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Q17

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

UPSC Civil Services Mains 2019 · GS I · 15 marks · World's Physical Geography

Salient features of world's physical geography.

Core demand of the question

- Explain how ocean currents affect marine life and the coastal environment, with examples
- Explain how water masses affect marine life and the coastal environment, with examples
- Show how those impacts differ

Revision summary

Currents are mainly horizontal flows that move heat, larvae, and nutrients.

Cold eastern-boundary currents create upwelling fisheries; El Niño shows how a current shift can crash them.

Warm currents milden some coasts; cold currents help fog deserts and longshore drift shapes beaches.

Water masses are temperature-salinity bodies that set oxygen and density layers.

Arabian Sea OMZ and Bay of Bengal freshwater layers are Indian examples.

Currents advect; water masses stratify; coasts feel both.

Introduction

Ocean currents are largely horizontal rivers in the sea. Water masses are large bodies of water with a shared temperature-salinity signature that move in three dimensions. Both shape fish, coral, fog, and coasts, but they do so through different physical paths.

Body**Ocean currents and marine life**

- Surface currents, driven mainly by wind and the Coriolis effect, carry heat, larvae, and nutrients along gyres such as the Gulf Stream, Kuroshio, and the **Humboldt (Peru) Current**.
- Cold eastern-boundary currents (Humboldt, Benguela, Canary, California) lift nutrient-rich water; the Peru-Chile and Benguela upwelling systems support some of the world's densest fisheries.
- Warm western-boundary currents keep coral and pelagic species in milder water; when they shift, as in El Niño years on the Pacific coast of South America, anchovy fisheries collapse and seabirds fail.
- In the north Indian Ocean, the reversing monsoon currents and the **Somali Current** create seasonal upwelling off Oman and Somalia, which pulses Arabian Sea productivity.

- The Agulhas Current around South Africa leaks warm Indian Ocean water into the Atlantic, which matters for fish stocks and for global climate that later returns as monsoon risk.

Ocean currents and coasts

- Warm currents raise coastal air temperature and moisture; the Gulf Stream-North Atlantic Drift keeps north-west Europe milder than Labrador at similar latitude, which shapes ports and settlement.
- **Cold currents bring fog, desert coasts, and limited rain:** the Atacama and Namib sit beside Humboldt and Benguela; India's west-coast summer monsoon is a different wind story, but local upwelling still cools patches of the Arabian Sea.
- Longshore drift and current-driven sediment nourish or starve beaches, spits, and harbours; training walls then fight that drift.
- Storm tracks riding on warm current pools can raise cyclone energy; a warmer Bay of Bengal surface helps storms that hit Odisha and Andhra coasts.

Water masses and marine life

- Water masses form where surface water sinks or mixes (for example **North Atlantic Deep Water**, Antarctic Bottom Water, Antarctic Intermediate Water) and they set the ocean's density layers.
- **Their temperature, salinity, and dissolved oxygen decide who can live at depth:** oxygen minimum zones in the Arabian Sea and eastern Pacific squeeze fish and favour anaerobic microbes.
- Nutrient content of a mass feeds the base of the food web when it is mixed upward; a nutrient-poor warm surface mass over a sharp thermocline can make a blue desert even if currents look lively.
- In the Indian Ocean, the Bay of Bengal's low-salinity surface layer from Ganga-Brahmaputra-Meghna discharge differs from the saltier Arabian Sea mass, so bloom patterns and cyclone heat content differ on two sides of India.
- The Indian Ocean Dipole moves warm and cool surface masses and changes rainfall and coral bleaching risk around Indonesia, East Africa, and India.

Water masses and coastal environment

- A fresh, light coastal water mass can cap mixing, trap sewage and hypoxia nearshore, and alter monsoon rainfall when it changes sea-surface temperature.
- Dense, salty masses sinking on shelves can ventilate fjords and basins-or, if they fail, leave stagnant toxic layers.
- Sea ice and polar water-mass formation far from India still drive the global conveyor that sets monsoon-era ocean heat on our coasts over long periods.
- Coral bleaching is often a water-mass heat story (a persistent warm layer) as much as a named current's shift.

How the impacts differ

- **Currents are the conveyor belts:** they move heat and larvae sideways and can create upwelling at the coast; their impact is often mapped as fisheries, fog deserts, and mild or stormy shores.
- **Water masses are the cargo and the rooms of the ocean:** they set oxygen, salinity, and density layers; their impact is often vertical-who lives at 200 metres, whether a bay goes hypoxic, whether coral cooks.

- A current can carry a water mass; they are not rivals, but a 15-mark answer must keep the verbs different: advect versus stratify.
- **Example pair:** Humboldt Current upwelling (current) versus **Arabian Sea oxygen minimum zone** (water-mass chemistry).

Way forward for study and policy

- Fishery forecasts should use both INCOIS current products and oxygen-salinity profiles, not only sea-surface temperature.
- Coastal management should watch Bay of Bengal freshwater layers and Arabian Sea OMZ trends as climate and river-dam changes rewrite water masses at India's door.

Flow diagram

Ocean currents -> Upwelling heat drift
Water masses -> Oxygen salinity layers
Upwelling heat drift -> Fisheries fog coasts
Oxygen salinity layers -> Hypoxia coral heat
Fisheries fog coasts -> Marine and coastal life
Hypoxia coral heat -> Marine and coastal life
Indian monsoon Bay vs Arabian -> Marine and coastal life

Conclusion

Currents steer heat, nutrients, and larvae along coasts and make upwelling fisheries or fog deserts. Water masses set the ocean's layers of salt, heat, and oxygen, which decide hypoxia, coral heat stress, and the Bay versus Arabian contrast around India. Their impacts differ as horizontal transport versus three-dimensional living conditions, even when they act together.

Facts & figures

Humboldt (Peru) Current

Cold eastern-boundary current whose upwelling supports a major anchovy fishery, sensitive to El Niño.

Somali Current

Seasonal western Indian Ocean current linked to monsoon upwelling off the Horn of Africa.

North Atlantic Deep Water

Dense water mass that sinks and helps drive the global thermohaline circulation.

Arabian Sea oxygen minimum zone

Thick low-oxygen layer that limits some marine life and shapes microbial chemistry.

Bay of Bengal low-salinity layer

River-fed surface mass that differs from the saltier Arabian Sea and affects storms and blooms.

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