The Truth about Whales' Contribution to Climate Change Mitigation

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For some time, the theory that whales significantly contribute to reducing atmospheric carbon dioxide linked to global warming and climate change has been highlighted by foreign media and anti-whaling groups, sometimes cited as new grounds for opposing whaling. In 2019, a paper titled "Nature's solution to climate change: a strategy to protect whales can limit greenhouse gases and global warming" (Finance Dev. 56, 34–38), authored by analysts from the International Monetary Fund (IMF), was published and generated significant attention. Furthermore, in February 2024, the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) stated on the official U.S. government website that "Whales can help mitigate climate change impacts by storing carbon in their bodies and transporting nutrients that benefit ocean food chains." This story has led to the claim being cited more frequently as an established fact.

This article examines the content of the NOAA story and introduces opposing views including that of researchers at Griffith University (Australia).

1. NOAA Story

On February 13, 2024, NOAA published a story titled "Whales and Carbon Sequestration: Can Whales Store Carbon?" on its official website. This story has been widely covered by media outlets, primarily overseas, and through repeated citation, it has become established as conventional wisdom.

So how does NOAA's story describe whales' contribution to climate change mitigation? Below is a summary with commentary.

It is well known that approximately one-third of the carbon dioxide released into the atmosphere is absorbed by the oceans, and without this oceanic absorption, atmospheric temperatures would rise significantly higher than they are today. This carbon dioxide (or its carbon) absorbed and sequestered by the oceans is called "blue carbon" and is attracting attention.

The breakdown of this blue carbon is as follows: (1) carbon absorbed by aquatic plants, algae, and phytoplankton; (2) carbon stored within the bodies of living animals; and (3) carbon sequestered in deep-sea sediments.

According to NOAA, "Scientists believe whales contribute to all three of these carbon storage mechanisms," and "They likely supported even greater amounts of blue carbon storage before their populations were depleted by commercial whaling in the 1800s." Therefore, "Conserving and recovering whale populations can mitigate climate change by increasing blue carbon capture, benefiting marine and terrestrial species alike."

So, specifically, by what mechanism does NOAA explain that whales contribute to blue carbon storage?

(1) Biomass Storage (Living Animal Bodies)

> "Whales are some of the largest and longest living animals on earth. This allows them to store greater quantities of carbon in their bodies for longer than smaller animals. Whales efficiently digest and store large quantities of carbon-rich prey and exhale very little carbon dioxide back into the atmosphere. This process allows whales to store more carbon in their bodies than trees. One whale can capture an average of 33 tons of carbon dioxide over its lifespan. A live oak tree, one of the most efficient carbon-capturing tree species, captures roughly 12 tons of carbon dioxide over a maximum 500-year lifespan."

It is true that organisms store carbon as a component of their bodies. However, the claim that whales "exhale very little carbon dioxide back into the atmosphere" requires verification.

Furthermore, according to Yinon M. Bar-On *et al*.[1], the total carbon mass of life on Earth (referred to as biomass in the paper) is estimated to be approximately 550 billion tons (550 gigatons C). Of this, plants account for approximately 450 billion tons (450 gigatons C, 82%), and bacteria account for approximately 70 billion tons (70 gigatons, 13%). Following these are fungi at 12 gigatons C, archaea (including halophiles, methanogens, thermophiles, etc.) at 7 gigatons C, and protists at 4 gigatons C, collectively accounting for 98.73% of total biological carbon. In contrast, the total carbon mass of animals is approximately 2 billion tons (2 gigatons C, 0.4%), with the total carbon mass of humans being a mere 60 million tons (0.006 gigatons C, 0.01%). Furthermore, the total carbon mass of marine mammals is reportedly one-tenth that of humans. Calling this a major contribution to climate change mitigation is a stretch.

(2) Whale Carcass Sinking to the Ocean Floor

> "After whales die, their carcasses often sink to the seafloor (called a "whale fall"), trapping the carbon stored in their bodies at the bottom of the ocean. Whale falls can sequester carbon for hundreds to thousands of years. Many deep-sea organisms have evolved to rely on nutrients from sinking carcasses. Whale carcasses are responsible for a large portion of those nutrients due to their massive size. As the carcass decomposes and is eaten by deep sea animals, that carbon is sequestered in sediment and cycled through the deep-sea ecosystem. This prevents it from returning to the atmosphere as carbon dioxide."

As seen in (1) above, even if all the carbon contained in whale carcasses—a fraction of the carbon total of marine mammals, which themselves account for less than 0.04% of the total

[1] Bar-On, Y. M., Phillips, R. and Milo, R., (2018). The biomass distribution on Earth, Proc. Natl. Acad. Sci. USA, 115(25):6506-6511. doi: 10.1073/pnas.1711842115. Epub 2018 May 21.

carbon of all living organisms—were to return to the atmosphere, the adverse effects on climate change should be undetectable. Estimating the total amount of whale-derived carbon supposedly isolated on the seafloor "for hundreds to thousands of years" and quantitatively discussing its contribution to climate change mitigation is difficult. It is common sense to consider that the amount of plant-derived carbon isolated from the atmosphere for many years in the form of leaf mold, coal, etc., is probably orders of magnitude greater. Therefore, it is reasonable to conclude that the quantitative analysis of carbon from whales sequestered on the seafloor itself holds little significant meaning.

To grasp the difference in magnitude, let us compare the total carbon content of existing marine mammals with the carbon contained in the annual anthropogenic carbon dioxide emissions—although it is an unrealistic assumption and an illogical comparison. According to the paper by Yinon M. Bar-On *et al.*, the total carbon mass of marine mammals (not just whales) is approximately 600,000 tons, about one-tenth of the 0.06 billion tons of total human carbon mass. On the other hand, annual anthropogenic carbon dioxide emissions reached 57.1 billion tons in 2023. Since carbon constitutes 27.3% of this carbon dioxide (Note: The carbon content in 1 kg of carbon dioxide (CO_2) is approximately 0.273 kg. This is the internationally used "carbon equivalent" for expressing CO_2 emissions, calculated from CO_2's molecular weight of 44 (atomic weight of carbon C: 12 + atomic weight of oxygen O: 16 × 2) (12 ÷ 44 = 0.273), the carbon content is thus approximately 15.6 billion tons. 600,000 tons is 0.00385% of 15.6 billion tons. The claim that the carbon stored in the bodies of all marine mammals contributes to climate change mitigation is utterly unrealistic given this figure of 0.00385%.

If the goal is to mitigate climate change through biomass, protecting plants and bacteria would be far more efficient.

(3) The Whale Pump

> "Some whale species, like the sperm whale, dive deep to hunt for nutrient-rich prey. As mammals, they must return to the surface to breathe. While there, they expel large amounts of nutrient-rich feces and urine, by-products of the digested deep-sea prey they've been hunting. This cycling is referred to as "the whale pump," because their movements "pump" nutrients like nitrogen, phosphorus, and iron from the deep sea up to the surface. These nutrients, combined with sunlight, stimulate carbon-capturing phytoplankton blooms. Globally, marine phytoplankton captures the equivalent of four Amazon rainforests' worth of carbon dioxide each year as they photosynthesize and produce half the oxygen we breathe. These microscopic plants also promote overall ocean productivity by providing food for other marine species."

There is no doubt that phytoplankton absorbs large amounts of carbon dioxide and produce oxygen. However, the claim that whales "pump" a significant portion of the nutrients required for phytoplankton growth from the deep sea requires separate verification. The NOAA story does not clearly distinguish this point and lacks quantitative information.

Generally, nutrients in seawater originate from terrestrial sources (including both natural and anthropogenic sources) via river inflow, and from vertical mixing of seawater such as upwelling. Additionally, atmospheric deposition contributes, making it difficult to quantitatively discuss the ocean's nutrient budget and the contribution of the "whale pump" within it.

While this is not a precise analysis but rather a thought experiment, if we focus on the nitrogen budget in the oceans, according to the paper by Capone, D.G. (2008)[2] cited by Koike (2010)[3], which indicates that land-based nitrogen inputs from rivers and other sources amount to 65 TgN (10^{12} g)/year, atmospheric inputs are 31.4 TgN/year, and nitrogen fixation by algae and other organisms ranges from 100 to 200 TgN/year. Since one trillion grams equals one million tons, the annual nitrogen supply to the ocean is approximately 200 to 300 million tons. Estimates of the annual prey consumption by cetaceans, as reported by Tamura and Osumi paper (1999)[4] is approximately 280 to 500 million tons. Assuming that about 90% of the weight of prey organisms is water, the protein mass is approximately 28 to 50 million tons. Since the nitrogen content of protein is about 16%, the nitrogen amount is calculated to be approximately 4.5 to 8 million tons. This means that approximately 1.5% to 4% of the nitrogen in the ocean passes through the digestive systems of cetaceans.

Opinions may differ on whether this figure is large or insignificant, but even in an extreme scenario where all cetaceans vanished from the Earth, it would only disrupt the movement of a few percent of the ocean's nitrogen. Ultimately, this gap would likely be filled by the movement of seawater, such as through ocean currents.

Furthermore, whaling conducted under catch limits based on the RMP involves a catch volume significantly below 1% of cetacean stock abundance. Consequently, the impact of whaling on the nitrogen cycle—already a few percent of the total—is less than one-hundredth of that percentage.

(4) The Whale Conveyor Belt

> "In addition to their vertical movements through the water column, most whale species migrate seasonally from nutrient-rich feeding grounds to nutrient-poor breeding grounds to mate and give birth. The nutrients whales consume on their feeding grounds are expelled as feces and urine along their migratory routes and in their breeding grounds. This stimulates phytoplankton blooms and increases carbon capture via photosynthesis. Baleen whales, including the blue, gray, and fin, and North Atlantic right whale, embark on some of the longest migrations on the planet—up to 12,000 miles. These large whales transport nutrients across oceans and encourage phytoplankton blooms along their migration corridors."

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2 Capone, D.G., (2008). The marine nitrogen cycle. Microbe, 3, 186-192.
3 Koike, I. Terrestrial nitrogen flux and its cycling in coastal and oceanic environments. AIRIES, 2010,179-187. (In Japanese).
4 Tamura, T. and Ohsumi, S. (1999). Estimation of total consumption by cetaceans in the world's ocean. Geiken Tsushin 402:10-22. (In Japanese).

Similar to the discussion in the section on “whale pumps,” while it is undoubtedly true that phytoplankton fix large amounts of carbon, the claim that whales transport a significant portion of the nutrients necessary for phytoplankton reproduction requires separate verification.

While it cannot be denied that nutrients contained in whale excrement may be utilized for phytoplankton proliferation, is it possible to quantitatively verify how much this contributes to global phytoplankton proliferation, and whether it makes a substantial contribution to climate change mitigation through phytoplankton carbon fixation?

The estimated ratio of nitrogen passing through cetacean digestive systems to total ocean nitrogen, as calculated above, likely suggests the proportion of nutrients in cetacean excretions relative to the total nutrients available to phytoplankton. It is likely that the proportion of nutrients derived from whale excretions among the nutrients used by phytoplankton for reproduction is extremely small. Of course, since this is a comparison covering the entire ocean, it cannot be denied that hotspots exist where nutrients from whale excretions play a role in phytoplankton reproduction during specific periods and in specific sea areas.

The proliferation of phytoplankton and its seasonal changes can be understood from chlorophyll-a distribution data. Generally, phytoplankton form blooms (mass proliferations) twice a year, in spring and autumn, in the high-latitude waters of both the Northern and Southern Hemispheres. Factors contributing to bloom occurrence include nutrient replenishment from snowmelt and ice melt, seasonal changes in sunlight, and upwelling currents influenced by seasonal winds and seafloor topography. These factors appear to explain the mechanisms behind bloom formation.

Following phytoplankton proliferation, zooplankton and other marine organisms that feed on them proliferate, attracting migratory whales and other species that prey on them. In other words, whales migrate after phytoplankton proliferation occurs; it does not appear to be the case that whales migrate and then phytoplankton proliferate. This also casts doubt on the aforementioned NOAA claim. Of course, it cannot be entirely ruled out that nutrients originating from whale excrement may contribute to phytoplankton proliferation in subsequent years.

Looking at chlorophyll-a distribution maps, it is evident that chlorophyll concentrations are quite low in the low-latitude waters used by many whales as breeding grounds. Furthermore, no areas of high chlorophyll concentration are found along the whales’ north-south migration routes (such as the east coast of Australia, where humpback whales migrate in large numbers). This does not negate the existence of limited periods and areas (hotspots) where nutrients derived from whale excrement significantly contribute to phytoplankton proliferation. However, the chlorophyll-a distribution map does not support NOAA's assertion that “The nutrients whales consume on their feeding grounds are expelled as feces and urine along their migratory routes and in their breeding grounds” and thereby “stimulates phytoplankton blooms and increases carbon capture via photosynthesis”. At the very least, it is unlikely that phytoplankton production along whale migration routes or in breeding grounds makes a substantial contribution to global phytoplankton production.

(5) NOAA's Conclusion

In the conclusion of its story, NOAA stated, "It's difficult to put an exact number on the amount of blue carbon storage for which whales are responsible. But it's clear that whales can assist in carbon capture and play an important role in marine nutrient cycles." It further noted that "Whales play an important role in the overall health of the marine environment. Conserving and recovering whales can stimulate marine nutrient flow and help to mitigate climate change by increasing the ocean's potential for carbon capture."

As verified above, it is undeniable that whales play a certain role in ocean carbon sequestration and nutrient cycling. However, their quantitative impact on climate change mitigation and marine ecosystem maintenance does not appear to be at the level suggested by NOAA's story. Moreover, this should not be used as a basis for whales' status as charismatic animals or as a tool to oppose limited whaling activities.

2. Are Whales Really the Saviors of Climate Change Mitigation?

The IMF paper and the NOAA story are repeatedly highlighted by the media and environmental groups, often treated as established facts beyond dispute. Yet scientists who challenge these claims exist. Furthermore, even simple calculations reveal the unrealistic nature of whale climate change savior theories. This chapter introduces counterarguments to these theories.

(1) Opinion of Griffith University Researchers

Jan-Olaf Meynecke and colleagues at Griffith University in Australia published a paper in 2023 titled "Do whales really increase the oceanic removal of atmospheric carbon?"[5] to examine the whale climate change savior theory.

This paper points out that while the media and others have elevated whales as saviors of climate change, few studies provide data supporting this hypothesis or conduct model-based verification. It scientifically examines the primary mechanisms purported to remove atmospheric carbon through whales (storage in whale biomass, sinking of carcasses to the seafloor, and whales as carbon pumps or conveyor belts).

As a result, the process of carbon sequestration and isolation by whales remains a hypothesis based on models; it has not been proven that whales make a substantial contribution. Furthermore, quantifying this impact is difficult and has inherent limitations. Significant natural variability in the amount and speed of carbon cycling across ocean regions and seasons makes estimation difficult. "Sequestrated" carbon, including that in whale excrement, rapidly decomposes and is released back into the atmosphere in the upper ocean. The release of carbon dioxide into the atmosphere through the respiration of migrating whales has not been accounted for. These points highlight numerous uncertainties, data gaps, and oversights.

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[5] Meynecke J-O, Samanta S, de Bie J, Seyboth E, Prakash Dey S, Fearon G, Vichi M, Findlay K, Roychoudhury A and Mackey B (2023) Do whales really increase the oceanic removal of atmospheric carbon? Front. Mar. Sci. 10:1117409. [doi: 10.3389/fmars.2023.1117409](https://doi.org/10.3389/fmars.2023.1117409).

They conclude that "the amount of carbon whales are potentially sequestering might be too little to meaningfully alter the course of climate change." Furthermore, they state that "The phenomenon of simplifying complex relationships to gain readers attention is particularly common in the "post-truth" era (Gobo and Marcheselli, 2022)[6] amplified by the increased use of social media.".

Furthermore, this paper sounds a strong warning: "The implications of a believe-driven process can result in a diversion of attention towards well-established methods of carbon sequestration. It can result in attention and resources drawn away from proven, effective nature-based solutions to climate change."

It should also be noted that this paper points out the important role whales play in marine ecosystems. While acknowledging that whales contribute to carbon sequestration and isolation, it takes the position that further data collection and research are needed to determine whether this role is substantial enough to consider whales saviors of climate change.

(2) Estimates using NOAA Figures

Here, the author presents a simplified calculation performed for illustrative purposes. Its sole objective is to confirm that the amount of carbon sequestration attributed to whales' contribution to climate change mitigation is negligible when viewed against the scale of the global carbon cycle as a whole. This calculation does not claim or guarantee scientific accuracy or the appropriateness of the assumptions made.

As cited in 1(2) above, global anthropogenic carbon dioxide emissions in 2023 amounted to 57.1 gigatons (Gt).

The total number of large whales in all oceans, according to figures published on the IWC website[7], is 1,131,258 (minke whales 778,000, blue whales 4,800, fin whales 43,000, Gray whales 19,662, bowhead whales 25,046, humpback whales 177,780, right whales 12,370, sei whales 29,600, Bryde's whales, 41,000). This does not include whale species for which the IWC has not agreed on estimated population sizes. For example, sperm whales' number in the millions, and North Pacific sei whales' number in the tens of thousands. Furthermore, this does not include population estimates for small cetaceans, which we will not consider here.

According to NOAA, "One whale can capture an average of 33 tons of carbon dioxide over its lifespan." However, it is not specified whether this accounts for differences in body weight among whale species. Furthermore, it is unclear what lifespan is assumed—how many years—and whether differences in lifespan among whale species are taken into consideration.

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[6] Gobo, G., and Marcheselli, V. (2022). Scientists, Experts and Public Opinion. In: Science, Technology and Society: An Introduction. Eds. G. Gobo and V. Marcheselli (Cham: Springer International Publishing), 163–178. doi: 10.1007/978-3-031-08306-8_8.

[7] https://iwc.int/about-whales/estimate

Let us make bold assumptions. We will set the total number of large whales in all oceans at 5,000,000. Of course, this does not account for differences in weight (biomass) between whale species. Furthermore, we will assume the average lifespan of large whales is 30 years. Again, differences between whale species are not considered here.

Based on the above assumptions,

the amount of carbon dioxide fixed by one large whale per year is

33 tons ÷ 30 years = 1.1 tons

Next, multiply this by the total number of large whales in all oceans, which is 5,000,000,

1.1 tons × 5,000,000 heads = 5,500,000 tons

The total annual anthropogenic carbon dioxide emissions for the entire planet are approximately 57.1 gigatons (Gt). Therefore, the proportion of carbon dioxide fixed by all large whales relative to the total is

5,500,000 tons ÷ 57,100,000,000 tons = 0.0000963（0.00963%）

In other words, the carbon sequestration by large cetaceans is less than 0.01% of total carbon dioxide emissions, making it extremely small. The uncertainties from analytical errors and natural variability are far greater.

Furthermore, the total number of whales caught by commercial whaling in Japan, Norway, and Iceland, combined with those caught by indigenous subsistence whaling, is approximately 1,200 (2023). Therefore, the ratio relative to the total number of large whales in all oceans assumed here, 5,000,000, is

1,200 heads ÷ 5,000,000 heads = 0.00024（0.024%）

Therefore, the amount of carbon dioxide capture that may have been lost due to whaling relative to the total carbon dioxide emissions is

0.01% × 0.024% = 0.00024%

It is self-evident how unrealistic the claim that whaling negatively impacts climate change mitigation is.

3. Conclusion

Recent trends in international politics reveal a stark reality: simple images and repeated misinformation wield greater influence than precise figures or logical arguments. The whaling issue, unfortunately, stands as a prime example of this phenomenon.

The whale climate change savior theory discussed in this article also falls into this category, and one can discern the intent to link whales to climate change, a global and urgent issue.

Those who have been involved in the whaling dispute would recognize that it is difficult to counter image-building and information strategies rooted in clear objectives and convictions of totally protecting whales. The expectation and hope that accurate figures and logical arguments would eventually be accepted have, unfortunately, been repeatedly betrayed. Even when governments of anti-whaling nations understand that whales can be caught sustainably in a scientifically and legally justified manner, domestic public opinion often makes acceptance impossible. This dilemma, or limitation, was one of the factors in Japan's decision to withdraw from the IWC.

The clash of differing values is not limited to the whaling issue in causing situations to become deadlocked or deteriorate. As Emmanuel Todd points out in "La Défaite de l'Occident"[8], the so-called global standards that Western nations have established and led are no longer endowed with their former divine power. The current chaos stems from the tension between the traditional image of an international order led by Western advanced nations and a multipolar international order premised on the existence and coexistence of diverse values, legal systems, history, cultures, governance models, and socioeconomic systems.

From a position of interest in and support for the sustainable use of marine living resources, including whales, the challenge lies in how to achieve the diversity, which was rejected by the IWC. Whatever form we aim for, one prerequisite remains the clear presentation of accurate facts—including inconvenient ones. While Japan withdrew from the IWC and resumed commercial whaling, the value of information dissemination for the future has only increased, not diminished.

18 November 2025.

[8] Emmanuel Todd, translated by Mai Ono. *The Defeat of the West: What is Happening to Japan and the World?* 2024, Bungeishunju, Ltd. 2024.ISBN 978-4-16-391909-6. (In Japanese).