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PHYSICAL PROPERTIES OF SEA WATER

V.V. Gopala Krishna
National Institute of Oceanography,
Dona Paula, Goa

The oceans cover about 70% of the earth and an average depth of something less than 4000 metres. A large part of physical oceanography is concerned with the processes responsible for the observed distribution of temperature and salinity in the ocean. Much can be learned about the ocean by observing temperature differences, changes in the salt content and changes in density.

Almost all the properties of sea water apart from the temperature, can be determined if genuine samples of water are available from each particular depth, because these properties show no appreciable alteration when the sample is brought from a given depth to the surface. However, the temperature of the sea water must be determined at the place and the depth from which the water sample was taken.

Temperature:

In general, the temperature of the ocean decreases with depth and the decrease is more rapid at the surface layers than at deeper depths. A typical temperature versus depth profile has a surface layer tens of metres thick, known as MIXED LAYER, because the winds at the sea surface play an important role in keeping the water well mixed and maintaining a nearly isothermal condition. Below the mixed layer, we notice a rapid change in temperature referred to as the THERMOCLINE. The characteristics of the thermocline vary with season, becoming stronger in summer when the mixed layer is warmer and weaker in winter when the surface layer cools (Fig. 1.1).

Below the thermocline the water temperature changes gradually with depth becoming nearly isothermal again. Oceanographers discuss the temperature of the ocean in two ways, in terms of insitu temperature and in terms of potential temperature. The former is simply the observed temperature. Potential temperature is complicated. If we consider a few litres of sea water from a depth of say 5000 m whose insitu temperature is 1°C . Let us rise this water sample to the sea surface without allowing it to mix with surrounding waters while rising, then we notice the temperature of the same water sample will be about 0.57°C instead of 1°C . That means potential temperature of the water parcel is 0.57°C .

There are numerous techniques available to measure water temperature. The temperature measurements should be accurate to meet scientific requirements.

Salinity

One of the most important properties of water is its ability to dissolve a very large number of solids and gases without chemically reacting with them. As a consequence of this property all the water on the earth is more or less

impure. Sea water is a complicated solution and contains the majority of the known elements. A significant feature of the sea water is, though the total concentration of the dissolved salts varies from place to place, the ratio of the more abundant components remain the same.

In simple words, the total amount of dissolved material in sea water is its salinity and it may be defined as "the total amount of solid materials contained in 1 Kg of sea water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine and all organic matter completely oxidized". For example, the average salinity of ocean water is 35 g/Kg of sea water, usually written as 35‰ and read as 35 parts per thousand.

Measurements of salinity must be made with considerable precision. No one routinely measures salinity in the manner of the definition. Until 1955 nearly all salinity measurements were made by determining the amount of the chlorine ion in sea water by titration with silver nitrate and relating chlorinity to salinity by an empirically derived formula

$$\text{Salinity} = 1.80655 \times \text{Chlorinity}$$

Nowadays most salinity determinations are made by determining the electrical conductivity of the sea water and then using the known relation between conductivity and salinity to calculate the latter.

Density

The density ρ of a material is the mass of a unit volume (gm/cm^3). The density of sea water is determined by its pressure, temperature and salinity. The differences in density of the ocean are small. In open ocean the values range from 1.02400 to 1.03000 gm/cm^3 . Lower values occur in the coastal waters. As a matter of convenience, in oceanography, density is represented as

$$\sigma = (\rho_{\text{StP}} - 1) \times 10^3$$

where ρ_{StP} = Density of sea water at a given depth (or) insitu depth (or) density of sea water with pressure effect.

The pressure effect on density can be ignored and a quantity σ_t is used, commonly called as σ_t (sigma tee). For example a water body having density of 1.0280 gm/cm^3 at sea surface would have density 1.0510 gm/cm^3 at 5000 m depth. In addition, the density of sea water is often referred to in terms of its specific volume, $\alpha = 1/\rho$. Specific volume is written in terms of the specific volume anomaly (δ):

$$\delta = \alpha_{\text{StP}} - \alpha_{35.0.P}$$

It is the difference between the insitu specific volume and that of sea water at the same pressure but $t=0$ and $s=35\%$.

Colour of the sea water:

The colour of the sea can vary widely and may assume any shade from a yellowish green to the deepest blue. At higher latitudes the colour changes through green blue to green in polar regions. Coastal waters are generally

greenish. If the sky is blue, the sea will still appear deep blue, but if the sky has white clouds, the white light reflected from the sea surface, will dilute the blue scattered light from the water and the sea will appear less intensity blue. In some regions, rivers bring in finely divided inorganic material, mud and silt, which may impart their own colour to the water by reflection from the particles.

Sound in the sea:

Light in the visible part of the spectrum is attenuated less than sound in the atmosphere, but in the sea the reverse is the case. With echosounders the depth of the bottom may be measured upto the maximum in the ocean with sonar the distance and direction of a submarine may be determined.

The speed of sound in the water is given by $V = \sqrt{\frac{E}{D}}$, where E is the adiabatic compressibility and D is density. The average speed of sound in sea water is 1500 m/sec. The speed of sound depends on temperature, salinity and pressure. In the open ocean the speed of sound varies with depth over a range of a few tens of metres per second.

Sea ice:

Approximately 3-4% of the ocean surface is covered by sea ice. Ice plays an important role in the heat budget and circulation of the ocean. One of the strangest properties of fresh water is the reversal of sign in the thermal expansion coefficient at 4°C. The density of fresh water increases as the temperature decreases. The density of sea water continues to increase as the temperature decreases until the freezing point is reached.

Extension coefficient in the sea:

In oceanography the greater interest is attached to the rate at which downward travelling radiation decreases. The rate of decrease can be defined by means of a coefficient known as extension coefficient

$$X_{\lambda} = 2.30 [\log I_{\lambda, z} - \log I_{\lambda, (z+1)}]$$

where $I_{\lambda, z}$ and $I_{\lambda, (z+1)}$ represent the radiation intensities of wave length λ on horizontal surfaces at the depth z and $z+1$ m. The extension coefficient of radiation of a given wave length varies within wide limits from one locality to another, and in a given locality it varies with depth.

REFERENCES

- John A. Krauss. 1975. Introduction to physical oceanography. Text Book.
- George L. Pickard. 1982. Descriptive physical oceanography: An Introduction. Text Book.
- Sverdrup, H.V., M.W. Johnson, R.H. Fleming. 1942. The oceans: Their Physics, Chemistry and General Biology.

Defant, A. 1961. Physical Oceanography, Vol. 1.

Dietrich, G. and K. Kalle. 1973 General oceanography - an introduction.

Hill, M.N. 1969. The seas: Ideas and observations, intersciences. Vol. I.

McLellan, J. Hugh. 1968. Elements of physical oceanography.