



Relationship between water mass characteristics to sound velocity profiler (SVP) from South China Sea and Indonesian Throughflow Currents in Sulawesi Sea

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ABSTRACT

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The Sulawesi Sea is the western entry point of the Indonesian throughflow, which brings water masses from the Pacific Ocean. This study aims to describe the relationship between water mass characteristics and Sound Velocity Profiler (SVP) in the Sulawesi Sea based on Marine Copernicus data from 2022 with a depth of up to 500 meters. Temperature and Salinity data were used to obtain water mass types from the Tpot-S diagram based on Emmerly's classification and Sound Velocity Profiler (SVP) based on the Medwin empirical equation. The temperature, salinity, and SVP data were visualized using ODV 5.6.2 software. The data processing results have identified several water mass characteristics that are believed to be influenced by the Eastern North Pacific Central Water (ENPCW) water mass type found at depths ranging from 130 to 318 meters, Western North Pacific Central Water (WNPCW) water mass found at depths ranging from 130 to 500 meters, Eastern South Pacific Central Water (ESPCW) water mass found at depths ranging from 92 to 453 meters, and Western South Pacific Central Water (WSPCW) water mass found at depths ranging from 130 to 500 meters. The ENPCW water mass type on average has a smaller difference in SVP values compared to the WNPCW water mass type. Meanwhile, the ESPCW water mass type on average has a greater difference in SVP values compared to the WSPCW water mass type. The results indicate a positive relationship between temperature and SVP, meaning that the higher the temperature, the higher the SVP. However, there is a negative relationship between salinity and SVP, meaning that the higher the salinity, the lower the SVP.

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Introduction

The Sulawesi Sea is the northern part of the Sulawesi island and serves as a territorial border with neighboring countries. The Sulawesi Sea is one of the main passages of the Indonesian Throughflow current (ITF), which transports water masses from the Pacific Ocean through the Mindanao Strait in the Philippine waters then flow towards the Sulawesi Sea, Makassar Strait, Flores Sea, and Banda Sea (Wyrski, 1961 ; Feng *et al.*, 2018 ; Yuliardi *et al.*, 2021). The South China Sea water mass originating from the north also influences the Sulawesi Sea mass. (Gordon *et al.*, 2012).

Water mass movement patterns contribute to the variability of oceanographic parameters such as sea

surface temperature, chlorophyll-a, and salinity (Kunarto *et al.*, 2011 ; Cao & Zhang, 2017). Sea surface temperature is one of the important oceanographic parameters in analyzing physical phenomena in the sea (Mario Putra Suhana, 2018). Therefore, data on the variability of sea surface temperature, salinity, and density are the main indicators that can be used to predict any physical phenomena occurring in the sea (Ima Nurmalia, 2020). Sea temperature is directly related to Salinity. High sea temperature indicates high Salinity because high temperatures cause seawater evaporates and leaves salt, which will dissolve back into the sea, increasing the level of salinity (Harvianto *et al.*, 2015). However, changes in seawater temperature and

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salinity can vary significantly depending on geographic location and other factors. Therefore, precise measurements and careful monitoring are necessary to understand how temperature and salinity interact in specific locations and conditions on the surface layer of the sea.

Salinity and temperature are some of the oceanographic factors that play a crucial role in both the physical in aquatic environments. (Kalangi et al. 2012). SVP is influenced by the density of seawater. The density of seawater, in turn, is determined by the temperature and salinity of seawater at various depths. To obtain the depth of the sea, pressure data is often used in a conversion process. Furthermore, pressure data can be used in calculations or mathematical models to calculate SVP, which is the sound velocity profile in seawater along a specific depth. This profile is important in various applications such as sonar, underwater data transmission, and marine environmental research. (Manik et al. 2022).

According to Urick (1983), the empirical equation for sound velocity profiler is divided into three, one of which is the Medwin empirical equation $c = 1449.2 + 4.6 \times T - 5.5 \times 10^{-2}T^2 + 2.9 \times 10^{-4}T^3 + (1.34 - 10^{-2}T) \times (S - 35) + 1.6 \times 10^{-2}z$, with the following limitations:

- $0 \leq T \leq 35^\circ\text{C}$ (in Celsius)
- $0 \leq S \leq 45\text{‰}$
- $0 \leq z \leq 1000$ meters

The TpotSalinity diagram is a diagram that shows the characteristics of currents and water masses passing through a body of water (Harvianto et al., 2015) (Table 1). The variability of the Tpot-S diagram depends on factors that influence the body of water, such as currents, water topography, temperature, salinity, local pressure acting on the water, and geographical conditions (Hautala et al., 2001). The mixed layer is a layer that has a nearly uniform temperature value and is higher than other layers (Suteja et al., 2015). Most of the mixing and circulation of water masses are influenced by ocean currents (Tanto et al., 2020).

Water mass is a relatively homogeneous body of water that can be described by its characteristics (King, 1963 in Agustinus, 2016:11). The types of ocean water masses in the Indian Ocean and Pacific Ocean are as follows (Emmery, 2003 in Indra Gunawan, 2019) are as follows:

Layer	Atlantic Ocean		Indian Ocean		Pacific Ocean	
Upper waters (0 – 500 m)	Atlantic Upper Water (ASUW) (0.0-4.0°C, 35.0‰)	Subarctic Central Water (34.0-36.7‰)	Bengal Bay Water (BBW) (25.0-29°C, 28.0-35.0‰)	Sea of Arabia Water (ASW) (24.0-30.0°C, 35.5-36.8‰)	Pacific Upper Water (PSUW) (3.0-15.0°C, 32.6-33.6‰)	Subarctic Central Water (WNPCW) (10.0-22.0°C, 34.2-35.2‰)
	Western Atlantic Central Water (WNACW) (7.0-20.0°C, 35.0-36.7‰)	North Atlantic Central Water (ENACW) (8.0-18.0°C, 35.2-36.7‰)	Indian Equatorial Water (IEW) (8.0-23.0°C, 34.6-35.0‰)	Indonesian Upper Water (IUW) (8.0-23.0°C, 34.4-35.0‰)	Eastern Pacific Central Water (ENPCW) (12.0-20.0°C, 34.2-35.0‰)	North Pacific Transition Water (ENPTW) (11.0-20.0°C, 33.8-34.3‰)
			South Central Water (SICW) (8.0-25.0°C, 34.6-35.8‰)	Indian Water (34.6-35.8‰)	Eastern Pacific Water (PEW) (7.0-23.0°C, 34.5-36.0‰)	South Pacific Central Water (WSPCW) (6.0-22.0°C, 34.5-35.8‰)
					Eastern Pacific Central Water (ESPCW) (8.0-24.0°C, 34.4-36.4‰)	South Pacific Transition Water (ESPTW) (14.0-20.0°C, 34.6-35.2‰)

This research aims to identify the relationship between the characteristics of water masses from the South China Sea Current and the Indonesian Throughflow with the use of the SVP in the Sulawesi Sea. The study utilizes temperature and salinity parameter values obtained from previous research conducted by Emmery, referring to the Tpot S diagram and SVP.

Materials and Methods

Location and time of research

The research location is around the Sulawesi Sea. This study divided the Sulawesi Sea into 6 areas to facilitate spatial analysis, namely Area section 1In with coordinates from 4.25° N to 6.08° N and 119.66° E to 122.25° E, section 1Out with coordinates from 6° N to 7.5° N and 119.17° E to 121.25°. This Area Section 1 are strategically positioned to examine the current patterns in the South China Sea (SCS).

While section 2In with coordinates from 2.08° N to 5.33° N and 124.75° E to 124.83° E, section 2out with coordinates from 2.17° N to 5.42° N and 126° E to 125.92° E, section 3In with coordinates from 1.33° N to 2° N and 119.17° E to 120.33° E, and

Table 1. Temperature-salinity characteristics of the world's water masses

section 3Out with coordinates from 0.58° N to 0.08° S and 118.17° E to 119.42°, Section 2 and 3 have been chosen to examine the influence of ME, HE and Indonesian Throughflow Current (Figure 1).

The selection of the section placement was to examine the influence of seawater circulation from the Pacific Ocean and also the relationship between the water mass and the sound velocity profiler (SVP).

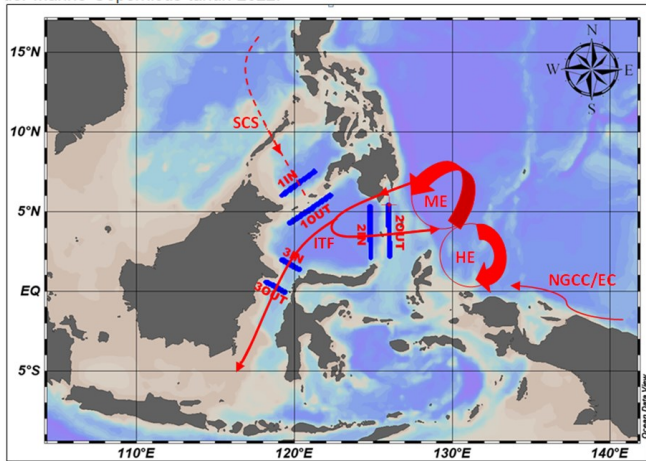


Figure 1. Research Design based on the Schematic of seawater circulation: South China Sea (SCS); Mindanao Eddy (ME); Halmahera Eddy (HE); Indonesian Throughflow (ITF); New Guinea Coastal Current (NGCC); Equatorial Current (EC).

The data used in this study are temperature and salinity data for the year 2022. The data were obtained from the Marine Copernicus website, which was downloaded directly by logging in to their official website at <https://data.marine.copernicus.eu>. The spatial resolution used for the temperature and salinity data available on Marine Copernicus is 1/12° or a horizontal grid size of approximately 9.25 km x 9.25 km. The temperature and salinity data have a temporal resolution of 1 month.

Data analysis

The temperature and salinity data analysis was conducted using Ocean Data View (ODV) software (Schlitzer, 2022), and the data were displayed in Tpot-S diagrams with SVP in the Sulawesi Sea, with a maximum depth of 500 meters. Temperature and salinity data were used to identify the characteristics of water masses in the Tpot-S diagram in the Sulawesi Sea (Harvianto et al., 2015). The parameter added to create the Tpot-S diagram is potential temperature obtained from the Derived Variables tool. The next step is to create the diagram by setting the X-variable as salinity, the Y-variable as potential temperature, and the Z-variable as SVP. Afterward,

the isopycnals function was added using the extras tool to obtain water mass values on the diagram.

The temperature and salinity data were also used to obtain sound velocity profile (SVP) values using the Medwin empirical equation (Medwin, H., 1975). Current patterns are used to identify the types of water masses transported from the Pacific Ocean to the Sulawesi Sea (M. Tomczak and J.S Godfrey, 2001; Emmerly, 2003; Arnold L. Gordon et al., 2012). Adapted from the global ocean circulation theory proposed by Tomczak and Godfrey, and the Indonesian Throughflow (ITF) circulation theory by Gordon. These theories assist in understanding and characterizing the flow of water masses and ocean circulation in this region, which can be crucial for comprehending the dynamics of the waters in the Sulawesi Sea.

In this research, a correlation analysis was conducted to determine the relationship between the variables SVP, Temperature, and Salinity using the Pearson correlation formula:

$$r = \frac{n\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{[n\Sigma X^2 - (\Sigma X)^2] [n\Sigma Y^2 - (\Sigma Y)^2]}}$$

Explanation:

r: Correlation value

n: Number of data pairs of X and Y

ΣX: Total sum of variable X

ΣY: Total sum of variable Y

(ΣX)²: Square of the total sum of variable X

(ΣY)²: Square of the total sum of variable Y

ΣXY: Sum of the product of variable X and Y

Results

The determination of the relationship between water mass characteristics and sound velocity profile (SVP) by analyzing the Tpot-S diagram with SVP is as follows:

1. The rainy season in January.

During the rainy season in January, the relationship between Temperature, Salinity and SVP is shown in Figure 2 for each area.

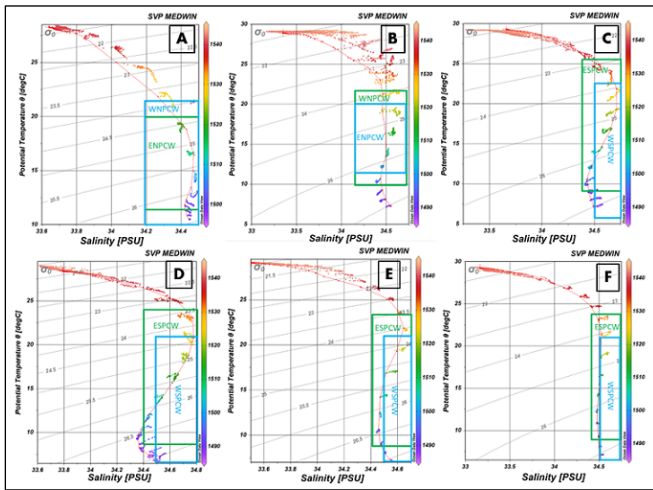


Figure 2. Display of the relationship between Temperature, Salinity and SVP during the rainy season in January in A. Area Section 1In, B. Area Section 1Out, C. Area Section 2In, D. Area Section 2Out, E. Area Section 3In, and F. Area Section 3Out.

In the area of section 1In and section 1Out, based on the temperature and salinity range parameters with respect to depth as determined by Emerry's research, it is suspected that the type of water mass is ENPCW with SVP ranging from 1496.31 to 1524.90 m/s at depths between 120 to 266 meters, and WNPCW with SVP ranging from 1487.73 to 1527.53 m/s at depths between 109 to 318 meters.

Meanwhile, in area section 2In, section 2Out, section 3In, and section 3Out, it is suspected that the water mass type is ESPCW with a SVP ranging from 1490.28 to 1534.44 m/s at depths of 109 to 380 meters. WSPCW water mass type was also found with a sound velocity ranging from 1485.95 to 1528.27 m/s at depths of 130 to 500 meters.

The results of the comparison of SVP during the rainy season in January are presented in Table 2. In the comparison of SVP during the rainy season in area section 1In and 1Out, ENPCW water mass was found with a difference value of 27.04 and 24.26.

While WNPCW water mass was found with a difference value of 37.75 and 28.25. In area section 2In, section 2Out, section 3In and section 3Out, ESPCW water mass was found with difference values of 41.62, 42.14, 40.19 and 41.1, while WSPCW water mass was found with difference values of 40.25, 41.27, 39.75 and 38.95.

Table 2. Comparison of SVP values during the rainy season in January

No	Area	SVP Value (m/s)	(Δ) SVP	Water Mass	Depth (m)
1	Section 1 In	1496.31 – 1523.35	27.04	ENPCW	130 - 266
		1489.71 – 1527.46	37.75	WNPCW	109 - 318
2	Section 1 Out	1500.64 – 1524.90	24.26	ENPCW	130 - 266
		1500.02 – 1528.38	28.25	WNPCW	109 - 318
3	Section 2 In	1492.27 – 1533.89	41.62	ESPCW	109 - 453
		1488.02 – 1528.27	40.25	WSPCW	130 - 500
4	Section 2 Out	1490.28 – 1532.42	42.14	ESPCW	109 – 380
		1485.95 – 1527.22	41.27	WSPCW	130 - 500
5	Section 3 In	1492.61 – 1532.80	40.19	ESPCW	109 - 380
		1487.81 – 1527.56	39.75	WSPCW	130 - 500
6	Section 3 Out	1493.34 – 1534.44	41.1	ESPCW	109 - 380
		1487.49 – 1526.44	38.95	WSPCW	130 - 500

2. The Transition Season from Rainy to Dry Season in April.

During the rainy-dry transition season in April, the relationship between Temperature, Salinity and SVP is shown in Figure 3 for each area.

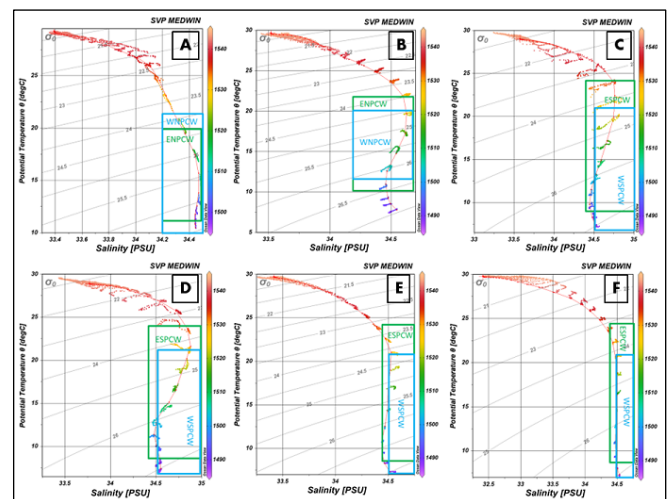


Figure 3. Display of relationship between Temperature, Salinity and SVP during the transition season from rainy to dry season in April in areas A. Section 1In, B. Section 1Out, C. Section 2In, D. Section 2Out, E. Section 3In, and F. Section 3Out.

In area section 1In and 1Out, ENPCW water mass with SVP values ranging from 1500.96 to

1523.59 m/s at depths of 130 to 266 meters and WNPCW water mass with SVP values ranging from 1495.71 to 1528.67 at depths of 109 to 500 meters were found.

Meanwhile, in area section 2In, section 2Out, section 3In, and section 3Out, ESPCW water mass with SVP values ranging from 1491.05 to 1533.91 m/s at depths of 92 to 380 meters were found. WSPCW water mass with SVP values ranging from 1486.53 to 1528.17 at depths of 109 to 500 meters was also found.

The results of the comparison of the Sound Velocity Profile (SVP) during the Rainy-Dry Transition Season in April are presented in Table 3. The comparison of SVP during the Rainy-Dry Transition Season in area section 1In and 1Out were found ENPCW water mass with a difference value of 21.85 and 20.88.

While WNPCW water mass with a difference value of 28.33 and 32.96. In section 2In, section 2Out, section 3In, and section 3Out, the ESPCW water mass was found to have difference values of 42.86, 40.02, 39.27, and 39.81, while the WSPCW water mass had difference values of 40.47, 40.86, 37.94, and 37.63.

Table 3. Comparison of SVP Values during the Rainy-Dry Transition Season in April

No	Area	SVP Value (m/s)	(Δ) SVP	Water Mass	Depth (m)
1	Section 1 In	1500.96 – 1522.81	21.85	ENPCW	130 - 266
		1499.78 – 1528.03	28.33	WNPCW	109 - 500
2	Section 1 Out	1502.71 – 1523.59	20.88	ENPCW	155 - 266
		1495.71 – 1528.67	32.96	WNPCW	130 - 318
3	Section 2 In	1491.05 – 1533.91	42.86	ESPCW	109 - 380
		1487.70 – 1528.17	40.47	WSPCW	130 - 500
4	Section 2 Out	1493.70 – 1533.72	40.02	ESPCW	109 - 380
		1486.53 – 1527.39	40.86	WSPCW	130 - 500
5	Section 3 In	1493.08 – 1532.35	39.27	ESPCW	92 - 380
		1487.78 – 1525.72	37.94	WSPCW	109 - 500
6	Section 3 Out	1493.04 – 1532.85	39.81	ESPCW	92 - 380
		1487.61 – 1525.24	37.63	WSPCW	130 - 500

3. The dry season in July.

During the dry season in July, the relationship between Temperature, Salinity and SVP is shown in Figure 4 for each area.

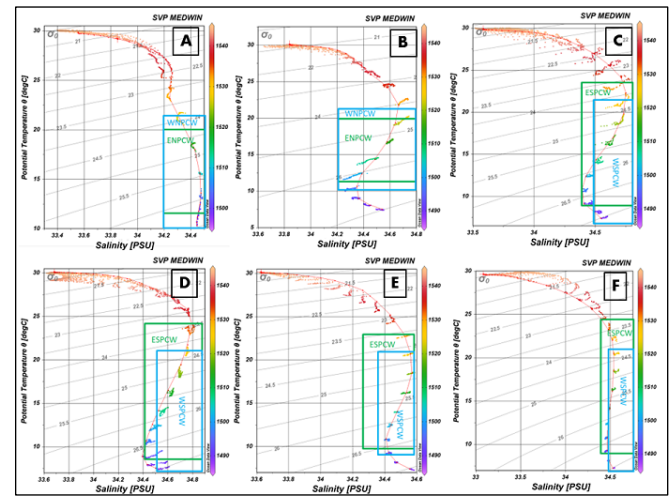


Figure 4. The Relationship between Temperature, Salinity and SVP during the dry season in July in A. Section 1In, B. Section 1Out, C. Section 2In, D. Section 2Out, E. Section 3In, and F. Section 3Out.

In area section 1In and 1Out, ENPCW water mass with SVP values ranging from 1501.05 to 1524.30 m/s at depths of 130 to 266 meters, and WNPCW water mass with SVP values ranging from 1494.44 to 1530.09 at depths of 109 to 500 meters were found

Meanwhile, in area section 2In, section 2Out, section 3In, and section 3Out, ESPCW water mass with SVP values ranging from 1491.50 to 1533.97 m/s at depths of 92 to 380 meters were found. WSPCW water mass with SVP values ranging from 1488.07 to 1528.06 at depths of 130 to 500 meters was also found.

The results of the comparison of the SVP during the Dry Season in July are presented in Table 4. The comparison of SVP during the Dry Season in area section 1In and 1Out were found ENPCW water mass with a difference value of 23.12 and 23.25.

While WNPCW water mass with a difference value of 30.79 and 34.48. In section 2In, section 2Out, section 3In, and section 3Out, the ESPCW water mass was found to have difference value of 41.72, 42.47, 40.68, and 39.67, while the WSPCW water mass had a difference value of 38.5, 39.36, 36.62, and 36.57.

Table 4. Comparison of SVP values during the Dry Season in July.

No	Area	SVP Value (m/s)	(Δ) SVP	Water Mass	Depth (m)
1	Section 1 In	1501.14 – 1524.26	23.12	ENPCW	130 - 266
		1499.30 – 1530.09	30.79	WNPCW	109 - 500
2	Section 1 Out	1501.05 – 1524.30	23.25	ENPCW	155 - 266
		1494.44 – 1528.92	34.48	WNPCW	130 - 318
3	Section 2 In	1492.11 – 1533.83	41.72	ESPCW	109 - 380
		1488.69 – 1527.19	38.5	WSPCW	130 - 500
4	Section 2 Out	1491.50 – 1533.97	42.47	ESPCW	109 - 380
		1488.70 – 1528.06	39.36	WSPCW	130 - 500
5	Section 3 In	1492.71 – 1533.39	40.68	ESPCW	92 - 380
		1488.30 – 1524.92	36.62	WSPCW	130 - 500
6	Section 3 Out	1493.22 – 1532.89	39.67	ESPCW	92 - 380
		1488.07 – 1524.64	36.57	WSPCW	130 - 500

4. The Transition from Dry to Rainy season in October

During the transitional season from dry to rainy season in October, the relationship between the characteristics of water masses and SVP is shown in Figure 5 for each area.

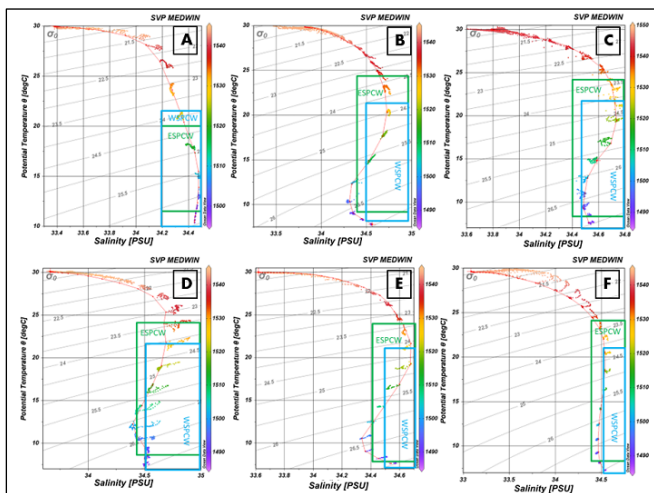


Figure 5. The relationship between Temperature, Salinity and SVP during the transition from dry to rainy season in October in A. Section 1In, B. Section 1Out, C. Section 2In, D. Section 2Out, E. Section 3In, and F. Section 3Out.

In section 1In and 1Out, ENPCW water mass with SVP values ranging from 1501.00 to 1524.11 m/s at depths of 130 to 318 meters and WNPCW water mass with SVP values ranging from 1494.97 to 1526.84 at depths of 130 to 500 meters were found.

Meanwhile, in area section 2In, section 2Out, section 3In, and section 3Out, ESPCW water mass with SVP values ranging from 1491.74 to 1534.20 m/s at depths of 92 to 453 meters were found. WSPCW water mass with SVP values ranging from 1488.07 to 1528.52 at depths of 130 to 500 meters was also found.

The results of the comparison of the SVP during the Dry-Rainy Transition season in Oktober are presented in Table 5. The comparison of SVP during the Dry-Rainy Transition season In area section 1In and 1Out were found ENPCW water mass with a difference value of 23.11 and 22.46.

While the WNPCW water mass with a difference value of 37.23 and 34.67. In section 2In, section 2Out, section 3In, and section 3Out, the ESPCW water mass was found to have difference values of 41.87, 41.6, 41.23, and 39.67, while the WSPCW water mass had differences values of 39.58, 39.08, 36.29, and 36.8.

Table 5. Comparison of SVP Values during the Transition Season from Dry to Rainy Season in October.

No	Area	SVP Value (m/s)	(Δ) SVP	Water Mass	Depth (m)
1	Section 1 In	1501.00 – 1524.11	23.11	ENPCW	130 - 266
		1499.61 – 1526.84	37.23	WNPCW	130 - 500
2	Section 1 Out	1501.41 – 1523.87	22.46	ENPCW	130 - 318
		1494.97 – 1529.64	34.67	WNPCW	155 - 266
3	Section 2 In	1491.74 – 1533.61	41.87	ESPCW	109 – 453
		1488.94 – 1528.52	39.58	WSPCW	130 - 500
4	Section 2 Out	1491.91 – 1533.51	41.6	ESPCW	109 – 453
		1488.34 – 1527.42	39.08	WSPCW	130 - 500
5	Section 3 In	1492.97 – 1534.20	41.23	ESPCW	92 - 380
		1489.60 – 1525.89	36.29	WSPCW	130 - 500
6	Section 3 Out	1493.22 – 1532.89	39.67	ESPCW	92 - 380
		1488.07 – 1524.87	36.8	WSPCW	130 - 500

The comparison of SVP values in each season is evidence that there is an influence of the South China Sea (SCS) current along with the Halmahera Eddy (HE) and Mindanao Eddy (ME) currents that bring significant changes to the oceanographic conditions in the waters of the Sulawesi Sea.

5. Analysis of SVP, Temperature, and Salinity Variables

The correlation analysis was obtained after processing the SVP, Temperature, and Salinity data as presented in Table 6. The data used for this correlation analysis comprised Section 1 and Section 2, where Section 1 represented ENPCW and WNPCW water mass, while Section 2 represented ESPCW and WSPCW water mass.

Table 6. Correlation Between SVP-Temperature and SVP-Salinity Variables in Each Season.

Season	Correlation SVP-Temperature		Correlation SVP-Salinity	
	Section 1	Section 2	Section 1	Section 2
The rainy season in january	1,0	0,9	-0,7	-0,6
The transition season from rainy to dry season in april	0,9	1,0	-0,6	-0,8
The dry season in july	0,9	1,0	-0,4	-0,7
The transition from dry to rainy season in october	0,9	1,0	-0,4	-0,7

The results indicate a positive relationship between Temperature and SVP, meaning that higher Temperature is associated with higher SVP values and Correlation value of 0.9. However, there is a negative relationship between Salinity and SVP, meaning that higher Salinity is associated with lower SVP values and Correlation value of -0.7

Discussion

This research shows that there is a relationship between water mass characteristics based on the range of temperature and salinity values and depth with SVP during the four seasons in the Sulawesi Sea. The ENPCW and WNPCW water masses are found in the 1In and 1Out areas. The ENPCW water mass was found at a depth of 130 to 318 meters with an SVP value range of 1496.31 m/s to 1524.90 m/s, while the WNPCW water mass was found at a depth of 130 to 500 meters with an SVP value range of 1487.73 m/s to 1530.09 m/s. This was influenced by the South China Sea (SCS) current (Gordon *et al.*, 2012), which brings water masses thought to be ENPCW and WNPCW from the Pacific Ocean. Where the temperature and salinity values of the water mass relative to depth correspond to the values of the reference temperature-salinity of water masses in the world conducted by Emmery's research in 2003 at a depth of 130 to 500 meters.

The ESPCW water mass was found at a depth of 92 to 453 meters with an SVP value range of 1490.28 m/s to 1534.44 m/s, while the WSPCW water mass was found at a depth of 130 to 500 meters with an SVP value range of 1485.95 m/s to 1528.27 m/s, this

is in accordance with the reference depth of research conducted (Agustinus *et al.*, 2016; Gunawan *et al.*, 2019).

Comparison of SVP values in four seasons in the Sulawesi Sea shows that the average water mass in the 1In and 1out areas which is thought to be ENPCW has a smaller difference in SVP compared to the WNPCW type. Meanwhile, in the 2In, 2Out, 3In and 3Out areas, the average water mass for the ESPCW type has a larger SVP difference compared to the WSPCW type. It is possible that SVP is influenced by temperature and salinity, where the higher the temperature, the higher the SVP value relative to depth, while the inversely proportional to salinity, where the higher the salinity, the lower the SVP.

This is also in accordance with the correlation results of SVP data processing, potential temperature and salinity, which represent water masses estimated at ENPCW and WNPCW and water masses estimated at ESPCW and WSPCW, showing a positive relationship between potential temperature and SVP and a negative relationship between salinity and SVP.

Conclusion

Based on the data processing of Marine Copernicus' temperature and salinity data in 2022 in the four seasons of the Sulawesi Sea with a depth of up to 500 meters, several characteristics of water masses were identified that were thought to be influenced by the ENPCW water mass found at depths of 130 to 318 meters, the WNPCW water mass found at depths of 130 to 500 meters, the ESPCW water mass found at depths of 92 to 453 meters, and the WSPCW water mass found at depths of 130 to 500 meters. The ENPCW water mass on average has a smaller difference in sound velocity or SVP compared to the WNPCW water mass. Meanwhile, the ESPCW water mass on average has a larger difference in SVP compared to the WSPCW water mass. The results indicate a positive relationship between temperature and SVP, which means that the higher the temperature, the higher the SVP. However, there is a negative relationship between salinity and SVP, which means that the higher the salinity, the lower the SVP.

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