Response to reviewers: (Manuscript ID: os-2020-127)

Plastics in the Indian Ocean – sources, transport, distribution and impacts

We would like to thank and acknowledge the reviewer for their careful reading and constructive comments on the manuscript. We believe that we have addressed the issues raised by the reviewer and the proposed changes to the manuscript are detailed in this document. We trust that the reviewer and the editor will find that the suggested changes will make the manuscript suitable for publication.

Please note that the line numbers referred to in this document are those in the original manuscript commented by the reviewers.

#	Reviewer comment			Author response
22	This paper reviewed the research on marine plastics in the Indian Ocean (IO). Focusing fields include the source, observations, transportation, fate, and impacts of marine plastics. Although the authors should check this manuscript warily because of many mistakes (e.g., not accurate section number, no figure 3), this paper contributes to understanding marine pollution by plastics in IO; hence, I recommended publishing this paper after careful and sincere revisions.			Thank you. We have done our best to address all mistakes.
	Specific comments			
	Location	Sentence	Comments / Question / Suggestion	
23	Abstract	In the northern Indian Ocean, the majority of the plastic material will most likely end up being beacheddue to the absence of a sub-tropical gyre,	This leads to misunderstanding. Why plastic materials being beached due to the absence of a subtropical gyre. You must explain more for this reasoning.	Buoyant plastics tend to accumulate in garbage patches in the subtropical gyres. In the northern IO, there is no subtropical gyre because the subtropics is blocked by land. Because there is no subtropical gyre, there is no associated subtropical garbage patch. So, instead of accumulating in a garbage patch, most plastics in the northern IO are likely to end up on land instead. We have clarified this in the abstract by rephrasing this sentence as: "In the southern IO, plastics accumulate in a garbage patch in the subtropical gyre. However, this garbage patch is not well defined and plastics may leak into the southern Atlantic or Pacific Ocean. In the northern IO, there is no subtropical gyre and associated garbage because the subtropics is blocked by land. Instead, the majority of plastics most likely end up on coastlines."

24	L97-98	Plastic waste enters the IO from coastal sources transported by wind and tides, from sources far into the hinterland transported by rivers, and directly from ocean-based sources.	Because the authors ignore "the coastal source transported by wind and tide," please explain its meaning in the following subsection.	The "coastal sources transported by wind and tides" refers to sources from coastal populations (so not transported by rivers, but entering the ocean 'directly' from coastal populations). The plastic waste input into the ocean from these sources were estimated by Jambeck et al. (2015). We discuss this in some detail in the paragraph following this one (under the sub-heading 2.1 Land-based sources). We have highlighted this in the text by adding: "around 15% of global ocean plastic entered the IO directly through coastal sources (Figure 1a)"
25	L129	Lebreton et al. (2017) estimated that plastic waste input from rivers in the IO peaks in August (Figure 1c).	Where is Figure 1c? If the author mean Figure 3 in Lebreton et al.(2017, https://www.nature.com/articles/ncomms15611.pdf), modify the sentence. If not so, show Figure 1c.	Thank you for pointing this out; this was an old reference that we did not update correctly. We have removed the reference to Figure 1c from the manuscript.
26	L 130	In the southern hemisphere,the largest coastal and riverine sources of IO plastic waste are from Indonesia and eastern Africa (Figure 1b).	I could not understand why the authors mean "the largest coastal and riverine source of IO plastic waste are from Indonesia and eastern Africa." For me, the largest looks like Indonesia only.	We have changed this sentence to: "In the southern hemisphere, the largest coastal and riverine sources of IO plastic waste are from Indonesia (Figure 1)."
27	L 170	This therefore highlights the need for a standardised global protocol for the study of plastic debris and should be a major priority in ocean plastic research going forward.	Already some researchers focus on the standardization of protocols. Refer them, for example: Michida Y., Chavanich S., Chiba S., Cordova M.R., Cózar Cabañas A., Galgani F. Hagmann P., Hinata H., Isobe A., Kershaw P., Kozlovskii N., Li D., Lusher A.L., Martí E., Mason S.A., Mu J., Saito H., Shim W.J., Syakti A.D., Agung Dhamar, Takada H.,Thompson R., Tokai T. Uchida K. Vasilenko K., Wang J (2020) Guidelines for Harmonizing Ocean Surface Microplastic Monitoring Methods. Ministry of the Environment Japan, 71 pp. Isobe A., Buenaventura N.T., Chastain S., ChavanichS., Cózar A., DeLorenzo M., Hagmann P., Hinata	We have rewritten this section and changed it to: "In contrast, the methods used in the sampling of plastics on beaches and in sediment vary widely (as illustrated in Table 1) and offer only a qualitative confirmation that plastics have been found on beaches and in sediment throughout the IO (Figure 2b). As discussed extensively in the review by Serra-Gonçalves et al. (2019), adopting a standardised framework to collect and report on beach debris is essential for these studies to be of use to the wider scientific community. Isobe et al. (2019) discuss the importance of a standardised protocol for laboratory analysis of plastics."

			H.,Kozlovskii N., Lusher A.L., Martí E., Michida Y., MuJ., Ohno M., Potter G., Ross P.S., Sagawa N., Shim W.J., Song Y.K., Takada H., Tokai T., Torii T.,Uchida K., Vassillenko K., Viyakarn V., and Zhang W. (2019) An interlaboratory comparison exercise for the determination of microplastics in standardsample bottles. Mar. Pollut. Bull., 146, pp. 831–837. https://doi.org/10.1016/j.marpolbul.2019.07.033. Gago J., Filgueiras A., Pedrotti M.L., Suaria G., Tirelli V., Andrade J., Frias J., Nash R., O'Connor I., Lopes C., Caetano M., Raimundo J., Carretero O., Viñas L., Antunes J., Bessa F., Sobral P., Goruppi A., Aliani S., Palazzo L., de Lucia G.A., Camedda A., Muniategui S., Grueiro G., Fernandez V., Gerdts G. (2018) Standardized protocol for monitoring microplastics in seawater. JPI-Oceans BASEMAN project. pp. 34.	We also refer to several review papers that discuss the standardization of plastic size classes as well as different types, etc. Please see our response to comment #11 for this.
28	L188 to L201	Buoyant plastics drifting (Maximenko et al., 2012).	this paragraph is redundant. Please organize a littlemore.	We have kept this paragraph in the manuscript, as it is the first time that we address this information. However, we had a lot of redundancy in section 5. We have removed section 5 (fate) completely from the manuscript, see our response to comment #15.
29	L 191	Ocean surface currents are forced by many different mechanisms such as wind, waves, tides, and density gradients (Talley et al., 2011; van Sebille et al., 2020). In combination with the Coriolis force, these forcing mechanisms result in Ekman currents, geostrophic	How waves force ocean currents? I think it is because of storks drift. Why the author divide Coriolis force and geostrophic currents? If readers are not physical oceanographers, these two sentences lead to misunderstanding. So, please modify them.	Yes, waves create Stokes drift. Regarding "dividing" Coriolis force and geostrophic currents, we think there is a bit of a misunderstanding here. These two sentences say that wind, waves, tides, and density gradients *together* with the Coriolis force create Ekman currents, geostrophic currents, etc. This is only meant as a brief summary of the relevant forces to take into account when considering the transport of buoyant plastics. For a more detailed description, we refer to the paper by van Sebille et al. (2020)

		currents, and Stokes drift that transport plastics.		as well as others papers. Readers who are not physical oceanographers can refer to these papers if they would like to understand more. We think this brief summary and the reference to other review papers is sufficient, so we have not made any changes to address this issue in the manuscript.
30	L 203	-	Where is Figure 3	Figure 3 is present in the manuscript, but it was not referred to in the text. We have corrected this, see our response to comment #37.
31	L 249	The presence of the land mass in the northern IO results in there being no subtropical gyre.	This explanation is too direct and incorrect. Refer the comments for the abstract	For clarification, we have replaced this sentence with: "Because the subtropics in the northern IO is covered by land mass, there is no subtropical gyre." See also our response to comment #23.
32	L 301	This location was selected as a central location where current reversals driven by the monsoon, but it does notreflect a source of plastics (see section 4).	Where is the location in section 4? Now I'm reading section 4.	This was meant to be section 2. We have corrected this.
33	L360 - L380	Subsection 4.3 To the best of our ~ needsfurther investigation.	Although I could understand what the author means,the explanation looks de-organized. Please modify.	We have removed subsection 4.3 and instead moved only the most relevant information from this subsection to subsection 4.2. As these changes are quite extensive, we will not list them all here. Instead, please see the manuscript with tracked changes.
34	L 400 to L 405	However, ~ in the IO.	The discussion is too rough. Please explain more details.	We have changed this section to: "Sinking and settling of plastics on the seafloor due to fragmentation and biofouling may be a major sink of plastic debris in the ocean (Koelmans et al., 2017). Based on deep-sea sediment core samples between 500-1000 m depth in the south-west IO, Woodall et al. (2014) estimated that 4 billion fibres per km2 were present in the IO, but did not report on a mass estimate. Ingested plastics by deep-sea fauna in the IO (Taylor et al.,

				2016) are also evidence that plastics sink to the seafloor. However, no evidence of the total size of this sink currently exists and the understanding of the exact processes of biofouling, fragmentation, and sinking, as well as the timescales on which these occur is limited. However, the IO is one of the most productive regions in the global oceans due to intense upwelling during the southwest monsoon (Qasim, 1977). This high surface productivity results in a high export flux of organic particles from the euphotic zone to the deep sea (Ittekkot et al., 1996; Guptha et al., 1997). As a result of this high productivity, it is possible that biofouling of plastic debris may occur rapidly in the IO. As a result, sinking of plastics due to biofouling may be particularly relevant in the IO."
35	L 413 to L 440	5. Fate	What is the difference from Section 4? Section 4 andSection 5 look similar to each other. Perhaps, reorganization of the section is required to help readers' understanding.	We have removed section 5 (fate) because, as you say, there was a lot of duplicate information. We have added the relevant information from this section to section 4. As these changes are quite extensive, we will not list them all here. Instead, please see the manuscript with tracked changes.
36	L 547	The main beaching region inthe southern IO is the coast of northern Madagascar.	Why can readers understand northern Madagascarhas a beach region from sections as mentioned above?	We have referred to Madagascar in Figure 4. This from the model results (Figure 7).
37	Figure 3		The authors do not refer to this figure in themanuscript. Refer to this figure to the proper place. In figure 3(a), the left side is the land (river); in contrast, in figure 3(b), the left side implies offshore. Please use the same direction in (a) and (b). The meaning of the arrow (ocean currents) in (a) is difficult to understand.	We have now referred to Figure 3 in relevant places in the manuscript. We have changed the colours in Figure 3b, so that in both sub-figures the left side represents land. We have added an explanation to the figure caption.
38	Table 1	A sequence of the location	Why do the authors choose this sequence?Arrangement with Observations (this might be	We have reorganised Table 1 so that it is sorted by Observation site first and then by publication date.

			"Observation site"?) is more fruitful for readers.	
	Technical corrections			
39	L152	Size categories as defined by GESAMP (2018; Frias and Nash, 2019) are: <0.1 mm (nanoplastics); 0.33–1.00mm (small microplastics); 1.01–4.75mm (large microplastics);4.76–200 mm (mesoplastic); and, > 0.200 mm (macroplastics).	Followings are mistakes. 4.76–200 mm (mesoplastic) > 0.200 mm (macroplastics) I recommend using the latest version of GESAMP GESAMP(2019) http://www.gesamp.org/publications/guidelines-for-the-monitoring-and-assessment-of-plastic- litter-in-the-ocean	We have removed this sentence from the revised manuscript; see our response to comment #11.
40	L 155	high- and low density polypropylene (HDPP and LDPP, respectively);	I have no experience using high- and low- density polypropylene. I do not think it is not shared. Check Figure 2.1 in GESAMP (2019).	We have removed this sentence from the revised manuscript; see our response to comment #11. The distinction between HDPE/LDPE is still made in a few studies summarized in Table 1. However, we have only made this distinction when the authors themselves do this as well (for papers that do not make this distinction, we have only listed PE as the plastic type in Table 1). Figure 2.1 in GESAMP (2019) shows PE in the piechart, but in the caption is does mention that this consists of both HDPE and LDPE. So, it seems that making this distinction is the choice of the authors.
41	L159	However, all types of plasticswere found in water and sediment samples (fibres, fragments, films, and pellets).	What about Foam? Check Figure 9.4 in GESAMP (2019).	We have removed this sentence from the revised manuscript; see our response to comment #11. We do mention foam under the shape/type column in Table 1, if studies reported this as a separate type.
42	L165	Global open ocean plastic samples were standardised by van Sebille et al. (2020) and the plastic concentrations from these samples in the IO can be quantitatively compared (Figure 2a).	In Figure 2a, the authors refer van Sebille et al.(2015). Which is the right?	Thank you for pointing this out. The correct reference is van Sebille et al. (2015), we have corrected this in the revised manuscript.

43	L 220	Convergent flows promotedownwelling causing an accumulation along the convergent flow boundary of buoyant plastic debris.	I recommend inserting "front" here.	Agreed and inserted: "accumulation of buoyant plastic debris along the convergent flow boundary defined as the front"
44	L215	Aggregations of plankton, larvae,and eggs are often found on the surface. Here, as thewater sinks at the front due to convergent flow buoyant materialwill remain at the surface. Predators such as fish and higherorder biota are found above and beneath the front.	I recommend referring to the paper to strengthen the importance of fronts. Miyao Y., and Isobe A. (2016) A combined balloon photography and buoy-tracking experiment for mapping surface currents in coastal waters. J. Atmos. Oceanic Technol., 33, pp. 1237–1250. https://doi: 10.1175/JTECH-D- 15-0113.1. (see Fig 5)	Agreed and inserted: "Here, as the water sinks at the front due to convergent flow, buoyant material will remain at the surface (Miyao and Isobe, 2016)."
45	L253	4.2.1 Northern Indian Oceansurface dynamics and plastic transport pathways	The font in the other sections (e.g., 4.2.2) isitalic.	Thank you, we have changed the font to be italic here too.
46	L 266	Along the coastlines of India andSri Lanka in the Arabian Sea, theWest Indian Coastal Current (WICC)	No WICC in Figure 4.	The WICC is shown in Figure 4b. It is not present in Figure 4a because it becomes the EICC during the SW monsoon season.
47	L269	After passing the coast of Sri Lanka, the ocean surface currentsform an anti-clockwise eddy called the Sri Lanka Dome (SLD; Su et al., 2021).	No SLD in Figure 4	The SLD is shown in Figure 4a, it is not shown in Figure 4b because it does not form during the NE monsoon season. There is typo in Figure 4 though, the SLD is referred to as the SD instead. We have corrected this in the figure.
48	L300	Passive particles (100,000) were released at a location to the southof Sri Lanka (Figure 4) on 1 Sep 2019 (end of the south-west monsoon) and tracked over a period of 12 months.	The authors used Figure 4; is it a mistake of Figure 5?	Yes, this should be Figure 5. We have removed this paragraph in the new version of the manuscript though (see our response to comment #62).

49	L 302 to L 313	During the first two months of ~ and Indonesia (Figure 4e).	Is Figure 4 a misrefer of Figure 5?	Yes, this should be Figure 5. We have removed this paragraph in the new version of the manuscript though (see our response to comment #62).
50	L 324	In the south, the gyre is boundedby the Antarctic Circumpolar Current (ACC).	I recommend adding ACC in Figure 4.	We have included the ACC in Figure 4.
51	L 347	Mheen et al. (2020a) showed thatbuoyant plastics can cross from the northern IO into the southern IO as they are transported by the SJC along the Sumatran coastline. This mainly occurred during the Second Inter-Monsoon in their simulations.	If need, I recommend referring to Figure 5.	We have added: "Mheen et al. (2020a) showed that buoyant plastics can cross from the northern IO into the southern IO as they are transported by the SJC along the Sumatran coastline (see an example of this happening in Figure 5f)."
52	L360	To the best of our knowledge, no studies have currently focussed on the transport of plastics from the Pacific Ocean into the IO through the ITF.	Perhaps, the words are no need to explain.	We have removed this sentence.
53	L 372 to L380	Based on Lagrangian particle tracking simulations, Maes et al.(2018) suggested ~ still needs further investigation.	Do you mean the pathway through FC? If so, use FC elsewhere.	We have removed this section from the manuscript, see our response to comment #33. We have added a shorter description of this pathway to section 4.2.2, it now reads: "Maes et al. (2018) suggested that there is also a "super convergence pathway" connecting the southern IO to the South Pacific Ocean. Their particle tracking simulation results showed particles being transported eastwards close to the southern Australian coastline. However, these results are potentially in contradiction to the westwards flowing FC in this region (Middleton and Cirano, 2002; Wijeratne et al., 2018), and so the existence of a super convergence pathway between the southern IO and the South Pacific Ocean along the

				southern Australian coast still needs further investigation.”
54	L 550	7.2 Knowledge gaps	Where is 7.1?	We have corrected this.
55	L567	colourants	additivities?	corrected
56	Figure 4		The authors should add more information(national, currents, date) to figure for easy understanding.	We have included numbers in Figure 4a and reference these in the caption: “The numbers in (a) refer to marginal seas (1: Arabian Sea; 2: Bay of Bengal) and countries listed in the text: 3: India; 4: Sri Lanka; 5: Somalia; 6: Madagascar; 7: Sri Lanka; and, 8: Sumatra (Indonesia).”
57	Figure 7		Brown looks like Red. Change color.	Colour has been changed
58	Table 1	Naidu, , 2019	Naidu, 2019	Corrected, thank you.
59	Table 1	Barnes,(2004	Barnes, 2004	Corrected, thank you.
60	Table 1	Nel and Froneman 2015	Nel and Froneman, 2015	Corrected, thank you.