Oshen C-Star: Preliminary Testing and Performance Evaluation of a Novel Accessible Ocean Sensing Platform

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Abstract

The C-Star platform is a novel, low-cost ocean sensing platform, developed by Oshen, a UK-based company focusing on providing accessible ocean sensing solutions. The platform, 1.2m in length, is primarily wind-driven using an actuating rigid sail, and can operate autonomously over multiple days. In collaboration with Synchro, an initiative of the Monterey Bay Aquarium Research Institute, a test campaign to evaluate the navigation and sensing performance of this platform has been carried out, involving multiple deployments in both California and the United Kingdom. The platform was able to autonomously navigate over a wide range of wind conditions and points of sail, although issues presented at very low wind speeds in the presence of ocean currents. A small, stern-mounted thruster was added, and found to partially alleviate these issues. Passive acoustic and metocean data were collected, and the latter compared to reference sources such as weather stations mounted to floating buoys. Good agreement was found in atmospheric pressure, air temperature and wind speed data, with discrepancies observed in measurements of wind direction and sea surface temperature. The ease of deployment and usage of the platform was also evaluated by the Synchro team.

1 Introduction

The ocean environment is rapidly changing, creating an unprecedented need to better understand core processes and continuously monitor as wide an area as possible. Recent advances in ocean technology have increased the offering of methods available for collecting data in the ocean for several different use cases. However, most of these methods are either too expensive to deploy in large quantities (e.g. moored buoys, long endurance autonomous surface vessels), or are inexpensive but don't provide the coverage needed (e.g drifting buoys). At present, there is no market-ready technology that could scale up to provide a low cost, long-duration, wide-coverage network of data capture across the world's oceans. This is thought in part to be due to the high costs of testing new products rigorously in the oceans: firstly, the resulting products that are taken to market are often highly expensive, and not accessible to the wider market of users who wish to better understand our ocean; and secondly, the lengthy testing cycle resulting from difficulties in getting to sea slows both the development and the adoption of new technologies.

The collaboration between Synchro and Oshen presented in this paper attempts to tackle these problems, combining Synchro's experience in the ocean technology testing field with Oshen's rapid development cycle and dynamic team.

1.1 Synchro

Synchro [1], an initiative of the Monterey Bay Aquarium Research Institute (MBARI) [2], works to address the obstacles that prevent ocean technology from moving beyond the prototype stages to practical use. By bringing together technology developers, resource managers, and other end-users for real-world testing, Synchro reduces costs and complexity in the evaluation process. The focus on data quality, usability, and ease of deployment ensures that once tools are validated, they can be rapidly adopted by the research community and broader user base. Through this streamlined approach, Synchro helps deliver reliable, accessible solutions essential for understanding and managing our rapidly changing oceans.

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Figure 1: The C-Star platform deployed in Monterey Bay

1.2 Oshen

Oshen Ltd. [3] is a UK-based company dedicated to creating low-cost, autonomous ocean-monitoring devices. Since its founding, Oshen has successfully deployed platforms to three continents, where they have demonstrated their ability to navigate autonomously and to survive severe weather events. To date, the company has manufactured nine such platforms, each designed to operate continuously and provide researchers, policymakers, and industry stakeholders with essential data on rapidly changing ocean conditions. By focusing on affordability and scalability, Oshen enables broader access to critical ocean observations without relying on prohibitively expensive infrastructure.

2 C-Star Platform

Oshen's platform, the C-Star, is a wind-driven vessel capable of carrying multiple sensor payloads, powered using a combination of batteries and solar panels. It functions like a controllable buoy, combining the maneuverability needed for targeted data collection with the endurance to remain at sea for extended periods. This small size reduces production and deployment costs, allowing multiple units to be launched in constellations for persistent, wide-area ocean observation. An example of the platform is shown deployed in Monterey Bay in Figure 1.

The platform's overall design is shown in Figure 2, which provides an annotated illustration highlighting its key features. The platform's core characteristics, such as dimensions, operational range, and propulsion mechanisms, are summarized in Table 1. Its compact structure and low weight enable straightforward manual deployment and retrieval by 1-2 operators, even in challenging sea conditions. The specific C-Star vessel used

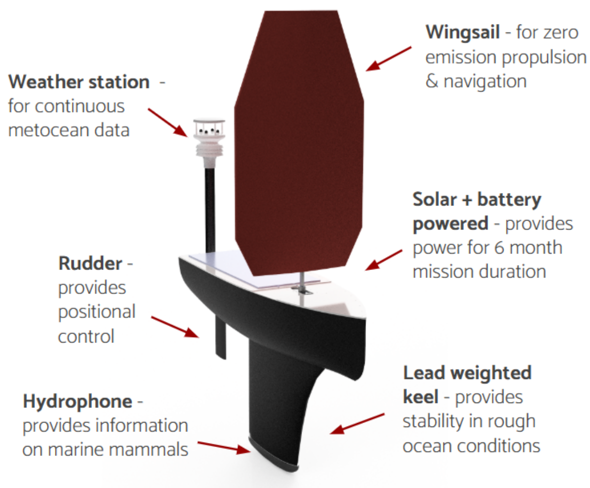


Figure 2: Key features of the C-Star platform

Table 1: C-Star Platform Characteristics

Property	Value
Boat Speed	1–2 knots
Weight	40 kg
Propulsion	Wind (and stern-mounted thruster for low winds)
Power Source	Battery & Solar
Length	1.2 m
Deployment	1-2 people

by the Synchro team, named *Emperor*, had a 100Ah battery and no solar panel, as missions durations were short. Other vessels are equipped with a deck-mounted 35W solar panel and 200Ah of battery capacity, allowing for extended mission durations.

2.1 Sensor Payload

The sensor payload deployed on *Emperor* for the testing presented in this report is summarized in Table 2. The sensor heights are given relative to the average waterline of the vessel, and as such can be taken as heights above sea level. The payload package includes instruments for passive acoustics, metocean data, and surface temperature measurements. Live readings from the sensors can be accessed during a mission, at a reduced sample rate of one reading per minute, aside from the hydrophone and significant wave height data, which must be retrieved post-mission with the full dataset of sensor readings.

Additional to be included

- Table of sensor types, manufacturers, sampling rates, precisions and estimated accuracies, if available

Table 2: Sensor payload on *Emperor* C-Star vessel

Sensor Type	Sensor Height
Wind Speed & Direction	0.5 m
Air Temperature	0.5 m
Air Pressure	0.5 m
Humidity	0.5 m
Sea Surface Temperature	-0.1 m & -0.7 m
Hydrophone	-0.7m
Significant Wave Height	n/a

3 Summary of Testing

The C-Star platform was tested extensively in the USA and the UK to evaluate its functionality, robustness, and user-friendliness. This report is primarily focused on the evaluations conducted in the USA by the Synchro team, but some UK trials are also referred to where relevant for determining critical performance metrics (e.g. upper operational limits).

An overview of the test campaign is provided here, and qualitative descriptions given of the tests carried out. The general test procedure is also described. For reference in subsequent sections, Table 3 lists all relevant tests performed, with a unique identifier assigned to each test.

3.1 USA Missions

The USA missions took place in Monterey Bay with the Synchro team, using the *Emperor* vessel. These missions were used to evaluate the navigation performance of the vessel, as well as evaluate the sensor package through comparisons with the M1 moored buoy.

3.1.1 Training and Orientation

An in-person training session at the Synchro base marked the beginning of the evaluation. Two Oshen team members provided an overview of the C-Star's design, deployment protocols, and operational workflows. This session ensured the Synchro team were equipped to handle the platform independently for subsequent missions.

3.1.2 Deployment and Retreival Process

Each mission adhered to a standardized process:

1. **Mission Planning**: An in-house code developed by Oshen was used to define waypoints, navigation constraints, and objectives.

2. **Deployment**: *Emperor* was transported off-shore on the vessel RV *Paragon*, powered on, checked for GPS connectivity, and deployed manually, as shown in Figure 3.

Figure 3: Deploying *Emperor* from the RV *Paragon*

Figure 4: Manually piloting the C-star platform from the skiff

3. **Monitoring**: The mission manager software and a redundant tracker provided real-time updates. The waypoints were dynamically adjusted as needed.

4. **Retrieval**: The platform's compact and durable design facilitated safe manual recovery, even in challenging conditions.

3.1.3 Mission Descriptions

MB1: Dockside Test A dockside test followed the training session to demonstrate key functionalities, such as wind propulsion with two sail sizes, waypoint navigation, and data logging. Conducted from a small skiff fitted with an outboard engine, the C-Star was deployed from the dock using a manual launch. During this test, operators utilized the 'full manual control' mode to pilot the platform with a handheld controller, gaining familiarity with its performance, as shown in Figure 4.

Table 3: Details to be completed

Ident	Location	Dates	Duration	Vessel	Summary
MB1	Monterey Bay, USA			*Emperor*	Key functionalities demonstration + shake-down
MB2	Monterey Bay, USA			*Emperor*	Short-duration sea trial
MB3	Monterey Bay, USA			*Emperor*	Performance evaluations
MB4	Monterey Bay, USA			*Emperor*	Performance evaluations
MB5	Monterey Bay, USA			*Emperor*	Performance evaluations
MB6	Monterey Bay, USA			*Emperor*	Updated hardware evaluations
PL1	Plymouth Sound, UK			*Emperor*	Commissioning trial
PL2	Plymouth Sound, UK			*PS1*	Long duration sea trial

MB2: Initial Sea Trial The first sea trial involved a one-day mission conducted approximately 2 nautical miles offshore. The C-Star was sent a set of waypoints, with the target waypoint updated several times to assess upwind performance in the light winds.

MB3-5: Independent Missions Three additional missions were conducted independently by the Synchro team, focusing on specific performance evaluations.

MB6: Hardware Modification Evaluations In January 2025, a final mission involved evaluating the impact of hardware upgrades, including integrating a thruster to augment the propulsion provided by the sail, enabling improved navigation under calm conditions.

3.2 Additional UK Missions

The method followed for UK missions was broadly similar to the US tests, with the platform deployed from a rigid inflatable boat (RIB) 3-4 nautical miles offshore from the coast of Cornwall or Devon.

3.2.1 Mission Descriptions

PL1: Commissioning Trial This was the final sea trial carried out using *Emperor* before shipping to the USA - in addition, the vessel sailed close to the E1 moored buoy, allowing metocean data to be compared to supplement the comparisons made in Monterey Bay.

PL2: Long-Duration Sea Trial This was a 6-day mission using a C-star vessel of similar design to *Emperor*, named *PS1*.

Additional to be included

- More detailed descriptions of each mission, including visualizations of GPS data

4 Results and Evaluations

The data collected in the tests presented in Section 3 was analyzed by the Synchro and Oshen teams, and is presented here - specifically Section 4.1 focuses on evaluating the navigation performance of the platform as observed in these tests, Section 4.2 on the sensor package performance, and Section 4.3 on other considerations, such as ease of deployment and platform durability.

4.1 Navigation Performance

To be included

- Visualization of typical waypoint triangle, highlighting different points of sail
- Tabulated/plotted parameters such as typical velocities, velocities made good, heading errors, sideslip, roll angle etc. across different points of sail/wind speeds/sea states
- Preliminary velocity polar, with approximate corrections for currents/tides made
- Comparison of performance in calm conditions with and without the thruster

4.2 Sensor Package Performance

The following sections present comparisons between metocean data collected by C-star vessels and by moored buoys, namely the M1 buoy in Monterey Bay [citation], and the E1 buoy in Plymouth Sound [citation]. The comparisons were restricted to when the separation distance between the vessel and the moored buoy was 10 nm or less - this limited the comparisons to tests MB3, MB5, MB6 and PL1. The full suite of metocean sensors used could be evaluated in the Monterey Bay tests, but unfortunately the sea surface temperature sensors were not fitted for test PL1, and due to a (since rectified) logging error, wind speed data from the C-star vessel was not saved, meaning comparisons of these with the E1 buoy's data could not be made.

The C-star microvessel metocean sensors sample at a nominal rate of 1 Hz, while the moored buoys typically provide data at a much lower rate: the M1 buoy historical data is time-averaged over 10 minute windows, excepting the sea-surface temperature data, which uses a 30 minute window; while the E1 buoy historical data is time averaged over 60 minute windows. To provide a clearer comparison, the C-star vessel data outputs were resampled and time-averaged to match the corresponding buoy output rate. Error bands have been plotted where available for the C-star vessel sensors, based on manufacturer specifications. No error bands are provided for the moored buoy data, and this is essentially treated as the ground truth in the comparisons.

To be included

- Table summarizing M1 and E1 moored buoy sensor packages, sensor heights and sample rates

4.2.1 Atmospheric Pressure

Figure 5 shows comparisons of atmospheric pressure data collected by *Emperor* and the M1 buoy. It should be noted that a hydrostatic correction has been applied (using a local calculation of air density) to the data from *Emperor* to account for the offset in heights between the two data sources. In general, agreement is excellent: *Emperor*'s data captures the general trends across all three tests, and differences in absolute value are small, with the M1 buoy reading typically within the error band of *Emperor*'s sensor. Occasionally, *Emperor*'s reading appears to lag that of the M1 buoy, for example during the rise in pressure between 21:00 and 01:00 at the beginning of the data presented in Figure 5a for test MB3, and the later fall between 13:00 and 19:00 in the same test. There are also differences in the peak pressure detected in test MB3 and the lowest pressure detected in MB6. It is possible these discrepancies are a result of local variations in atmospheric pressure, although overall there appears to be little common trend across the three tests in terms of the effect of separation distance on reading agreement.

To assess the reproducibility of these results, Figure 6 shows a comparison of data collected in the PL1 test, performed in the UK, against the E1 buoy. Similar agreement is observed in this comparison as to those made against the M1 buoy data.

4.2.2 Air Temperature

Comparisons of measured air temperature over the three tests are plotted in Figure 7. No correction has been made using lapse rate for the difference in height betweeen the two sensors, as this was estimated to be on the order of 0.02 °C and therefore effectively negligible. While agreement is not as close as for atmospheric pressure, it is still reasonable - in particular, the sudden increases in temperature between 11:00 and 15:00 in test MB3 and between 00:00 and 02:00 in test MB6 recorded by the M1 buoy were both also registered by *Emperor*. Again, as for the atmospheric pressure data, there appears to be little correlation between measurement differences and separation distance - it is likely that local variations in air temperature are sufficiently low over the distances in question that sensor performance is the dominating cause of these differences. The difference in sensor heights (0.5m for *Emperor* vs. 2.5m for the M1 buoy) may also be a contributing factor, with *Emperor*'s readings likely much more affected by heat exchange with the sea surface.

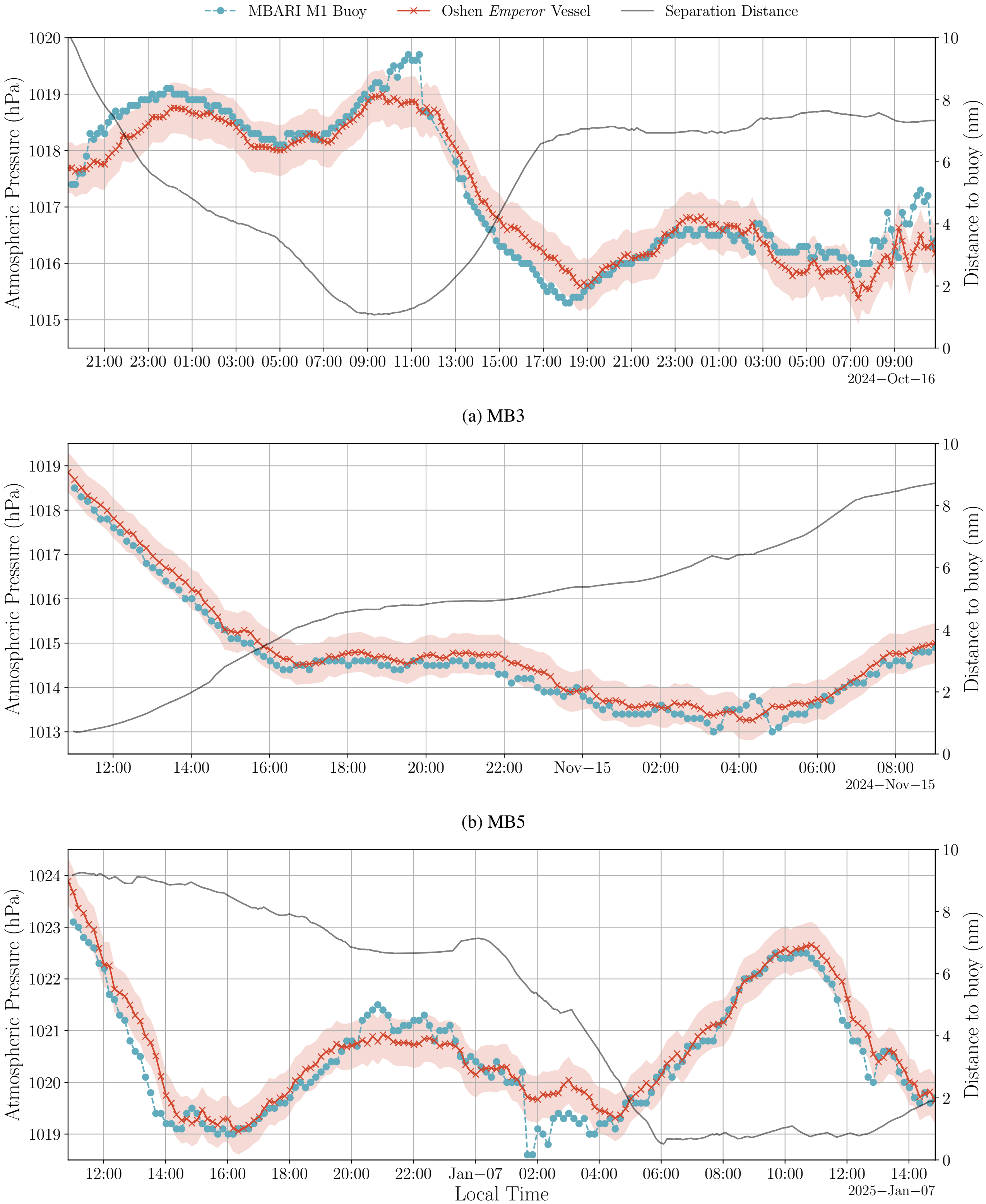
Figure 8 shows a similar comparison against the E1 buoy. This shows arguably better agreement than against the M1 buoy - this may be because the sensor heights are in closer agreement, although it is also possible the longer averaging window has smoothed out some discrepancies.

4.2.3 Sea Surface Temperature

- Below will be fully written up once analysis concluded
- Arguably time-varying trends have been captured, which is encouraging, although less so for test MB5
- M1 buoy's readings however would be expected to be the coldest (as they come from the deepest sensor), and yet seem to sit amongst *Emperor's* SST readings. Perhaps there are zero-errors on the *Emperor* SST sensors. Give an evaluation of these low cost sensors - perhaps in-house calibration is the answer in future.
- The almost constant offset between the hull and keel sensors is also perhaps suspicious - would we not expect the temperature profile to change between night and day, as it seems to looking at the additional data taken at 10m from the M1 buoy? Could both our sensors be in a part of the temperature profile which is expected to remain at roughly constant temperature throughout, in which case this could just be different zero-errors for each sensor?

4.2.4 Wind Speed and Direction

- Below will be fully written up once analysis concluded
- Wind data from *Emperor* has been corrected for difference in sensor height to M1 buoy, and for the effect of the vessel's velocity vector
- Wind speed data (Figure 10) appears to be in good agreement, and arguably within the expected variation inferred from the two differing wind sensors on



(a) MB3

(b) MB5

(c) MB6

Figure 5: Plots/data not finalised. Comparisons of atmospheric pressure data collected from *Emperor* and the M1 Buoy

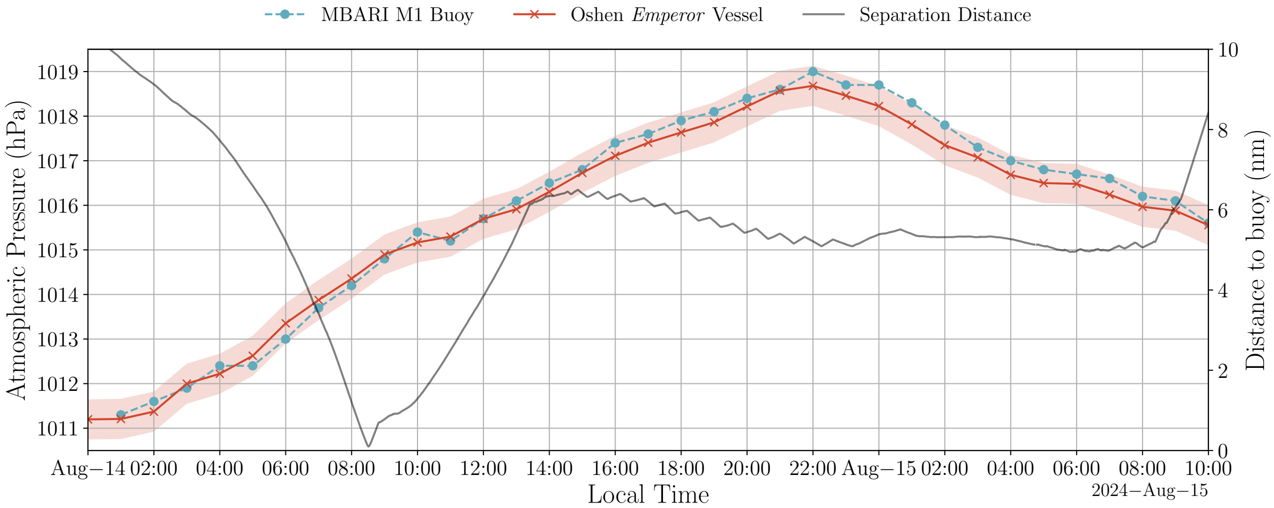


Figure 6: Legend has not been updated. Plots/data not finalised. Comparison of atmospheric pressure data collected from *Emperor* and the E1 Buoy in test PL1

the M1 buoy - but only when distance to the buoy is small. This does seem to be a variable strongly affected by separation distance.

- Wind direction data (Figure 11), while appearing in acceptable agreement in test MB5 (especially considering the large variation between the two M1 buoy sensors) shows strong discrepancies with the buoy data in MB3 and MB6, even close to the buoy. In these latter two tests trends are also not captured - the buoy shows wind directions are roughly constant, while the wind direction measured by the C-star is very variable. Note these plots will include an additional trace of shortest-angle difference between the data sources to better show errors (as the wrap around nature of the angular data means the errors are currently difficult to visualize).
- The comparison with data collected by the E1 buoy (Figure 12) shows similar levels of discrepancy.
- There are a number of possible explanations being explored: heading measurement errors in the vessel's IMU directly affect wind direction; vessel rolling, as the wind direction sensor is designed to be used in a vertical orientation; the presence of the vessel's sail, as the wind sensor is immersed in its wake

4.2.5 Other Data Collected

To be included

- Selections of raw acoustic data, highlighting any interesting events
- Spectral analyses, drawing out any frequencies commonly attributed to whales
- Significant wave height data using GPS z readings

4.3 Other Performance Considerations

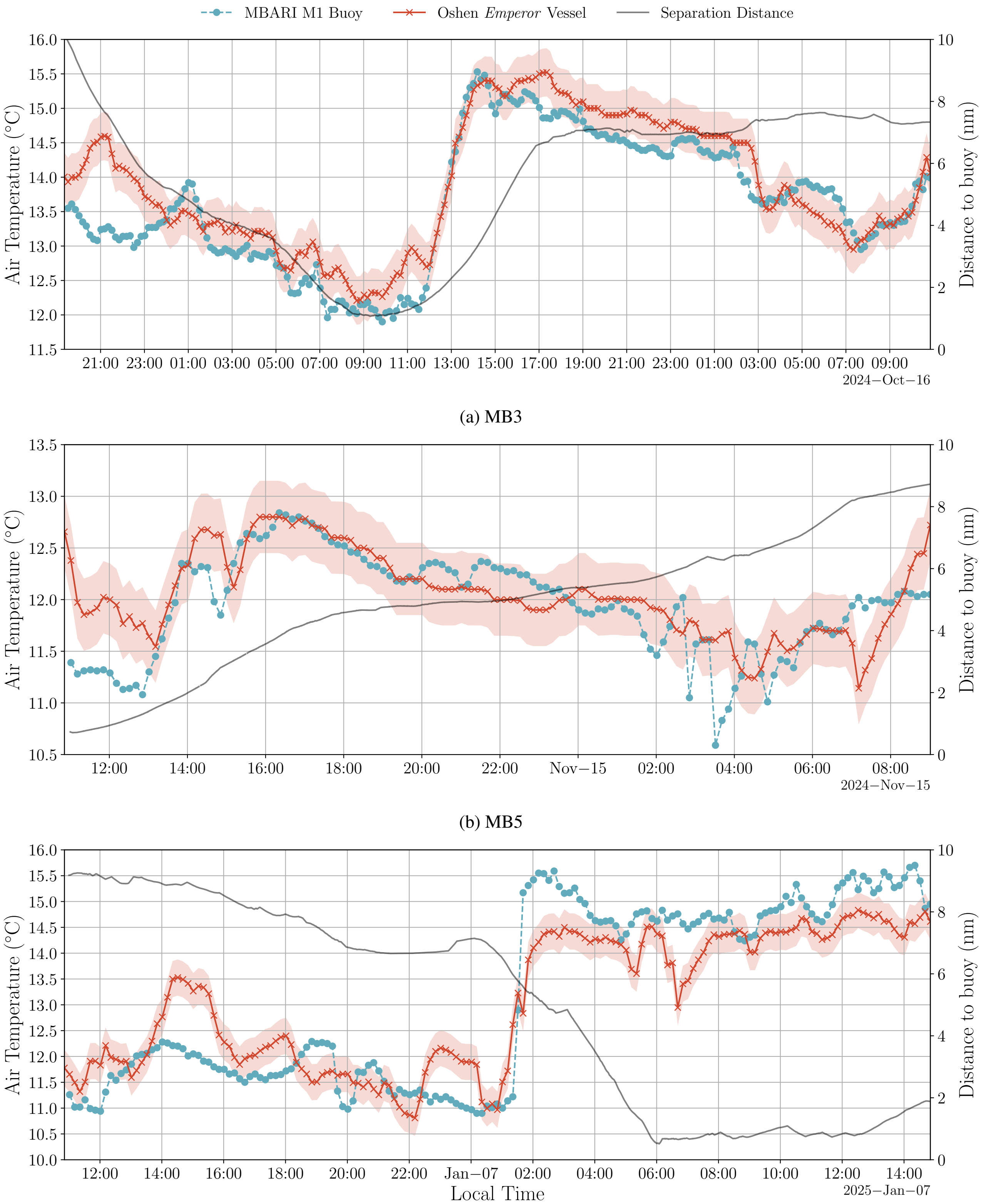
To be included

- Statistics relevant to vessel longevity/durability, such as: total hours at sea/miles at sea/missions completed for individual vessels, number of hours in each mission with vessel on direct course i.e. heading error less than e.g. 10 deg
- Qualitative evaluations from Synchro team on ease of deployment/recovery
- Qualitative evaluations from Synchro team on ease of use/training

5 Conclusions

To be included

- Four sections of conclusions, summarising: high-level conclusions; navigation performance conclusions; sensor performance conclusions; other performance conclusions e.g. durability, ease of use
- Lessons learnt section summarizing any useful procedural changes that may be recommended for similar test campaigns
- An outlook on future development of the platform



(a) MB3

(b) MB5

(c) MB6

Figure 7: Plots/data not finalised. Comparisons of air temperature data collected from *Emperor* and the M1 Buoy

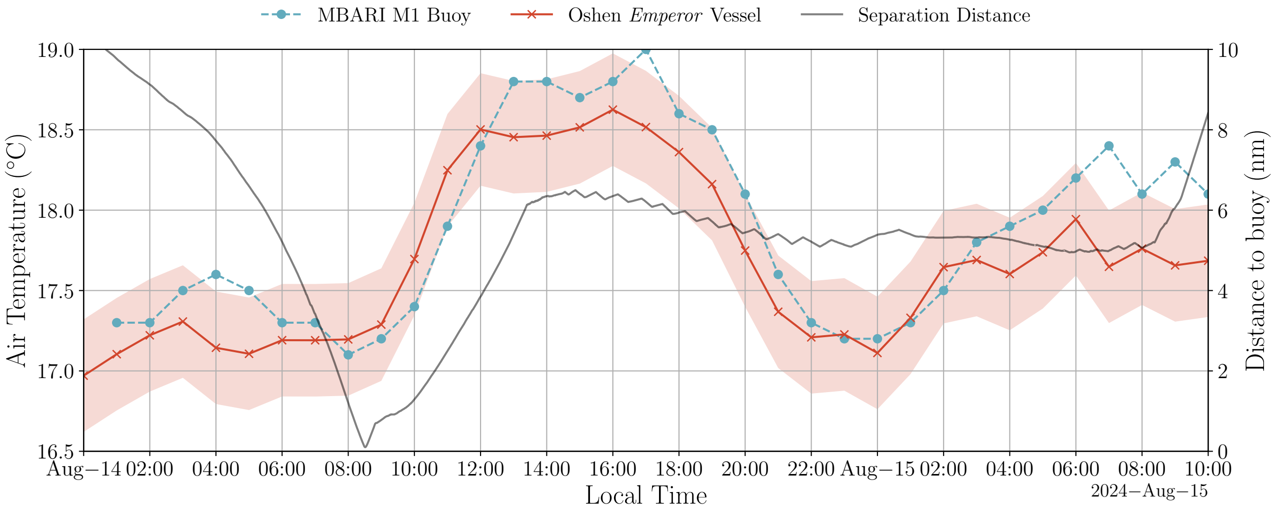


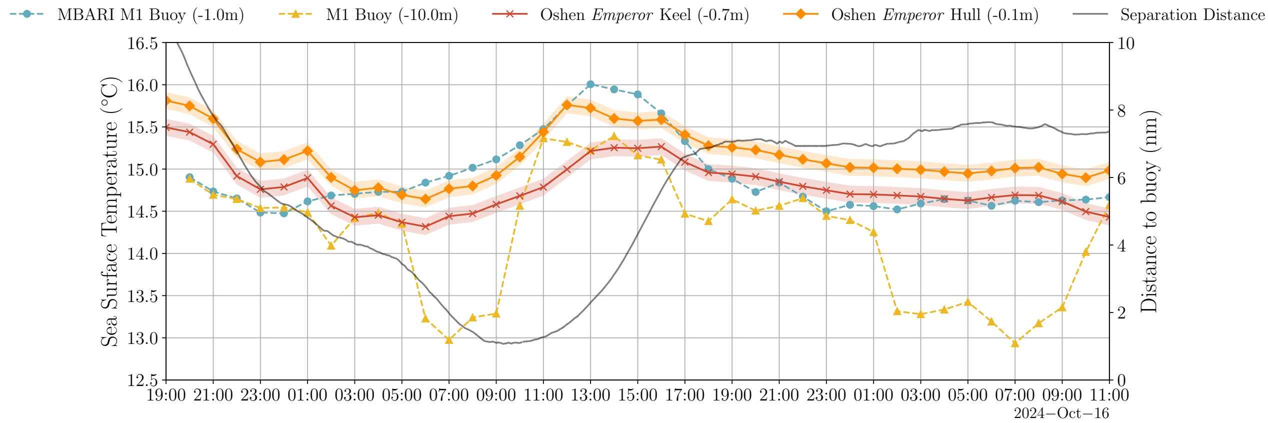
Figure 8: Legend has not been updated. Plots/data not finalised. Comparison of air temperature collected from *Emperor* and the E1 Buoy in test PL1

References

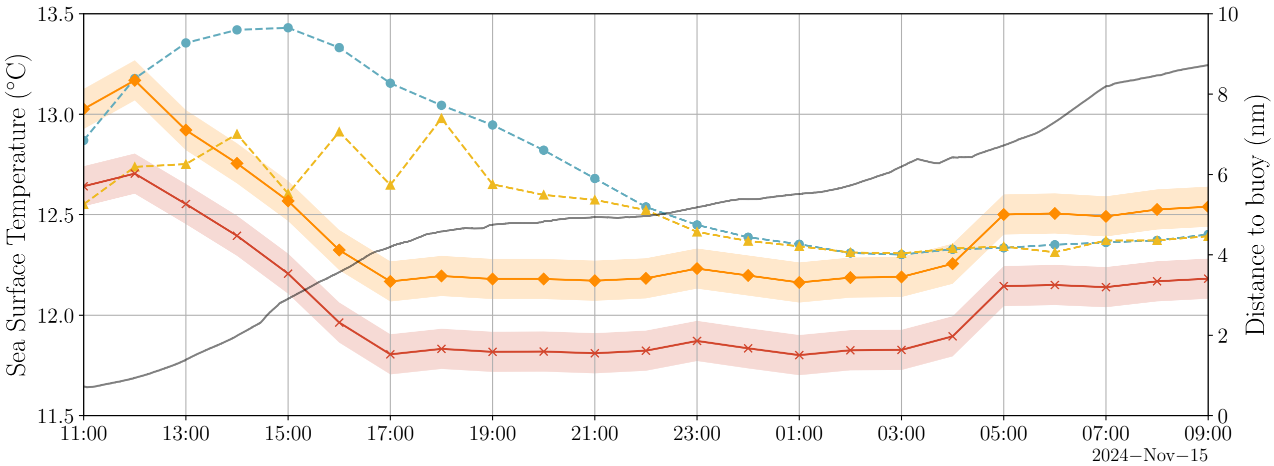
[1] Ocean Synchro. www.oceansynchro.io.

[2] Monterey Bay Aquarium Research Institute. www.mbari.org.

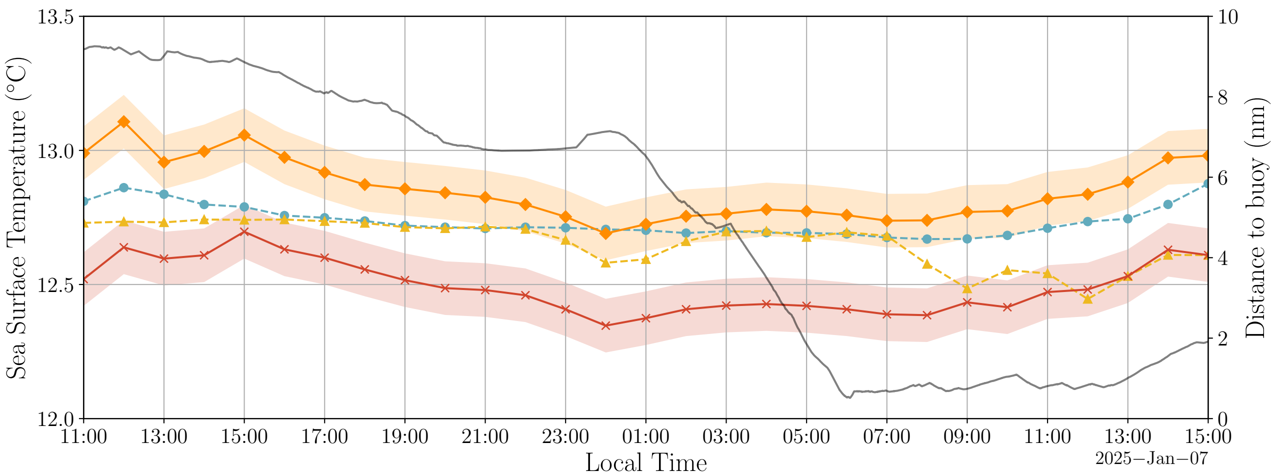
[3] Oshen Ltd. www.oshensail.com.



(a) MB3

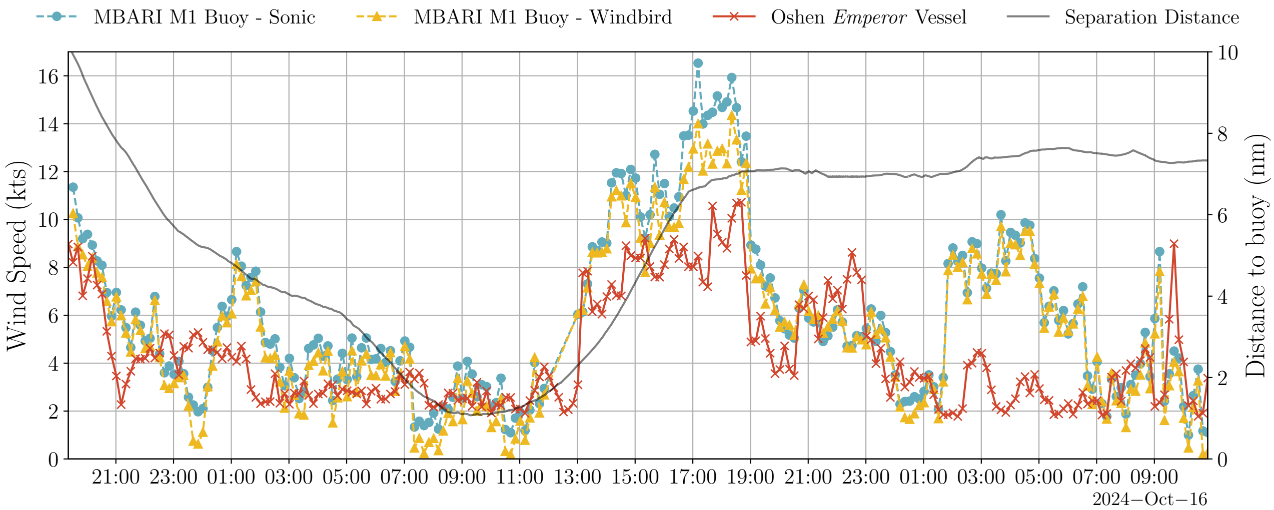


(b) MB5

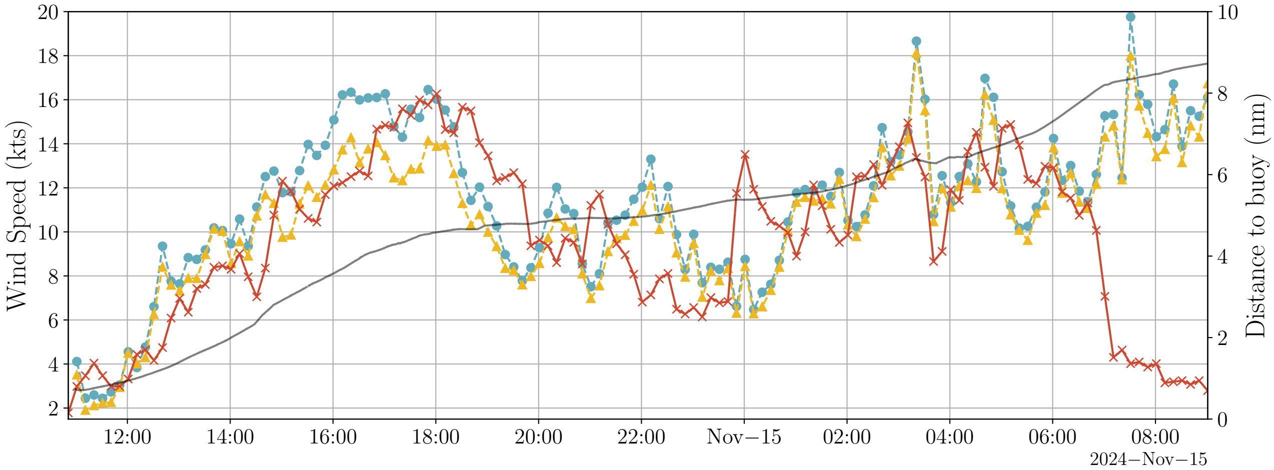


(c) MB6

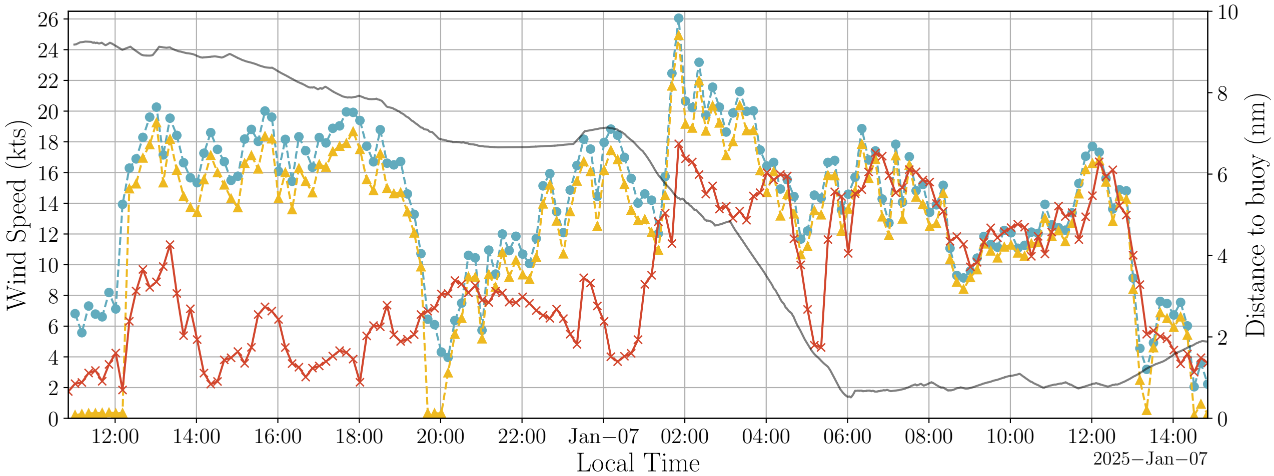
Figure 9: Plots/data not finalised. Comparisons of sea surface temperature data collected from *Emperor* and the M1 Buoy



(a) MB3

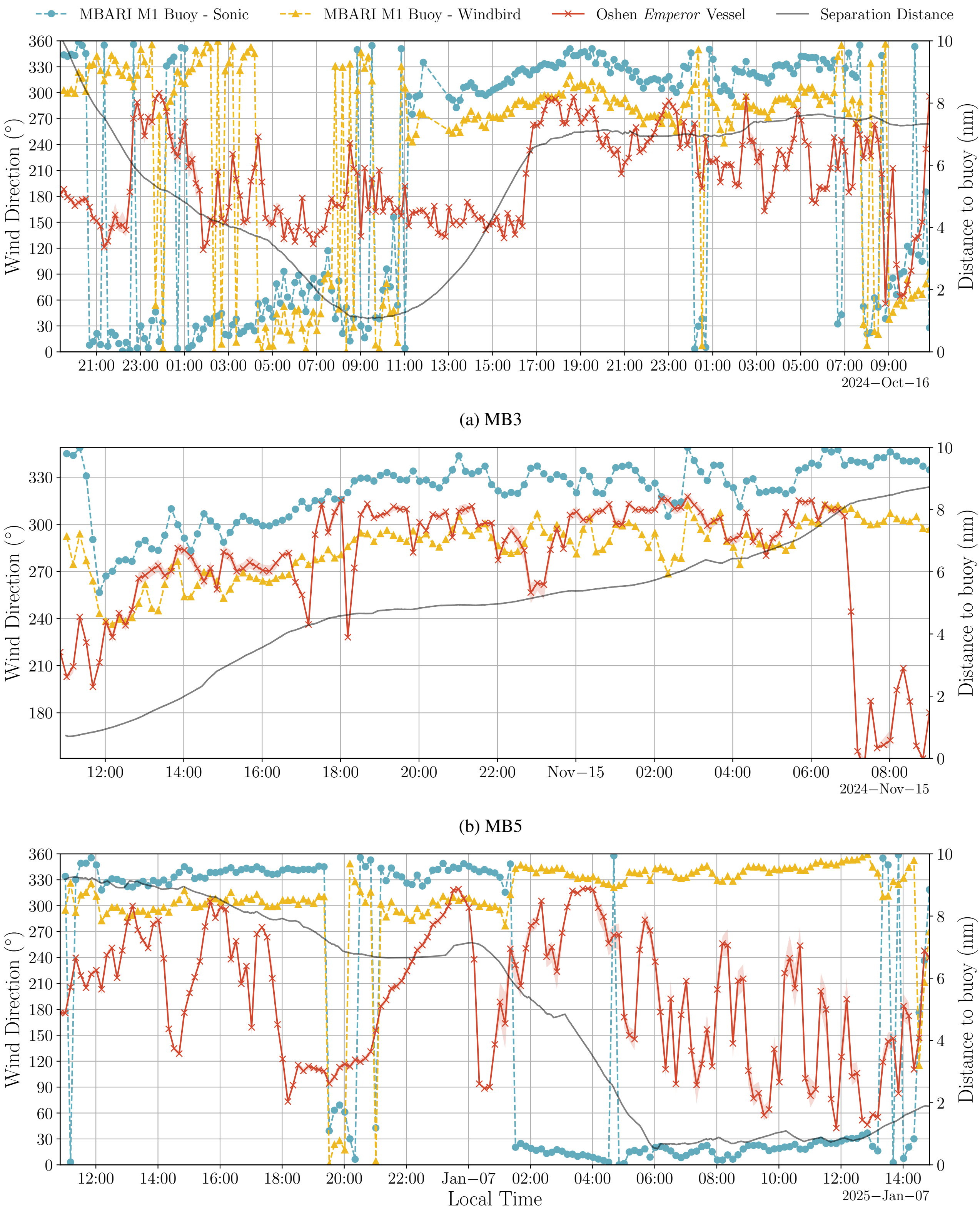


(b) MB5



(c) MB6

Figure 10: Plots/data not finalised. Comparisons of wind speed data collected from *Emperor* and the M1 Buoy



(a) MB3

(b) MB5

(c) MB6

Figure 11: Plots/data not finalised. Comparisons of wind direction data collected from *Emperor* and the M1 Buoy

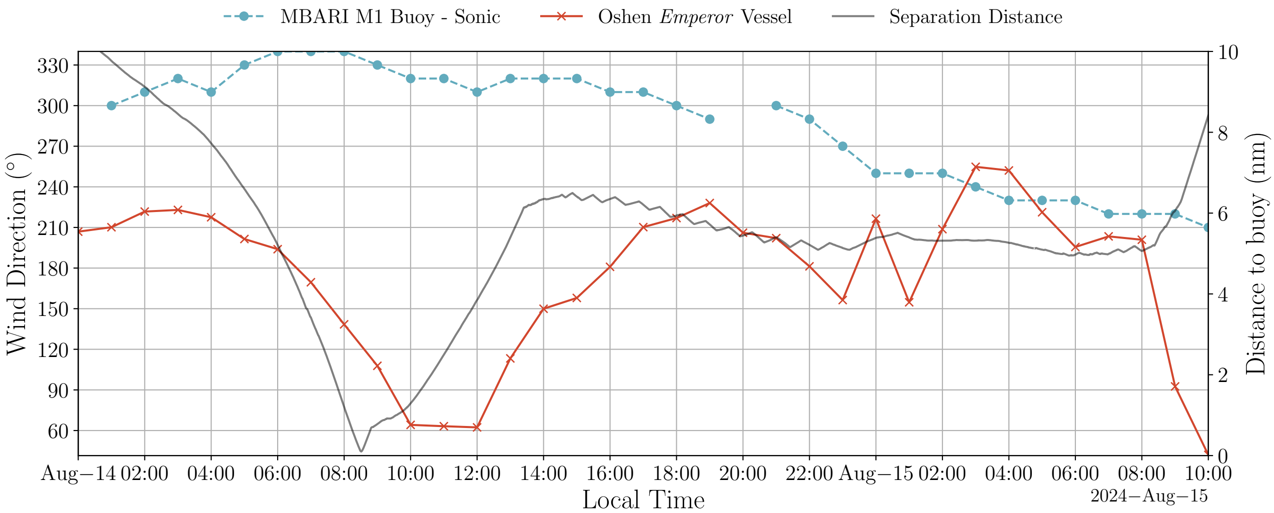


Figure 12: Legend has not been updated. Plots/data not finalised. Comparison of wind direction data collected from *Emperor* and the E1 Buoy in test PL1