

PLOS Science Wednesday: Hi Reddit, we're Dr. Bob Brewin, Dr. Lee de Mora, and Dr. Thomas Jackson, here to discuss our PLOS ONE paper investigating the potential of using recreational surfers as a means

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## ABSTRACT

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Since surfers are going to be very selective in their choice of beaches/sites/habitats, what biases will their data be subject to. What won't they be measuring and how do you overcome this bias?

[Jobediah](#)

Bob: Good question! You are right in stating that surfers will have a preference towards certain beaches and sites. There will also be temporal biases in data collection, with surfers more likely to sample during periods of the year when conditions are more favourable for surfing. As we showed in our paper (see [Figure 6](#) of the paper doi:10.1371/journal.pone.0127706.g006), the spatial and temporal distribution of surfing varies in the UK. In all regions around the UK, the frequency of surfing is biased toward autumnal months (when surfing conditions are good and water temperature is warm). Hence, any data collection by surfers is likely to be more frequent in autumn in the UK. The South-West of England (Devon and Cornwall) has the largest number of surfers, and therefore, one would expect many more measurements to be collected in this region, in comparison to other regions in the UK. Within Devon and Cornwall, there are also beaches more commonly surfed, and one would expect more data could be collected at these beaches than other beaches in Devon and Cornwall. These biases transcend to other regions (e.g. US or any countries where surfing is popular). There are also many coastlines where surfing is not popular, or there are rarely any waves for surfing, and it is in these regions where surfers will not be measuring. Of course, one would have to consider these biases when analysing data.

So how to overcome these biases? Well, there are many other recreational activities that occur at the coastline, some of which take place when the the surf is flat (no waves). We believe our approach could be expanded to other popular marine recreational activities, which is likely to improve sampling coverage and help overcome some of the biases in data collection by surfers alone. Also, by integrating and combining observations collected by surfers with other datasets (e.g. satellite remote-sensing and/or ocean modelling) one can begin to account for some of the biases or at least better understand their impact on data analysis.

One thing to note, whereas we acknowledge there are likely to be spatial and temporal biases in data

collected by surfers, demand for measurements on environmental data (such as temperature) is not met by datasets currently available, and inadequate sampling coverage in the coastal zone is regarded as a major challenge. Furthermore, surfers visit some uninhabited and remote regions in search for great waves, and countries with little or no coastal monitoring and coastal management that may benefit significantly from data collection. Therefore, any data collected by surfers are likely to improve already large biases apparent currently in data collection.

Thanks for the AMA. Are you interested in information from the states? How difficult is the data gathering/sharing for the participant?

#### [Pleurotus Bibendum](#)

Tom: So far we have been collecting data around the UK, but in an ideal world surfers from across the globe would be able to contribute to a single dataset. If you would be willing to participate in future studies then please fill in the form at

[https://docs.google.com/forms/d/1w2b3PNOr5xHAmt1UYfyDTt\\_bV8zwDlxs-WZY9WvN3gU/viewform?usp=send\\_form](https://docs.google.com/forms/d/1w2b3PNOr5xHAmt1UYfyDTt_bV8zwDlxs-WZY9WvN3gU/viewform?usp=send_form) and we will involve more people as the project grows.

Currently the data collection takes bit of processing at the participant end, but we are working to minimise this and increase the ease of data collection so that everyone can focus on the surfing. In the future, we hope to leverage emerging citizen-based technologies (mobile phone applications), Bluetooth Smart miniaturised temperature sensors (e.g. Blue Maestro Tempo Disk), to help in this direction.

Lee: In addition to Tom's comment, we should add that we're in the process of looking for funding to support a larger scale project but we don't yet have a specific timeline for regional expansion.

So basically, you guys found a way to get paid while you Surf?

#### [I Punch Blind Kids](#)

Lee: I wish! We did all the data collection in our own time!

Tom: We volunteered our time in the same way we hope others will :).

Bob: That's the dream! But seriously, we believe it's been important work with lot of potential!

Is it possible for others who frolic in the ocean and at the coast line to help with the research? Or is this limited to surf breaks?

I only say this as there is a huge amount of people getting in to open water swimming and snorkelling/freediving in the UK who will be attracted to the coast line where there are no waves and they could be involved to help where the surfers aren't going to be. There are also large areas where surf just doesn't happen along the UK as there are a lot of sheltered but shallow coast line. I ask this as myself and my partner freedive/snorkel all around the UK and specifically look for calmer waters. If it is, there are quite a few groups who may be interested in helping out. British Freediving, Open Water Swimming Society, etc.

Final question, what information are you looking for? Temperature? Is it possible to get the information you are after with a dive watch or similar?

#### [effortDee](#)

Bob: Yes it is! In fact it would be feasible for anyone who "frolics" in the ocean to help with the research. As we mention in the paper, we believe our approach could be expanded to other popular marine recreational activities. For instance, at the UK coastline it has been estimated that there are approximately: 337,000 kayakers; 362,000 small boat sailors; 190,000 scuba divers; 2.8 million outdoor swimmers; 96,000 water-ski and wake-boarders; 98,000 windsurfers; and 62,000 kite-surfers. As you quite rightly mention, by expanding the approach to other popular marine recreational activities (e.g. snorkelling/freediving), one may improve sampling coverage and help overcome some of the biases in data collection by surfers alone (for instance in conditions or locations where there is no surf). Thank you so much for your suggestion to contact the British Freediving and Open Water Swimming Society, this is a good idea!

Regarding your final question, we are looking to improve the collection of data on environmental indicators in general at the coastline. What we mean by an environmental indicators is a simple variable that can be used to track the state of an environment. This could be physical (e.g. pressure, currents, temperature, salinity, turbidity), biological (e.g. phytoplankton abundance and composition) or chemical (e.g. nutrient concentrations, pH, toxic contaminants). In our paper, we focused on temperature for two reasons: 1) temperature is a very important environmental indicator, influencing the physical environment (e.g. changes in water density impacting currents), biological environment (controls growth of all marine organisms, from bacteria to fish) and chemical environment (impact dissolved oxygen and the reaction rates of some chemicals); and 2) it is a property that can be measured relatively easily and cheaply. Considering the recreational water-user as a data platform, any mounted environmental sensors measuring an environmental indicator would need to be unobtrusive, so as not to interfere with recreational activity. I completely agree that there is great potential in extracting temperature data from a dive watch, especially considering the diver can potentially capture vertical changes in temperature, which is not possible using surfers.

Collecting sea surface data at the beaches?

Wouldn't that be the equivalent of collecting temp. data in city centers?

[CancerousBacon](#)

Lee: In some ways it is similar. Temperature in the near shore environment will behave very differently to temperature far out at sea. For one thing, coastal waters are more susceptible to tidal effects, like when the sand is heated by the sun at low tide. Coastal waters are also more influenced by runoff water, like rivers and streams.

The analogy doesn't hold too much further though, due to the difference in the thermal capacities of water vs air. There may be some anthropogenic thermal effect in beaches very near cities, but we do not expect the thermal heating caused by human activities to have influence of the sea temperature on the scales that we can measure relative to the other confounding effects (wave mixing, thermal heating on shore, etc.) These effects may become visible if we had access to large scale long term datasets to study climate change, but at the moment, we have approximately 20 months of weekly sea surface temperatures measurements from two beaches near Plymouth, and some other data collected opportunistically at other beaches.

It is very important to record both temperature nearshore and offshore, but at the moment, there isn't a very good record of nearshore sea surface temperature, because it is so difficult to record data there. Traditional ocean monitoring methods are challenging in the coastal zone due to expense and practicality. It's not feasible or safe to send marine research vessel into shallow water with pounding surf. Similarly a buoy would be vulnerable to wave damage, algal growth or even vandalism.

We hope that the citizen science approach presented in this study will allow an expansion of the nearshore temperature record (as well as leaving the door open for other important environmental

indicators.)

I've seen studies on the use of smart phones being tested for things like earthquake monitoring and meteorological measurements, and with smartphone tech now being ubiquitous, it seems like an obvious tool for crowd sourcing data.

With the devices required for measuring coastal SST from surfers, how do ye plan on getting them out there? Will ye provide the devices, or do ye hope some surfers will take it upon themselves to buy them and upload their data? How many participants would be required to make it a useful source of coastal SST data.

Thanks.

[IceBean](#)

Tom: Thus far we have been using scientific-grade sensors (0.2°C accuracy, a resolution of 0.02°C, and stability of 0.1°C per year) and provided them to a small number of surfers. Now that we have shown that the data is of use for scientific applications (such as satellite temperature validation), we are looking for more user-friendly way to collect data. A smartphone (with associated app) would allow simple data uploads and return of surfing statistics but most users might be a little apprehensive to dunk theirs in the sea. Ideally there would be a device that is simple to use and might connect to a smartphone for data transfer.

Recently, a UK based company, BlueMaestro, have developed the Tempo Disk TM range of sensors, including a waterproof temperature sensor that utilises Bluetooth Smart technology. We have been in discussion with them. There is also a group in the USA called Smartfin who are currently trialling a device designed to take coastal-zone measurements.

For this type of sampling to work on a large scale it could take two routes: 1) the surfers would have to buy the device and upload the data, or 2) a research project funds the provision of sensors to surfers. Either way, we don't intend this to be a one-way information transfer. The GPS data can be used to provide surf performance information (as done in the paper) that would be returned to the surfers.

As to the number of participants required to make this a useful source of SST data, it depends on the quality of the data and the application that you wish to use it for. One of the principles of 'big data' is that if you have a lot of lower quality data it can still provide an insight that might not be achieved with a single great data point. In the paper we estimated that getting 1% of the UK surfing community involved would provide 400,000 data points per year, more than enough to be useful! Even a 0.1% engagement by surfers would provide us with a great source of coastal SST data.

hey whats a good oceanography book at university level? author etc? specifically about gyre?

[BBQnaoplox111](#)

Lee: I used "Introduction to physical oceanography" by Robert H. Stewart when I started learning about marine science. Its a great book and it's available legally for free [online here](#).

Do you have any plans to your data to test the quality of numerical models? What do you think your data will teach modelers about the dynamics of the coastal zone?

It's an extremely energetic region and it's difficult to capture that in sub-grid scale parameterizations of the relevant processes.

[phireal](#)

Lee: At Plymouth Marine Laboratory, we work closely with marine numerical modellers. In fact, the bulk of my work is modelling the global marine ecosystem (NEMO-ERSEM in the ORCA1 domain, if that means anything to you).

One of our groups projects is a high resolution finite volume model (FVCOM) of the Plymouth Sound. This model domain covers the two beaches where the data has been collected. We intend to continue to collect data from these spots, and we hope to use that data to validate this model in the near shore environment.

One of the interesting things we've noticed with our data is how much the sea temperature is influenced by land runoff (streams), even very small ones. We can sometimes detect a difference in temperature up to a degree Celsius between each side of a small beach, due to streams (as long as the surf is small). This underlies the importance that surface runoff can play on the small scale, which is not currently included in many models.

Unfortunately, even the highest resolution models like FVCOM do not usually include breaking surface waves, which may hinder these efforts. Do you know of any numerical models that could this kind of data in a validation exercise? We're keen to collaborate!

Question from @Bio\_prof via Twitter:

Are you aware of any similar initiative on the California coast?

[PLOSReddit](#)

Lee: We have been in contact with Steph from smartfin, if that is who you mean. Smartfin are building a surfboard fin which will record a range of environmental variables, including temperature and pH. It's a very exciting project and we're keen to watch it develop. (We'd love to try one out some day too!)

Also, there are other sensors that focus on the sports performance side, such as the RipCurl surf GPS watch or the Trace sensor. Both of which are very cool!

Our expertise as marine scientists is not to develop new hardware, but rather to focus on using existing sensors to collect environmental data and use it in a scientific context. We aim to use the data to inform about the quality of numerical models and satellite algorithms, and also to help with marine planning and protection.

Thanks for taking time to answer questions.

I fully support the secondary benefit of directly involving ocean-loving people in making measurements. You have certainly identified an under-utilized resource !

That said, millions of sensors definitely adds up to real investment, which makes me question the broad application of this technology beyond this demonstration project.

It seems to me the limited regional and dynamic environments that would be serviced by the surfing community could be expanded if, for example, the recreational sailing community were engaged. I mean there are only so many decent shore breaks, and most of the time even those will be too quiet for surfers.

Are you giving consideration to other platforms for these systems?

[Wrathchilde](#)

Bob: Great to hear you are in support of our project, and involving ocean-loving people in taking measurements. The investment in sensors, required to support a large scale citizen science project, would be dependent upon the cost of the sensor, which in turn would be dependent upon the variable being measured. With respect to temperature, thermistor-based devices are relatively cheap, and are likely to become cheaper and more widespread in the future. There are many companies developing cheap and relatively accurate temperature sensors that could be of use in project like this, including the HOBO Tidbit V2 temperature logger we used in the paper, but also the ibutton, and the labjack. We have recently been in contact with a UK based company (BlueMaestro) who have been developing a Tempo Disk TM range of sensors, including a waterproof temperature sensor with reasonable accuracy (~0.3 °C) and is fairly cheap (retails at ~£19.99). There is also the potential of utilising smartphone technology to minimise costs. Relative to the cost of surfing equipment in general (and other scientific sensors), these temperature sensor are not expensive. To fund a larger-scale project, however, requires investment which can only be achieved by demonstrating the use of the data. Considering the importance of temperature in the marine environment (controlling the physical, biological and chemical environment), and that there is a limited data collection at the coastline, we hope we can attract the funding to conduct a larger citizen-science project.

We agree there are many other recreational activities that occur at the coastline, some of which take place when there are no waves. We are giving consideration to other recreational platforms (such as small boats) and believe our approach could be expanded to other popular marine recreational activities. This may improve sampling coverage further and help overcome some of the biases in data collection by surfers alone.

Lee: Another reason why we focused on surfers instead of sail boats is that there are already large databases of high quality offshore physical data due to the ARGO float program and the NOAA drifters database. At any given time, there are thousands of drifters and profiling floats that produce high quality data out at sea. These data are freely available but do not include any near shore environmental indicators.

Tom: In addition to the existing float programs etc there is also satellite data available for SST but the quality of satellite estimates diminishes as you approach the near-shore. The use of recreational sailors would depend on how close to the shore they spend most of their time. As mentioned in response to other questions, we are open to collecting data from any water user, provided they are in frequenting the near-shore environment.

Do you need anyone in San Diego, CA? My crew and I surf a ton of different spots regularly, and I'd love to help!

[Seneca Talks](#)

Tom: Great to hear of more interested surfers! As mentioned in the response to Pleurotus\_Bibendum, if you would be willing to participate in future studies then please fill in the form at [https://docs.google.com/forms/d/1w2b3PNOr5xHAmt1UYfyDTt\\_bV8zwDlxs-WZY9WvN3gU/viewform?usp=send\\_form](https://docs.google.com/forms/d/1w2b3PNOr5xHAmt1UYfyDTt_bV8zwDlxs-WZY9WvN3gU/viewform?usp=send_form) and we will involve more people as the project grows.

On the east coast of the US, there is a man-made channel that travels along the coast, called the inter-coastal waterway (ICW). It's a protected waterway for boat travel: [https://en.wikipedia.org/wiki/Intracoastal\\_Waterway](https://en.wikipedia.org/wiki/Intracoastal_Waterway)

Would data from this waterway be beneficial to you? In addition to this waterway, there are inlets every 10-30 miles that have directional buoys. Would it be possible to attach sensors to buoys in the

waterway and inlets to collect long term data?

If not on the buoys, there are lots of piers and boat docks that you could potentially use as anchors for year-round sensors.

Count me in as someone who would like to help. I have access to a dock along the ICW and could volunteer time to collect data. I also have desire to work on a data collection system for this application.

Others have pointed out the inherent problems with surfers for data collection, have you also considered near shore fishermen? In my area, people fish year-round, and water temperature doesn't seem to keep them at home.

[Jmauld](#)

Bob: Thanks for the questions Jmauld. I am aware of the inter-coastal waterway (ICW) on the east coast of the US, and yes, I believe it would be straight-forward to attach a temperature sensor like the one we used in the paper to buoys in the waterway and inlets, in order to collect long term data. Whereas we have focused mainly on beaches in our study and not concentrated on inland waters (though as I understand the ICW does connect to bays in some regions), the approach (using recreational water users to help collect data) can easily be expanded to other inland waters, which are also very important to monitor. Great to hear you are interested to help (Tom has set-up a form for people willing to participate in future studies, see [https://docs.google.com/forms/d/1w2b3PNOr5xHAmt1UYfyDTt\\_bV8zwDlxs-WZY9WvN3gU/viewform?usp=send\\_form](https://docs.google.com/forms/d/1w2b3PNOr5xHAmt1UYfyDTt_bV8zwDlxs-WZY9WvN3gU/viewform?usp=send_form))!

I agree nearshore fishermen could be very useful for data collection! We have been working with design and technology students at a school here in the UK who have been investigating ways to attach temperature and salinity sensors to fishing gear (including crab pots) and to small boats. Looks very promising! We focused on surfers in our study partly due to the popularity of this sport in the region we are located (many people surf all year around here), however, the popularity of a particular marine recreational activity is likely to be dependent on location and season. Thus it seems sensible to keep open minded about using other marine recreational activities to help with data collection.

Can you recommend any good text books on oceanography and marine geology?

[Toginator](#)

Lee: I don't know much about marine geology, but a good textbook about physical geography is "Introduction to physical oceanography" by Robert H. Stewart. Its a great book and it's available legally for free [online here](#).

Another book that I can recommend is [A dance of air and sea, by Arnold Taylor](#). It's not a textbook, it's popular science book about marine biology in the global ocean.