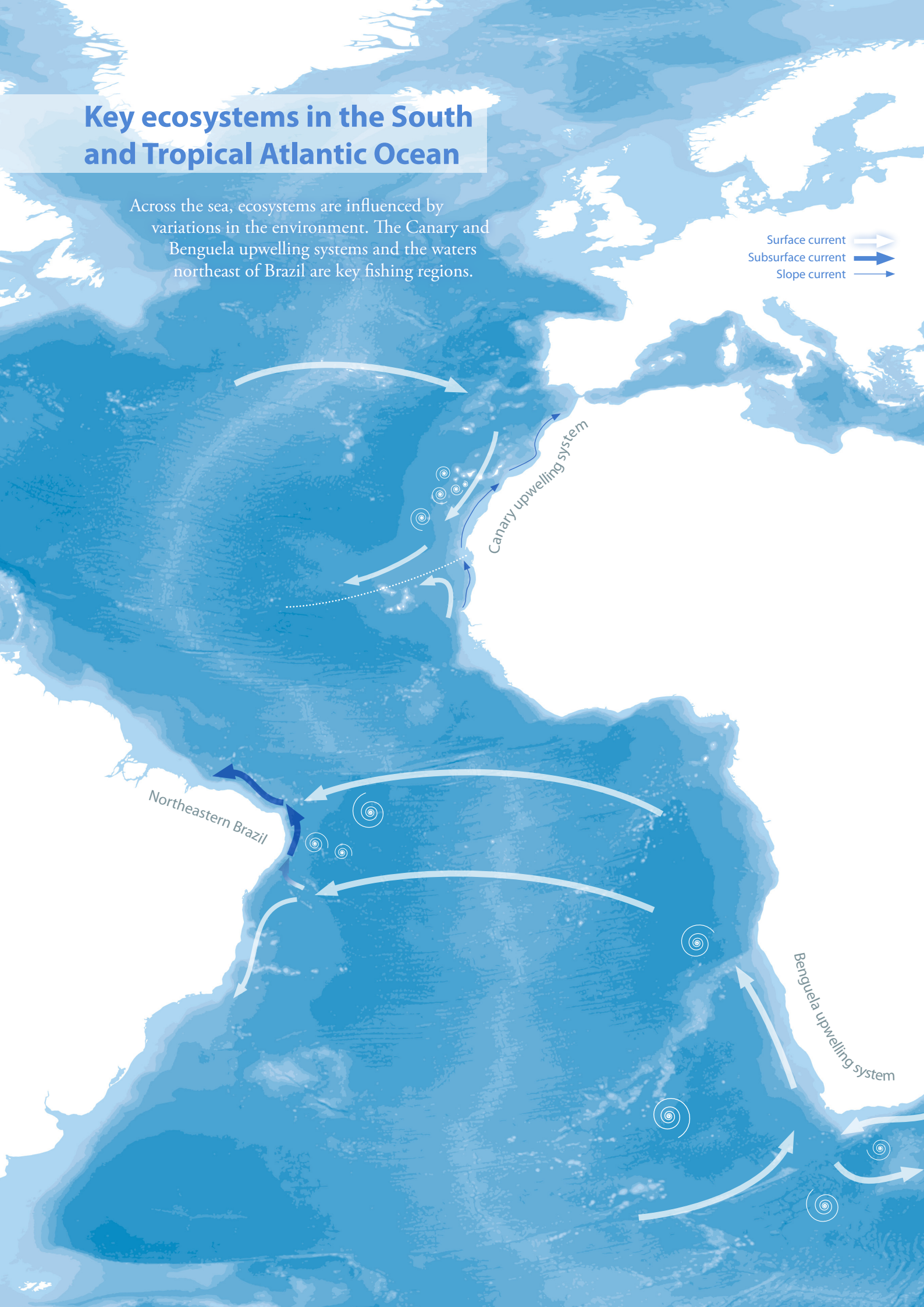


Key ecosystems in the South and Tropical Atlantic Ocean

Across the sea, ecosystems are influenced by variations in the environment. The Canary and Benguela upwelling systems and the waters northeast of Brazil are key fishing regions.

Surface current →
Subsurface current →
Slope current →



Around the Atlantic Ocean nations rely heavily on fishing and other coastal activities. Even minor changes in the environment may affect the catch.

The Atlantic plays a pivotal role in regulating Earth's climate through the Atlantic Meridional Overturning Circulation. This system of currents redistributes heat throughout the ocean, together with nutrients and oxygen, crucial for marine ecosystems.

Marine life is influenced by its environment, and small changes may affect the distribution and productivity of species. Both global warming and natural variations in the ocean circulation are seen to cause shifts in populations.

Among key fishing areas are the coast of north-

eastern Brazil and the Canary and Southern Benguela upwelling regions on the eastern side of the Atlantic.

Situated on the eastern shore, the Canary and Southern Benguela regions are prototypical eastern boundary upwelling systems, playing a disproportionate role in global ocean productivity.

Conversely, the northeastern region of Brazil lacks nutrients, except in specific locations where topographic barriers drive water nutrient-rich water to the surface.

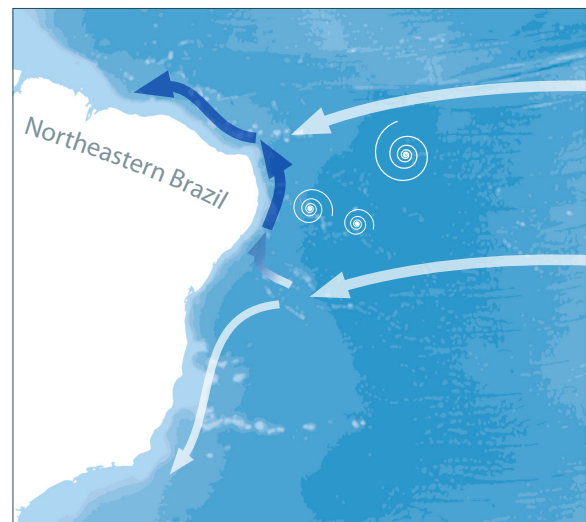
Northeast Brazil

The waters off the northeastern coast of Brazil are of fundamental importance for biodiversity and the life cycle of marine species. Overall, the region is oligotrophic, lacking nutrients.

However, oceanic islands, underwater canyons and seamounts act as topographic obstacles to currents, driving nutrient-rich water to the surface. This increases primary production, enhancing the available energy throughout the food chain.

The availability of nutrients is closely linked to seasonal patterns of dominant physical structures.¹ In fall, the upper, mixed layer is shallower than in spring, increasing the concentration of nutrients and intensifying primary production.

This supports larger populations of zooplankton, benefiting mesopelagic fish as well as seabirds. Birds like the masked boobies and red-footed boobies reproduce in fall, when they can find food closer to their nests.^{2,3}



The opposite occurs in spring, when the mixed layer is much deeper. The ocean is then much less productive and dominated by species such as salps.⁴

A warmer ocean is anticipated to be more stratified, with a deeper upper, mixed layer.⁵ Such conditions may not be conducive to commer-

cial species. Spring conditions may be a window into a future with less productive oceans.^{6,7}

Southern Benguela

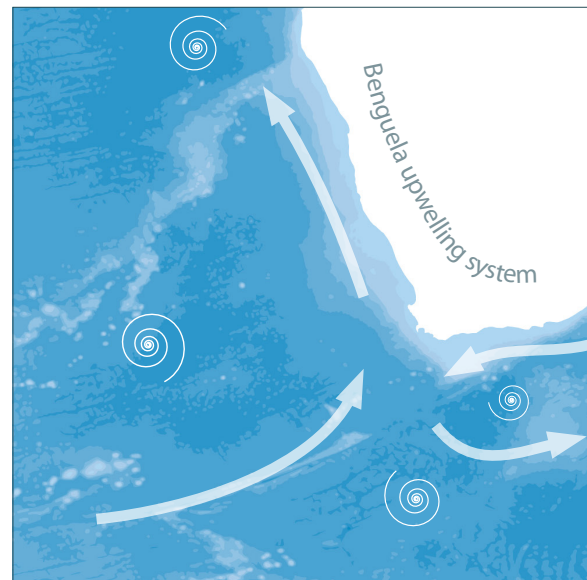
Off the west coast of South Africa, the primary driver of ecosystem dynamics is the coastal upwelling driven by the southeasterly trade winds during the Southern Hemisphere spring and summer. This system is linked to a system farther south, where the Agulhas Current rounds the cape from the east.

Overfishing of sardine on the west coast triggered an ecosystem-wide regime shift in the early 1960s⁸ as well as in the mid-1990s to early 2000s.^{9,10} The latter began due to environmental factors,^{11,12} but is thought to have been exacerbated by fishing pressure.¹³

Although inshore resources and fisheries are generally in crisis, offshore fisheries maintain a lower yet stable resource base compared to the 1950s.¹⁴

The interaction between predators and prey is complex. During the early 1990s, increased upwelling intensity and variability impacted the abundance of prey for fish and top predators in the Benguela ecosystem.

A model study has shown that sardines were the dominant species in 40 percent of the 40 most sensitive predator-prey interactions.¹⁵ Sardines exerted top-down control on small phy-



toplankton, while microzooplankton exerted bottom-up control on sardines. In the absence of other forcing, sardines and anchovies controlled microzooplankton.

The abundance of sardines also controlled several species of seabirds, while various predators controlled the sardines. No interactions were found between anchovies and their predators. These findings have implications for the management and conservation of the Benguela ecosystem and its fisheries.

The Canary Current

The Canary Current is a wide and slow eastern boundary current flowing from Iberia and along the African coast. Supported by the cur-

rent is a highly productive marine ecosystem spanning from 12°N to 43°N in the North Atlantic. The system is divided into two distinct

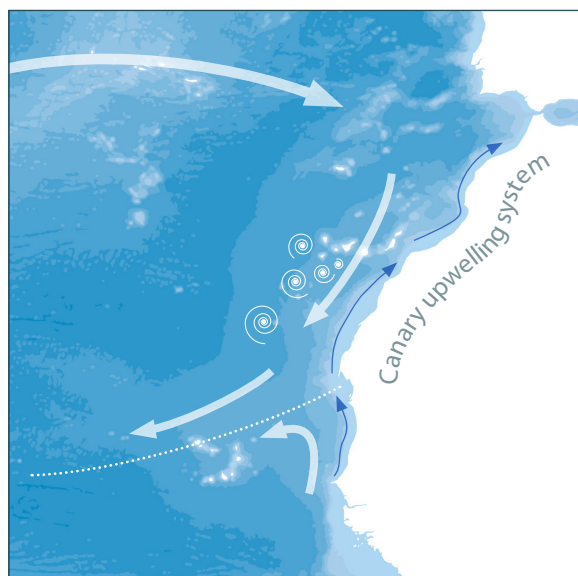
regions: the Canary upwelling region off north-western Africa and the Iberian upwelling region off the Iberian coast.

The Canary upwelling system features cold, nutrient-rich waters driven to the surface by the prevailing trade winds. The upwelling leads to high primary productivity, supporting a diverse marine ecosystem, crucial for fisheries in Spain, Portugal, Western Sahara, Mauritania and Senegal

A variety of fish is supported by the upwelling, ranging from boreal and temperate groups in the north to subtropical and tropical groups in the south. The sardine dominates pelagic catches, its contribution growing constantly till the mid-1990s, then dropping to pre mid-1970 levels. Fluctuations are attributed to environmental changes and changes in exploitation.

The catch of groundfish has decreased persistently since the early 1970s. Small-scale and industrial fisheries have expanded over the whole region.^{16,17,18}

During the last two centuries, the upwelling has oscillated synchronically with the sea sur-



face temperature off the coast of northwestern Africa. The relationship is most pronounced from June to October and has no consistent long-term trend.¹⁹

An analysis of the resilience of the Canary Current upwelling system revealed that despite significant annual variations and major challenges like overfishing and climate change, marine pelagic resources, including fish and plankton, were relatively stable over a 20-year period.²⁰

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