West Coast National Marine Sanctuaries

Blue Carbon Facts

Blue Carbon Definitions:	
Blue carbon	any carbon stored in coastal or ocean ecosystems.
Biological carbon	carbon stored in the tissues of living things, including bacteria, protists, plants, and animals. If these species are found in the ocean, they are a type of blue carbon.
Carbon sequestration	the process of absorbing or drawing down atmospheric carbon dioxide.
Carbon storage	the long-term confinement of carbon, over centuries to millennia, in plant materials or sediment. This is measured as a total weight of carbon stored.
Carbon sink	an environment that absorbs more carbon than it releases.
Carbon Reservoir	a location where carbon is stored for long periods of time, such as ocean sediments. Note: a place can be both a carbon sink and a reservoir (e.g., mangrove forest).
Carbon fixation, uptake, or capture	the part of the growth process, where plants capture carbon dioxide from the air and convert it into plant parts such as leaves, stems, or roots.
Mitigate	To make less severe, serious, or painful.

1. Blue carbon is the term for carbon captured and stored by the world's ocean and coastal ecosystems.

- Carbon dioxide cycles through the global ecosystem through the air, water, and soil.
- With more than 70% of the planet covered by water, coastal and ocean ecosystems play a significant role in the global carbon cycle by capturing, storing, and cycling 93% of Earth's CO_2.
- Over half of the world's biological carbon is stored in living marine organisms.
- The ocean influences the flow of temperature and water through the climate system similar to how a heart pumps oxygen and carbon dioxide through the blood and regulates body temperature. The ocean is not just the "heart" of the planet, it is also the largest carbon cycler.
- Some healthy coastal and ocean ecosystems can sequester carbon up to ten times more effectively than tropical forest ecosystems.
- Blue carbon ecosystems can store three to five times more carbon per unit area than tropical forests.

2. Blue carbon ecosystems help mitigate climate change.

- Coastal and marine ecosystems help mitigate climate change and its impacts by capturing atmospheric CO_2 or absorbing aqueous CO_2 from the water, fixing this CO_2 into carbon in the tissues of the plant or alga, and transporting that carbon into sediments or deep ocean waters, where it remains trapped and cannot re-enter the atmosphere and contribute to global warming.
- Seafloor sediments hold vast amounts of carbon on geologic timescales from thousands to millions of years if left undisturbed and are the largest non-fossil pool of organic carbon on the planet.
- By protecting ocean ecosystems, we preserve long term storage of carbon, helping mitigate the effects of climate change (i.e., preventing disturbance to habitats that sequester and store carbon in marine protected areas).

3. Specific species play critical roles in blue carbon ecosystems.

Seagrasses and Salt Marshes

- Eelgrass (*Zostera marina*) is a species of seagrass that thrives in protected coastal waters. It provides habitat and food for other species, prevents erosion, buffers acidic water, stores carbon in its root systems for long periods, and improves water quality.
- Seagrasses absorb CO_2 from the atmosphere and water column, storing it in underground roots.
- Coastal ecosystems such as salt marshes are subject to tidal fluctuations. These conditions (i.e., layers of decomposing dead material and salty water) create a lack of oxygen that slows decomposition, storing carbon and resulting in the storage of carbon in the leaves and roots of marsh plants.
- In addition to creating long term storage of carbon, salt marshes reduce erosion by creating wave buffer zones for upland and subtidal habitats.
- In the last century, the West Coast of the U.S. has lost 90% of its salt marshes due to development and disturbance. Coastal and marine protected areas can preserve the remaining salt marshes, which are critical for maintaining their carbon sequestration and storage benefits.

Whales

- There are three ways whales play a significant role in the global carbon cycle - 1) feeding and defecating; 2) migrating from cooler feeding grounds to warmer breeding grounds; and 3) sinking to the seafloor at death.

    1. When sperm whales feed at depth and defecate near the surface, the nutrients from the feces act as fertilizer nourishing and stimulating phytoplankton growth. Phytoplankton absorb carbon through photosynthesis converting it into usable food for other ocean consumers. This is also called the biological pump, where nutrients are cycled and carbon is absorbed through photosynthesis. (Note: whales physiologically can only defecate near the surface, not in the deep sea).
    2. When whales migrate from the cooler nutrient rich feeding waters to warmer nutrient poor waters (such as calving/breeding areas), the whales presence stimulates phytoplankton growth by making nutrients available through defecation. This phytoplankton growth enhances carbon absorption and storage.
    3. Whales store tons of carbon in their bodies (referred to as a biological carbon). When a whale dies, its body falls to the ocean floor, where it is slowly absorbed into the sediment layer. A large whale stores an average of 9 tons of carbon, the greenhouse gas equivalent of 7 gasoline-powered passenger vehicles driven for one year.

Kelp

- Kelps are photosynthetic: they absorb carbon dioxide and convert it to simple sugars, supporting a wide diversity of marine life.
- Kelp can grow as fast as two feet in a day, which means it absorbs carbon very efficiently with rapid growth.
- Kelps are important carbon recyclers. During winter storms, torn kelp fronds (~10%) drift into the ocean before sinking and settle on the seafloor to become part of ocean sediment. Torn kelp that doesn't drift and sink offshore, washes ashore on beaches forming "kelp wracks" that provide food and habitat for beach invertebrates, which in turn are fed upon by migrating shorebirds. While this does not contribute to carbon storage, it is important for other ecological processes.

Phytoplankton

- Microscopic phytoplankton are photosynthetic plant-like organisms that blanket the sunlit ocean's surface.
- Phytoplankton are responsible for generating approximately 50% of the world's oxygen
- Phytoplankton absorb CO_2 and, when they die, some sink to the ocean floor resulting in the movement of carbon from surface waters to the deep sea, where it can be stored for the long term.
- Sometimes referred to as "grasslands of the sea," phytoplankton are consumed by zooplankton and many larval invertebrates, converting carbon in the atmosphere into biological carbon (the carbon stored in living things). Additionally, a portion of those animals' feces may then sink to the ocean floor depositing carbon on the ocean floor as a carbon sink.

Fish

- Midwater fish, or "mesopelagic fish" that live between 650–3,300 feet (200–1,000 m) below the ocean's surface, transport carbon to the deep ocean by consuming plankton and other organisms at the surface of the ocean, and excreting waste at depth.
- When fish are eaten by other predators, their carbon is transferred from organism to organism (biological carbon). When fish and their predators die, their remains fall to the sea floor, storing carbon in the deep sea longterm.
- Sustainable fishing practices maintain robust fish populations and their important role in carbon sequestration.

4. Marine protected areas preserve blue carbon habitats and processes.

- Marine protected areas, such as national marine sanctuaries and marine national monuments, are nature-based solutions that enhance climate resilience by prohibiting activities that disrupt carbon storage (i.e., oil/gas extraction, seafloor disturbance, coastal development) and conserving biodiversity.
- Marine protected areas support conservation, research, and restoration of critical blue carbon habitats.
- National marine sanctuaries on the West Coast help keep carbon in long term storage by protecting estuaries from draining and development, restoring eelgrass, and by prohibiting sediment-disturbing activities like gas and oil exploration and extraction.

- National marine sanctuaries implement management practices to help keep whales safe from ship strikes when traveling through sanctuary waters adjacent to busy commerce shipping lanes.
- In 2020, the United States and world wide partners committed to conserve at least 30% of the world's oceans/waterways and 30% of the land by 2030, in part to protect these efficient carbon sink areas.
- Marine protected areas protect valuable blue carbon habitats and processes, and must be included in efforts to reduce the impacts of climate change.
- When blue carbon systems are damaged, an enormous amount of previously stored carbon is emitted back into the atmosphere, where it can then contribute to climate change. Protecting and restoring coastal habitats is essential to reducing the impacts of climate change.
- When we protect the carbon in coastal systems, we protect healthy coastal environments that provide many other benefits to people, such as recreational opportunities, storm protection, and nursery habitat for commercial and recreational fisheries.
- Putting a healthy ocean at the heart of decision-making is essential so that effective protection of coastal and marine carbon cycles, sinks, and reservoirs can help mitigate the effects of climate change and support biodiversity

Carbon-rich salt marsh habitat along the shores of Bolinas Lagoon Photo: NOAA

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