Volvo Ocean Race 2017-18

Science programme

Final Report

Photo: Jeremie Lecaudey / Volvo Ocean Race

Preface

This report was compiled using data provided by Dr Toste Tanhua and Dr-Ing. Sören Gutekunst, GEOMAR Helmholtz Centre for Ocean Research with the support of Cluster of Excellence - Future Ocean.

With contributions from Shaun Dolk, NOAA; Gonzalo Infante, Volvo Ocean Race Meteorologist; Dr Zhankun Wang NCEI, NOAA and Dr Shawn Smith, Florida State University Centre for Ocean-Atmospheric Prediction Studies.

This is not a scientific report but rather a summary of the Science Programme and where possible a description of the data collected. Detailed scientific analysis is ongoing to be submitted for peer-reviewed scientific publication.

Particular thanks to the Turn the Tide on Plastic and Team AkzoNobel race teams, and especially Liz Wardley and Nicolai Sehested of those teams respectively, for facilitating and conducting the data collection.

Further correspondence contact:

Toste Tanhua
ttanhua@geomar.de

Sören Gutekunst
sgutekunst@geomar.de

Media & Communication:
Robin Clegg
robin.clegg@volvooceanrace.com

Central Coordination - Volvo Ocean Race:
Anne-Cécile Turner
annececile.turner@volvooceanrace.com

Contents

Summary

An elite consortium

The Volvo Ocean Race Science Programme brought together an elite scientific consortium to capture data that will contribute to a better understanding of the world's ocean and climate.

There were three elements to the programme:

- onboard sampling of oceanographic variables and microplastic concentrations;
- scientific drifter buoy deployment;
- sharing of boats' meteorological measurements.

A rare sampling opportunity

Significantly, the race provided **rare opportunities to sample geographically extreme areas** where microplastic concentrations and other oceanographic and environmental parameters have rarely or never before been directly measured.

Environmental and oceanographic measurements contributed a considerable wealth of data especially from critical data-sparse areas. The datasets are available to scientists and weather forecasters to improve the reliability of forecasts and simulation predictions relating to climate, weather, storms and ocean health.

A valuable microplastic dataset

The dataset relating to microplastic distribution, captured by the nine-month global circumnavigation, has provided an **internally consistent picture of the distribution of microplastic pollution along the race route**.

This microplastic research has the potential to contribute to the establishment of a worldwide standardised approach to microplastic sampling, analysis and instrumentation.

Over an approximate 45,000 nautical miles (83,000 km) sailed between Alicante and The Hague, 75 locations were sampled by the Turn the Tide on Plastic team, providing a picture of microplastic distribution along their route. An additional 11 locations were sampled by Team AkzoNobel after the fitting of a sampling unit in Auckland. The samples were analysed by GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany.

Remote but not isolated

Overall the preliminary results confirmed the all-pervading extent of microplastic pollution in a boundaryless marine environment. Marine habitats that are geographically remote are not isolated from the effects of our choices and habits on land.

Microplastics were found in 93% of samples collected along the route by both samping boats, including those taken closest to Point Nemo in the South Pacific, **the most remote location in the world's ocean**. Close to Antarctic waters in the South Indian Ocean levels of microplastics were as high as 25 (± 10*) particles/m^3.

* ± values indicate the estimated certainty of each measurement (see also page 31).

The **highest microplastics concentration was recorded in the waters of the South China Sea** where the level was 349 (± 49) particles/m^3. An adjacent sample from the north Philippine Sea, east of Taiwan, also had a relatively high level of 243 (± 32) particles/m^3.

North European waters showed the second highest level recorded. There were up to 307 (± 27) particles/m^3 in samples from the Mediterranean and the inshore Atlantic close to Portugal and Spain.

As expected, measurements were typically highest in the more inshore samples. There were **consistent levels recorded in the offshore waters of the Atlantic**, in some cases comparable to inshore measurements. In the Pacific concentrations recorded were relatively more patchy.

Parameters of ocean health

As well as plastic pollution there are other pressures affecting our ocean so alongside the sampling of microplastic, measurements of **oceanographic parameters** relating to overall ocean health, climate and environmental conditions were also recorded. Onboard sampling provided direct measurement of partial pressure of carbon dioxide, temperature, salinity and chlorophyll a and indirect derivation of pH levels. The latter can indicate the extent of ocean acidification.

Carbon dioxide data are of particular significance in assessing the ocean's annual capacity to absorb excess atmospheric carbon dioxide and mitigate climate change. Also, CO_2 data are important for climate predictions via the Tropical Pacific Observing System (TPOS) - the single-most important ocean observation unit for predicting climate on an annual and interannual time-scale.

Two years of data collection

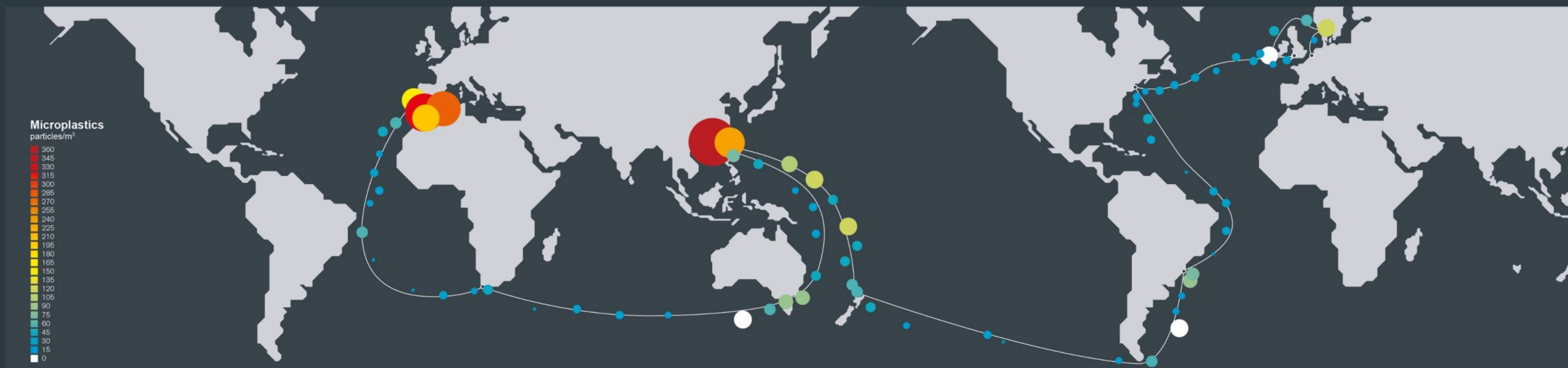
30 scientific drifter buoys deployed in five different areas by Volvo Ocean Race boats during the race will potentially continue to transmit temperature data for up to two years as they drift with ocean surface currents. The positions transmitted by the buoys over time will provide information relating to ocean current movements and the surface drifter buoys serve as a good proxy for microplastic pollution, which circulates with these currents.

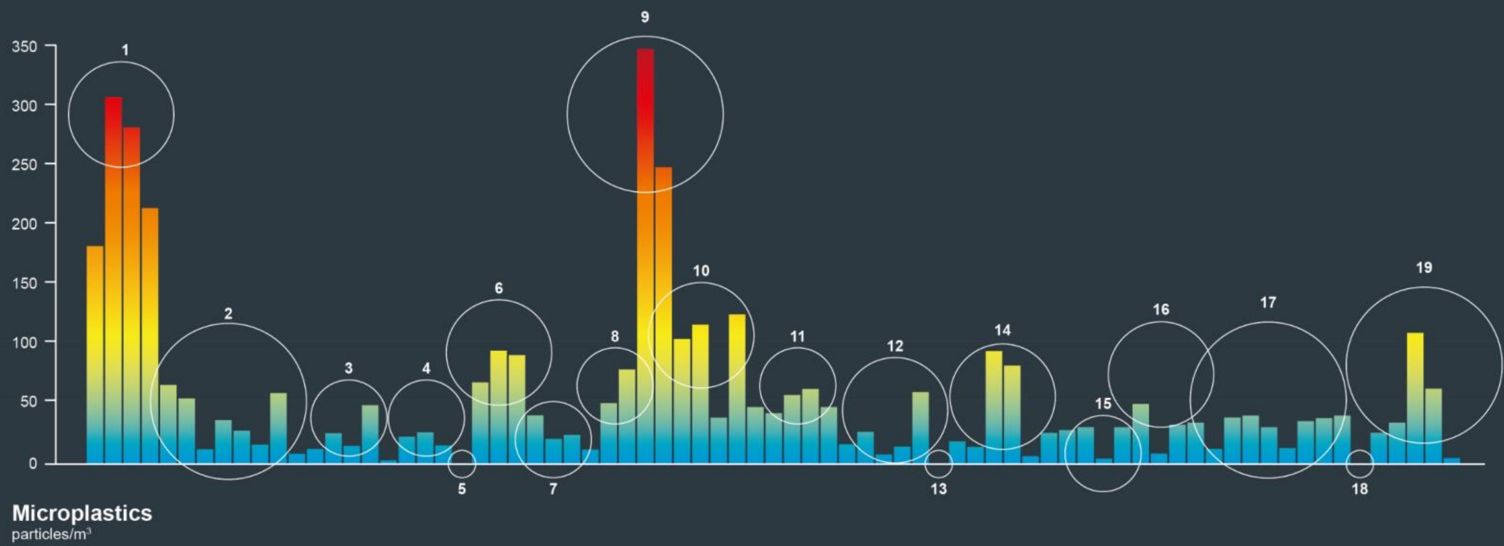
Direct meteorological measurements

Weather forecasts and climate predictions rely significantly on remote sensing of data by satellites. To increase the reliability of forecasts and longer-term climate predictions the data from satellites need to be validated using direct measurements. Along the often extremely remote route of the race opportunities for such direct measurements are typically rare. By sharing meteorological data recorded by each boat with the World Meteorological Organisation, the 2017-2018 Volvo Ocean Race contributed direct measurements to help scientists and weather forecasters better predict our planet's climate and weather.

Volvo Ocean Race 2017-18

Microplastics Data / Turn the Tide on Plastic preliminary results



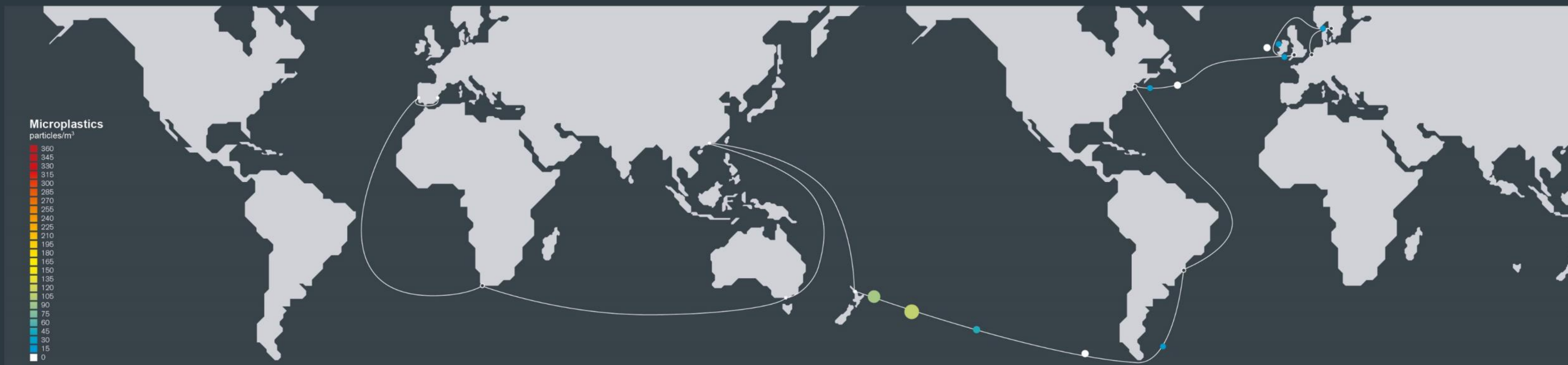


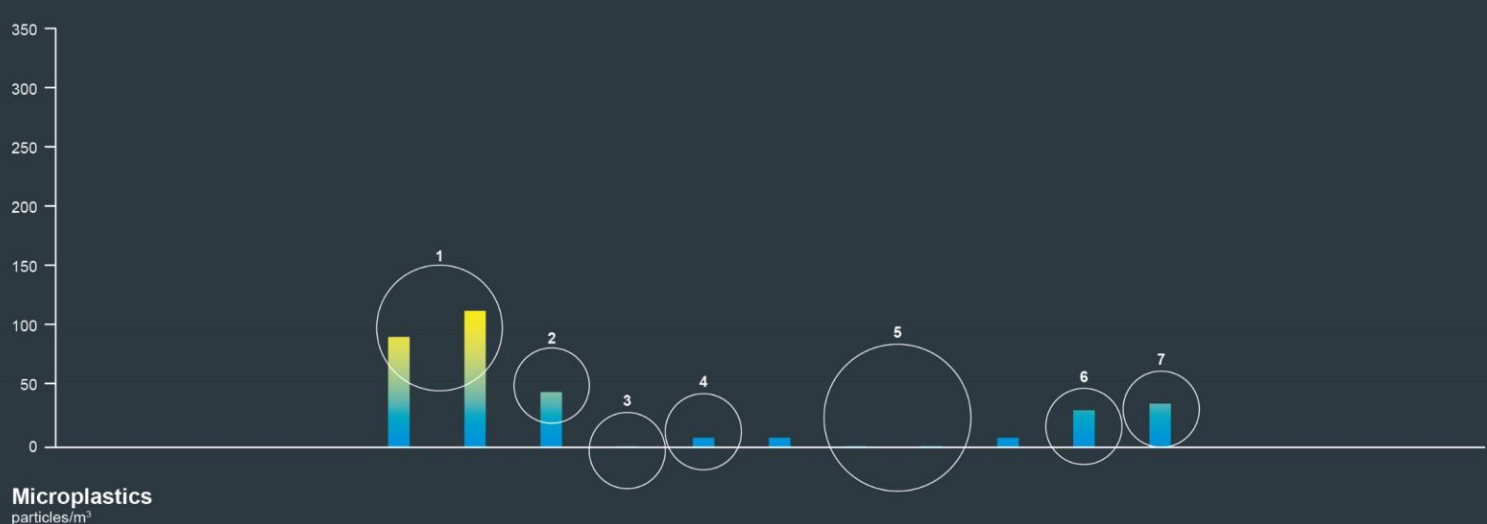
1. **North Atlantic Ocean and Mediterranean Sea:** High microplastics levels may be attributed to the proximity to the coast, strong ocean currents and busy shipping routes.
2. **Atlantic Ocean:** Progressing south, levels decreased with distance from land, with a relative increase closer to South America, an area with strong surface currents.
3. **South African coast:** Microplastic pollution near Cape Town may partly originate further north due to the strong Aguhlas current, which flows from the northern Indian Ocean.
4. **Indian Ocean:** Relatively high microplastic content in these remote areas are likely due to currents originating further north.
5. **South of Great Australian Bight:** One of only three Turn the Tide on Plastic sample areas where no microplastics were recorded.
6. **Australian coast:** Microplastic concentrations will be affected by currents coming from the northern Indian Ocean & Indonesian archipelago.
7. **From Melbourne to Hong Kong:** Recorded levels were low in the open water of the Equatorial Pacific.
8. **Philippine Sea:** The measurement of 75 particles/m³ may be due in part to patchiness of particle distribution as higher levels were recorded in a more inshore sample from this area.
9. **South China and North Philippine Sea:** High levels were measured in an area coinciding with the Kuroshio current which feeds into the North Pacific Subtropical Gyre.
10. **Equatorial Pacific:** Average levels in this region were higher than recorded on the previous leg. Prevailing currents have a significant impact on microplastic distribution in this area.
11. **Approach to New Zealand:** Progressing south through the Coral Sea the concentration increased steadily to a level of 60 particles/m³ in the sample closest to Auckland.
12. **Remote Pacific near Point Nemo:** Microplastic levels of 9-26 particles/m³ in an area further from land than anywhere else on Earth, & a level of 57 particles/m³ off Cape Horn.
13. **South America east coast:** One of only three Turn the Tide on Plastic sample areas where no microplastics were recorded.
14. **Brazilian coast:** Levels were highest in the samples closest to mainland.
15. **Caribbean Sea:** A low measurement in this area may have been due partly to filter blockages by sargassum seaweed.
16. **East of the USA:** Measurements were between 15 and 45 particles/m³.
17. **North Mid-Atlantic Ocean:** Levels were very consistent and comparable to more inshore concentrations, maybe corresponding to the North Atlantic Gyre.
18. **West of Ireland:** One of the three samples containing no microplastics, out of a total of 75 Turn the Tide on Plastic samples.
19. **Skagerrak area:** Relatively high levels in the busy shipping area were the Baltic and North seas mix.

Preliminary Data provided by
Dr-Ing. Sören Gutekunst and Dr Toste Tanhua,
GEOMAR Helmholtz Centre for Ocean Research Kiel

Volvo Ocean Race 2017-18

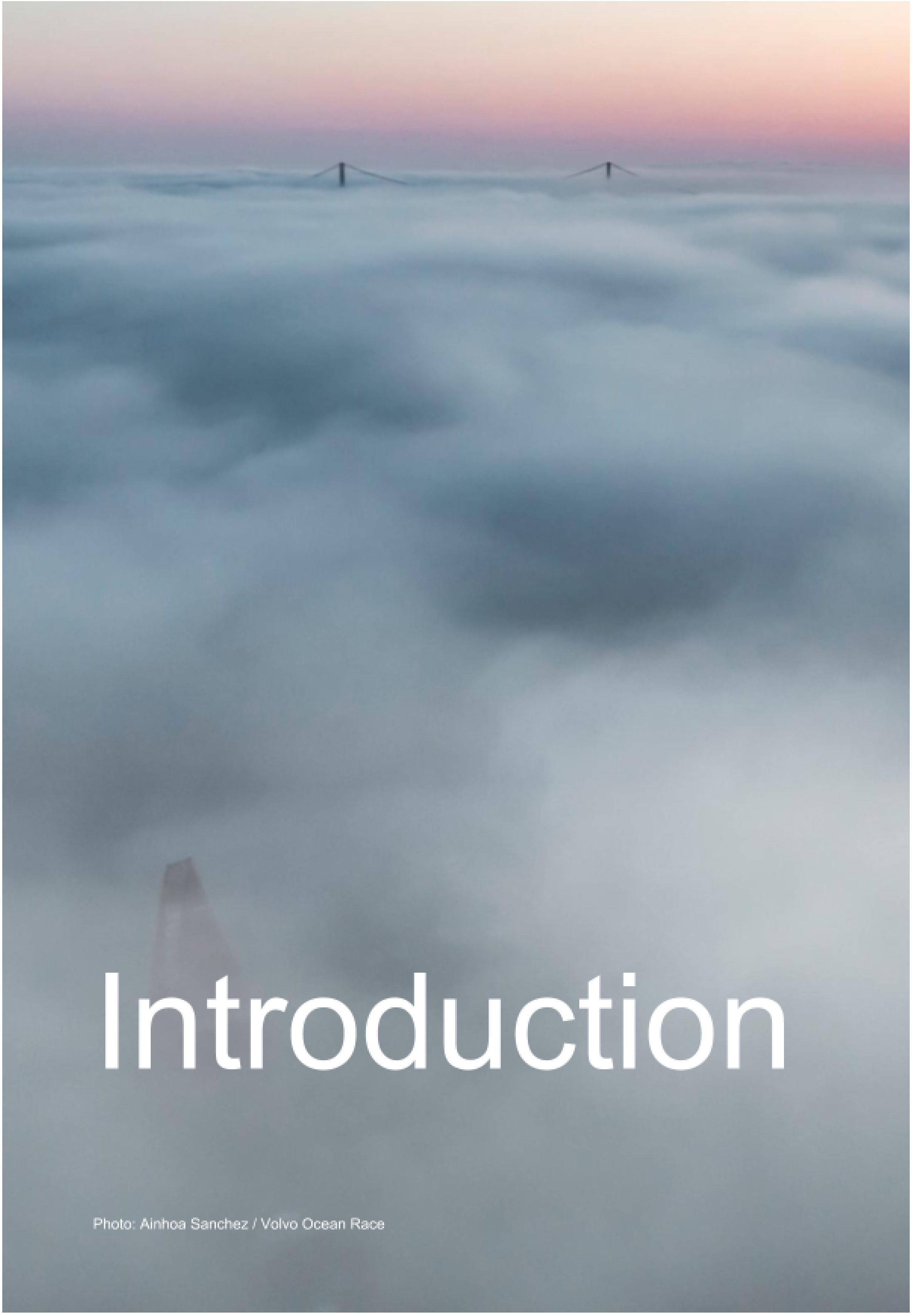
Microplastics Data / team AkzoNobel preliminary results





1. **Pacific southeast of New Zealand:** Relatively high levels were recorded close to the New Zealand coast and in remote waters to the southeast.
2. **Mid-South Pacific:** In the open South Pacific average levels as high as 41 particles/m³ were detected.
3. **West of Cape Horn:** A zero level was recorded west of Cape Horn.
4. **Atlantic east of South America:** The recorded concentration was comparable to that measured by Turn the Tide on Plastic in a similar sampling area.
5. **North Atlantic:** Two zero measurements were recorded. No samples were collected in the mid-Atlantic.
6. **Inshore North Atlantic:** This point shows up on land as it is an average value for three sampling points south, west and northwest of Ireland.
7. **North Sea:** The concentration recorded was not as high as that recorded in the Skagen channel by Turn the Tide on Plastic.

Preliminary Data provided by
Dr-Ing. Sören Gutekunst and Dr Toste Tanhua,
GEOMAR Helmholtz Centre for Ocean Research Kiel



Introduction

Photo: Ainhoa Sanchez / Volvo Ocean Race

A Scientific Legacy

The 2017-2018 Volvo Ocean Race carried an impactful message regarding our overuse of plastic and the detrimental effects this convenience-led habit can have on our ocean. This message reached millions of people and effected change, action and commitments on individual, organisational, municipal, regional and national levels.

The Science Programme sought to extend the positive legacy both in relation to plastic pollution and overall ocean and global environmental health. By advancing scientific research using prototype systems and collaborative data collection, the programme initiated a scientific legacy to potentially influence policy change.

The ocean is seriously under-sampled and the lack of data is most notable in remote areas outside of routine shipping routes and at locations difficult and expensive for scientific surveys to reach. Volvo Ocean Race boats served as 'ships of opportunity' for scientific data collection.

Ships of Opportunity

The race's global circumnavigation and the opportunity to equip some of the racing boats with prototype equipment presented an exceptional opportunity to:

- Directly sample remote areas otherwise hard to access for data collection;
- Capture a comparable dataset from around the globe over a relatively short period of time;
- Test the efficacy of a microplastic sampling system in combination with pioneering *ex-situ* analyses of the samples collected;
- Contribute to the establishment of a worldwide standardised approach to microplastic sampling, analysis and instrumentation;
- Contribute direct measurements to increase the reliability of climate prediction models;
- Demonstrate the feasibility of conducting oceanographic measurements from race yachts.

….And to thereby influence legislative change by advancing instrumentation and sharing knowledge relating to the scale and geographical distribution of microplastic pollution in the ocean, and relating to parameters associated with climate change.

Microplastic pollution

The extent of microplastic pollution in the world's oceans is largely unknown. Scientists are currently able to account for just 1% of the plastic that enters our ocean on an annual basis. That is – for every kilogram of plastic that enters the ocean we know where 10 grams of it is. The majority of previous microplastic surveys have studied northern hemisphere waters, and mostly the sea surface layer, using plankton nets, and shorelines [(1)].

Compounding this lack of knowledge and research, the study of ocean microplastic pollution lacks a globally recognised protocol for data collection and coordinated destination and standard for data. Target 14.1 for SDG 14 Life Below Water identifies the need to establish an indicator of floating plastic debris density, with 2020 set as the target date for completion of the indicator. Progress towards this target involves the development of guidelines for sampling methodologies.

Oceanographic and meteorological data

The monitoring of environmental and oceanographic variables provide measures of overall ocean health, climate variation and global environmental status.

The lack of actual measurements of environmental and oceanographic variables in data-sparse areas affects the reliability of forecasting and modelling simulations. For some variables remote sensing, via satellite, can be used, but for predictions to be accurate satellite measurements need to be validated by real measurements. The contribution of onboard sampling, meteorological and drifter buoy data to more accurate weather, climate and ocean health predictions is valuable.

Inextricably-linked roles for our planet

To appreciate the value of the data collected it is worth acknowledging, in brief, the roles that some of the targeted parameters play in relation to climate and the overall environmental and ecological balance of our planet.

The ocean has absorbed approximately one third of anthropogenic **carbon dioxide** emissions over time and is currently taking up an estimated quarter of annual excess atmospheric carbon dioxide. This 'service' provided by the ocean mitigates climate change but may have a detrimental effect on marine organisms if ocean pH (linked to increased CO_2 levels) decreases - the term 'ocean acidification' is given to this chemical change [(2)].

Sea Surface Temperature is an important indicator of climate change as the ocean absorbs more than 90% of the excess heat in the earth's system [(3)]. It is therefore a critical parameter in models of Ocean Heat Content (OHC) and climate change. Significantly, sea temperature increase is not uniform through all ocean basins, with some areas (southern oceans, tropical and subtropical Pacific and Atlantic) experiencing greater warming than others [(4)]. The effects of rising sea temperatures are potentially catastrophic for marine ecosystems and vulnerable coastal communities in particular. Global temperature changes are predicted to cause increasingly destructive hurricanes and tropical storms, due to stronger wind speeds and intensified rainfall [(5)].

Sea Surface Salinity (SSS) affects the density of sea water and thereby influences currents. Changes in the distribution of salinity in the (surface) ocean are good indicators of changes in the global hydrological cycle. Changes in SSS will have an impact on water circulation in the ocean (and therefore heat, nutrient and carbon cycling between deep and shallow waters) thereby influencing the global water cycle, productivity and the sea's capacity to absorb or release CO_2, as described above.

Chlorophyll a levels are an indirect measure of phytoplankton activity which is the primary production at the base of the marine food web and the main driver of biogeochemical processes in ocean ecosystems i.e. marine phytoplankton harness non-living chemicals (nutrients) and make them available in the ocean food web. Furthermore, marine phytoplankton account for approximately 50% of the global biological uptake of CO_2[(6)] which links back to carbon dioxide levels, ocean acidification and climate change. Chlorophyll a measurements are an important component of Indicator 14.1.1: Index of Coastal Eutrophication (ICEP) and Floating Plastic debris Density, which is a target for SDG 14.

Ocean currents affect the distribution of heat globally and changes in average current speed and direction indicate the occurrence of climate cycles such as El Niño and La Niña, which impact world-wide weather and catastrophic weather events. Also, surface currents affect the distribution of microplastic particles. By combining microplastic data with surface current information scientists will be better able to understand where microplastic pollution is originating, dispersing and accumulating.

Data Sharing

The data collected by the race's sampling efforts has and will be shared to the most relevant open-source databases including NOAA's National Centers for Environmental Information (NCEI), EMODnet and global ocean data centres including SOCAT, GOSUD and Coriolis. Refer to 'Sharing Data' on page 48 for a complete list of data destinations.

Aligning effort

In The Hague at the end of the race in June a workshop was held to bring together scientists from universities and recognised laboratories; medical experts; instrumentation experts; private sector, NGO and UN representatives; Volvo Ocean Race race teams and Science Programme partners. The workshop aimed to expose some of the latest findings of research on micro and nano-plastic pollution, to identify the gaps to fill in order to advance understanding of these issues and to discuss how efforts could be coordinated for a collaborative approach.

Collaboration, Funding and Support

The **onboard sampling** component of the Science Programme was a collaboration between Volvo Cars, Cluster of Excellence *Future Ocean* Kiel, GEOMAR, SubCtech GmbH, bbe Moldaenke, Turn the Tide on Plastic and Team AkzoNobel crews, with invaluable input from the race's Boatyard. Volvo Cars funded the onboard equipment through profits from the sale of their Cross Country Volvo V90 Ocean Race edition cars.

The **scientific drifter buoys** are part of the National Oceanic and Atmospheric Administration's (NOAA) drifter programme and their deployment was in collaboration with race teams and the Boatyard team.

The sharing of **meteorological data** by Volvo Ocean Race meteorologists, supported by the race's IT experts, was part of a pilot project developed by JCOMM (Joint technical Commission for Oceanography and Marine Meteorology, WMO – IOC1) partners using a programme developed by NOAA.

These organisations and teams were brought together by the **Volvo Ocean Race Sustainability Programme**, in order to increase ocean knowledge, pioneer a new approach to data collection and advance the technology of instrumentation to contribute to a global map of standardised data, particularly in the area of microplastic concentration.

GEOMAR Helmholtz Centre for Ocean Research Kiel

future ocean KIEL MARINE SCIENCES

NOAA

jcommops

subCtech

With the support of

VOLVO

Capturing data: Onboard sampling

Photo: Jeremie Lecaudey / Volvo Ocean Race

The **OceanPack™ RACE** sampling units onboard our race boats Turn the Tide on Plastic (all race legs) and Team AkzoNobel (from Auckland, Legs 7 to 11), combined two devices sampling:

• **Partial pressure of carbon dioxide** (pCO_2) measured as parts per million (ppm);
• **Sea Surface Temperature** (SST) measured as degrees Celsius (° C);
• **Sea Surface Salinity** (SSS) measured as Practical Salinity Units (PSU);
• **Chlorophyll a** measured as milligrams per cubic metre (mg/m^3);
• **Microplastic concentration** measured as particles per cubic metre ($particles/m^3$).

When seawater was being pumped to provide the boat and crew's fresh water, typically for one hour every 20 hours, the 'underway' was sampled. The critical task of carrying out the onboard sampling was completed by Turn the Tide on Plastic Boat Captain Liz Wardley and by Boat Captain Nicolai Sehested of Team AkzoNobel.

The water was taken from just below the ocean surface with the exact depth depending on the heel of the boat. This was significant as most previous research on microplastics has focussed on sampling the surface of the water.

The **microplastics sampling devices** incorporated a **filter system** with up to three filters that were changed every two days. On board Turn the Tide on Plastic filter change frequency was increased to daily on all race legs after Newport (Legs 9, 10, 11). Filter mesh sizes were 500µm, 100µm, 5µm (Legs 0 and 1), but as the 5µm filter tended to become blocked it was replaced with a dummy filter for Legs 2 – 6 and later a 30 µm filter was used (Legs 7 – 11).

Each unit also incorporated sensors that recorded *in-situ* measurements of the oceanographic variables and these data were downloaded via USB at each stopover.

The unit and sampling had to be tailored to comply with the limitations of the one-design rule for competing boats.

Pioneering microplastic analysis

The filter system captured microplastics and at each race stopover GEOMAR scientist, Dr-Ing. Sören Gutekunst, recovered the filters for analyses at their laboratory in Kiel, Germany.

A pioneering prototype system (developed by bbe Moldaenke) was used to identify and quantify microplastics levels: A holographic camera measured the size of particles and a RAMAN spectrometer identified which particles were plastic. The process, although still quite time-consuming (6 hours per filter), is considerably more efficient and less subjective than manual analyses using a microscope.

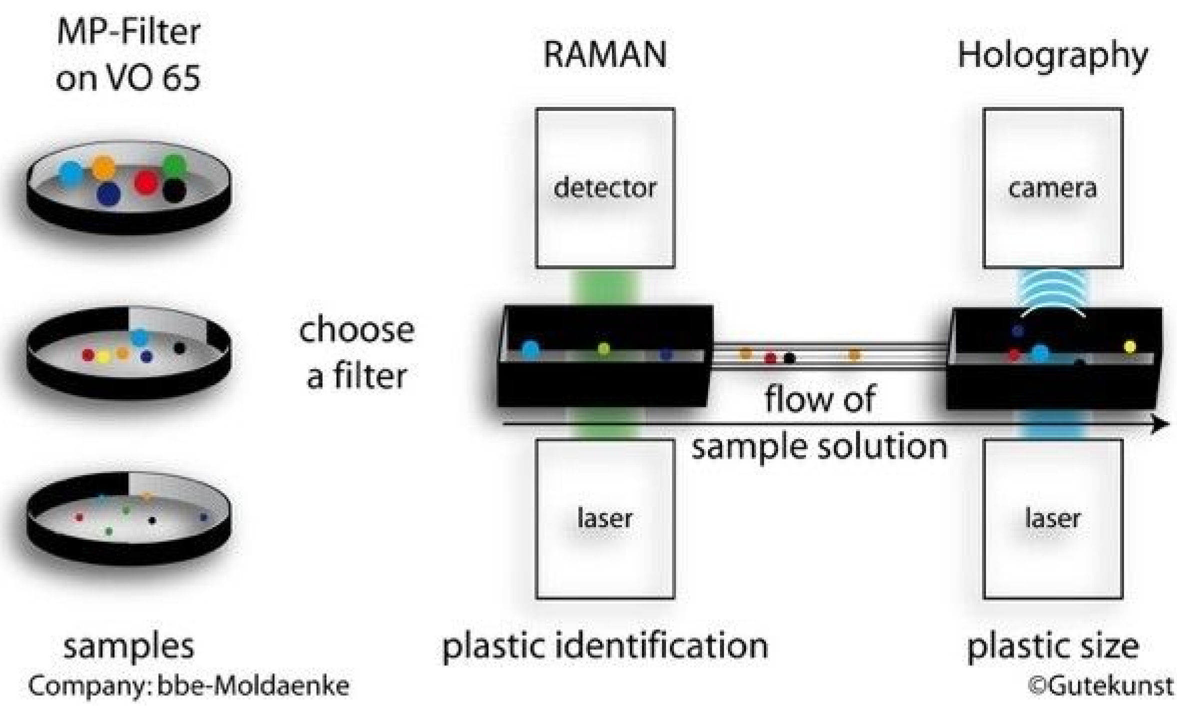


Diagram representation of the analysis process

Photo: Ugo Fonollá / Volvo Ocean Race

The racing yachts were requested to deploy one drifter buoy each during four of the race legs. Additionally, on the leg between Itajaí and Newport, because of the availability of extra drifter buoys, several deployments were possible. To prevent non-deploying teams from gaining any advantage in that instance, they were required to carry bags of water weighing equal that of a drifter buoy and to empty the bags at the predetermined location.

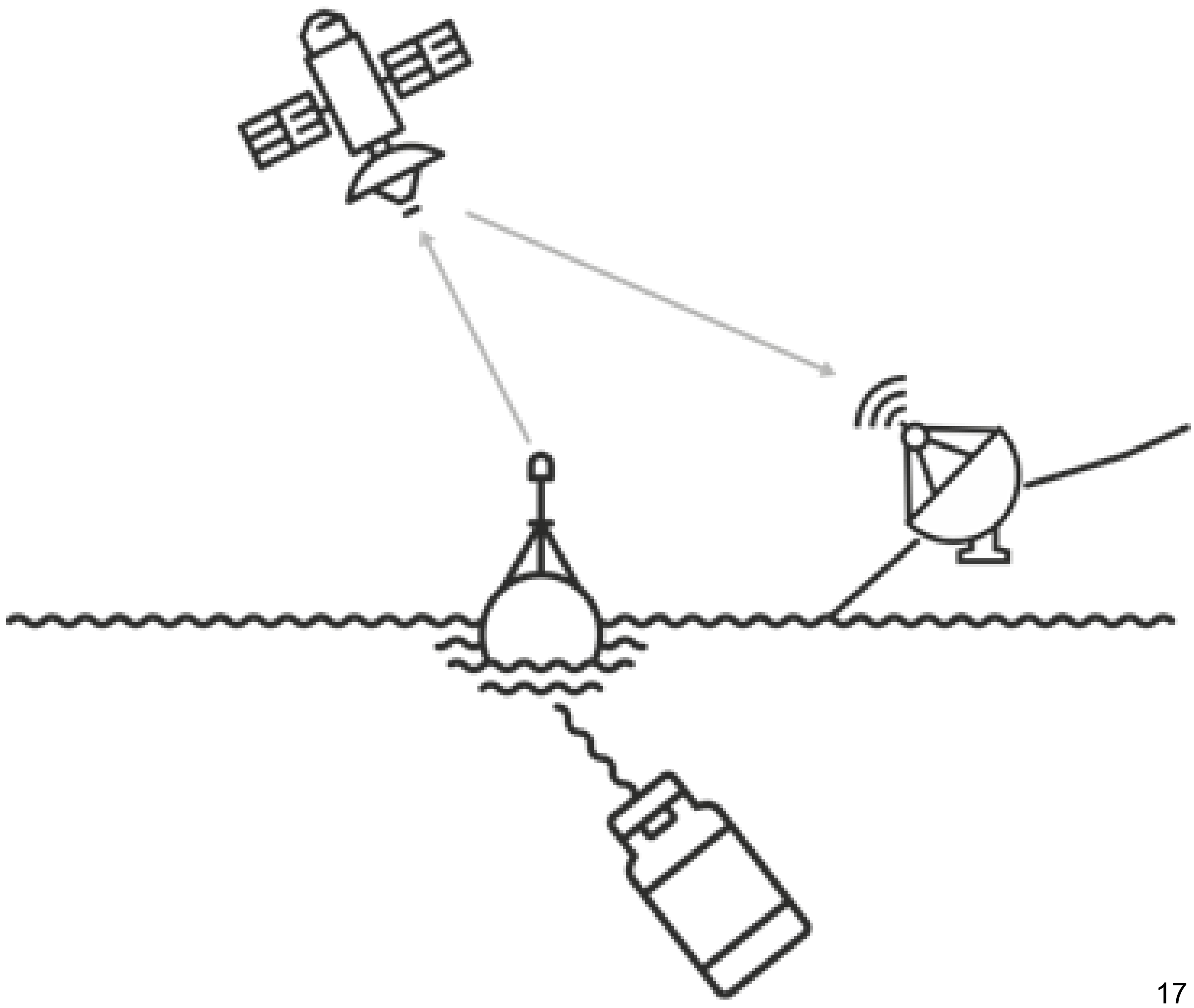
The buoys are part of the National Oceanic and Atmospheric Administration's (NOAA) drifter programme.

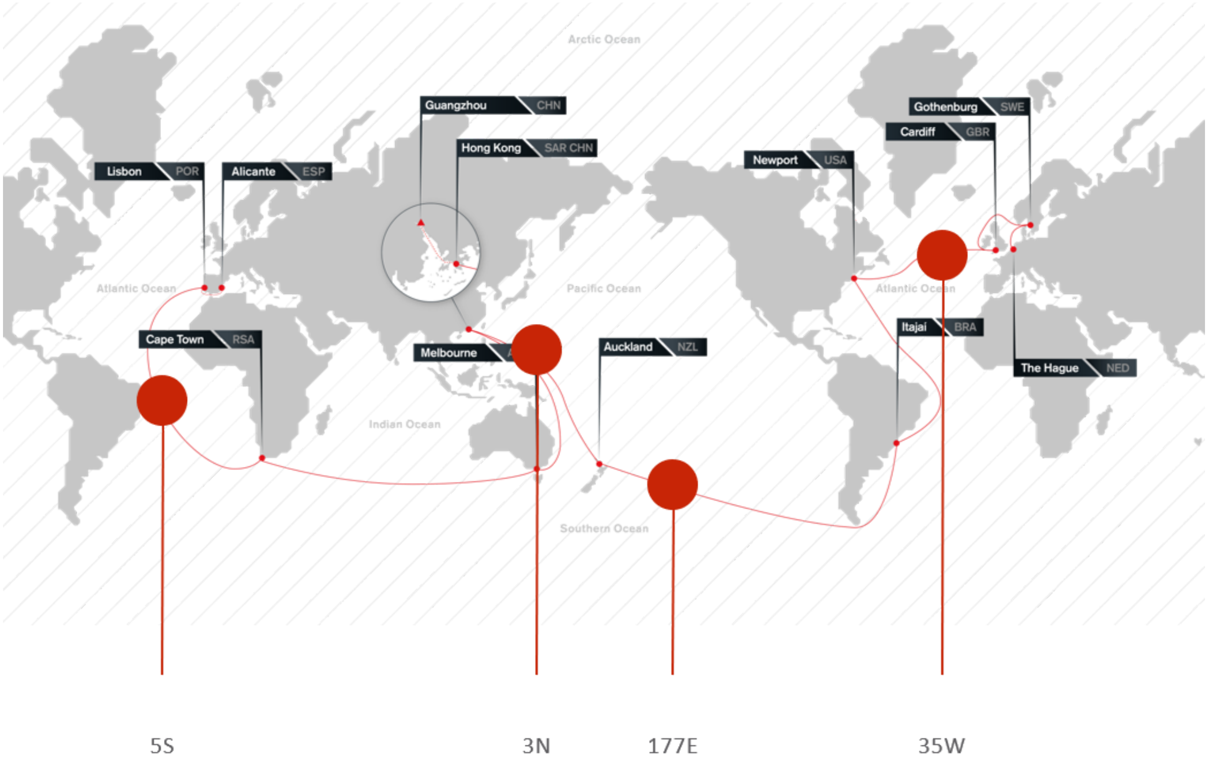
The deployment locations were selected by NOAA scientists to target crucial areas for which data will be especially useful.

The buoys have a 'drogue' so that they move with the ocean surface currents rather than the wind and they transmit sea surface temperature measurements and position via satellite every hour.

The near real-time sea surface temperature measurements can provide information for predicting the strengthening of storms and the archived data can be accessed by scientists to validate and increase the accuracy of simulations.

Ocean currents affect the distribution of, amongst other things, heat and microplastics globally. Data about their speed and direction (derived from position over time) are critical for the study of climate and microplastic distribution.





Leg 2 - Alicante to Cape Town

Because of limited access to vessels transiting between Europe and South Africa, the Gulf of Guinea is a difficult region to seed with drifters. Deployments on the western edge of the Gulf of Guinea will fill a large gap and provide much-needed data.

Leg 6 - Hong Kong to Auckland

The race route provided access to the far western Pacific, an area where NOAA's Global Drifter Programme has limited access to operating vessels. Because of the strong equatorial currents, drifters quickly leave this area, yet the data collected for El Niño/La Niña identification are extremely valuable.

Leg 7 - Auckland to Itajaí

Deployments during this leg were particularly valuable because this region typically sees minimal vessel traffic, contains viewer fixed data sources, and is one of the largest uninterrupted ocean basins. Thus, data from autonomous platforms (i.e. drifters) provide data otherwise unattainable.

Leg 8 – Itajaí to Newport

Leg eight was not part of the initial deployment plan, but because of the availability of extra buoys, several deployments were possible during this transect. Deployments at 3° N were chosen to reduce the possibility of drifters quickly running aground onto the Brazilian coast.

Leg 9 - Newport to Cardiff

Deployments during the transatlantic leg were chosen to fill gaps within the north Atlantic. Many of the deployment opportunities within the Atlantic basin are south of the race route, so these deployments helped to seed gaps that otherwise rely on buoys fed by the Gulf Stream.

Capturing data: Meteorological measurements

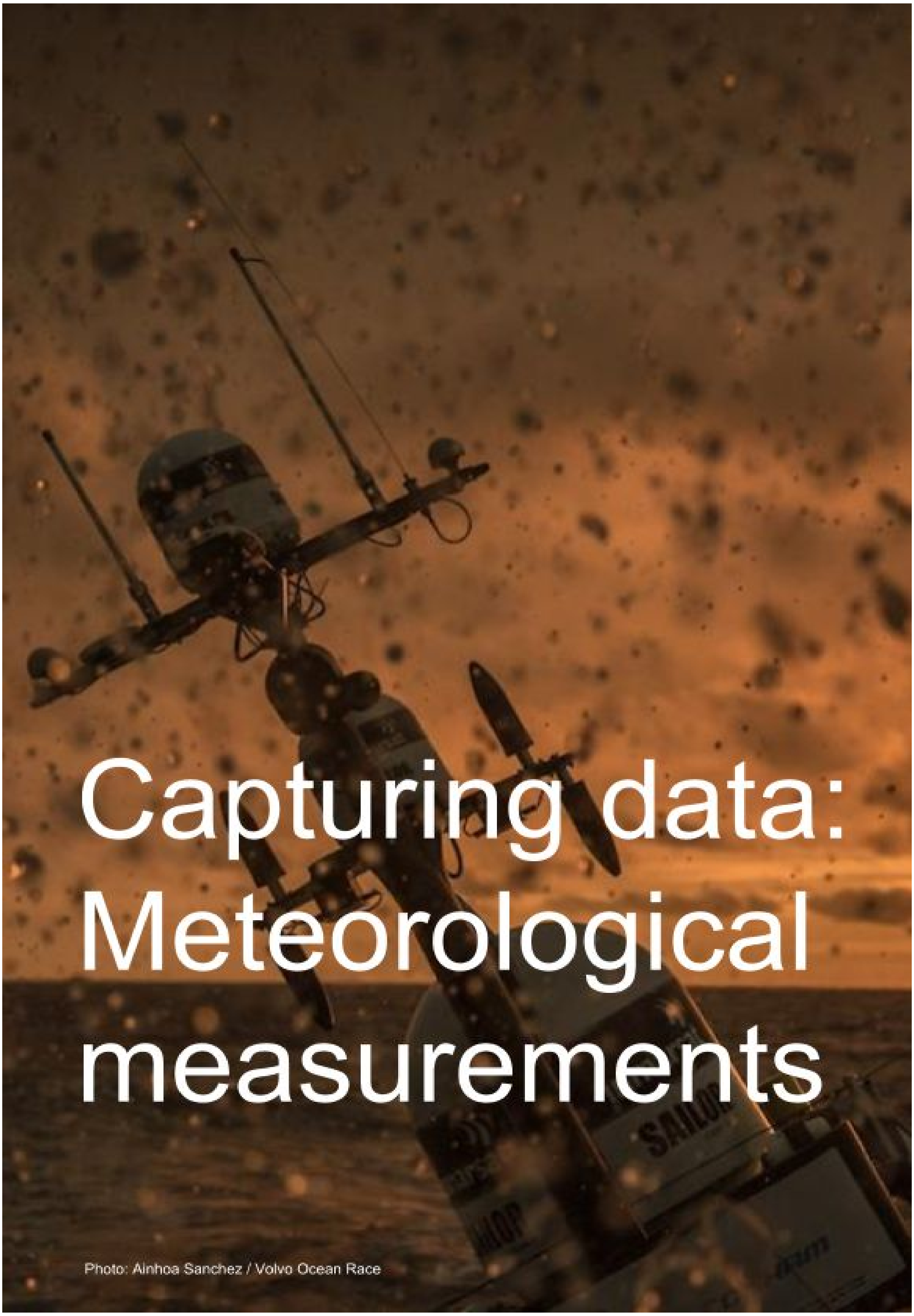


Photo: Ainhoa Sanchez / Volvo Ocean Race

All race boats carried onboard instruments that measured:

• True wind speed
• True wind direction
• Latitude | Longitude
• Air temperature
• Sea temperature
• Barometric pressure
• Timestamp of the telemetry measurement

The data collected by the boats was sent every 10 seconds to our race headquarters and was then shared as a readable file with the National Oceanic and Atmospheric Administration (NOAA).

The data was incorporated into the **Global Telecommunication System** (GTS) which is the communications and data management component of the **World Meteorological Organisation** (WMO). This was done using NOAA's ERDAPP programme. Once in the GTS the data are available publicly for use by scientists and weather forecasters. This was a programme piloted by JCOMMOPs.

The data was shared in a similar way with the **Shipboard Automated Meteorological and Oceanographic System Initiative** (SAMOS) and archived by the **National Center for Environmental Information** combined with the onboard and microplastic measurements.

A better understanding of ocean microplastic

Photo: Jesus Renedo / Volvo Ocean Race

Microplastic results

The preliminary data summarised here were provided by Dr Toste Tanhua and Dr-Ing. Sören Gutekunst, GEOMAR Helmholtz Centre for Ocean Research Kiel. Refer also to the graphics on pages 6 and 7 above.

Unprecedented microplastics dataset

The Volvo Ocean Race ocean microplastic data give a unique near-synoptic picture of the distribution of microplastics in the ocean along the race route.

It represents a remarkable dataset given the coverage of previously unsampled ocean and the fact that the data from different areas are comparable, having been measured in a consistent way using the same sampling device.

Interpreting data

Analysis is continuing to statistically examine the data for scientific publication. The inclusion of a second sampling boat has given scientists a critical opportunity to examine optimal sampling procedures for the system.

It is important to remember that results are based on single samples and also to consider the 'averages' that the numbers represent due to the potential geographical range of a single sample - for the most part filters were changed every two days (later daily by Turn the Tide on Plastic) so each sample may have ranged over the corresponding area traversed, depending how often water was pumped through the system.

Values listed here are accompanied by a ± value which indicates the certainty of each measurement (see also page 31).

It is premature at this stage to attribute the microplastic levels recorded entirely to either local sources or long-range transport as microplastics concentration will be related to average surface currents. Furthermore, local levels of pollution in general should be considered 'per capita' in relation to contributing populations.

To examine this a project is being proposed with ocean modellers at GEOMAR to combine microplastics data with surface current modelling to attempt to 'back track' the origin of the plastic pollution. Modelling of the microplastics distribution based on ocean current movements will provide a better insight into the areas where microplastic pollution originates, disperses and accumulates. The drifter buoys deployed during the race provide a good proxy for the movement of microplastic as they drift with currents below the ocean surface (see also page 45).

Microplastics results overview

Microplastics were detected in 93% of samples from both Turn the Tide on Plastic and Team AkzoNobel's sampling efforts, illustrating the pervasiveness of microplastic pollution in our ocean.

The most stark results were those demonstrating the presence of microplastics in samples from extremely remote areas, considerable distances from any major landmass.

Along the Turn the Tide on Plastic route levels as high as 26 (± 11) particles/m^3 were recorded in the mid-South Pacific. Close to Antarctic waters in the southern Indian Ocean 25 (± 10) particles/m^3 were detected in a sample collected by Turn the Tide on Plastic.

The Zeros

There were only three Turn the Tide on Plastic samples that didn't contain microplastic particles. These samples were from locations south of Australia (± 8 particles/m^3), east of Argentina (± 35 particles/m^3) and west of Ireland (± 15 particles/m^3). Team AkzoNobel samples included three zero measurements - one west of Cape Horn in the South Pacific (± 21 particles/m^3) and two from offshore in the North Atlantic (± 20 and 25 particles/m^3).
It is likely that the zero measurements are coincidental, influenced by factors such as weather, wave state and levels of plankton bloom for example. The contribution of weather and oceanographic data measured in coincidence with microplastic data provides critical metadata necessary to increase the robustness of the dataset for future analyses and comparisons.

The Highs

The highest concentration of microplastic pollution recorded during the race was **349 (± 49) particles/m^3 in a sample from the South China Sea.** This area is impacted by high population densities and river input affected by that population.

An adjacent sample from the north Philippine Sea, east of Taiwan, also had a relatively high level of **243 (± 32) particles/m^3**. Significantly, the area sampled coincides with the Kuroshio current which feeds into the North Pacific Subtropical Gyre.

The second highest relative level along the whole race route was recorded **northwest of the Strait of Gibraltar**, i.e. in the North Atlantic off Portugal, where an average of 307 (± 27) particles/m^3 was recorded. In the **western Mediterranean Sea** the recorded level was also relatively high, 280 (± 24) particles/m^3. The adjacent coast is heavily populated and the route sampled coincides with strong currents and busy shipping routes.

In the Skagerrak area, bordered by Norway, Sweden and Denmark, where the Baltic and North Seas mix there was a level of 112 (± 47) particles/m^3 recorded. This measurement was previously reported as 224 particles/m^3 but after further analysis a lower value was confirmed. In this channel the flow of water from the Baltic to the Atlantic may concentrate microplastic amounts from surrounding countries and rivers.

Remarkably, the highest level recorded by Team AkzoNobel was offshore in the South Pacific southeast of New Zealand. The level of 107 (± 36) particles/m^3 recorded there was higher than a more inshore sample that measured 89 (± 30) particles/m^3 closer to Auckland. Direct comparison with Turn the Tide on Plastic is not possible due to the boats' different courses. It is possible that input from currents originating further north may increase the microplastic burden in this remote area, but it should be noted that it is possible that the relatively high measurement was an artifact of sampling.

Similar spikes of microplastic concentrations greater than 100 particles/m^3 were recorded in the north and equatorial Pacific - possibly due to relatively higher pollution loads in currents as microplastics disperse from their source.

Preliminary microplastic data from the Pacific

Most notable in the Pacific overall was the detection of microplastic particles in all but one sample (± 21 particles/m^3). Point Nemo in the South Pacific is the point furthest from land on the Earth. One of the samples taken closest to Point Nemo contained a microplastic concentration of 26 (± 11) particles/m^3. One of the most remote samples collected by Team AkzoNobel in the South Pacific contained 41 (± 44) particles/m^3, but the relatively high uncertainty (related to a low filter volume) associated with this measurement should be considered. The results are a reminder that these extreme reaches of the world's ocean are remote but not isolated from anthropogenic impacts.

In other Turn the Tide on Plastic samples from the South Pacific, microplastic concentrations ranged between 45 (± 15) particles/m^3, in the sample closest to New Zealand, and 9 (± 10) particles/m^3 in the remote open ocean.

Remarkably, the highest level recorded by Team AkzoNobel was offshore in the South Pacific southeast of New Zealand. The level of 107 (± 36) particles/m^3 recorded there was higher than a more inshore sample that measured 89 (± 30) particles/m^3 closer to Auckland. Although it is possible that input from currents originating further north may increase the microplastic burden in this remote area it is also possible that the high measurement was an artifact of sampling.

Notably two of the highest microplastic concentrations recorded were in the North Pacific, 349 (± 49) particles/m^3 in a sample from the South China Sea and 243 (± 32) particles/m^3 in an adjacent sample from the north Philippine Sea, east of Taiwan. These are areas that contribute to the Kuroshio Current and North Pacific Gyre. This area is impacted by high population densities and associated pollution in rivers.

Two race legs transected the western Pacific - Leg 4 passed south to north from Melbourne, Australia to Hong Kong and Leg 6 went south from Hong Kong to Auckland, New Zealand. One of the features of the dataset from this region was the difference in average values recorded from comparable areas during the different race legs. For example, average levels between 101 (± 16) and 113 (± 19) particles/m^3 were measured in the region between latitude 15° North and the equator during the southbound leg, compared to levels between 11 (± 5) and 48 (± 10) particles/m^3 during the earlier passage north.

The differences in these measurements may be attributed to several factors: the prevailing local currents in the areas sampled will have a major influence on microplastic density; patchiness in the distribution of microplastic particles closer to the source will also affect recorded averages – with distance from the source there is likely to be more even distribution of particles on a local scale; wave and weather conditions may also influence measurements. Significantly for the latter of these, the metadata provided by meteorological and oceanographic measurements alongside microplastic data confer robustness to the dataset for future analysis and comparisons.

Preliminary microplastic data from the Atlantic

North European waters showed the second and third highest levels of microplastic pollution recorded along the race route in the inshore Atlantic close to Portugal (180 (± 16) particles/m^3 and 307 (± 27) particles/m^3) and in the Mediterranean (212 (± 31) particles/m^3 and 280 (± 24) particles/m^3). The accumulation of microplastic particles in enclosed seas such as the Mediterranean is a known pattern[7] due to the retention of water in such enclosed areas for long periods of time. These high concentrations were also adjacent to densely populated coastlines.

Interestingly, levels measured by Turn the Tide on Plastic during the transatlantic leg from Newport to Cardiff were relatively consistent in inshore and mid-Atlantic samples. In the open Atlantic consistent concentrations, on average 36 (SD = 3) particles/m^3, were measured in the mid-Atlantic, comparable with more inshore measurements of 35 (± 37) and 38 (± 41) particles/m^3 close to the United Kingdom, and 38 (± 41) particles/m^3 in the sample taken after departing Newport, U.S.A. These measurements in the mid-Atlantic might coincide with the North Atlantic Gyre or ‘Garbage Patch’.

Team AkzoNobel measured two ‘zero’ concentrations (± 20 and 25 particles/m^3) in the offshore Atlantic but otherwise their measurements were within a range similar to that measured by Turn the Tide on Plastic. One of the ‘zero’ results (± 15 particles/m^3) recorded by Turn the Tide on Plastic was from the North Atlantic west of Ireland. But as described earlier it is likely that the zero measurements were coincidental, influenced by factors such as weather, wave state and levels of plankton bloom for example. This illustrates the considerable value of the metadata provided by the oceanographic and meteorological datasets collated in coincidence with microplastic sampling.

In the South Atlantic levels indicating microplastic pollution were highest close to the Brazilian mainland (95 (± 18) particles/m^3). A level of 57 (± 19) particles/m^3 was found in the area sampled by Turn the Tide on Plastic off Cape Horn. The adjacent sample taken represented one of the Turn the Tide on Plastic ‘zero’ measurements (± 18 particles/m^3). This zero level was recorded east of Argentina in an area largely influenced by the Malvinas or Falklands current which originates further south.

Otherwise on the Atlantic transects south of the equator measurements varied between 7 (± 8) and 79 (± 23) particles/m^3 with a general pattern of higher concentrations closer to the coast.

Due to a technical issue with Team AkzoNobel’s sampling unit microplastic measurements were not possible during the Leg 8 south to north passage through the Atlantic (Itajaí to Newport).

Preliminary microplastic data from the South Indian Ocean and Tasman Sea

The race leg between Cape Town and Melbourne was particularly significant as it traversed remote waters of the South Indian Ocean and provided an especially unique opportunity for sampling.

Even in this remote stretch of water close to the Antarctic, microplastics were found in all but one sample. Microplastic concentrations were as high as 25 (± 10) particles/m^3. This is likely related to currents and gyres that deliver and concentrate relatively high densities of microplastic from areas further north. The most southerly area sampled along this leg was one of only three Turn the Tide on Plastic samples to contain no microplastic particles (± 8).

As Leg 3 progressed through the Great Australian Bight and closer to the Australian coast microplastic levels increased to 92 (± 31) particles/m^3. This reflected the proximity to mainland and associated anthropogenic impacts, although some of the microplastic density was likely due to materials transported by prevailing currents from the northern Indian Ocean or Indonesian archipelago.

East of Melbourne as the race advanced into the Tasman Sea microplastic levels decreased as expected in coincidence with increased distance from the coast.

Preliminary microplastic data from the North Sea

A relatively high level of 112 (± 47) particles/m^3 was recorded in the Skagerrak by Turn the Tide on Plastic. This measurement was previously reported as 224 particles/m^3 but after further analysis a lower value was confirmed. The Skagerrak is an area bordered by Norway, Sweden and Denmark where the Baltic Sea and North Sea mix, therefore, it is likely that high densities of microplastics entering the Baltic from surrounding countries and rivers concentrate as they pass through this Skagen channel as water flows to the equilibrate with the more open ocean. The relatively high density recorded may also be attributed to the coincidence with a busy shipping channel as high concentrations of microplastics can be associated with proximity to shipping routes [(1)].

Microplastic levels in the North Sea were otherwise between 63 (± 37) particles/m^3 and 8 (± 16) particles/m^3. The last sample captured by Turn the Tide on Plastic, taken at an average distance 341 km from The Hague, appeared to be relatively low, but the measure of certainty of the value should be considered. Furthermore, the sample was from a relatively open stretch of the North Sea. The low concentration, close to busy shipping areas and the densely populated European mainland may be due to patchiness of microplastic particles as pollution disperses from source.

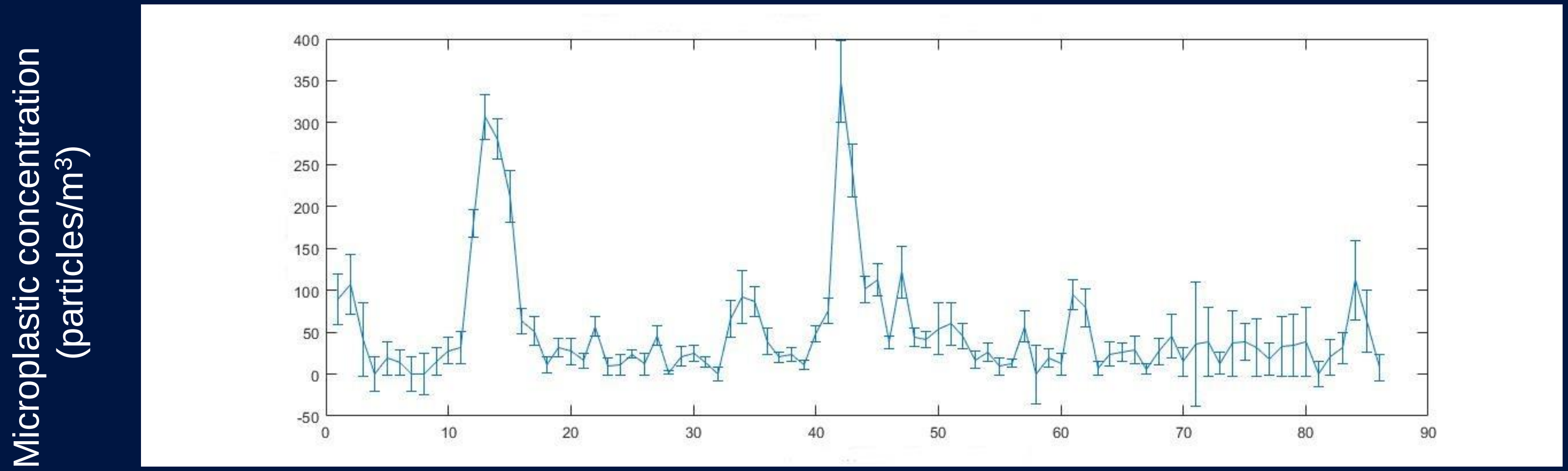
Calculating certainty

With all scientific measurements a level of certainty needs to be attributed to values or results. This provides ‘error bars’ for results and makes the data more reliable and valuable for scientific comparison.

For the methodology used there was a level of uncertainty associated with the analytical equipment. By performing extensive uncertainty analysis measurements the recovery rate for microplastic particles was determined to be 92%. This means that due to loss of particles in the apparatus during the analytical process 92 out of 100 particles were reliably detected. The results were corrected for this systemic bias in the technique.

Next to this, there was measurable uncertainty depending on the volume of water that was filtered for any given sample. Most of this uncertainty was due to counting error statistics – the analysis typically measured a few tens of particles, so that one more or less particle in a sample, due to chance, affected the final projected value for a cubic metre. Lower filtration volumes resulted in higher uncertainty, for example Turn the Tide on Plastic sample numbers 60-69 when filter change frequency was increased to daily and therefore filter volume per sample decreased. These lower volumes however had the advantage of a much higher spatial resolution due to the more frequent sampling.

The graphic following presents the calculated uncertainty per sample for both Turn the Tide on Plastic and Team AkzoNobel results. Turn the Tide on Plastic samples are represented as sample numbers 1-75 and Team AkzoNobel are samples numbered 76-86.



Sample number
Turn the Tide on Plastic 1-75 | AkzoNobel 76-86

A better understanding of ocean health

Photo: Martin Keruzore / Volvo Ocean Race

During the race

- **25,826 one minute averages** of oceanographic measurements were recorded
- Meteorological measurements were shared by **all boats every 10 seconds** for the duration of the race
- 30 drifter buoys were deployed that continue to transmit data **every hour**

Scientists and weather modellers can access and utilise the oceanographic and meteorological data for simulations and weather predictions, and more importantly the archived data will be available forever to the scientific community.

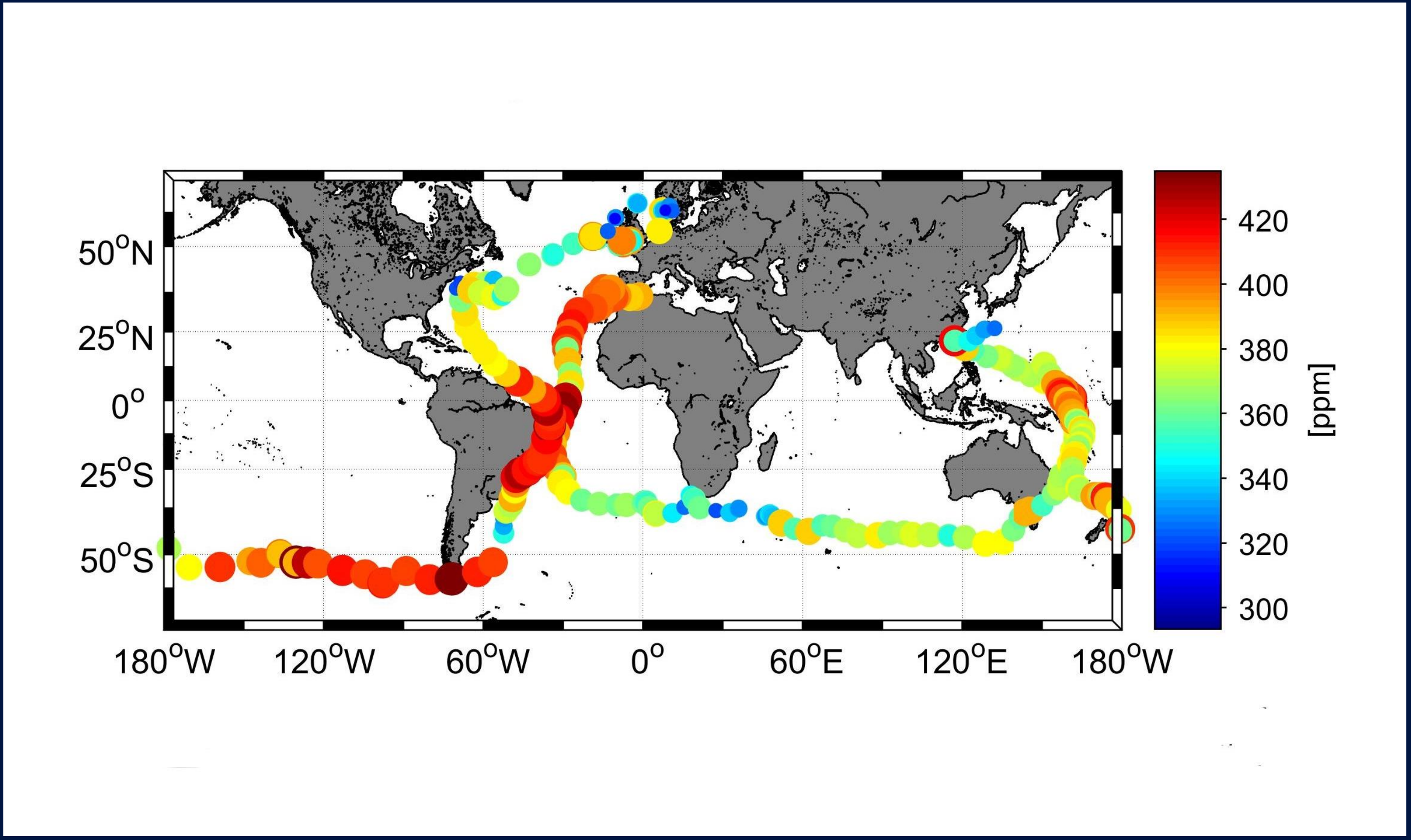
Most of the measurements in the open ocean are derived from satellites and these data may have inherent imperfections as they are not a direct measurement but a result of a correlation between radiance and meteorological variables. It's therefore important to examine the accuracy of remote sensing (i.e. satellites) when studying climate trends. The race data provide vital direct measurements to assess the accuracy of numerical reanalysis and correct the imperfections of satellite measurements.

The onboard sampling delivered in-situ measurements for salinity, temperature and chlorophyll-a, all variables that can currently be measured from space. There is currently no technology to measure dissolved carbon dioxide from space but satellite-derived data relating to temperature and salinity are used to extrapolate observed pCO_2 to get complete basin-scale coverage over time.

Refer to the table in 'Sharing Data' on page 48 for an overview of all destinations for the data.

.

Oceanography
pCO_2



pCO_2 (parts per million)
Map © Sören Gutekunst, GEOMAR Helmholtz Centre for Ocean Research Kiel

Dissolved CO_2 and the global carbon 'sink' budget

When the amount of dissolved carbon dioxide is less than the atmospheric level (approximately 400 ppm in 2017), the ocean has the capacity to uptake carbon dioxide. In this way the ocean acts as a 'sink' by absorbing one quarter of the excess CO_2 in our atmosphere, thereby mitigating climate change. Even in areas where ocean CO_2 is high, such as around the equator, high concentrations in the atmosphere reduce the outward flux and, compared to pre-industrial conditions, the ocean can still act as a sink.

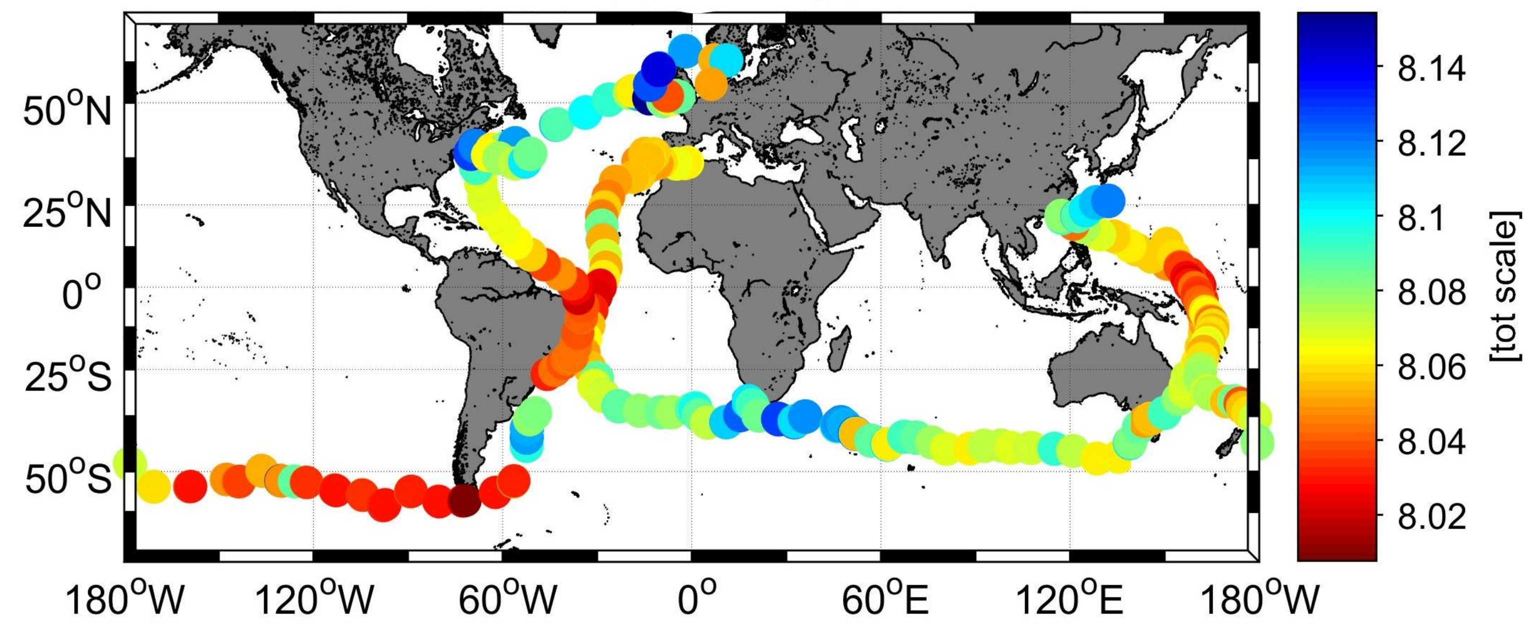
Lowest dissolved carbon dioxide levels were recorded in the south Indian Ocean, and in the North Atlantic and North Sea. The relatively low values recorded in those areas were related to the timing of samples - southern and northern hemisphere summers respectively. During summer at these higher latitudes high productivity of phytoplankton sequesters carbon dioxide from the seawater. This allows for a flux of carbon dioxide from the atmosphere to the ocean.

The measurements in the southeast Pacific, during Leg 7 - Auckland to Itajaí, showed relatively high dissolved CO_2 concentrations (420-430 ppm) in contrast to the relatively lower CO_2 concentrations in the Indian Ocean sector of the Southern Ocean. This was likely due to the more southerly passage of the boats through surface waters affected by 'upwellings' from deeper ocean. Water that reaches the surface due to upwelling typically has relatively high pCO_2 concentrations and these upwellings play an important role in the cycling of carbon (and nutrients) in the ocean.

The areas around the equator in the Atlantic (Legs 2 and 8) and Pacific (Legs 4 and 6) had pCO_2 concentrations higher than typical atmospheric levels due to the upwelling of subsurface water, high in CO_2, to the ocean surface. With such levels these areas of ocean release CO_2 to the atmosphere. The 'outgassing' of CO_2 due to such equatorial upwelling is a critical factor affecting the global carbon budget and therefore, the Volvo Ocean Race data will support the estimation of the global CO_2 'sink' budget.

These equatorial upwellings tend to be small during El Niño years and so this CO_2 data is also important for climate predictions via the 'Tropical Pacific Observing System' (TPOS). The TPOS is the single-most important ocean observation unit for predicting climate on an annual and interannual time-scale.

Oceanography
pH



pH (total scale)
Map © Sören Gutekunst, GEOMAR Helmholtz Centre for Ocean Research Kiel

pH and ocean acidification

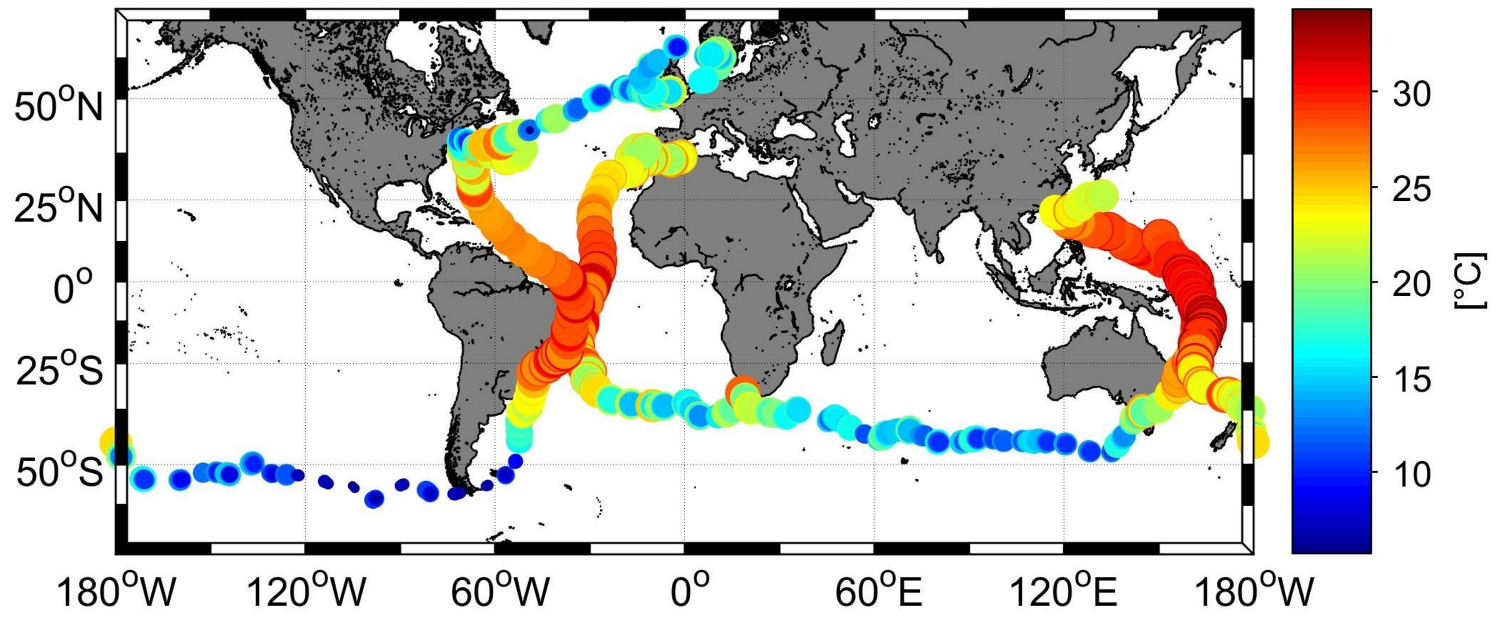
pH was not measured directly, but calculated from:

- known relations between salinity (measured) and alkalinity
- well-known thermodynamic equations for the inorganic carbon system (i.e. relationships between pH, alkalinity, total carbonate and pCO_2).

pH levels were closely related to CO_2 measurements. In correspondence with low dissolved carbon dioxide ocean pH was relatively basic i.e. high pH value. The most acidic pH values were calculated for areas where CO_2 levels were highest – the South Pacific and equatorial waters. This very clearly shows the relationship between dissolved carbon dioxide and potential ocean acidification.

The drop in pH from the overall assumed ocean average of 8.2 down to values of 8.0 or even lower indicates a potentially significant problem for the marine ecosystem. Marine organisms with calcium carbonate structures – for example crustaceans, shellfish, corals – rely on slightly basic conditions in our ocean. The combination of carbon dioxide (at increased levels) with water leads to the formation of carbonic acid, with potential negative effects on these organisms and ocean carbonate levels.

Oceanography Temperature



Temperature (degrees Celsius)
Map © Sören Gutekunst, GEOMAR Helmholtz Centre for Ocean Research Kiel

Temperature, Ocean Heat Content and global weather

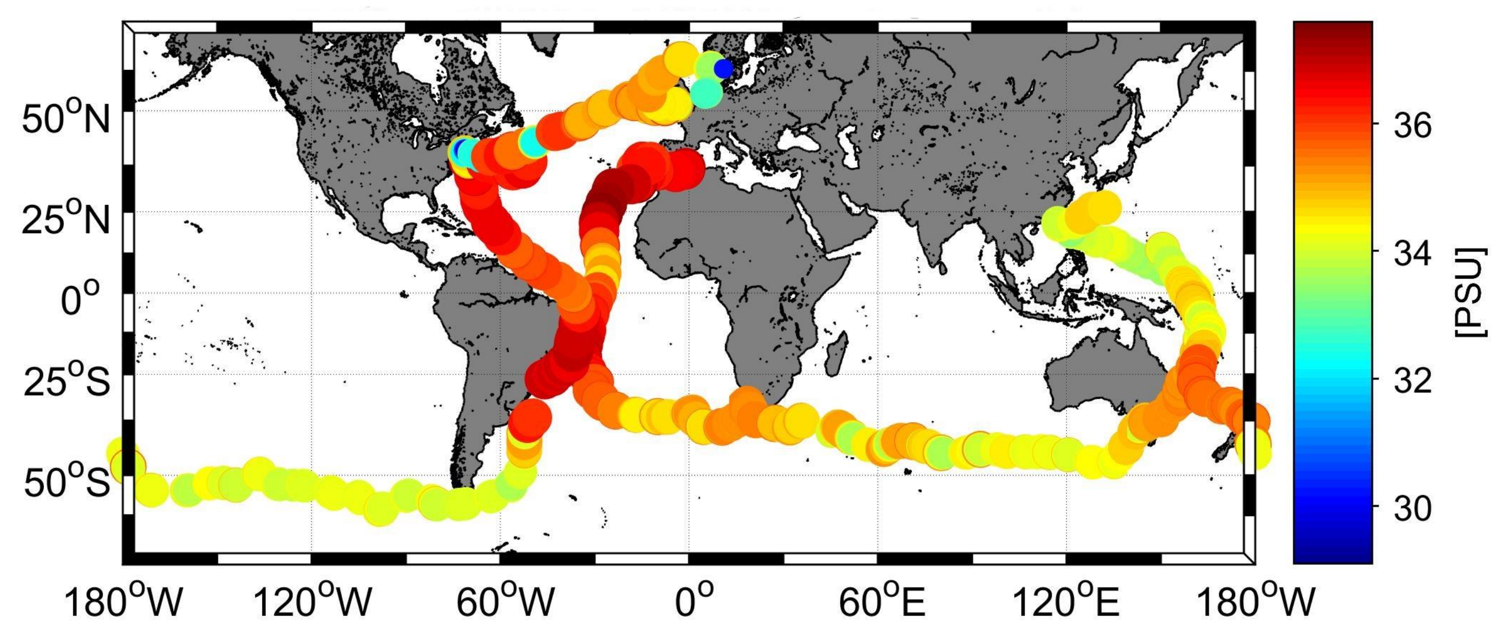
Temperature and salinity data support the carbon dioxide observations and contribute to the calculation of pH.

The lowest recorded temperature along the race route was six degrees Celsius corresponding to the lowest latitudes sampled in the South Pacific where Antarctic input affects temperatures, and salinity. The data clearly showed warm areas such as the 'West Pacific warm pool', the warmest part of the global ocean. The expansion and warming of this warm pool has resulted in the highest rate of sea-level rise in the world in recent years(8), with catastrophic implications for populations in the region.

The most northerly temperature observations recorded in the north Atlantic and North Sea during the last legs of the race coincided with the northern hemisphere summer. It's noteworthy that during the earlier legs of the race the temperature in the north Atlantic tended to be higher than in the south Atlantic at the same latitude, despite it being early summer in the southern hemisphere. This is due to the circulation of the ocean and the Southern Ocean being essentially a gigantic "weather machine" with almost unrestricted flow of currents and wind around the south of the planet - this movement distributing, amongst other things, heat.

Sea surface temperature data continue to be recorded by the surface drifter buoys deployed by all boats. The importance of each of the deployment locations was detailed above (see page 18). 30 drifter buoys were successfully deployed and 25 of these continue to transmit data, and will potentially do so for up to two years. Refer to Appendix A for a list of the buoys deployed by each race team and to 'Ocean Currents' on page 45 for further detail.

Oceanography
Salinity



Salinity (Practical Salinity Units)
Map © Sören Gutekunst, GEOMAR Helmholtz Centre for Ocean Research Kiel

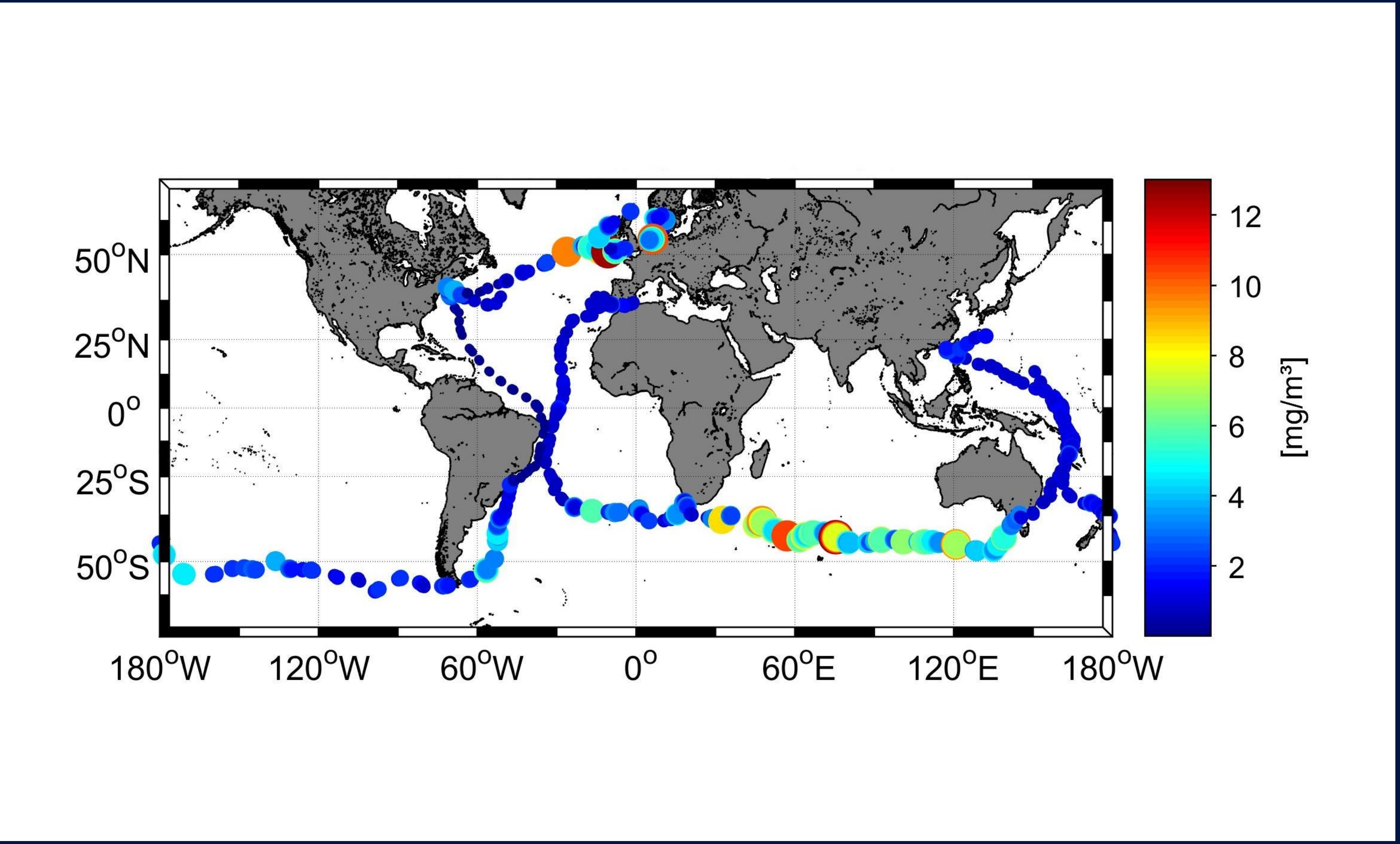
Salinity and ocean circulation

Overall the patterns relating to salinity were within expected ranges and can be related closely to sea surface temperature. Salinity affects the density of sea water and therefore drives ocean currents and the consequential circulation of carbon, other nutrients and heat.

Relatively lower salinity conditions were observed in the doldrum areas of the the tropical Pacific. In these areas heavy rains (squalls) typically dilute surface waters. Other low salinity values were recorded in the South Pacific in a region influenced by upwellings from deep Antarctic water with typically low salinity.

The lowest value (30 PSU) was observed in the North Sea where Baltic water mixes with the more open water of the North Sea. In the western North Atlantic there were also some locations likely affected by cold water currents from the north. Highest values were recorded in the warm saline waters of the sub-tropical Atlantic (maximum 37.51 PSU).

Oceanography
Chlorophyll a



Chlorophyll a (mg/m³)
Map © Sören Gutekunst, GEOMAR Helmholtz Centre for Ocean Research Kiel

Chlorophyll a and productivity

Chlorophyll a measurements, which provide a proxy for primary production measurement, and therefore phytoplankton biomass, are affected by the season and time of day when samples were measured, photosynthesis being restricted to daylight hours.

One of the features illustrated by the data was the characteristically low primary productivity of tropical waters where stratification of the water column traps nutrients at depth due to the lack of mixing.

The map of data illustrates nicely the global importance of the South Indian Ocean for its levels of phytoplankton activity and therefore potential to absorb excess atmospheric carbon dioxide. Similarly areas with high phytoplankton activity were observed in the North Atlantic during the northern hemisphere summer. Seasonal variations in water temperature at these latitudes result in mixing within the water column which makes nutrients available for primary production by phytoplankton.

Importantly, this primary productivity uses carbon dioxide, thereby lowering dissolved carbon dioxide levels, and providing a greater capacity for absorption of excess atmospheric CO_2. Excessive primary productivity however can be detrimental to the marine environment if it is caused by coastal eutrophication - when excessive amounts of nutrients enter the water due to terrestrial runoff and result in potentially harmful algal blooms.

Ocean currents

The drifter buoys, mentioned above in relation to temperature, track currents over time by relaying their position coordinates. This data is important for example in predicting climate cycles such as El Niño and La Niña, which are associated with changes in current patterns.

Knowledge about average sea surface currents is also essential to understanding microplastic pollution transport and can be combined with microplastic density data to examine where floating debris is dispersing and accumulating. A surface drifter buoy is particularly suited to act as a proxy for microplastic pollution as the drogue, or anchor, drifts below the sea surface at a depth similar to microplastic particles.

Since deployment four of the Volvo Ocean Race buoys have run aground and one was picked up. The map on the next page illustrates the tracks of the Volvo Ocean Race drifter buoys as they circulate with surface currents in the North Atlantic, equatorial Atlantic, South Pacific and equatorial Pacific.

Our drifter buoy tracks can be viewed online:

1. Search for the Volvo Ocean Race drifter buoys in the list on the NOAA website. Or refer to the table in Appendix A of this document.

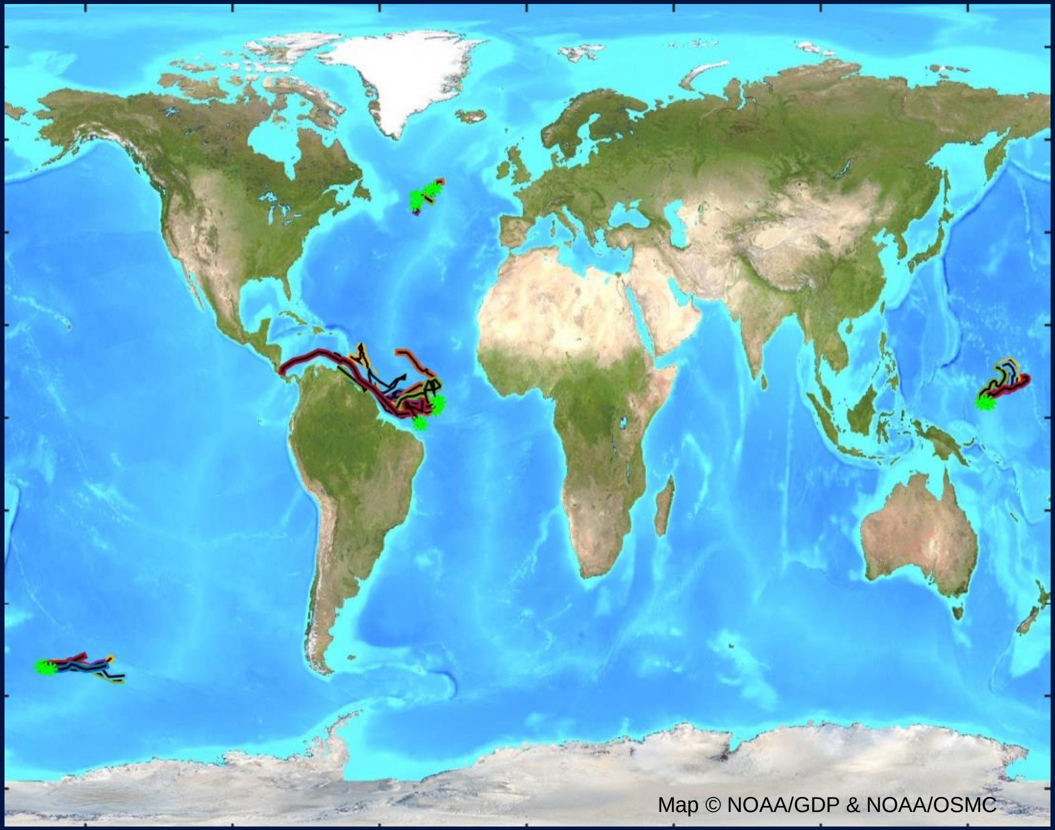
2. Insert the WMO# of any of the buoys on the map page.

3. Change the time range, and choose Display ‘All Positions’.

4. Refresh the map to see the track line from where each buoy has been transmitting.

Further detail of where the real-time, metadata and quality-controlled datasets can be accessed is included in ‘Sharing data’ on page 48.

Drifter Buoys



Map showing the tracks of all of the Volvo Ocean Race Drifter buoys

Meteorological measurements

By sharing high-frequency information worldwide, weather modellers can better describe small-scale phenomena and improve the accuracy not only of the forecast systems but also the forensic studies that improve our understanding of climate change.

Due to the open-access availability of data it is difficult to determine who is using them and for what.

Data on the GTS, where the race measurements were shared, are widely used by National Meteorological and Hydrographic Services in models for weather and ocean forecasting.

The archived data, at NOAA’s NCEI, will be used by researchers in a historical sense to evaluate ocean or atmospheric models or to evaluate observations made by satellites at they passed over the racing yachts. The dataset is also a valuable asset for the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). The high frequency data is very useful for studies where diurnal cycles are important. For example, to study climate scientists need to remove intra-day changes in order to get more low frequency insights.

Sharing data

Measured	Data
• Microplastic particle concentrations	➢ continue to be analysed for peer-reviewed publication ➢ will be shared to NOAA's National Centres for Environmental Information (NCEI) database ➢ will be incorporated into EMODnet microplastics data portal (currently in development)
• Partial pressure of carbon dioxide • Sea Surface Temperature • Sea Surface Salinity • Chlorophyll a • pH (by derivation) • Latitude | Longitude • Time	➢ has been shared to NOAA's National Centres for Environmental Information (NCEI) database where it will also provide metadata to support the microplastic dataset ➢ will fill significant gaps in the Surface Ocean CO_2 Atlas - SOCAT (2019 update) - and from there will be available to scientists for modelling purposes ➢ will be submitted to the Coriolis data centre and to the Surface Ocean data centre, GOSUD, to be made available for modelling
• True Wind Speed • True Wind Direction • Latitude | Longitude • Air temperature • Sea temperature • Barometric Pressure • Time	➢ was shared with NOAA who: incorporated the data into the Global Telecommunication System (GTS), which is the communications and data management component of the World Meteorological Organisation (WMO) and the Shipboard Automated Meteorological and Oceanographic System Initiative (SAMOS) archived the data in: NOAA's National Centre for Environmental Information ➢ was submitted to NOAA's NCEI database alongside the microplastics measurements to provide a more robust dataset
• Sea Surface Temperature • Latitude | Longitude • Time	➢ can be viewed raw near real-time at on the NOAA website, where metadata can also be accessed ➢ can be seen in map-view ➢ once quality-controlled is available via the World Meteorological Organisation's GTS (Global Telecommunication System)

A platform for science communication

We used our social media platforms and website to host content on the outputs of our Science Programme including stories, videos and infographics that brought the issues and our valuable data to life for audiences far beyond the world of sailing.

The fact that the race aligned a premier sporting event with a pressing environmental issue proved very effective, with the resulting coverage carrying a positive tone and being on message. Publications linked to the sport of sailing covered various elements of the Science Programme, many focussing on the data collection being carried out by Liz Wardley from the Turn the Tide on Plastic team.

The microplastic sampling was considered particularly newsworthy because, for the first time, an ocean race was also acting as a vehicle for the collection of valuable scientific data. This presented the opportunity to leverage the output into more mainstream media offering the opportunity to deliver our message on the impacts and solutions to a more mainstream and global audience.

The link between the race and the Science Programme was strengthened as the boats were helping gather this information and sailors became scientists, thus providing a strong interconnectivity.

The strategic communications combined press releases and web stories, accompanied by compelling imagery, with bespoke digital collateral for platforms including Facebook and Twitter. Anne-Cécile Turner acted as main spokesperson for the programme but other members of the team, sailors and the scientists analysing the data, also responded to media requests, including radio and television interviews.

An audience of millions was exposed to the story through international media outlets providing considerable cut through and adding further legitimacy to this science-based programme.

The Science Programme formed part of our wider sustainability communications which resulted in a total of 24,102 online articles, attracting 820,555,488 online views.

A CNN report on Team AkzoNobel's Nicolai Sehested's extra onboard duties collecting seawater samples added another dimension to the life of a sailor at sea. CNN's global reach and the positive tone of the story offered a deeper exploration of the subject whilst promoting the programmatic work by including interviews with Sehested and a race scientist.

The Guardian has a significant global reach through its website and the newspaper is distributed across the UK. Featuring the article on page 3 of the paper and website, the story about scientific efforts to chart microplastic contamination of the oceans, including a graphic of the data at the time brought our message, backed up by race scientist quotes, to millions of people.

Support The Guardian | Subscribe | Search jobs | Sign in | Search | International edition

News | Opinion | Sport | Culture | Lifestyle | More

The Guardian

Environment ▸ Climate change | Wildlife | Energy | Pollution

Oceans

Microplastics pollute most remote and uncharted areas of the ocean

First data ever gathered from extremely remote area of the South Indian Ocean has a surprisingly high volume of plastic particles, say scientists

Sandra Laville

Mon 12 Feb 2018 07.00 GMT

3,028 | 129

This article is over 8 months old

most viewed

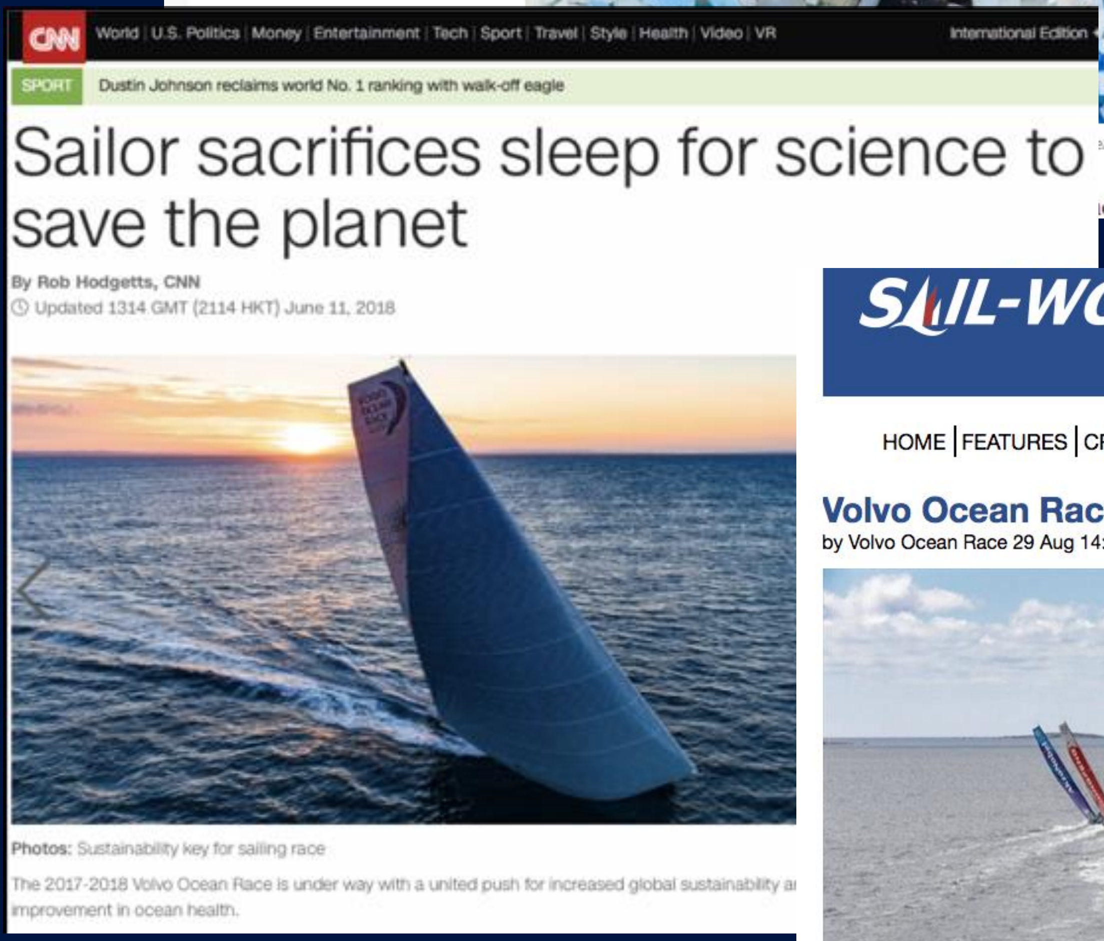
Live Midterm elections: Democrats '100%' confident of House win as civil rights leader points to 'scars of racism' in Georgia - live

New discovery throws light on mystery of pyramids' construction

Canada debates assisted death laws after woman is forced to end life early

Live May says she will not agree Brexit deal 'at any cost' as No 10 hints cabinet decision imminent - Politics live

Midterms 2018: when do the polls close and when will results be announced?



CNN | World | U.S. Politics | Money | Entertainment | Tech | Sport | Travel | Style | Health | Video | VR | International Edition

SPORT | Dustin Johnson reclaims world No. 1 ranking with walk-off eagle

Sailor sacrifices sleep for science to save the planet

By Rob Hodgetts, CNN

Updated 1314 GMT (2114 HKT) June 11, 2018

Photos: Sustainability key for sailing race

The 2017-2018 Volvo Ocean Race is under way with a united push for increased global sustainability a[nd] improvement in ocean health.

SAIL-WORLD

IT STARTED WITH A… The Story Of North Sai[ls]

HOME | FEATURES | CRUISING | CLUBS | CLASSES | PHOTOS | PARTNERS | JOBS | NEWSLETTE[R]

Volvo Ocean Race provides global microplastic map

by Volvo Ocean Race 29 Aug 14:11 UTC

Volvo Ocean Race Leg 11, from Gothenburg to The Hague, start day. 21 June 2018 © Ainhoa Sanchez / Volvo Ocean Race

Tweet | Like | Share 43 people like this. Be the first of your friends.

Only three of the 75 samples collected during the race, south of Australia, east of Argentina and west of Ireland, have been found to contain no microplastics.

The most recent data collected, before the race finale in The Hague, by scientific devices on board Team AkzoNobel and Turn the Tide on Plastic boats, found particularly high levels of microplastics, 224 particles per cubic metre, in Skagerrak, a 150-mile strait that runs between Norway, Sweden and Denmark where the outflow from the Baltic Sea meets the Atlantic Ocean.

The highest levels of microplastic, 349 particles per cubic metre, were found in a sample taken in the South China Sea that feeds into the Kuroshio Current and the North Pacific Gyre. The second highest, 307 particles per cubic metre, came close from the point where the Mediterranean Sea and Atlantic Ocean meet (Strait of Gibraltar).

Even close to Point Nemo, the furthest place from land on Earth, where the nearest humans are on the International Space Station, between nine and 26 particles of microplastic per cubic metre were recorded.

An aligned effort for a healthier ocean

Photo: James Blake / Volvo Ocean Race

An aligned effort for a healthier ocean

Analyses of the microplastic data is ongoing for peer-reviewed scientific publication. At the MICRO2018 conference in Lanzarote in November 2018 GEOMAR scientist Dr-Ing. Sören Gutekunst presented the research titled 'Distribution of microplastics in the mixed layer; results from the Volvo Ocean Race' to an international gathering of scientists and microplastic experts. Furthermore, a conference talk in Southampton at CommOCEAN 2018 is scheduled. The presentation titled 'Communicating microplastic around the world, the Volvo Ocean Race experience' will describe the research and results, and give an insight into the powerful impact of combining science with sailing.

To optimise the contribution to science of the race's pioneering ocean microplastic research a workshop was held in The Hague in June 2018. The workshop facilitated a cross-sector brainstorm focussed on the science of microplastic and nanoplastic pollution issues. The objective was to provide direction for a collaborative and aligned approach to advance ocean plastic pollution research and to increase data accessibility and its impact.

The workshop brought together scientists from universities and recognised laboratories; medical experts; instrumentation experts; private sector, NGO and UN representatives; Volvo Ocean Race race teams and Science Programme partners.

There was consensus that essential requisites going forward are:

- the establishment of an organisation to coordinate research and standardisation of data and data collection;
- identification of a host or creation of a federated database for data;
- increased engagement with policy makers and the public;
- development of a consortium to collaboratively research aspects of nanoplastic pollution including isolation, characterisation, impact and mitigation studies.

The datasets collated by the combined efforts of sailors and scientists have provided an impressive legacy from the 2017-2018 race. In addition to increased knowledge of microplastic distribution the contribution to understanding the ocean carbon dioxide sink is important and the pilot study demonstrated the feasibility of conducting high accuracy measurements with modern instruments from race yachts.

Aside from the data produced the Science Programme stirred cross-sector discussions relating to microplastic pollution at the seven Volvo Ocean Race Ocean Summits and beyond. The scientific legacy, and the associated potential to influence legislative change, of this ambitious collaboration between sailing and science are accompanied by an increased awareness beyond the scientific community of the vulnerability of the ocean to human impact.

With thanks...

This research was made possible by the contributions and commitment of many, with special mention for the following: all race teams and in particular Liz Wardley and Dee Caffari of Turn the Tide on Plastic and Nicolai Sehested of Team AkzoNobel for their exceptional dedication to onboard sampling; Fletcher Kennedy of Turn the Tide on Plastic shore team; NOAA's Shaun Dolk and Kevin O'Brien; Shawn Smith from the Center for Ocean-Atmospheric Prediction Studies; instrumentation developers SubCtech, in particular Stefan Raimund, and bbe Moldaenke.

Photo: Yann Riou / Volvo Ocean Race

References

(1) GESAMP (2015). “Sources, fate and effects of microplastics in the marine environment: a global assessment” (Kershaw, P. J., ed.). (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 90, 96 p.

(2) Raven J., Caldeira K., Elderfield H., Hoegh-Guldberg O., Liss P., Riebesell U., Shepherd J., Turley C., and Watson A. (2005): Ocean Acidification due to Increasing Atmospheric Carbon Dioxide. Policy Document 12/05. The Royal Society, London, 59 pp.

(3) Levitus, S., Boyer, T.P., Baranova, O.K., Garcia, H.E., Locarnini, R.A., Mishonov, A.V., Reagan, J.R., Seidov, D., Yarosh, E.S. and Zweng, M. M. (2012), World ocean heat content and thermosteric sea level change (0–2000 m), 1955–2010. Geophys. Res. Lett., 39, L10603, doi:10.1029/2012GL051106.

(4) Cheng, L, Trenberth, K.E., Fasullo, J., Boyer, T., Abraham, J. and Zhu, J. (2017). Improved estimates of ocean heat content from 1960 to 2015. Science Advances, Vol. 3, no. 3, e1601545.

(5) Patricola, C.M. and Wehner, M.F., (2018). Anthropogenic influences on major tropical cyclone events. Nature, Vol. 563: 339-346.

(6) Field C.B., Behrenfeld M.J., Randerson J.T., Falkowski P. (1998) Primary production of the biosphere: Integrating terrestrial and oceanic components. Science 281: 237–240.

(7) Collignon, A., Hecq, J.-H., Galgani, F., Voisin, P., Collard, F. & Goffart, A. (2012). Neustonic microplastic and zooplankton in the North Western Mediterranean Sea. Marine Pollution Bulletin, 64 (4). pp 861-864.

(8) Weller, E., Min S-K., Cai, W., Zwiers, F.W., Kim, Y-H. and Lee, D. (2016). Human-caused Indo-Pacific warm pool expansion. Science Advances 01 July 2016: E1501719.

Appendix A

Team	WMO Numbers
Dongfeng Race Team	5201639 1301541 5401559 1301543 5401561
MAPFRE	5401571 5201643 5401564 5201642 5401566
Team AkzoNobel	1301540 1301542 5401570 5401509
Team Brunel	5201641 1301539 5401563 5401572 5401557
Turn the Tide on Plastic	5201640 1301545 5401569 5401562
Sun Hung Kai Scallywag	1301546 1301544 5401558 5401508
Vestas 11th Hour Racing	5201638 5401568 5401567

Contacts

Central Coordination
Anne-Cécile Turner
Volvo Ocean Race Sustainability Programme Leader
annececile.turner@volvooceanrace.com

Volvo Ocean Race Scientific Consortium coordinator
Dr Toste Tanhua
GEOMAR Helmholtz Centre for Ocean Research
supported by Cluster of Excellence Future Ocean
ttanhua@geomar.de

On site coordinator, data analysis and reporting
Dr-Ing. Sören Gutekunst
GEOMAR Helmholtz Centre for Ocean Research
supported by Cluster of Excellence Future Ocean
sgutekunst@geomar.de

Communication & Media
Robin Clegg
Sustainability Communications
robin.clegg@volvooceanrace.com

Photo: Yann Riou / Volvo Ocean Race