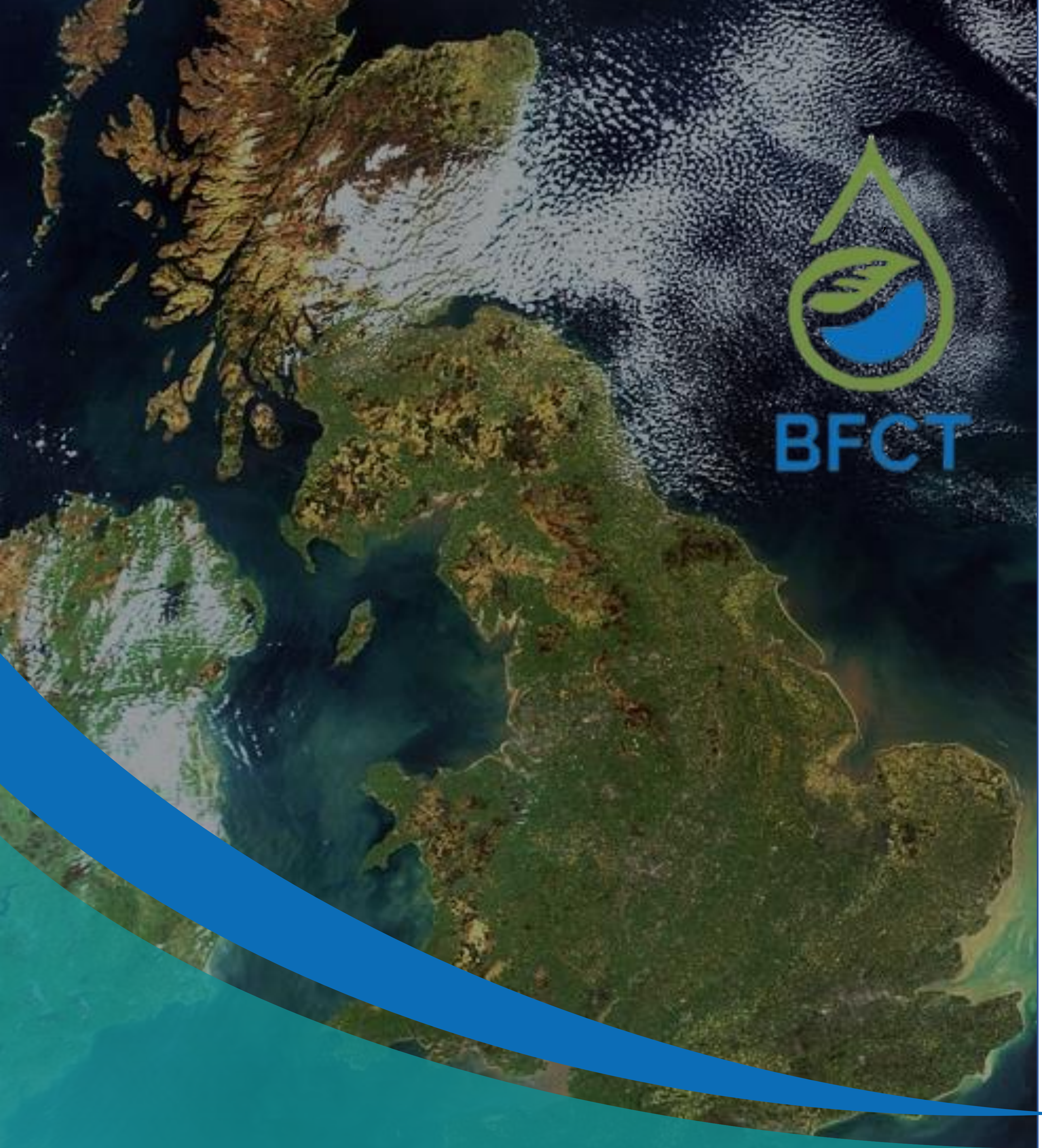
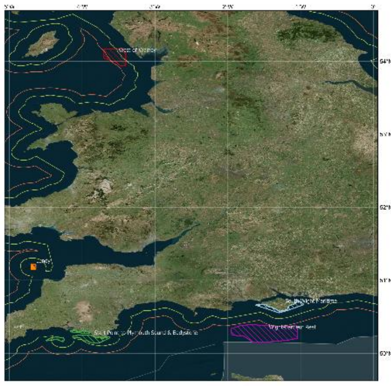


Becht Family Charitable Trust – UK MPA Project

In partnership with:

The Inshore Fisheries and Conservation Authorities

Marine Management Organisation

Summary table	
Area of interest (AOI) 	Marine Protected Areas (MPAs) within the United Kingdom (UK) Exclusive Economic Zone (EEZ): • West of Walney Marine Conservation Zone (MCZ) • Lundy MPA • Start Point to Plymouth Sound & Eddystone Special Area of Conservation (SAC) • South Wight Maritime SAC • Wight-Barfleur Reef SAC
Analysis period	1st June 2021 – 30th November 2021
Data sources	Satellites and Unmanned Aerial Vehicles (UAVs)
Submitted to	Becht Family Charitable Trust and UK MPA working group
Date submitted	26th January 2021
Report number	21 – 359
Report compiled by	Julian Engel, Greg Brown
Quality control by	Samantha Elliott
Key findings; Phase 2	• The requirements for monitoring, control and surveillance vary between the selected sites. • Electro Optical satellites are an important method for all sites, but cloud coverage may be a limiting factor. • Aerial surveillance will therefore be a critical component in identifying infringements. • Vessel tracking and Synthetic Aperture Radar can greatly support the intelligence gathering for specific sites.
Next steps; Phase 3	• Acquire permissions for aerial surveillance. • Agree flight plans. • Acquire satellite imagery that aligns with UAV flight plans. • Train OceanMind's machine learning algorithm on vessel tracking data • Evaluate all data sources and make recommendations for use in different areas of the UK.

Acronyms and Abbreviations					
AIS	Automatic Identification System	IFCA	Inshore Fisheries and Conservation Authority	SAR	Synthetic-Aperture Radar
AOI	Area of Interest	I-VMS	Inshore Vessel Monitoring System	SDG	Sustainable Development Goals
BFCT	Becht Family Charitable Trust	MCS	Monitoring, Control and Surveillance	SPA	Special Protected Areas
BVLOS	Beyond Visual Line Of Sight	MCZ	Marine Conservation Zones	UAVs	Unmanned Aerial Vehicles
CCTV	Closed Circuit Television	MMO	Marine Management Organisation	UK	United Kingdom
DVWF	Detection of Vessels Wide Far	MPA	Marine Protected Area	VHF	Very High Frequency
D&S	Devon & Severn	NM	Nautical Mile	VIIRS	Visible Infrared Imaging Radiometer Suite
EO	Electro Optical	RF	Radio Frequency	WUF	Wide Ultra-Fine
IUU	Illegal, Unreported and Unregulated	SAC	Special Areas of Conservation	XF	Extra Fine

Contents Page

Executive Summary

The UK MPA Project is a collaboration between the Becht Family Charitable Trust and OceanMind. The project works with key partners responsible for MPA protection and enforcement to identify a range of new Monitoring, Control and Surveillance (MCS) tools for use in English waters. This partnership aims to provide deterrent-by-detection solutions that are cost effective, high impact and scalable, and therefore can be applied to MPAs around the globe.

The project will increase the visibility of activity in the United Kingdom's MPAs. To achieve this, OceanMind will introduce a suite of previously unused tools to the relevant UK authorities with the aim to highlight risk areas and increase compliant behaviour.

The project is split into five phases:

1. Site identification,
2. Risk & Technology Assessment,
3. Plan & Methodology,
4. Technology Pilot,
5. Final Report.

This report comes at the end of Phase 2 to meet the following objectives:

- To carry out risk assessments of each individual pilot site,
- Assess technology availability and suitability for each site,
- To provide a report and recommendation based on the findings.

The purpose of this report is to provide an overview of the selected sites and the technologies available, and the consolidated information will then inform the analytical assessment for the deployment of the technologies for each site.

The technology assessment looks at vessel tracking, some of the key remote sensing methods for vessel detection and explores their relative strengths and limitations in the context of operation within the UK.

These methods include:

- Electro Optical,
- Synthetic-Aperture Radar,
- Aerial Surveillance using manned aeroplanes,
- Unmanned Aerial Vehicles or drones that operate beyond the line of visual sight,
- Other methods including electronic monitoring and radio frequency.

The strengths and limitations of the various methods were scoped for their suitability to the selected sites to ensure that they meet the unique compliance and enforcement challenges of those sites. For each site at least two suitable technologies have been identified for each site and will be deployed during Phase 4 of the project.

Sites were chosen by an Inshore Fisheries and Conservation Authority (IFCA) or the Marine Management Organisation (MMO).

Five sites were identified as suitable for the project:

- West of Walney Marine Conservation Zone (MCZ)
- Lundy Marine Protected Area
- Start Point to Plymouth Sound & Eddystone Special Area of Conservation (SAC)
- South Wight Maritime SAC
- Wight-Barfleur Reef SAC

The sites represent a good geographical diversity around the country and have a mix of characteristics that make them suitable for trialling the various tools available, and they differ in the management measures and approaches which necessitates various monitoring styles.

The Joint Nature Conservation Committee (JNCC) of the United Kingdom (UK) reports that over 88.5 million hectares (38 %) of UK waters are under a form of marine protection or management:

There are 91 Marine Conservation Zones (MCZ) in waters around England which are designated to protect important species, habitats, and ecological processes.

There are 656 Special Areas of Conservation (SACs) that contain animals, plants and habitats that are considered rare, special, or threatened within Europe.

Due to the central role of migratory bird populations in European ecosystems, 275 Special Protected Areas (SPA) are designated for their protection.

Whilst not all MPAs have management measures in place, many of those that do have challenges with effective Monitoring, Control, and Surveillance (MCS). For the Becht Family Charitable Trust (BFCT) UK MPA project, OceanMind will work to address this issue, with the aim to increase visibility of activity within UK MPAs including that of non-compliant behaviour by trialling a suite of tools previously unused by UK authorities. This project will then inform the MMO and IFCAs about available tools for MCS.

Five sites have been selected to pilot potential monitoring methods and assess their appropriateness for widespread application. The sites were selected based on ecological features, fishing activity, non-compliance concerns and existing management measures. The selection of sites was chosen to represent different site variations including fully inshore (within 6 NM), fully offshore (beyond 6 NM), and straddling sites (cross either the 6NM or 12NM boundary). This variety ensures that the sites represent the range of different sites in UK waters that could benefit from remote sensing support.

We believe that the findings will be directly relevant to the UK's progress towards Sustainable Development Goal (SDG) 14, the 25-year environment plan, the MMO's evidence strategy 2021 – 2025 and the IFCA high level objectives and should improve MPA integrity and fisheries compliance within UK national waters.

Effective compliance and enforcement regimes are crucial components of sustainable fisheries and environmental protection, and the UK MPA project will contribute to the development of sustainable, well managed fisheries and so consequently the wider blue economy. The project will increase MMO's awareness of the tools available and their applicability in a UK context and should help inform the conservation and management of MPAs by providing independent quantitative information..

The BFCT-funded UK MPA project will set an example on how emerging technology and artificial intelligence can support monitoring, control and surveillance efforts within marine protected areas and help to define risks and improve risk mitigation across Marine Protected Areas in the UK.

At sites such as the Wight-Barfleur SAC where management measures are not implemented, the Intelligence outcomes will provide information about the activity levels at the sites which may be used to inform fisheries assessments.

Technology Assessment

Introduction

A demand for technological solutions to the problem of monitoring large Areas of Interest (AOIs) has led to improved remote sensing capabilities over the last decade. However, all these solutions have relative strengths and benefits and so their application should be assessed on a case-by-case basis. To help understand our assessment of different remote sensing methods, within this section each technology will be introduced and compared and we will then demonstrate why each technology has been selected for each of the five sites.

Satellites

All vessel tracking and remote sensing methods in this section exist within the context of satellite systems (except for I-VMS which operates through GPRS cellular communication). Acquisition of satellite data is dependent on satellite orbit, constellation, and orientation. These parameters impact revisiting times, coverage, extent ratio (length and width in relation to latitude and longitude) and adaptability. This is especially relevant when there is little knowledge on an area. Ideally an area would be covered by a large image with low resolution, comparable to a zoomed-out image with a camera, to assess risks. This image can then be followed up with more targeted acquisition (zooming in on identified risks).

A key consideration in satellite imagery is incidence angle. This describes the relationship between the orientation of a sensor on a satellite and the surface of the Earth to be targeted. Incidence angle determines the degree of reflection expected from objects, and so the likelihood that they will be detected. For example, a higher image resolution under an unfavourable incidence angle may still not adequately detect vessels or activity.

Incidence angle is an especially important consideration for active sensors. These sensors emit energy and measure the degree of its return after transmission to the Earth's surface (or atmosphere) and subsequent reflection, refraction, or scattering. A passive sensor, in contrast, relies on an external energy source (for example, light emitted by the sun), and measures the return of this energy after reflection from the Earth’s surface and/or atmosphere.

Aerial Surveillance

Aerial surveillance can support satellite sensing in the detection of non-compliant activities. Besides traditional manned aviation methods, use of Unmanned Aerial Vehicles (UAVs) is increasing due to their application to MCS[1].

The main two types of UAVs are fixed-wing and quadcopters. Fixed-wing UAVs generally provide greater operation time and range and can carry heavier payloads of monitoring equipment. In the UK however, the extended range has limited advantage because in accordance with the Civil Aviation Authority, special permits are typically required to fly UAVs beyond 500m from the location of the pilot – known as Beyond Visual Line Of Sight (BVLOS). Although the fixed-wing UAVs are technically capable of flying further distances, legally this is subject to approval and a permit, which has associated cost and time requirements.

[1] MCS Application of UAV in the Southern IFCA district (https://fishingnews.co.uk/news/new-ifca-drone-proves-its-worth/)

Vessel tracking

Every vessel which transmits positional information on a regular basis shows a unique movement pattern, which allows the determination of the type of vessel and activity. Machine learning algorithm alerts can be generated when these patterns match specific activities in an area of interest, for example by associating the vessel track and speed with fishing activity types within an MPA.

Automatic Identification System (AIS)

AIS is a maritime collision avoidance system transmitted on marine Very High Frequency (VHF) radio and provides information on position, speed, course, and identity of a vessel. The data is publicly accessible and can be received by terrestrial antennae and satellites. Under the Merchant Shipping Regulations 2004 (as amended in 2011), fishing vessels of 15 m or more in length overall, UK registered or operating in UK waters, must be fitted with an approved (Class A) AIS. Although there is currently no requirement for vessels under this size to have AIS fitted, some vessels do choose to install units for safety purposes.

Vessel Monitoring System (VMS)

All commercial fishing vessels over 12m operating in the UK are required to carry VMS. The data is confidential and only shared between the vessel and flag-state. The frequency of transmission and usually once per 2-hour period for UK vessels.

Inshore Vessel Monitoring System (I-VMS)

Besides AIS and VMS, I-VMS is a tracking system specifically designed for fishing vessels in the UK that are below 12m. Currently I-VMS has only been rolled out as a pilot in certain parts of the UK but the system is scheduled for a wider roll-out in 2022.

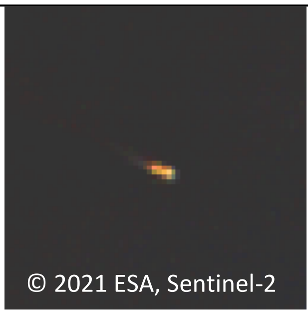
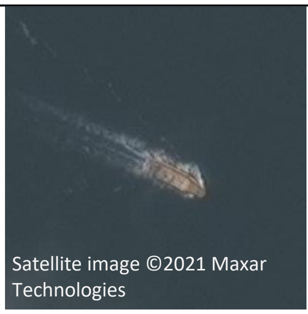
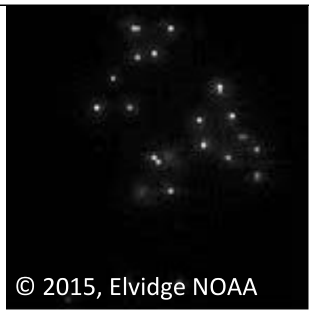
Remote Sensing

Not all vessels transmit positional information and even for those which do transmit, activity cannot always be determined with certainty. Remote sensing can improve analytical confidence and support the detection of 'dark vessels' - vessels not transmitting positional information. There are two main types of sensors used for this purpose, which complement each other well.

Electro Optical (EO)

Electro Optical sensors are passive sensors which receive visible, near infra-red and ultra-violet light from the sun. The light is reflected from earth, captured in different bands in a similar way to a camera. If light is emitted for example a vessel fishing during the night, this can be detected through a different sensor called, Visible Infrared Imaging Radiometer Suite (VIIRS). Use cases of both types of EO data are dependent on the resolution which can vary considerably between satellites (Table 1).

Table 1 | Different satellites available for EO imagery, the extent covered within one image (swath) and its resolution.

Satellite	ESA – Sentinel 2 (EO)	Digital Globe Constellation* (EO)	Suomi NPP (VIIRS)
Number of Satellites	2	6	1
Approximated extent [km^2]	111 x 111	(15 – 25) x (5 – 180)	Global coverage
Resolution [m]	10 - 30	0.3	350 – 750
Image example**			

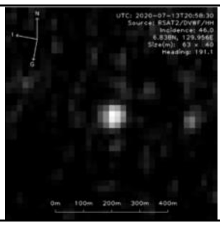
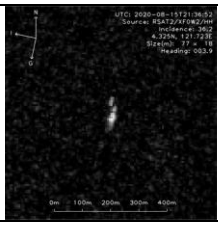
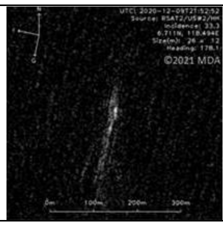
*Ikonos, Quickbird, Geoeye-1, Worldview I – III

** The vessel size of the Sentinel and Digital Globe image is similar, both detections appear to be transiting.

Synthetic-Aperture Radar (SAR)

SAR is an active sensor which sends pulses of electromagnetic waves over a targeted area. A portion of each pulse is reflected back to the sensor by objects within the resolution detection range. The strength of this reflection is dependent on the material properties of the object. Reflection intensity is translated into a black (no reflection) to white (maximum reflection) scaled image. If the electromagnetic waves have to cover a larger area, the pulse density decreases and so does image resolution which creates limitations in the maximum range covered by a single SAR image and the minimum detection size of a vessel (Table 2). This shows for instance that Wide Ultra Fine (WUF) mode holds the highest resolution but also covers the smallest area.

Table 2 | Different modes for SAR imagery, the extent covered within one image (swath), its resolution and a detection example of a confirmed target.

Mode	DVWF	XF	WUF
Name	Detection of Vessels Wide Far	Extra Fine	Wide Ultra-Fine
Approximated extent [km^2]	450 x 500	125 x 125	50 x 50
Resolution [m]	20	6.3	3
Example			
Description	Purse seiner	Purse seiner with by-boat	Purse seine operation

Analytical Assessment

Introduction

This chapter focusses on the assessment of the introduced technological solutions with respect to their MCS capabilities in the UK and how these solutions apply to the different sites and their limitations.

Satellites

Satellites enable remote global vessel tracking and detection, within frequent time periods, independent of long preparation and state permissions. OceanMind uses these remote capabilities to help inform decision makers on risks such as areas with potential Illegal, Unreported and Unregulated (IUU) fishing which in turn helps with the effective deployment of assets such as patrol vessels. Satellite imagery could also represent an important evidence source in prosecution cases.

Aerial Surveillance

Aerial surveillance can be used to further investigate risks which may have been detected by satellite surveillance. This allows the determination of exact locations, activity, and identity of vessels and to validate remote sensing observations and vessel tracks. However, restrictions on BVLOS UAV flights can make these operations cost-intensive in the UK.

Vessel tracking

From a monitoring and enforcement perspective, vessel tracking is a cost-effective way to determine the activity and identity of a vessel. Successful prosecutions can be mounted based on vessel tracking data, however supplementary evidence is often required. There are instances of successful prosecutions in the UK based on vessel tracking data. One of the main uses of vessel tracking is as an indicator for risk (for example there is a vessel operating at fishing speeds within an area closed to fishing), which would need to be followed up with surveillance.

Automatic Identification System (AIS)

While there can be good coverage of vessels over 15 m, the majority of the UK fleet is made up of vessels below this size. Furthermore, even for vessels over 15 m that are required to have AIS installed, the system is still not tamper-proof and therefore can be set-up by users to transmit false, or incomplete data or can simply be turned-off.

Inshore Vessel Monitoring System (I-VMS)

I-VMS is a lot more robust than AIS, as any changes to the data output is violating fisheries regulations and would be subject to investigation. Whilst on occasion I-VMS devices will not be able to send positional data (due to lack of network coverage), the devices themselves have a store-and-forward function. Furthermore, authorities understand the locations that suffer no network coverage and therefore know where to expect devices to not be sending positional information.

Remote sensing

Electro Optical (EO)

The use-case for EO is highly variable depending on the resolution. Application of low-resolution EO and VIIRS can be used to further increase the confidence of the occurrence of targets identified through other sources (such as SAR). High resolution EO data can determine vessel types, activity and, in some instances, positively confirm the identity of a vessel. The acquisition of reliable data is limited by reduced visibility on cloudy days and EO data is expensive.

Synthetic-Aperture Radar (SAR)

SAR satellites provide the most cost-effective way to obtain data on 'dark vessel' detections, while holding a high resilience to weather conditions and images are frequently available. However, it is not usually possible to detect if fishing activity is occurring. Furthermore, the identities of detections cannot be determined without supplementary information. Therefore, the use-case for SAR lies in the provision of intelligence on 'dark vessel' detections in areas where vessels exceed 10 m in length and are made from dense material (e.g. metal). Provided intelligence should be followed up with high resolution EO data or further surveillance.

UAV Capacity Assessment

Compared to remote sensing, UAVs hold the ability to precisely record the activity and identity of a vessel over a desired time period. This allows for a more direct enforcement application, where supplementary evidence may not be required, for example in cases where vessels are operating in closed areas, or outside of curfewed hours. UAVs can be utilized at a distance where they remain unnoticed or fly in close proximity for deterrence without compromising the health and safety of enforcement officers.

Short Range UAVs

UAVs which operate within the visual line of sight of the pilot are much cheaper to operate and do not require regular revision of flight permissions.

As an example, one of the leading providers, DJI, has developed a quadcopter solution, the Matrice 300 RTK, which is used by enforcement officers of different departments and all around the country. This unit has a 15 km range and can locate targets within a 1.2 km radius by triangulating the distance from the target in relation to the UAVs position.

Figure 1 | An IFCA officer prepares the Matrice 300 RTK for a test flight

Beyond Visual Line of Sight

Figure 2 | Marble fixed wing BVLOS UAV.

To overcome the BVLOS limitation, OceanMind has partnered with a UK supplier called Marble to use UAVs for offshore monitoring for the first time in the UK. Operations can cover the territorial waters (up to 12 NM from shore) once the correct CAA permits have been requested and approved. The fixed wing UAV has a visual range of 6 km and can operate for one hour. While this performance is superior to other UAV solutions, the costs are also higher so currently the use-case to replace possible deployments of patrol assets is limited.

Other BVLOS drones have a smaller range, and providers are often reluctant to acquire the necessary authorisations to use them to their full capability. These solutions may be more feasible in the future, if the BVLOS regulation is revisited and simplified. This would allow for these drones to more widely be adopted for MCS purposes.

Other Remote sensing technology methods

There are other remote sensing methods available which were considered as part of the scoping exercise but are unlikely to be used within this project. We continue to monitor and consider these methods since they may offer valuable insights or alternatives in the future.

Radio Frequency

Nearly all offshore communication is conducted by either marine radar, satellite communications, VHF radio, or emergency beacons. Radio Frequency (RF) solutions utilize these technologies to detect signal sources, including time location and orientation of the target. Whilst this creates a high confidence on the presence of a target, it currently does not provide any further insight into the identity of the source. This lack of further insight makes RF inefficient at its current cost level.

Aviation

A traditional method to monitor vessels is the use of small aircraft. Close-to-shore operations can be conducted with single engine aircraft, whilst offshore operations generally require the longer duration/range offered by more expensive twin-engine planes.

Aviation comes with similar advantages and disadvantages to UAVs. Whilst aircraft can operate longer and further offshore, and individual flights are currently more cost-effective small planes hold a higher risk to the health and safety because they are crewed, and aircraft emit more carbon equivalents than drones. An advantage of UAVs is that they can be acquired as an asset which reduces operational costs over longer time periods, whilst planes will always need to be requested and available.

Further limitations to the suitability of aviation are primarily due to regulation of aviation assets, which may make them less viable, especially as other technologies scale up and their regulations adapt. Therefore, aviation solutions will become less attractive and more resource intensive in comparison.

Terrestrial Monitoring Devices

Options for monitoring from land includes visual tools like Closed Circuit Television (CCTV), shore-based radar, and acoustic detection such as radio communications. Radio communications will require a monitoring station that will be known to vessel operators, and this offers strong deterrence for a specific area but is very resource intensive.

Patrol vessels and remote sensing

Deployment of patrol vessels can be both time and resource intensive. Patrol vessels also require significant capital investment as well as continued maintenance and upkeep.

Both IFCAs and the MMO are able to use sea-going assets in order to enforce and ensure compliance with regulations at sea. Both the IFCAs and the MMO have large areas to cover and sometimes with conflicting priorities. This is more challenging at sea than on land due to weather and sea conditions, logistical challenges (such as tidal constraints, vessel, and crew availability) as well as the sheer expanse of the area to be covered.

Remote sensing and vessel tracking are important tools in MCS - intelligence gathered can direct sea going assets to the right place at the right time, which provides a deterrence effect, resulting in greater compliance and enforcement. Research has shown that IUU fishing operations will significantly reduce when it is known that an area is regularly monitored (Rowlands et al., 2019).

Using remote sensing tools to direct patrol effort to high-risk areas can reduce costs, help make best use of limited resources and ultimately improve environmental protection. These tools may improve the intelligence and risk-based approach to enforcement practised by the IFCAs and MMO

Site Applications

Introduction

Each selected site has a unique setting which allows for the consideration and subsequent deployment of the most suitable MCS applications to different scenarios. Recommendations can then be made which may be applicable to other MPAs around the UK. This chapter will explore the technologies which are best suited to enhance MCS capabilities at the various sites and support the MMO and the IFCAs in their efforts to reduce non-compliance, where management measures apply.

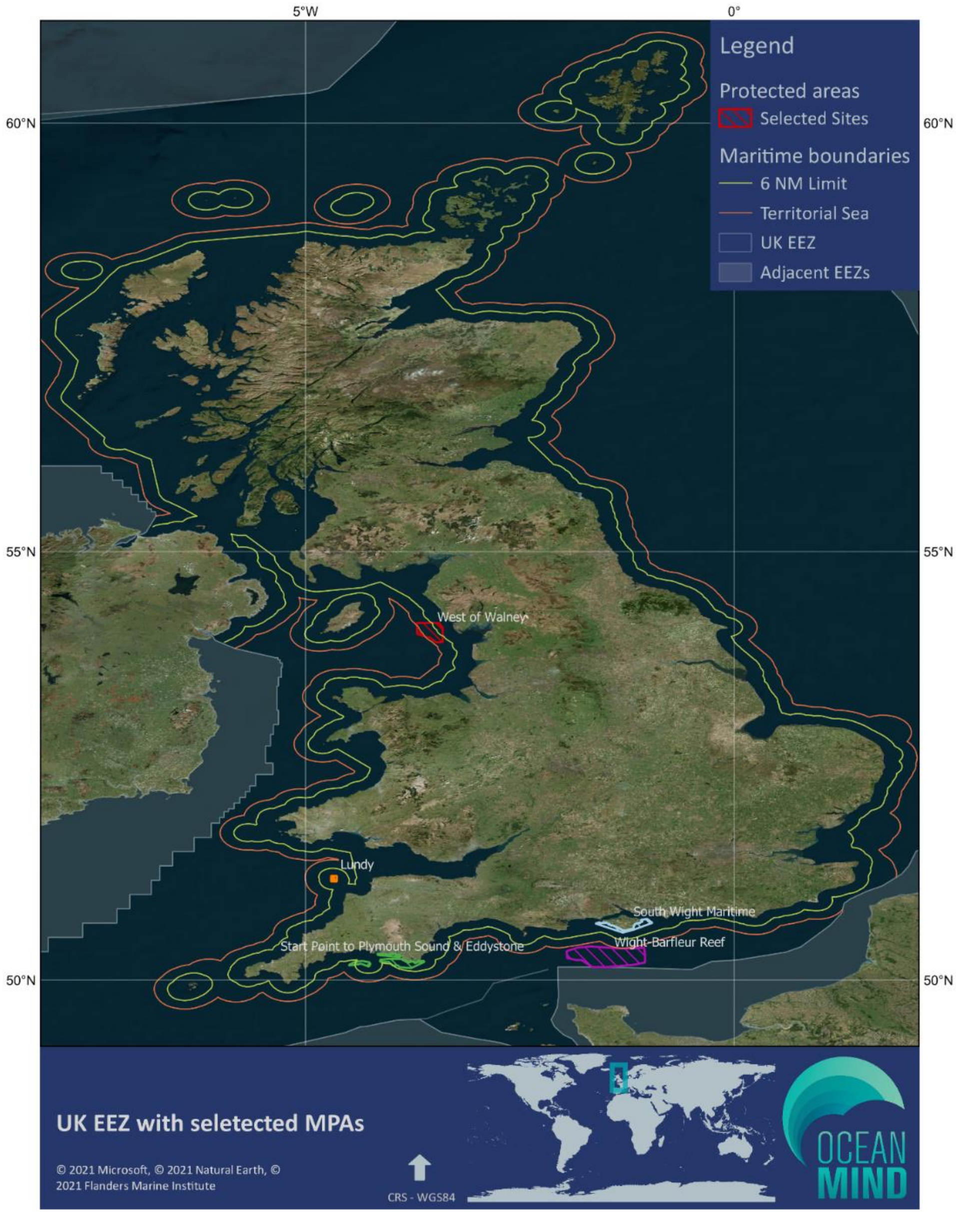
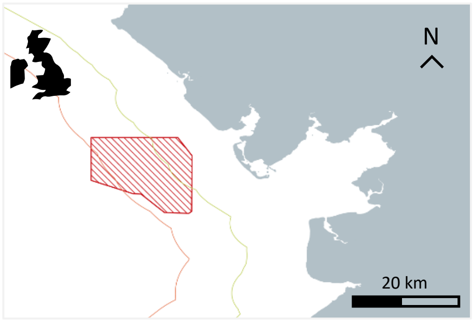


Figure 3 | Selected sites around the United Kingdom

West of Walney



West of Walney was proposed as a site for the project by the North Western IFCA. The West of Walney MCZ[2] is situated 8 km west of Walney Island and was formally designated in January 2016[3]. The West of Walney MCZ also falls within the Liverpool Bay SAC. Protected features at the West of Walney MCZ site include:

- Subtidal sand (Broad-Scale Habitat)
- Subtidal mud (Broad-Scale Habitat)
- Sea-pen and burrowing megafauna communities (Habitat Feature of Conservation Importance)

The soft mud habitat found in the West of Walney MCZ is also characterized by the presence of burrowing animals such as the Norway lobster (*Nephrops norvegicus)* and mud shrimp *(Callianassa subterranea).* Species such as *N. norvegicus* are of commercial interest to bottom towed gears. The site is the subject to a byelaw that closes much of this habitat to bottom towed gear within both the 6 and 12NM limit, however protection stops at the 12 NM limit.

Vessel tracking

Vessels within the site may use AIS, and larger vessels may have VMS fitted. I-VMS is not in use or operation within the site.

Remote Sensing

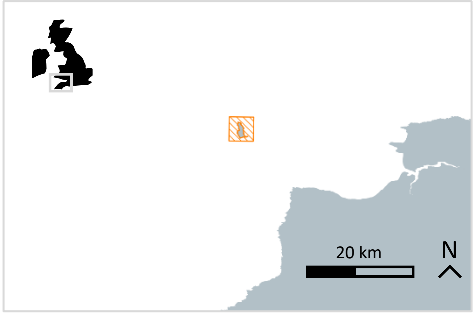
WUF-mode SAR is likely to be the primary remote sensing tool employed for the West of Walney MCZ, due to the profile of the vessels (<24 m, steel hulled vessels) potentially operating in and around the site and possible non transmission on vessel tracking systems. EO will primarily be used as a verification tool, due to the size of the MCZ.
Use of UAVs may be an option for monitoring of the West of Walney MCZ, although the site distance from shore necessitates the use of a fixed-wing design of UAV to operate beyond visual line of sight. However, a smaller, alternative design may be viable for launch from the NWIFCA patrol and enforcement vessel at sea. Options for this are being explored with the NWIFCA who have offered the potential use of their vessel if a suitable UAV can be sourced.
Close by Walney Island airport could provide manned aircraft operations as a viable alternative to UAV, however given the infrequent and irregular nature of towed bottom gear fishing vessels operating in the MCZ, speculative tasking of either UAV or manned flights to achieve effective coverage will not be cost effective.

Analytical assessment

Data collected will provide intelligence to the NW IFCA, in order to inform planning and support compliance and enforcement activity, including use of their patrol vessel the North Western Protector. Following the pilot, NW IFCA will have access to more information about risk areas and activity levels within and in proximity to the site.

[2] The West of Walney MCZ Factsheet
[3] The West of Walney Marine Conservation Zone Designation Order 2016

Lundy



Lundy was proposed as a site for the project by Devon & Severn IFCA (D&S IFCA). The Lundy MPA[4] encompasses several designations associated with different protections. The area was originally established as a Marine Nature Reserve in 1986 and in 2005 the area became a SAC[5]. In 2010 it became a MCZ and in 2016 in the whole MPA was included within the much larger Bristol Channel Approaches SAC.

Features at the site include:

- Reefs
- Sandbanks which are slightly covered by sea water all the time
- Submerged or partially submerged sea caves
- Grey seal, *Halichoerus grypus*
- Spiny lobster, *Palinurus elephas* (MCZ)
- Harbour porpoise, *Phocoena phocoena*

The granite and slate reef system at Lundy is an outstanding representation of reef habitats in South-West England. This range of physical conditions, combined with the site's topography, has resulted in the presence of diverse and complex marine habitats and associated marine communities within a small area. The site is the subject of several byelaws, most notably a no-take zone in part of site, and areas of the site that are closed to demersal mobile fishing gear e.g. dredgers and trawlers.

Vessel tracking

Commercial fishing vessels between 6.99 and 15.25m in length that operate with bottom towed gear within the Devon and Severn IFCA district must have a fully functional I-VMS unit working whilst in the district. Vessels may use AIS within the area, and larger vessels (>12 m) are fitted with VMS. All of these vessel tracking technologies can be used, but it is notable that some non-fishing or recreational vessels within the site will not have a requirement to have any of these fitted, and as a result there is limited knowledge and information to understand site use by these vessels.

Remote Sensing

Electro Optical (EO) is the primary remote sensing technology chosen for this site; the MPA is small the key areas can easily be covered using EO imagery. The higher resolution of the imagery will allow for a more accurate assessment of vessel type and site use to support ongoing monitoring controls and surveillance. SAR will be used to supplement EO and to give a better understanding of overall activity within the site.

Analytical assessment

Data collected will provide intelligence to the D&S IFCA, in order to inform planning and support compliance and enforcement activity. Following the pilot D&S IFCA will have more information about risk areas and activity levels within the site.

[4] Lundy MCZ Factsheet
[5] The Lundy Marine Conservation Zone Designation Order 2013

Start Point to Plymouth Sound & Eddystone

This large Special Area of Conservation (SAC) was proposed as a site for the project by Cornwall IFCA. The area is a straddling site with multiple competent authorities including Devon and Severn IFCA and the MMO. The site has three distinct areas, Eddystone (Area A), Bigbury Bay to Plymouth Sound (Area B) and Start Point to West Rutts (Area C)[6]. Features at the site include numerous areas of inshore and offshore reef, notably bedrock reef.

Management locally is shared by several authorities who must work co-operatively to safeguard the area. There are byelaws in place including spatial closures with fishing corridors for active gears (trawlers)[7]. Scallop dredgers are subject to curfew hours to limit fishing effort[8]. Limited resources, the exposed nature of the site and the issue of patrol efforts often being sighted before arrival create challenges to the enforcement.

Vessel tracking

Commercial fishing vessels between 6.99 and 15.25m in length that operate with bottom towed gear within the Devon and Severn IFCA district must have a fully functional I-VMS unit working whilst in the district. Vessels may use AIS within the area, and larger vessels (>12 m) are fitted with VMS. Historic analysis of AIS transmission could give some insight into site use and activity and how this has changed over time.

Remote Sensing

High resolution SAR will be used over the site to detect the fishing and recreational vessels. Tasking of this imagery will cover the area twice a week and will be followed up with high-resolution EO imagery for secondary validation.

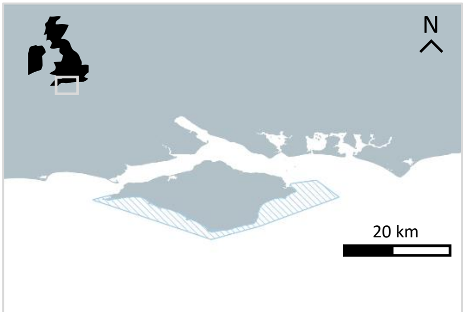
UAVs have been used by Cornwall IFCA to support enforcement and surveillance efforts over their inshore sites, however these UAV flights were restricted to Line of Sight (LOS) operation only and so had very limited applicability. This site is ideal for testing the capabilities and applicability of the larger BVLOS UAVs. The offshore Eddystone site can be reached from shore with the larger drone which will support MCS efforts, and the extended inshore sites can be covered with a flight from a single take off/vantage point.

Analytical assessment

Data collected will provide intelligence to Cornwall IFCA, D&S IFCA and the MMO to inform planning and support compliance and enforcement activity. This type of intelligence gathering has been used in other territories to support patrol efforts in real time and it is hoped that the pilot trials, particularly the UAV flights, can coincide with patrol activity to help direct interceptions. The remote sensing methods selected will give some really useful insight into site activity and highlight areas of high risk.

[6] Further information regarding the site features can be found here.
[7] The Start Point to Plymouth Sound and Eddystone European marine site (specified areas) bottom towed fishing gear byelaw.
[8] Scallop Dredge (Limited fishing Time) byelaw

South Wight Maritime



South Wight Maritime sits wholly within the Southern IFCA district. Dover sole and other benthic species are mainly targeted by commercial trawling gear, the spring months are the prime fishing period. A byelaw which came in to force in 2012 (updated in 2016) protects vulnerable features from these gears[9]. Features at the site include:

- Reefs
- Vegetated sea cliffs of the Atlantic and Baltic Coasts
- Submerged or partially submerged sea caves

The site represents a wholly inshore MPA; this site is difficult to monitor, as patrol efforts are often sighted before arrival therefore alerting possible operators within the area. The area is also relatively exposed and difficult to access from the mainland[10].

Vessel tracking

Most vessels do not exceed 12m in length and are not equipped with AIS or VMS units. However, there are some vessels of interest which will be monitored when they operate in proximity to the AOI.

Remote Sensing

Since vessel tracking and on-site monitoring have limitations for this site, remote sensing will be useful for MCS efforts. Because of the variation in vessel material between sizes and types of fishing vessels both EO and SAR data will be useful for the site and give good insight into fishing activities, which currently has limited quantitative information.

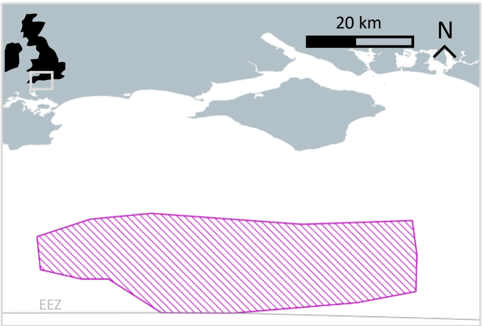
Analytical assessment

The Sandown airport and the proximity to land may support single engine aviation operations as a viable alternative. Double engine planes could allow monitoring of the SAC in combination with Wight Barfleur. These flights could be undertaken in combination with risk assessments using SAR imagery in XF-Mode, which would allow coverage of both sites with a single image. OceanMind is currently still assessing the effectiveness of such an operation compared to BVLOS UAV flights.

The combination of remote sensing with more traditional on the ground monitoring will significantly increase awareness of the fishing activity around the SAC and will likely improve compliance with the management measures. This could further inform decision makers to improve fisheries and environmental management in the South Wight Maritime area.

[9] The Southern IFCA bylaws booklet: Bottom Towed Fishing Gear Bylaw 2016 (Page 10-24)
[10] More information about the South Wight Maritime SAC can be found on the Natural England site here.

Wight-Barfleur



The Wight-Barfleur SAC sits between 6 NM and 12 NM in the English Channel and is managed by the MMO. Target species include a range of finfish and shellfish species, targeted by potters, trawlers, and dredgers fishing from both the UK and Europe. The SAC was established in 2019 and covers an area of 138 km^2. The site was selected because it can provide important insight into monitoring and surveillance of offshore sites in the UK, especially those with possible foreign flagged vessel incursions.
Features at the site include bedrock and stony reef with rocky outcrops, ridges, and channels. The stony reefs support a large array of reef fauna[11].

Vessel tracking

With sizes ranging between 12 – 80 m, all fishing vessels operating in proximity to Wight-Barfleur should be equipped with AIS and/or VMS. Vessel tracking will therefore play a critical role to better understand the activity on the site. Comparing VMS and remote sensing data with AIS data will allow for a better understanding of AIS use within the site. Using OceanMind's machine learning algorithms on the vessels may further support the MMO to identify risks faster and more efficiently in the future, but would require access to VMS data which is not currently accessible.

Remote Sensing

Since it is expected that the vessels will transmit positional information, remote sensing holds mainly a verification purpose for the Wight-Barfleur SAC. SAR will be used to detect possible 'dark vessels'. Due to the size of the SAC and the vessels, imagery in XF-Mode will be collected, which may partly cover the South Wight Maritime SAC as well. This will ensure the greatest coverage of imagery over the large area SAC to detect the fishing vessels operating in the area (12-25 m).

Analytical assessment

While Wight-Barfleur and South Wight Maritime sites are used by different vessel types and have different risks, the proximity of the sites allows us to pilot remote sensing methods over both sites at the same time. Besides SAR, this may include trialling aviation to compare it to other sensing techniques and to determine the accuracy of the vessel tracks and satellite imagery.

[11] Further information about the Wight-Barfleur Reef can be found in the JNCC Final Impact Assessment.

Annex

Table 3 | List of methodology used for each site. Bracket in cells for SAR and EO relates to the dependence of data availability from the satellite. Aviation has not been confirmed.

Methodology \ Site	West of Walney	Lundy	Start Point to Plymouth Sound and Eddystone	South Wight	Wight-Barfleur
SAR WUF	–	✓	✓	✓	–
SAR XF	✓	–	✓	(✓)	✓
EO	(✓)	✓	(✓)	(✓)	(✓)
UAV	✓	–	✓	–	–
Vessel Tracking (AIS)	✓	✓	✓	✓	✓
Vessel Tracking (I-VMS/VMS)	–	✓	✓*	–	✓
Aviation	–	–	–	(✓)	(✓)

*Only available in the Devon and Severn IFCA part of the site.

UK MPA Project: Phases and Timeline