



## Deep-Water Circulation

**For Prelims:** Deep-water Circulation, Central American Seaway, Antarctic Bottom Water (AABW), Ocean Current, Indian Ocean, Iron-manganese crusts, Authigenic Neodymium Isotope.

**For Mains:** Significance of Deep-Water Circulation (DWC), Deep-Water Circulations of the Indian Ocean.

### Why in News?

Recent studies have indicated that [tectonically driven changes in the ocean gateways](#) had a dramatic impact on the global overturning circulations.

### What do the Latest Findings Suggest?

- Studies suggest that **changes in ocean routes caused by tectonics**, like the closing of the **Central American Seaway**, had a big effect on [ocean circulation](#).
  - **Central American Seaway** is a body of water that **once separated North America from South America**,
- These changes **may have led to the creation of two distinct water bodies**:
  - Northern component water in the **North Atlantic Ocean**.
  - [Antarctic Bottom Water \(AABW\)](#) in the Southern Ocean.
- Consequently, it is also **hypothesised that there would have been large-scale changes in the Deep-Water Circulation (DWC)** in the oceans across the world, impacting [global climate](#) and heat exchanges.

### What is Deep Water Circulation (DWC)?

- **About:**
  - It refers to the movement of water in the deep ocean. It is **driven by the density differences between water masses** caused by variations in temperature and salinity.
  - In the Earth's polar regions ocean water gets very cold, forming sea ice. As a consequence, the **surrounding seawater gets saltier, because when sea ice forms, the salt is left behind**.
  - As the **seawater gets saltier**, its density increases, and **it starts to sink**. Surface water is pulled in to replace the sinking water, which in turn eventually becomes **cold and salty enough to sink**.
    - This creates a circulation pattern that is known as the **thermohaline circulation**.
- **Significance:**
  - **Heat Distribution:** It helps to distribute heat around the globe, which helps to **regulate the Earth's temperature** and keep different regions from becoming too hot or too cold.
  - **Maintaining Carbon Dioxide Levels:** It plays a critical role in controlling [atmospheric carbon dioxide levels](#) by **helping to transport carbon from the surface to the deep ocean**, where it can be stored for long periods of time.
  - **Shaping Ocean Currents:** It is responsible for **shaping the ocean's currents** and the circulation patterns of the world's oceans.

- These currents in turn influence the [marine ecosystem](#), **weather patterns, and coastal regions.**
- **Maintaining Sea level:** It also has an impact on sea level, as **warm water is less dense than cold water**, therefore it can also affect [sea level](#) by redistributing heat and thermal expansion.
- **Deep-Water Circulations of the Indian Ocean:**
  - The Indian Ocean does not produce its own deep water, it **only receives it from other sources** such as the North Atlantic and Antarctic.
  - The **northern part of the Indian Ocean is located far away from the areas where deep water is formed** and ocean routes, making it a good place to study the impact of ocean circulation changes.
  - Studies have been done in the Indian Ocean to understand past deepwater circulation **using records from iron-manganese crusts and authigenic neodymium isotope composition** of sediment cores.
    - These records have few limitations:
      - **Iron-manganese crusts are found at deeper depths** and are only bathed by **Antarctic Bottom Water (AABW)**, so they can only provide information about the history of AABW.
      - **Authigenic neodymium isotope** records are only available from the **Bay of Bengal region**, but they are also not accurate as the [Himalayan rivers that flow into the Bay bring in a lot of neodymium particulates](#) which can interfere with the results.
    - However, recently Scientists have generated an **authigenic neodymium isotope record from the Arabian Sea** and reconstructed the **DWC record of the [Indian Ocean](#)** for the period from **11.3 million years ago (Miocene era) to 1.98 million years ago (Pleistocene era).**

### UPSC Civil Services Examination Previous Year Question (PYQ)

**Q.** How do ocean currents and water masses differ in their impacts on marine life and coastal environment? Give suitable examples. **(2019)**

**Q.** What are the forces that influence ocean currents? Describe their role in fishing industry of the world. **(2022)**

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