THE ECONOMIC VALUE OF

STRANDED CETACEANS

A Comprehensive Valuation Framework for

Baleen Whales, Toothed Whales, Medium Cetaceans, and Small Cetaceans

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A White Paper by StrandedNoMore

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Based on peer-reviewed research by Chami et al. (IMF, 2022), Roman et al. (2016), Smith et al. (2013), Pershing et al. (2010), Lavery et al. (2010, 2014), Gilbert et al. (2023), Freitas et al. (2025), Roman et al. (2025), Monreal et al. (2024), and Collins et al. (2025)

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Executive Summary

This white paper estimates the total economic value of stranded cetaceans across four species categories: baleen whales, large toothed whales, medium cetaceans, and small cetaceans. The valuation framework draws on peer-reviewed research to quantify six distinct categories of ecosystem services: carbon sequestration in body biomass, phytoplankton carbon capture enhancement (the whale pump), ocean nutrient cycling, fisheries enhancement, ecotourism revenue generation, and reproductive capacity.

The analysis extends the single-species humpback whale valuation developed by StrandedNoMore (2026) to encompass the full range of cetacean species encountered in stranding events worldwide. All calculations are presented at two carbon price points: the EU Emissions Trading System (ETS) market price of approximately $25 per tonne of CO_2, and the social cost of carbon (SCC) of $500 per tonne.

Comparative Summary — All Four Categories

Category	Baleen Whale	Large Toothed	Medium Cetacean	Small Cetacean
Avg body mass	33 t	25 t	1.5 t	0.15 t
Carbon content	5.48 t C	4.16 t C	0.25 t C	0.025 t C
Expected lifespan	70 yr	60 yr	45 yr	25 yr
Direct (market)	$672,991	$475,584	$27,480	$2,089
Direct (social)	$8,626,918	$6,053,635	$311,435	$20,899
Total female (social)	**$83.7M**	**$24.1M**	**$1.85M**	**$94,779**

Note: Non-carbon services (nutrient cycling, fisheries, ecotourism) are valued independently of carbon pricing and remain constant across both price scenarios. The social cost figures are conservative; including second-generation calves would substantially increase totals.

1. Background and Methodology

1.1 The Whale Pump: How Cetaceans Drive Ocean Productivity

Cetaceans are increasingly recognised as powerful ecosystem engineers. Through their normal feeding, resting, and migratory behaviour, they transport nutrients vertically and horizontally through the ocean in mechanisms known as the "whale pump" and the "whale conveyor belt" (Roman & McCarthy, 2010; Roman et al., 2014). Whales and dolphins dive to depth to feed, then return to the surface to breathe and defecate. Their faecal plumes, rich in nitrogen, phosphorus, iron, and trace metals, are released in the photic zone where sunlight enables phytoplankton to use these nutrients for photosynthesis.

Roman et al. (2016) documented this process in North Atlantic right whales in the Bay of Fundy, finding that ammonium and phosphate concentrations in whale faecal material were orders of magnitude higher than typical coastal water values. Smith et al. (2013) demonstrated that pygmy blue whale faeces stimulated the photosynthetic performance and growth of three marine phytoplankton species in a dose-dependent manner, establishing that faecal nutrients deposited by baleen whales in the photic zone are bioavailable and directly stimulate phytoplankton growth.

Critically, Gilbert et al. (2023) expanded this understanding to show that the roles of small cetaceans, deep-diving cetaceans, and baleen whales differ both quantitatively and functionally. In some regions, the nutrient contributions of small cetaceans and deep divers exceed those of large whales, demonstrating that every category of cetacean plays a measurable role in ocean nutrient cycling.

1.2 Nutrient Cycling: Beyond Carbon

Freitas et al. (2025) provided the first comprehensive measurement of nutrients in baleen whale faeces and urine across the Nordic and Barents Seas, estimating that six species of baleen whales collectively recycle 147,000 tonnes of nitrogen and 59,000 tonnes of phosphorus during their 180-day feeding season, along with 143 tonnes of iron, 254 tonnes of zinc, 74 tonnes of copper, and 13 tonnes of manganese. Their ecosystem modelling showed that these whale-derived nutrients enhance net primary production by an average of 0.63%, with regional peaks of 2–4.5%, and cascading effects increasing mesozooplankton biomass by up to 10%.

Monreal et al. (2024) further revealed that organic ligands in whale excrement enhance iron bioavailability while reducing copper toxicity, demonstrating that whales do not merely release raw nutrients but transform prey biomass into highly labile micronutrients optimised for phytoplankton uptake — a mechanism that whaling reduced by over 90%.

These nutrient services support fisheries productivity, ocean ecosystem balance, biodiversity, and climate regulation simultaneously. This white paper values nutrient cycling as a separate service category to capture its full importance beyond carbon sequestration alone.

1.3 Valuation Framework

This report follows the market-based valuation framework developed by Chami et al. (2022) at the International Monetary Fund, which treats individual natural resources as capital assets that produce streams of ecosystem services with market-assignable values. The value of the asset is calculated as the discounted present value of all future service flows over the organism's expected lifetime. A 2% real discount rate is used throughout, consistent with Chami et al.'s analysis.

1.4 Six Service Categories

1. Carbon stored in body biomass: The CO_2 equivalent of carbon locked in the whale's body, sequestered for centuries via whale fall when the animal dies naturally. Valued at carbon price.

2. Phytoplankton carbon capture enhancement: The dominant climate service. Through the whale pump, each cetacean's nutrient contributions stimulate phytoplankton that capture atmospheric CO_2. Following Chami et al. (2022), 1% of global phytoplankton carbon capture (370 million tonnes CO_2/year) is attributed to the global whale population, distributed by biomass share.

3. Ocean nutrient cycling: The replacement cost of nitrogen, phosphorus, iron, and trace elements that cetaceans recycle to the photic zone. Based on commercial fertiliser prices and ocean iron fertilisation costs. This captures the ecosystem productivity value beyond carbon alone.

4. Fisheries enhancement: Following Chami et al. (2022), 1% of global commercial fishing revenue ($150 billion/year) is attributed to whale-driven productivity enhancement, distributed by biomass share.

5. Ecotourism revenue: A share of the global whale-watching industry ($2.0 billion/year), distributed by biomass share.

6. Reproductive value: The present value of all ecosystem services provided by a female's surviving offspring over their lifetimes, using species-specific reproductive parameters.

1.5 Market Price vs. Social Cost of Carbon

All carbon-related calculations (Services 1 and 2) are presented at two price points. The EU ETS market price (~$25/tonne CO_2) reflects the price companies currently pay for emission permits. The social cost of carbon (~$500/tonne CO_2) represents the total economic damage caused by each additional tonne of CO_2, including healthcare costs, agricultural losses, infrastructure damage, and ecosystem degradation (Rennert et al., 2022). Services 3–5 are valued independently of carbon pricing.

1.6 Scaling Across Species

The humpback whale valuation serves as the reference case. Values for other categories are scaled using two methods: (a) biomass share of the global whale population for carbon capture, fisheries, and ecotourism services; and (b) allometric metabolic scaling (body mass$^{0.75}$) for nutrient cycling, following the bioenergetic model of Gilbert et al. (2023). Reproductive parameters are drawn from species-specific literature.

2. Baleen Whales

Reference species: humpback whale (Megaptera novaeangliae). This category includes humpback, minke, fin, blue, sei, right, gray, and bowhead whales.

Parameter	Value
Average body mass	~33 tonnes (adult)
Carbon content of body	5.4842 tonnes C (Pershing et al., 2010)
CO_2 equivalent (C × 11/3)	20.11 tonnes CO_2
Expected lifespan (rescued)	70 years
Age at first reproduction	6 years
Interbirth interval	2.36 years
Calf survival rate	0.76
Annual N released (faeces + urine)	~3.5 tonnes N (Roman & McCarthy, 2010; Freitas et al., 2025)
Annual P released	~0.45 tonnes P
Annual Fe released	~4.3 kg Fe
Biomass share of global whale pop.	1.205×10^{-6}
Discount rate	2% (real, risk-free)

2.1 Carbon Stored in Body

Carbon content: 5.4842 tonnes C × (11/3) = 20.11 tonnes CO_2. At market: 20.11 × $25 = $503. At social cost: 20.11 × $500 = $10,055.

2.2 Phytoplankton Carbon Capture

Annual CO_2 capture attributed: 370,000,000 × 1.205×10^{-6} = 446 tonnes CO_2/year. Present value annuity factor (70 years, 2%): 37.50. Market PV: 446 × $25 × 37.50 = $418,125. Social PV: 446 × $500 × 37.50 = $8,362,500.

2.3 Nutrient Cycling

Nitrogen replacement: 3.5 t × $500/t = $1,750/year. Phosphorus: 0.45 t × $700/t = $315/year. Iron and trace metals (Fe, Zn, Cu, Mn): estimated $500/year based on ocean iron fertilisation costs and concentration data from Monreal et al. (2024) and Freitas et al. (2025). Total: $2,565/year. PV over 70 years at 2%: $2,565 × 37.50 = $96,188.

2.4 Fisheries Enhancement

Annual: $1,500,000,000 × 1.205×10^{-6} = $1,808/year. PV over 70 years: $1,808 × 37.50 = $67,800.

2.5 Ecotourism Revenue

Annual: $2,000,000,000 × 1.205 × 10^{-6} = $2,410/year. PV over 70 years: $2,410 × 37.50 = $90,375.

2.6 Reproductive Value

Reproductive years: 6–55 = 49 years. Calves: 49/2.36 = 20.8. Surviving: 20.8 × 0.76 = 15.8 calves. Average birth year ~30; discount factor 0.55. Market: 15.8 × $672,991 × 0.55 = $5,854,402. Social: 15.8 × $8,626,918 × 0.55 = $7,499,402 + carbon-scaled component = $75,109,000.

Service Category	Market ($25/t CO_2)	Social Cost ($500/t CO_2)
1. Carbon stored in body	$503	$10,055
2. Phytoplankton carbon capture	$418,125	$8,362,500
3. Nutrient cycling	$96,188	$96,188
4. Fisheries enhancement	$67,800	$67,800
5. Ecotourism revenue	$90,375	$90,375
Direct services subtotal	**$672,991**	**$8,626,918**
6. Reproductive value (1st gen)	$5,854,000	$75,109,000
TOTAL (one rescued female)	**$6,527,000**	**$83,736,000**

3. Large Toothed Whales

Reference species: sperm whale (Physeter macrocephalus). This category includes sperm whales, beaked whales (Ziphiidae), and orcas (Orcinus orca). These species are characterised by deep diving behaviour that creates a uniquely valuable allochthonous nutrient pump.

Special note on sperm whales as net carbon sinks: Lavery et al. (2010) demonstrated that Southern Ocean sperm whales stimulate the export of 400,000 tonnes of carbon per year to the deep ocean while respiring only 200,000 tonnes, making them a net carbon sink that removes 200,000 tonnes more carbon from the atmosphere than they add during respiration. This allochthonous contribution (nutrients sourced from below the photic zone) is qualitatively different from baleen whale recycling and uniquely valuable in iron-limited waters.

Parameter	Value
Average body mass	~25 tonnes (category average)
Carbon content of body	4.155 tonnes C
CO_2 equivalent	15.24 tonnes CO_2
Expected lifespan	60 years
Age at first reproduction	9 years (sperm whale)
Interbirth interval	5.0 years
Calf survival rate	0.70
Annual nutrient value	$2,044/year (metabolic scaling from baleen)
Biomass share	9.12×10^{-7}
Key nutrient role	Allochthonous nutrient pump; high Cu from squid diet (Gilbert et al., 2023)

3.1–3.5 Service Calculations

Carbon in body: 15.24 t CO_2. Market: $381; Social: $7,620.

Phytoplankton capture: 370M × 9.12×10^{-7} = 337 t CO_2/year. PV (60yr): Market $293,200; Social $5,864,012.

Nutrient cycling: $2,044/year × 34.76 = $71,049.

Fisheries: $1,368/year × 34.76 = $47,552.

Ecotourism: $1,824/year × 34.76 = $63,402.

Reproductive value: 5.04 surviving calves; avg discount 0.59. Market: $1,415,000; Social: $18,030,000.

Service Category	Market ($25/t CO_2)	Social Cost ($500/t CO_2)
1. Carbon stored in body	$381	$7,620
2. Phytoplankton carbon capture	$293,200	$5,864,012
3. Nutrient cycling	$71,049	$71,049
4. Fisheries enhancement	$47,552	$47,552
5. Ecotourism revenue	$63,402	$63,402
Direct services subtotal	**$475,584**	**$6,053,635**
6. Reproductive value (1st gen)	$1,415,000	$18,030,000
TOTAL (one rescued female)	**$1,891,000**	**$24,084,000**

4. Medium Cetaceans

Reference species: long-finned pilot whale (Globicephala melas). This category includes pilot whales, false killer whales (Pseudorca crassidens), melon-headed whales, Risso’s dolphins (Grampus griseus), and pygmy/dwarf sperm whales (Kogia spp.). Many species in this category are deep divers that contribute significantly to the allochthonous nutrient pump.

Gilbert et al. (2023) found that deep-diving cetaceans in this size range are the dominant nutrient contributors in tropical oligotrophic regions, providing 60–80% of all cetacean-released nutrients in areas such as Hawaii, New Caledonia, and the French Antilles. Their contribution is especially important for copper cycling, providing over 50% of cetacean Cu release in 10 of 14 study areas.

Parameter	Value
Average body mass	~1.5 tonnes
Carbon content of body	0.249 tonnes C
CO_2 equivalent	0.914 tonnes CO_2
Expected lifespan	45 years
Age at first reproduction	7 years
Interbirth interval	3.0 years
Calf survival rate	0.80
Annual nutrient value	$234/year
Biomass share	5.47×10^{-8}

4.1–4.5 Service Calculations

Carbon in body: 0.914 t CO_2. Market: $23; Social: $457.

Phytoplankton capture: 20.24 t CO_2/year. PV (45yr): Market $14,922; Social $298,443.

Nutrient cycling: $234/year × 29.49 = $6,903.

Fisheries: $82/year × 29.49 = $2,418.

Ecotourism: $109/year × 29.49 = $3,214.

Reproductive value: 7.44 surviving calves; avg discount 0.66. Market: $135,209; Social: $1,533,710.

Service Category	Market ($25/t CO_2)	Social Cost ($500/t CO_2)
1. Carbon stored in body	$23	$457
2. Phytoplankton carbon capture	$14,922	$298,443
3. Nutrient cycling	$6,903	$6,903
4. Fisheries enhancement	$2,418	$2,418
5. Ecotourism revenue	$3,214	$3,214
Direct services subtotal	**$27,480**	**$311,435**
6. Reproductive value (1st gen)	$135,209	$1,533,710
TOTAL (one rescued female)	**$162,689**	**$1,845,145**

5. Small Cetaceans

Reference species: common bottlenose dolphin (Tursiops truncatus). This category includes all dolphins (Delphinidae smaller species), porpoises (Phocoenidae), and other small odontocetes. Despite their small individual size, small cetaceans are the most abundant cetacean group, and Gilbert et al. (2023) demonstrated that they are the dominant nutrient contributors in several regions.

In the Mediterranean Sea, small cetaceans contribute 62–74% of all nutrients released by the cetacean community. In French Guyana, they contribute 74–85%. Their high phosphorus and manganese release, rapid nutrient turnover from fish-based diets, and year-round feeding (unlike migratory baleen whales) make their cumulative ecosystem contribution substantial.

Parameter	Value
Average body mass	~150 kg (0.15 tonnes)
Carbon content of body	0.0249 tonnes C
CO_2 equivalent	0.0914 tonnes CO_2
Expected lifespan	25 years
Age at first reproduction	5 years
Interbirth interval	2.5 years
Calf survival rate	0.75
Annual nutrient value	$37/year
Biomass share	5.47×10^{-9}

5.1–5.5 Service Calculations

Carbon in body: 0.0914 t CO_2. Market: $2; Social: $46.

Phytoplankton capture: 2.024 t CO_2/year. PV (25yr): Market $988; Social $19,754.

Nutrient cycling: $37/year × 19.52 = $722.

Fisheries: $8.2/year × 19.52 = $160.

Ecotourism: $10.9/year × 19.52 = $213.

Reproductive value: 4.5 surviving calves; avg discount 0.78. Market: $7,753; Social: $73,766.

Service Category	Market ($25/t CO_2)	Social Cost ($500/t CO_2)
1. Carbon stored in body	$2	$46
2. Phytoplankton carbon capture	$988	$19,754
3. Nutrient cycling	$722	$722
4. Fisheries enhancement	$160	$160
5. Ecotourism revenue	$213	$213
Direct services subtotal	**$2,085**	**$20,895**
6. Reproductive value (1st gen)	$7,753	$73,766
TOTAL (one rescued female)	**$9,838**	**$94,661**

6. Context and Implications

6.1 The Role of Small Cetaceans in Ecosystem Function

While the per-individual value of a small cetacean is orders of magnitude lower than that of a great whale, their ecological importance should not be underestimated. Gilbert et al. (2023) demonstrated that small cetaceans dominate nutrient cycling in several ecosystems and provide qualitatively different nutrient profiles (higher phosphorus and manganese) than baleen whales. Their year-round feeding, in contrast to the seasonal presence of migratory baleen whales, means they sustain baseline nutrient inputs throughout the year. **A mass stranding event involving hundreds of dolphins can therefore represent millions of dollars in lost ecosystem services.**

6.2 Comparison with Carbon Removal Technology

Current direct air capture (DAC) technology costs \$250–\$600 per tonne of CO_2 removed. A single baleen whale facilitates the capture of 446 tonnes CO_2 per year through phytoplankton fertilisation at zero operating cost. The equivalent annual DAC cost would be \$111,500–\$267,600. A whale does this for free, while simultaneously cycling nutrients, enhancing fisheries, supporting tourism, and producing offspring.

6.3 Implications for Stranding Response

The cost of a cetacean stranding rescue operation typically ranges from \$10,000 to \$100,000 for large whales and \$2,000 to \$20,000 for dolphins. Even at the conservative market carbon price, the value of a successfully rescued baleen whale (\$672,991 in direct services) exceeds the rescue cost by a factor of 7 to 67. At the social cost of carbon, the return on investment exceeds 86 to 1. For small cetaceans, the economics still favour intervention: a dolphin rescue costing \$2,000–\$5,000 preserves \$2,085–\$20,895 in direct ecosystem services.

6.4 Application to Stranding Data

The StrandedNoMore global stranding dashboard applies these valuations to real stranding data, mapping each recorded species to one of the four categories. For each country, the dashboard calculates the cumulative value preserved (rescued animals) and the cumulative value lost (animals that died or were euthanised). A toggle between market and social cost carbon pricing allows users to see both perspectives. This provides policymakers and the public with a concrete, evidence-based measure of what is at stake in every stranding event.

7. Species Classification Guide

The following table shows how common stranding species are mapped to the four valuation categories. Species without published data are assigned to the category of their closest taxonomic relative.

Species	Category	Data Basis
Humpback whale	Baleen whale	Primary reference
Minke whale	Baleen whale	Freitas et al., 2025
Fin whale	Baleen whale	Freitas et al., 2025
Blue whale	Baleen whale	Lavery et al., 2014
Southern right whale	Baleen whale	Roman et al., 2016
North Atlantic right whale	Baleen whale	Roman et al., 2016
Gray whale	Baleen whale	Category average
Sei whale	Baleen whale	Freitas et al., 2025
Bowhead whale	Baleen whale	Freitas et al., 2025
Bryde’s whale	Baleen whale	Category average
Sperm whale	Large toothed whale	Lavery et al., 2010
Orca / Killer whale	Large toothed whale	Category average
Cuvier’s beaked whale	Large toothed whale	Category average
Blainville’s beaked whale	Large toothed whale	Category average
Long-finned pilot whale	Medium cetacean	Gilbert et al., 2023
Short-finned pilot whale	Medium cetacean	Gilbert et al., 2023
False killer whale	Medium cetacean	Category average
Pygmy sperm whale	Medium cetacean	Category average
Dwarf sperm whale	Medium cetacean	Category average
Risso’s dolphin	Medium cetacean	Gilbert et al., 2023
Bottlenose dolphin	Small cetacean	Gilbert et al., 2023
Common dolphin	Small cetacean	Gilbert et al., 2023
Striped dolphin	Small cetacean	Gilbert et al., 2023
Spinner dolphin	Small cetacean	Gilbert et al., 2023
Harbour porpoise	Small cetacean	Gilbert et al., 2023
Hector’s dolphin	Small cetacean	Category average
Māui dolphin	Small cetacean	Category average

Dusky dolphin	Small cetacean	Category average
Pantropical spotted dolphin	Small cetacean	Category average

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This document represents one credible valuation framework drawn from peer-reviewed macro-economics and marine biology.

These figures illustrate scale; they are not financial projections.