We want to thank the reviewer 1 for its detailed reading of our ms and useful suggestions.

Our replies to comments are in blue.** « Blue quoted text » **is the updated text in the ms.

Note that an error was spotted in table 2. Some values for layer 5-300 m have changed, and some sentences in results and discussion have also been changed accordingly.

General comments

The paper examines the heterogeneity observed in the central Ionian Sea with respect to hydrology, productivity and particle properties, using in-situ data collected in 2017 by ship survey as well as remote sensing and Lagrangian modelling data. The sampled biogeochemical and physical data are used to track the various sources and processes that contribute to the marine status of the central Ionian. The manuscript is interesting, however it would benefit by presenting the scope of the research in a more focused way. It is not clear to me if the scope is to show the complexity of the marine environment in the surveyed area or to show different water masses properties and the responsible mechanisms or maybe both.

We have now clarified the main topic of the ms, which is to show the complexity of the particle distribution in the Ionian Sea, overlooked by the coarse sampling of previous studies.

General comments per Section are listed here below. The use of English is rather good; some "polishing" could be of help. Finally, the ms needs careful editing since there are many minor errors (see Specific comments).

We have addressed all these specific comments.

1 Introduction

Since the manuscript aims at focusing on the particle abundance of different water masses in the Ionian Sea, I would like to see a detailed introduction on the importance of studying particle abundance and their dynamics in the world ocean, the Mediterranean Sea, and the Eastern Mediterranean – Ionian Sea in particular. Following that, I believe a listing of methods employed so far to study particle properties should be presented, and then, the authors can present their own methods, combination of methods applied to better describe the particle properties within different water masses.

We have reorganized the introduction following these lines, also taking into account remarks from R2.

"The study of particle abundance, size structure and dynamics is a key to understand the marine ecosystem, from primary and secondary production, export and remineralization all the way through food-web dynamics (McDonnell et al 2015, Giering et al 2020). In the semi-enclosed Mediterranean Sea, the main particles sources are the biological production in the open ocean and over continental shelves, rivers discharge, atmospheric deposition as well as sediment resuspension. From West to East and North to South, the Mediterranean Sea harbours areas of very distinct productivity, going from eutrophic (e.g. in the Alboran Sea) to ultra oligotrophic (e.g. in the Levantine basin, Moutin et al 2017). This heterogeneity is further developed by the complex general and mesoscale circulation that favor exchanges between these contrasted areas, leading to a fine scale spatial distribution of biogeochemical properties and particles (Karageorgis et al 2008, Durrieu de Madron et al, 1992, Rousselet et al 2019).

Located in the center of the Mediterranean Sea, the Ionian Sea is a cross road where three different surface water masses meet: i) recent Atlantic water (AW) flowing from the Sicily channel ii) older AW flowing from the East after its cyclonic circulation in the Levantine basin and iii) fresher (Po influenced) water coming from the Adriatic Sea (Malanotte-Rizzoli et al 1997). Circulation in the North Ionian is strongly variable, as is the path of AW spreading. The most stable branch of the Atlantic Ionian Stream entering the Ionian Sea follows a rather direct pathway to the SouthEast, connecting the Sicily Channel with the Cretan Passage (Mid Ionian Jet, MIJ, Menna et al 2019). South of the MIJ, circulation pattern is more stable and anticylonic, known also as the Syrte Gyre (Pinardi et al, 2015). North of the MIJ, two alternate circulation states have been proposed, the anticyclonic and cyclonic mode of the so called North Ionian Gyre (NIG, Gačić et al 2010). In addition, semi-permanent mesoscale gyres are observed in the western part (Maltese Channel Crest, Medina Gyre, Messina Rise Vortex) as well as in the eastern part (Pelops Gyre), some of them triggered by wind. Although the AW circulation has been documented according to seasons and NIG modes (Malanotte-Rizzoli et al 1997, Gačić et al 2011, Menna et al 2019), the fine-scale pathways of AW crossing the Ionian Sea have only seldom been sampled. The mode of the NIG has a strong influence on the dispersal of water masses and properties in the Ionian basin, also impacting its productivity (Lavigne et al 2018).

The Ionian Sea is generally considered oligotrophic (Boldrin et al 2002), with a north-south gradient of Chl-a (d'Ortenzio et Ribera d'Alcala 2009). However, it is not homogeneous, as distinct phytoplankton communities associated to the main water masses have been described (Casotti et al 2003). Three main phytoplankton communities were associated with water coming from Adriatic in the north west, water from the Eastern Mediterranean in the north east and AW from the Sicily channel to the south. Zooplankton community was also contrasted between northwestern and eastern Ionian (Mazzocchi et al 2003).

Particle distribution in the Ionian Sea is less described. The particle concentration in the water column can be measured with several instruments. Discrete sampling is carried out using bottles or pumps followed by filtration, allowing bulk mass measurements (McDonnell et al 2015). Continuous sampling can be carried out using optical measurements that give either bulk measurements (transmissometer, backscatter (Briggs et al 2013)) or size-resolved measurements: Laser In Situ Scattering and Transmissometry- LISST, (Karageorgis et al 2012), Underwater Vision Profiler – UVP (Picheral et al 2010), Laser Optical Particle Counter – LOPC, (Herman, 2004) for the most common instruments, see Giering et al (2020) for a comprehensive review. In the Ionian Sea, few data are available on the horizontal distribution of particles. These data have a coarse horizontal resolution and are mostly from transmissometry, water filtration (Rabitti et al 1994, Boldrin et al 2002, Karageorgis et al 2008, 2012) while few data are from optical devices (Karageorgis et al 2012, Ramondenc et al 2016). Here we used the LOPC, providing size resolved abundances over the size range [100-2500] µm. This instrument was mounted on a free-fall MVP fish, allowing high resolution horizontal and vertical sampling of particles and water mass properties along the ship track, to investigate their joint distribution in the Central Ionian Sea.

The objective of this paper is to document particle distribution in the central Ionian Sea, based on a high-resolution multi-parametric transect. In particular we analyse particle distribution with regard to water mass properties and transport, to propose scenarios of histories of these waters masses and discuss implications for the functioning of the Ionian Sea ecosystem. "

2 Material and Methods

With respect to the methodological design (Section 2), the authors employed several classic and more advanced instruments/methods to study water mass characteristics and particle properties, resulting in the production of a hefty dataset, rather unique, and certainly not previously available for the Ionian Sea marine area.

We thank the reviewer for recognizing the importance of our new dataset.

3 Results

Results are adequately presented in brief manner (Section 3) and accompanied by a number of well-designed and informative figures. Given that several parameters and measurements are discussed, whilst certain parameters, such as MEP proportion and AI attenuance index are not so common, a moderately lengthier presentation would be beneficial for the reader.

We added a more detailed description of MEP and AI in the methods.

"LOPC also provides information about the MEPs allowing to compute an attenuance index (AI), which is essentially a normalized opacity index (an AI of 1 means a fully opaque object) although the MEP shape also has an impact (Espinasse et al 2018). The living fraction of particles can be estimated, using a calibration based on comparison with plankton net tows (Espinasse et al., 2018), as this fraction is linked with the percent of MEP with respect to the total particle count (%MEP)."

With respect to Section 3.2, I do not think that the full depth T-S diagrams (fig. 6) shown are of any significant use in the ms since observations are focusing on the upper water layers. Consider removing. I would only keep the depth-limited vertical profiles (fig. 7).

As suggested we have removed the deep layers in figure 7.

The *origin of particles* presented in section 3.4 is not clear. Particles may be transported as part of water masses circulation, but particles are also introduced locally in the water column via atmospheric precipitation and primary production. Since the scope of the paper is about particles, it would be interesting to differentiate between transported and in situ particle origin.

Thank you for your remark. We now clarified in section 3.4 that we only focus on the 'transported' particle pool in our backtracking simulations. As all particles are transported by circulation, we rather distinguish 'recent' particles and 'old' particles, that have been transported away from their source area. This distinction is discussed in section 4.3 : Considering the late spring season, nutrient depletion in the surface layer and the surface phytoplankton community, we hypothesize that, above the DCM, most particles are 'old', therefore imported through transport.

Beyond this hypothesis, distinguishing 'recent' and 'old' particles solely based on the particle properties estimated with the LOPC data is not possible, as the size structure results from various integrated mechanisms that we cannot sort out. Direct observations of particles (bottle, Marine Snow Catcher) may help, but were not available for this study. This point is discussed in section 4.3 Biological history of water masses sampled along ION-Tr.

A 'particle properties signature' on water masses is a challenge, and I would appreciate if the authors could look deeper into their rich dataset to provide such information, if possible.

This is an interesting point. Looking at table 2 and fig 7, we can say that

i) At the Ionian basin scale, comparing the three water masses seen at ST7-SAV, ST8 and ION, we do have three distinct particle signatures in terms of abundance, vertical profile, %MEP and AI, especially when we restrict the analysis to the top 5-50m layer, which has the most contrasted particle loads.

ii) Along ION-Transect, comparing ION-W, ION-C and ION-E we only have two clearly distinct water masses (ION-C and the others). In this case, particle signatures allow to distinguish ION-E and ION-W, with distinct vertical profiles, %MEP and AI. Thus particle properties are complementary to water masses properties as they bring information on their biological history along their pathways.

Conversely, distinct ranges of particle properties can identify one single water mass as for ION-E and ION-W. The main difficulty with particle parameters is to define the spatial scale of the ensemble to average (depth layers and profiles), as these parameters have a large variance vertically and horizontally. This is beyond the scope of this study.

This discussion was added to the conclusion.

In several cases across the document, variable units are following the numerical values without a space (e.g. L171: 70m; L180: 20-90m, etc.). Please check and correct throughout the document. In addition, decimal separator used is sometimes a comma (e.g. L136: 0,09 $mg.m^{-3}$) or point (e.g. L149: 38.2). Please decide and correct throughout the document. In the same context, units are sometimes given as fractions (e.g. L175 0.3 m/s) or as exponents (e.g. L177: 5 10^4 $\#.m^{-3}$). Please correct throughout the document.

We have checked and homogenized units and numbers throughout the text.

4 Discussion

The circulation patterns and water mass distribution patterns are presented in the discussion sections 4.1 and 4.2. However, a lot of information seems to fit more nicely at the Results section, and hence should be moved there. That leaves very little a pure discussion to the section. The latter applies also to Section 4.3 on the biological history of water masses.

We believe that the summary of the different figures is best located in the discussion. Therefore we moved some introductory sentences to results but left the summarizing parts in the discussion.

Here, the authors claim that abundant aggregates of diameter larger than 100 µm maybe associated with intense primary production, which, however, does not seem to be the case in the Ionian Sea during the sampling period or some weeks earlier. The authors could consider the presence of Transparent Exopolymer Particles (TEP) as an alternative factor facilitating particle coagulation and thus aggregates formation.

Thank you for this remark. We have now added a paragraph explaining that the presence of the large aggregates we observed could also result from enhanced concentrations of TEP in the surface layers. (Unfortunately TEP data are not available at the time of this review. They may be available and published in the future.)

"LOPC detects particles of ESD >100µm (median ESD was 130-145 µm along ION-Tr). Typically, such large aggregates form as a result of intense primary production (Briggs et al., 2020; Martin et al., 2011). In addition, the presence of transparent exopolymer particles (so called TEP) represents an important upper ocean process by which dissolved organic matter is converted into particles. Besides, these compounds act as glue enhancing small particles aggregation and leading to the formation of marine snow aggregates (Engel et al 2004) of the size we observe here."

5 Conclusions

This Section briefly summarizes all findings: heterogeneity, water masses origin, particle behavior and implications. What about the initial hypothesis, can we characterize and identify water masses by their particle properties and abundance?

We have added our point on the added value (section 3.4) of particle properties.

Specific comments:

Abstract: The abstract needs some restructuring. I suggest the last sentence (lines 27-30) could move at the beginning of the abstract. I leave this to authors' decision.

We followed this suggestion. The abstract was updated in accordance to the changes made to the text:

"Particle abundance in situ measurements are useful to discriminate water masses and derive circulation, together with T-S properties. In the upper layers of the Ionian Sea, the fresher Atlantic Waters (AW) recently crossing the Sicily channel meet the resident and saltier AW which have cyclonically circulated in the Eastern basin and come back modified after evaporation and eventually cooling. In May 2017, during the PEACETIME cruise, fluorescence and particle content sampled at high resolution revealed unexpected heterogeneity in the central Ionian. Surface salinity measurements, together with altimetry-derived and hull-mounted ADCP currents, describe a zonal pathway of AW entering the Ionian Sea, consistent with the so-called cyclonic mode in the North Ionian Gyre. The ION-Tr transect, located ~19-20°E- ~36°N turned out to be at the crossroad of three water masses, mostly coming from the west, north and from an isolated anticyclonic eddy northeast of ION-Tr. Using Lagrangian numerical simulations, we suggest that the contrast in particle loads along ION-Tr originates from particles transported from these three different water masses. Waters from the west, identified as AW carried by a strong southwestward jet, were moderate in particle load, probably originating from the Sicily channel. Water mass originating from the north was carrying abundant particles, probably originating from the northern Ionian, or further from the south Adriatic. Waters from the eddy, depleted in particles and Chl-a may originate from south of Peloponnese, where the Pelops eddy forms. The central Ionian Sea hence appears as a mosaic area, where waters of contrasted biological history meet. This contrast is particularly clear in spring, when blooming and non-blooming areas co-occur. This work showed that interpreting the complex dynamics of physical-biogeochemical coupling from discrete measurements made at isolated stations at sea is a challenge, that can be overcome by the combination of multiparametric in situ measurements at high resolution with remote sensing and Lagrangian modeling."

Line 12 and throughout the text. MAW and AW acronyms are both used for Atlantic water in the ms. Since (mostly in older literature) MAW stands for Modified Atlantic Water and in the ms it stands for Mediterranean Atlantic Water (the latter is not used in literature), I strongly suggest that whenever you refer to Atlantic Water you should use the acronym AW.

We now use AW everywhere as suggested, and removed MAW, as this study is fully in the Mediterranean Sea.

Lines 12 and 19: What is "young AW"? Is there an "old AW"?

We changed the sentence to be more explicit : recent AW flowing from the Sicily channel and older AW (modified after its cyclonic circulation in the Eastern Mediterranean).

Line 20: Try replacing the word "intermediate" with another one to avoid confusion with layer-depth meaning. I suggest "moderate" instead.

Done

Line 42: **The** Ionian Sea (check and correct throughout the manuscript)

Done

Line 55-59: Please provide information regarding station SAV, which appears to be isolated both from other stations and the transect area. Based on what properties was SAV selected?

During the cruise, a drifter was launched at the SAV station. Then a CTD cast was carried out. In our study, the SAV station is important as it represents a northern Ionian situation. We now justify this choice of station in the material and methods.

Line 61: Change "salinity" to "conductivity" which is what the sensor directly reads. ***Done***

Line 62: State if the fluorometer was calibrated to report chlorophyll-a concentration in mg m^{-3} ***Done***

Line 63: The primary parameter measured is light transmission (LT, %) and then the beam attenuation coefficient (c, m^{-1}) is estimated according to the path-length (L) of the transmissometer according to: c = -1/L ln(LT/100). Please describe in more detail or give references. ***Done***

Line 70: WetLabs ***Done***

Line 78: I cannot find ST8-Tr in figure 1. ***We now have added ST8-Tr to figure 1.***

Line 70: What is the depth reached by LOPC? Give a range. ***Done (it was ~300m)***

Line 85: TSG most probably means ThermoSalinoGraph. Please expand the acronym to its proper meaning. ***Done***

Line 122: Same as above for SVP. ***Done***

Line 123: Consider replacing "numerical" with "simulated". "Numerical particles" sounds a bit strange. ***Done***

Line 131: Please provide link for the database. ***Done***

Line 136: Provide value for maximum chlorophyll-a concentration ***Done***

Line 147: Please provide a range for "low, high" salinity. ***Done***

Line 159: I do not think that the altimetry shows anticyclonic circulation “across” the basin.

We have rephrased the sentence: anticyclonic circulation in the southwestern part of the basin.

Line 163: Please state that ~0.4° refers to longitude. Same throughout the text. ***Done***

Line 168: Maybe ‘water mass’ properties ***Done. changed to ‘water masses and biological properties’***

Lines 169-171: This is confusing. You could say that the surface layer which reaches depths up to 30 or 70 m in this or that area, carries a low salinity AW signal, below which salinity increases to more than 39 etc. Please rephrase. ***The sentence was rephrased.***

Line 180: term**s** ***Done***

Line 186: The density values refer to potential density? Please state in the text. Moreover here and throughout the text density units are missing. Please correct. ***Done***

Line 196: Replace “carousel” with “CTD”. I do not think that the water sampling at discrete levels from the carouse/rosette can produce continuous profiles as in fig. 7. These are most certainly the product of CTD sensors.

Done (actually only nitrate was measured from bottle)

Line 216: Paragraph 3.4 is a bit repetitive. Please restructure.

The paragraph was rewritten removing redundancy.

Lines 261-2-3: I am not sure if the presentation of specific density values here has any particular meaning. Consider omitting.

The particle vertical distribution closely matches the density isolines (see figure 5d), so we kept our presentation as is.

Line 318: Change “*This eddy may have trapped waters from the eastern Ionian, more oligotrophic (Casotti et al 2003),….*” to “*This eddy may have trapped waters from the more oligotrophic eastern Ionian (Casotti et al 2003),….*”.

Done

Line 321: The acronym UVP is used here with no explanation. Please add full meaning: Underwater Video Profiler.

Done

Line 364: Correct 4 to 5

Done

Figure captions:

Fig. 1: What is the difference between full and dotted lines?

The dotted line is the average AW path. This was added to the legend.

Fig. 7: Please add variable names at all x axes

Done

Fig. 8: In the phrase “*Black dots are the final positions*”, the word “final” possibly refers to the positions of the particles calculated at the beginning of one month before the sampling. If that is true, then “final” should be replaced with “starting” or something similar to avoid confusion.

The legend was changed as follows: *« Black dots are the particle positions at the end of the backward advection, ie one month before our sampling. »*