Environmental assessment of deploying MarkSetBot technology

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Report prepared for MarkSetBot by Earth to Ocean Ltd.

Introduction

MarkSetBot is a robotic race mark that aims to provide environmental benefits by avoiding the need for mark laying anchors and mark laying boats. The concept was driven by the frustration of needing to change mark positions due to shifty winds as well as deep water anchors needing to be laid and mooring lines being left in the water. The result is a robotic race mark, that requires fewer volunteers or race officials, easy adjustment of the marks during set up and racing and fewer mark laying boats and a potential reduction in the environmental impact from mark laying.

From an environmental perspective, the concept targets reducing:

- emissions from mark laying,
- damage to the seabed and
- risk from pollution incidents.

This study looks to quantify these potential environmental benefits. In addition, the study quantifies the number of improved race and coaching days. The analysis of the financial return on investment has been assessed by MarkSetBot and is available on their website.

Earth to Ocean Ltd has carried out this assessment and developed an assessment calculator for MarkSetBot to assess different scenarios. We include 6 illustrative scenarios in this report. Earth to Ocean Ltd is a UK based sustainability consultancy with a core interest and expertise in the sailing industry and environmental impact assessment. This report has been carried out by Earth to Ocean Director Susie Tomson, who developed World Sailing's Sustainability Strategy and currently directs the SailGP sustainability programme and Alexandra Rickham, Paralympian medallist and World Champion sailor who has first-hand use of racing with MarkSetBots and also supports the SailGP sustainability programme. The report contains qualitative background research as well as quantifying the types of impacts avoided by grass roots sailing clubs at their weekly events to major international regattas where additional impacts are avoided from fewer race officials travelling to the event and fewer boats on the water.

The MarkSetBot

The MarkSetBot is an inflatable mark weighing 72.5 kgs, is just under a metre tall and just over a metre in diameter. When deflated, the MarkSetBot folds down to around a third of its inflated size. The MarkSetBot is driven by a small 12v electric trolling motor from Minn Kota and a battery which is available in two sizes. The smaller 50ah battery is able to hold course for 10-12 hours in up to 10 knots with a moderate chop and the larger 100ah battery can hold course for 20-14 hours under the same conditions. The MarkSetBot is able to move at around 4 knots, more in some conditions.

For racecourses further offshore, a high speed tow raft is available where the inflated Bots are then easily launched from the raft.

The life span of the MarkSetBot is anticipated to be 30 + years assuming regular maintenance and occasional upgrades. It is also estimated that annual maintenance is low and would cost around $100-200. To ensure the Bots do not go obsolete MarkSetBot provide software upgrades free of charge.

Environmental considerations

The following section explores the following environmental considerations:

- Elimination of mark laying boats
- Charging requirements and energy consumption
- Eliminating anchor damage
- Abandoned mooring tackle
- Biosecurity
- Carbon capture of marine ecosystems
- Storing and shipping

The impact from manufacturing the MarkSetBot has not been included in this study. This may be the topic of future work, and will help MarkSetBot improve across the manufacturing impact. For the purposes of this study it is assumed the production of the inflatable Bot, the motor and battery will be considerably lower than a small mark laying RIB and traditional race marks.

Eliminating mark laying boats

Whilst in some cases, mark laying boats do double up as safety boats, this would potentially impact the ability for racing to continue when a safety boat is actively undertaking its primary duty. Whilst this may be valid, we assume that mark laying boats will be removed from the water with the use of the MarkSetBots. This is based on guidance for mark laying and has been taken from UK's national sailing governing body which can be taken as best practice and has been used in the development of the scenarios (RYA, 2018). This guidance states that should equipment and personnel be available, a mark laying boat per mark is desirable. Between starting and finishing, the mark layer may also be used as a patrol/safety boat, although its main task is to stand by for alterations to the course in the event of a wind change. It should also be noted that to be an official National or International level mark layer there are required qualifications and registration, with the associated costs.

On site, the Bots can be autonomous, however, unless the racecourse is just offshore, they will need to be towed in channels as they do not "understand" traffic and will generally require towing out to the race area. This could be done by the race committee boat rather than mark laying boats so would not incur additional resource. For courses close to shore, the Bots can be set off from the shore.

The Bot's ability to move at 4 knots means the Race Officer can reposition them without the use of a RIB. MarkSetBot have analysed the time taken to reposition a Bot, e.g. to adjust its position for a 10°

wind shift on a 1nm windward leg will take a Bot 2.6 minutes. This rapid self-deployment is likely to be faster and more accurate than most manual mark laying.

The impact of eliminating the need for mark laying boats is as follows:

- Fuel consumed by these boats travelling to racecourse and during racing.
- For international events, fewer personnel flown to the event and accommodated in hotels
- Zero pollution risk from outboards on the water
- Improved efficiency for coaching and mark laying

We have calculated the fuel consumption and corresponding carbon emissions. We have also calculated total time on the water as a proxy of risk of pollution, as there is limited data or research into the actual pollution resulting from outboard engines.

From the social perspective, ensuring mark laying can continue regardless of whether safety boats are otherwise occupied, will improve the quality of racing. In addition, it may enable more effective coaching to be undertaken, with a single coach boat able to lay marks accurately thus significantly reducing non-productive coaching time.

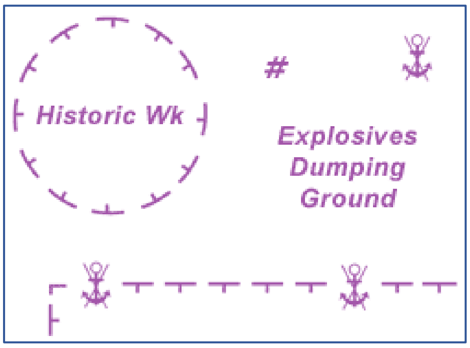
Charging requirements and energy consumption

Whilst the MarkSetBot may replace mark laying boats, they still require power. The engines are electric and battery life enables them to last a full 10-12 hours on the smaller battery (50 ah) in 10 knots of wind to 20-24 hours for the larger battery (100 ah) in up to 10 knots of wind and a moderate chop. Charging the batteries overnight or 10-14 hours for a full recharge requires 0.25 - 0.5 kWh. It should be noted that whilst the Bot is impacted by wind and tide, it is still able to operate in 25 knot winds working at full power; however, the batteries under these conditions would last significantly less time, around 4 hours.

As with all electric mobility, it is only truly “green” when the supply is from a renewable energy source. This may be difficult to find in the marine setting. The ideal charging will be from a mains renewable energy source. Where temporary power is provided through generators, the carbon content can be reduced using biofuels or recycled vegetable oils. These factors have been built into the assessment model.

Eliminating anchor damage

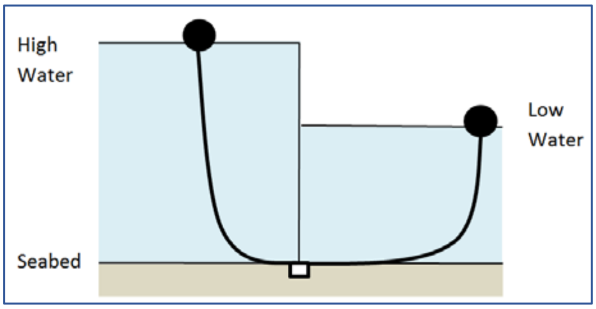
Nautical charts may indicate the nature of the seabed, but the information is largely provided to indicate hazards or areas where anchoring is prohibited due to cables, explosives or wrecks.



The nature of the seabed may be only of concern in terms of the holding it gives for anchoring. In relation to race marks, these are laid for the short term and may be dropped and redropped until the correct position is attained.

Whilst the seabed is out of sight, it is a thriving ecosystem. Regardless of the global location, this benthic zone supports microorganisms as well as larger invertebrates, such as crustaceans and marine worms, and depending on the location, areas of seagrass, soft and hard corals, sponges, bryozoans and other animals which are considered eco-engineering species, creating the seafloor ‘animal forest’. Damage is only short lived but is often continuous in an area. Some habitats are more able to recover from these disturbance events than others.

The race mark anchor is likely to be reasonably small but provide enough holding so it will not move if hit during racing or be swept by any tides or currents. During the laying process, it may be dropped and adjusted by dragging the mark through the water and across the seabed at the instruction of the race officer.



Once laid, the warp is generally not long enough to create scour as this would provide an inaccurate position for the racing and the time of the racing is not long enough to cover large areas of tidal range. Any sort of movement of the anchor or the warp could cause abrasion of the seafloor and damage to these benthic ecosystems. Research from the impact of anchors has identified soft sediment scars able to recover in 3 months (Backhurst and Cole, 2000), but damage to seagrass beds and corals can take decades to recover.

Seagrass beds

As ecosystem engineers and habitat formers, seagrasses provide important functions to marine ecosystems and contribute to human well-being (Spalding et al, 2003). Seagrass meadows provide a nursery habitat for certain fish species, they attenuate wave energy and thus contribute to coastal defence and erosion control, and they support water purification and nutrient cycling. They also sequester carbon through the growth of the grass as well as securing carbon in the soft sediments that they grow in.

Damage from anchors and moorings is well documented on seagrass areas and repeated dropping and dragging of anchors will create damage to the integrity of the grasses and potentially also release carbon from the sediments underneath. Figure 1 and 2 show seagrass areas from the UK in heavily anchored areas.

Damage from mooring and anchoring in seagrass beds (Seahorse Trust)

Healthy seagrass beds

Coral reefs

Coral reefs are vital ecosystems, like seagrass beds providing nursery grounds for fish species as well as habitats and sources of food for local communities. Reefs also provide a valuable coastal protection function. They are generally found in shallow water areas often near the shore. As a result, they are particularly vulnerable to human activities, such as anchoring and groundings. A study of a heavily used recreational area in the British Virgin Islands showed in heavily used areas corals were 40% smaller, 60% less dense and 60% less species compared to rarely anchored sites (Flynn and Forrester 2019).

Microscopic algae within the coral's tissues make use of the coral's metabolic waste for photosynthesis. The algae produce oxygen, remove wastes, and supply the organic products of photosynthesis that coral polyp needs to grow, thrive, build up the reef, actively removing carbon from the atmosphere and providing a nursery for marine life. This mutual exchange is the reason why coral reefs are the largest structures of biological origin on Earth, and rival old-growth forests in the longevity of their ecological communities.

These delicate structures can be instantly damaged by an anchor or its chain and depending on the size of the structure can take more than 10 years to recover. However, recovery is typically thwarted through continued human pressure and increased nutrients in the oceans resulting in algae quickly colonising areas, taking the space once occupied by healthy coral. Work carried out in the Caribbean showed recovering from a single anchor damage episode took more than 11 years to show any signs of recovery (Forrester et al, 2015)

Healthy coral reef

Soft sediments

Unless totally damaged from dredging or similar, soft sediments on the seabed are rarely "just mud" and contain an array of diversity from worms to shellfish providing food for both human consumption and seabirds. In addition, shells, skeletons and plant detritus create and continually add to the carbon stored in the seabed soft sediment, and when this is disturbed by anchors, carbon dioxide is released back to the atmosphere. Whilst each 'release' is small, with more scientific research required in this area, over a season of dropping and lifting race mark anchors, the release of carbon can become significant.

Whilst the damage from racing marks is likely to be minimal globally, increased human and climate pressures over a 25-year period, have caused an estimated US$12.5 billion in costs related to carbon release linked to disturbance of coastal and shelf sea sediment carbon stores (Luisetti et al, 2019). As recreational sailors we should be aiming for zero harm to our environment, not just minimal damage.

Abandoned mooring tackle

Whilst racing buoys will typically be anchored for only a few hours before being lifted, there are some locations where deep-water results in the line and block being left on the sea floor. Whilst not documented, it is common in deep-water venues, like those found in mountainous regions, to lay race marks using thin lines which are then pulled up by several meters and cut leaving several hundred meters of line and the block on the seabed accumulating race after race.

The impact of the lines will be akin to abandoned fishing line and abandoned fishing gear that could entangle or be ingested by marine life. Lines or chains attached to the blocks may continue to scour the seabed. In tidal conditions, abandoned blocks and lines whether left on purpose or by accident may drag over the seabed. Depending on the type of seabed these may damage fragile organisms, create scars or even entangle marine life (Macfadyen et al., 2009). Line is often made of plastic which can last up to 600 years in the marine environment and add to the issue of microplastics which have been documented for over 15 years (Thompson et al., 2004). According to the United Nations, more than 640,000 tonnes of nets, lines, pots and traps used in commercial fishing are dumped and discarded in the sea every year. Whilst not as significant as the impact from commercial fishing, arguably recreational pursuits should not have any detrimental impact on the environment and should avoid any disturbance.

The impact of the lines has also been seen to cause problems with water intake and sewer systems. According to a recent article in the Italian newspaper Bresciaoggi, "*regatta cords abandoned on the seabed is a problem that periodically comes to the surface on the occasion of outcrops, unwelcome finds or episodes such as the recent one in Gardone Riviera, with the sewerage system remaining dangerously tense for days precisely because of some of these, after being dragged to the bottom by a barge poured down*" (https://www.bresciaoggi.it/territori/garda/ecologiche-e-smart-ecco-le-boe-del-futuro-1.6694778).

Biosecurity

A further risk from mark buoys used across different venues is the biosecurity risk from transport of invasive alien species attached to the anchor and warp which is lifted and taken to alternative venues. Because the blocks and lines are left for short periods of time on the seabed, the risk is small. However, countries such as Australia have severe restrictions on the transfer of alien species and along with boats, blocks and lines should be carefully washed down between events (Anderson et al. 2015).

Carbon capture of marine ecosystems

The marine ecosystems of seagrass meadows, tidal marshes, and mangrove forests all capture and store carbon from the atmosphere and the carbon dioxide disolved in the oceans; this is often refered to as Blue Carbon. The system is complex and the methodology to quantify the amount of carbon both stored in the sediments and sequestered in the growth of marine ecosystems such as seagrasses, corals and mangroves is not yet agreed.

Thompson et al (2017) explain the reasons for the complexity of the carbon cycle in the ocean. One reason is that carbon is stored in the ocean for different durations: long term and short term. Short-term storage in living biomass is stored in a marine plant or organism for the duration of its lifetime. Long-term sequestration is stored for millennia in marine soil and sediment, including as gas hydrates. To further add to the complexity of the ocean carbon cycle, carbon 'fixed' in one marine location can be exported over great distances to another location and either recycled or deposited there.

Increased atmospheric carbon further impacts marine ecosystems by increasing the acidity of the oceans, dissolving the foundations of coral reefs and shellfish releasing carbon back into the atmosphere.

Storing and shipping

Whilst not included in this assessment, it should be noted that the design of the MarkSetBots is for compact shipping and storage. The Bots pack down into 158 cm x 66cm x 38cm when deflated, enabling 3 Bots to fit into most family cars. In terms of shipping and storage they are smaller than the combination of race marks, anchors and mark laying boats. However, if shipped internationally it is likely that mark laying boats may be sourced locally.

Methodology to assess the environmental benefits

This assessment has looked at quantifying the environmental benefits. Some of these can be reasonably well quantified, whilst for others we have used proxy indicators. The methodology used in our assessment can be seen below:

- **Carbon emissions**. One of the biggest environmental threats is from the increase in atmospheric carbon and associated change in climate, increased severity of weather conditions and the increased acidity of our oceans. Decarbonising our energy source is a critical action to mitigate against increasing carbon emissions. These result from fuel consumption directly used in mark laying boats, travel (flights and local ground travel) of people required to man the mark laying boats and accommodation for these people.
- **Damage to the seabed.** Whilst this is clearly a concern along with abandoned anchors and lines, we cannot generically model the impact on biodiversity as systems and recovery rates will be so variable. Instead we use the area of seabed impacted as an indicator of likely damage.
- **Risk of pollution incidents.** The risk of pollution will depend on the maintenance and age of mark laying boats as well as the capability of the drivers. This will vary too much to be able to be modelled generically, so we have taken the hours the boats fuelled by hydrocarbons are on the water as a measure of risk.

Assumptions

We have made several assumptions for the assessment model:

- Average fuel consumption for a mark laying boat is based on 1 gallon/ 4.5 litres of fuel per hour per 10 hp of engine power
- Average speed to racecourse is based on 15 knots
- Carbon coefficients for fuels, global accommodation, air travel and mains energy supply are taken from the UK Government's 2019 DEFRA GHG reporting carbon coefficients
- Recharging of a Bot is based on MSP data of 0.25 – 0.5 kWh and we have used 0.5 kWh
- Mark laying boats are not safety boats. However, as this is debatable, the model is set up to allow specification of number of boats replaced by the Bots to be defined.

We have not included the impact of shipping or manufacturing of the Bot's at this stage. This may be covered in further assessments which MarkSetBot will use to work towards minimising the impact of manufacturing and supplying Bots globally. However, a Bot will replace the need to manufacture a support boat, its engine and the inflatable mark and is likely to be significantly lower in terms of manufacturing impact.

Identifying the social considerations

Whilst not a core aspect of this evaluation, we have identified and highlight here the potential social considerations of the MarkSetBot. At the grass roots level, volunteers are a continual challenge to find and clubs often mandate members to provide several volunteer days to enable safe and effective racing. The position of the marks is critical to good and fair racing and eliminating the need for individuals, who are potentially inexperienced, will be beneficial to the quality of racing. This will also enable more individuals to take part in the actual racing.

At the coaching level, individuals who want coaching will be able to have a single coach and coach boat with essentially little down time as the coach sets the race marks from the coach boat. Training may well become more accessible and time on the water more effective.

We have used two indicators for the improved racing conditions:

- Total number of people benefitting from improved racing or coaching
- Number of days of improved sailing

Case Studies

The assessment model calculates the impact of using the MarkSetBots in place of traditional mark laying boats and anchored race marks across the following parameters on an annual basis:

- carbon savings
- seabed damage avoided
- hours of potential pollution risk avoided
- people benefitting from improved racing
- number of days of improved sailing

The input data and results from the modelled scenarios can be seen Table 1 and 2. The scenarios are discussed below:

1. Local sailing club

The local sailing club scenario is based on club racing 1 x weekday evening and 1 x weekend. This scenario is set in the UK but is applicable to many, if not most average sized sailing clubs with a strong membership base and racing community.

Many clubs use permanent marks and structures which in some instances have been permanently placed by the club itself. Such marks can require permissions, maintenance and replacing. For these clubs, racing can only be done to a limited standard with marks unable to be moved or additional marks are required to suit the wind direction. This can add additional cost, resource and potential for environmental degradation of marine habitats. For other clubs where permanent structures are not an option due to fragile ecosystems etc, the resource for mark laying and dependence on club volunteers is high.

The MarkSetBot gives clubs with limited resource the opportunity to get small races off. Though many clubs have an informal style to racing and mark laying boats operate as safety cover, it does mean that in the event of a safety requirement e.g., capsize, a race does not have to be delayed or cancelled due to marks being unable to be set. The Race Officer still can control all aspects of the course whilst a safety boat can deal with the safety issue. In addition, for more vulnerable fleets such as beginners, children and disabled competitors the MarkSetBot ensures safety boats can solely focus on safety support not multiple roles.

Over a year, the carbon saving for a club operating as described would save just over 2 tonnes of carbon. A potential impacted 600m^2 of seabed impacted and over 200 hours on the water of potential pollution avoided. In addition, significantly 3,120 person/days of improved racing as a result of accurate racecourses and less time waiting for courses to be set of races abandoned.

For these impacts at clubs, there is a multiplier effect. In the UK alone, there are over 2500 clubs, the US reports 1500 clubs all of which will be running similar club racing events.

2. National Championships

The National Championship scenario is based on the numbers seen at a single-handed national event such as a Laser/Laser radial national championship based in the United States. The scenario represents a single event for that fleet of which there would likely be 2 to 3 events, equivalent to 80 to 120 competitors total. It is thus assumed the impact could be at the very least doubled as one race committee is likely to deliver two events per day.

The National Championships and levels below are unlikely to have mark layers from outside of the local area. A National Championship which is linked to an international level event such as Olympic Classes regatta may have a non-local Race Officer with a preferred team to work with. Within the USA this could require interstate movement.

The total calculated carbon saving is around 3 tonnes per 4-day event, 60 m^2 of seabed protected and 12 hours of potential pollution risk avoided and a total 160 person days over the 4 days of improved sailing experience.

3. Olympic Class Regatta (OCR)

The OCR scenario is based loosely on the impact of an event such as the World Sailing World Cup event in Miami, Florida, USA.

At a higher-level event the expectation is that you may have a mark laying or race operating crew from within the USA but with interstate movement. A high accuracy of courses at such events is required which is a reason for potential race committee teams to need a high level of experience and the ability to work in established teams where a high level of confidence is demanded. MarkSetBot offers the potential to control the racecourse to a higher level of accuracy in a shorter space of time without the reliance on an experienced team.

At an event such as this, marine habitats including flora and fauna and depths will affect the way in which the classes operate. Additionally, venues like Biscayne Bay are relatively shallow and non-anchored marks may give the opportunity to have racecourses closer to shore thus reducing the distances to the racecourse.

The total calculated carbon saving is 5.9 tonnes of carbon per 6-day event, 66 m^2 of seabed protected and 11 hours of potential pollution avoided and a total 125 person days over the 5 days of improved sailing experience.

4. SailGP Inspire Racing

Inspire Racing delivered by SailGP offers a unique take on junior racing. The racing is short and dynamic to fit into the broadcast window of SailGP F50 racing. The course is short between 0.1-0.2nm but requires setting up in 2 minutes. SailGP's sustainability programme is committed to reducing their carbon impact and in partnership with MarkSetBot have been deploying 5 to 7 Bots during the Inspire racing. The compressed timescale would otherwise require 1 boat per mark including start and finish lines. The MarkSetBot offers the opportunity for the Race Officer to control the setup quickly and move marks for use in multiple positions without a mark laying boat entering the racecourse and potentially disrupting racing. Without the Bots, the racing would require 5 additional mark laying boats and an experienced mark laying crew typically flown in to lay the course in time.

As a result, the total calculated carbon saving is 35.3 tonnes of carbon per 3-day event, 50 m^2 of seabed protected and 3 hours of potential pollution avoided and a total 24 person days over the 3 days of improved sailing experience.

5. Olympics – per class during an Olympic year

The Olympic scenario is based on suppositions relating to the Rio 2016 Games. The Olympic scenario similarly to the OCR scenario considers a single class at the event. The increased number of mark laying boats to ensure the high accuracy race management required in addition to timing including for television slots. The increased likelihood of international level mark layers and established race committee teams working together has been considered. The likelihood that this scenario will apply to every course is unlikely as some courses will be facilitated by local teams.

The total calculated carbon saving per Olympic class is 24.7 tonnes of carbon per 6-day event, 55 m^2 of seabed protected and 11 hours of potential pollution avoided and a total 120 person days over the 6 days of improved sailing experience.

6. Coaching

MarkSetBot has the potential to positively impact training and coaching, whilst this is difficult to quantify, we have described the potential benefits here. The expectation is that training would occur possibly 1 evening per week, most weekends and large percentage of summer holidays. For regions with year-round good weather conditions this is likely to increase exponentially. Training would incorporate a similar scenario to the impact of local club racing but with increased time on water and distances being likely.

A significant consideration of the training time is coaching time. Coaching time is expensive and, in some instances, requires multiple resource. The benefits for coaches across all levels is incredibly high with less time being used on setting marks, better ability to give better racing scenarios with the ease to adapt to changing conditions including the ability to find marks more easily in inclement conditions. For areas which have full winter conditions the MarkSetBot potentially offers coaches the opportunity to maximise on time on the water in cold conditions by reducing setup time, thus sailors benefit from more coach contact hours than those spent moving marks for exercises and race practice.

Conclusions

Whilst the scenarios are illustrative of the potential environmental and social impact from different types of events, it is clear that MarkSetBot provides a non-invasive, low carbon solution to mark laying and should be considered as part of the environmental improvements to be taken on a racecourse.

The evidence presented demonstrates the key sustainability benefits that are:

- **Zero emissions from mark laying boats**
- **Zero damage to the seabed**
- **Improved quality of racing and coaching for participants**

User feedback to the MarkSetBot team illustrates these benefits:

Ken Read, President, North Sails: I recently did a Club-Swan 50 event and they used really cool self-propelled, no anchor GPS-controlled race marks – they were working in current and good breeze and waves and it made for simple racecourse adjustments and far fewer people needed to run the races. If you are a starting-line perfectionist PRO this gives you free reign to move the mark up to about five minutes before the start and still allow people to ping the pin.

Fewer people. Fewer anchor lines. Fewer boats needed. Less fuel. I couldn't believe how something like this wouldn't be cost-effective for all yacht clubs around the globe.

Geoff from Royal Akarana Yacht Club: We had our single safety boat/mark layer absorbed assisting a sailor for 30 minutes but were able to run four races without any requirement for that boat to assist with marks. Truly a game changer

Table 1: User input data for different scenarios[1]

Scenarios - user input data for each scenario		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Name of event		**Local sailing club**	**National Championship**	**Olympic Classes Regatta - per class**	**SailGP Inspire Racing**	**Olympics - per class in an Olympic year**
Country		UK	United States	United States	Australia	Brazil
Distance to racecourse	km	0.2	1.9	3	1	4
Number of races per event	#	2	3	2	8	2
Frequency of event	weekly/ monthly/ annually	week	year	year	year	year
Days/ event frequency (e.g., 1 day/ weekly / 5 day / yr)	#	2	4	6	3	6
Size of mark laying boat	hp	10	60	70	50	70
Average marks laid per race	#	3	6	6	5	5
Number of Bots	#	3	4	4	5	4
Number of mark laying boats replaced	#	1	4	4	5	4
Time for each race	mins	60	70	60	20	60
Type of energy available for recharging	Mains (renewable/unknown)/ generator(biodiesel/ diesel)	Mains - unknown/ avg mix	Mains - unknown/ avg mix	Mains - unknown/ avg mix	Biodiesel generator	Mains - unknown/ avg mix
Number of people participating per race	#	30	40	25	24	20
Travel avoided for race committee duties - people	#	0	0	3	5	5
Average distance travelled to event by air	km	200	0	2000	17000	10000
Type of flights	short/ long haul/ international	None	None	Short haul	Long haul	Long haul
Hotel nights (total number of nights saved over the race period)	nights	0	0	18	25	100

[1] Methodology, assumptions and data sources can be found in the section: Methodology to assess the environmental benefits of this report

Environmental assessment of deploying MarkSetBot technology

Environmental impact		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 6
Name of event		**Local sailing club**	**National Championship**	**Olympic Classes Regatta - per class**	**SailGP Inspire Racing**	**Olympics - per class in an Olympic year**
Hotel impact per night	kg CO2/night	17.4	21.4	21.4	44.9	14.9
Carbon saving from hotel accommodation	***kgCO2***	***0.00***	***0.00***	***385.20***	***1122.50***	***1490.00***
Carbon impact from flight/ pax.km	kgCO2/pax.km	0	0	0.158	0.196	0.196
Carbon saving from flights	***kgCO2***	***0.00***	***0.00***	***1899.84***	***33255.40***	***19562.00***
Number of charging nights for Bots	charges	104	4	6	3	6
Carbon from Kwh charging	***kgCO2***	***9.20***	***2.04***	***2.56***	***0.03***	***3.07***
Total number of races/ year	#	208	10	11	24	11
Fuel consumption saved on racecourse	l	936	1260	1386	900	1386
Fuel consumption saved on travel to racecourse	l	7	60	165	25	220
Carbon saving from fuel	***kgCO2***	***2182.54***	***3054.93***	***3590.08***	***2140.24***	***3717.27***
TOTAL carbon saving per annum	***kgCO2***	***2,143***	***3,053***	***5,872***	***36,518***	***24,766***
Seabed damage avoided per annum	***m2***	***624***	***60***	***66***	***120***	***55***
Hours of potential pollution risk avoided per annum	***hrs***	***209***	***12***	***11***	***8***	***11***

Social impact - improved racing/ improved coaching						
People benefitting from improved racing/ coaching	***person days***	***3,120***	***160***	***150***	***724***	***120***
Number of days of improved sailing	***days***	***104***	***4***	***6***	***3***	***6***

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