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Revisiting the Oceanographic Processes

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Content of the Lecture

- Introduction to Oceanography and its types
- Why Oceanography is important?
- What causes the ocean to circulate?
- Revisiting the oceanographic processes-Fisheries Production
- Conclusion

Introduction to Oceanography

Definition

"Oceanography is the study of the ocean, with emphasis on its character as an environment"

The shape, size, depth and bottom relief of ocean, distribution of oceans,ocean currents and various life forms existing in ocean are also studied under oceanography

Types

- Physical oceanography (Temperature,Currents,Tides,Winds and Depth)
- Chemical oceanography (Salinity, Nutrients (NO3,PO4,Si&Fe) and DO)
- Biological oceanography(Primary productivity and Fisheries production)
- Geological oceanography (Earth properties)

Why Oceanography is important?

- Management of marine living resources for sustainable use (Marine Fisheries)
- Detecting and forecasting of oceanic parameters such as SST,Ocean Colour(Chlorophyll),Sea surface height (elevation) and surface roughness etc.,
- Protection and conservation of marine ecosystems (Coral Reefs,Mangroves,Seagrass,Mudflats)
- Prediction and mitigation of Natural Hazards (Tsunami, Storm Surges, Cyclones and Coral bleaching)
- National Security (Navy and Coast Guard)
- Assisting marine merchants for safe and efficient marine operations (Shipping,Navigation,Fishing and ONGC)
- Strengthening and enlightening of education and knowledge to professionals

What causes the ocean to circulate?

- **Energy and matter** are continually exchanged between the ocean and atmosphere and these processes drive the ocean and atmosphere circulation
- Evaporation,precipitation,heating and cooling bring about changes in the **temperature and salinity** of surface waters
- Density changes that accompany changes in temperature and salinity can cause water to sink or rise in the ocean
- Kinetic energy (energy of motion) is transferred from the wind (air in motion) to ocean depths of a few hundred meters

Main oceanographic processes influencing fisheries production

- MLD,Thermocline,Halocline,Nutricline and Oxycline
- Upwelling,Mixing and Downwelling
- Ocean Fronts
- Ocean Currents
- Ocean Eddies and Gyres

These are mainly caused by combination of earth rotation (Coriolis effect),wind patterns,coastal geomorphology and bottom topography which playing a significant role in the spatiotemporal distribution of fisheries resources

MLD,Thermocline,Halocline,Pycnocline Nutricline and Oxycline

MLD (Mixed Layer Depth)

It is a well mixed upper layer of the sea and typically 150m deep and due to the fact it is well mixed, the temperature and salinity (and therefore the density) are fairly uniform

Thermocline- Rapid change in **temperature** with respect to ocean depth

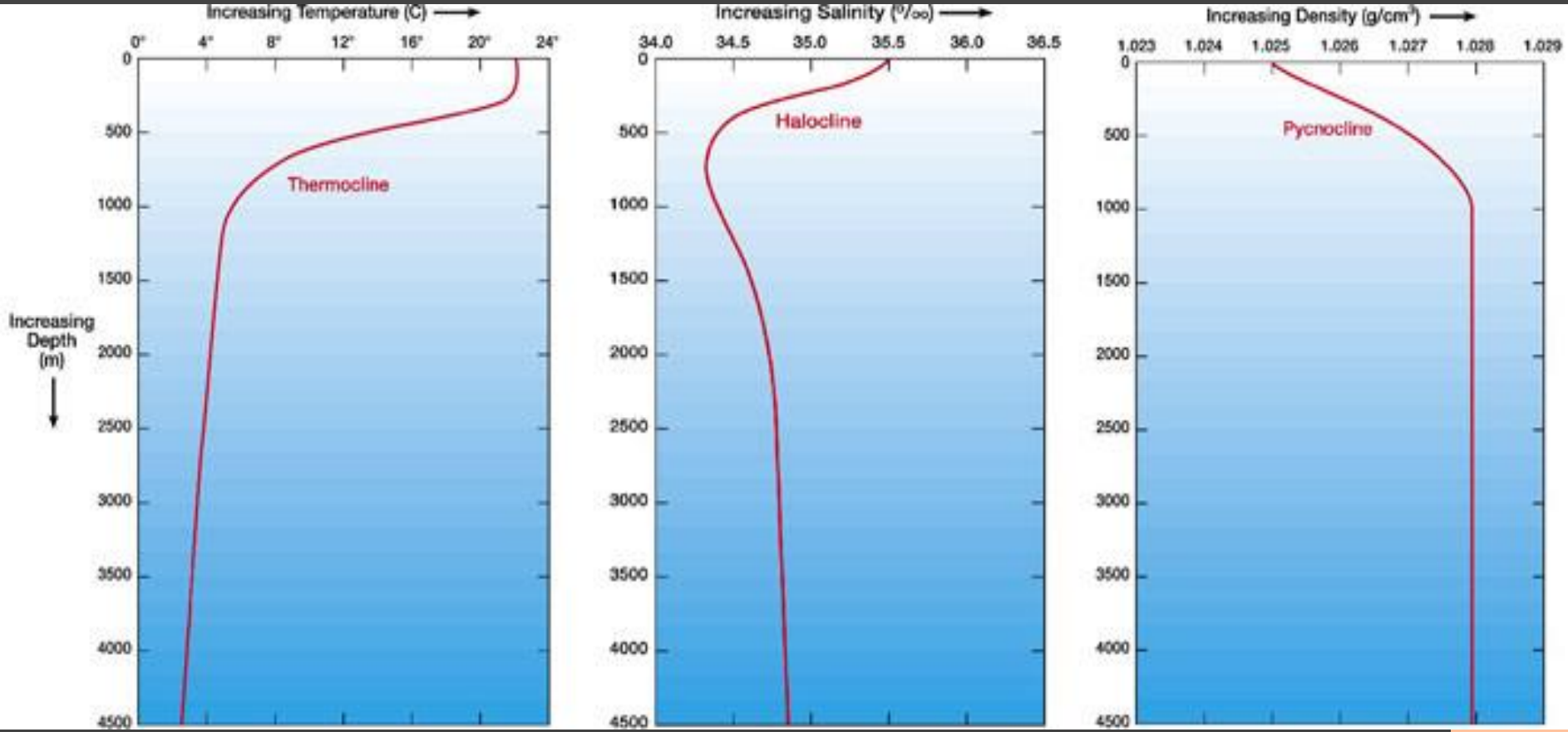
Halocline- Rapid change in **salt concentration** with respect to ocean depth

Pycnocline-Rapid change in **density** with respect to ocean depth

Nutricline-Rapid change in **nutrients** with respect to ocean depth

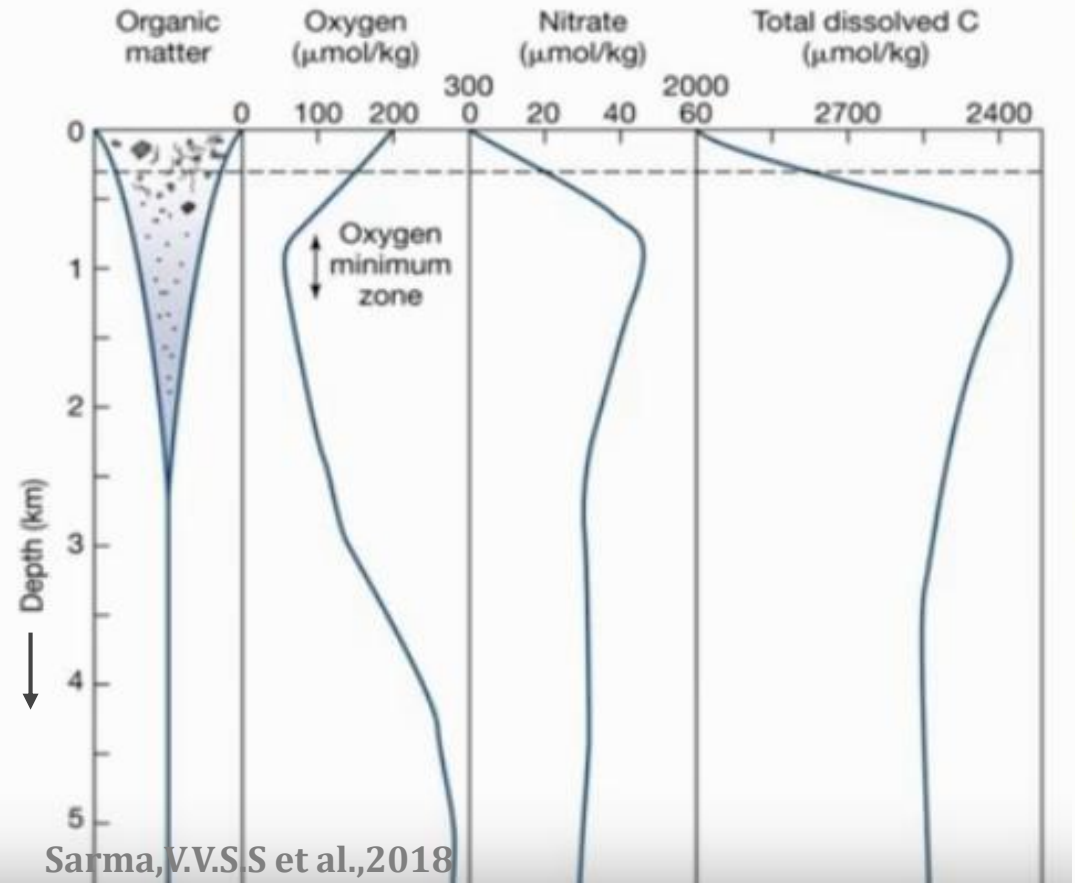
Oxycline-Rapid change in **oxygen** level respect to ocean depth

Thermocline Halocline Pycnocline

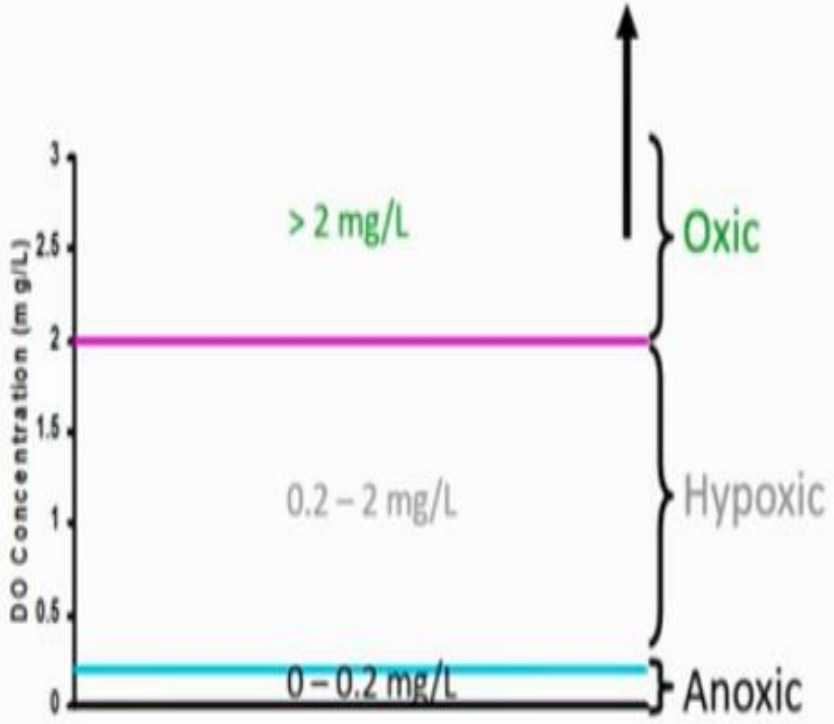


Source:hurricanescience.org

Nutricline and Oxycline



Sarma,V.V.S.S et al.,2018



Most fish need oxygen levels > 2.0 mg/L

Upwelling

Upwelling is the cold,nutrient-rich water that rises from oceanic depths usually near the continents, when wind blows the overlying surface away or along the equator

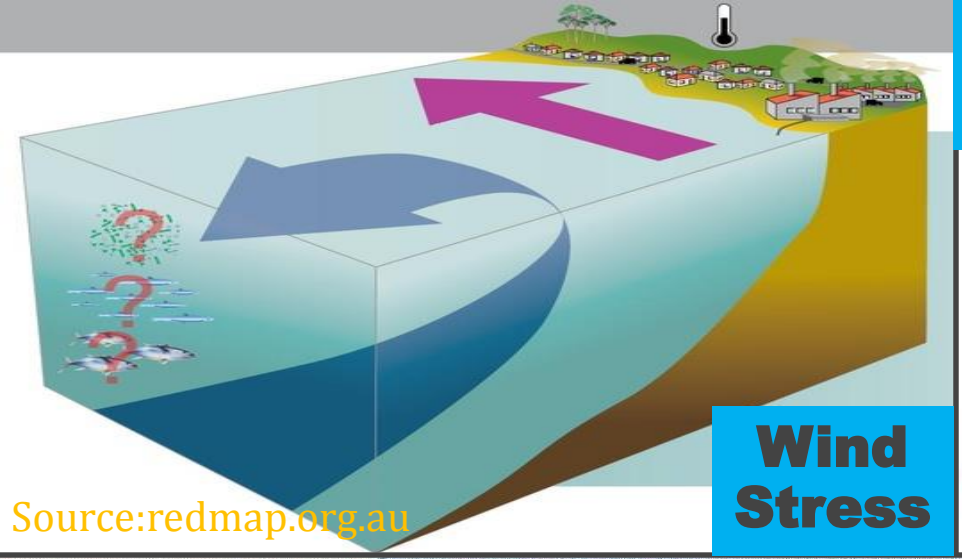
Main factors that create/forms upwelling in ocean

1.Wind stress

2.Coriolis force

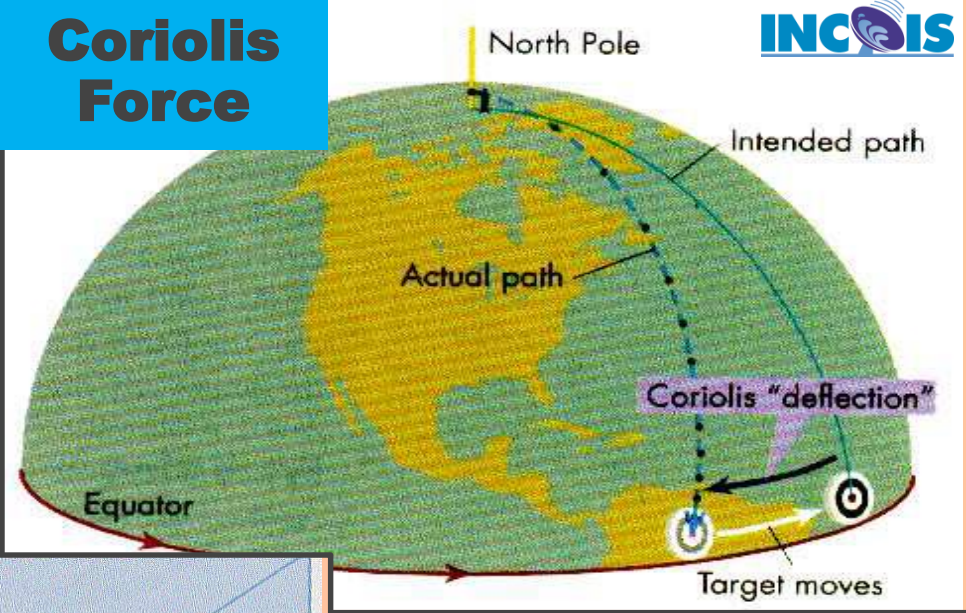
3.Ekman transport

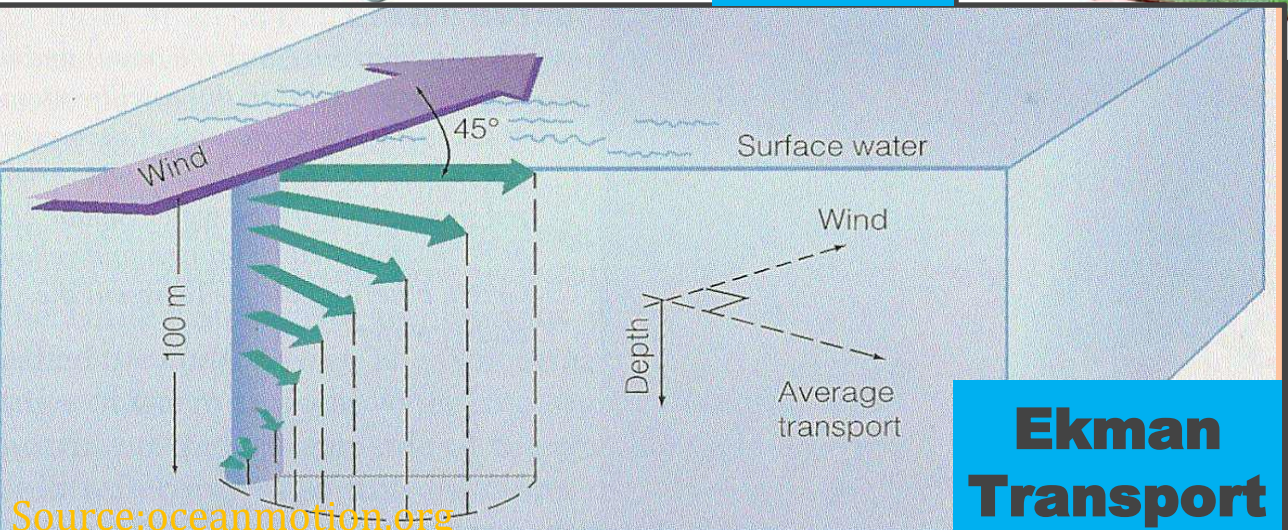
Coriolis Force



Source:redmap.org.au

Wind Stress





Source:oceanmotion.org

Ekman Transport

Upwelling and Mixing

- Marine ecosystems are supplied by nutrients that are recycled within the euphotic zone by influx from intermediate and deep waters.
- The upwelled water is usually from below the pycnocline (deep water masses) and **nutrient rich.**
- When the wind blows over the surface of the ocean it sets up a stress, which causes the water to move in the same direction as the wind
- If the Ekman transport is set up away from the coast, the surface waters are moved offshore and are replaced by deeper cold water that is upwelled close to the coast.

Globally, most upwelling regions are found along the eastern sides of ocean

Source:redmap.org.au

Ecological Importance of Upwelling

Cause

Nutrients are brought up to euphotic zone

Effects

- Maximum support of phytoplankton & zooplankton production
- More food for fish and larger organisms
- Strong food chains and food webs

Importance to marine fisheries

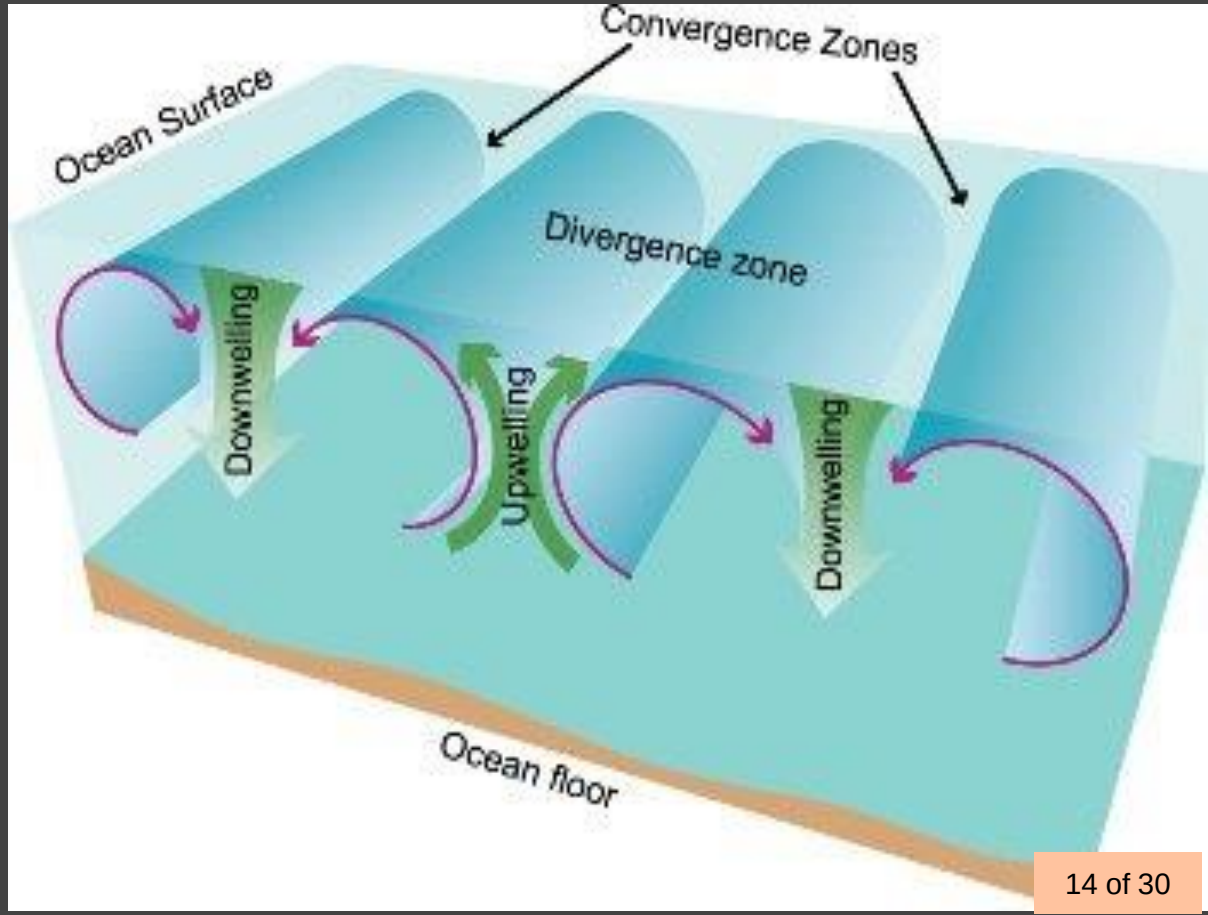
- Because of the increase in primary productivity of upwelling areas which take about **5 per cent** of the ocean surface area it is found that they account around **25 per cent** of the world's fisheries

Downwelling

- Downwelling occurs when surface waters converge (come together) pushing the surface water downwards

- Regions of downwelling have low productivity because of the nutrients get used up and are not continuously resupplied by the cold, nutrient-rich water from below the surface

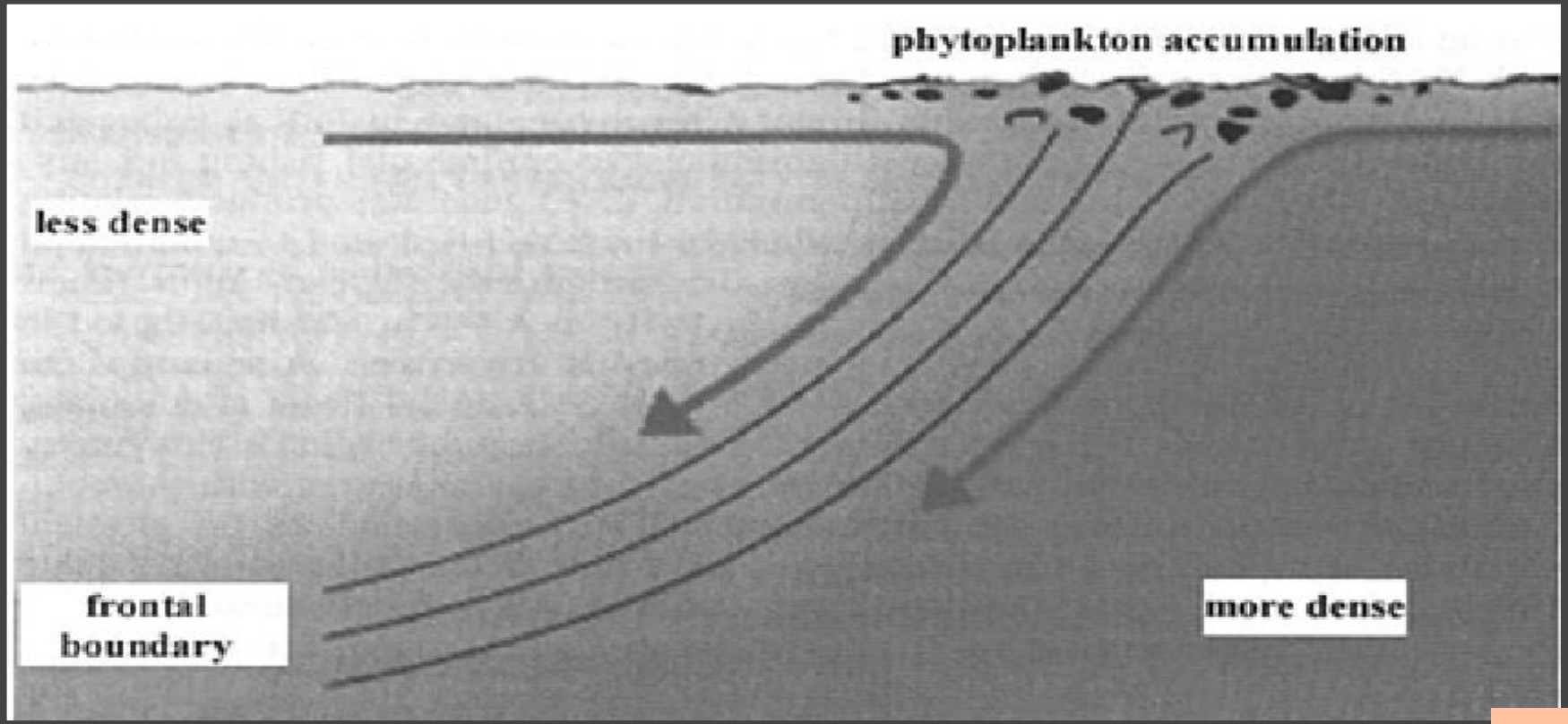
Source:redmap.org.au



Ocean Fronts

- Oceanic fronts are areas of particular interest contributing to the **continual nutrient mixing** in the oceans
- In oceanic front areas, there is **rapid change in temperature,CHL and salinity distribution** while the horizontal gradients of these properties are homogeneous in the surrounding water masses
- Usually, these events take the form of long stripes on the sea surface and may be connected to other oceanographic processes such as upwelling and currents
- It have significant effects on marine biology.These systems tend to form zones of convergence of different water masses resulting in accumulation of planktonic organisms.

Productivity increases at fronts due to accumulation of phytoplankton



Source:Valavanis,V.D., 2002

Ocean Currents

Ocean currents are coherent streams of water moving through the ocean and include long permanent features such as the gulf stream and smaller episodic flows in both coastal waters and the open ocean.

They are formed by

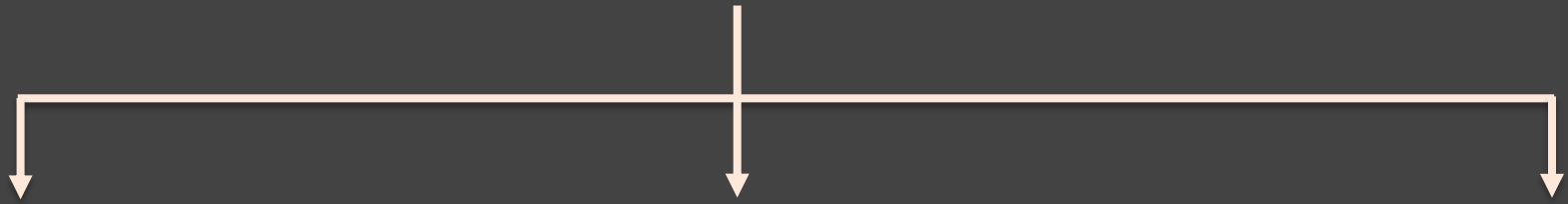
1.Wind blowing across the surface of the ocean and

2.Differences in the temperature, density and pressure of water

3.Rotation of Earth (Coriolis force)

4.Location of the continents and topography of the ocean bottom

Classification of Ocean Currents



Depth

1.Surface
2.Deep

Speed and Direction

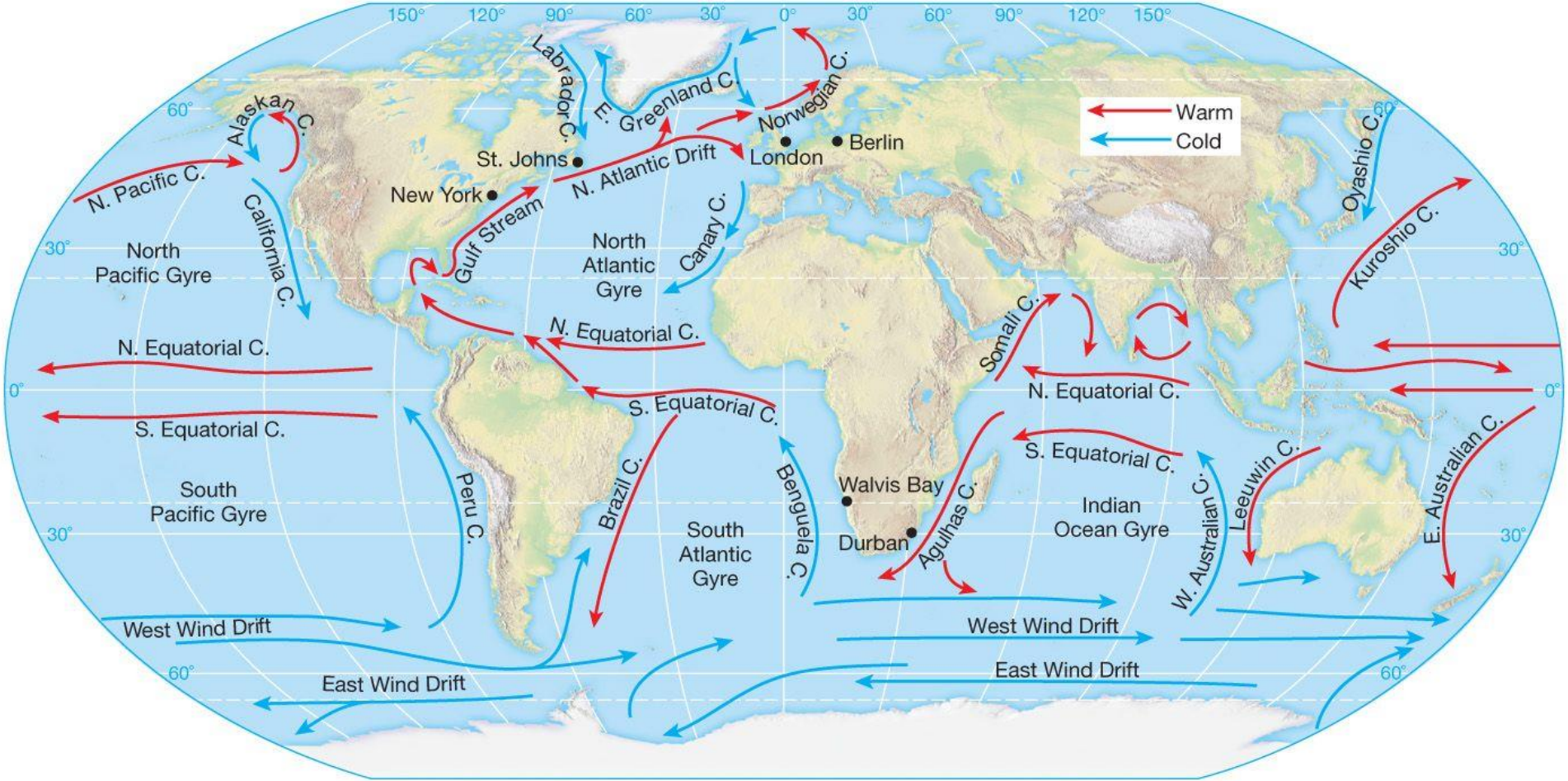
1.Drift
2.Current
3.Stream

Temperature

1.Warm
2.Cold

Fastest ocean current in world oceans
Gulf stream

Ocean Current Pattern



Importance of Ocean Currents to Fisheries

- It plays major role in migration routes of marine species are predicated upon moving against the flow of ocean currents **(contranatant)** to spawn, thereby optimizing the subsequent downstream drift of eggs and larvae **(denatant)** to suitable nursery habitat

- Ocean currents are an important abiotic factor that significantly influences food webs and reproduction of marine organisms

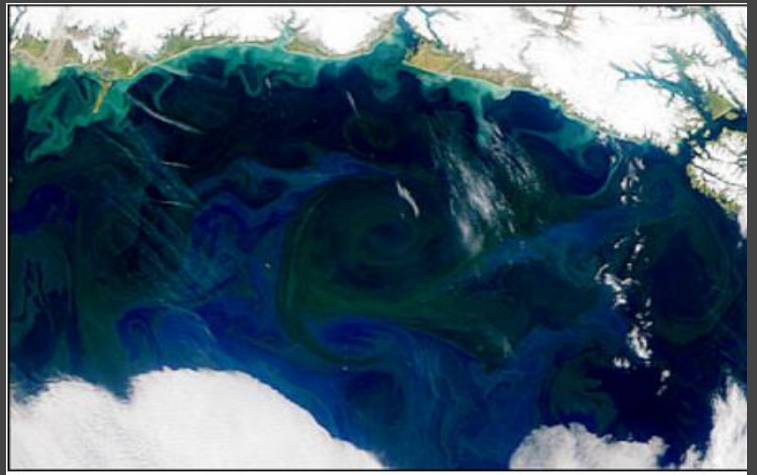
- Many species with limited mobility,ocean currents bring food and nutrients to them and to distribute larvae and reproductive cells

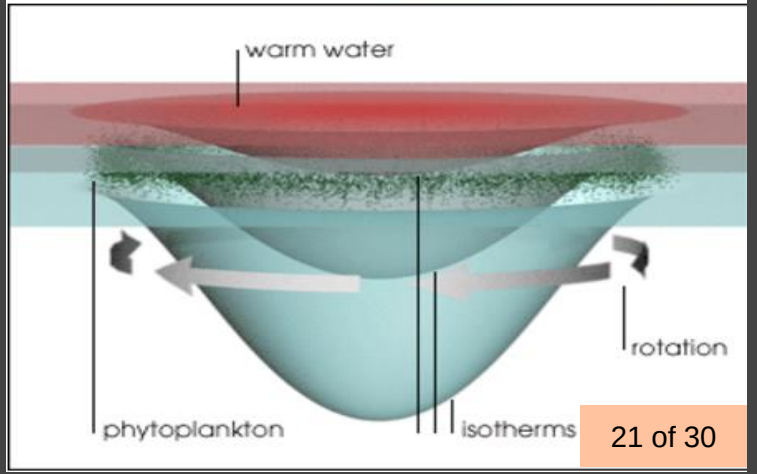
- Even fish and mammals living in the ocean may have their destinations and food supply affected by currents

Ocean Eddies

- An eddy is a current of water or air running contrary to the main current especially ,a small whirlpool
- Mesoscale eddies are circular currents of water that widely exist in the ocean and they spanning **10 to 100 of kilometers** over tens to hundreds of days.
- Mechanisms which generate eddies
  - Baroclinic instability of large scale currents
  - Topographic steering
  - Wind
  - Rossby waves and
  - Local barotropic instabilities

Source:Faghmous, J.H., et al.,2012





Types and characteristics of different eddy zones

Eddy types	Eddy zone	Zone properties
Cyclonic (cold core)	Core area	Depressed sea surface, divergence/upwelling and considered productive
	Periphery area	Elevated sea surface, convergence/downwelling and not considered productive
Anticyclonic (warm core)	Core area	Elevated sea surface, convergence / downwelling and not considered productive
	Periphery area	Depressed sea surface, divergence/upwelling and considered productive
Interaction (Between eddies)	Converging flows	Between cyclonic and cyclonic eddy pairs **or** high-gradient area between cyclonic and anticyclonic eddy pairs
	Diverging flows	Between two anticyclonic eddy pairs
Non-eddy	No	Sea levels influenced by non-eddy processes

Source:Arur et al.,2014

Importance of ocean eddies to fisheries

- The eddies reduce thermocline depth and bring nutrients to the photic zone, improving the productivity in stratified tropical and subtropical regions of the oceans

- Meso-scale eddies influence productivity at every trophic level, such as the primary production and concentration of zooplankton,micro-nekton, plankton feeders which in turn form a forage base and attract tertiary-level producers (tunas, marlin, turtles, sea birds, and cetaceans) by Arur *et al*.,(2014&2020)

- **Identification:**Satellite altimetry has contributed significantly to physical oceanography. It provides accurate global sea surface height (SSH) measurements and anomalies.

Gyres

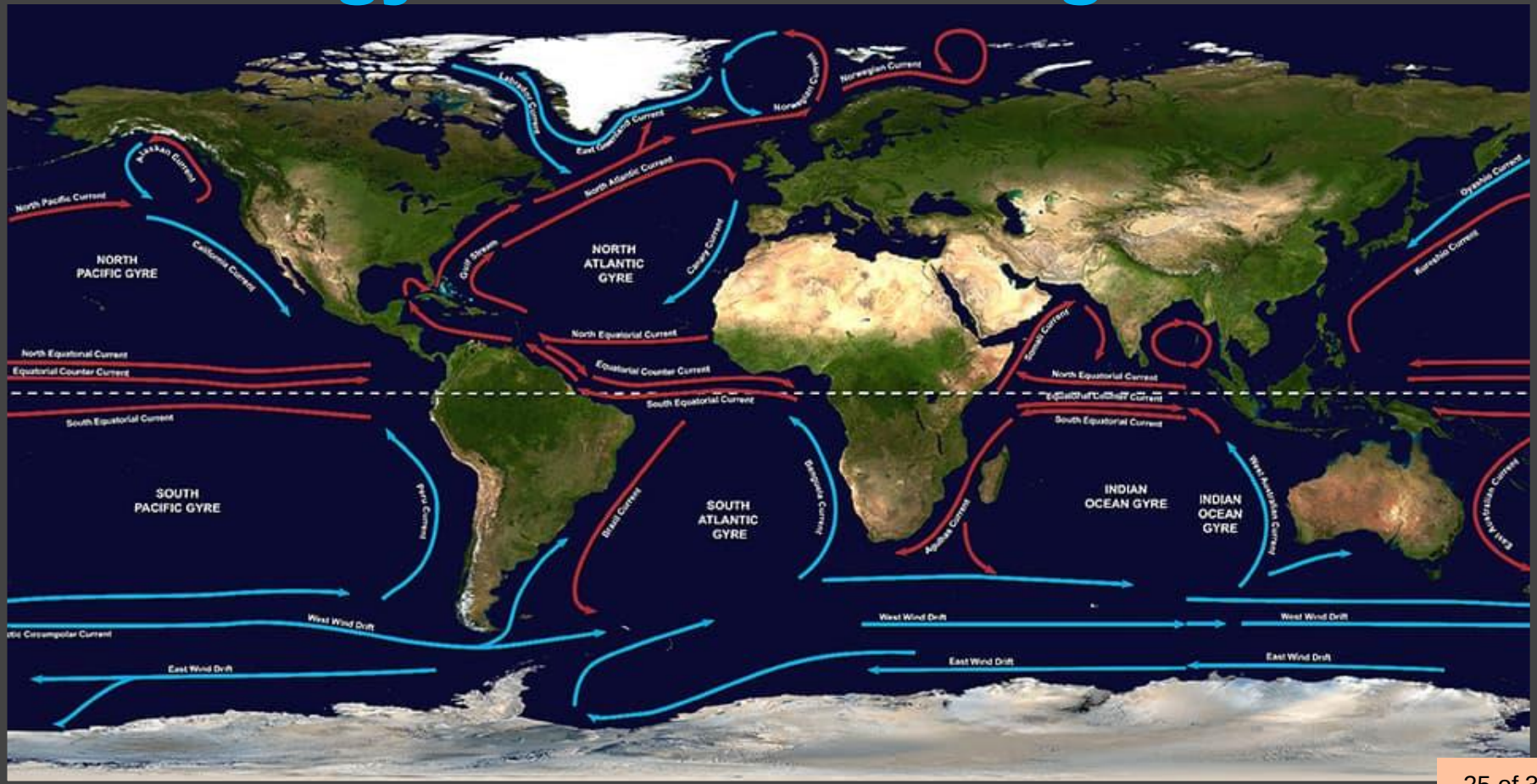
- Gyres are spiraling circulations thousands of miles in diameter and rimmed by large, permanent ocean currents.Usually, gyres are characterized by certain seasonality and vary in duration, strength and size

- Some of these gyres may be viewed as another type of upwelling.Often,these processes are open sea upwelling events of dynamic pumping of bottom water to the surface.

- Depending on the direction of the process, a gyre may create a region with warmer (cyclonic gyre) or colder (anticyclonic gyre) SST

- The monitoring of gyre activity in the oceans becomes important because it reveals surface geostrophic currents, seasonal CHL concentrations and seasonal offshore fish feeding grounds

Different gyres formation in global ocean



Source:oceanservice.noaa.gov

Oceanic environment set to screen out for regions of fish abundance

Ocean conditions	Fish abundance
Thermal fronts, favourable chlorophyll condition, upwelling zones,cyclonic eddies	Very High probability (VH)
Thermal fronts, favourable chlorophyll condition,cyclonic eddies	High probability (H)
Favourable chlorophyll condition, upwelling zones	High probability (H)

Source:Jishad et al.,2019

Indicators of the resources and locations

- The problem that occurs next is where to look for fishing locations in the vast oceans

- To find correlations between plankton crops and fisheries and to identify indicator organisms will help to find fishery location, sustainable development and policy making of particular fish groups.

Indicator organisms

S.No	Name of the Fishery	Indicator organisms	Ocean/Sea
1	Indian oil sardine	*Fragillaria oceanica (Diatom)*	Arabian sea (Northern Indian Ocean)
2	Lesser sardines	*Hemisdiscus hardmanianus* (Diatom)	Bay of Bengal (Northern Indian Ocean)
3	Bombay duck (Discontinuous distribution)	*Acetes indicus*	Northern Indian Ocean
3	Tuna	Blacknaped Tern bird	Indian and Pacific Ocean
4	Herring	Calanus (Kind of water flea)	North sea (Atlantic ocean)
5	Blue whale	*Euphausia superba* (Antarctic krill)	Antarctic region
6	Basking shark	Calanus sp	Mostly Atlantic oceans
7	Antarctic krill	*Fragillariopsis antarctica* (Diatom)	Antarctic region

Sources:Academic manuals and Research articles

Conclusion

- To complete understanding of the physical, chemical and biological processes as well as their interactions in ocean will be useful for assessment of primary production and fisheries production over continental shelf areas

- A thorough understanding of the various oceanographic processes is important for finding a satisfactory solution to the major problem of the difference in the fisheries production in coastal/open ocean

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