Why the ocean is gaining heat

Increasing atmospheric greenhouse gases strengthen the greenhouse effect. The ocean absorbs much of the resulting excess energy, raising ocean temperatures and changing marine conditions.

1. CONNECT THE ATMOSPHERE TO THE OCEAN

MORE GASES

Human activities increase greenhouse gas concentrations.

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ENERGY IMBALANCE

Less heat initially escapes to space at the same temperature.

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OCEAN HEAT UPTAKE

The ocean gains stored heat, warming marine habitats.

Ocean heat uptake slows atmospheric warming but does not remove the energy from the climate system. Currents redistribute heat; warming differs between regions, seasons and depths.

2. LONG-TERM WARMING AND MARINE HEAT WAVES

Long-term ocean warming is a sustained change in ocean temperature. A marine heat wave is an episode of unusually warm water for its location and season. Such episodes can expose organisms to temperatures beyond their tolerance, even where the long-term average change seems small.

3. SUPPORTING LINK: LAYERING AND SEA LEVEL

Warmer seawater expands, contributing to sea-level rise. Surface warming can also strengthen density layering, called stratification. Reduced vertical exchange can limit the supply of deep nutrients to surface producers and the renewal of oxygen in deeper water. Local winds and currents still matter.

> Keep the processes separate: ocean warming is a temperature change from heat uptake. Ocean acidification is a chemical change caused mainly by dissolved CO_2, lowering pH. They can occur together, but they are not the same mechanism.

Heat uptake, sea level and carbon uptake: NASA, The Ocean and Climate Change.
Heat waves and stratification: IPCC AR6 WGII, Chapter 3.
Oxygen and nutrient exchange: IPCC SROCC, Chapter 5.

Scope: College Board APES CED, Topic 9.6, STB-4.G.1-3, p. 188.

Marine life has temperature limits

Ocean warming can change habitat availability, metabolism and reproduction. Responses depend on the species, life stage, warming intensity and duration, and access to suitable habitat.

1. METABOLISM: DEMAND CAN RISE

Ectotherms rely largely on external heat. Warming within their tolerable range often speeds biochemical reactions and raises metabolic demand. They may need more food and oxygen to maintain normal function. Beyond thermal limits, performance declines; warmer does not always mean faster growth or healthier animals.

2. OXYGEN: SUPPLY CAN BECOME MORE LIMITED

At the same salinity and pressure, warmer water holds less dissolved oxygen at saturation. Stronger stratification can further reduce oxygen replenishment below the surface. Rising oxygen demand alongside reduced availability can constrain activity, growth and survival; actual oxygen levels also depend on local biology and mixing.

3. REPRODUCTION: TIMING AND SURVIVAL CAN CHANGE

Temperature can alter spawning schedules, development and the survival of eggs or larvae. For example, warmer conditions can raise a fish embryo's oxygen demand beyond what reaches it. A mismatch between larval feeding needs and prey availability can reduce the number surviving to join the population.

4. HABITAT: MOVEMENT HAS LIMITS

Some populations shift poleward or deeper toward cooler water. Others lose suitable habitat because food, oxygen, substrate or migration routes are unsuitable elsewhere. Fixed reef-building corals cannot simply move as adult colonies. Range shifts can rearrange food webs and change where fisheries operate.

Physiology and reproduction: IPCC AR6 WGII, Chapter 3.
Oxygen availability and mixing: IPCC SROCC, Chapter 5.
Temperature and fish embryo oxygen demand: NOAA Fisheries.
Observed changes in fish distributions: NOAA Fisheries, Our Changing Climate.

Scope: College Board APES CED, Topic 9.6, STB-4.G.1-3, p. 188.

Coral bleaching is loss of a partner

Many shallow-water reef-building corals contain symbiotic algae called zooxanthellae. The algae provide photosynthetic products; corals provide a protected environment and materials the algae use.

1. TRACE HEAT STRESS TO BLEACHING

HEAT STRESS

Unusually warm water disrupts the coral-algal partnership.

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ALGAE ARE LOST

Corals lose algae and much of the color they provide.

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CORAL LOOKS WHITE

The white skeleton shows through the coral tissue.

Bleaching is not household bleach entering the water, and it is not proof that the coral is already dead. Living bleached coral has lost a major energy source and is more vulnerable to prolonged stress.

2. BLEACHED CORAL HAS TWO POSSIBLE OUTCOMES

STRESS EASES: RECOVERY

Algae may return and the partnership may recover. Recovery takes time and depends on coral condition and later stress.

STRESS PERSISTS: DEATH

Prolonged or repeated stress can exhaust energy reserves and kill coral. Bleaching does not always end this way.

3. FROM CORAL LOSS TO REEF CHANGE

If many corals die, reef growth and habitat quality can decline, affecting dependent species and people. Reducing local pollution and other pressures can support resilience, but it does not replace reducing the greenhouse gas emissions driving ocean warming.

Coral-algal partnership: NOAA, Zooxanthellae: Corals' Best Friends.
Bleaching, stress and survival: NOAA, What Is Coral Bleaching?
Recovery and local pressures: NOAA, Reef Resilience.

Scope: College Board APES CED, Topic 9.6, STB-4.G.1-3, p. 188.