

Annual SCOR Working Group Reports to SCOR

1. Name of group

Floating Litter and its Oceanic Transport Analysis and Modelling (FLOTSAM)

2. Activities since previous report to SCOR (e.g., virtual or in-person meetings, email discussions, special sessions). Limit 1000 words

The period from February 2020 to May 2021 was characterised by the COVID 19 pandemic. Most of countries worldwide enforced limitations to travels and all activities were affected.

At the second official WG153 meeting in Utrecht (NL) on May 6-9th 2019 the FLOTSAM group decided to have the third and last meeting of the project in Japan, thanks to the hospitality of Japan Agency for Marine-Earth Science and Technology in spring/summer 2020. At the beginning of the COVID emergency, we decided to postpone the meeting to fall 2020, but the evolution of the pandemic in the world suggested to further postpone this meeting.

At the time of this report, the pandemic situation in Japan is still critical and even the Olympic Games are at risk, so we are not in the position to plan a physical SCOR meeting in Japan. Alternatives are under discussion, including the possibility to meet virtually or elsewhere but Japan.

WG 153 is a global and widely geographically distributed SCOR group and regular videoconferences, which are challenging to schedule across widespread time zones, were not an effective tool to communicate within the group. A shared space on Google Drive was used to write papers or to exchange large files. We used email exchanges as the main way to communicate and we met virtually twice.

Many partners of this WG group regularly used to gather at major Meetings and Congresses and the updates and exchange of information was prompt and complete. This was not possible during 2020 when many activities were in standby or postponed. Nevertheless, the project was active with virtual conferences as well as with the publication of papers and books.

On April 29 2020, a virtual meeting was held among Chairs and Patricia Miloslavich (SCOR) who fostered discussion about the feasibility to detect whether reduction in human activities due to COVID has led to any changes in the amount and/or distribution of marine floating plastics since the beginning of the pandemic, and if any subsequent impact can be measured / forecasted. The topic is still under discussion in the group; however, a paper has been recently published by a WG153 member about this (see below).

On May 10 2021, a virtual meeting of Chairs was held. The agenda was to discuss how to proceed with activities under or after COVID. We made an analysis of our outcomes and future perspectives, and how to include the new generation of scientists in future activities on the topic. We also discussed whether it's feasible to have the last meeting in Japan or another location, to meet virtually, or to have a hybrid meeting.

Virtual discussions are very difficult and not as efficient as physical meetings. Virtual meetings are best for presenting results than a true discussing platform, so FLOTSAM is working hard to organise a physical meeting when the conditions will allow.

After the meeting in Utrecht, we identified the need to:

- Revisiting the current state of knowledge on the dynamics and ocean phenomena that control the dispersion of floating marine debris;

- Identifying key knowledge gaps in this dispersion.
- Writing a review paper on the findings of the workshop.

These topics were addressed in several works published in the last year. The list of meeting or seminars where the FLOTSAM topics had been addressed is reported.

In 2020 PHYSICAL CONFERENCES BEFORE THE PANDEMIC

Ocean Science Meeting in S. Diego USA. 16-21. February 2020

Plenary keynote on 18 February 2020. The connected ocean: the global-scale transports of heat, nutrients, plankton and plastic by ocean currents by Erik van Sebille.

Dedicated sessions:

- [OM41A - Lagrangian Methods for Understanding Ocean Circulation and Tracer Transport I eLightning](#)
 - [OM42A - Lagrangian Methods for Understanding Ocean Circulation and Tracer Transport II eLightning](#)
 - [OM44A Lagrangian Methods for Understanding Ocean Circulation and Tracer Transport III Posters](#)
 - [OM41A-03 Antarctic Biological Invasions Driven by Stokes Drift and Mesoscale Variability](#)
 - [CP52B-08 Photochemical dissolution of buoyant microplastics to dissolved organic carbon: Rates and microbial impacts](#)
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- [PS31A - Physical Processes Governing the Distribution and Transport of Dispersed Particles in the Ocean I](#)
 - [PS33A - Physical Processes Governing the Distribution and Transport of Dispersed Particles in the Ocean II](#)
 - [PS34D - Physical Processes Governing the Distribution and Transport of Dispersed Particles in the Ocean III Posters](#)
 - [PS44C - Physical Processes Governing the Distribution and Transport of Dispersed Particles in the Ocean IV Posters](#)

E. van Sebille and N. Maximenko participated in the “Surface Currents in the Coupled Ocean-Atmosphere System Workshop, held Feb 22-23, 2020 at Scripps Institution of Oceanography, in which observations and applications of ocean currents were discussed.

N. Maximenko participated in OceanObs RCN workshop, held Feb 16, 2020 in San Diego, in which he discussed with OceanObs colleagues the information system that would collect, process, archive, and distribute data of marine debris.

The planning and initial phase of these sessions have already been introduced in the previous annual report to SCOR and here we just recall that they were successfully carried out and reports delivered. There were many interesting communications in the sessions and the baseline for a new generation of questions on the topic of the transport of floating plastic has been defined.

In 2020 and 2021 CONFERENCES DURING THE PANDEMIC

EGU European Geoscience Union - Virtual general Assembly
vEGU21: Gather Online 19–30 April 2021

Keynote presentation at EGU Apr 2021: Erik van Sebille for the Georg Wüst lecture and award: The motion of the ocean: The physical oceanography of the transport of marine plastic.

List of **communications**:

EGU21-4342 | vPICO presentations ITS2.5/OS4.8/BG1.27/HS12.8/SSS12.8 Modelling size distributions of marine plastics under the influence of continuous cascading fragmentation Mikael Kaandorp, Henk Dijkstra, and Erik van Sebille Mon, 26 Apr, 11:31–11:33

EGU21-1203 | vPICO presentations ITS2.5/OS4.8/BG1.27/HS12.8/SSS12.8 Sinking microplastics in the water column: simulations in the Mediterranean Sea Rebeca de la Fuente, Gábor Drótos, Emilio Hernández, Cristóbal López, and Erik van Sebille Mon, 26 Apr, 11:17–11:19

EGU21-4092 | vPICO presentations ITS2.5/OS4.8/BG1.27/HS12.8/SSS12.8 Global modelling of plastic beaching indicates coastlines and coastal waters as significant plastic reservoirs Victor Onink, Cleo Jongedijk, Matthew Hoffman, Erik van Sebille, and Charlotte Laufkötter Mon, 26 Apr, 11:29–11:31

EGU21-15275 | vPICO presentations ITS2.7/ESS12/EOS7.14/GI4.3/HS12.7/OS4.10 Mapping Windrows as Proxies for Marine Litter Monitoring from Space (WASP) Manuel Arias, Romain Sumerot, James Delaney, Fatimatou Coulibaly, Andres Cozar, Stefano Aliani, Giuseppe Suaria, Theodora Papadopoulou, and Paolo Corradi Thu, 29 Apr, 13:55–13:57

EGU21-1149 | vPICO presentations ITS2.5/OS4.8/BG1.27/HS12.8/SSS12.8 Physical processes behind interactions of microplastic particles with ice Irina Chubarenko Mon, 26 Apr, 11:13–11:15

EGU21-13603 | vPICO presentations ITS2.5/OS4.8/BG1.27/HS12.8/SSS12.8 Analysis of the influence of storms on massive marine litter wash-outs to the shore of the Sambian Peninsula Sergei Fetisov and Irina Chubarenko Mon, 26 Apr, 13:44–13:46

OTHER VConf

Presentation by Erik van Sebille at **NSF Frontiers in Ocean Sciences Symposium**, June 2020: Why solving the ocean plastic problem requires international partnerships and a radically open science

Presentation by Peter Ryan at **Ocean Plastic Webinars June 2020: Bottles**, lids and the lockdown: using beach litter to monitor marine plastic pollution. https://www.youtube.com/watch?v=ZWC_SZdrZeY

Presentation by Erik van Sebille at **Ocean Plastic Webinars Aug 4, 2020: 15 Years of ocean plastic research** What are the pressing open questions? <https://www.youtube.com/watch?v=r44dgiBzTSk>

Presentation by Atsuhiko Isobe at **Ocean Plastic Webinars Sept 8, 2020**: Observed and modeled abundance of pelagic microplastics in the world's ocean.

<https://www.youtube.com/watch?v=DRmTm50aUyI>

Presentation by Erik van Sebille at **Micro2020** Nov 2020: about our ERL paper: The physical oceanography of the transport of floating marine debris. See also

<https://www.youtube.com/watch?v=3L5IOryjHn8>

Presentation by Kara Lavender Law at **U.S. Coastal Research Program (USCRP) Virtual Nearshore Human & Ecosystem Health Workshop** Jan 7, 2021: Location, Location, Location: The Importance of Staying Local to Understand and Address Ocean Plastic Pollution in Nearshore Regions.

Presentation by Kara Lavender Law at **Scripps Institution of Oceanography/CASPO seminar** Apr 7, 2021: Ocean plastics: Trash, tracer & remote sensing target.

Presentations by N. Maximenko on Physical and Biological Processes Maintaining the Neopelagic Ecosystems of the Garbage Patch at the Ocean Sciences Meeting 2020, Surface Currents in the Coupled Ocean-Atmosphere System Workshop, Feb 22-23, 2020 at Scripps Institution of Oceanography, Ocean Surface Topography Science Team meeting (virtual), Oct 10-19, **The 52nd International Liège Colloquium on Ocean Dynamics, May 17-21, 2021 (virtual), and Citizen Science Virtual Conference, May 2021.**

CONTRIBUTION TO OTHER WORKING GROUPS OUTSIDE SCOR

The Regional Action Plan on Marine Litter developed by PAME for the Arctic Region, which builds upon the Phase I Project Desktop Study on Marine Litter including Micro-plastics in the Arctic (2019) was based on best available science (including FLOTSAM contribution), indigenous knowledge, and other information at the time of completion.

The Implementation of this action plan involved AMAP, another working group of IASC, and the chapter about floating litter of the monitoring plan was also based upon FLOTSAM expertise (<https://litterandmicroplastics.amap.no/>).

FLOTSAM was considered in The CleanAtlantic initiative (Tackling Marine Litter in the Atlantic Area) , and especially in one of the results of this project, the CleanAtlantic Knowledge Tool. This tool aims to facilitate the access to the existent knowledge and resources relevant to tackle marine litter, by indexing them in a user-friendly online database. Very briefly, CleanAtlantic is a project funded by the EU-INTERREG Atlantic Area Programme that aims to protect biodiversity and ecosystem services in the Atlantic Area by improving capabilities to monitor, prevent and remove marine litter.

Outcomes of FLOTSAM, especially from the ERL review paper (van Sebille et al. 2020) and OceanObs 19 Community White Paper published in *Frontiers in Marine Science*(Maximenko et al. 2019) have contributed to the content of a report in preparation by the U.S. National Academies of Sciences, Engineering and Medicine (NASEM) Committee on United States Contributions to Global Ocean Plastic Waste (K. L. Law, committee member).

Momentum gained at OceanObs19 is maintained through OceanObs RCN (Research Coordination Network), in whose periodic virtual meetings N. Maximenko discusses plans and challenges of marine debris observations and research.

IOCCG (International Ocean Color Coordination Group) Task Force on Remote Sensing of Marine Litter and Debris (<https://ioccg.org/group/marine-litter-debris/>) has been formed, including (the TF is led by the FLOTSAM members including S. Garaba, V. Martinez, P. Corradi, and N. Maximenko). Among other TF initiatives is the proposal to extend ESA's Sentinel-2 coverage into the North Pacific Garbage Patch.

E. van Sebille and N. Maximenko are members of the **ESA World Ocean Circulation Expert Panel**, including Theme 3: Surface Lagrangian drift for a Clean Ocean.

N. Maximenko helped to establish and actively participates in the GIANT working group, in which scientists, agencies, non-profit organizations, and commercial companies collaborate to streamline the ocean cleanup from debris modelling, tracking, and detection to retrieval and recycling.

N. Maximenko helped to establish and actively participates in the Tuesday Satellite working group hosted by NOAA NESDIS, in which US and European space agencies, scientists, and satellite companies develop new approaches to remote sensing of plastic marine debris.

N. Maximenko leads projects FloatEco (Floating Ecosystem; floateco.org) and GO-SEA (Citizen Science; goseascience.org), partly sponsored by NASA and uniting specialists with different backgrounds to advance understanding of the impacts of anthropogenic marine debris on marine ecosystems.

P. Corradi and N. Maximenko worked on the review panel of AI Moonshot Challenge, hosted by the Portugal Space Agency in September-December 2020: The global competition to advance monitoring of plastic litter on a planetary scale, making use of AI and Satellite Data.
(<https://www.moonshotchallenge.ai/>)

3. Documents published since previous report to SCOR (e.g., peer-reviewed journal articles, reports, Web pages) and should be limited to publications that resulted directly from WG activities and which acknowledge SCOR support

The website <http://scor-flotsam.it> has been regularly updated. It is hosted on GitHub and CNR servers and administrated by E. Van Sebille. WG 153 is also hosted in SCOR website (http://www.scor-int.org/SCOR_WGs_WG153.htm).

The major result of SCOR WG meeting was the scientific framework for the review paper "**The physical oceanography of the transport of floating marine debris**" published in 2020. It was submitted to Environmental Research letter Topical Review and published in 2020 as Open Access free available article. References are van Sebille et al 2020 Environ. Res. Lett. 15 023003.

This paper had an impressive impact and one year after publication, has been cited 111 times (Scholar). It also had a Field-Weighted Impact of 12.54 (source: Scopus). Field-Weighted Citation Impact shows how well cited this document is when compared to similar documents. A value greater

than 1.00 means the document is more cited than expected according to the average. This index takes into account:

- The year of publication
- Document type
- Disciplines associated with its source.

The FWCI is the ratio of the document's citations to the average number of citations received by all similar documents over a three-year window. Each discipline makes an equal contribution to the metric, which eliminates differences in researcher citation behaviour.

Other papers have been submitted or publication finalised in the last year:

Maximenko et al Towards the Integrated Marine Debris Observing System (IMDOS). Frontiers in Marine Science Community White Paper presented in OceanObs 19 in Honolulu USA.

The paper has been published

It can be downloaded from: <https://iopscience.iop.org/article/10.1088/1748-9326/ab6d7d/pdf>

Martinez-Vicente et al. Towards marine plastic debris detection from satellite remote sensing. Remote Sensing of the Environment.

The paper has been published.

It can be downloaded from: <https://www.mdpi.com/2072-4292/11/20/2443>

Lauren Biermann, et al., Finding Plastic Patches in Coastal Waters using Optical Satellite Data. Scientific Reports

The paper has been published.

It can be downloaded from: <https://www.nature.com/articles/s41598-020-62298-z>

G. Suaria et al., Microfibers in oceanic surface waters: A global characterization

The paper has been published.

It can be downloaded from: <https://advances.sciencemag.org/content/6/23/eaay8493>

G. Suaria et al., The transport of plastics and other pollutants at oceanic fronts.

Springer Book Chapter, under revision

M. Thiel et al., COVID lessons from the global south – Face masks invading tourist beaches and recommendations for the outdoor seasons

The paper has been published.

It can be downloaded from:

<https://www.sciencedirect.com/science/article/pii/S0048969721025572?dgcid=author#!>

Topouzelis et al., Floating marine litter detection algorithms and techniques using optical remote sensing data: a review. Mar Poll. Bull in press

4. Progress toward achieving group's terms of reference. List each term of reference separately and describe progress on each one. Limit 1000 words

The WG made relevant progresses toward objective through meeting, sessions at scientific congresses, email exchanges and Skype calls.

TOR1 - Identify gaps in our knowledge of the near-surface ocean dynamics that may affect litter distribution and transport

The list of relevant oceanographic processes affecting marine litter distribution and transport in surface ocean has been provided in published papers. After the implementation of the list some work has been dedicated to describe some processes, which included communications at congresses and field cruises dedicated to the gaps in knowledge identified by SCOR. For example, the field cruise PoPlast recently carried out in the Mediterranean Sea was fully dedicated to answer the questions on coastal plastic accumulation by fronts.

TOR 2 - Improve future marine litter modelling capabilities

The current state of modelling of marine debris has been discussed in different occasions and in the review paper some Chapters relevant to ToR2 have been included. The capability to model plastic transport was greatly improved in the last time and new approaches and codes are almost ready for dissemination, FLOTSAM is an active part of this change in modelling with relevant contribution to major findings. In the final WG meeting the new challenges in modelling will be addressed.

TOR3 - Evaluate existing and emerging remote sensing technologies that can be applied to marine litter in the open ocean.

The community white paper submitted to OceanObs in Hawaii has been published and they have been the basis of 2 ESA funded projects related to remote sensing of marine debris on the shoreline and in the open ocean. In the last year, these projects provided the first preliminary results that are coherent with theoretical ideas discussed in FLOTSAM. The Remote Sensing of Marine Litter and Debris" taskforce was created by IOCCG and is dedicated to plastic monitoring by satellite, which can be seen as a follow up of the really forward-looking idea developed by SCOR WG FLOTSAM.

TOR4 - Improve awareness of the scientific understanding of marine debris, based on better observations and modelling results.

FLOTSAM website has been regularly updated, although the website was not the communication media we decided to use most. On the contrary we dedicated more effort to chaired sessions at several conferences and education talks.

Many SCOR partners have been regularly involved in media communication and interviews in many different broadcasting networks. As a result the general awareness has changed after FLOTSAM and the WG made a difference in this new perception of floating marine litter at academic and public level.

5. WG activities planned for the coming year. Limit 500 words

The last meeting of the project planned for summer 2020 in Japan thanks to the hospitality of Japan Agency for Marine-Earth Science and Technology was not carried out. At the time of this report, the pandemic situation in Japan is still critical and even Olympic Games are at risk and we are not in the position to guarantee physical SCOR meeting in Japan. Alternatives are under discussion, including to meeting virtually or elsewhere.

The chairs of FLOTSAM have submitted a proposal for an Innovative Session at OSM 2022 where many partners will likely attend the meeting. A hybrid in-person/remote session was proposed. That would be a perfect place for partners to gather for the last WG153 meeting.

Virtual conference will be the necessary solution if the COVID emergency did not release. The proposal for this activity is available in the appendix.

New publications are in preparation or submitted.

6. Is the group having difficulties expected in achieving terms of reference or meeting original time schedule? If so, why, and what is being done to address the difficulties Limit 200 words

We encountered fundamental problems to organize the last meeting due to COVID19 pandemic and the resulting lockdown in many countries. The WG plans to reschedule the meeting in 2021 when and where possible. At present travel limitations are still enforced in many countries and we cannot have confirmation from all FLOTSAM partners that they have full travel authorisations.

The possibility to meet at Ocean Science Meeting 2022 in Honolulu (USA) on 27 Feb – 4 March 2022 is a possible solution.

7. Any special comments or requests to SCOR. Limit 100 words.

We would like to submitted to SCOR a request for a time extension of the project.

The chairs of FLOTSAM are organising an Innovative Session at OSM2022 on the topics of WG153 (<https://agu.confex.com/agu/fm20/meetingapp.cgi/Program/2902>). Innovative sessions are special sessions dedicated to innovations and integrate virtual participation, "meeting-within-a-meeting", and presentations in a dynamic way and creatively demonstrate the value and potential of remote participation and engagement. Innovations will include half-day and shorter presentations designed around a unifying theme, building off some of the creative programming that made up AGU's Centennial and hoping to encourage creative ways to expand virtual or hybrid engagement and programming and connect with other disciplines. After this session, the traditional WG meeting will take place.

The extension of FLOTSAM to 2022 will provide SCOR a two-fold return: i) the workplan of WG153 can be fully developed with a 3rd physical meeting and the new gaps in knowledge can be addressed, also within the perspective of the UN Decade that was not under implementation at the time of the proposal; ii) the innovative work we plan for OSM session will fall under SCOR.

Additional information can be submitted and will be included in the background book for the SCOR meeting at the discretion of the SCOR Executive Committee Reporter for the WG and the SCOR Secretariat.

APPENDIX 1

Engaging Emerging Leaders to Chart the Course in Ocean Science Research towards Mitigating Plastic Pollution

A proposal for an **Innovative Session**, Ocean Sciences Meeting 2022

Half-day (4-hour) session: ideally a mix of online and on-site participants (if technically feasible - see details in agenda)

Primary Organizer: Kara Lavender Law, Sea Education Association (USA)
Co-Organizer: Stefano Aliani, CNR ISMAR (Italy)
Co-Organizer: Nikolai Maximenko, University of Hawaii (USA)
Co-Organizer: Erik van Sebille, Utrecht University (Netherlands)

Plastic pollution, especially in the oceans, is recognized as a major environmental problem. Marine debris (marine litter) appears in many international policy agendas, and has motivated legislation by national, state and municipal governments hoping to slow the leakage of plastics to the environment. Scientific research continues to rapidly accelerate on all aspects of ocean plastics, including its sources, transport, distribution and fate, and its impacts on marine life, marine ecosystems and human health. Effective mitigation measures will require scientific baselines and assessment tools, as well as knowledge integration across academic disciplines and with non-academic stakeholders.

We will engage emerging leaders in the field to spur inclusive collaboration across disciplines, geographies and career stages. We will utilize a variety of formats (interactive, discussion, panel) to collectively formulate key research questions that will advance scientific knowledge and inform the design and assessment of mitigation measures. Themed roundtable discussions will offer opportunities for engagement across diverse groups and with invited experts on topics such as:

- Scientific themes: e.g., quantifying sources, multi-disciplinary study of exposure and impacts
- Novel/emerging approaches: e.g., machine learning, nexus between plastics and climate change
- Citizen engagement: e.g., citizen science networks, empowering future leaders (K-12)
- Funding agency priorities
- Engaging with policymakers, “changemakers”, and the industrial/corporate sector

The session will utilize a hybrid format to attract remote and in-person participants in subdisciplines of ocean science and policy, as well as non-academic stakeholders, across the globe. We will invite geographically diverse early career researchers to take part in developing details of the agenda and to lead aspects of the meeting. Proposed outcomes include a Perspectives article and an article for a broader audience.