

Plastic Pollution in the Ocean

Ecology, pollution, waste, global warming are now key words in our day to day lives. Industrials work to have ever less impact on the environment as for example in transports; people pay more and more attention to their consumptions, to their waste but it is still not enough. We are now entering a period of energy transition after years of excessive consumption. Along years, the spatial technologies have evolved and finalized systems allowing us to watch, to observe these environmental phenomena, to see their evolution and to determine their causes. An incredible monitoring center was sent into orbit and dozens of satellites permanently scrutinize Earth's surface. They are essential tools to better understand its functioning and help us to protect it.

The picture as far as plastic is concerned is especially striking: in 60 years, since its creation and commercialization, people have managed to pollute the entire planet and we cannot live without it anymore today. The world production reached 288 million tons in 2013 with 57 million tons produced by Europe (20 % of the world production). It is used in various sectors and it plays a fundamental role in the consumer society in which we live. It is resistant, light, easy to model as one pleases, inexpensive, practical, insulating etc. But its durability appreciated for its use is the cause of the oceans pollution. Furthermore, we do not recycle it has much as it could be. The installation of recycling systems can also vary strongly between two geographical zones according to the mentalities, the profitability, the technical conditions and other parameters. For example, the northern countries policies are more focused on the economic recovery after the crisis and on the unemployment rate decrease than on environmental issues (despite the dynamic initiated in Rio in 1992) while the Southern countries (poor or developing) politics have to deal with more short-term worrisome situations such as wars, and find themselves without any waste management systems and citizens having for habit to bring their waste to the sea to get rid of them since they have no other alternatives.



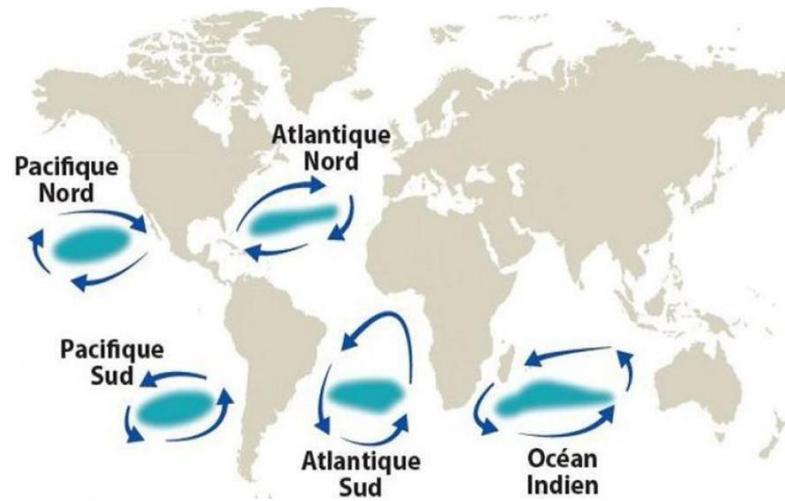
Cycle life of a plastic bag

Plastic bag is the typical example of what it is necessary to change in our habits in the coming years. Indeed, as we can see in the picture created by Tara Expéditions, we need only one second to produce a plastic bag which we shall use during 20 min for shopping before throwing it. The problem appears with the fact that it will spend most of its life – around 450 years – as a polluting waste if it is not properly

discarded. France will forbid the plastic bags on January 1st, 2016. Today we know that between 70 and 80 % of the waste which are in the oceans come from the ground. Most waste thrown in the nature or in the street will arrive in the sea thanks to wind and rivers transportation. Hence the slogan "Throwing on the ground, is throwing at sea ". For the anecdote, it is said that "the quantity of plastic produced since the beginning of plastic age is sufficient to pack 6 times the earth» (movie Plastic Planet - 2011).

We now speak about a 7th continent or about garbage patch to describe the plastic pollution in the oceans. It is the pollution which countered invisible because microscopic but is well present and sneaky. Teams have gathered and built expeditions programs in several places around the globe including in France. I am lucky to have the opportunity to participate in the one of them that is the "Expédition 7eme Continent" which sailed this year in the North Atlantic Ocean from May 15th until June 15th. I am a part of the ground team and am in charge of the boat routing from the CNES (French Space Agency) in Toulouse.

What happens in the ocean?



The 5 gyres

Surface currents converge very slowly, towards every ocean's center, mainly guided by the Coriolis force due to Earth rotation. These currents form oceanic gyres which trap and accumulate plastics in their centers. In fact, oceans are in perpetual motion and four main factors have a role on the movements of the water: the rotation of the Earth, winds, the uneven distribution of the solar energy and the attraction of the moon. Their combined influence create diverse movements, strongly influenced by the stratification of the fluid and the existence of continents as well as waves and tides, whirlwinds or deep or surface currents.

The ocean pollution in the oceans which consists in an accumulation of plastic is collectively called "7th continent" or "garbage patch". This 7th continent is an artificial continent compound of waste whose degradation cycle is very long but contrary to what we could think, it is not a proper continent on which we can walk but a grouping of micro-plastics (of the order of the cm for the biggest pieces) which is also called plastic soup, scattered in the ocean. Thus, the 7th continent is not visible of a simple look on the immense ocean.



The plastic soup



Dead albatross

Animals are the first victims of this sneaky pollution. Turtles confuse plastic bags and jellyfishes which they are very fond of. Birds, fish and other zooplanktons ingest microplastics which they cannot digest. Plastics accumulate in their stomachs leading to their death. On the left, we have the example of an albatross found dead with not only corks of various colors in the stomach but also a lighter and other pieces of objects. The abandoned fishing nets are also very murderous for animals and numerous examples are on the Internet.

To go further, studies focused on the most polluting countries and in particular, the works of Jenna Jambeck (USA) published in the scientific journal "Science". The scientists consider that 9 million tons of plastics would finish in the oceans just for year 2015. Without real surprise, China is classified in the front row with a discharge of 30 % of the world pollution. Indonesia and Philippines complete the podium. The United States, the only rich country are classified in the 20th place while Europe is at the 18th place if it is considered as a single entity.

Just like for global warming, we can act individually or in a group. Paying attention not to throw anything on the ground even if we are in thousands of kilometers from the oceans, recycling our waste a maximum are examples of ways to improve our behaviors. Some associations also work on nature conservation such as Tara Expéditions, Surfrider Foundation, Expedition 7e Continent, Race for Water, Mava foundation, Foundation 5gyres ...

My Job

It would be a huge improvement if we managed to map the accumulation zones: the purpose of it being to know if there are smaller convergent zones where plastics would accumulate within the gyre. If we can determine the location of these concentration zones directly with satellites in live, we would be able to get back to these areas more precisely and could intend to remedy this problem.

According to previous expeditions, which results are in the literature, there would be waste in a column of water going from the surface, where the concentration would be the most important, up to 30m deep at some places. With regards to deep ocean, it is supposed that the pollution exists too but there is no real technical mean to verify it so far. Furthermore, at certain depth, the degradation is much slower due to a lack of oxygen and light, and the pollution is thus more "visible" (macrowaste) ...

Our main focus here on surface plastics and micro-plastics. Today, we know that plastics are imprisoned into oceanic gyres. Yet, to date there is no exact mapping of gyres and the scientists do not agree on their demarcation. The only simulations that exist, are based on surface parameters such as currents or winds or on the previous expedition's results which revealed the plastics rates in certain points. Furthermore, there is no way to correct these models and the expeditions are not numerous. That is why, it is interesting to look for smaller scales whirlwinds which form thanks to space-based Earth observation technologies. It is the work of my internship.

A previous internship focused last year on studying how it would be possible to localize microplastics at sea thanks to high definition satellite imagery and collocated measures at sea with the boat. For that purpose, several satellites have been used such as Pléiades (high definition imagers), TerraSAR-X, Spot... However, we realize that either these satellites were not adapted for this kind of mission, or we did not reveal what we looked for.

Thanks to the in-situ observations made during the 2014 expedition and to a post-expedition analysis conducted by Mercator Océan (center of analyses and oceanographic forecasts in Toulouse in charge of the program Copernicus Marine Service), it would seem that there are zones where plastics tend to accumulate within the gyre. Thereafter are SSH maps (Sea Surface Height - height of water due to the currents) and currents maps with the plastics concentrations collected at some points.

EXPEDITION 7^e CONTINENT

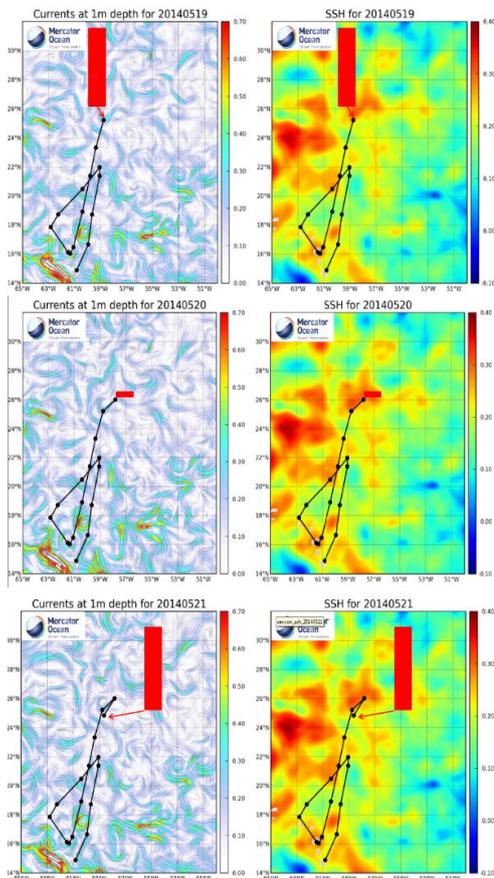
The "Expédition 7e Continent" is an association managed by Patrick DEIXONNE, member the society of the French Explorers. Its main mission is to make, more in detail, the scale of this pollution known. It has been now 4 years since the CNES is partner of the "Expédition 7e Continent". I shall be in charge of the routing, key element of this 2015 mission.



This year, the expedition restarts for the North Atlantic Ocean gyre. Departure planned for Thursday, May 28th. Before that, one week of educational meetings (from Friday, May 16th till Saturday, May 23rd) was organized with the classes of Martinique, Dominique, Guadeloupe, saint Martin and saint Barth.



Samplings and takings are planned every day, at the same time on the road of 4 days towards the gyre and also in the gyre, at several moments of the day of the rise at sunset as well as during the night (sunset + 2 hours). You find all the information in almost real-time as the logbook or the routing on the site of the expedition : www.septiemecontinent.com or follow them on facebook and twitter.



LEGEND: on the left, maps of the currents at 1m of depth and SSH maps at various dates: 19th, 20th and 21st of May 2014. It would seem that the collection of plastics is more important at the edge of the "bumps" rather than in their center.

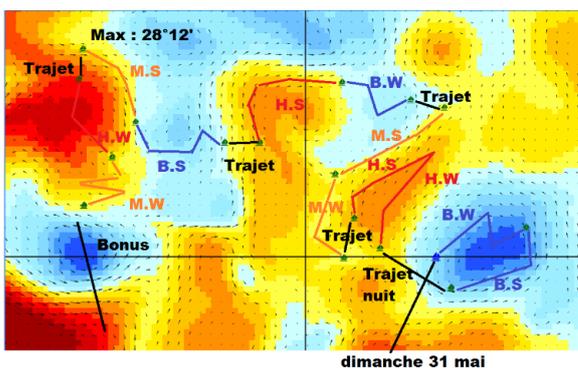
We decided to verify this hypothesis this year. To be able to produce the maps that are necessary to guide the boat, Mercator Océan supplies me every day with files of d-days, d+1 and d+2. They are on a dedicated server and in the NetCDF format (Network Common Data Form). These files contain 3 raster layers (digital technology which is, in our case of cartographic context, accompanied with a file of geography-referencing.): SSH, u (current zonal of surface) and v (current meridian of surface). I use the free Qgis software to process these data. We decided to focus our work on maps going from 14°N to 35°N (that is a 2 235 km height) and from -50°W to -65°W (that is a 1 676 km width).

Maps of currents (left) and SSH (right) on 3 days

After dialogue with the scientists, we decided to make a laminated protocol. We thus agreed to class the first parameter SSH in three different categories (blue for the low heights of water – 10-15 cm, yellow for the averages – 25 – 26 cm and the red for the high values – 30 - 36 cm) to which we added the current parameter (strong or weak). It gave us a table of 6 compartments, corresponding to 6 different types of ocean areas. We decided that every compartment should be visited and studied at least once (which corresponds in a day of manipulations of the rise at sunset +2H for night manipulations). If possible, we repeat the manipulations twice by compartment which correspond to 12 days in the gyre which match the duration planned by the expedition team, the remaining days will thus be bonus days.

		COURANT	
		Faible : Weak	Fort : Strong
SSH	Bas : B	2 jours	2 jours
	Moyen : M	2 jours	2 jours
	Haut : H	2 jours	2 jours

We can see a map with the provisional road of the boat in the gyre:



LEGEND :
 SSH : B=Low, M=Medium, H=High
 Currents : : W=Weak, S=Strong

PARTNERS

CNES : French Space Agency : home



Mercator Océan: Ocean Forecasters: they supply carts all day



CLS : Collect Satellite Localization : tracker Argos' data to follow the boat



SATELLITES USED

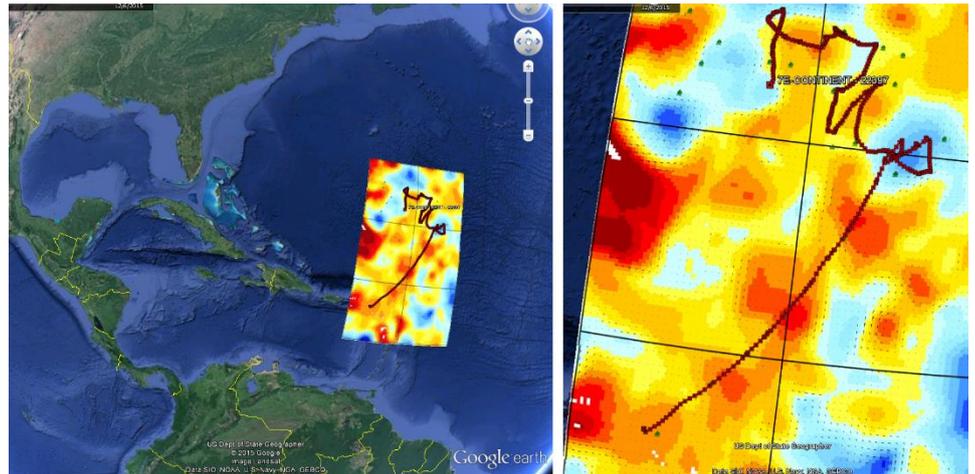
A lot of satellites are used in this application. First of all, it's Jason 2 which is used by Mercator Ocean for the simulations. It's a satellite of altimetry, radiometry developed by Nasa and CNES. Moreover, Jason 3 will normally be launched in July 2015, the 21th. We also have Sara/Altika, another satellite altimetry radar launched in 2013 and Cryosat

For information, satellites used in 2014 : Pléiades 1A et 1B, Spot 6, Aqua and Terra, Envisat, Sentinel and TerraSAR-X.

We also speak of Swot (Surface Water Ocean Topography).

Later on, I plan on stacking other parameters such as SLA (Sea Level Anomaly) or SST (Sea Surface Temperature) to see if we can find new trends that we could explore further on. Furthermore, thanks to CLS localization website and to a tracker installed on the boat, I know the exact position of the boat with an hour delay. I could verify the good course of the boat every time and see in which zones of SSH and currents it passed. In return, they will supply me with the concentrations of collected plastics.

I will compare all these data :



We hope to be able to find a relation between SSH, currents and plastics.