“Poop, Roots, and Deadfall: The Story of Blue Carbon”

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THE OCEAN FOUNDATION

Why Blue Carbon?

- Blue carbon offers a win/win/win
- It allows for collaborative multi-stakeholder engagement in climate change adaptation and mitigation

The Ocean and Carbon

- The ocean is by far the largest carbon sink in the world
- It removes **20-35%** of atmospheric carbon emissions
- Biological life in the ocean captures and stores **93%** of the earth’s carbon dioxide
- It has been estimated that biological life in the high seas capture and store **1.5 billion metric tons** of carbon dioxide per year

What is Blue Carbon?

Christiaan Triebert

Blue Carbon is the ability of tidal wetlands, seagrass habitats, and other marine organisms to **take up carbon dioxide** and other greenhouse gases from the atmosphere, and store them helping to **mitigate the effects of climate change**.

- **Carbon Sequestration** – The process of capturing carbon dioxide from the atmosphere, measured as a rate of carbon uptake per year
- **Carbon Storage** – the long-term confinement of carbon in plant materials or sediment, measured as a total weight of carbon stored

Carbon Stored and Sequestered By Coastal Wetlands

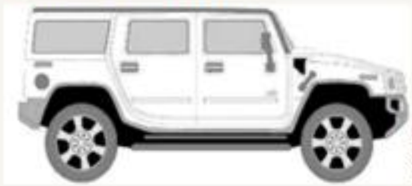
- Carbon is held in the above and below ground plant matter and within wetland soils and seafloor sediments.
- As plants grow, carbon accumulates annually and is held within soils for centuries.

When degraded or lost, these habitats not only lose their ability to capture and store carbon, but also release their stored carbon – sometimes **8,000 years' worth** – back into the atmosphere!

Commission for Environmental Cooperation, 2016

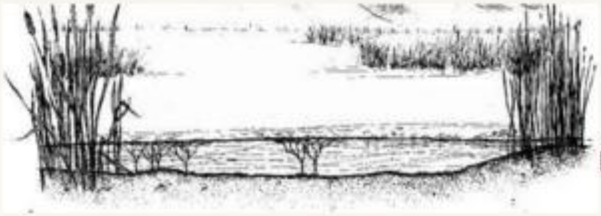
Carbon Comparisons

Carbon Comparisons:



Hummer driving 15,000 miles emits 11 tons CO_2e (carbon dioxide equivalents)

Prius driving 15,000 miles emits 3.7 tons CO_2e



....while just 1 hectare (about 0.004 square miles) of Salt Marsh REMOVES 8 tons CO_2e every year.

E. Pidgeon, 2014

Types of Coastal Storage Habitats

- Seagrass
- Salt Marsh
- Mangroves

Seagrass

- Seagrasses are underwater marine flowering plants that root in the sediments and produce flowers, pollen, and seeds below the oceans surface
- Seagrass meadows are found from the intertidal zone to 90m deep, and range in area from a few square meters to hundreds of square kilometers
- Seagrasses are estimated to be responsible for 15% of total carbon storage in the ocean, even though they only occupy 0.2% of the area of the ocean.

Salt Marsh

- Salt marshes are found from the Arctic to the tropics and typically are composed of grasses, sedges and rushes.

- Carbon accumulates in both the above-ground (leaves and stems) and below-ground (roots and rhizomes) tissue due to salt marshes ability to translocate this CO_2 into soil biomass.

Commission for Environmental Cooperation, 2016

U.S. Fish and Wildlife Service

Mangroves

- The term mangrove is applied to intertidal, arboreal species, including ferns, that tolerate salinity along the coasts of bays and estuaries in tropical climates
- Mangrove soils are a major carbon pool where organic carbon is stored for millennia
- More carbon stocks are lost to conversion from mangroves to cattle pastures, than terrestrial forests to cattle pasture.

Commission for Environmental Cooperation, 2016

Anton Bielousov

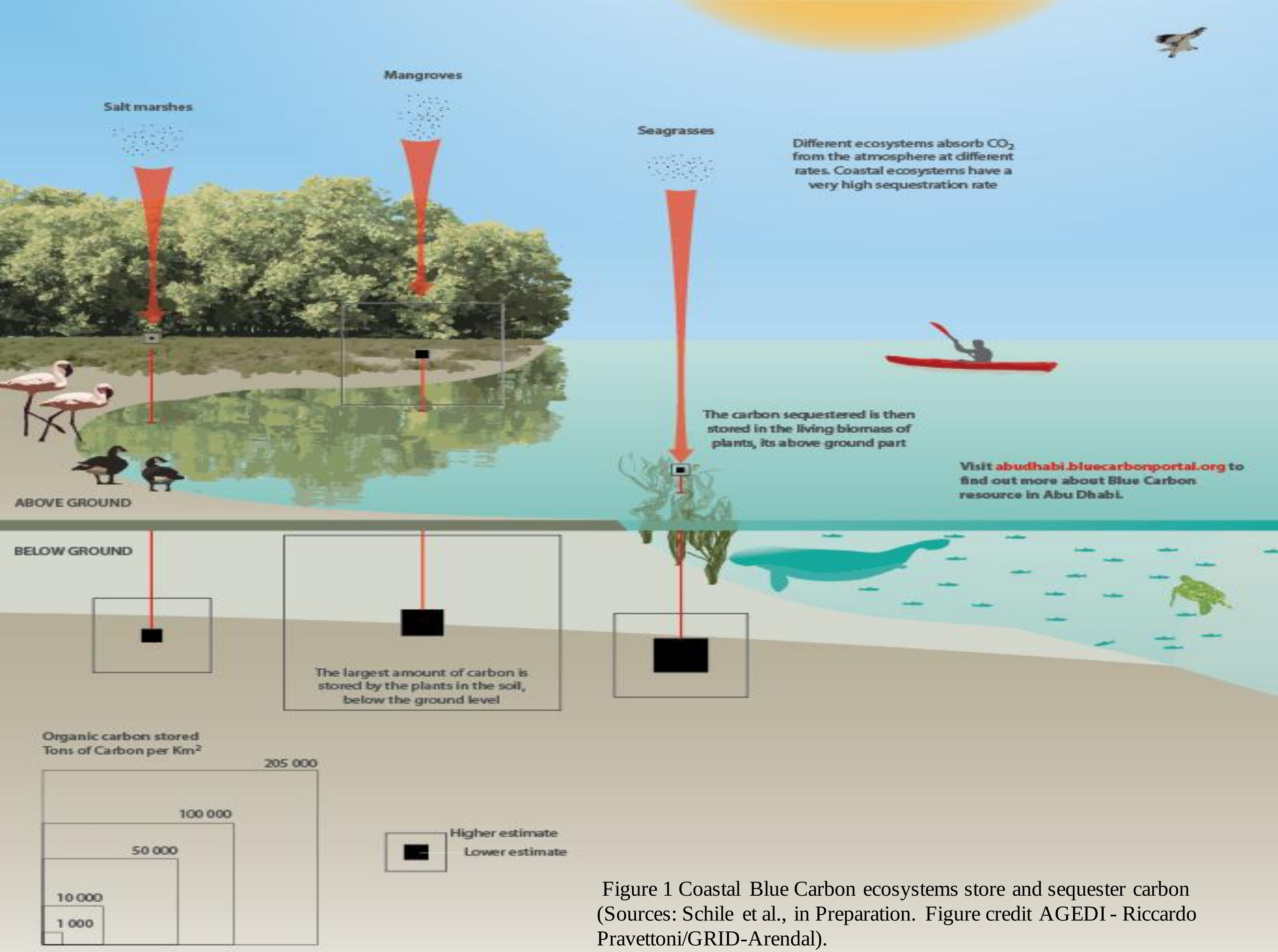


Figure 1 Coastal Blue Carbon ecosystems store and sequester carbon (Sources: Schile et al., in Preparation. Figure credit AGEDI - Riccardo Pravettoni/GRID-Arendal).

What Else Stores CO_2 in the Ocean?

- Coastal plants are not the only marine organisms that sequester and store carbon
- An increasing number of studies are being published that explore the value of marine biota, other than plankton, in the biological carbon pump
- The role of higher level marine life may play a larger role in carbon cycling than previously thought

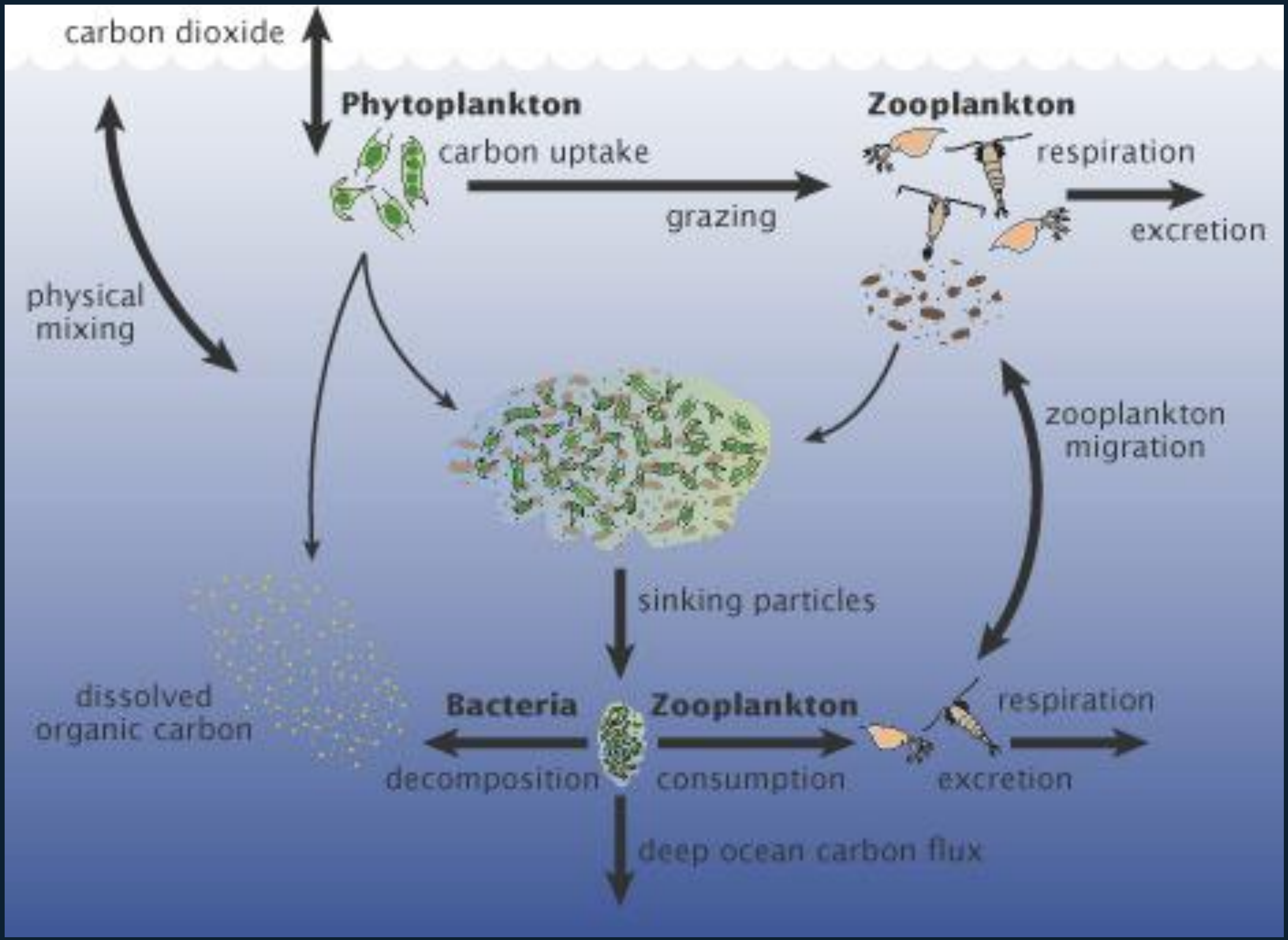
Saba and Steinberg, 2012; Lebrato et al. 2013; Marlow et al. 2014; Roman et al. 2014

Phytoplankton and Zooplankton

- Phytoplankton are responsible for most of the transfer of carbon dioxide from the atmosphere to the ocean through photosynthesis
- This so called “biological pump” is believed to be responsible for the removal of about half of the CO_2 produced

Lutz and Martin, 2014

Phytoplankton Photosynthesis

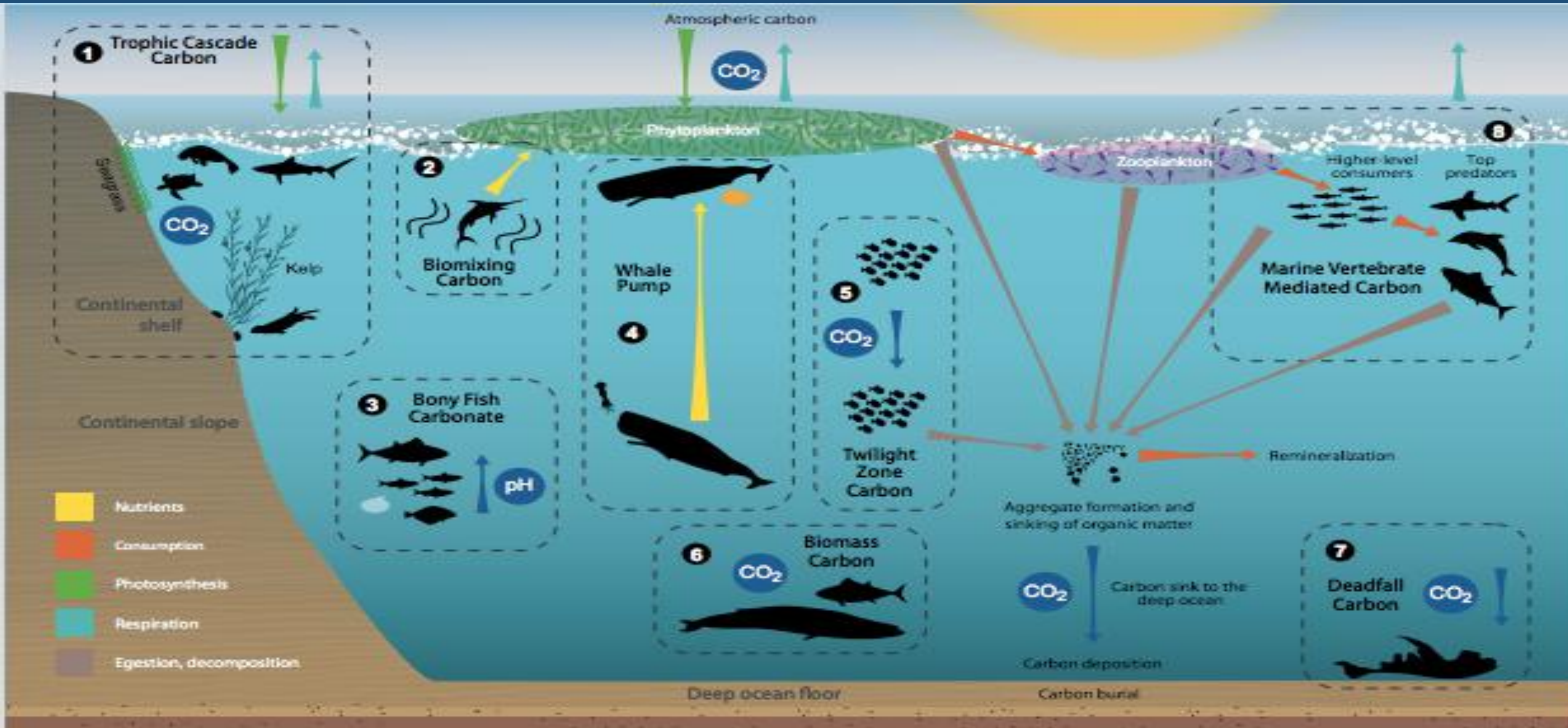


A New Wave of Ocean Science, U.S. JGOFS

Fish Carbon

- Through **8** different biological carbon cycling mechanisms, marine vertebrates facilitate **long term carbon sequestration** through the uptake of atmospheric carbon transferred to deep waters and sediment

Lutz and Martin, 2014



1	**Trophic Cascade Carbon**	Food web dynamics help maintain the carbon storage and sequestration function of coastal marine ecosystems (e.g. the health of primary producers such as seagrass meadows and kelp forests is maintained by herbivory and predation).
2	**Biomixing Carbon**	Turbulence and drag, associated with the movement of marine vertebrates, causes enhanced mixing of nutrient rich water from deeper in the water column towards the surface, where it enhances primary production by phytoplankton and thus the uptake of dissolved CO_2.
3	**Bony Fish Carbonate**	Bony fish excrete metabolised carbon as calcium carbonate (CaCO3) enhancing oceanic alkalinity and providing a buffer against ocean acidification.
4	**Whale Pump**	Nutrients from the faecal material of whales stimulate enhanced primary production by phytoplankton, and thus uptake of dissolved CO_2.
5	**Twilight Zone Carbon**	Mesopelagic fish feed in the upper ocean layers during the night and transport consumed organic carbon to deeper waters during daylight hours.
6	**Biomass Carbon**	Marine vertebrates store carbon in the ocean as biomass throughout their natural lifetimes, with larger individuals storing proportionally greater amounts over prolonged timescales.
7	**Deadfall Carbon**	The carcasses of large pelagic marine vertebrates sink through the water column, exporting carbon to the ocean floor where it becomes incorporated into the benthic food web and is sometimes buried in sediments (a net carbon sink).
8	**Marine Vertebrate Mediated Carbon**	Marine vertebrates consume and repackage organic carbon through marine food webs, which is transported to deep waters by rapidly sinking faecal material.

1. Trophic Cascade Carbon

- The trophic cascade of carbon through marine systems is regulated by food web dynamics

- Grazing animals consume plants such as kelp and seagrass, which contributes to carbon storage and sequestration function by stimulating regenerative growth

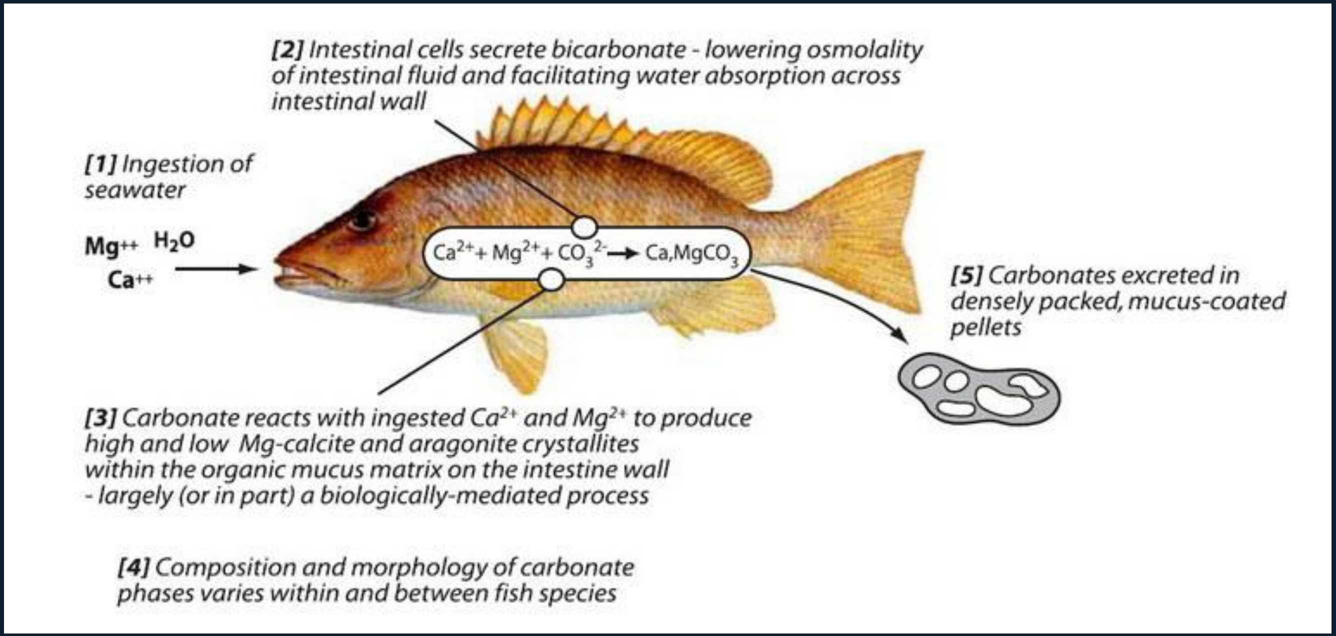
Preen 1995, Aragones and Marsh 2000, Kuiper-Linley et al. 2007

2. Biomixing Carbon

- Turbulence and drag, associated with the movement of marine vertebrates, transport nutrient-rich water from the deep to the upper ocean
- This mixing of nutrient-rich water enables primary production by phytoplankton in otherwise nutrient-poor waters.
- This process enhances the uptake of dissolved CO_2 through primary production by phytoplankton

Dewar et al. 2006, Lavery et al. 2012

3. Bony Fish Carbonate



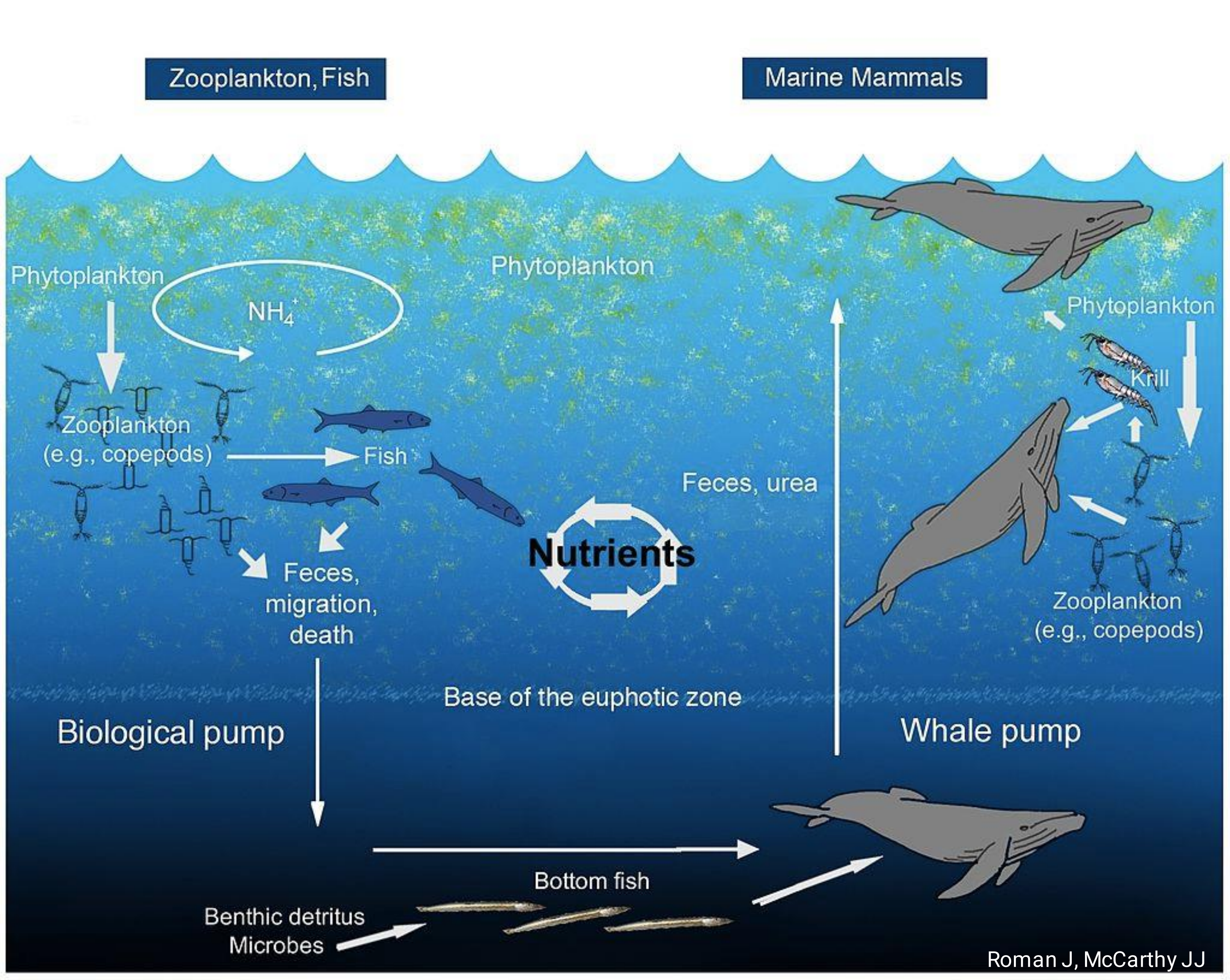
Bony fish **poop metabolised carbon** as calcium carbonate ($CaCO_3$) **enhancing oceanic alkalinity** and providing a buffer against ocean acidification

Wilson et al. 2011

4. Whale Pump

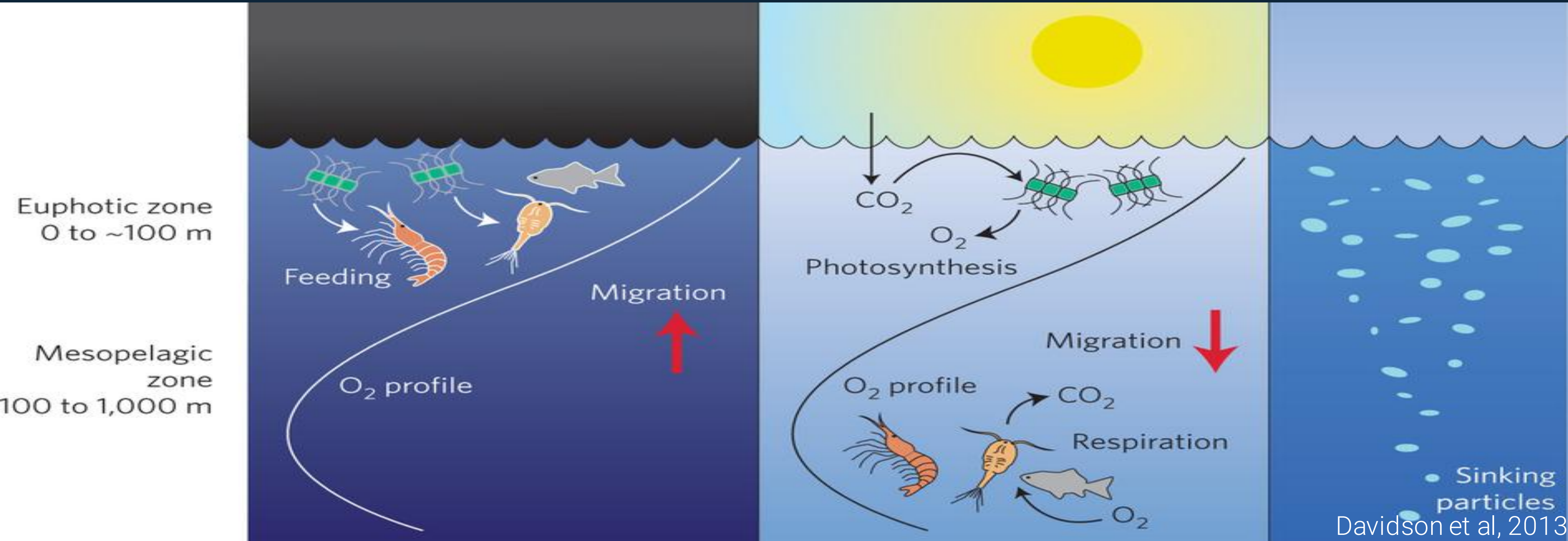
- Nutrients from the fecal material of whales stimulate enhanced uptake of **dissolved CO_2** through primary production by phytoplankton

- As highly migratory organisms, whales **transport nutrients** across oceans


Zooplankton, Fish
Marine Mammals
Phytoplankton
NH_4^+
Phytoplankton
Phytoplankton
Krill
Zooplankton
(e.g., copepods)
Fish
Feces, urea
Nutrients
Feces,
migration,
death
Zooplankton
(e.g., copepods)
Base of the euphotic zone
Biological pump
Whale pump
Bottom fish
Benthic detritus
Microbes
Roman J, McCarthy JJ

5. Twilight Zone Carbon

- Mesopelagic fish feed in the upper ocean layers during the night and **transport consumed organic carbon** to deeper waters during daylight hours



Davidson et al, 2013

6. Biomass Carbon

- Marine vertebrates store carbon in the ocean as biomass throughout their natural lifetimes, with larger individuals storing proportionally greater amounts over prolonged timescales

- CO_2 storage in the tissues of large vertebrates is comparable to the centennial timescale of CO_2 storage associated with terrestrial forests

Sedjo, 2001; Fenton et. Al, 1991; George et al., 1999

7. Deadfall Carbon

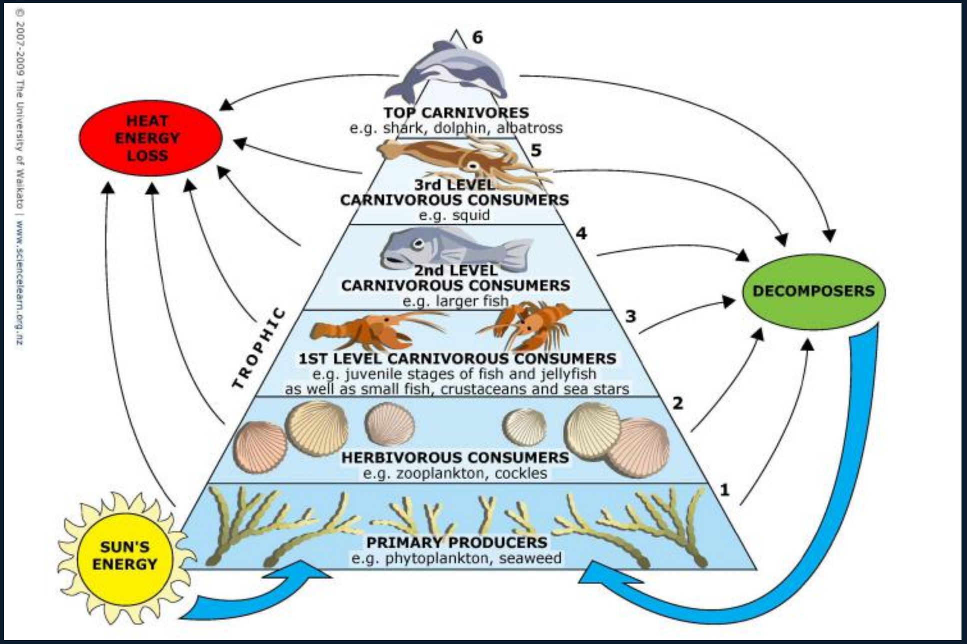
- The carcasses of large pelagic marine vertebrates **transport carbon** to the ocean floor when they die and sink
- It has been estimated that if whale populations were at pre-whaling levels, an additional **160k tons of CO_2 emissions annually** would be transferred to the deep sea through whale dead falls!
- When CO_2 enters deep sea ecosystems, it can be stored on timescales of **thousands to millions of years**

Lutz et al, 2007; Pershing et al. 2010

8. Marine Vertebrate Mediated Carbon

- Through marine food webs, marine vertebrates consume and repackage organic carbon, which is transported to deep waters by rapidly sinking fecal material

- Fecal matter contains high amounts of carbon and sinks at faster rates than that of plankton



Saba and Steinberg, 2012; Robison and Bailey, 1981

What does Blue Carbon need?

- A healthy ocean
- Good, clean water quality
- Natural levels of nutrients
- Little or no land-based sources of pollution
- No human disturbance

Threats to Blue Carbon

Threats to Blue Carbon

- Effects of climate change
  - Warming waters, sea level rise, increased storm intensities, etc.
- Onshore Human Activities
  - Coastal development, sea level rise, nutrient runoff, etc.
- Overfishing
  - As we consider marine vertebrates as playing a vital roll in carbon sequestration and storage

Climate Change

- Basic physical changes caused by global warming threaten food supplies, species health, habitat, and reproduction
- Inundation of nearshore and coastal mangrove forests, seagrass meadows, and coastal marshes
- Erosion from storm surge
- Transition to less-sensitive plant species in response to changing chemistry and warmer temperatures
- Risk of added debris, ship groundings (fuel spills), and other consequences of intensified, less predictable storm activity

Human Activities

- Unwise coastal development (e.g. shrimp aquaculture, resort development)
- Hardening of shorelines (seawalls, riprap etc.) diverts wave action and removes natural barriers (and carbon storage capacity)
- Reckless boaters in vulnerable areas— prop scars, animal collisions (manatees), sediment disturbance, fuel spills
- Dredging
- Energy infrastructure

Land Based Pollution

- Sources of land based pollution that threaten blue carbon habitats include:
  - Toxic runoff
  - Untreated sewage
  - Nutrient enrichment from land runoff
  - Heavy siltation
  - Marine litter
  - Oil spills
  - Organic pollutants and heavy metals

Overfishing and Whaling

- Undermine the role of marine vertebrates in carbon sequestration by removing biomass
- **60%** of world fisheries (an important link in the carbon cycle story) have been affected by overfishing
- Fishing methods such as bottom trawling **reduces carbon and nutrient flux** to bottom habitats while disrupting sea floor sediments and its stored carbon.

Pusceddu *et al*. 2014; Pitcher and Cheung 2013; Lutz and Martin 2014

Blue Carbon Solutions

Gaining Ground

- Blue carbon is gaining attention and is a concept that could become the catalyst for the protection and restoration of our natural coastal and marine environments

- Blue carbon projects can work to fulfill the dual purpose of climate change mitigation and enhanced coastal ecosystems values

- There is an unmet need for coastal conservation funding

Blue Carbon Focus at COP21

- **Dominican Republic Blue Carbon NAMA** – the worlds first ‘blue carbon’ Nationally Appropriate Mitigation Action (NAMA) submitted to the UNFCCC

- **Just Blue It** report by the UNEP/GEF Blue Forests Project explores how blue carbon has been applied in recent policy and management and can to help meet the UN Global Goals on Sustainable Development.

Blue Carbon Focus at Paris COP21

- **Mikoko Pamoja** - the world’s first working community-based payments for mangrove carbon–offset project. Located in Gazi Bay, Kenya, and verified by Plan Vivo, it involves community-based policing of illegal mangrove harvesting, as well as the application of local expertise in mangrove planting.

Abu Dhabi Global Environmental Data Initiative (AGEDI)

- The Abu Dhabi Blue Carbon Demonstration Project serves as a snapshot of Abu Dhabi’s insights concerning their own blue carbon ecosystems, the roles these ecosystems play in their society and economy, and options to ensure their continued existence

- Introductory guide to share experience and stimulate discussion regarding projects that support the conservation and restoration of coastal ecosystems based on blue carbon approach

AGEDI. 2014. Building Blue Carbon Projects – An Introductory Guide. AGEDI/EAD. Produced by GRID-Aren

Key Takeaways in Abu Dhabi

- When healthy, Blue Carbon ecosystems store and sequester carbon helping to mitigate climate change, help safeguard biodiversity, and are also vital to many coastal and island communities through the numerous important ecosystem services they provide.

- When degraded, Blue Carbon ecosystem contribute to climate change by releasing stored greenhouse gases into the atmosphere and providing fewer ecosystem services.

AGEDI. 2014. Building Blue Carbon Projects – An Introductory Guide. AGEDI/EAD. Produced by GRID-Arendal.

Coastal Carbon in U.S. Federal Statues and Policies

- 2015 National Ocean Policy (NOP) Implementation Plan
  - Contains an action item that directs federal agencies to pay special attention to coastal carbon in new coastal management and conservation polices and incorporate it into existing policies.
  - Mentions the consideration of blue carbon when conducting risk-based climate change vulnerability assessments and developing adaptation action plans for the future.

“Report on the Implementation of the National Ocean Policy. 2015. The White House

Federal Agencies

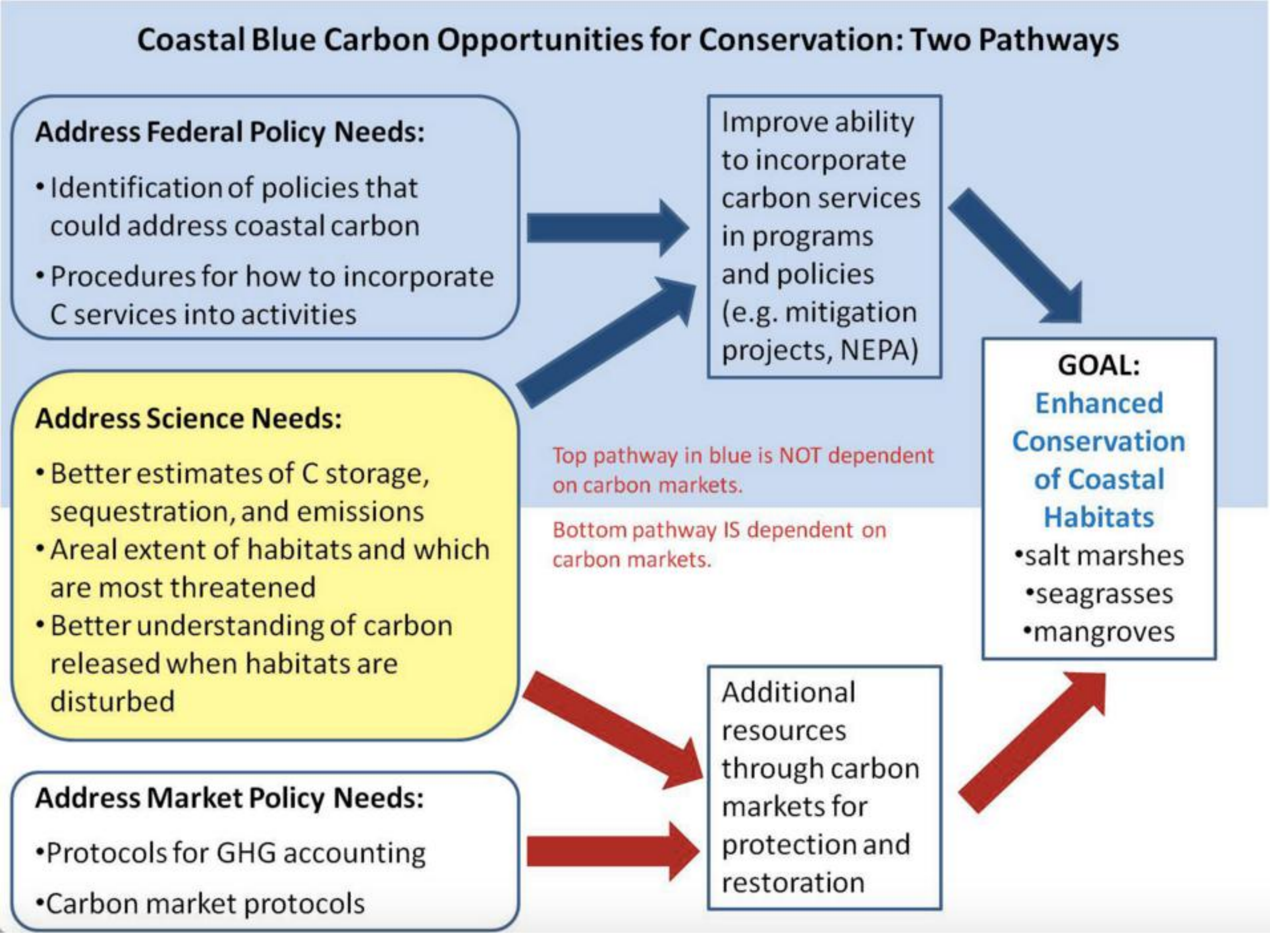
- **NOAA, FEMA, U.S. Army Corps of Engineers, and U.S. Global Change Research Programs** in partnership with **Restore America’s Estuaries (RAE)** are working to advance awareness of coastal blue carbon by

  - Exploring how to incorporate carbon services along with other ecosystem services

  - Fill science gaps to more effectively and accurately account for carbon services these habitats provide

  - Develop protocols for including coastal carbon services into carbon markets

“Report on the Implementation of the National Ocean Policy. 2015. The White House


Coastal Blue Carbon Opportunities for Conservation: Two Pathways
Address Federal Policy Needs:
•Identification of policies that could address coastal carbon
•Procedures for how to incorporate C services into activities
Improve ability to incorporate carbon services in programs and policies (e.g. mitigation projects, NEPA)
Address Science Needs:
•Better estimates of C storage, sequestration, and emissions
•Areal extent of habitats and which are most threatened
•Better understanding of carbon released when habitats are disturbed
Top pathway in blue is NOT dependent on carbon markets.
Bottom pathway IS dependent on carbon markets.
GOAL:
Enhanced Conservation of Coastal Habitats
•salt marshes
•seagrasses
•mangroves
Additional resources through carbon markets for protection and restoration
Address Market Policy Needs:
•Protocols for GHG accounting
•Carbon market protocols

Domestic Blue Carbon Project

- RAE’s Coastal Blue Carbon Opportunity Assessment for the Snohomish Estuary, in partnership with NOAA, determined that planned and ongoing restoration projects in the Snohomish estuary will result in at least **2.55 million tons** of carbon dioxide sequestered over the next 100 years!

“Report on the Implementation of the National Ocean Policy. 2015. The White House

Blue Carbon Solutions

- Certain coastal and marine ecosystems—such as healthy mangrove forests, seagrass meadows and saltwater **marshlands—sequester significant amounts of carbon**
- This sequestered carbon can be quantified and its **economic value calculated**, similar to how forests are currently traded as carbon credits
- The revenue from a blue carbon credit mechanism can then be used to **fund restoration efforts**, which in turn generate more credits

Blue Carbon Solutions

- The revenue from a blue carbon credit mechanism can then be used to fund restoration efforts, which in turn generate more credits

- **11 US Senators** recently endorsed this potential expansion of the market for carbon offsets in the **American Power Act** and the **Clean Energy Partnerships Act**

- Blue Carbon projects can create jobs, restore degraded ecosystems, protect coastal communities and stimulate local economies… **all while helping address climate change!**

TOF’s Blue Carbon Solution

SeaGrass Grow

SeaGrass Grow

- Established in 2008, SeaGrass Grow was created as a way to address climate change, drive ocean investment and innovation, and restore critical endangered habitat that provides considerable ecosystem services to the communities it supports.

- A recent article in the *Nature Geoscience* journal asserts that seagrass meadows, currently one of the world's most threatened ecosystems, is a critical solution to climate change.

Fourqurean, J.W. et al. 2012. Seagrass ecosystems as a globally significant carbon stock. Nature Geoscience. doi: 10.1038/NGEO1477

Why Seagrass?

Carbon Storage

Seagrass habitats can store up to 45 times more carbon than terrestrial forests.

Economic Benefits

For every $1 invested in coastal restoration projects, $15 in net economic benefits is created.

Food & Habitat

A single acre of seagrass may support as many as 40,000 fish, and 50 million small invertebrates like crabs, oysters, and mussels.

Safety Benefits

Seagrass meadows reduce flooding from storm surges and hurricanes by soaking up seawater and dissipating wave energy.

Carbon Seaquestration

Seagrasses occupy 0.1% of the seafloor, yet are responsible for 11% of the organic carbon buried in the ocean. Seagrass meadows, mangroves and coastal wetlands capture carbon at a rate two to four times greater than tropical forests.

Ecosystem Services

Seagrass meadows form the basis of the world's primary fishing grounds, supplying 50% of the world's fisheries. They provide vital nutrition for close to 3 billion people, and 50% of animal protein to 400 million people in the third world.

Alarming Rate of Loss

Between 2–7% of the earth's seagrass meadows, mangroves and other coastal wetlands are lost annually, a 7x increase compared to only 50 years ago.

Your Role

If more action is not taken immediately to restore these vital habitats, most may be lost within 20 years. SeaGrass Grow gives you the opportunity to help restore these areas AND reduce your carbon footprint.

SeaGrass Grow

- This innovative carbon offset program employs the first ever verified carbon offset “Methodology for Tidal and Wetland Restoration” by the Verified Carbon Standard (VCS).

- There are three components to our seagrass blue carbon offset program:
    - **Direct Benefits (VCS):** The carbon storage that occurs over the lifetime of the restored seagrass meadow.
    - **Benefits from Erosion Prevention:** The carbon storage that occurs in protected seagrass meadows.
    - **Benefits from Prevention of Rescarring:** The carbon storage that would occur from an absence of boat propeller scars and groundings.

Offset Your Carbon Footprint Defend Our Coasts & Ocean

Begin by Calculating for:

Trip

Household

Business

Our Impact on the Ocean to Date:

223,481 Total Tons of Carbon Offset

335,222 Sq. Ft. of Seagrass* Planted to Date!

*or other wetland equivalent

SeaGrass Grow

- Our blue carbon calculator allows us to quantify blue carbon and calculate its economic value, similar to how forests are currently traded as carbon credits
  - We currently provide offsets at the competitive rate of **$10/1ton CO_2**
- The revenue from this blue carbon credit mechanism is used to fund restoration efforts, which in turn generate more credits, a cycle that benefits all involved.

Challenge of Blue Carbon Solutions

- Blue carbon is a relatively new concept and we don’t have all the science we need for every setting

- Demonstrating blue carbon and implementing project results are challenging goals as they go beyond business as usual in order to create and understand and secure carbon and coastal ecosystem benefits.

The Hope behind Blue Carbon Solutions

- Blue carbon offers a win/win/win– for local habitat/storm buffer restoration, local and regional acidification mitigation, and for replication in multiple settings
- It allows for collaborative multi-stakeholder engagement in climate change adaptation and mitigation in something of a "neutral zone" politically
- More Critters! A Healthier Ocean!

Thank You!

www.oceanfdn.org

wwww.oceanfdn.org/calculator

THE OCEAN FOUNDATION

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