

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed
☒	☒ The exact sample size (<i>n</i>) for each experimental group/condition, given as a discrete number and unit of measurement
☒	☐ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☒	☐ The statistical test(s) used AND whether they are one- or two-sided <i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>
☒	☐ A description of all covariates tested
☒	☐ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☒	☐ For null hypothesis testing, the test statistic (e.g. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted <i>Give P values as exact values whenever suitable.</i>
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐ Estimates of effect sizes (e.g. Cohen's <i>d</i> , Pearson's <i>r</i>), indicating how they were calculated

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection	No software was used.
Data analysis	Data and analysis are available on Figshare: https://figshare.com/articles/dataset/Great_Whale_Conveyor_Belt/25021040 . Key packages employed for data analysis include R statistical software version 4.3.1, CoordinateCleaner, AdeHabitatHR, Python 3.9.10, SciPy 1.11.2, NumPy 1.22.3, and pandas 1.4.1. The backgrounds for maps are from Natural Earth.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

The data reported in this article were extracted from published sources cited below. The data files and code for the population-level nutrient and carbon calculations are available on Figshare: https://figshare.com/articles/dataset/Great_Whale_Conveyor_Belt/25021040

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender	N/A
Reporting on race, ethnicity, or other socially relevant groupings	N/A
Population characteristics	N/A
Recruitment	N/A
Ethics oversight	N/A

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see [nature.com/documents/nr-reporting-summary-flat.pdf](https://www.nature.com/documents/nr-reporting-summary-flat.pdf)

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	In this study, we examined the seasonal movement of nitrogen by baleen whales from high-latitude summer feeding grounds to lower latitude winter breeding grounds. To examine this movement, we included the total biomass for each species, along with estimates for the transfer of carbon and nitrogen. We estimate the carbon fixation from urea on the breeding grounds. Equations for these calculations are provided in the methods under "Calculations for Nutrient Transport by Whales from Feeding to Breeding Grounds." Summer and winter timings for whale populations in each oceanic basin were set by the seasons in each hemisphere.
Research sample	Spatial data for feeding and breeding grounds are derived from publicly available databases including Whaling History (www.whalinghistory.org), Ocean Biodiversity Information System-Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP, seamap.env.duke.edu), and Global Biodiversity Information Facility (GBIF, www.gbif.org). In some cases, whale sightings from aerial and ship-based surveys were added to supplement missing data (e.g., Antarctic and Brazilian humpback whales).
Sampling strategy	We used all sightings data available in the databases mentioned in the research sample.
Data collection	Data were collected from publicly available databases, supplemented by whale sightings from aerial and ship-based surveys. All spatial data are available at the Github repository (see Software and Code). Present and past population sizes were estimated from Smith et al. 2019 and updated for this study.
Timing and spatial scale	Data were collected from all oceans and extend from whaling logbook records to contemporary (Aug 31, 2019) sightings data from aerial and ship-based surveys.
Data exclusions	Analyses for poorly sampled species (such as fin and blue whales) are included only in the supplementary information. Minke whales were not included in our analysis because of a dearth of knowledge about their seasonal movements. We screened all data using the 'CoordinateCleaner' package in R statistical software. Specifically, we flagged coordinates that occurred on land, had equal latitude and longitude or 0-0 coordinates, or were assigned to biological institutions.
Reproducibility	All data collected are publicly available and can be reproduced or updated with new data following analyses available on GitHub.
Randomization	Whales were grouped according to species and ocean basin based on species identifications, location, and timing.
Blinding	Blinding was not used for sample collection. The great majority of the data came from publicly available databases.
Did the study involve field work?	☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging