Template for Annual SCOR Working Group Reports to SCOR

Summary

FLOTSAM is dedicated to address floating plastics pollution based upon the integration of in situ, modelling and remote sensing approaches. Over the year this integrated approach became a mainstream and the main papers from the WG are now seminal part of scientific knowledge on marine litter and are driving important decision in this field of science.
The original FLOTSAM group has grown to became a wide global network and ECOPs are an important part. They actively participate to WG works and designed and executed a virtual workshop on "The Future of Ocean Plastics: Designing Diverse Collaboration Frameworks".

The new efforts of FLOTSAM are toward the creation of an Integrated Marine Debris Observing System (IMDOS). IMDOS is based upon the FLOTSAM framework to dynamically integrate shoreline and at-sea in situ observations, remote sensing and numerical modelling (Maximenko et al., 2019). The idea has been thoroughly discussed with relevant people and organizations such as TGML, GEO Blue Planet, GOOS, UNEP, IOCCG and it was clear that an observing system dedicated to plastic pollution does not exist yet.

FLOTSAM network of experts has the potential to grow and become the leading reference to the global program dedicated to Marine Litter observation that is so much needed. In the last year, the IMDOS interim Steering Committee has been defined with relevant FLOTSAM people involved. IMDOS has been officially presented at UN Ocean Conference in Lisbon and the Interim Steering Committee is going to meet in the next months to plan future activities.

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 2021-2022 activities were impacted by the COVID 19 pandemic, even if less critically than before. Most countries worldwide enforced limitations to travels or did not provide evidence that they would have not in the near future. Under these uncertain circumstances, the opportunities for physical meetings were affected and we were **not in the position to plan a physical SCOR meeting** in Japan as originally planned. Necessarily most of interactions were moved online.

The main papers from the WG are now seminal part of scientific knowledge on marine litter, supported by > 400 citations in two years (Google scholar). In 2021-2022 the work of the WG continued to improve the concept introduced with the white paper at the OceanObs'19 Conference about the Integrated Marine Debris Observing System (IMDOS). The ideas **behind IMDOS have been thoroughly discussed during several online meetings within FLOTSAM and with relevant people** and organizations outside FLOTSAM, such as GEO Blue Planet, GOOS, UNEP and IOCCG (International Ocean Colour Coordination Group. It is clear that an observing system dedicated to marine litter does not exist yet is very much needed. Therefore, we regularly met online to explore if a global Observing System for Marine Debris was possible, to set up a workplan and finally to start building it.

IMDOS is a conceptual model based upon the FLOTSAM framework to dynamically integrate shoreline and at-sea *in situ* observations, remote sensing and numerical modeling, tasked to address the most urgent and important needs of the stakeholders, embracing the full complexity of the composition, dynamics, and impacts of anthropogenic debris, particularly plastics. IMDOS is a global project and aims to integrate the needs of different actors to address the global and pervasive problem of plastic pollution.

The first presentation of the idea to stakeholders and scientists occurred a dedicated workshop under the UN Decade of Ocean Science for Sustainable Development and UN Sustainable Development Goal 14 "Life below water", an official satellite activity to the Ocean Decade's 3rd Laboratory: A Clean Ocean. The workshop "One Integrated Marine Debris Observing System (IMDOS) for a Clean Ocean" took place from 17 to 19 November 2021. Attended by 197 participants from 46 countries, the event consisted of a series of three live online sessions in English and French. 26 excellent speakers and panellists from 18 different countries world-wide came together to share their knowledge and discuss the growing threat and multidimensional problem of marine debris to marine ecosystems, and ocean and coastal users. The event was organized by a consortium of 14 international ocean experts, and FLOTSAM was one of the leading projects. FLOTSAM co-chairs Nikolai Maximenko from the University of Hawaii opened the event with an introduction to the IMDOS and Stefano Aliani from CNR ISMAR chaired Session 3 - Defining the future of IMDOS on 19 Nov 2021, 9 - 11.30 AM CET (8 - 10.30 AM UTC). Erik Van Sebille gave Talk on Marine Debris in the Digital Twin Ocean.

After this preliminary event the official presentation of IMDOS concept was on 29 June 2022, during the UN Ocean Conference side event, "Integrating Marine Litter Monitoring to Inform Action" at Centre Cultural de Cascais & Hotel Baia in Cascais, Portugal. The event welcomed 86 people from 23 countries across the globe, who came out to Cascais for this full-day event. Stefano Aliani gave a talk to describe IMDOS, and FLOTSAM partners Atsuhiko Isobe introduced the Japanese monitoring action plan and Victor Martinez Vicente represented the remote sensing community of FLOTSAM and the IOCCG Task force in marine litter and debris.

A virtual, workshop entitled, "The Future of Ocean Plastics: Designing Diverse Collaboration Frameworks" was held on April 5, 6 and 7, 2022 in sessions spanning multiple time zones across the globe. This workshop was designed and executed by a team of Early Career Ocean Professionals (ECOPs) from 11 countries, in association with OceanBRIDGES and with support from SCOR FLOTSAM and the Richard Lounsbery Foundation. The workshop aimed to facilitate a knowledge exchange between ECOPs, experienced ocean professionals, and a diverse array of stakeholders within and beyond academia who are working on aspects of ocean plastic pollution. Each day the workshop explored one theme with a panel of experts (morning session) followed by an interactive discussion with all participants (afternoon session):

- April 5: Public & community engagement: art, documentaries and beyond
- April 6: Innovative technologies to monitor and mitigate ocean plastics
- April 7: Policies and actions for a plastic-free ocean

In total, eighteen sessions across multiple time zones drew 533 attendees. In addition, a manuscript is being prepared for publication to share insights gained during the workshop on the stakeholder engagement process related to research on plastics in marine environments, and some of the ECOP leaders were speakers and served on the organising committee of the UN Ocean Conference side event in Cascais dedicated to IMDOS. This event has been listed as an official UN Ocean Commitment.

In the period 2021 2022 FLOTSAM presented results and chaired open sessions at other scientific meetings both virtual and physical. For instance, FLOTSAM was present at Ocean Science Meeting, on 28 February-4 March 2022; at the Banff workshop at https://www.birs.ca/events/2022/5-day-workshops/22w5073/videos. Special Sessions run by FLOTSAM are planned at 7 International Marine Debris Conference in Busanv in Sptember 2022.

A relevant outcome of FLOTSAM WG meeting and decisions takes at IMODOS interim steering committee is to propose Marine litter as a new Essential Ocean Variable. GOOS and other relevant organisations have been contacted and the proposal is under preparation.

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

A list of some papers that were based upon FLOTSAM results written by Full and Associated partners. Asterisk indicate papers where FLOTSAM is cited.

2020 Viatte	https://doi.org/10.1007/s10712-020-09599-0
2020 Morales Maqueda*	https://doi.org/10.1029/2020JC016826
2021 Cozar	https://doi: 10.3389/fmars.2021.571796
2021 Tokai	https://doi.org/10.1016/j.marpolbul.2021.112111
2021 Chenillat*	https://doi.org/10.1016/j.marpolbul.2021.112116
2021 Chubarenko*	ISBN 978-5-91522-513-7, 520 in Russian
2021 Topouzelis	https://doi.org/10.1016/j.marpolbul.2021.112675
2020 Aliani	ISBN 978-3-030-38944-4 publisher Springer
2021 Stubbins*	https://doi.org/10.1126/science.abb0354
2022 Aliani*	https://doi.org/10.3389/fmars.2021.827907
2022 Gallardo	https://doi.org/10.3389/fmars.2021.688224
2022 Suaria	https://doi.org/10.1007/698_2021_814
2022 Bergmann	https://doi.org/10.1038/ s43017-022-00279-8

Technical Reports that took advantage of FLOTSAM contribution

2021 Elvind	hdl:10013/epic.6c65be8a-df84-4836-80ff-d45622d1f317
2021 AMAP	https://www.amap.no/documents/download/6714/inline

Information about IMDOS events and the workplan are reported in the following websites.
https://www.eu4oceanobs.eu/marine-litter-monitoring-to-inform-action/
https://www.eu4oceanobs.eu/integrated_marine_debris_observation/
https://www.oceanplasticworkshop.com/

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

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

The papers gained a lot of attention and the outcomes have been disseminated at conferences and lectures. After the first description of the major processes, some work has been dedicated to describe selected processes such as Ekman currents, geostrophy, and Stokes drift, waves and also the role of mesoscale physical processes. Communications at congresses, book chapters and field cruises have been dedicated to the gaps in knowledge identified by SCOR.

TOR 2 - Improve future marine litter modelling capabilities
The current state of modelling of marine debris has been discussed in different occasions. The capability to model plastic transport was greatly improved in the last time and new approaches and codes are now available. FLOTSAM is an active part of this change in modelling effort. One major improvement is the development of the Digital Twin of the Ocean. Modelling is an important part of IMDOS and an important pillar of it is devoted to modelling.

TOR3 - Evaluate existing and emerging remote sensing technologies that can be applied to marine litter in the open ocean.
ESA funded projects related to remote sensing of marine debris on the shoreline and in the open ocean after FLOTSAM. The Remote Sensing of Marine Litter and Debris taskforce by IOCCG was 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. FLOTSAM experts also contributed to the UN Ocean Decade Side Event organised by International Atomic Energy Agency on 28 June 2022 at Altice Arena, Lisbon, Portugal with the title "Addressing Marine Plastic Pollution".

TOR4 - Improve awareness of the scientific understanding of marine debris, based on better observations and modelling results.
FLOTSAM website has been updated, although the website was not the communication media we decided to use most. On the contrary we dedicated more effort to gather top scientists around the FLOTSAM literacy to build up IMDOS.
However, many SCOR partners have been regularly involved in media communication and interviews in many different broadcasting networks. It is noteworthy that FLOTSAM made a difference in the new perception of floating marine litter at academic and public level and SCOR now is a point of reference addressing marine litter at global scale.

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

IMDOS will be implemented in 2022 and 2023. After meetings in Lisbon, **IMDOS confirmed an interim Steering Committee** in charge of defining the workplan and implement it. The co-chairs of FLOSAM give a relevant contribution to this Steering Committee and will lead the development together with other global experts.

The first decision was to continue the work toward including **Marine Litter as an Essential Ocean Variable** as initially proposed at online meetings in 2021. Work is in progress and interactions with GOOS are ongoing to include plastics in the list of EOVs. There are positive feedbacks, the full request is under preparation and will be submitted to GOOS for approval soon. Fundamental consequences are expected from this decision.

Further work is required to include the definition of the scientific pillars of IMDOS. Based upon FLOTSAM concept, some of them are identified. Our ToR have been already included as fundamental for IMDOS.

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

YES. The major difficulties depended on the different restrictions enforced by states to address the problems of the **COVID19 pandemic**. However, we were able to collaborate online and identify IMDOS as the much-needed objective that builds upon FLOTSAM ToRs.

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

One of the most relevant outcomes of FLOTSAM is the **large network of experts** that was built after the WG. The original ToR were addressed and the WG moved forward working on more updated objectives, which has led to the implementation of IMDOS.

So far, no money for SCOR has been used to implement IMDOS and we believe that we can get the best of SCOR remaining funds if the last efforts of FLOTSAM are moved toward the creation of IMDOS. FLOTSAM network has the potential to grow and became the leading reference to the global program dedicated to Marine Litter observation that is so much needed.

The **FLOTSAM leadership group asks SCOR to consider supporting the development of the IMDOS** program. A possible practical contribution could be **to allow the use of remaining FLOTSAM funds** to support the participation of selected people to IMDOS planning events in 2022.
More information on IMDOS is in Annex 1.

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.

This is still a draft and confidential version do not publish

Annex 1 - A brief description of IMDOS

The goal of the **Integrated Marine Debris Observing System (IMDOS)** is to **provide guidance and coordination of a global sustained observing system for marine debris** addressing knowledge gaps and diverse stakeholder needs with adequate data and information.

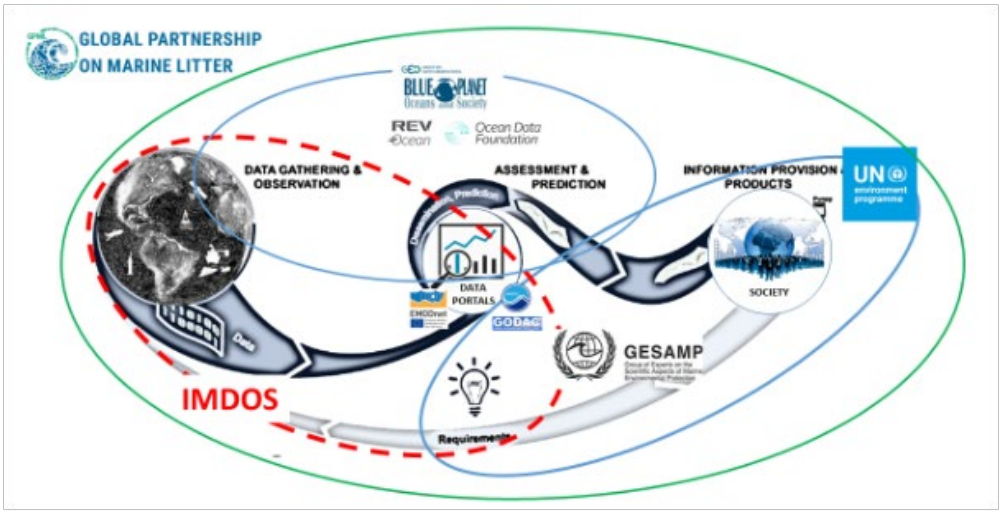
IMDOS is being developed as a joint project by the Global Ocean Observing System (GOOS) and the Group on Earth Observations (GEO) Blue Planet, in collaboration with the United Nations Environment Program (UNEP) Global Partnership on Marine Litter (GPML) and SCOR FLOTSAM among others.

Why do we need an IMDOS?

There is a strong, shared demand for global marine litter/debris monitoring expressed by a diverse group of stakeholders forming the Global Partnership for Marine Litter (GPML). Monitoring of marine litter has already been initiated to various degrees through Action Plans of the Regional Seas Programme, and there are ongoing efforts to harmonise and standardise monitoring methods regionally and globally, supported by UNEP, IOC-UNESCO, G7 and G20 initiatives among others. However, there is insufficient coverage, resolution and quality of data to meet the science and policy requirements expressed by SDG Target 14.1.1b, and other indicators recommended for global scale monitoring, also included under the new Marine Plastics Debris Essential Ocean Variable.

Availability and transfer of data into science-based decision making is hindered by, among other things, challenges in extracting quality information from collected data (e.g. beach litter), and limited integration and interoperability of existing data sources. Moreover, there is currently no international scientific advisory body with a mandate to undertake periodic evaluation of the state of the oceans, trends and changes in marine debris as a basis for scientific advice to policy makers.

A coordinated and collaborative global response to these challenges will be fundamental in providing the adequate technical and scientific support for all parties engaged in implementing the now negotiated UN treaty on plastic pollution, and would offer a significant contribution to the UN Decade of Ocean Science for Sustainable Development.



The IMDOS ambition

Inspired by the collective vision of the marine debris scientific community and guided by an international Interim Scientific Committee, IMDOS aims to:

- **promote the development of a global network of marine debris observations** according to Regional Seas Programme Action Plans and integrated within GOOS in cooperation with existing ocean observing infrastructures, networks and communities of practice
- **define globally acceptable strategies and priorities** for coordinated and harmonised marine debris observations based on most relevant monitoring methods, standards and practices
- **develop and promote interoperable data management activities** for free, open and FAIR access to marine debris data accessible to stakeholders, e.g. via the GPML Digital Platform;
- **support the development of remote sensing methods to detect marine debris** by enhancing availability of required ground truthing data;
- **strengthen the interface between marine debris monitoring and modelling communities** to support the development of a Digital Twin of the Ocean for Marine Litter Pollution;
- **evaluate and promote technological advancements** with the potential to increase the readiness level of global observing approaches
- **develop and support training activities** for enhanced use of standard sampling protocols and best practices in marine litter data collection
- **provide communication services for the marine debris community** as well as advocacy and links to a multidisciplinary sustained global ocean observing system.

Building IMDOS as a collective impact organisation

Designed according to the principles of collective impact organisations, IMDOS will serve as backbone support for many international and national organisations and initiatives which: (i) **share a vision** for coordinated marine debris observations to address the complex issue of marine pollution, (ii) are **collecting data and measuring results consistently**, (ii) contribute with **differentiated yet mutually reinforcing activities**, (iv) engage in **consistent and open communication**, and (v) are **coordinated by a group of dedicated staff.**

Currently, part-time coordination support for IMDOS is provided by GOOS and GEO Blue Planet with funding from the EU4OceanObs and H2020 EuroSea projects. **A dedicated (globally distributed) staff of 3 full-time employees** is needed to provide overall coordination and communication of IMDOS operations and execution of Terms of Reference according to the Strategy and Implementation Plan which are being developed.

Organisations and initiatives so far involved or interested in building IMDOS together include:

GEO BP, GOOS, IOCCP, UNEP GPML, IOCCG Task Force on ML, GESAMP WG40, SCOR-FLOTSAM, MSFD TG ML, OceanOPS, MOEJ, EMODnet

Ifremer, SEA, Uni Hawaii, Ispra, CNR ISMAR, Uni Sao Paolo, ESA, GEOMAR, JAMSTEC, Kyushu Uni, MOI, IOPAN...