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Ocean commitments under the Paris Agreement

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Under the Paris Agreement nations made pledges known as nationally determined contributions (NDCs), which indicate how national governments are evaluating climate risks and policy opportunities. We find that NDCs reveal important systematic patterns reflecting national interests and capabilities. Because the ocean plays critical roles in climate mitigation and adaptation, we created a quantitative marine focus factor (MFF) to evaluate how governments address marine issues. In contrast to the past, when oceans received minimal attention in climate negotiations, 70% of 161 NDCs we analysed include marine issues. The percentage of the population living in low-lying areas—vulnerable to rising seas—positively influences the MFF, but negotiating group (Annex 1 or small island developing states) is equally important, suggesting political motivations are crucial to NDC development. The analysis reveals gaps between scientific and government attention, including on ocean deoxygenation, which is barely mentioned. Governments display a keen interest in expanding marine research on climate priorities.

The decision by 195 countries to adopt the Paris Agreement[1] at the 21st Conference of the Parties (COP) on 12 December 2015 marked a historic turning point for climate change policy and a major success in multilateral diplomacy[2]. Unlike the Kyoto Protocol adopted nearly two decades earlier, the Paris Agreement includes prominent focus on impacts of climate change and adaptation[3]. This shift is potentially auspicious for policy attention to the oceans and marine ecosystems. Despite the central role the ocean plays in regulating the climate and absorbing anthropogenic CO_2 emissions[4,5], prior to Paris, climate diplomacy devoted scant attention to the ocean[6,7]. Although the 1992 UNFCCC formally recognized the importance of marine ecosystems as sinks and reservoirs of greenhouse gases[8], ocean, marine, or coastal ecosystems were largely left out of subsequent COP negotiations[6,7]. Paris represented a significant turning point for recognition of the oceans within the climate negotiations[9], evidenced by an increase in ocean-related side events, greater participation of ocean scientists and non-governmental organizations, and the signing of the 'Because the Ocean' declaration by 22 Parties[10]. Furthermore, in contrast to the Kyoto Protocol (1997)[11] in which marine systems are not formally recognized, the Paris Agreement[1] explicitly includes the ocean within the Preamble.

We assess empirically whether and how the Parties to the Paris Agreement are focusing on the ocean and marine ecosystems. To do that, we take advantage of a novel institutional feature at the centre of the Paris Agreement: pledge and review, covered in Article 4 of the Paris Agreement[1]. Unlike earlier attempts to negotiate climate accords, prior to the Paris meeting nearly all countries submitted 'intended nationally determined contributions (INDCs)' to indicate their national strategies for climate action[12]. Countries were encouraged to submit their strategies for reducing greenhouse gas emissions (that is, mitigation component) and invited to communicate undertakings in climate adaptation planning (that is, adaptation component) in their INDCs. These INDCs—which become simply NDCs as each country formally joins the Paris Agreement—are the basic building blocks for implementing the Paris Agreement and reflect the highest possible ambition. Parties may adjust their NDCs at any time, but must revise and update NDCs every five years. The NDCs provide a window into how governments view their climate policy priorities, thus opening a gold mine of information with nearly global coverage that was previously unavailable to scholars, who have struggled to obtain reliable, systematic information about national preferences[12].

As of June 2016, 161 governments had filed NDCs[13], of which 70% include some mention of marine issues (Fig. 1). This group of 161 covers 188 nations, since the NDC from the European Union spans all 28 EU members[14]. The majority (103) of ocean-inclusive NDCs focus on climate change impacts and adaptation needs in marine areas. Of those Parties that ignore the oceans in their NDCs, 14 are coastal, some with very large Exclusive Economic Zones (EEZs) such as Australia, Brazil, the European Union, Micronesia, New Zealand, Norway, the Russian Federation, and the United States of America.

Marine-focused sections of NDCs were read and specific categories involving marine ecosystems intersection with climate change policy were identified. The dominant concerns raised by governments were coastal impacts (95 NDCs), ocean warming impacts (77 NDCs), and fisheries impacts (72 NDCs) (Fig. 2). Some NDCs provided specific plans to address these impacts, whereas others include them more generally as adaptation needs. Mangrove conservation, restoration, and management plans are included in 45 NDCs, and are included in both mitigation and adaptation sections. Coral reefs are included in 28 NDCs, but are typically included as adaptation components (Table 1). Mangroves and coral reefs are both habitat-forming marine species that provide key ecosystem services[15,16], including fisheries production and coastal buffering, but sustain negative impacts from climate change[5]. Blue carbon[17,18] mitigation contributions were included in 27 NDCs (Table 1), encompassing ocean carbon storage and the protection, replantation, or management of mangroves, salt marshes, sea grass

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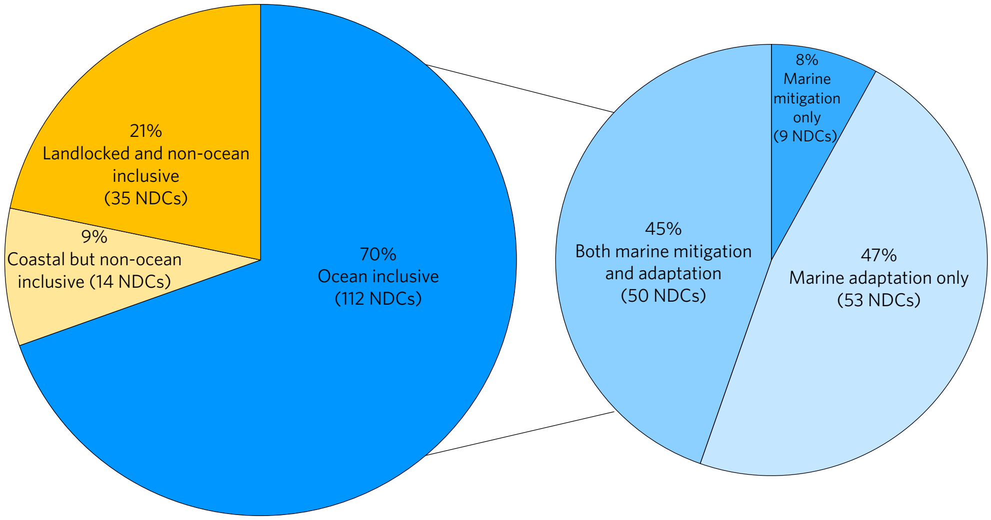

Figure 1 | Inclusion of ocean issues in NDCs. Of 161 NDCs (left) most are ocean-inclusive (right). Most NDCs that exclude oceans are from landlocked states. Most ocean-inclusive NDCs focus on climate impacts and adaptation (103 NDCs), but 59 Parties include marine topics in the mitigation section. A list of which Parties included marine issues as adaptation or mitigation components is provided in Supplementary Section 1, and a map visualizing the MFFs of different countries' NDCs is provided in Supplementary Section 2.

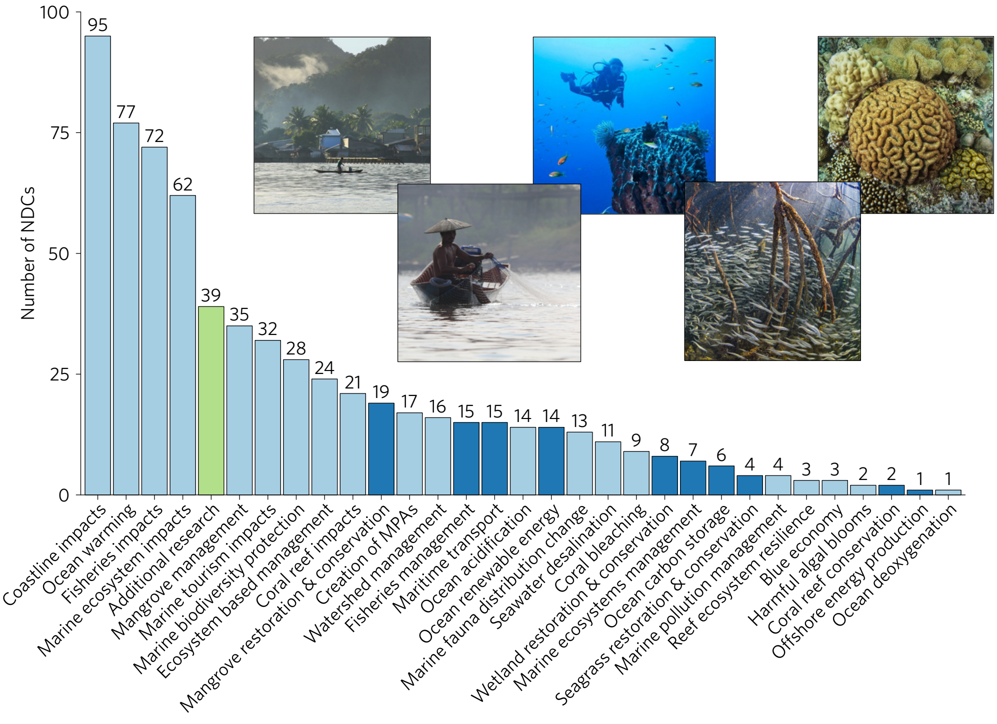

Figure 2 | Frequency of marine mitigation and adaptation categories in NDCs. Bar graph shows the frequency of different marine mitigation (dark blue) and marine impacts and adaptation (light blue) categories included in NDCs. Number of NDCs requesting additional marine research shown in green. Marine impacts and adaptation actions and concerns received much greater attention across NDCs than marine mitigation actions. Categories selected were based on multiple occurrences in NDCs and in the marine climate science literature.

beds, or other marine ecosystems. Significant opportunities exist to further expand the carbon mitigation potential of blue carbon ecosystems[19]. Several NDCs contained an ecosystem approach to climate change adaptation and included marine biodiversity preservation, creation of marine protected areas (MPAs), and utilization of conservation and ecosystem-based management in their adaptation plans (Fig. 2).

Ocean warming, acidification, deoxygenation, and changes in primary productivity are considered the four main climate change stressors of marine ecosystems[20], and occur simultaneously, creating high risk for synergistic impacts[21,22]. These effects will arise even with aggressive mitigation of global emissions—under the RCP2.5 scenario, model-mean sea surface temperature will increase 0.71 ($\pm$0.45) °C, sea surface pH will decrease 0.07 ($\pm$0.001) pH units, and global oxygen content will decrease 1.81 ($\pm$0.31)% by the 2090s compared to the 1990s[20]. As shown in Fig. 2, general concerns about ocean warming are widespread (77 NDCs), but a much smaller number of NDCs (mostly from small island developing states (SIDS)) specifically address ocean acidification as an additional stressor from anthropogenic CO_2 emissions (14 NDCs).

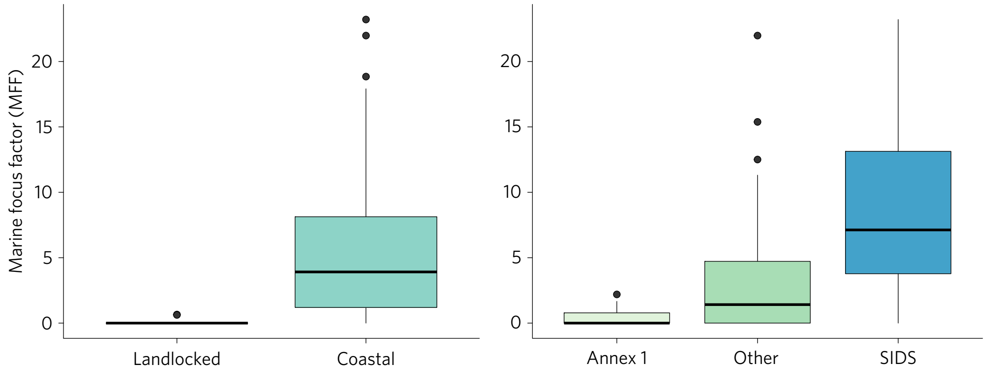

Figure 3 | Differences in marine focus factor across NDCs. Boxplots show differences in marine focus factor (MFF) between NDCs from landlocked ($n=37$) and coastal countries ($n=124$) (left); and between NDCs from Annex 1 ($n=15$), SIDS ($n=39$) and Parties that are neither Annex 1 nor SIDS ($n=107$) (right). Coastal countries had a significantly higher MFF than landlocked countries (Kruskal–Wallis, $H=67.053$, 1 d.f., $p<0.0001$). The difference in MFF between negotiating groups is also significant (Kruskal–Wallis, $H=41.741$, 2 d.f., $p<0.0001$). Comparisons between other negotiating groups were not possible because most Parties belong to more than one negotiating group.

Table 1 | Occurrence of specific marine topics in NDCs.

Ocean warming ($n=76$)	Angola, Antigua and Barbuda, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Brunei Darussalam, Cabo Verde, Cambodia, Cameroon, China, Comoros, Congo, Costa Rica, Cuba, Democratic Republic of Congo, Djibouti, Dominica, Egypt, El Salvador, Eritrea, Equatorial Guinea, Fiji, Gambia, Georgia, Grenada, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iraq, Kiribati, Kuwait, Lebanon, Liberia, Madagascar, Malaysia, Maldives, Marshall Islands, Mauritania, Mauritius, Morocco, Mozambique, Myanmar, Nauru, Nigeria, Niue, Oman, Palau, Papau New Guinea, Qatar, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Singapore, Solomon Islands, Somalia, South Africa, Sudan, Suriname, Tonga, Trinidad and Tobago, Tunisia, Tuvalu, United Republic of Tanzania, Vietnam, Yemen
Ocean acidification ($n=14$)	Antigua and Barbuda, Bangladesh, Comoros, Dominica, Eritrea, Iraq, Kiribati, Marshall Islands, Mauritania, Nauru, Niue, Palau, Seychelles, Tonga
Ocean deoxygenation ($n=1$)	Mauritania
Mangroves ($n=45$)	Angola, Bahamas, Bahrain, Bangladesh, Benin, Brunei Darussalam, Cambodia, Cameroon, Congo, Côte d'Ivoire, Cuba, Djibouti, El Salvador, Fiji, Gabon, Grenada, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Kiribati, Liberia, Madagascar, Marshall Islands, Mauritius, Mexico, Myanmar, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Somalia, Sudan, Suriname, Thailand, United Republic of Tanzania, United Arab Emirates, Vietnam, Yemen
Coral reefs ($n=28$)	Barbados, Belize, Brunei Darussalam, Cuba, Djibouti, Dominica, Egypt, Eritrea, Grenada, Honduras, Iraq, Kiribati, Madagascar, Maldives, Mauritius, Mexico, Nauru, Niue, Palau, Papau New Guinea, Qatar, Saint Vincent and the Grenadines, Saudi Arabia, Solomon Islands, Somalia, Sudan, Tonga, Yemen
Blue carbon ($n=27$)	Angola, Antigua and Barbuda, Armenia, Bahamas, Bahrain, Bangladesh, Brunei Darussalam, China, Dominica, El Salvador, Guinea, Guyana, Haiti, Iceland, Kiribati, Madagascar, Marshall Islands, Mexico, Philippines, Saudi Arabia, Senegal, Seychelles, Solomon Islands, Suriname, Ukraine, United Arab Emirates, Vietnam

Certain marine climate impacts and marine ecosystems were recognized in many NDCs, whereas others received little attention. The table specifies which Parties have included specific mention of the three main climate change stressors for marine ecosystems (warming, acidification and deoxygenation) within their NDCs. Many Parties also included mangroves and coral reef ecosystems in their NDCs. Coral reefs were typically included as adaptation components, whereas mangroves received attention as both adaptation and mitigation components, with Parties recognizing the carbon sequestration service of mangroves. Carbon sequestration in marine ecosystems is called 'Blue Carbon' and 27 NDCs reference management of mangroves, sea grass beds, salt marshes, wetlands or ocean carbon as mitigation strategies. The number of NDCs including each category is indicated under the category name.

Only Mauritania raised concerns about ocean deoxygenation in its NDC, even though a greater than 2% loss in the global ocean oxygen inventory has already been observed since 1960[23]. This suggests a lack of knowledge at the international policy level about ocean deoxygenation, which is a result of warming-induced changes in seawater solubility, stratification, and respiration[24], and carries significant ecosystem consequences[25].

To better understand the variance in how countries have identified marine issues in their NDCs, we first compute a marine focus factor (MFF)—a quantitative metric of the frequency and diversity of marine-related topics in each NDC. The NDCs with the highest MFF were Maldives, Oman, St. Kitts and Nevis, Kiribati, Bahrain, Seychelles, Mauritania, Mauritius, St. Vincent and the Grenadines, and Nauru—several of which are members of the SIDS designation that has become a powerful bloc in the climate negotiations[26]. Coastal countries ($n=124$) had a higher MFF than landlocked countries ($n=37$) ($H=67.053$, 1 d.f., $p<0.0001$) and MFF differed significantly among negotiating groups ($H=41.741$, 2 d.f., $p<0.0001$), with NDCs from Annex 1 Parties having the lowest MFF (Fig. 3).

Next we identified a host of factors that would plausibly influence MFF. These are: how much marine and coastal territory a country has, how much of the country's land area and population is vulnerable to sea-level rise, the importance of marine sectors for the economy, the country's commitment to marine conservation, the economic situation, and the country's political negotiating history within the UNFCCC. We then selected global data sets for variables that represented these factors. EEZ size, ratio of EEZ to land area, and coastline length were selected to reflect how much marine and coastal territory countries had. Percentage of land area below 5 m above sea level (%Land Area < 5 m) and percentage of population living in these low-lying areas (%Pop < 5 m) were selected to reflect vulnerabilities to sea-level rise. Domestic fisheries landing value was selected to reflect the value of marine resources. Percentage of territorial areas that are marine protected areas (MPAs) was selected to reflect commitment to marine conservation. Gross domestic product (GDP) was selected to reflect the economic situation. The UNFCCC negotiating group that Parties belonged to provided a reflection of their political negotiating history.

We hypothesized a priori that variables that would be positively related to MFF were: total EEZ area, ratio of EEZ to land area, coastline length, percentage of territorial waters that are marine protected areas, value of domestic fisheries landings, percentage of low-lying land area, percentage of the population living in low-lying areas, and whether the country is a SIDS. By contrast, we hypothesized that two closely related factors would be negatively correlated with MFF: whether the country is a member of Annex 1 of the UNFCCC and its gross domestic product (GDP). We chose these variables with possible negative correlation with MFF to reflect that the advanced industrialized countries have framed the climate issue as one of mitigation[27] and been reluctant to focus on climate impacts and adaptation[28], particularly for the ocean. We were unable to include other explanatory variables based on political system or administrative competence, because Annex 1 countries represent the developed countries where these are highly collinear. Scatterplots showing the relationship between each explanatory variable and MFF are provided in Supplementary Section 6.

These hypotheses were tested empirically in a multiple linear regression analysis, yielding a significant regression equation ($F_{10,107} = 6.676$, $p < 0.0001$) with a model that explains 38% of the variance in MFF for NDCs of coastal countries ($R^2 = 0.384$). Selecting the best model fit with Akaike's information criterion modified for small sample sizes (AICc) (Supplementary Section 4) yields:

$$\begin{aligned} \text{MFF}^{0.5} = {} & 1.672 + 5.534\text{e}^{-1}(\text{SIDS}) + 3.362\text{e}^{-2}\ (\%\text{Pop} < 5\,\text{m}) \\ & + 2.191^{-2}\ (\%\text{Land Area} < 5\,\text{m}) - 1.310\ (\text{Annex 1}) \\ & - 1.215\text{e}^{-4}\ (\text{EEZ:Land}) \end{aligned}$$

Figure 4 summarizes the standardized coefficients and significance for each of the hypothesized variables. Two factors have a significant positive influence on MFF ($p < 0.05$): the percentage of the country's population that lives in low-lying areas and being a SIDS. Many other factors, including fisheries catch and coastline length, have no significant effect. The result that the percentage of the population living in low-lying areas positively influences the MFF, whereas other coastal factors (for example, coastline length) do not, suggests that sea-level rise vulnerabilities are particularly important in shaping climate policy priorities. As hypothesized, being an Annex 1 Party negatively influences MFF (Figs 3 and 4), although GDP does not. Despite Annex 1 countries having large marine territories, economically important fisheries, and a commitment to marine conservation, indicated by having large MPAs (Supplementary Section 7), their NDCs have a low MFF (Fig. 3).

Contrary to our hypothesis, the value of domestic fisheries landings had no significant influence on MFF. This is striking because national economies are vulnerable to the impacts of climate change on fisheries[29,30] and 72 Parties include fisheries impacts in the adaptation sections of their NDCs (Fig. 2). The fisheries sector is also included by 15 NDCs within the mitigation section, showing that fisheries concerns are relevant to both climate mitigation and adaptation plans. However, the results of the analysis show that the value of fisheries is not statistically influencing the amount of focus dedicated to marine topics in NDCs. Two additional fisheries-related explanatory variables were also tested and had no significant influence on MFF (Supplementary Section 8), suggesting this result is robust.

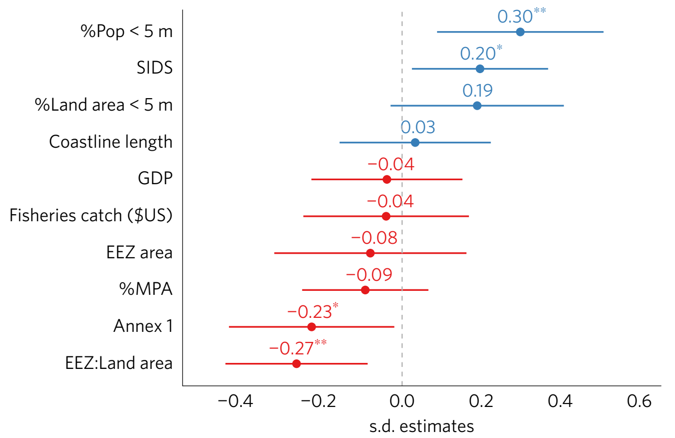

Figure 4 | Ability of different explanatory variables to explain variance in NDC marine focus. Standardized coefficients from the multiple linear regression with Marine Focus Factor (MFF) as the dependent variable. Variables with positive (blue) and negative (red) impacts on MFF shown, with bars indicating two standard deviations in the error estimate. Asterisks denote statistically significant variables ($^*p < 0.05$, $^{**}p < 0.01$). Explanatory variables tested were: percentage of the population living in areas less than 5 m above sea level (%Pop < 5 m), whether the country was a SIDS, percentage of land area that was less than 5 m above sea level (%Land Area < 5 m), the coastline length (m), the GDP, the domestic fisheries landing value (Fisheries Catch ($US)), the total EEZ Area, the percentage of the marine territory that was protected (%MPA), whether the country was an Annex 1 Party, and the ratio of EEZ to land area (EEZ:Land Area).

Although we had initially hypothesized that increasing marine territory would positively influence MFF, we found no significant relationship between EEZ Area and NDC MFF. We also found a significant negative relationship between the ratio of EEZ to land area and the NDC MFF (Fig. 4). Since the SIDS represent a large negotiating bloc of countries and have large EEZ to land areas (Supplementary Section 7), we additionally tested this finding in the SIDS alone and found that the result was consistent (Supplementary Section 10). This trend was largely driven by Tuvalu and the Marshall Islands, which have extremely high EEZ to land area ratios, but submitted NDCs with relatively low MFFs. This result suggests that the marginal value of marine territory may decrease as EEZ size increases relative to land area.

Also unexpected is the finding that percentage of marine territory that was protected (%MPA) was negatively (but not significantly) correlated with MFF (Fig. 4). To further assess if countries with better marine management and healthier ocean ecosystems were more inclusive of marine issues in their climate pledges, we used the Ocean Health Index[31,32] as an additional explanatory variable. We found that the Ocean Health Index was not significantly correlated with MFF ($p > 0.05$) for all coastal countries (Supplementary Section 9) as well as for the SIDS-only negotiating bloc (Supplementary Section 10). When the MFF was deconstructed into a coastal and ocean component, percentage of protected marine territory still had no significant influence on either of these (Supplementary Section 11). Although the explanatory variables tested here accounted for 38% of the variance in MFF, the way NDCs were developed (with input from international consultants who are well acquainted with scientific issues versus a more government-driven process) may also be an important factor influencing marine focus and may account for a component of the variance not explained by the model.

The results of the multiple linear regression analysis suggest that historical political behaviours may be an important driving factor in influencing how countries are including oceans in their NDCs.

We hypothesized that variables relating to ocean value (that is, fisheries, EEZ area, coastline length) and ocean conservation and governance (that is, %MPA, Ocean Health Index) would have a positive influence on marine inclusion in NDCs, but found this not to be the case. Instead, we found a stark difference in how countries in Annex 1 and SIDS included oceans in their NDCs (Fig. 4). This difference may be attributed to the different historical roles these two groups have played within the international climate negotiations[27,33]. Annex 1 Parties represent countries with highly developed economies that have contributed the most to climate change and have historically focused on mitigation of emissions. That focus was reflected in the Kyoto Protocol, which concentrated on emission reduction goals only for Annex 1 Parties, while marginalizing the adaptation needs of developing countries[34]. SIDS are developing coastal countries that contribute minimally to global emissions but are some of the most vulnerable to climate change impacts. To represent their shared vulnerabilities, these countries organized into the Alliance of Small Island States (AOSIS) around 1990, and rapidly emerged as a powerful voice within the UNFCCC negotiations[35,36]. Throughout the negotiations, AOSIS has advocated for a greater emphasis on adaptation, with a special focus on climate impacts on oceans[26]. The strong influence of negotiating group (Annex 1 or SIDS) on MFF that we find in the present study suggests political and not principally scientific motivations are largely driving current patterns of ocean inclusion in NDCs. Even though attention to climate impacts and adaptation have risen in the past decade, the Annex 1 countries remain systematically focused on climate change as a problem of mitigating emissions, and under-represent oceans in their NDCs, whereas the SIDS are increasingly focused on marine climate impacts and adaptation.

We also assessed if Parties were including information on additional marine research needs in their NDCs, and found this to be the case in 39 NDCs (Fig. 2). These needs can roughly be divided into four categories: improve scientific climate models and marine observations; strengthen the capacity of local marine and resource management institutions; conduct additional studies on marine climate change vulnerabilities, losses, and damages to improve management plans and national development frameworks; and conduct research on mitigation potential of marine ecosystems, specifically, carbon storage, development of renewable ocean energy, and low-carbon fisheries practices. In their NDCs, least developed countries (LDCs) and SIDS largely look to the international community to provide the financial support to meet their NDC goals. It is likely that additional financing streams, in addition to the Green Climate Fund, will be necessary to support stated ocean and climate research needs. One possibility may be the proposed Ocean Bank for Sustainability and Development[37]. Increased cooperation and collaboration between marine institutions in developing and developed countries may help address capacity building challenges raised in NDCs. Climate impacts in certain marine ecosystems, such as the deep sea[38], remain poorly understood and will require additional international cooperation.

The Paris Agreement commits nations to limit global temperature rise to well below 2 °C, while pursing efforts to limit to 1.5 °C; however, marine ecosystems experience impacts even under the most ambitious mitigation scenarios[39,40]. Concrete financial incentives exist for meeting the goals of the Paris Agreement, especially for countries reliant on marine fisheries[41]. The results of this analysis show that oceans are not only becoming more prominent in the climate negotiations, but that countries are actively including marine ecosystems in their national climate plans. However, we find a large spread in the marine focus of NDCs, with Annex 1 Parties showing a lack of focus on marine issues. Certain marine impacts, such as ocean deoxygenation and acidification, continue to receive limited attention from governments, emphasizing the need for additional scientific engagement and education. Secondary impacts from climate mitigation and adaptation plans should also be considered. For example, 11 NDCs include seawater desalination plans, which carry environmental risks including larval entrainment and outflow of chemical-contaminated brine[42].

Over half a billion of the world's poorest people rely heavily on the ocean for food, jobs, and revenue and live in countries that will be impacted by simultaneous changes in ocean biogeochemistry from climate change[21]. Not considering the ocean in NDCs has several consequences, including missed mitigation opportunities involving marine ecosystems and the development of national climate adaptation plans that fall short of addressing the needs and vulnerabilities of coastal communities[43]. Certain Parties have stated that including oceans in NDCs is necessary for the successful implementation of the Paris Agreement[44]. Since the high seas experience climate impacts but remain outside of the legal jurisdiction of the UNFCCC, it is important to consider how action under the Paris Agreement interacts with other UN treaties, including the UN Convention on the Law of the Sea, the Convention on Biological Diversity, and the Sustainable Development Goals. Climate impacts may also shape the biodiversity treaty under development in areas beyond national jurisdiction. Under the Paris Agreement, NDCs are reviewed and communicated anew every five years, allowing for improvements to be made on identified gaps. The Intergovernmental Panel on Climate Change (IPCC) special report on the ocean and cryosphere (due out in 2019) could provide additional guidance on marine impacts in time to inform the next round of NDC revisions. Engagement of ocean scientists is essential to ensure that marine ecosystems are being appropriately considered in national climate action plans[45].

Methods

Methods, including statements of data availability and any associated accession codes and references, are available in the online version of this paper.

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Author contributions

N.D.G. performed the analysis and wrote the manuscript, D.G.V. and L.A.L. contributed equally in providing guidance on the analysis and revising the manuscript.

Additional information

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Competing financial interests

The authors declare no competing financial interests.

Methods

All 161 pledges submitted to the UNFCCC Secretariat[13] by June 2016 were analysed for inclusion of marine keywords and categories (Supplementary Section 3). These pledges were known as intended nationally determined contributions (INDCs), but became nationally determined contributions (NDCs) once the Paris Agreement came into force in November 2016, and are therefore referred to as NDCs throughout the manuscript. The total NDC data set represented 1,997 pages of NDC text and a text mining approach was used. For this analysis, marine ecosystems include estuarine, coastal, and open ocean ecosystems.

A core set of 23 marine keywords (Supplementary Section 3) was selected and a standardized search for this core set of keywords was carried out for each NDC. Marine keywords were determined based on the authors' knowledge of terms commonly used in the marine and climate science, marine conservation, and marine policy fields, and represent general terms that reference specific marine habitats, climate impacts, and ocean industries or economic sectors. The core set of keywords represented a balance between being broad enough to appropriately identify marine-focused sections of text, while reducing the number of keywords required for the standardized search applied to all NDCs. Sections of text in which these core keywords were found were then read to identify other marine keywords (ex. 'beach', 'desalination', 'fishermen'). The frequency of use of all marine keywords in each NDC was then tabulated. In some cases, such as 'fisheries,' the authors evaluated whether the use of this keyword in the NDC referred to freshwater or marine sectors, and only included keywords in the total count that were marine-focused. A total marine word count was then determined for each NDC. To account for differences in NDC length (Supplementary Section 5), the marine word count was standardized to total NDC word count.

Sections where marine keywords appeared were extracted, read in their entirety, and were used to determine if Parties were including marine ecosystems as mitigation or adaptation contributions in their NDCs. Although NDCs varied considerably in length and content, they did follow a format that, although not consistent across all NDCs, was similar for many submitted NDCs. The format included an introductory section, a section on mitigation contributions and (for some) a section on adaptation contributions. If specific marine topics were included in the mitigation section or annexes to the mitigation section, they were considered as mitigation components, and are referenced this way in the manuscript. Mitigation refers to actions that result in reductions to national greenhouse gas emissions. If marine topics were included in the adaptation section of the NDC or if marine impacts or vulnerabilities were discussed within other components of the NDC, these were considered adaptation components and are referenced this way in the manuscript. Adaptation refers to vulnerabilities from climate change and actions that reduce climate impacts. Descriptions of marine impacts were categorized as adaptation components, despite these sections not always containing specific adaptation plans. A total of 31 specific marine categories were identified across NDCs (Fig. 2 and Supplementary Section 3) based on marine concepts that were included in NDCs; these represent a general grouping of ways in which marine issues were included.

Using the tabulated marine keywords and categories, a Marine Focus Factor (MFF) was then calculated for each NDC.

$$\text{MFF} = 1{,}000 \times \left(\frac{\text{Marine Keywords in NDC}}{\text{Total NDC Word Count}}\right) \times \left(1 + \frac{\text{Marine Categories in NDC}}{\text{Total Marine Categories}}\right)$$

The MFF is meant to be used as a comparative metric for evaluating how much marine consideration different countries are including in their climate pledges, across all submitted NDCs. The MFF does not differentiate between marine activities that are environmentally beneficial (for example, mangrove replanting) or potentially environmentally detrimental (for example, seawater desalination), so the MFF should not be used alone as a metric to evaluate how beneficial an NDC is for the marine environment. Twenty NDCs were randomly selected, read in their entirety, and marine components summarized to provide a qualitative assessment of how well the MFF was capturing actual differences in marine focus (Supplementary Section 12).

Although most NDCs were available in English, those that did not have an English translation available (Spanish (8), French (12), and Arabic (2)) were analysed by native language speakers who were also fluent in English, following the same protocol. Specifically, the core set of 23 marine keywords were translated into the native language, with care taken to ensure that the translation was accurately capturing the concept. The core keywords were then used to identify sections of marine-focused text, and these sections were translated into English. Additional marine keywords were then identified and a count was obtained for all marine keywords in the NDC. The author who processed all of the English NDCs also utilized Google Translate to translate the foreign language NDCs in their entirety, and this rough translation was read through to ensure that the keyword count and identification of marine categories was consistent across the English and non-English NDCs. We also tested NDC language as an additional explanatory variable in the multiple linear regression analysis and found no statistically significant influence on MFF ($p > 0.05$) (Supplementary Section 5).

Developing the MFF as a comparative metric allowed us to test which factors give rise to differences in the amount of marine consideration in NDCs. We hypothesized a priori that factors that influence how likely Parties are to include marine issues in their NDCs were: total EEZ area, ratio of EEZ to land area, coastline length, percentage of territorial waters that are marine protected areas, value of domestic fisheries landings, percentage of low-lying land area, percentage of the population living in low-lying areas, gross domestic product (GDP), and whether the country is a SIDS or Annex 1 Party. Data for continuous explanatory variables were obtained from the World Bank[46] and the Sea Around Us Project[47]. Data for GDP originated from the World Bank national accounts data and the OECD National Accounts data files and represent GDP at market prices (in constant 2005 $US) for the year 2010. Data for MPAs originated from the United Nations Environmental Program and the World Conservation Monitoring Center, and represent percentage of territorial intertidal and subtidal terrain and overlying water that have been protected by law or other effective means, for the year 2014. Data for percentage of low-lying land area and percentage of the population living in low-lying areas originated from the Center for International Earth Science Information Network and measure the percentage of total land area where the elevation is 5 m or less and the percentage of the total population living in these areas, for year 2010. Data for domestic fisheries landing values were obtained from the Sea Around Us project on 6 September 2016 and represent fisheries landed value reconstructed domestic catch in constant 2005 $US.

All data were collected in an Excel spreadsheet and all statistical analyses were performed in R[48], a free software environment for statistical computing and graphics. Since the data for MFF were not normally distributed, we used a nonparametric one-way analysis of variance (ANOVA) (Kruskal–Wallis) to test if there was a significant difference in marine inclusion between coastal and landlocked countries, and among Annex 1, SIDS, and all Other Parties for the whole NDC data set ($n = 161$). We then tested the influence of all the hypothesized explanatory variables on the MFF using a multiple linear regression analysis to determine which explanatory variables had a significant effect on an NDC's MFF. Only coastal countries with data for all explanatory variables were included in the multiple regression analysis ($n = 118$), which excluded all landlocked countries and Montenegro, EU, Cook Islands, Monaco, Nauru, and Niue, for which data on the full-suite of explanatory variables were not available. Since the dependent variable was not normally distributed, we first square-root-transformed the MFF to meet the assumptions of normality. As a robustness check, both absolute marine word count and standardized marine word count were also tested as dependent variables in the model (Supplementary Section 5) and an additional analysis deconstructed the MFF into a coastal and ocean component (Supplementary Section 11). Additional explanatory variables including the Ocean Health Index[31,32] and the government effectiveness index were also tested and included in the multiple linear regression model (Supplementary Sections 9 and 10).

Results for the significance of each explanatory variable and the overall model fit were reported for the multiple linear regression analysis. The best model was then selected using a stepwise algorithm using Akaike's Information Criterion, modified for small sample size (AICc)[49] employing the AICc function in the AICcmodavg package for R[50]. Although AICc allows us to select the best model, we acknowledge the limitations of the data set, specifically the small sample size ($n = 118$) and the large number of degrees of freedom. Candidate models are provided in Supplementary Section 4. Multicollinearity and variance inflation factors were checked for the explanatory variables tested (Supplementary Section 5). Standardized coefficients for each explanatory variable from the multiple linear regression analysis were extracted using the lm.beta function in the QuantPsyc package for R[51] and plotted using the sjPlot package[52]. An additional multiple linear regression analysis was also carried out for the SIDS-only data set (Supplementary Section 10). Additional figures were produced using the ggplot2 package[53] in R.

Data availability. The authors declare that all data supporting the findings of this study are available within the Zenodo data repository with the identifier (http://dx.doi.org/10.5281/zenodo.845500)[54] and within the article's Supplementary Information files.

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