

July 11, 2023

Dear Dr. Rosemary Hails,

On behalf of the author team, I am pleased to submit our revised manuscript, "If you build it, they will come: coastal amenities facilitate human engagement in marine protected areas", for consideration as a Research Article in *People and Nature*.

We carefully reviewed the comments from you and the reviewers and are grateful for this thoughtful feedback. We address each comment individually below with the original comment shown in black text and the response shown in indented blue text. This feedback and the associated revisions have greatly improved the manuscript.

Briefly, we made the following notable changes to the manuscript text and analysis:

1. Added text on the contributions of the study to UN COP25 30x30 goals
2. Added text on the potential implications of our results for climate change mitigation
3. Added text to clarify and caveat the MPA vs. non-MPA counterfactual analysis
4. Expanded Table S3 and added text to clarify key limitations of the various indicators
5. Added text to highlight cultural, spiritual, and emotional human use benefits
6. Added text to clarify that limiting human engagement can also be a management goal
7. Added text to clarify the role of the social vulnerability data in the analysis
8. Added text to highlight the role of qualitative methods in advancing participatory design

Thank you for your consideration and please let us know if you have any questions.

On behalf of all authors,
Sincerely,

Christopher Free

Associate Editor

This manuscript is an excellent and timely contribution to PaN.

The comments/suggestions provided by both reviewers will provide the necessary guidance for revising the manuscript.

In my opinion the authors may also consider adding how their study will contribute to the UN COP15 30 x 30 Goals in relation to MPAs; and also some considerations in terms of the role that MPAs can play in terms of climate mitigation actions.

We are grateful for this acknowledgement and feedback.

We added the following underlined text to the introduction and discussion to highlight that the study framework and results can help guide the expansion of MPA coverage, specifically as the world aims to protect 30% of the ocean by 2030 (30x30):

Introduction: “These insights are helpful as California (Executive Order N-82-20, 2020), the United States (Executive Order on Tackling the Climate Crisis at Home and Abroad, 2021), and the world (CBD, 2021) aim to protect 30% of the ocean by 2030 (30x30) to meet an array of conservation, fisheries, and other cultural objectives (Sullivan-Stack et al., 2022).”

Discussion: “As California prepares to expand its MPA network to meet 30x30 goals, it will be important to build on the successes and lessons of the original participatory planning process (Gleason et al., 2013) to further enhance the ability for community members, especially indigenous people, to ensure that their values are reflected in the objectives, regulations, and design of the expanded network (Voyer et al., 2015; Voyer & Gladstone, 2018).”

Discussion: “Understanding the ability and enabling conditions for MPAs to achieve human engagement objectives is important as entities around the world aim to protect 30% of the ocean by 2030 to meet objectives for people and nature (CBD, 2021).”

We added the following underlined text to the discussion to highlight the potential implications of our results for mitigating climate change impacts:

Paragraph 4: “Alternatively, if reducing human engagement is desired — for example, to enhance protection of biodiversity or other ecosystem or cultural services sensitive to human visitation or to limit cumulative stressors to promote climate resilience — then planners could locate MPAs far from people or land-based parks and amenities (Campbell et al., 2020).”

Paragraph 6: “Furthermore, MPAs also aim to achieve conservation and fisheries benefits and MPAs with low human engagement can be critical contributors to these goals. This is especially true given that human engagement with MPAs has the potential to negatively impact ecosystem function and MPA performance (Milazzo et al., 2002). Limiting human engagement can also reduce the cumulative impacts of multiple stressors on MPAs, including climate change, eutrophication, and pollution (Mach et al., 2017). MPAs with low human engagement are thus key in the design of effective MPA networks, as they can buffer or offset the impacts of human activities in MPAs with greater engagement and limit cumulative impacts in a multi-stressor environment.”

Mach, M. E., Wedding, L. M., Reiter, S. M., Micheli, F., Fujita, R. M., & Martone, R. G. (2017). Assessment and management of cumulative impacts in California’s network of marine protected areas. *Ocean & Coastal Management*, 137, 1–11.
<https://doi.org/10.1016/j.ocecoaman.2016.11.028>

Reviewer 1

What a pleasure to get sent paper to review which is this interesting and polished.

Great paper, no notes.

Okay I’m joking I have a few.

The paper is a really wide-ranging evaluation of human activities within Marine Protected Areas in California. The authors have been really creative and entrepreneurial in digging up and combining different data sources to understand human activities across this network. The analyses are well done and well presented. The real strength of this paper is presentation of a range of human activities which are rarely evaluated and estimates of the MPA characteristics (or enabling factors) that drive this engagement. This is a really understudied area, it has rarely been addressed in this kind of quantitative and comprehensive way, in this paper is a great and important addition to the literature.

We are grateful for the close review of our manuscript and thoughtful and constructive feedback. We detail how we addressed these comments and suggestions in the indented blue text below. This led to a much improved paper.

The closest thing I have to a major criticism is a little bit of hesitation about their use of the data on consumptive uses and related data on enforcement citations. I think there are potentially some complex issues with interpreting this data which would require a deeper dive into the specific regulations in each protected area and the effort being put into enforcement in each protected area. So for example around line 397 the authors suggest that a negative correlation between observations of active consumptive activity and citations might indicate that active consumptive activity is sanctioned, but I could also imagine that that negative correlation might be driven by people poaching less in areas with more active enforcement. I think on balance it is

more valuable to keep this data in the paper despite the challenges to its interpretation, and I think the authors are pretty good about not making overly confident statements about what it means.

We added the following underlined text to *Section 2.3* in the methods to better highlight that we have limited ability to infer the legality of consumptive activities reported by MPA Watch volunteers because (1) harvest is allowed in some MPAs and (2) the volunteers are not legal authorities on MPA boundaries or regulations:

“Volunteers use a standardized survey protocol (MPA Watch, 2022b) to record consumptive (e.g., fishing) and non-consumptive (e.g., surfing, boating, tidepooling, running, etc.) activities occurring both on- and off-shore of coastal sampling sites (**Table S4**). Consumptive activities are classified as either active (e.g., fishing line in water) or inactive (e.g., fishing pole on boat but not being used); we focus on active consumptive activities. We caution that SMRMAs and some SMCAs allow some forms of consumptive activity and that MPA Watch volunteers, while well trained, are not legal authorities on MPA boundaries and regulations. Thus, our ability to infer the legality of consumptive activities documented by MPA Watch volunteers is limited.”

We also added the the following underlined text to this section to further highlight the limitations in using the citations data to infer rates of non-compliance:

“We used records of citations issued by the CDFW Law Enforcement Division for regulatory violations occurring within California’s MPA network as an indicator of compliance. From 2016-2021, 2,812 citations were issued for violations occurring within 85 of California’s state MPAs (**Figs. S16 & S17**)..... We caution that a lack of patrol effort information limits our ability to infer non-compliance rates (i.e., whether more citations corresponds to more effort or more illegal activity) and advise that, going forward, CDFW record information on effort (e.g., number of patrol hours) to improve ability to document patterns of non-compliance and target patrol strategies.”

We also added both of these caveats to a new “Limitations” column in **Table S3**.

Finally, we added the following underlined text to the discussion to include the insightful alternative hypothesis proposed by the reviewer:

“Interestingly, the number of citations was negatively correlated with the observation of active consumptive activity by MPA Watch observers (**Fig. S17D**), which could indicate that the active consumptive activity reported by MPA Watch observers is sanctioned or that active consumptive activity is more prominent in areas with less active enforcement.”

Specific comments:

line 64: “stakeholder engagement” is used here in a pretty different context than in the rest of the paper and I think could create confusion for readers less familiar with the California process. I would change this to “stakeholder acceptance” or some other word

We changed “stakeholder engagement” in this sentence to “community participation” to clarify that we are referring to participation in the design process and not to the types of recreational, educational, and scientific engagement referred to throughout the remainder of the manuscript:

“In the long term, and with concerted community participation and buy-in, well-designed MPAs can also yield fisheries benefits through increased productivity and spillover resulting from improved biomass and age structure of populations in the MPA (Di Lorenzo et al., 2020; Marshall et al., 2019).”

We replaced “stakeholder” with “community” in two other places in the manuscript given that we recently learned of the colonial origins of the term stakeholder.

You say several times that this is the largest “scientifically based MPA network in the world”. It feels weirdly like a veiled attack on some other MPA network as not being scientifically based. Is this a criticism of the great barrier reef MPAs? I would like to see a citation to the paper in which this claim is argued in more detail or just say “one of the largest MPA networks in the world”

We clarified that California’s MPA network is the largest network of MPAs scientifically designed to function as a connected network in the abstract and introduction:

Abstract: “In this paper, we characterize human engagement in California’s MPA network, the world’s largest MPA network scientifically designed to function as a coherent network (124 MPAs spanning 16% of state waters and 1,700 km of coastline), and identify traits associated with higher human engagement.”

Introduction: “Here, we use California’s MPA network, the world’s largest MPA network scientifically designed to function as a coherent network (Botsford et al., 2014), as a case study for identifying conditions that promote or limit human engagement in MPAs.”

Botsford, L. W., White, J. W., Carr, M. H., & Caselle, J. E. (2014). Chapter Six—Marine Protected Area Networks in California, USA. In M. L. Johnson & J. Sandell (Eds.), *Advances in Marine Biology* (Vol. 69, pp. 205–251). Academic Press.
<https://doi.org/10.1016/B978-0-12-800214-8.00006-2>

There’s a ton of acronym jargon but I think it’s unavoidable. Section 2.1 does a pretty good job of laying it out. The label on figure A1 does not make sense without that section or without the

supplementary table. I'm guessing positioning of the figure in the final manuscript will solve this. But possibly could add a pointer to section 2.1 in that already very long caption.

We added the following underlined text to the caption to refer the reader to *Section 2.1*:

“See *Section 2.1* and **Table S1** for the definition of each MPA designation.”

I didn't love section 2.5. I just get a little nervous about this whole matching process. But I don't really have specific criticisms here, I just worry that someone else could sit down and come up with a pretty different way to do this matching. I also wonder why this was not done as a unified model with the matching factors included and then looking at the MPA effect on top. But I guess that approach also has a pile of assumptions as well.

We added the following underlined sentence and citations to illustrate how similar statistical matching approaches have been used in other MPA studies:

“The methods described above were used to determine which MPAs within California's MPA network generate the most human engagement and to identify the factors that drive differences in the levels of engagement; however, they are unable to reveal whether MPAs generate more, less, or equivalent human engagement as similar non-MPA areas. To understand the degree to which MPA designations impact human engagement in coastal areas, we compared engagement in MPA areas to similar counterfactual non-MPA areas. We identified similar counterfactual areas through statistical matching (Ferraro, 2009), which is being increasingly used to elucidate the ecological impacts of MPAs (Ahmadia et al., 2015; Gill et al., 2017). In short, we rasterized California's state waters into 200 m raster cells and paired each MPA cell with a non-MPA counterfactual cell with otherwise similar properties.”

Ahmadia, G. N., Glew, L., Provost, M., Gill, D., Hidayat, N. I., Mangubhai, S., Purwanto, null, & Fox, H. E. (2015). Integrating impact evaluation in the design and implementation of monitoring marine protected areas. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 370(1681), 20140275. <https://doi.org/10.1098/rstb.2014.0275>

Gill, D. A., Mascia, M. B., Ahmadia, G. N., Glew, L., Lester, S. E., Barnes, M., Craigie, I., Darling, E. S., Free, C. M., Geldmann, J., Holst, S., Jensen, O. P., White, A. T., Basurto, X., Coad, L., Gates, R. D., Guannel, G., Mumby, P. J., Thomas, H., ... Fox, H. E. (2017). Capacity shortfalls hinder the performance of marine protected areas globally. *Nature*, 543(7647), 665–669. <https://doi.org/10.1038/nature21708>

We also added the following underlined text to clarify this limitation and to highlight that we have accounted for all known and quantifiable drivers of MPA site selection and human engagement in ocean areas:

“We identified non-MPA counterfactual cells that were similar to their MPA reference cells in their depth (m), distance from shore (km), nearby population

density, proximity to parks, and proximity to public beaches. These matching variables were selected based on their association with engagement based on theory (Cinner et al., 2018; Ravenstein, 1885) and as revealed through the regression analysis (**Fig. 6**). Ideally, we would also match based on pre-MPA visitation rates (Devillers et al., 2015), but the lack of sufficient pre-MPA visitation data (see limited pre-2007 data in **Figure S8**) precluded this gold standard. However, by controlling for these known and quantifiable drivers of MPA site selection and human engagement, we can isolate, to the greatest extent practicable, the impact of MPA designation on human engagement. We derived these values for both MPA and counterfactual cells using the sources listed in **Table S6.**"

As mentioned above I'm not sure I believe the interpretation on 395 to 399, or at least I could imagine alternatives. Somewhere the paper should acknowledge that citation frequency is going to be of joint function of citable activity and enforcement activity, and enforcement activity is not accounted for here.

I thought the section from 447 to 463 was pretty good and good about not over-reading this data.

This was a very valuable comment and we added text to discuss (1) the limitations in both the CDFW enforcement data and MPA Watch non-consumptive activity data and (2) highlight the insightful alternative hypothesis posed by the reviewer. Please see our response to the first major comment to see how we addressed this important comment.

I don't know why, but I love figure 4 so much. I feel like it's only glancing mentioned, but there's already so much good stuff in the paper I understand that everything is getting squeezed.

We appreciate the encouragement to incorporate more discussion of Figure 4 in the paper. We revisited the results section and confirm that each paragraph discussing an indicator featured in the figure highlights pertinent results from the figure:

iNaturalist: "MPA engagement was less selective than predicted by human population density for this form of human engagement (**Fig. 4**)."

eBird: "Despite the tendency for eBirders to visit estuarine MPAs, the selectivity of birders was generally proportional to that predicted by population density (**Fig. 4**), suggesting that estuarine MPAs are located in areas with high population density."

REEF: "REEF divers have been more selective in their MPA visitation than any of the other evaluated user groups (**Fig. 4**)."

Scientific permits: “The distribution of scientific research throughout the MPA network has been more even than other types of human engagement (**Fig. 4**).”

Citations: “Citations were more highly concentrated in certain MPAs than would be predicted by human population density alone (**Fig. 4**).”

We also confirm that the results presented in this figure are featured in the discussion:

“Finally, engagement is moderated by the selectivity of different user groups. For example, whereas divers are highly selective in their choice of MPAs to visit, scientists have conducted research much more evenly across the statewide MPA network. Birders disproportionately visit estuarine MPAs, which tend to harbor large bird populations due to their high productivity (Paracuellos & Tellería, 2004).”

Figure 6 is also magnificent but more central to the story.

We appreciate this acknowledgement.

Reviewer 2

I enjoyed reading this paper and I believe the authors do what they say they are going to do in terms of quantifying human uses and engagement in MPAs in California. I can see that this paper will have application in the future management and planning of MPAs. I have a few minor comments and some expanded feedback - please see document below. I recommend this paper for publication. Please feel free to get in touch if you want to discuss anything further. Warm Regards, Dr. Freya Croft (University of Wollongong).

I would firstly like to congratulate the authorship team on submitting a refined and well written article. It was clear that the research was rigorous, and I was impressed by the analysis and the figures. It was apparent that a lot of work has gone into the article. I liked that this paper aimed to address human dimensions and look at the social components of MPA management which I think can tend to be overlooked. The paper has done well to unpack certain elements of human engagement using a variety of quantitative methods using existing data sets and has made a compelling case that MPAs close to larger populations, or with aspects that make them ‘charismatic’ including amenities, have higher rates of engagement than others with less amenities or that are more remote. The paper does what it says it will do in relation to quantifying the ways that people engage with MPAs. I can therefore see that the findings of this paper will have application outside of academia and will be beneficial in the future planning and management of MPAs.

We are grateful for the close review of our manuscript and thoughtful and constructive feedback. We detail how we addressed these comments and suggestions in the indented blue text below. This led to a much improved paper.

I have a few relatively minor points of feedback. These were largely related to points I had noted down where I think some more elaboration, or critical discussion could enhance the conversation. They are as follows (and in no particular order):

1) Some further justification of why human engagement in MPAs is important earlier on would be beneficial. I think this could be set up in two ways. Firstly, a more comprehensive discussion on human dimensions of engagement with ocean spaces. For example, the *High Level Ocean Panel – Human relationships to the ocean planet* (Allison et al. 2020), which outlines the diversity of human relationships to ocean spaces. I felt like the ‘human dimensions’ were a little limited and didn’t account for intangible human engagement – such as spirituality, emotional connection etc. Secondly, providing some more analysis as to why (or why not) humans should be engaging in these areas. It was not until the Discussion that the idea was raised that in some areas it would be beneficial to limit/restrict human engagement. I think this point needs to be made earlier on in the paper. For example, I would have liked to see some more discussion around the question – should prioritising engagement in MPAS be a management objective?

First, we added the following underlined sentence to the introduction to highlight the intangible benefits of MPAs and reference the Allison et al. (2020) report:

“Similarly, the U.S. Framework for the National System of Marine Protected Areas identifies the benefits of U.S. MPAs as: (1) “supporting social and economic benefits [including] coastal tourism”, (2) “providing new educational opportunities”, and (3) “enhancing research opportunities” (NOAA, 2015). In some cases, MPAs may aim to enhance cultural, spiritual, emotional, or intrinsic value benefits derived from the ocean (Allison et al., 2020).”

Allison, E. H., Kurien, J., Ota, Y., Adhuri, D. S., Bavinck, J. M., Cisneros-Montemayor, A., Jentoft, S., Lau, S., Mallory, T. G., Olukoju, A., van Putten, I., Stacey, N., Voyer, M., & Weeratunge, N. (2020). *The Human Relationship with Our Ocean Planet*. World Resources Institute. <https://oceanpanel.org/blue-papers/HumanRelationshipwithOurOceanPlanet>

Second, we dramatically rewrote the opening paragraph of *Section 2.3* to clarify that we focus on recreational, educational, and scientific engagement because (1) this is one of the MLPA management objectives and (2) there is limited data on less tangible cultural, emotional, and spiritual engagement in MPAs. It now reads as follows:

“We developed indicators of human engagement in recreational, educational, and scientific activities in California’s state MPA network using a mixture of citizen science, naturalist, and state agency datasets (**Table S3**). We focused on recreational, educational, and scientific engagement given that they are specific objectives of the network (Marine Life Protection Act, 1999) and given the lack of data on other cultural, spiritual, or emotional types of human engagement.”

Third, we introduced the fact that limiting human engagement can be an important management objective earlier in the paper by adding the following underlined text:

Abstract: “Understanding how humans engage with MPAs and identifying traits of MPAs that promote engagement is critical to designing MPA networks that achieve multiple goals effectively, equitably, and with minimal environmental impact.”

Abstract: “*Synthesis and applications:* These results suggest that achieving MPA goals associated with human engagement can be promoted by developing land-based amenities that increase access to coastal MPAs or by locating new MPAs near existing amenities during the design phase. Alternatively, human engagement can be limited by locating MPAs in areas far from population centers, coastal amenities, or sandy beaches.”

Introduction: “Evaluating human engagement in MPAs is needed to track progress towards achieving these objectives and for identifying the design principles that determine human engagement in MPAs. Here, we use California’s MPA network, the world’s largest MPA network scientifically designed to function as a coherent network (Botsford et al. 2014), as a case study for identifying conditions that promote or limit human engagement in MPAs.”

In the last example, “determine” used to read “promote” so we chose a word that could imply promote/limit and then added “or limit” in the next sentence.

- 2) It could be useful to define/explain what is meant by ‘sustainable human engagement’ and ‘sustainability achieving other human use objectives’

Given the subjectivity of this term and variability in its definition within MPA management plans, we removed the “sustainable” modifier from the manuscript. See below:

Abstract: “Understanding how humans engage with MPAs and identifying traits of MPAs that promote engagement is critical to designing MPA networks that achieve multiple goals effectively, equitably, and with minimal environmental impact.”

Introduction: “While the ability and prerequisites for MPAs to achieve conservation and fisheries objectives have been comparatively well-studied (e.g., Claudet et al., 2008; Edgar et al., 2014; Giakoumi et al., 2017; Goñi et al., 2010; Lester & Halpern, 2008; Wilson et al., 2020), the enabling conditions for ~~sustainably~~ achieving other human use objectives has received less attention (Ban et al., 2019; Erskine et al., 2021; Gerber et al., 2003; Naidoo et al., 2019; Turnbull et al., 2021).”

Introduction: “Evaluating human engagement in MPAs is needed to track progress towards achieving these objectives and for identifying the design principles that promote ~~sustainable~~ human engagement in MPAs.”

Discussion: “Critical next steps in MPA and human engagement research are to identify strategies for designing MPA networks to promote equitable human engagement, capturing the full extent and value of MPAs in promoting sustainable recreation and tourism, education and outreach, and scientific research, and minimizing negative impacts of engagement on the conservation and fisheries objectives.”

See the response to the comment above to see how we also better highlight that reducing human engagement can also be a management goal.

3) In the paper you make the case that the ‘human dimensions of engagement’ are recreation, education, and science. I think providing a little more critical analysis on this would be useful. These dimensions were based on policy documents (some of which were quite old), so I think some justification on why these three dimensions were chosen, would reinforce your methods section. In terms of clarity, I also think it would be useful to have slightly better delineation/definition of the terms that are used (human use objectives, human dimensions, indicators, drivers).

The California MPA network was enacted through a piece of legislation called the Marine Life Protection Act (MLPA), which was passed in 1999. While this is over two decades ago, it is the piece of legislation that governs California MPAs to this day; thus, it is not outdated, as the objectives of the MLPA remain active to this day.

We dramatically rewrote the opening paragraph of *Section 2.3* to clarify that we focus on recreational, educational, and scientific engagement because (1) this is the focus of the MLPA and (2) there is limited data on less tangible cultural, emotional, and spiritual engagement in MPAs. This rewrite also does a better job of tying the indicators to each of these categories and explaining why data from popular social media platforms was not included. We underline the new text most relevant to this comment below:

“We developed indicators of human engagement in recreational, educational, and scientific activities in California’s state MPA network using a mixture of citizen science, naturalist, and state agency datasets (**Table S3**). We focused on recreational, educational, and scientific engagement given that they are specific objectives of the network (Marine Life Protection Act, 1999) and given the lack of data on other cultural, spiritual, or emotional types of human engagement. We used data from two citizen science programs (MPA Watch and Reef Environmental Education Foundation) and two naturalist social networks (iNaturalist and eBird), which provide spatially referenced records of activities (e.g., surfing, swimming, boating, tidepooling, diving, etc.) or observations of wildlife submitted by individual users, as indicators of recreational and educational engagement in MPAs. While popular social media platforms such as Instagram, Facebook, Flickr, and Twitter may provide a better indicator of visitation rates than specialist platforms such as iNaturalist and eBird (Tenkanen et al., 2017), the volume of data generated by these platforms requires careful

subsampling to be manageable (e.g., (Hausmann et al., 2017)). Although analysis of these social media indicators of engagement was outside the scope of this study, we encourage their use in future research. We used data from the California Department of Fish and Wildlife (CDFW) on the annual numbers of permits issued for scientific research in California's MPAs as an indicator of scientific engagement. Finally, we used CDFW data on regulatory citations as an indicator of regulatory compliance within the network."

4) It would have been useful to discuss the limitations of the methods chosen a bit earlier on in the paper, perhaps moving this from the Discussion to the Methods section? I think perhaps some better justification on why certain data sets were chosen. For example, the Tenkanen (2017) reference, seems to refer to more prominent platforms (Twitter, Instagram etc) than *ebird* and *Inaturalist*. I would argue that these nature-based platforms have perhaps less influence, and perhaps tell us something slightly different about visitation. A sentence or two just outlining some of the limitations of the data sets and methods would be useful.

We addressed this comment in several ways.

First, we added a new "Limitations" column to **Table S3** to be more transparent about the limitations of the various indicators.

Second, we added the following sentences to highlight especially important limitations in the methods section:

MPA Watch: "We caution that SMRMAs and some SMCAs allow some forms of harvest and that MPA Watch volunteers, while well trained, are not legal authorities on MPA boundaries and regulations. Thus, our ability to infer the legality of consumptive activities documented by MPA Watch volunteers is limited."

Enforcement: "We caution that the lack of patrol effort information limits our ability to infer non-compliance rates (i.e., do more citations correspond to more effort or more illegal activity) and advise that CDFW record information on effort (e.g., number of patrol hours) to improve ability to document patterns of non-compliance and target patrol strategies."

Finally, we added the following sentence to the methods to explain our decision not to include data from Instagram, Facebook, Flickr, or Twitter in this analysis:

"While popular social media platforms such as Instagram, Facebook, Flickr, and Twitter may provide a better indicator of visitation rates than specialist platforms such as iNaturalist and eBird (Tenkanen et al., 2017), the volume of data generated by these platforms requires careful subsampling to be manageable (e.g., (Hausmann et al., 2017)). Although analysis of these social media indicators of engagement was outside the scope of this study, we encourage their use in future research."

5) Also, in methods was the 2010 census data the most recent that is available? It seems a little dated. If this is the latest available, I think a quick explainer as a footnote could be useful.

We added the following underlined text to clarify that 2010 is the most recent data available because the census, which is only conducted every 10 years, was delayed for political reasons in 2020 and the delayed data are still undergoing processing:

“We characterized the human population living near MPAs using population demographics data from the 2010 U.S. Decennial Census (USCB, 2010a). The 2010 data is the most recent available data given extended delays in the release of the 2020 U.S. Census data (Schneider, 2023).”

Schneider, M. (2023, May 31). Census Bureau delays release of some of census' most detailed data until 2024. *AP News*. <https://apnews.com/article/2020-census-data-households-race-f4767583f0819f0ba79e9752fbf8129e>

6) Some clarification as to why it is important to know the social vulnerability data alongside the MPA data. This was not clear to me. I couldn't work out the purpose of that analysis as I don't feel like it was adequately addressed and analysed in relation to the rest of the results. Figure S4 seemed to indicate that MPAs tend to be located close to areas with less social vulnerability. Was this the case? I am wondering if this ties into your paragraph on equity later in the paper – and if maybe that point just needs to be made a little clearer?

We added the following topic sentence to *Section 2.2* to clarify why we quantify the number of people living near each MPA and the social vulnerability of this population:

“We hypothesized that the number of people living near an MPA and the socioeconomic vulnerability of this population would contribute to human engagement. In short, we expected that MPAs with larger and less vulnerable human populations (i.e., populations with more disposable income and time for recreation) would experience greater engagement. We characterized the human population living near MPAs using population demographics data from the 2010 U.S. Decennial Census (USCB, 2010a)....”

We added the following sentence to the results section to highlight the social vulnerability results (which were non-significant, refuting our hypothesis):

“Counter to our hypothesis, social vulnerability was not a significant driver of human engagement in MPAs (**Table S7**).”

7) In relation to the paragraph on equity, it might be worth mentioning that future work exploring equity of MPAs would also need to consider how management decisions are made and who gets a say in this. I think a discussion on equity could also discuss how Indigenous groups engage with MPAs and how they are involved in the management.

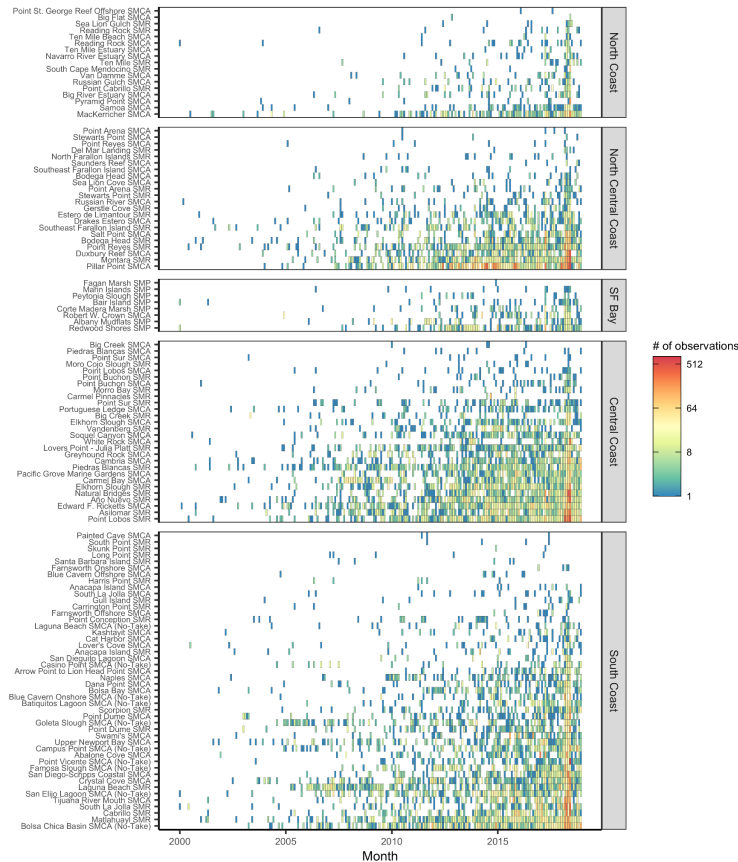
We added the following sentence to the discussion paragraph on equity (immediately following the text on the importance of qualitative methods such as surveys and focus groups) to highlight the value of qualitative methods to facilitate community participation, especially of indigenous groups, in the MPA planning process (which encompasses the specification of objectives, regulations, and placement):

“As California prepares to expand its MPA network to meet 30x30 goals, it will be important to build on the successes and lessons of the original participatory planning process (Gleason et al., 2013) to further enhance the ability for ocean users, especially indigenous people, to ensure that their values are reflected in the objectives, regulations, and design of the expanded network (Voyer et al., 2015; Voyer & Gladstone, 2018).”

This is also relevant to Comment #9 below.

8) I appreciate the steps taken to compare MPAs to non MPAS. I am wondering if this method accounted for natural features/ prior reputation of the area etc. Or if it largely was related to depth/ distance from shore? In the results section, you draw the conclusion that MPA status attracts engagement, particularly amongst divers. There is also the potential argument that it is not the MPA that draws human engagement, but rather ‘charismatic MPA’s’ were charismatic places prior to being designated as an MPA and engagement in this area would be high regardless of MPA status. I am not sure; I am just pondering here... but it could be worth thinking about? It would also be useful to include information on a general levels of awareness of MPAs amongst ocean users in California, if this information is available.

This is a very interesting and important comment. We assessed the potential to use pre-MPA engagement in iNaturalist (the most rich and universal of our engagement indicators) as an indicator of the pre-MPA popularity/awareness/charisma of MPA cells and counterfactual cells. Unfortunately, we found that the pre-MPA data is too limited for this to be a reliable indicator of pre-MPA popularity/awareness. Refer to **Figure S8**, provided below for convenience, to see how little data is available in the pre-MPA (pre-2007) era. The data is even more sparse when summarized at the 200m raster cell level rather than the MPA level, as shown here.



Thus, we added the following underlined text to clarify this limitation and to highlight that we have accounted for all known and quantifiable drivers of MPA site selection and human engagement in ocean areas:

“We identified non-MPA counterfactual cells that were similar to their MPA reference cells in their depth (m), distance from shore (km), nearby population density, proximity to parks, and proximity to public beaches. These matching variables were selected based on their association with engagement based on theory (Cinner et al., 2018; Ravenstein, 1885) and as revealed through the regression analysis (Fig. 6). Ideally, we would also match based on pre-MPA visitation rates (Devillers et al., 2015), but the lack of sufficient pre-MPA visitation data (see limited pre-2007 data in **Figure S8**) precluded this gold standard. However, by controlling for these known and quantifiable drivers of MPA site selection and human engagement, we can isolate, to the greatest extent practicable, the impact of MPA designation on human engagement. We derived these values for both MPA and counterfactual cells using the sources listed in **Table S6.**”

9) I liked that included the need for qualitative methods, I think this could be made more explicitly clear, including a sentence or two on why qualitative methods would be needed to

explore more of the nuance surrounding human engagements – particularly in relation to exploring some of the more intangible (and difficult to quantify) human dimensions/relationships – cultural, spiritual, emotional etc. The paper by Barclay et al. (2017) *The importance of qualitative social research for effective fisheries management* could be useful to look at/ reference. There are also some papers that look at values, emotions, and the place of community in MPA management, and these could be worth looking at or referencing. For example, Voyer and Gladstone (2018) <https://doi.org/10.7882/AZ.2015.029> and Voyer et al. (2015) - <https://doi.org/10.1016/j.marpol.2014.10.027>

We added the following sentence to the discussion paragraph on equity (immediately following the text on the importance of qualitative methods such as surveys and focus groups) to highlight the value of qualitative methods to facilitate community participation, especially of indigenous groups, in the MPA planning process (which encompasses the specification of objectives, regulations, and placement):

“As California prepares to expand its MPA network to meet 30x30 goals, it will be important to build on the successes and lessons of the original participatory planning process (Gleason et al., 2013) to further enhance the ability for community members, especially indigenous people, to ensure that their values are reflected in the objectives, regulations, and design of the expanded network (Barclay et al., 2017; Voyer et al., 2015; Voyer & Gladstone, 2018).”

Gleason, M., Fox, E., Ashcraft, S., Vasques, J., Whiteman, E., Serpa, P., Saarman, E., Caldwell, M., Frimodig, A., Miller-Henson, M., Kirlin, J., Ota, B., Pope, E., Weber, M., & Wiseman, K. (2013). Designing a network of marine protected areas in California: Achievements, costs, lessons learned, and challenges ahead. *Ocean & Coastal Management*, 74, 90–101. <https://doi.org/10.1016/j.ocecoaman.2012.08.013>

This includes citations to the Barclay et al. (2017) and two Voyer et al. papers recommended by the reviewer:

Voyer, M. and Gladstone, W. (2018) Human considerations in the use of marine protected areas for biodiversity conservation. *Australian Zoologist* 39(2): 173-180.

Voyer, M., Gollan, N., Barclay, K. and Gladstone, W. (2015) ‘It’s part of me’: understanding the values, images and principles of coastal users and their influence on the social acceptability of MPAs. *Marine Policy* 52: 93-102.

Barclay, K., Voyer, M., Mazur, N., Payne, A.M., Mauli, S., Kinch, J., Fabinyi, M. and Smith, G. (2017) The importance of qualitative social research for effective fisheries management. *Fisheries Research* 186: 426-438.

10) In line 416 – delete ‘its’ from in front of MPAs. Grammatical error. And reference on line 634 in the reference list seems to be out of order?

We deleted “its” in this sentence. Thanks for catching this typo.

We moved the MLPA reference to the correct location in the reference list.

Overall, I thought this was great. And these comments are just aspects that I thought could be interesting to elaborate on. I hope they are helpful. And well done on an excellent article.

Warm Regards,

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We appreciate this acknowledgement.