Reply Reviewer #1

The present work proposes a new methodology for improving beach clean-up, to reduce marine plastic debris. The case study is dedicated to the Galapagos islands and the methodology is using a network to select the optimum criteria for the beach clean- up purposes.

The manuscript is of very good quality, well organized with no specific structure problem or methodological problem. Although quite dense for the part explaining the criteria, it is possible for non-specialist to understand the goal of the selected criteria.

In summary, the overall quality of this work is up to the expected standards and to my point of view can be published as it is (after some typo and minor possible mistakes). I emphasize the fact that such decision (to my experience of reviewer) is very rare. I therefore thank the authors for having so well prepared their work before submission.

We thank the reviewer for the positive feedback and valuable comments. Part of our future research is to further improve the macroplastic transport simulations and to incorporate the role of atmospheric conditions and we appreciate the reviewer's suggestions related to these concepts. Our response to each individual comment can be found below.

However, in order to improve the manuscript, or give ideas for new works, I wish to share some questions or comments:

1. *a very basic but tricky one to start with: could the authors imagine what the results could be with an irregular grid with a strong refinement close to the coast, or with a high-resolution regular grid of, let say, 300 m in resolution on the horizontal? I reckon that this point could be discussed using some literature. My main concern is that, the present study does not prove that the results are not strongly dependent on the OGCM resolution used. If it were, the overall methodology might provide different scores in terms of criteria?*

Indeed, a tricky question, which is also to some extend raised by reviewer #2 comment (4). A higher near-shore spatial resolution will likely impact the local macroplastic transport, but will have little impact on the transition matrix as the eventual 'beaching' would still be parameterized. E.g., the most probable connections might shift by a few nodes, but the overall structure of the transition matrix, and therefore the most effective centrality rankings will likely not change. The near-shore area is a region where additional coastal processes such as rip currents, swell, and wind shadow zones of islands become important, that, regardless of the spatial resolution, are often not incorporated (Moulton et al., 2023). We think that it is the inclusion of the latter processes that might impact the scores from the various criteria used.

Regardless, the main aim of the paper is to introduce a network methodology that can assess the impact of cleanup strategies when a transition matrix is available. As mentioned in the manuscript, the 'method can be easily extended' once the macroplastic transport in the near-shore is more realistically represented in the transition matrix. We did make some changes to the introduction, method and discussion section to make our aim of our work and the applicability of the results clearer and would like to refer the reviewer to the track-changed revised manuscript.

Moulton, M., Suanda, S. H., Garwood, J. C., Kumar, N., Fewings, M. R., & Pringle, J. M. (2023). Exchange of Plankton, Pollutants, and Particles Across the Nearshore Region. *Annual Review of Marine Science*, *15*(1), null. https://doi.org/10.1146/annurev-marine-032122-115057

2. *the beaching probability: despite the fact that this has been already published, I am still very skeptical about the tuning of this probability. I am pretty sure that replacing this rather "adamant" formula by a probability calculated on the average wind direction versus the coastline layout in the area would be more realistic...Of course, I understand that there has to be a beaching time-scale of some sort to compensate the lack of grid resolution, but just days, regardless of general weather conditions in the area is strange to me. This is of course just my point of view, but this is what we can see when deploying drifters in general. Of course, this is complicated as the results can be different when looking at different scales, from large to very local scale (at the scale of a beach for example), but for a statistical approach, using regional winds might be ok.*

We thank the reviewer for this suggestion. Part of our future work will focus on the insights from a recent drifter field campaign in the marine reserve to make the beaching parameterization more realistic and we plan to indeed investigate the correlation between local atmospheric conditions, in addition to wave and tidal conditions, for drifter beaching events.

3. *A remark concerning the overall network method: according to some literature, connectivity and oceanic distance can be calculated out of the Lagrangian model "quite" simply, I mean without using a complex machinery. Therefore, it could have been interesting to show some comparisons with some basic diagnostics (overall stranding rate / source identification / oceanographic distance), to better prove the real added value of this complex work presented here. In other words, one might think that rather simple diagnostics could deliver nearly the same message or present similar general results, with a computational cost or calculation cost quite reduced. I understand that the authors might reply that their diagnostics are way refined and accurate, which is probably true, but the fact remains that, in the end, when it comes to mobilizing a cleaning team to go on site, maybe simple diagnostics can already deliver the necessary information for the management? (ok, I am teasing a bit here, but never underestimate the robustness of simplicity!)*

We agree that simple approaches are favorable and can potentially increase applicability. That is why we included diagnostics like the 'retention rate' and 'loss rate', which can be directly deduced from the transition matrix and are easy to understand. As suggested by reviewer #2, we slightly changed the description of these centralities to improve clarity. The 'overall stranding rate' suggested by the reviewer is very similar to the Source-Sink Index proposed in our manuscript.

The highest computational cost is by far the Lagrangian simulation itself, not the calculation of the diagnostics. So, we don't think that using the proposed 'simple' diagnostics will reduce the calculation costs. Furthermore, it is to us unclear how the oceanographic distance can be used as a diagnostic for the cleanup. As we focus on the time-mean system, it makes more sense to use the probability to travel between two nodes instead of the distance (which is time related). Either way, this would still require a Lagrangian simulation and does not provide in our opinion a 'simpler' or easier to interpret diagnostic.

4. *Concerning the seeding of the particles, the random seeding is one interesting case, but when targeting real cases, I am quite surprised that the authors have not tried to perform test cases for which the seeding was increased after heavy rains. If so, they would have put themselves in the position of delivering a real connectivity between islands with identified real sources, i.e. the beaches receiving inland waste through rivers or waste management pipes just after the rain events?*

This is a good suggestion, but not applicable to the Galapagos Islands as the main source of macroplastic arriving at the islands is remote (Sebille et al., 2019, Escobar-Camacho et al., 2021). The 'real sources' therefore can only be identified by either high resolution spatial and temporal observations of marine debris abundance along the coastlines (which is currently lacking), or by long-term simulating macroplastic transport pathways form the mainland and fishing activity towards the islands. The latter is tricky, as there are many unknowns in the source abundance and variability. Therefore, our overall aim of our studies is to combine the presented methodology with predicting the episodic arrival of high-concentration macroplastic patches. Heavy rains might indeed be important for the variability in e.g. river outflow from the mainland and would be interesting to incorporate in the predictive system.

Sebille, E. van, Delandmeter, P., Schofield, J., Hardesty, B. D., Jones, J., & Donnelly, A. (2019). Basin-scale sources and pathways of microplastic that ends up in the Galápagos Archipelago. *Ocean Science*, *15*(5), 1341–1349. https://doi.org/10.5194/os-15-1341-2019

Escobar-Camacho, D., Rosero, P., Castrejón, M., Mena, C. F., & Cuesta, F. (2021). Oceanic islands and climate: Using a multi-criteria model of drivers of change to select key conservation areas in Galapagos. *Regional Environmental Change*, *21*(2), 47. https://doi.org/10.1007/s10113-021-01768-0

5. *In addition, I think that, as the final goal is to deliver advice for where and when to go for beach cleaning, one missing part can be the part looking at the correlation between the weather conditions and the stranding or accumulation close to the shore. This is a temporal advice that can be more efficient than the cleaning frequency advice that can be deduced from the present work. Indeed, as mentioned in their introduction, waste distribution is highly heterogeneous, and one cause is the high variability of regional to local weather conditions. Therefore, one could think that the general cleaning plan could be quite different if the weather conditions variations were selected as one of the key parameters.*

We would like to refer the reviewer to our reply to comment (2). We agree that a better understanding of the role of local atmospheric conditions might aid to an even more effective cleanup strategy then repeated cleanup activities and have incorporated this suggestion in the discussion section of our manuscript:

'In addition, local atmospheric conditions can play an important role for both beaching and resuspension of macroplastic. The presented methodology to assess the removal impact is based on an explicit connectivity network where the edge weights are constant between iterations. As not only the resuspension and beaching timescales are likely to vary in time, but also the probability of pathways between the various nodes, it would be interesting to extend the impact assessment methodology to allow for a time-varying connectivity network.'