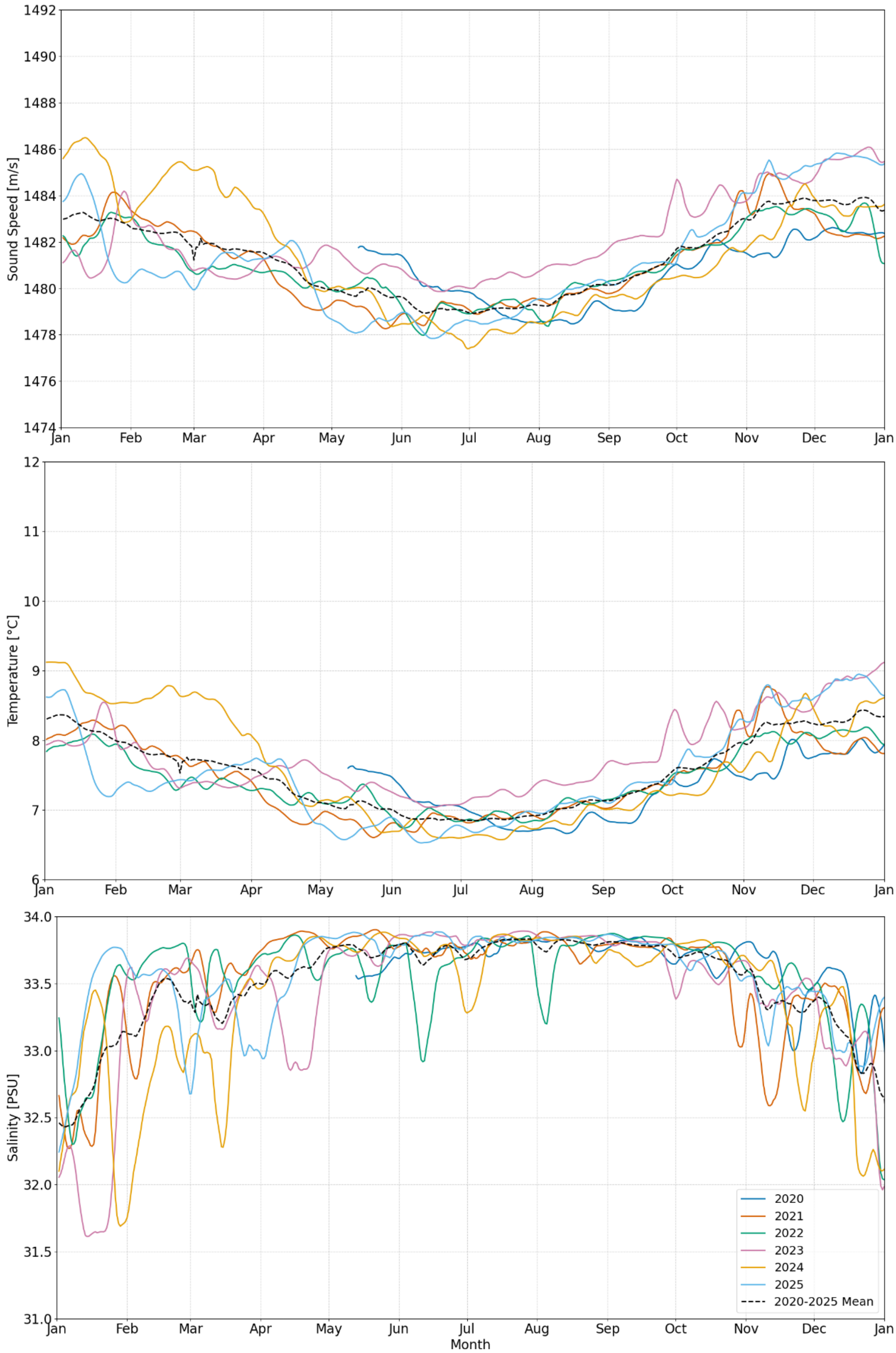

Figure 6: Sooke 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

4.1.2 Swiftsure Bank and Strait of Juan de Fuca Anomalies

The sound speeds and temperatures were elevated from summer 2023 and remained elevated through to spring 2024 from Swiftsure Bank into the Strait of Juan de Fuca. The summer seasonal averages for sound speeds and temperature were approximately 1.0 m/s and 0.2-0.4 ºC greater compared to previous years at each of the locations in this basin. During the fall and winter months, the values continued to increase and reached maximum speeds and temperatures in the spring. At Swiftsure Bank, monthly average sound speeds were 4-5 m/s greater in February 2024 with values of 1486.0 ± 3 m/s and temperatures were 1.0 ºC higher at 9.7 ± 0.7 ºC than the average calculated over all years. In the Strait of Juan de Fuca, the sound speeds and temperatures were greatest in January 2024. At this time, the sound speeds were 2.0 m/s greater compared to the 2020-2025 monthly average and temperatures were 0.6-0.7 ºC greater. The moorings at the western extent of this basin showed the strongest diversion from average measures from previous years, and so potentially were the most influenced by the broader El Niño conditions (Boldt et al. 2024 and 2025).

4.2.1 Haro Strait, Boundary Pass, Swanson Channel Seasonal Properties

At Haro Strait, no data were collected from January 25 to July 6 2024 due to instrument failure (Figure 7). In the spring, the seasonal sound speed was 1481.9 ± 0.3 m/s with the lowest speeds observed in March with an average monthly speed of 1481.0 ± 1.0 m/s (Table A13). The summer transitioned to higher speeds reaching the highest velocities in October (1487.0 ± 1.0 m/s, Figure 7). The winter saw decreases in sound speeds and returned to seasonal lows in the spring. Following a similar pattern, the temperature was its lowest and salinity the highest values in the spring, respectively. The seasonal low for temperature was 7.9 ± 0.1 ºC, with the coolest temperatures experienced in March with an average monthly value of 7.8 ± 0.2 ºC (Figure 7, Table A14). The seasonal salinity low was observed in the winter, with the freshest values recorded in January, with a monthly average of 31.0 ± 0.6 PSU (Table A15). The seasonal temperature and salinity highs occurred during different times, with average temperatures of 9.1 ± 0.4 ºC and 32.4 ± 0.1 PSU, respectively. The differences in timing of oceanographic maximums and minimums were likely the result of surface water runoff and deepwater renewal over sills.

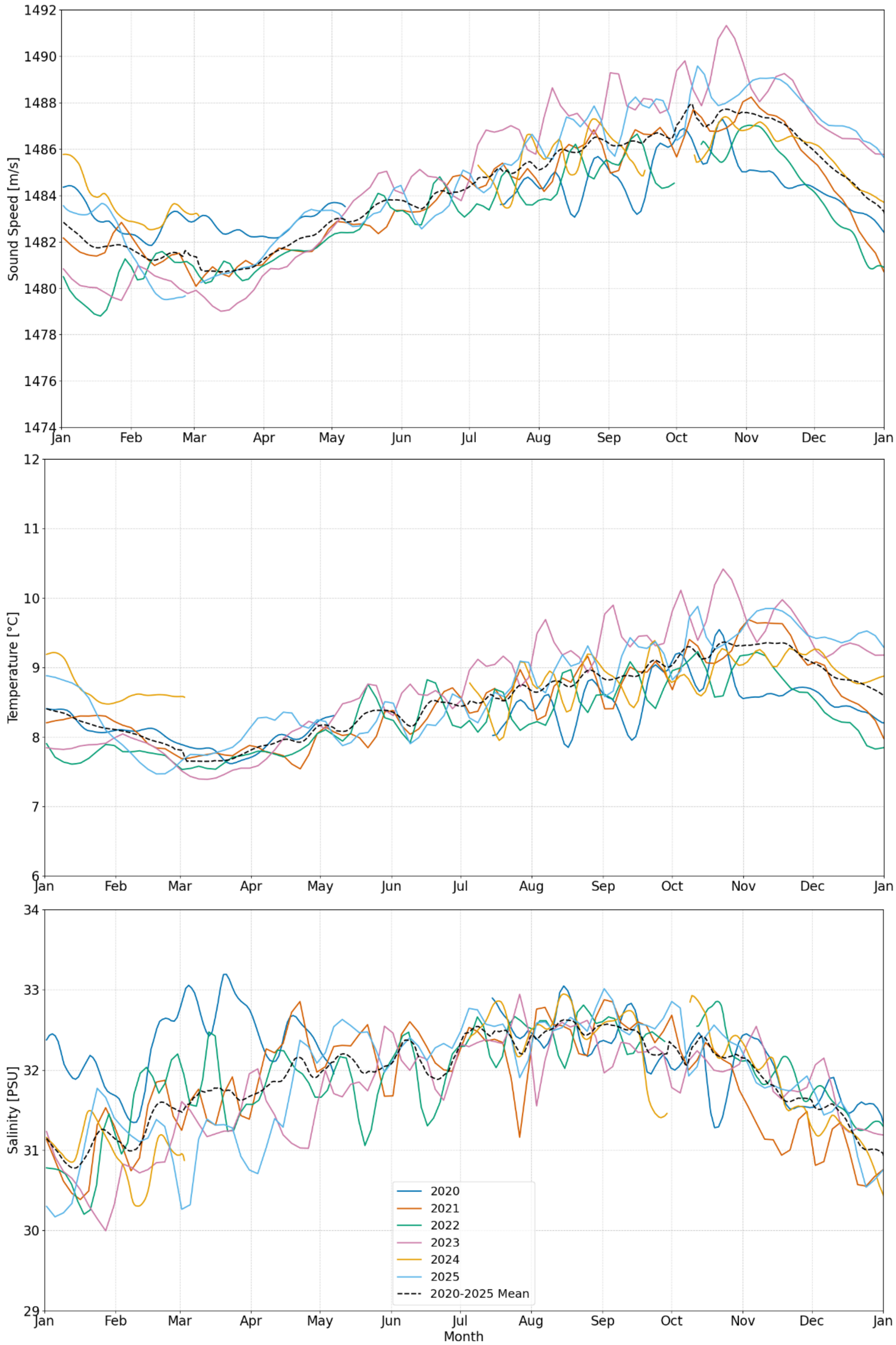

Figure 7: Haro Strait 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025. No data were collected from January 25 to July 6 2024 due to instrument failure.

In the late winter and early spring at Boundary Pass, seasonal sound speeds were at their lowest values, specifically in February and March, with monthly average sound speeds of 1479.9 ± 0.9 m/s and 1480.0 ± 1.0 m/s, respectively (Figure 8, Table A16). April onwards, and into the summer, were transitionary periods where sound speeds began to increase. In the fall, monthly average highs were reached in September and October at 1486.0 ± 1.0 m/s and 1487.0 ± 1.0 m/s, respectively (Figure 8). Similarly, the monthly average temperatures reached lows in the late winter and early spring and highs in the fall. Minimums were observed in March, averaging 7.9 ± 0.4 ºC, and maximums in October averaging 9.5 ± 0.4 ºC (Figure 8, Table A17). Salinity maximums occurred earlier in comparison to sound speed and temperature in August and September, with salinities of 32.1 ± 0.2 for both months. The minimums were observed in January with monthly averages of 30.6 ± 0.2 PSU (Figure 8, Table A18), which was also earlier than the other oceanographic measures.

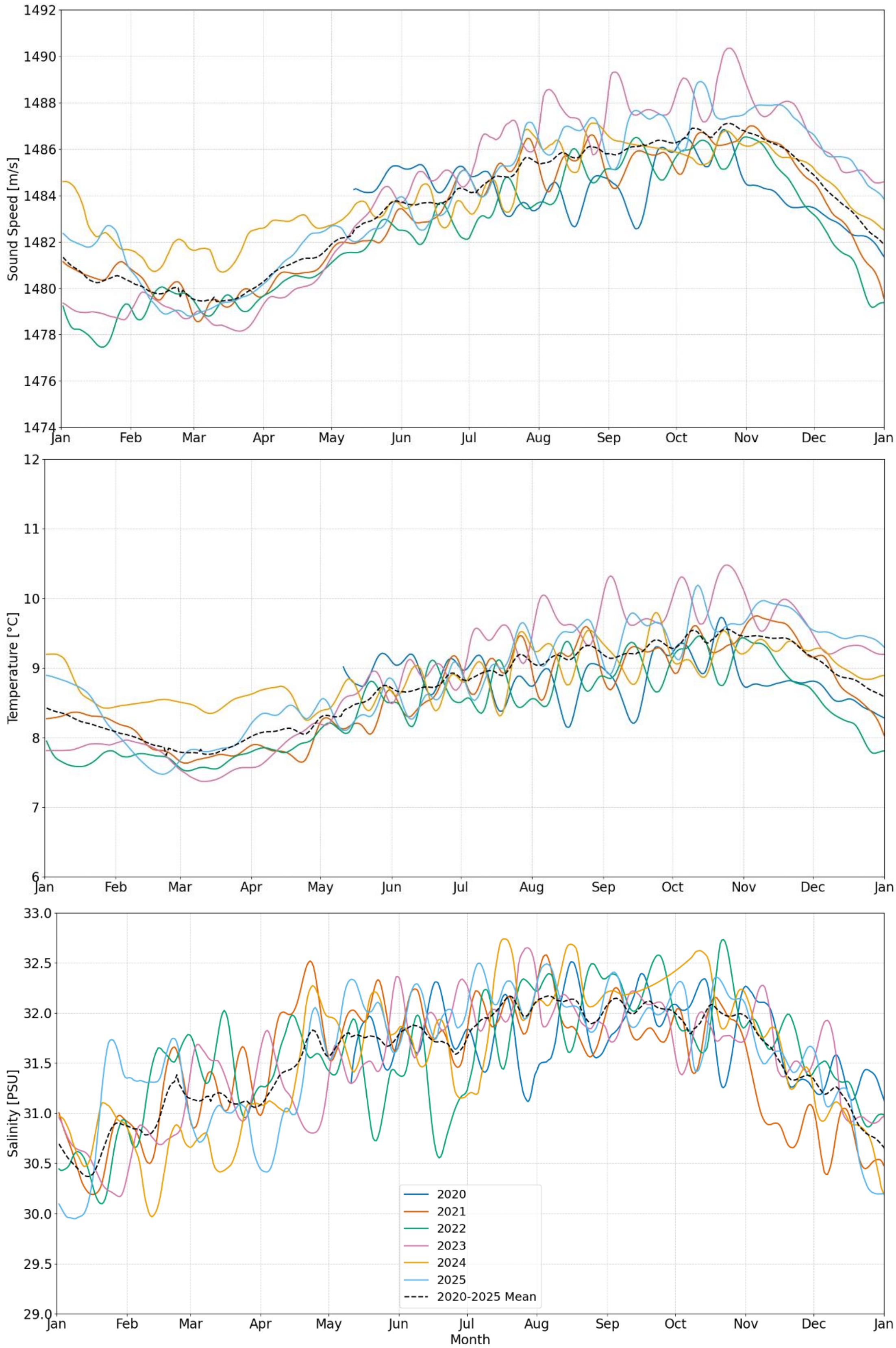

Figure 8: Boundary Pass 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

In Swanson Channel, sound speed, temperature, and salinity lows were observed in late winter and early spring during February and March (Figure 9). The sound speeds were 1477.0 ± 1.0 m/s for both months, with temperatures averaging at 7.9 ± 0.3 ºC, and salinity 30.5 to 30.6 ± 0.2 PSU (Table A19-A21). The remaining spring and into summer were a transition period where sound speeds, temperatures, and salinities increased until maximums were reached in late summer and early fall. The sound speed and temperature monthly average maximums were observed in August and September of 1485.0 ± 1.0 m/s and 10.2 ± 0.3 ºC for both months, respectively (Figure 9, Table A19). Salinity maximums were observed in October and November where both monthly averages were 30.9 ± 0.2 PSU. The remaining months of fall and winter showed salinity values decrease until minimums were reached again (Figure 9).

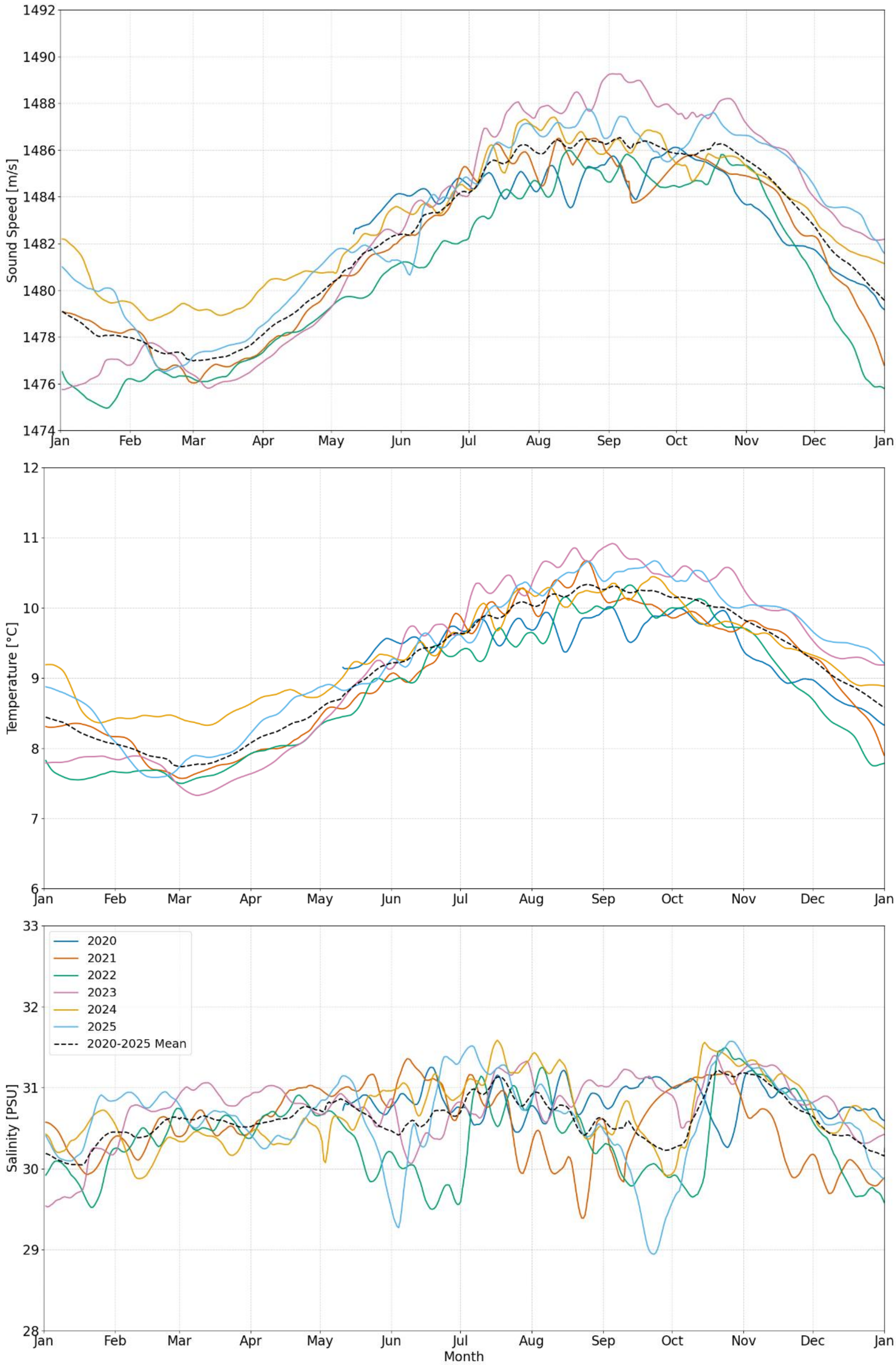

Figure 9: Swanson Channel 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

4.2.2 Haro Strait, Boundary Pass, and Swanson Channel Anomalies

In the summer and fall of 2023, sound speeds and temperatures were elevated in Haro Strait, Boundary Pass, and Swanson Channel. During this time, the sound speeds were up to 2.0 m/s greater based on monthly averages from July to September, while temperatures were 0.5 ºC greater for these months. This is similar to the increases observed in the eastern portion of the Strait of Juan de Fuca. The late winter 2023-24 and spring 2024 continued to have elevated sound speeds and temperatures until May. It is unknown when the changed occurred at Haro Strait due to loss of data mentioned previously, but were evident when the time-series was restored. Similar values were observed in 2025 November and December to those in 2023, resulting in an increase in sound speed and temperature compared to other years in the time series. This is suggestive of another El Niño event, predicted for 2026.

4.3.1 Strait of Georgia Seasonal Properties

The southeast Strait of Georgia (SOG) mooring was first deployed in July of 2023, and therefore, has only two years of data. Sound speed minimums were observed in the winter and early spring, with minimums reached in February and March, averaging 1479.0 ± 2.0 m/s for both months (Figure 10, Table A22). Speeds began to increase in the summer and reached maximums in late summer and early fall with values of 1489.0 ± 1.0 m/s during August and September. The remainder of the fall and winter were transitionary months where speeds decreased to observed minimums in February and March (Figure 10). The same trends were observed for temperature and salinity, where temperature maximums occurred in August and September with monthly average values of 10.4 ± 0.2 ºC and 10.5 ± 0.2 ºC for temperature, and 31.2 ± 0.1 PSU and 31.2 ± 0.1 PSU for salinity (Table A23 and A24). Similarly, minimums occurred in February and March for temperature and salinity with an average temperature of 8.2 ± 0.6 ºC and salinity of 30.3 ± 0.2 PSU, and 8.3 ± 0.3 C and 30.2 ± 0.2 PSU in March (Figure 10).

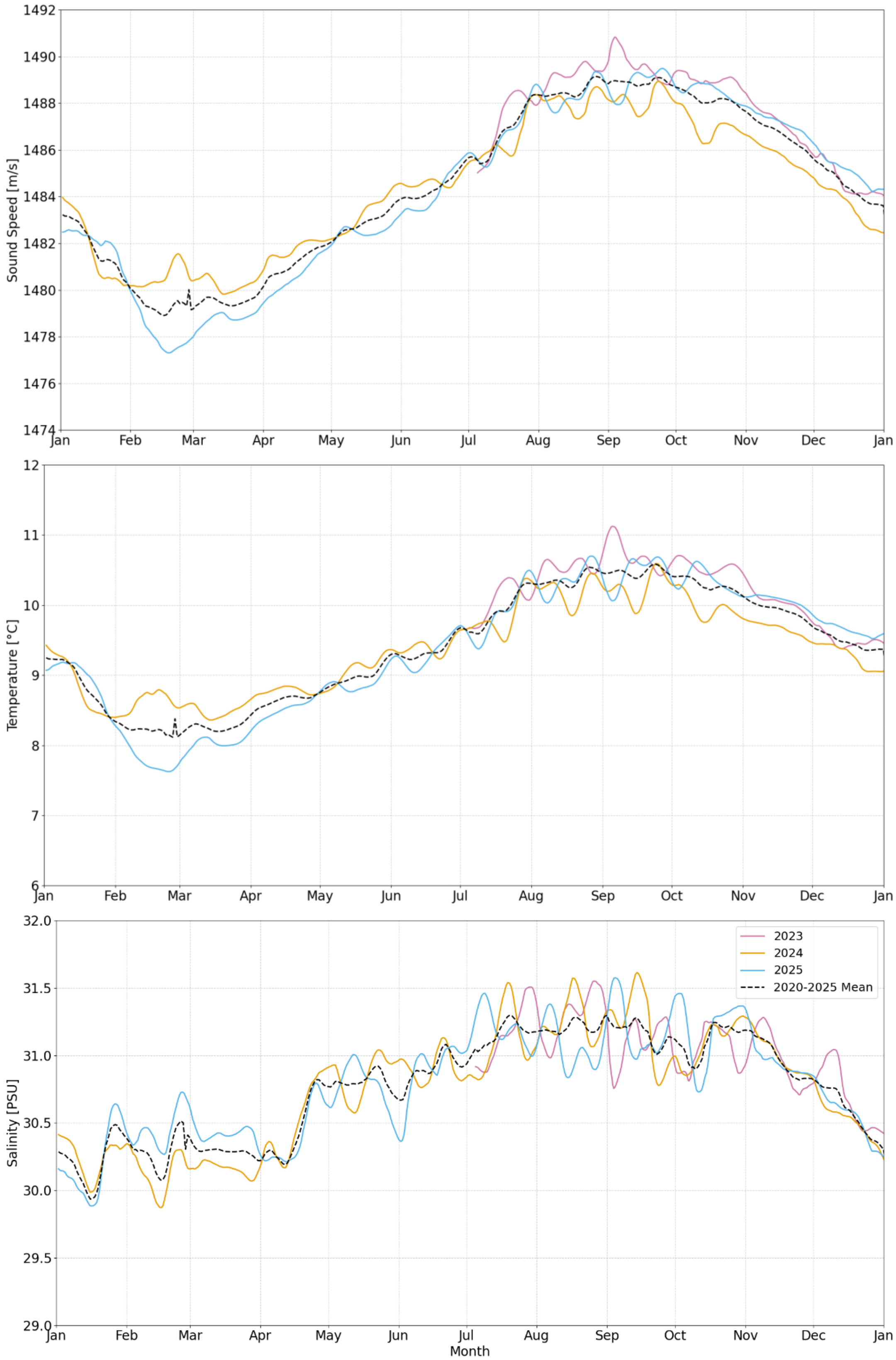

Figure 10: SOG Southeast 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2023 to 2025. Black dashed line represents the 7-day rolling mean from 2023-2025. First deployed in July 2023, therefore, only approximately 2.5 years of data available.

At the Strait of Georgia South mooring, sound speed, temperature, and salinity lows were observed in the late spring. The May monthly averages were 1484.0 ± 1.0 m/s, 8.7 ± 0.5 ºC, and 30.9 ± 0.1 PSU, respectively, and were the lowest of the year (Figure 11, Table A25-A27). The maximums occurred in the late fall with sound speed, temperature, and salinity highs observed in November with monthly averages of 1488.0 ± 1.0 m/s, 9.8 ± 0.3 ºC, and 31.4 ± 0.1 PSU (Figure 11). Notably, the seasonal variation in values for the oceanographic measures was less than other sites in the Strait of Georgia, and other sites within the Salish Sea.

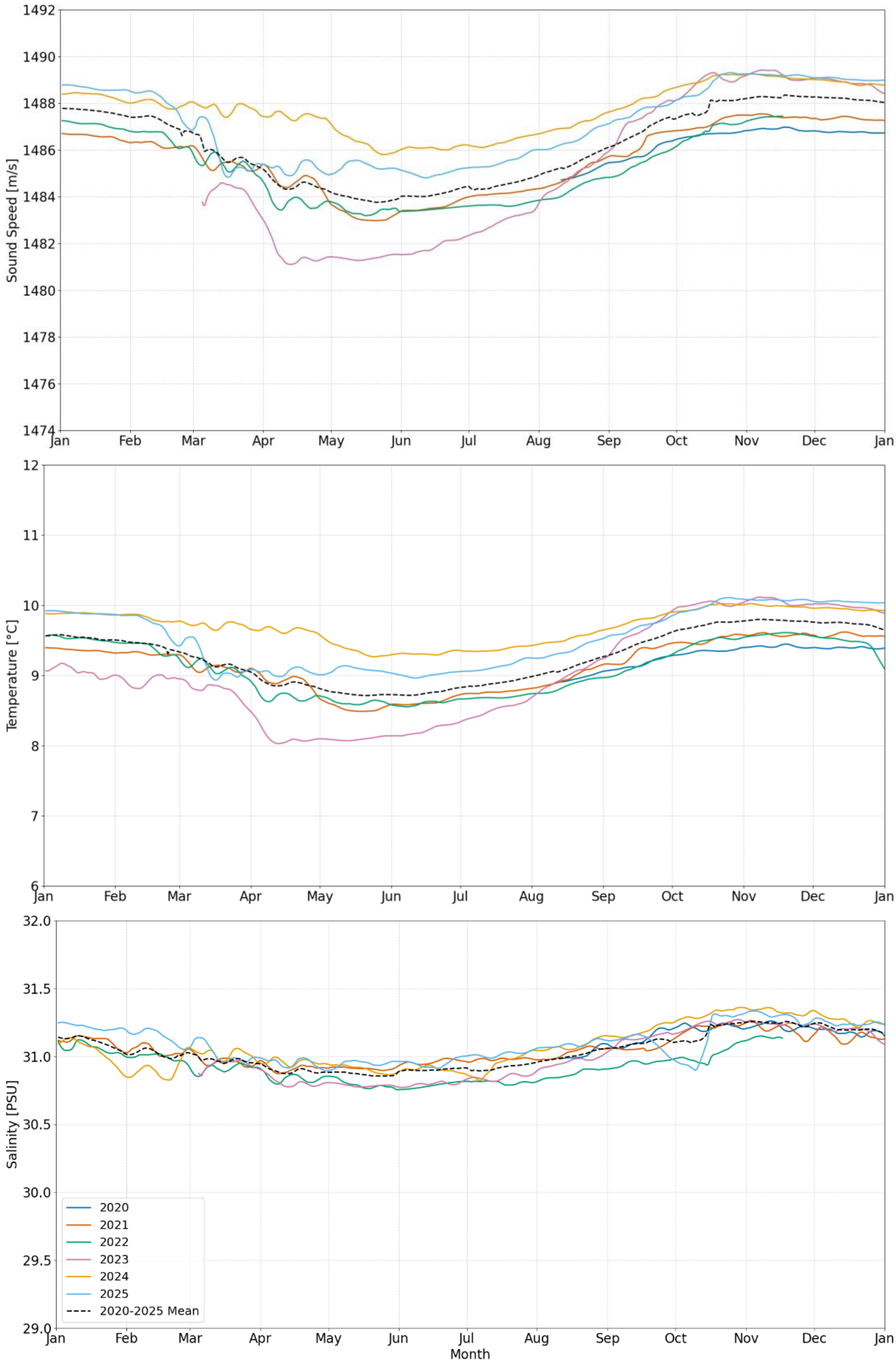

Figure 11: SOG South 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

The Strait of Georgia North mooring location demonstrated the strongest seasonal variation (Figure 12). Sound speed, temperature and salinity minimums occurred during the spring months with seasonal averages of 1482.0 ± 2.0 m/s, 8.5 ± 0.5 ºC, and 30.7 ± 0.1 PSU, respectively (Table A28-A30). Over the summer, the variables increased until reaching maximums in the fall. The fall seasonal averages for sound speed, temperature, and salinity were 1488.0 ± 1.0 m/s, 9.9 ± 0.3 ºC, and 31.1 ± 0.1 PSU (Figure 12, Table A28-A30).

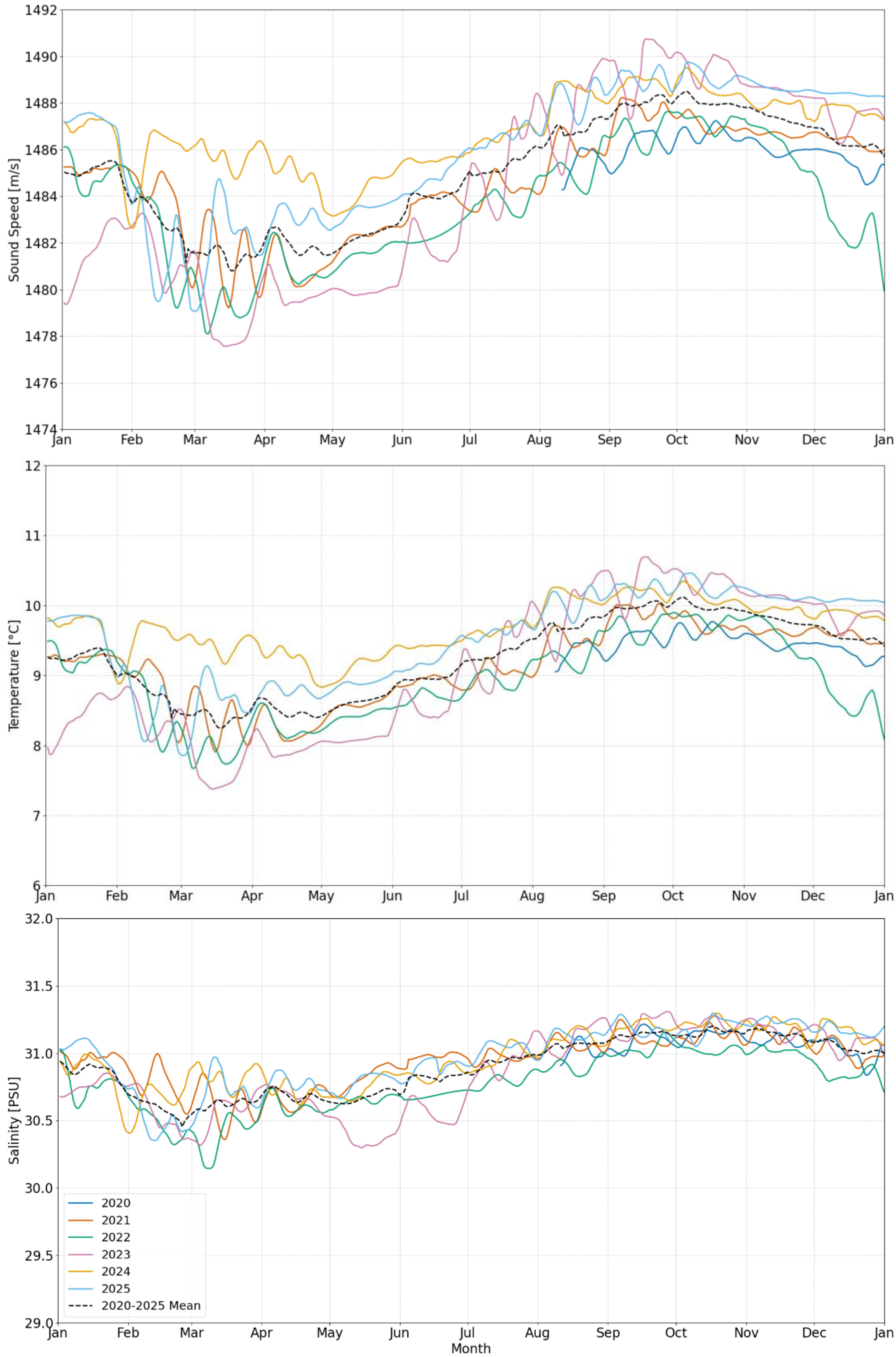

Figure 12: SOG North 7-day centered rolling average sound speed (top), temperature (middle), and salinity (bottom) from 2020 to 2025. Black dashed line represents the 7-day rolling mean from 2020-2025.

4.3.2 Strait of Georgia Anomalies

During the winter of 2022-23, the sound speeds and temperatures were notably lower than previous years for SOG South. This trend of reduced temperatures continued until August 2023, when sound speeds and temperatures increased to values above those observed in fall and winter 2020-2022. This warming increased the sound speeds for the summer of 2023. In 2024, sound speeds and temperatures remained elevated. At SOG South in 2024, the seasonal temperatures were 0.5-0.7 ºC higher compared to 2020-2022 values, while the sound speeds were 1.6-2.9 m/s greater. At SOG North in 2024, seasonal averages for temperature and sound speed were 0.4-1.0 ºC and 1.8-3.8 m/s greater, respectively. In 2025, these properties began to decrease closer to seasonal averages in the winter and spring observed in previous years, but then began to increase in the fall and winter to values similar to 2024. This shows that, although not the site of greatest change in temperature and sound speeds resulting from the El Niño, that the influence of this wider-ranging climactic event persisted in the Strait of Georgia for several months longer, at least, than other neighbouring sampling sites.

5. DISCUSSION AND CONCLUSIONS

In recent years the Salish Sea has been subjected to climate induced changes and atmospheric forcings. Shifts in the intensity and timing of the Aleutian low- and North Pacific high-pressure systems influence the estuarine flow regime, upwelling/downwelling mixing, and tidal turbulence over sills. As sound transmission is defined by water properties, it is possible that ocean warming may lead to an increase in sound speeds. Using the oceanographic data collected from 10 locations in the Salish Sea, spatiotemporal trends and anomalies have been described for the near-bottom sound speed and water properties for three main Salish Sea basins.

5.1 Swiftsure Bank and Strait of Juan de Fuca

Seasonal trends at Swiftsure Bank were different compared to the Strait of Juan de Fuca. While the timing of seasonal maximums and minimums occurred within the same time periods, the magnitude of sound speed, temperature, and salinity were distinctly greater. At Swiftsure Bank, temperatures were higher and salinities lower, mostly notably in the late fall to early spring. The divergence in values is likely due to the proximity to the west coast of Vancouver Island, and complex bathymetry and shallow water depths. The Swiftsure Bank mooring is located outside of the mouth of the Strait of Juan de Fuca. This region is strongly influenced by larger atmospheric pressure systems, such as the Aleutian low in the late fall to early spring, and the North Pacific high in the late spring to early fall. These systems determine the timing and strength of upwelling (North Pacific high) and downwelling (Aleutian low) seasons along the west coast. This influence is evident at Swiftsure Bank, where the shift to warmer near-bottom waters results in increased sound speeds during the downwelling season and lower sound speeds and cooler waters during the upwelling season. In addition, as the mooring is located at approximately 70 m depth, vertical mixing to the depth where measurements were made is easier compared to the deeper depths for the sites in the Strait of Juan de Fuca.

In the Strait of Juan de Fuca, as previously mentioned, the seasonal timing of minimums and maximums are similar to that of Swiftsure Bank. The primary difference is that near-bottom waters are colder and more saline, resulting in lower sound speeds. In the summer, estuarine flow dominates as well as inflows of cold, dense water from the Pacific Ocean in the mid- to lower water column. In the winter, downwelling results in vertical mixing, warming and freshening of the near-bottom water, resulting in higher sound speeds. Overall, the water properties and sound speeds from Port Renfrew to Sooke show similarities, however, the Port Renfrew mooring location had the coldest and most saline properties throughout the year. However, because of the higher salinity the sound speed calculated were still similar to the other Juan de Fuca sites, even though the water is cooler. The temperature at the Jordan River and Sooke moorings were comparable, but the salinity at Jordan River was lower, notably in the winter and spring. The difference is likely due to the proximity to the river, Jordan River, where fresher water at the surface is vertically mixed through the water column. This changes the sound speed between the two sites, where Jordan River speeds are lower compared to Sooke, even though the temperatures are similar.

5.2 Haro Strait, Boundary Pass and Swanson Channel

Near-bottom water travels eastward from the Strait of Juan de Fuca into Haro Strait and Boundary Pass which are bounded by two shallow sills, the Victoria Sill south of Haro Strait and Boundary Pass Sill, east of Boundary Pass. In this region, strong tidal currents produce intense mixing through the water column. At all three mooring locations, the winter near-bottom water had the slowest speeds due to cooler temperatures and intense vertical mixing through the entire water column. In the summer, as estuarine flow brings cooler, denser waters from the west, the mixing within the region changes the water properties. The salinity increases from winter to summer, but mixing allowed for increased temperatures, and therefore, faster sound speeds. The measures taken at the Swanson Channel mooring location differed by having fresher near-bottom water throughout the year, but seasonal changes in water temperature. Interestingly, these differences resulted in sound speeds similar to Haro Strait and Boundary Pass in the summer, although temperatures were higher at Swanson Channel.

5.3 The Strait of Georgia

The sound speed fields and water properties at all three mooring locations in the Strait of Georgia showed distinct oceanographic characteristics. Based on observations, it appears that the proximity to the inflow from the Boundary Pass Sill and the bottom depth where the mooring resides, have an effect on the sound speed at each location. Of the three locations, the northern and southeastern moorings were most similar in properties and seasonal trends. In the winter while estuarine flow is weak and vertical mixing is strong, seasonal temperature and salinity lows were observed. Moving into the summer and fall as estuarine flow takes over, the salinity increased as a result of mixing with open ocean water, and temperature increases resulted from mixing with the upper water column. The result was sound speed lows in the winter and highs in the summer/fall, with some differences between the north and southeast moorings. As the north mooring location is further from the strong mixing over the sill and deeper at 190 m, it is likely that there is overall less mixing to the bottom, resulting in warmer, more saline conditions in the winter compared to the southeast mooring. As estuarine transport strengthens in the summer and fall, the conditions at both locations become more aligned. These similarities and differences result in reduced sound speeds at the southeastern location and higher sound speeds at the northern location in the winter. The south mooring location in the Strait of Georgia had differed in its water properties from all other locations. Throughout the year, both temperature and salinity show less seasonal variation compared to the other mooring sites. This is likely due to the depth of the mooring (240 m), where it is more difficult for vertical mixing to occur. The sound speed field at this location, therefore, had less variability throughout the seasons.

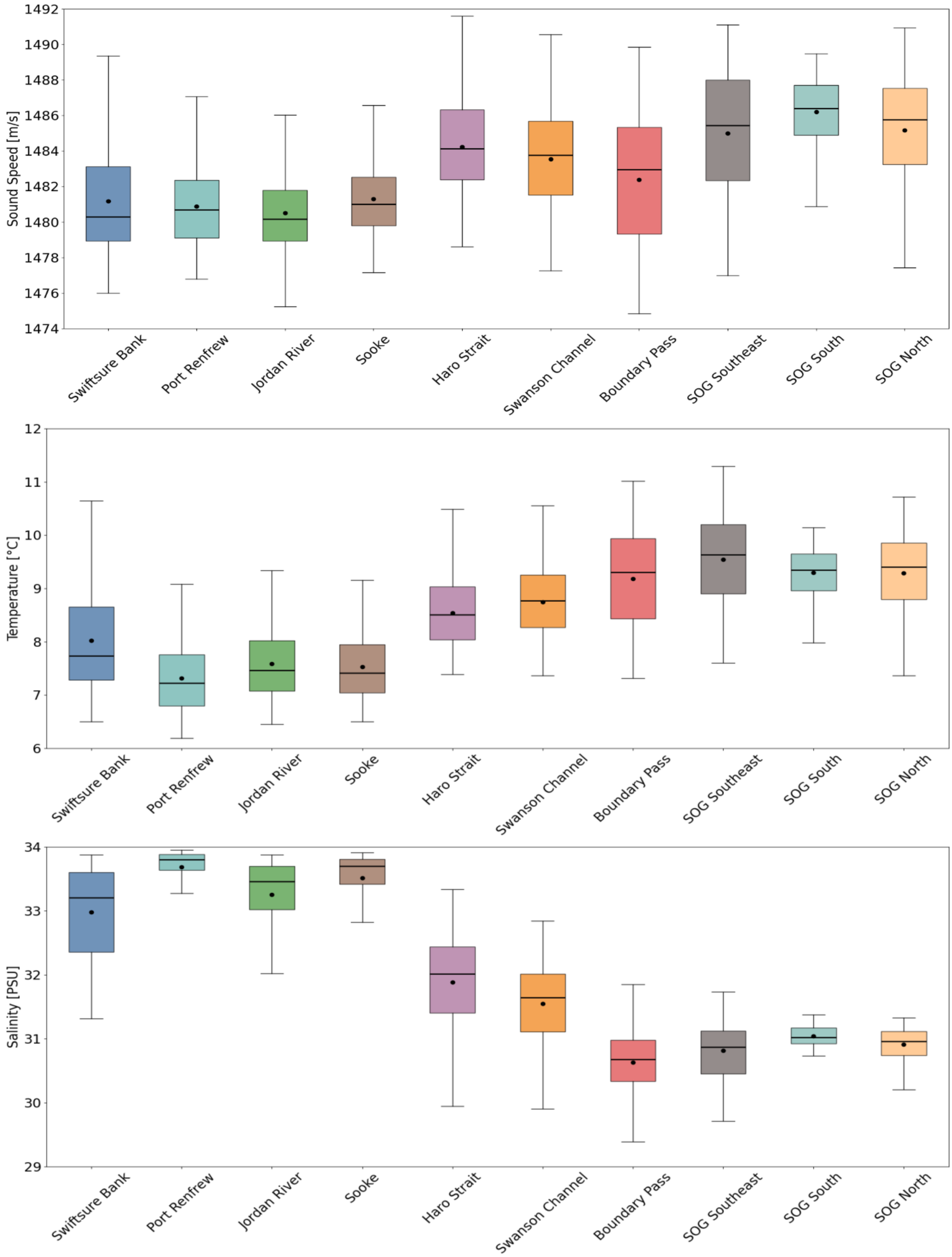

Figure 13: Box plots of the average sound speed (top), temperature (middle), and salinity (bottom) at each mooring site based on daily averages from 2020 to 2025. The coloured box represents the upper and lower quartiles. The black line within the box is the median value and the black circle is the mean value. The upper and lower bars represent the maximum and minimum values, respectively.

5.3 Sound Speed Scape, Temperature, and Salinity of the Salish Sea

The average sound speed, temperature, and salinity were calculated from 2020-2025 based on daily averages (Figure 13). The near-bottom temperature and salinity in the region ranged from 6.0 to 11.0 ºC and 29.0 to 33.0 PSU, respectively. The sound speeds of the Salish Sea on average ranged from 1474.0 to 1491.0 m/s. In the western extent of the Salish Sea, from Swiftsure Bank into the Strait of Juan de Fuca, the temperature is low and the salinity is high, resulting in lower sound speeds in the sub region. The eastern extent of the Salish Sea from Haro Strait to the Strait of Georgia, the temperature and salinity are higher and lower, respectively, resulting in a faster sound speed . As previously stated, these overarching trends are related to the estuarine flow regime of the Salish Sea. Pacific Ocean near-bottom water transports cold and saline conditions, which are then mixed with warmer and fresher water from the upper water column, all resulting in these variations of the sound speed scape.

5.4 Sound Speed Scape Anomalies in 2023-2024 and late 2025

In the Salish Sea, elevated sound speeds were observed in 2023-2024. In late 2023, near-bottom water temperatures increased at all mooring locations and remained elevated into spring/summer 2024. This period of warming was associated with the onset of El Niño conditions along the coast of British Columbia and the Salish Sea (Boldt et al. 2024). The result was elevated bottom sound speed from Swiftsure Bank and into the Strait of Georgia. Another marine heatwave was observed in the northeast Pacific Ocean beginning in May 2025 (Leising et al. 2026). Coastal sea surface temperatures were anomalously warm in the winter 2025, and were comparable to the strong marine heatwave of 2014-2015 (Leising et al. 2026). Similar to 2023-2024, the near-bottom sound speed fields across all mooring locations were elevated compared to previous years. As extreme sea surface warming events become more frequent, it is likely that the sound speed characteristics of the Salish Sea will influence the overall sound-scape.

5.5 Summary

In the near-bottom waters of the Salish Sea, the sound speed scape varied throughout the three primary basins. Sound speeds were higher at Swiftsure Bank due to warmer conditions, and as waters were transported eastward by estuarine flow, sound speeds were lowered in the Strait of Juan de Fuca. In the Haro Strait, Boundary Pass, and Swanson Channel, the near-bottom water moved over the Victoria Sill, resulting in mixing of warmer, fresher waters from higher in the water column, and therefore, faster sound speeds. Continuing to the Strait of Georgia, further mixing of warmer and fresher water over the Boundary Pass Sill resulted in a further increase in sound speeds in the near-bottom waters. Warming events were observed in 2023 through 2024, and in late 2025, resulting in a faster sound speed scape broadly throughout the Salish Sea.

6. ACKNOWLEDGMENTS

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8. APPENDIX

Table A1: Swiftsure Bank mean and standard deviations (SD) of sound speeds (m/s), and monthly average sound speed (m/s) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020											1479.4	0.8	1478	1	1478	1	1479	2	1481	1	1481.6	0.9	1482	1
2021	1483	2	1482	1	1479.8	0.5	1478	1	1478	1	1478.7	0.9	1478.3	0.7	1478.2	0.7	1480.3	1.6	1483	3	1486	2	1485	2
2022	1482	2	1480.9	0.9	1479.3	0.4	1479.1	0.6	1479.3	0.6	1478.9	0.8	1478.3	0.8	1478.7	0.7	1479.2	0.5	1481	1	1483.4	0.8	1483	1
2023	1484	2	1481	1	1478.2	0.8	1479.8	0.8	1480.2	0.8	1479	1	1479.7	0.9	1480.7	0.9	1482	2	1486	2	1486.0	0.9	1487	2
2024	1485	2	1486	3	1484	1	1481	1	1479	1	1478	1	1477.4	0.9	1479	1	1479.3	0.7	1481	2	1485	2	1486	2
2025	1484	2	1480	1	1480	2	1480	2	1479	1	1478	1	1478	1	1479	1	1480	1	1484	2	1487	1	1487	2
Average	1484		1482		1480		1480		1479.0		1478.6		1478.3		1479		1480		1483		1485		1485	
SD	1		2		2		1		0.9		0.7		0.7		1		1		2		2		2	

Table A2: Swiftsure Bank mean and standard deviations (SD) of temperature (°C), and monthly average temperature (°C) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020											7.3	0.4	7.0	0.4	7.0	0.4	7.4	0.5	7.9	0.4	8.1	0.5	8.3	0.4
2021	9.0	0.5	8.4	0.4	7.8	0.3	7.2	0.3	7.0	0.4	7.1	0.4	7.1	0.3	7.2	0.3	7.6	0.5	8.5	0.9	9.7	0.6	9.2	0.8
2022	8.6	0.5	7.9	0.4	7.6	0.1	7.4	0.3	7.4	0.3	7.3	0.4	7.1	0.3	7.2	0.3	7.4	0.2	7.9	0.4	8.6	0.3	8.6	0.4
2023	9.1	0.6	8.2	0.4	7.5	0.1	7.9	0.2	7.8	0.3	7.3	0.3	7.4	0.3	7.7	0.3	8.2	0.6	9.3	0.6	9.4	0.4	9.8	0.5
2024	9.3	0.4	9.7	0.7	9.2	0.3	8.1	0.6	7.3	0.5	7.0	0.5	6.9	0.3	7.2	0.4	7.4	0.3	7.8	0.6	9.2	0.9	9.6	0.6
2025	9.1	0.7	7.8	0.3	8.1	0.6	7.9	0.6	7.1	0.4	6.9	0.4	7.0	0.4	7.4	0.3	7.6	0.3	8.7	0.7	9.6	0.5	9.8	0.7
Average	9.0		8.4		8.0		7.7		7.3		7.2		7.1		7.3		7.6		8.3		9.1		9.2	
SD	0.3		0.8		0.7		0.4		0.3		0.2		0.2		0.2		0.3		0.6		0.6		0.6	

Table A3: Swiftsure Bank mean and standard deviations (SD) of salinity (PSU), and monthly average salinities (PSU) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020											33.6	0.1	33.7	0.1	33.7	0.1	33.6	0.2	33.4	0.2	32.9	0.5	32.6	0.3
2021	31.9	0.3	32.3	0.4	32.6	0.5	33.4	0.2	33.5	0.2	33.7	0.1	33.7	0.1	33.3	0.3	33.4	0.2	33.2	0.5	31.9	0.2	32.1	0.4
2022	32.0	0.5	33.1	0.4	32.7	0.3	33.2	0.4	33.2	0.3	33.4	0.2	33.7	0.1	33.6	0.1	33.4	0.1	33.6	0.2	32.9	0.3	32.2	0.3
2023	31.9	0.2	32.3	0.4	32.3	0.3	32.2	0.3	33.1	0.4	33.6	0.2	33.8	0.1	33.6	0.1	33.1	0.3	33.0	0.3	32.6	0.3	32.3	0.2
2024	32.0	0.2	31.7	0.2	31.9	0.2	32.9	0.4	33.4	0.2	33.5	0.2	33.7	0.1	33.7	0.1	33.7	0.1	33.5	0.3	32.6	0.5	32.1	0.2
2025	32.3	0.4	32.5	0.3	32.2	0.3	32.6	0.7	33.5	0.1	33.7	0.1	33.8	0.1	33.7	0.1	33.7	0.1	33.3	0.3	32.6	0.2	32.3	0.3
Average	32.0		32.4		32.3		32.8		33.4		33.6		33.7		33.6		33.5		33.3		32.6		32.3	
SD	0.2		0.5		0.3		0.4		0.2		0.1		0.0		0.1		0.2		0.2		0.3		0.2	

Table A4: Port Renfrew mean and standard deviations (SD) of sound speed (m/s), and monthly average sound speeds (m/s) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020											1479.1	0.4	1478.1	0.3	1478.3	0.4	1479.5	0.8	1481.0	0.4	1481.4	0.6	1482.4	0.3
2021	1482.8	0.7	1482.4	0.6	1481.0	0.5	1478.6	0.4	1478.1	0.6	1478.5	0.4	1479.0	0.2	1479.4	0.4	1480.5	0.3	1481.8	0.7	1482.9	0.6	1481.9	0.4
2022	1482.5	0.7	1480.8	0.8	1480.5	0.4	1479.6	0.6	1479.4	0.8	ND	ND	1478.8	0.3	1479.6	0.4	1480.5	0.4	1481.8	0.5	1482.9	0.2	1483.1	0.2
2023	1481.4	0.8	ND	ND	1480.8	0.3	1481.3	0.5	1480.1	0.4	1479.2	0.2	1480.0	0.2	1480.8	0.3	1482.0	0.4	1483.1	0.3	1483.9	0.4	1485.5	0.5
2024	1485	1	1484.6	0.6	1484	1	1480	1	1479	1	1477.6	0.4	1477.8	0.3	1478.9	0.5	1479.8	0.3	1480.7	0.6	1482.7	0.9	1483.2	0.5
2025	1481	2	1480.3	0.3	1481.3	0.2	1480	2	1478.0	0.4	1477.7	0.5	1478.5	0.3	1479.6	0.3	1480.6	0.4	1482.3	0.7	1484.2	0.5	1485.0	0.3
Average	1483		1482		1481		1480		1478.8		1478.4		1478.7		1479.4		1480.5		1481.8		1483		1484	
SD	2		2		1		1		0.9		0.7		0.8		0.8		0.9		0.9		1		1	

Table A5: Port Renfrew mean and standard deviations (SD) of temperature (ºC), and monthly average temperatures (ºC) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020											6.79	0.09	6.5	0.1	6.60	0.09	6.9	0.2	7.3	0.1	7.4	0.2	7.7	0.1
2021	7.9	0.2	7.7	0.2	7.3	0.2	6.7	0.1	6.6	0.2	6.6	0.1	6.75	0.06	6.9	0.1	7.16	0.09	7.5	0.3	7.9	0.3	7.6	0.2
2022	7.9	0.2	7.3	0.2	7.2	0.1	6.9	0.2	6.9	0.2	6.6	0.1	6.71	0.07	6.9	0.1	7.2	0.1	7.5	0.1	7.85	0.07	8.1	0.1
2023	8.0	0.1			7.31	0.06	7.4	0.2	7.1	0.1	6.86	0.06	7.04	0.05	7.23	0.08	7.6	0.1	7.9	0.2	8.1	0.2	8.7	0.2
2024	8.7	0.3	8.5	0.1	8.2	0.4	7.0	0.3	6.7	0.3	6.4	0.1	6.46	0.08	6.7	0.1	6.98	0.08	7.2	0.2	7.9	0.4	8.1	0.3
2025	7.5	0.7	7.2	0.1	7.47	0.08	7.1	0.5	6.5	0.1	6.4	0.1	6.64	0.09	6.93	0.10	7.2	0.1	7.7	0.2	8.2	0.2	8.5	0.2
Average	8.0		7.7		7.5		7.0		6.7		6.6		6.7		6.9		7.2		7.5		7.9		8.1	
SD	0.4		0.6		0.4		0.3		0.2		0.2		0.2		0.2		0.2		0.2		0.3		0.4	

Table A6: Port Renfrew mean and standard deviations (SD) of salinity (PSU), and monthly average salinities (PSU) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020	32.9	0.5	33.4	0.4	33.73	0.04	33.64	0.03	ND	ND	33.87	0.01	33.90	0.02	33.89	0.02	33.86	0.04	33.82	0.05	33.7	0.2	33.7	0.2
2021	33.4	0.4	33.6	0.2	33.8	0.1	33.90	0.02	33.85	0.07	33.91	0.02	33.90	0.03	33.89	0.04	33.88	0.03	33.8	0.2	33.6	0.2	33.6	0.2
2022	33.3	0.3	33.7	0.1	33.7	0.1	33.87	0.05	33.83	0.04	ND	ND	33.90	0.02	33.89	0.02	33.84	0.03	33.76	0.06	33.73	0.05	33.2	0.5
2023	32.0	0.5	ND	ND	33.7	0.1	33.7	0.2	33.80	0.06	33.73	0.06	33.88	0.08	33.88	0.01	33.83	0.05	33.74	0.05	33.65	0.07	33.2	0.3
2024	33.1	0.5	33.1	0.4	33.5	0.3	33.87	0.03	33.89	0.04	33.89	0.02	33.90	0.02	33.89	0.02	33.87	0.02	33.8	0.1	33.5	0.3	33.1	0.5
2025	33.6	0.3	33.6	0.2	33.6	0.1	33.8	0.2	33.90	0.02	33.93	0.02	33.91	0.02	33.88	0.02	33.85	0.03	33.75	0.06	33.7	0.1	33.6	0.1
Average	33.2		33.5		33.7		33.8		33.84		33.87		33.89		33.87		33.85		33.78		33.65		33.4	
SD	0.2		0.2		0.1		0.1		0.05		0.07		0.03		0.04		0.03		0.03		0.09		0.2	

Table A7: Jordan River mean and standard deviations (SD) of sound speed (m/s), and monthly average sound speeds (m/s) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									1481.0	0.6	1479.2	0.9	1477.9	0.6	1477.9	0.5	1479	1	1481.0	0.7	1481.3	0.7	1481.6	0.2
2021	1482	1	1481.5	0.5	1480.5	0.4	1478.8	0.7	1478.2	0.8	1477.9	0.8	1478.6	0.6	1479.1	0.5	1480.2	0.7	1482	2	1484	1	1481.8	0.5
2022	1481	1	1480.7	0.7	1479.8	0.3	1479.5	0.4	1479.2	0.6	1477.7	0.5	1478.5	0.4	1479.1	0.4	1480.0	0.4	1481.3	0.6	1482.8	0.5	1481.8	0.9
2023	1481	1	1481.1	0.7	1479.4	0.6	1480.3	0.4	1479.9	0.6	1478.4	0.6	1479.7	0.5	1480.5	0.5	1482	1	1484	1	1484.7	0.9	1484.8	0.3
2024	1484	1	1483.0	0.8	1483.0	0.6	1480	1	1478	1	1477.6	0.8	1477.5	0.5	1478.5	0.7	1479.5	0.4	1481	1	1483	1	1482.7	0.3
2025	1482	2	1479.5	0.6	1479.8	0.4	1480	1	1477.3	0.4	1477.0	1.0	1478.2	0.8	1479.4	0.6	1480.4	0.7	1482	1	1484.7	0.7	1484.9	0.3
Average	1482		1481		1481		1479.8		1479		1478.0		1478.4		1479.1		1480		1482		1483		1483	
SD	1		1		1		0.7		1		0.8		0.7		0.9		1		1		1		2	

Table A8: Jordan River mean and standard deviations (SD) of temperature (^oC), and monthly average temperatures (^oC) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									7.6	0.3	7.2	0.3	6.8	0.2	6.8	0.2	7.1	0.4	7.6	0.3	7.8	0.4	7.9	0.2
2021	8.15	0.09	7.9	0.2	7.6	0.1	7.0	0.2	6.9	0.3	6.9	0.2	6.9	0.2	7.0	0.2	7.3	0.3	8.0	0.6	8.6	0.5	8.1	0.2
2022	7.9	0.1	7.5	0.2	7.4	0.1	7.2	0.2	7.2	0.2	6.9	0.2	6.9	0.1	7.0	0.2	7.3	0.2	7.7	0.2	8.2	0.2	8.1	0.1
2023	8.1	0.2	7.7	0.3	7.35	0.05	7.6	0.1	7.4	0.2	7.1	0.2	7.2	0.2	7.5	0.2	7.9	0.4	8.5	0.5	8.7	0.4	8.9	0.2
2024	8.8	0.3	8.57	0.06	8.5	0.2	7.5	0.4	7.0	0.3	6.7	0.3	6.7	0.2	7.0	0.3	7.2	0.2	7.6	0.4	8.4	0.5	8.5	0.3
2025	8.0	0.6	7.4	0.1	7.6	0.1	7.4	0.4	6.7	0.2	6.7	0.3	6.8	0.2	7.2	0.3	7.4	0.3	8.1	0.5	8.8	0.4	8.9	0.3
Average	8.2		7.8		7.7		7.4		7.1		6.9		6.9		7.1		7.4		7.9		8.4		8.4	
SD	0.4		0.5		0.5		0.2		0.3		0.2		0.2		0.2		0.3		0.4		0.4		0.4	

Table A9: Jordan River mean and standard deviations (SD) of salinity (PSU), and monthly average salinities (PSU) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									33.3	0.3	33.4	0.3	33.6	0.2	33.7	0.1	33.60	0.17	33.6	0.2	33.3	0.5	33.1	0.5
2021	32.4	0.8	33.0	0.6	33.2	0.4	33.7	0.2	33.6	0.2	33.4	0.4	33.7	0.2	33.8	0.1	33.74	0.16	33.4	0.5	32.7	0.6	32.8	0.6
2022	32.6	0.8	33.5	0.2	33.3	0.5	33.5	0.3	33.4	0.3	33.1	0.2	33.8	0.1	33.79	0.08	33.78	0.08	33.7	0.1	33.3	0.3	32.7	0.5
2023	31.9	0.6	33.2	0.5	33.1	0.4	32.9	0.6	33.4	0.2	33.1	0.3	33.8	0.2	33.78	0.08	33.68	0.21	33.4	0.2	33.2	0.3	32.5	0.4
2024	32.3	0.7	32.3	0.6	32.6	0.6	33.6	0.2	33.5	0.2	33.5	0.2	33.8	0.1	33.7	0.1	33.78	0.06	33.6	0.2	32.9	0.6	32.5	0.8
2025	33.1	0.7	32.9	0.4	32.7	0.4	33.3	0.5	33.5	0.3	33.4	0.4	33.7	0.2	33.8	0.1	33.74	0.11	33.5	0.2	33.1	0.3	32.7	0.5
Average	32.4		32.9		33.1		33.4		33.5		33.4		33.71		33.75		33.71		33.5		33.1		32.7	
SD	0.4		0.4		0.3		0.3		0.1		0.2		0.09		0.05		0.08		0.1		0.2		0.2	

Table A10: Sooke mean and standard deviations (SD) of sound speed (m/s), and monthly average sound speeds(m/s) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									1481.5	0.2	1480.1	0.5	1478.9	0.5	1478.9	0.5	1479.8	0.9	1481.5	0.5	1481.8	0.6	1482.4	0.2
2021	1482.9	1.0	1482.8	0.4	1481.7	0.4	1479.7	0.6	1478.9	0.5	1479.0	0.6	1479.3	0.4	1479.7	0.4	1480.6	0.5	1482	1	1483.9	0.9	1482.3	0.3
2022	1482.4	1.0	1481.8	0.7	1480.8	0.2	1480.4	0.3	1480.0	0.5	1478.8	0.6	1479.3	0.3	1479.7	0.9	1480.7	0.4	1482.0	0.4	1483.4	0.3	1482.8	0.9
2023	1482	2	1482.0	0.7	1480.7	0.3	1481.3	0.4	1481.0	0.4	1480.1	0.3	1480.5	0.3	1481.2	0.3	1482.5	1.0	1483.7	0.6	1484.7	0.5	1485.7	0.3
2024	1485	1	1484.6	0.7	1484.2	0.8	1481	1	1479.4	0.8	1478.3	0.6	1478.2	0.4	1479.1	0.5	1480.0	0.4	1481.0	0.6	1483	1	1483.4	0.3
2025	1483	2	1480.6	0.3	1481.2	0.4	1481	1	1478.5	0.4	1478.3	0.5	1478.8	0.5	1480.0	0.4	1480.8	0.5	1482.6	0.9	1484.9	0.6	1485.6	0.2
Average	1483		1482		1482		1481		1480		1479.2		1479.2		1479.8		1481		1482.2		1484		1484	
SD	1		1		2		1		1		0.8		0.7		0.7		1		0.9		1		2	

Table A11: Sooke mean and standard deviations (SD) of temperature (ºC), and monthly average temperatures (ºC) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									7.5	0.1	7.1	0.2	6.8	0.2	6.8	0.2	7.1	0.3	7.5	0.2	7.7	0.3	7.9	0.1
2021	8.2	0.1	7.9	0.2	7.6	0.1	7.0	0.2	6.8	0.2	6.8	0.2	6.9	0.1	7.0	0.1	7.2	0.2	7.8	0.4	8.3	0.4	7.9	0.2
2022	8.0	0.1	7.6	0.2	7.4	0.1	7.2	0.1	7.1	0.2	6.9	0.2	6.9	0.1	7.0	0.2	7.3	0.1	7.6	0.2	8.1	0.2	8.1	0.1
2023	8.1	0.3	7.7	0.2	7.37	0.06	7.6	0.1	7.4	0.2	7.1	0.1	7.2	0.2	7.4	0.2	7.8	0.3	8.2	0.4	8.5	0.3	8.9	0.2
2024	8.8	0.3	8.6	0.1	8.4	0.3	7.4	0.3	7.0	0.3	6.7	0.2	6.7	0.2	6.9	0.2	7.1	0.2	7.4	0.3	8.1	0.5	8.3	0.3
2025	8.0	0.6	7.4	0.1	7.6	0.1	7.4	0.4	6.7	0.2	6.7	0.2	6.8	0.2	7.1	0.2	7.3	0.2	7.9	0.3	8.5	0.3	8.8	0.2
Average	8.2		7.8		7.7		7.4		7.1		6.9		6.9		7.1		7.3		7.7		8.2		8.3	
SD	0.4		0.5		0.4		0.4		0.3		0.2		0.2		0.2		0.2		0.3		0.3		0.4	

Table A12: Sooke mean and standard deviations (SD) of salinity (PSU), and monthly average salinities (PSU) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									33.6	0.1	33.7	0.1	33.8	0.1	33.80	0.07	33.8	0.1	33.7	0.1	33.5	0.4	33.3	0.4
2021	32.8	0.7	33.3	0.4	33.6	0.3	33.84	0.07	33.8	0.1	33.8	0.2	33.8	0.1	33.8	0.1	33.80	0.05	33.6	0.4	33.1	0.5	33.2	0.4
2022	33.0	0.6	33.7	0.1	33.5	0.3	33.7	0.2	33.7	0.3	33.5	0.4	33.81	0.08	33.7	0.4	33.84	0.04	33.76	0.08	33.5	0.2	32.9	0.6
2023	32.1	0.6	33.5	0.3	33.4	0.3	33.2	0.4	33.7	0.1	33.85	0.08	33.86	0.06	33.84	0.03	33.8	0.2	33.6	0.1	33.4	0.2	32.9	0.4
2024	32.7	0.7	32.8	0.4	33.1	0.5	33.7	0.1	33.81	0.07	33.7	0.2	33.8	0.2	33.80	0.09	33.71	0.08	33.75	0.09	33.3	0.4	32.8	0.7
2025	33.3	0.5	33.4	0.3	33.3	0.3	33.6	0.3	33.8	0.1	33.8	0.1	33.82	0.07	33.84	0.04	33.81	0.05	33.7	0.1	33.4	0.2	33.2	0.3
Average	32.8		33.3		33.4		33.6		33.76		33.8		33.80		33.78		33.79		33.68		33.4		33.1	
SD	0.4		0.3		0.2		0.2		0.08		0.1		0.05		0.09		0.05		0.07		0.1		0.2	

Table A13: Haro Strait mean and standard deviations (SD) of sound speed (m/s), and monthly average sound speeds (m/s) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020	1483.3	0.8	1482.6	0.6	1482.5	0.4	1482.9	0.6	1483.6	0.2	ND	ND	1484.4	0.6	1485	1	1485	1	1486	1	1484.7	0.4	1483.4	0.5
2021	1481.9	0.6	1481.2	0.6	1480.8	0.4	1481.8	0.4	1482.8	0.5	1484.0	0.8	1484.8	0.7	1486	1	1486.2	0.9	1487.1	0.8	1487.0	0.9	1483	1
2022	1480	1	1481.0	0.6	1480.6	0.4	1481.6	0.3	1483.1	0.7	1483.6	0.9	1484.0	0.8	1485	1	1485.5	1.0	1486.2	0.7	1485.8	1.0	1482	1
2023	1480.0	0.4	1480.4	0.6	1479.5	0.5	1481.4	0.5	1484.0	0.8	1484.5	0.7	1486.4	0.8	1487.5	1.0	1488.2	0.9	1490	1	1488.5	0.7	1486.3	0.4
2024	1484	1	1483.0	0.5	ND	ND	ND	ND	ND	ND	ND	ND	1485	1	1486	1	1485.8	0.6	1486.8	0.7	1486.6	0.4	1484.8	0.8
2025	1483.0	0.6	1480.1	0.6	1480.8	0.3	1482.8	0.6	1483.3	0.7	1484	1	1485	1	1487	1	1487	1	1488	1	1488.7	0.5	1486.7	0.5
Average	1482		1481		1481		1482		1483.6		1484.3		1485.1		1486		1487		1487		1487		1484	
SD	2		1		1		1		0.8		0.8		0.9		1		1		1		2		2	

Table A14: Haro Strait mean and standard deviations (SD) of temperature (°C), and monthly average temperatures (°C) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020	8.2	0.2	8.05	0.08	7.75	0.10	8.0	0.1	8.3	0.1	ND	ND	8.4	0.2	8.4	0.4	8.6	0.5	9.0	0.4	8.6	0.1	8.4	0.1
2021	8.27	0.04	7.9	0.2	7.75	0.06	7.8	0.2	8.1	0.2	8.4	0.3	8.6	0.3	8.7	0.4	8.8	0.3	9.2	0.3	9.5	0.3	8.6	0.3
2022	7.7	0.1	7.74	0.08	7.62	0.09	7.8	0.1	8.3	0.3	8.3	0.4	8.3	0.3	8.5	0.4	8.7	0.3	9.0	0.3	8.9	0.2	8.1	0.2
2023	7.87	0.05	7.9	0.2	7.46	0.07	8.0	0.2	8.5	0.3	8.6	0.2	9.0	0.3	9.3	0.4	9.5	0.3	10.0	0.4	9.6	0.3	9.23	0.09
2024	8.8	0.3	8.59	0.05	ND	ND	ND	ND	ND	ND	ND	ND	8.5	0.5	8.8	0.4	8.9	0.4	8.9	0.3	9.2	0.1	8.9	0.2
2025	8.6		7.6	0.2	7.8	0.1	8.3	0.1	8.1	0.3	8.2	0.3	8.6	0.4	9.0	0.4	9.1	0.4	9.4	0.4	9.7	0.2	9.43	0.08
Average	8.2		8.0		7.8		8.1		8.3		8.5		8.6		8.8		9.0		9.2		9.3		8.8	
SD	0.4		0.3		0.2		0.4		0.2		0.2		0.2		0.3		0.4		0.4		0.4		0.5	

Table A15: Haro Strait mean and standard deviations (SD) of salinity (PSU), and monthly average salinities (PSU) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020	32.0	0.3	32.0	0.6	32.9	0.3	32.4	0.2	32.1	0.1	ND	ND	32.5	0.2	32.5	0.4	32.4	0.4	32.0	0.5	31.9	0.4	31.6	0.2
2021	30.9	0.5	31.3	0.5	31.5	0.3	32.3	0.4	32.2	0.3	32.2	0.3	32.2	0.5	32.5	0.3	32.6	0.3	32.1	0.2	31.3	0.3	30.8	0.4
2022	30.7	0.5	31.8	0.5	31.7	0.5	31.9	0.3	31.8	0.4	31.9	0.5	32.4	0.3	32.5	0.3	32.4	0.2	32.5	0.3	31.9	0.2	31.5	0.2
2023	30.4	0.4	30.9	0.3	31.4	0.3	31.3	0.4	32.0	0.4	32.0	0.3	32.5	0.4	32.4	0.4	32.2	0.2	32.0	0.2	31.9	0.3	31.4	0.4
2024	31.1	0.2	30.7	0.4	ND	ND	ND	ND	ND	ND	ND	ND	32.5	0.3	32.6	0.2	32.3	0.5	32.4	0.3	31.8	0.3	31.1	0.3
2025	30.9	0.7	31.2	0.2	31.0	0.5	31.6	0.7	32.4	0.3	32.3	0.2	32.5	0.4	32.6	0.2	32.6	0.2	32.4	0.3	31.8	0.2	31.2	0.5
Average	31.0		31.3		31.7		31.8		32.1		32.2		32.4		32.5		32.4		32.2		31.8		31.3	
SD	0.6		0.5		0.6		0.4		0.2		0.2		0.1		0.1		0.2		0.2		0.3		0.3	

Table A16: Boundary Pass mean and standard deviations (SD) of sound speed (m/s), and monthly average sound speeds (m/s) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									1484.7	0.5	1484.9	0.5	1483.9	0.9	1484	1	1484	1	1485.9	0.9	1483.9	0.4	1482.4	0.6
2021	1480.7	0.4	1479.9	0.6	1479.4	0.6	1480.7	0.4	1482.2	0.5	1484	1	1485	1	1485	1	1485.4	0.7	1486.2	0.7	1485.9	0.8	1482	1
2022	1478.3	0.8	1479.5	0.7	1479.2	0.4	1480.4	0.4	1482.1	0.6	1482.6	0.7	1483.6	0.9	1485	1	1485.5	0.8	1485.9	0.6	1485	1	1481	1
2023	1478.9	0.2	1479.3	0.5	1478.5	0.4	1480.1	0.5	1483.1	0.9	1484.6	0.6	1486.3	0.8	1487	1	1488.0	0.8	1489	1	1487.6	0.6	1485.2	0.5
2024	1483	1	1481.4	0.5	1481.7	0.7	1482.8	0.2	1483.4	0.4	1483.5	0.8	1485	2	1486.3	0.9	1486.3	0.2	1486.2	0.6	1485.8	0.4	1483.7	0.8
2025	1482.0	0.6	1479.4	0.6	1479.4	0.3	1481.6	0.8	1482.7	0.7	1484	1	1485	1	1486.5	0.7	1487	1	1488	2	1487.5	0.5	1485.2	0.8
Average	1481		1479.9		1480		1481		1483		1483.8		1485		1486		1486		1487		1486		1483	
SD	2		0.9		1		1		1		0.8		1		1		1		1		1		2	

Table A17: Boundary Pass mean and standard deviations (SD) of temperature (ºC), and monthly average temperatures (ºC) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									9.0	0.2	9.0	0.3	8.8	0.4	8.8	0.4	8.8	0.4	9.2	0.4	8.8	0.1	8.5	0.2
2021	8.31	0.05	7.9	0.2	7.73	0.07	7.8	0.2	8.3	0.3	8.7	0.4	9.0	0.4	9.1	0.4	9.1	0.3	9.3	0.3	9.6	0.2	8.7	0.3
2022	7.7	0.1	7.72	0.06	7.6	0.1	7.9	0.1	8.4	0.3	8.6	0.4	8.6	0.4	8.8	0.4	9.0	0.3	9.2	0.3	9.0	0.3	8.2	0.3
2023	7.86	0.05	7.8	0.1	7.46	0.08	7.9	0.2	8.6	0.3	8.9	0.3	9.4	0.4	9.7	0.4	9.8	0.3	10.2	0.3	9.8	0.2	9.3	0.1
2024	8.8	0.3	8.51	0.04	8.5	0.1	8.5	0.2	8.6	0.2	8.7	0.3	9.0	0.5	9.2	0.4	9.2	0.4	9.2	0.3	9.3	0.1	9.0	0.2
2025	8.6	0.3	7.7	0.2	7.9	0.1	8.4	0.1	8.4	0.3	8.6	0.4	9.1	0.5	9.4	0.3	9.5	0.4	9.7	0.6	9.8	0.1	9.45	0.06
Average	8.2		7.9		7.9		8.2		8.6		8.8		9.0		9.2		9.3		9.5		9.4		8.8	
SD	0.5		0.3		0.4		0.4		0.3		0.2		0.3		0.3		0.4		0.4		0.4		0.5	

Table A18: Boundary Pass mean and standard deviations (SD) of salinity (PSU), and monthly average salinities (PSU) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									31.7	0.3	31.9	0.4	31.6	0.5	31.9	0.5	32.1	0.3	31.9	0.5	31.7	0.4	31.3	0.3
2021	30.6	0.4	31.1	0.5	31.2	0.4	32.0	0.5	31.9	0.4	31.8	0.4	32.0	0.3	32.0	0.4	31.9	0.3	31.9	0.3	31.0	0.3	30.7	0.3
2022	30.5	0.4	31.4	0.5	31.4	0.4	31.6	0.3	31.4	0.5	31.2	0.6	32.0	0.5	32.2	0.4	32.3	0.3	32.0	0.5	31.7	0.3	31.2	0.3
2023	30.5	0.3	30.8	0.3	31.4	0.3	31.2	0.4	31.6	0.4	32.0	0.4	32.1	0.4	32.0	0.2	32.0	0.2	31.7	0.2	31.7	0.4	31.2	0.4
2024	30.8	0.3	30.5	0.4	30.8	0.3	31.6	0.5	31.8	0.3	31.6	0.3	32.0	0.6	32.3	0.3	32.2	0.1	32.2	0.3	31.6	0.3	30.9	0.3
2025	30.7	0.8	31.4	0.2	30.9	0.2	31.2	0.6	32.0	0.3	32.0	0.3	32.2	0.3	32.1	0.3	32.1	0.2	31.8	0.5	31.6	0.2	30.8	0.5
Average	30.6		31.0		31.1		31.5		31.7		31.7		32.0		32.1		32.1		31.9		31.5		31.0	
SD	0.1		0.4		0.3		0.3		0.2		0.3		0.2		0.2		0.1		0.2		0.3		0.3	

Table A19: Swanson Channel mean and standard deviations (SD) of sound speed (m/s), and monthly average sound speeds (m/s) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									1483.5	0.6	1484.2	0.5	1484.5	0.8	1485	1	1485	1	1485.0	0.8	1482.4	0.7	1480.4	0.7
2021	1478.6	0.4	1477.1	0.8	1476.8	0.4	1478.6	0.8	1481.2	0.6	1483	1	1485.5	0.9	1486	1	1485	2	1485.2	0.3	1484	1	1480	2
2022	1475.5	0.5	1476.3	0.4	1476.6	0.5	1478.4	0.5	1480.1	0.6	1481.6	0.6	1483.8	0.9	1485	1	1485.0	0.9	1485.0	0.7	1483	1	1478	1
2023	1476.4	0.5	1477.2	0.5	1476.3	0.4	1478.2	0.6	1482	1	1483.8	0.7	1487	1	1488.1	0.9	1488.6	0.9	1487.7	0.7	1485.7	0.9	1482.8	0.6
2024	1480	1	1479.1	0.3	1479.3	0.4	1480.6	0.2	1482.7	0.7	1483.8	0.7	1486	1	1486.5	0.9	1486	1	1485.4	0.7	1484.2	0.6	1481.8	0.5
2025	1480.0	0.6	1477.2	0.7	1477.7	0.3	1480.0	0.9	1481.6	0.5	1483	2	1486	1	1487.0	0.9	1486	1	1486.9	0.7	1485.8	0.6	1483.2	0.7
Average	1478		1477		1477		1479		1482		1483		1486		1486		1486		1486		1484		1481	
SD	2		1		1		1		1		1		1		1		1		1		1		2	

Table A20: Swanson Channel mean and standard deviations (SD) of temperature (ºC), and monthly average temperatures(ºC) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									9.4	0.3	9.5	0.3	9.7	0.5	9.8	0.6	9.8	0.6	9.8	0.4	9.1	0.2	8.6	0.2
2021	8.29	0.07	7.8	0.2	7.7	0.1	8.1	0.2	8.7	0.3	9.3	0.5	10.0	0.6	10.3	0.7	10.0	0.5	9.8	0.3	9.6	0.2	8.7	0.4
2022	7.61	0.07	7.64	0.08	7.7	0.1	8.1	0.1	8.7	0.3	9.2	0.4	9.5	0.5	9.9	0.7	10.1	0.6	9.9	0.4	9.2	0.3	8.2	0.3
2023	7.84	0.04	7.8	0.1	7.5	0.1	7.9	0.2	8.9	0.3	9.6	0.4	10.3	0.5	10.7	0.6	10.7	0.5	10.5	0.2	9.9	0.2	9.29	0.08
2024	8.7	0.3	8.45	0.04	8.4	0.1	8.8	0.1	9.1	0.4	9.4	0.4	10.0	0.7	10.2	0.5	10.3	0.6	9.8	0.4	9.5	0.2	9.0	0.2
2025	8.6	0.2	7.7	0.2	7.9	0.1	8.6	0.2	8.9	0.3	9.4	0.5	10.0	0.6	10.4	0.6	10.5	0.6	10.3	0.4	10.0	0.1	9.5	0.1
Average	8.2		7.9		7.8		8.3		9.0		9.4		9.9		10.2		10.2		10.0		9.5		8.9	
SD	0.5		0.3		0.4		0.4		0.3		0.2		0.3		0.3		0.3		0.3		0.4		0.5	

Table A21: Swanson Channel mean and standard deviations (SD) of salinity (PSU), and monthly average salinities (PSU) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020									30.8	0.2	30.9	0.3	30.7	0.4	30.8	0.4	31.0	0.3	30.8	0.4	30.9	0.3	30.7	0.2
2021	30.2	0.3	30.4	0.3	30.5	0.2	30.8	0.3	31.0	0.3	31.0	0.4	30.7	0.6	30.1	0.6	30.2	0.5	31.1	0.2	30.4	0.4	29.9	0.2
2022	29.9	0.3	30.4	0.3	30.5	0.2	30.7	0.3	30.3	0.4	29.8	0.4	30.8	0.5	30.6	0.5	30.0	0.4	30.5	0.9	31.0	0.3	30.0	0.3
2023	29.9	0.3	30.7	0.2	30.9	0.2	30.9	0.2	30.8	0.3	30.4	0.4	31.0	0.4	30.9	0.3	31.1	0.3	31.0	0.4	31.1	0.3	30.6	0.2
2024	30.5	0.2	30.2	0.2	30.3	0.2	30.4	0.3	30.8	0.3	30.9	0.4	31.3	0.4	30.9	0.5	30.4	0.5	31.1	0.6	31.1	0.2	30.6	0.2
2025	30.4	0.4	30.9	0.2	30.6	0.1	30.4	0.3	30.6	0.6	30.6	0.9	31.1	0.4	30.7	0.3	29.6	0.6	30.9	0.7	31.0	0.2	30.4	0.3
Average	30.2		30.5		30.6		30.6		30.7		30.6		30.9		30.7		30.4		30.9		30.9		30.4	
SD	0.3		0.3		0.2		0.2		0.2		0.5		0.2		0.3		0.6		0.2		0.3		0.3	

Table A22: SOG Southeast mean and standard deviations (SD) of sound speed (m/s), and average monthly sound speeds (m/s) from 2023-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2023													1487	1	1489.3	0.5	1489.5	0.7	1489.0	0.3	1487.0	0.7	1484.6	0.7
2024	1482	2	1480.6	0.7	1480.3	0.4	1481.9	0.3	1483.4	0.8	1484.7	0.4	1487	1	1488.1	0.5	1488.1	0.6	1486.9	0.6	1485.7	0.5	1483.5	0.8
2025	1482.0	0.9	1477.9	0.7	1478.8	0.3	1480.7	0.7	1482.6	0.4	1484.6	1.0	1487	1	1488.4	0.7	1488.9	0.7	1488.5	0.4	1487.1	0.4	1485.1	0.6
Average	1481.958		1479		1480		1481.3		1483.0		1484.66		1486.9		1488.6		1488.8		1488		1486.6		1484.4	
SD	0.004		2		1		0.8		0.6		0.05		0.4		0.6		0.7		1		0.8		0.8	

Table A23: SOG Southeast mean and standard deviations (SD) of temperature (ºC), and average monthly temperatures (ºC) from 2023-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2023													10.1	0.3	10.5	0.2	10.7	0.3	10.6	0.1	10.0	0.1	9.5	0.2
2024	8.8	0.4	8.6	0.2	8.5	0.1	8.78	0.06	9.1	0.2	9.4	0.2	9.8	0.4	10.2	0.3	10.2	0.3	10.0	0.2	9.6	0.1	9.3	0.2
2025	8.9	0.3	7.8	0.2	8.0	0.1	8.5	0.1	8.9	0.1	9.3	0.2	9.9	0.4	10.4	0.3	10.5	0.3	10.34	0.2	10.07	0.08	9.6	0.1
Average	8.89		8.2		8.3		8.6		9.0		9.36		9.9		10.4		10.5		10.3		9.9		9.5	
SD	0.07		0.6		0.3		0.2		0.1		0.06		0.1		0.2		0.2		0.3		0.2		0.2	

Table A24: SOG Southeast mean and standard deviations (SD) of salinity (PSU), and average monthly salinities (PSU) from 2023-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2023													31.2	0.3	31.3	0.2	31.1	0.2	31.0	0.2	31.0	0.2	30.7	0.2
2024	30.3	0.2	30.1	0.2	30.16	0.07	30.6	0.3	30.8	0.2	30.9	0.2	31.1	0.3	31.3	0.2	31.2	0.3	31.1	0.2	31.0	0.1	30.5	0.1
2025	30.2	0.3	30.5	0.2	30.42	0.07	30.4	0.2	30.8	0.2	31.0	0.2	31.2	0.2	31.1	0.2	31.2	0.3	31.2	0.3	30.93	0.09	30.5	0.2
Average	30.22		30.29		30.29		30.48		30.80		30.93		31.16		31.21		31.18		31.10		30.96		30.57	
SD	0.05		0.23		0.18		0.11		0.06		0.04		0.05		0.12		0.06		0.08		0.03		0.08	

Table A25: SOG South mean and standard deviations (SD) of sound speed (m/s), and average monthly sound speeds (m/s) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020															1485.1	0.3	1485.9	0.4	1486.7	0.1	1486.9	0.1	1486.76	0.07
2021	1486.6	0.1	1486.2	0.2	1485.4	0.6	1484.6	0.6	1483.2	0.2	1483.6	0.2	1484.2	0.1	1485.0	0.5	1485.8	0.2	1487.3	0.2	1487.4	0.1	1487.33	0.09
2022	1487.1	0.2	1486.5	0.5	1485.3	0.8	1483.7	0.5	1483.4	0.4			1483.7	0.1	1484.4	0.4	1485.5	0.4	1486.8	0.4	1487.37	0.08	ND	ND
2023	ND	ND	ND	ND	1484.1	0.6	1481.5	0.5	1481.4	0.1	1481.9	0.3	1482.9	0.4	1484.9	0.6	1487.2	0.6	1489.0	0.2	1489.2	0.2	1488.8	0.2
2024	1488.3	0.2	1488.0	0.2	1487.7	0.4	1487.4	0.2	1486.2	0.3	1486.1	0.1	1486.4	0.2	1487.1	0.3	1488.2	0.3	1489.1	0.2	1489.11	0.09	1488.9	0.1
2025	1488.6	0.1	1487.9	0.8	1486	1	1485.2	0.4	1485.3	0.3	1485.0	0.2	1485.5	0.3	1486.5	0.4	1487.7	0.3	1488.7	0.5	1489.20	0.07	1489.03	0.06
Average	1488		1487.2		1485.7		1484.5		1483.9		1484.2		1484.5		1485.5		1486.7		1487.9		1488.2		1488.2	
SD	1		0.9		1.3		2.2		1.9		1.8		1.4		1.1		1.1		1.1		1.1		1.0	

Table A26: SOG South mean and standard deviations (SD) of temperature (ºC), and average monthly temperatures (ºC) from 2020-2025

	Jan		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020															8.97	0.06	9.17	0.08	9.35	0.04	9.41	0.05	9.39	0.03
2021	9.36	0.03	9.31	0.04	9.1	0.1	8.9	0.2	8.53	0.05	8.62	0.05	8.77	0.03	9.0	0.1	9.3	0.1	9.51	0.06	9.58	0.05	9.57	0.05
2022	9.53	0.04	9.4	0.1	9.1	0.2	8.7	0.1	8.62	0.08	8.61	0.05	8.69	0.03	8.85	0.09	9.1	0.1	9.48	0.07	9.59	0.02	9.5	0.1
2023	9.1	0.2	8.9	0.1	8.8	0.1	8.1	0.1	8.10	0.03	8.22	0.08	8.5	0.1	9.0	0.2	9.6	0.2	10.01	0.04	10.06	0.06	9.98	0.04
2024	9.88	0.02	9.82	0.07	9.7	0.1	9.64	0.09	9.35	0.09	9.32	0.03	9.38	0.04	9.54	0.07	9.79	0.08	9.98	0.05	9.99	0.03	9.94	0.02
2025	9.89	0.03	9.7	0.2	9.2	0.3	9.0	0.1	9.08	0.10	9.01	0.04	9.13	0.07	9.36	0.10	9.7	0.1	10.01	0.09	10.08	0.02	10.05	0.02
Average	9.5		9.4		9.2		8.9		8.7		8.8		8.9		9.1		9.4		9.7		9.8		9.7	
SD	0.4		0.4		0.3		0.6		0.5		0.4		0.4		0.3		0.3		0.3		0.3		0.3	

Table A27: SOG South mean and standard deviations (SD) of salinity (PSU), and average monthly salinities (PSU) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020															31.03	0.06	31.13	0.08	31.22	0.05	31.22	0.05	31.18	0.05
2021	31.11	0.07	31.04	0.07	30.96	0.09	30.91	0.07	30.91	0.04	30.96	0.03	30.98	0.03	31.03	0.05	31.06	0.04	31.23	0.04	31.20	0.07	31.15	0.06
2022	31.06	0.08	30.99	0.08	30.91	0.09	30.84	0.07	30.80	0.06			30.81	0.03	30.87	0.04	30.95	0.04	31.03	0.07	31.14	0.04	ND	ND
2023	ND	ND	ND	ND	30.95	0.04	30.81	0.05	30.79	0.02	30.80	0.04	30.85	0.03	30.96	0.04	31.12	0.04	31.25	0.03	31.24	0.02	31.19	0.05
2024	31.04	0.10	30.91	0.10	31.01	0.07	30.96	0.04	30.90	0.03	30.90	0.03	30.95	0.08	31.08	0.04	31.19	0.05	31.32	0.04	31.33	0.03	31.26	0.04
2025	31.22	0.03	31.13	0.08	31.02	0.09	30.95	0.05	30.95	0.04	30.96	0.04	31.02	0.03	31.09	0.04	31.10	0.07	31.10	0.20	31.29	0.04	31.25	0.03
Average	31.11		31.02		30.97		30.89		30.87		30.90		30.92		31.01		31.09		31.2		31.24		31.20	
SD	0.08		0.09		0.05		0.07		0.07		0.08		0.09		0.08		0.08		0.1		0.07		0.05	

Table A28: SOG North mean and standard deviations (SD) of sound speed (m/s), and average monthly sound speeds (m/s) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020															1485.5	0.8	1486.2	0.8	1486.7	0.5	1486.0	0.3	1485.4	0.8
2021	1485.2	0.5	1483	2	1481	2	1481.0	0.9	1482.3	0.4	1483.9	0.3	1484.3	0.8	1486	1	1487.7	0.8	1487.1	0.5	1486.7	0.1	1486.3	0.4
2022	1485	1	1482	2	1479	1	1481	1	1481.6	0.4			1483.8	0.7	1485	1	1486.8	0.9	1487.2	0.6	1485.7	0.8	1483	2
2023	1482	1	1482	2	1479	2	1479.8	0.7	1479.9	0.2	1482	1	1486	2	1488	2	1490	1	1489.5	0.7	1488.5	0.2	1487.4	0.8
2024	1486	2	1486	1	1485.8	0.9	1485	1	1484.3	0.8	1485.6	0.2	1486.6	0.5	1488.4	0.8	1488.9	0.5	1488.7	0.5	1487.8	0.5	1487.7	0.3
2025	1487	2	1481	2	1482	2	1483.0	0.7	1483.5	0.4	1485.1	0.8	1486.5	0.6	1488	1	1489.0	0.8	1489.3	0.5	1488.6	0.1	1488.37	0.07
Average	1485		1483		1481		1482		1482		1484		1485		1487		1488		1488		1487		1486	
SD	2		2		3		2		2		2		1		1		1		1		1		2	

Table A29: SOG North mean and standard deviations (SD) of temperature (ºC), and average monthly temperatures (ºC) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020															9.3	0.2	9.5	0.2	9.6	0.1	9.45	0.09	9.3	0.2
2021	9.3	0.1	8.9	0.5	8.4	0.5	8.3	0.2	8.6	0.1	8.9	0.1	9.0	0.2	9.5	0.3	9.9	0.2	9.7	0.1	9.62	0.07	9.6	0.1
2022	9.3	0.3	8.6	0.6	7.9	0.4	8.3	0.2	8.43	0.09	8.7	0.1	9.0	0.2	9.3	0.2	9.7	0.2	9.8	0.1	9.6	0.3	8.7	0.4
2023	8.4	0.3	8.4	0.4	7.7	0.4	8.0	0.2	8.08	0.04	8.6	0.3	9.4	0.6	10.0	0.5	10.4	0.4	10.4	0.2	10.11	0.06	9.8	0.2
2024	9.7	0.3	9.5	0.4	9.5	0.3	9.2	0.3	9.1	0.2	9.43	0.07	9.7	0.1	10.1	0.2	10.2	0.1	10.1	0.1	9.9	0.1	9.9	0.1
2025	9.7	0.4	8.5	0.6	8.6	0.5	8.8	0.2	8.88	0.08	9.2	0.2	9.6	0.2	10.0	0.3	10.2	0.2	10.3	0.2	10.13	0.05	10.07	0.03
Average	9.3		8.8		8.4		8.5		8.6		9.0		9.3		9.7		10.0		10.0		9.8		9.6	
SD	0.5		0.4		0.7		0.5		0.4		0.4		0.3		0.4		0.3		0.3		0.3		0.5	

Table A30: SOG North mean and standard deviations (SD) of salinity (PSU), and average monthly salinities (PSU) from 2020-2025

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2020															31.0	0.1	31.1	0.1	31.15	0.05	31.09	0.07	31.0	0.2
2021	31.0	0.1	30.8	0.2	30.6	0.2	30.7	0.1	30.8	0.1	30.98	0.04	30.96	0.07	31.05	0.08	31.12	0.09	31.12	0.09	31.1	0.1	31.0	0.1
2022	30.8	0.2	30.5	0.2	30.4	0.2	30.6	0.1	30.65	0.07			30.80	0.07	30.91	0.08	31.04	0.09	31.02	0.05	31.0	0.1	30.8	0.1
2023	30.76	0.08	30.5	0.2	30.6	0.2	30.66	0.09	30.38	0.09	30.6	0.1	30.9	0.1	31.1	0.1	31.2	0.1	31.21	0.05	31.17	0.08	31.07	0.09
2024	30.8	0.2	30.7	0.2	30.8	0.1	30.7	0.1	30.7	0.1	30.85	0.07	31.0	0.1	31.11	0.07	31.20	0.05	31.23	0.06	31.2	0.1	31.2	0.1
2025	31.0	0.1	30.5	0.2	30.7	0.2	30.78	0.09	30.79	0.08	30.90	0.07	31.03	0.07	31.12	0.07	31.17	0.09	31.2	0.1	31.23	0.05	31.16	0.06
Average	30.9		30.6		30.6		30.7		30.7		30.8		30.94		31.06		31.14		31.15		31.13		31.0	
SD	0.1		0.1		0.2		0.1		0.2		0.2		0.08		0.08		0.07		0.07		0.08		0.1	