Evaluating BRUV methods for key, small-scale biodiversity projects within data-deficient sites.

Dissertation is submitted in part fulfilment of the Marine Environmental Management MSc

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DECLARATION

I, Lauren Storer, declare that the work submitted in this dissertation is the result of my own work and investigation and all the sources I have used have been indicated by means of completed references.

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Date: ……………22/09/2020………………………………………………

Abstract

Baited Remote Underwater Video (BRUV) methods are increasingly being promoted as a non-destructive, standardized approach for monitoring marine biodiversity to improve upon traditional surveying techniques. This has led to their use in 2018/19 by the Alderney Wildlife Trust (AWT) within a trial biodiversity project, in which camera units were deployed at 14 sites around the island. This study aimed to assess the results of this project, to improve the current understanding of the fish/shellfish biodiversity in Alderney's territorial waters and provide a critical evaluation of the survey method. To do this, the video footage was reviewed, and measures of species richness (Number of species) and relative abundance (MaxN) were recorded for each site, with the mean species richness compared between 2018 and 2019. Comparisons of species richness between sites and of MaxN could not be made due to a lack of sample repetitions and low abundances. To evaluate the ability of the current method to record accurate diversity levels, species richness was compared against previous UVC surveys in the area. In addition, the attraction success of the bait choice was examined, alongside the effectiveness of the length of deployment times for recording all species. Overall, the BRUV systems recorded 12 species across 12 useable videos, with no significant difference in species richness found between the two years. Prevalent species across all sites include *P.pollachius* and *L.bergylta*, whilst *A.tobianus* was found to have the highest relative abundance overall. Despite providing a useful indication of the species present within Alderney's territorial waters, the BRUV method only recorded 20% of the diversity reported by SeaSearch divers in 2018/19, only one species was shown to actively feed upon the bait (*S.stellaris*) and multiple deployments did not meet the soak time needed to record the mean first arrival time of all species. Therefore, it is recommended that the AWT utilise an oilier bait choice to increase the olfactory attraction of the bait plume, ensure all deployment soak times are above 65 minutes and increase the sampling effort of the BRUV surveys to at least 4 replicates per site, set >200m apart, with the same sites sampled each year to allow for more accurate temporal and spatial comparisons.

Keywords: Baited Remote Underwater Video (BRUV); Biodiversity; Alderney Wildlife Trust

1. Introduction

The conservation of marine ecosystems is a key target for governments and environmental organisations internationally (Hastings *et al.*,2012). Persistent threats from human activities have resulted in commitments to ocean protection, for example through the Convention on Biological Diversity (CBD) and the Ramsar Convention (Campbell and Gray, 2019;Davidson, 2018). However achieving these goals requires a detailed understanding of ocean biodiversity, i.e. the variety of flora and fauna, in order to produce effective management plans. The challenging conditions of the underwater environment can make monitoring difficult; nevertheless improvements over time, through increased knowledge and technology, have allowed for a wide range of available methods (Colton and Swearer, 2010;Murphy and Jenkins, 2010). Therefore, it is critical that surveying techniques are regularly reviewed to ensure their continued effectiveness (Sala and Knowlton, 2006).

Traditional methods, i.e. bottom trawl surveys, have often been capture-based; however their destructive nature can compromise management objectives by impacting the ecosystem and biasing future surveys (Brooks *et al.*,2011). Alternative fisheries-independent methods have included a variety of visual census techniques, such as Underwater Visual Census (UVC), whereby divers or snorkellers record their on-site observations (Stobart *et al.*,2007). Whilst UVC methods are non-destructive, relatively cheap and do not require lab work, sources of error have been raised (Colton and Swearer, 2010). For example, all surveys involving diving are constrained by environmental conditions and the accuracy of recordings is dependent upon observer skill level (Stobart *et al.*,2007). Furthermore, studies have identified species-specific variability in attraction/repulsion behaviour of marine organisms towards divers, creating bias in observations, which reduces their accuracy (Langois *et al.*,2010).

Remote methods, where sampling occurs independently of an observer i.e. by using video equipment, have been suggested as an alternative or complementary monitoring technique (Cappo *et al.*,2006). The principal advantage of remote video methods is their success in overcoming some of the biases of UVC, i.e. responses of fish to human presence, as they do not require observers to be present in the field (Brooks *et al.*,2011). Additionally, they can be deployed in inaccessible environments (i.e. depths beyond 40m), are not size selective in the species they record, can be used for long periods of time and perhaps most importantly, provide a permanent record for validation by multiple observers (Langois *et al.*,2010). Remote video methods have grown in popularity in recent years due to technological improvements and cheaper underwater cameras (Stobart *et al.*,2007).

Baited remote underwater videos (BRUVs), whereby cameras are attached to stationary objects along with an accessible bait source and set underwater for a period of time, are now commonly used to study marine populations (Mallet and Pelletier, 2014). They are thought to be particularly useful for sampling large carnivorous species which are attracted to the bait but would otherwise avoid divers and for increasing fish counts by attracting individuals from wide areas (Stobart *et al.*,2007). Numerous studies have compared BRUV methods to traditional UVC techniques and found BRUV to be highly suitable for monitoring fish assemblages e.g. De Vos *et al.*,2013;Schramm *et al.*,2020. In contrast, BRUV surveys have received criticism over bias introduced by using bait which may not attract all species, a failure to capture cryptic species which may only be viewed by close inspection of the substrate and an inability to measure density due to an unknown attraction area of the bait (Lowry *et al.*,2012). There are also variable approaches to the design of BRUV surveys, with differences in the choice of bait, length of the BRUV deployment and the camera technologies used across studies (Whitmarsh *et al.*,2017).

The Alderney Wildlife Trust, a member of the UK-wide group of Wildlife Trusts, trialled the use of BRUV methods in 2018-2019 in multiple offshore sites, to survey fish and shellfish biodiversity. Prior to these trials, data was limited to information provided by local SeaSearch dive surveys, a voluntary project conducted by recreational divers, and overall there is a widespread deficit of information regarding marine life in certain areas. Currently the AWT has no results from these surveys and consequently has no estimate of the suitability of the BRUV methodology. Therefore, firstly this study aims to assess the 2018/19 BRUV trial results in order to provide baseline information on fish/shellfish presence, abundance and distribution in Alderney's territorial waters. Secondly, this study aims to critically evaluate the current survey techniques in order to provide recommendations for the future. Evaluation will focus largely on aspects of survey design that are frequently raised in the literature as factors which influence the success of BRUV surveys, such as a) the ability of the BRUVs to accurately represent true fish/shellfish diversity; b) the suitability of the bait choice; c) the length of deployment times.

If successful this study will contribute to both the baseline understanding of the marine life around Alderney and the improvement of the organisations surveying techniques, which will ultimately support more accurate management of important ecological sites around the island.

2. <u>Method</u>

2.1. <u>Study Location</u>

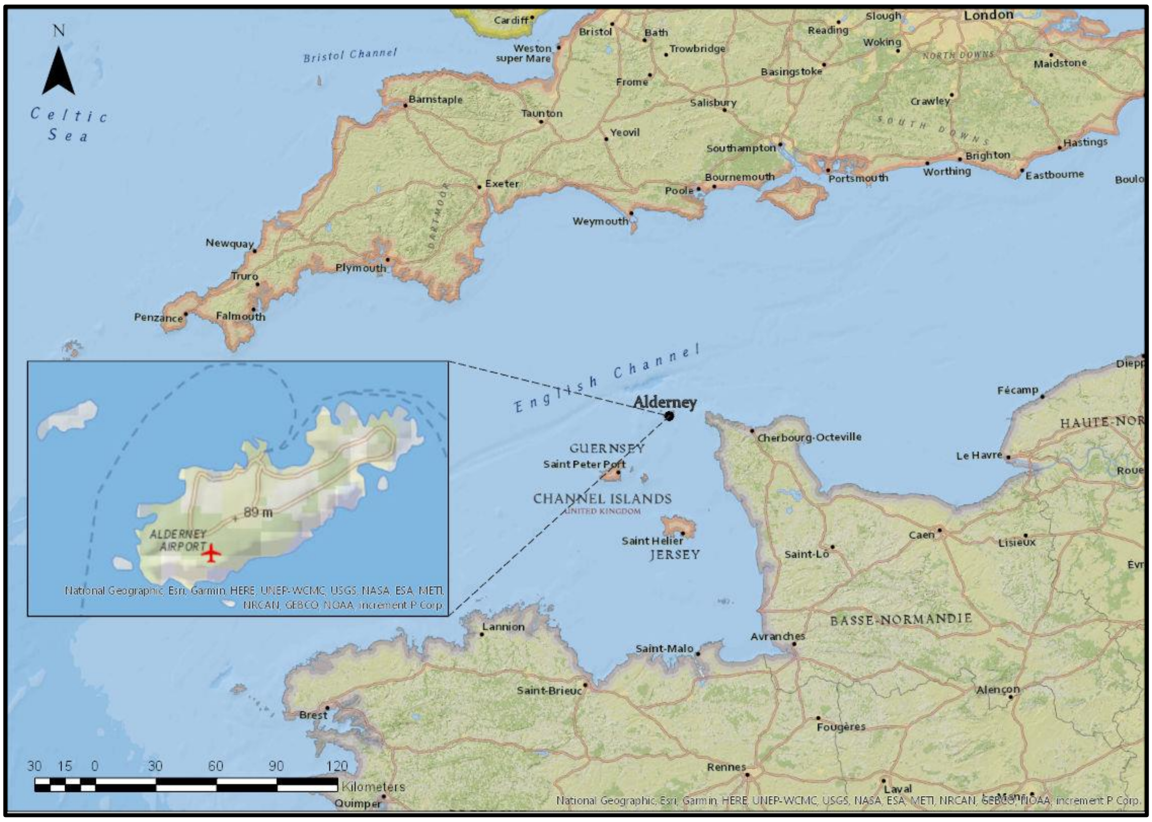

Figure 1: Geographic location of Alderney and surrounding islets within the English Channel.

Alderney is located within the English Channel Islands, a collection of British Crown Dependencies situated between the southern coast of England and the northern coast of France (Chambers, 2008;Knight, 2015). Alderney is the third largest Channel Island at ~8km^2 in area and the most northerly (Wood, 2010). The marine environment is characterised by nutrient rich waters, a highly varied landscape and strong ocean currents which form renowned tidal streams known as 'The Swinge' and 'The Race' (Chambers, 2008; Pienkowski, 2005). A mild Atlantic climate contributes to diverse flora and fauna and previous research suggests that many species present on Alderney are absent in nearby areas, as they exist here at the limit of their geographic distribution (Chambers, 2008). The AWT's BRUV surveys occurred primarily within the Alderney West Coast and Burhou Islands Ramsar site, which was designated in 2005 and covers 15,629km^2 (AWT, 2016).

2.2.<u>Data Collection</u>

Sampling was conducted between August – October 2018 and July – September 2019 by the AWT. In total 14 locations were sampled, with one BRUV unit deployed per location. Sites were chosen for deployment semi-randomly in an opportunistic manner, based on ease of access, weather and tidal conditions and sampling was undertaking between 9:00am and 18:00pm. The BRUV units used were similar in design to previous BRUV biodiversity studies (e.g. Cappo *et al.*,2006) and consisted of a GoPro camcorder mounted upon a metal frame, opposite a bait container (Figure 2). Bait consisted of discarded whiting pieces from local fishermen. Two differing BRUV frames (cage and lobster pot) were used throughout the study period, due to limited resources, but the differences in system were assumed to have a negligible impact upon fish presence, if any. In 2018 the bait container was a plastic box, whilst in 2019 the container was changed to a mesh bag. BRUV frames were lined with a subsurface buoy to keep the camera view clear and marker buoys to aid with retrieval. Once the camera was set to record mode, the units were lowered to the seabed, between depths of ~5-18m and submerged for ~60 minutes, although soak times varied. Time, depth and GPS location were recorded alongside any relevant weather or disturbance information (i.e. marine traffic). After the allotted time the BRUV unit was retrieved and the video footage uploaded.

Figure 2: BRUV units used in surveys. Left: Lobster pot unit with attached bait box and GoPro camera out of view. Right: Cage unit with attached bait box and GoPro camera visible . (photo crd. S Robertson) Source: Alderney Wildlife Trust, 2020.

2.3.<u>*Video Analysis*</u>

Analysis of footage was carried out by a single observer, beginning 5 mins after the apparatus settled on the seabed to allow for disturbances to settle (Langlois *et al.,* 2018). A description of the habitat was recorded alongside each fish/shellfish sighting, including the time of arrival and exit. Each species was identified to the lowest possible level. If identification could not occur due to poor water visibility, the individual was recorded as 'unknown'. Individuals observed over 8m from camera were automatically rejected due to the known decline in accuracy of recording software beyond 8m (Harvey *et al.*,2010). MaxN (the maximum number of individuals of a species observed at any one time) was used as a measure of relative abundance to avoid double-counting of the same individual (Santana-Garcon *et al.*,2014). The behaviour of each individual was recorded and categorised as either 'ignores bait' or 'eats bait' to determine the attraction success. Videos with obscured footage, i.e. vegetation obstructing the lens, were rejected.

2.4. *Quantitative and Statistical Analysis*

2.4.1. Assessing the 2018/2019 trial BRUV results.

All statistical analysis was conducted using the IBM SPSS Statistics 26 software. Species identification was determined following Plaster and Chambers, 2018 and personal communication with Dr Melanie Broadhurst-Allen, Alderney Wildlife Trust.

a) *Species richness.* To provide a baseline measure of diversity, the total number of species observed in all footage was quantified. However, as the video footage from each location varies substantially in length, (from just over 26 minutes to 98 minutes) the sampling effort was standardized prior to further analysis. Hence, only species observed within the first 50 minutes of each video (after the 5-minute resting period) were included in spatial and temporal comparisons. Due to this, the footage from site 10 (Ortac 2), at only 26 minutes in length, was excluded from comparisons. A Shapiro-wilk test for normality showed that the standardized data followed a normal distribution and the Levene's Test showed variances to be equal. Therefore, the mean number of species present in each 50-minute video, was compared between 2018 and 2019 using a t-test to determine any differences in species presence between the two years. Due to a lack of repetitions at each deployment location, spatial differences in species richness could only be compared to a basic level.
b) *Species abundance.* The prevalence of each species was recorded as the number of samples in which a species occurred as a proportion of all samples. In addition, the total relative abundance of each species was given by the Sum of MaxN values for each species divided by the number of sites sampled i.e. Mean MaxN. As previously noted, due to limited data quantities, statistical comparisons of MaxN could not be made between species.

2.4.2. Critical Evaluation of Current BRUV Survey Techniques

a) Ability to accurately represent true diversity. To provide an indication of how accurately the BRUV technique measures the diversity of Alderney's territorial waters, the total species richness and species identity recorded by the BRUVs were compared against the results of Seasearch surveys undertaken in 2018/2019. Detailed comparisons were made between Longis and Clonque Bay, as these were the only sites sampled by both methods.
b) Choice of bait for increasing abundance counts. To determine the success of the bait in attracting individuals to the BRUV unit, the proportion of occasions in which a fish/shellfish was observed on the footage and approached the bait was quantified.
c) Survey Design. To provide an indication of whether the AWT is employing an appropriate soak time, the average time of first arrival i.e. the time in each deployment at which the first fish/shellfish was observed was calculated across all species and for each species to determine the time taken for all species to be recorded.

3. Results

In total fourteen BRUV deployments were conducted by the AWT, (eight in 2018 and six in 2019), (Figure 3). Videos from two deployments (sites 4 and 9) were excluded due to obstruction of the camera. This provided just over 13 hours and 56 minutes of useable footage. The majority of deployment locations were within the Ramsar site, with one deployment conducted within the Longis Nature Reserve. In 2018, deployments were spread widely around the island, with distances of up to 2.4km between neighbouring sample sites, whereas in 2019 deployments focused solely on the Ramsar Site but were spaced up to 2.9km between adjacent sites.

Figure 3: Locations of Baited Remote Underwater Video deployments around Alderney shown as coloured points, red points represent surveys conducted in 2018 and blue points represent surveys conducted in 2019 . The Alderney West Coast and Burhou Islands Ramsar site is represented by the green shaded area and Longis Nature Reserve is represented by the yellow shaded area. . 1 = Clonque Bay, 2 = Hannaine Bay 1, 3 = Burhou 1, 4 = Burhou 2, 5 = Platte Saline 1, 6 = Platte Saline 2, 7 = Behind Burhou 1, 8 = Behind Burhou 2, 9 = Ortac 1, 10 = Ortac 2, 11 = Behind Burhou 3, 12 = Longis Bay, 13 = Crabby Bay, 14 = Hannaine 2.

Regions of Alderney's seabed had previously been mapped as part of the European Marine Observation and Data Network (EMODnet) initiative in which an 'EUSeaMap' was created and the benthic habitats classified under the EU-wide EUNIS system (EMODnet.eu, 2020). Whilst some BRUV sites were located in unclassified areas, all other points were either situated within 'infralittoral rock and biogenic reef' or 'infralittoral coarse sediment' (Table 3). However, analysis of the BRUV footage shows in higher detail that the habitats varied from bare sand to densely vegetated mixed rock substrate, with surveys in both years covering a range of habitat types (Table 3). Appendix 1 shows the habitat types in more detail with images taken from each deployment.

Table 1: Location descriptions of the BRUV deployments conducted by the Alderney Wildlife Trust, based on video footage. 'EUINS Classification' shows the broad-scale seabed habitat classification given by the EUSeaMap as part of the European Marine Observation and Data Network (EMODnet) initiative. Shaded sites were excluded from comparisons.

Deployment	Year	Location	Habitat Description	EUINS Classification
1	2018	Clonque Bay	Dense kelp/algal growth	Infralittoral rock and biogenic reef
2	2018	Hannaine	Dense kelp/algal growth	Unclassified
3	2018	Burhou	Rocky bottom and sparse algal growth	Unclassified
4	2018	Burhou	Rocky bottom and dense algal growth	Unclassified
5	2018	Platte Saline	Sandy bottom	Infralittoral rock and biogenic reef
6	2018	Platte Saline	Dense kelp/algal growth	Infralittoral rock and biogenic reef
7	2018	Behind Burhou	Sandy bottom	Unclassified
8	2018	Behind Burhou	Unclear	Infralittoral rock and biogenic reef
9	2019	Ortac	Dense kelp/algal growth	Infralittoral coarse sediment
10	2019	Ortac	Dense kelp/algal growth	Infralittoral course sediment
11	2019	Behind burhou	Dense kelp/algal growth	Infralittoral rock and biogenic reef
12	2019	Longis	Sandy bottom and sparse eel grass (*Zostera marina*)	Unclassified
13	2019	Crabby Bay	Unclear	Infralittoral coarse sediment
14	2019	Hannaine	Sandy bottom	Infralittoral rock and biogenic reef

3.1.1. Diversity

Overall, 11 fish and 1 crustacean taxon were identified from 11 different orders, with 9 taxa recorded as present in 2018 and 7 in 2019 (Table 1). Whilst some species were present across both years, within each year unique species were also observed. Nine out of 11 taxa could be identified to species level, whilst three could only be identified down to order level due to the poor quality of footage. In three videos no fish/shellfish were recorded (sites 8, 10 and 14).

Table 2: Total number of different taxa observed in all recorded footage. X represents species presence.

Species Description				Deployment Site										
				2018							2019			
Common Name	Species	Family	Order	1	2	3	5	6	7	8	11	12	13	14
Pollack	*Pollachius Pollachius*	*Gadidae*	*Gadiformes*	x	x	x	x	x	x		x			
Ballan Wrasse	*Labrus Bergylta*	*Labridae*	*Labriformes*	x	x		x	x	x		x		x	
Goldskinny Wrasse	*Ctenolabrus rapestris*	*Labridae*	*Labriformes*		x						x			
European Sea Bass	*Dicentrarchus labrax*	*Moronidae*	*Perciformes*		x		x							
Two-spotted Goby	*Gobiusclus flavescens*	*Gobiidae*	*Gobiiformes*			x		x					x	
Lesser Sand Eel	*Ammodytes tobianus*	*Ammodytidae*	*Trachiniformes*				x							
Atlantic Mackeral	*Scomber scombrus*	*Scombridae*	*Scombriformes*				x							
Greater Spotted Dogfish	*Scyliorhinus stellaris*	*Scyliorhinidae*	*Carcharhiniformes*								x			
Thick-lip Grey Mullet	*Chelon labrosus*	*Muglidae*	*Mugiliformes*									x		
Unknown	*Unknown*	*Unknown*	*Pleuronectiformes*				x							
Unknown	*Unknown*	*Unknown*	*Rajiformes*				x							
Unknown	*Unknown*	*Unknown*	*Isopoda*									x		
Total number of species per site				2	4	2	7	3	2	0	4	2	2	0
Total number of species per year				9							7			
Total number of unique species per year				5							2			

After standardization of sampling effort only 11 species were included for analysis (Table 3), with the data suggesting that diversity was highest at site 5 (Platte Saline 1) where 6 species were observed within the first 50 minutes of recording and lowest at sites 8 (Behind Burhou 2) and 14 (Hannaine 2) where no species was recorded (Figure 1). However, differences in species richness between locations cannot be tested statistically due to the lack of sufficient repetitions at each site. On average 2.29±1.89 taxa were present per site in 2018 and 2.0±1.63 in 2019, however the mean number of species recorded did not differ significantly between the two years (*$t = 0.252$, $df = 9$, $p = 0.744$*), (Figure 2).

Table 3: Species present at each BRUV deployment site within the standardised sampling effort (the first 50 minutes of footage).

	BRUV Deployment Site										
Species	1	2	3	5	6	7	8	11	12	13	14
P. pollachius	X	X	X	X	X	X		X			
L. bergylta	X	X		X		X		X		X	
C.rapestris		X						X			
D. labrax				X							
G. flavescens			X							X	
A.tobianus				X							
S.scombrus				X							
S.stellaris								X			
C.labrosus									X		
Rajiformes sp.				X							
Isopoda sp.									X		

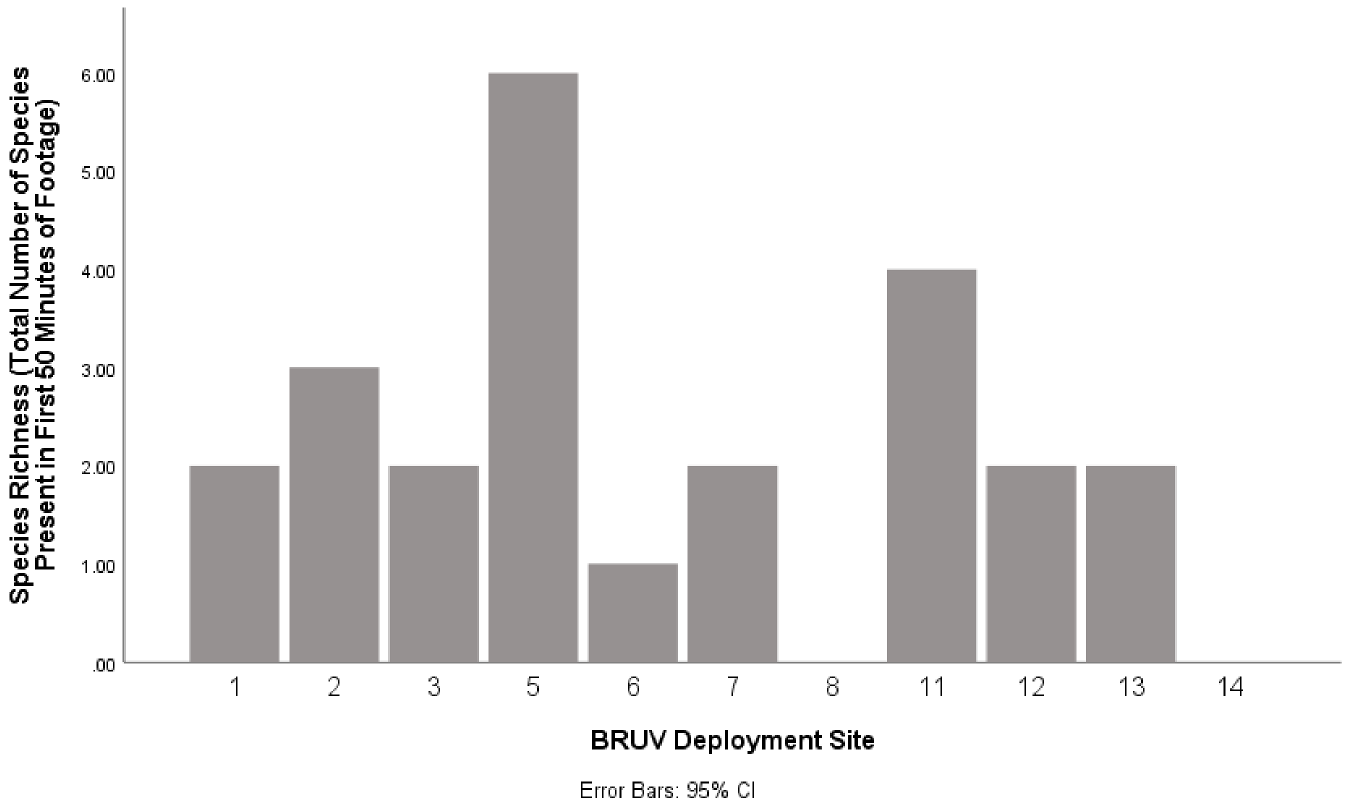

Figure 1: The species richness recorded within the first 50 minutes of recording at each BRUV deployment site within Alderney's territorial waters.

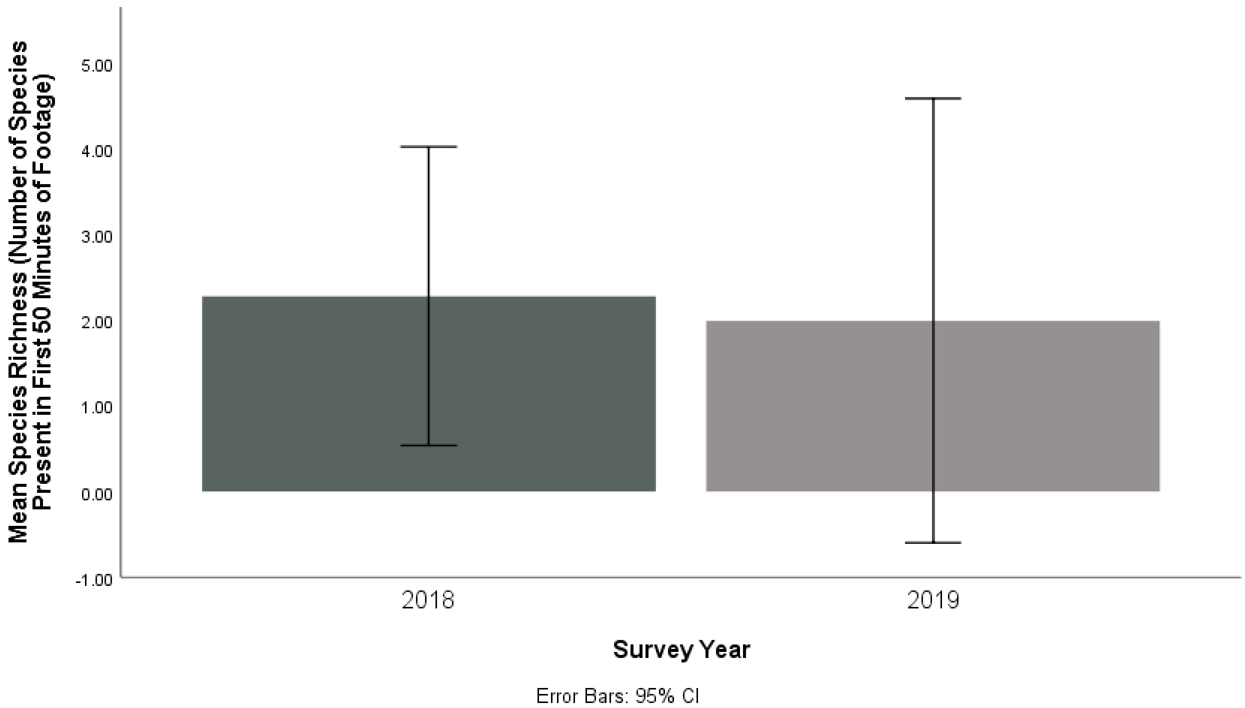

Figure 2: The mean number of species observed to be present within the first 50 minutes of each BRUV deployment in each year within the territorial waters of Alderney, English Channel Islands.

3.1.2. Abundance

Pollachius pollachius (Pollack) was most prevalent on the video footage, observed in 58.3% of deployments over the study period, followed by *Labrus bergylta* (Ballan Wrasse) present on 50% of videos, *Ctenolabrus rapestris* (Goldskinny wrasse) and *Gobiusclus flavescens* (Two-spotted goby), each present on 16.7% of videos. The remaining taxa were observed on only one video each (8.3% of videos). Despite only being present at one deployment site, *A. tobianus* (Lesser sand eel) very clearly has the highest relative abundance (Mean MaxN) due to its shoaling behaviour resulting in over 500 individuals being recorded at once. However, the high density of the shoal prevented a more accurate MaxN from being measured, and therefore this species was removed from further analysis of abundance. *G. flavescens* , has the second highest relative abundance, with a mean MaxN of 0.75 individuals across all sites and years, followed by *P.pollachius* and *L. bergylta*, each with a Mean MaxN of 0.58 individuals.

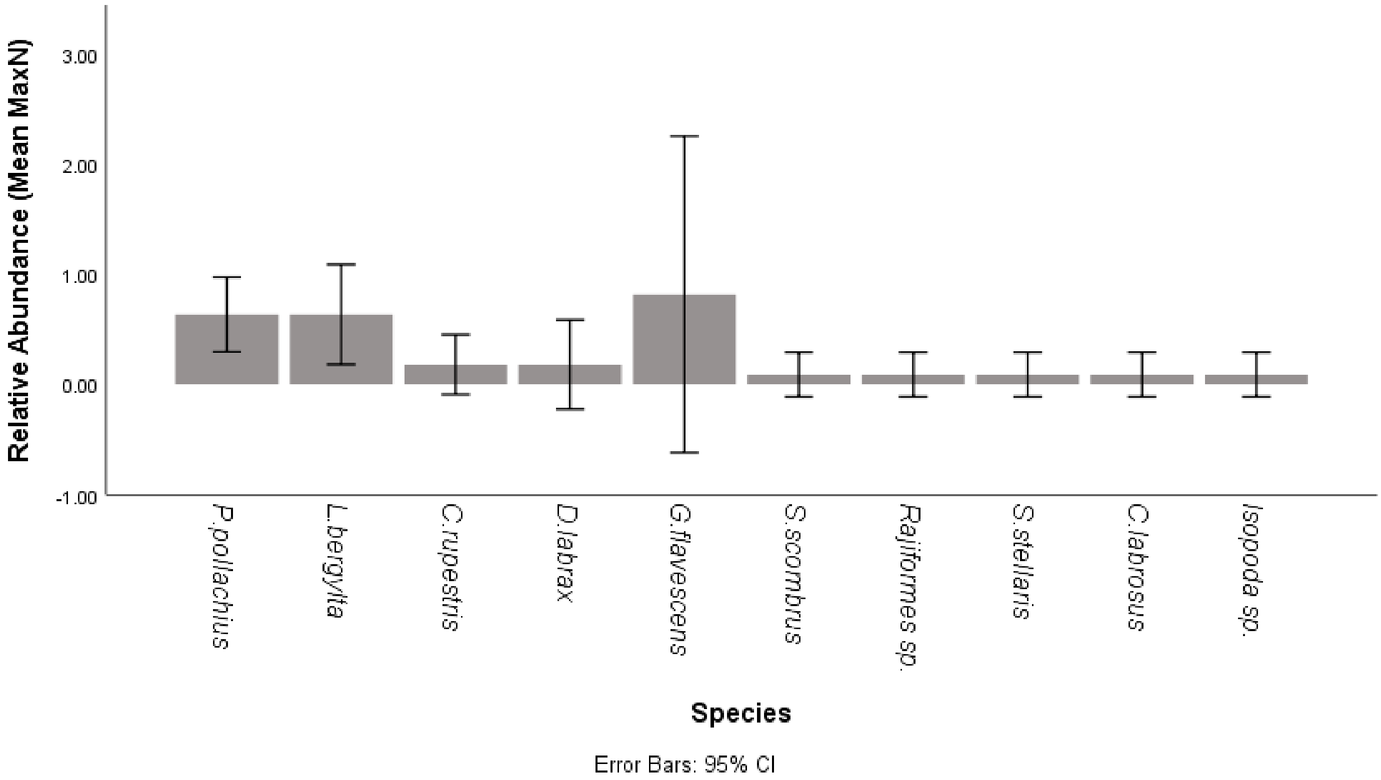

Figure 2: The relative abundance (Mean MaxN) of each species across all footage from BRUV units deployed around the island of Alderney.

3.1.3. Ability to accurately recorded true diversity of Alderney's territorial waters.

In 2018/19 Seasearch divers recorded and identified 60 fish and shellfish taxa around Alderney. Comparatively, the BRUV surveys only recorded 20% of this diversity. Clonque Bay and Longis Bay were surveyed by both the BRUV trial and SeaSearch divers in 2018-2019. At Clonque Bay, the BRUV footage only recorded 1 of the 6 species (16.7%) observed by Seasearch divers, whilst at Longis bay only 1 of the 9 species recorded by Seasearch was observed on camera (11.1%). However, at each of these sites 1 additional species was recorded to be present on BRUV footage which had not been seen by Seasearch divers. No detailed comparisons can currently be made however between the results from Seasearch dives and the BRUV trial due to the substantial differences in sampling effort and design.

Clonque Bay				Longis Bay			
SeaSearch		BRUV		Seasearch		BRUV	
Species Present	Date	Species Present	Date	Species Present	Date	Species Present	Date
Centrolabrus exoletus	28/7/2019	*Labrus bergylta*	6/8/2018	*Ammodytes sp.*	21/7/2019 – 15/9/2019	*Muglidae sp.*	26/8/2019
Ctenolabrus rupestris				*Ctenolabrus rupestris*			

Gobiusculus flavescens				*Dicentrarchus labrax*			
Labrus bergylta				*Gobiusculus flavescens*			
				Labrus bergylta		*Isopoda sp.*	
Pomatoschistus sp.				*Mugilidae sp.*			
				Platichthys flesus			
Trachinidae sp				*Spondyliosoma cantharus*			
				Zeugopterus punctatus			

1.1.1. Attraction success of bait

There is only evidence of one species, *S.stellaris* (Greater Spotted Dogfish), actively approaching the bait and feeding upon it, which occurs on every occasion in which *S.stellaris* is observed on camera. All other species were observed to ignore the bait, suggesting the choice of bait may not be the most suitable option for increasing fish presence counts.

1.1.2. Length of deployment

The average first attraction time to the BRUV system across all deployments was 12.4mins ± 13.4mins, with 50% of all recorded species arriving on average within the first half an hour of the video. 75% of species had a mean first arrival time within the first 40 minutes of the video, 83.3% within the first 50 minutes and all species had a mean first arrival time within the first 60 minutes, although one observation of seabass (at site 2) occurred at 65 minutes, 11 seconds into recording. Where present, the *A.tobianus* arrived earliest at 3.35 minutes into the footage, followed by *C.rupestris* at 8.17 minutes on average.

Discussion

The trial BRUV surveys successfully recorded a range of marine fauna, which will contribute to a greater understanding of Alderney's marine biodiversity. Across the 12 useable deployments, 12 species from 11 families were observed, including commercially and recreationally important fish like pollock, Atlantic mackerel and European seabass (Plaster and Chambers, 2018). Whilst all species encountered are common within the Channel Islands, a particularly noteworthy observation was the Nursehound shark, a species which is less frequently observed around Alderney than the similar, small-spotted catshark (*Scyliorhinus canicula*) (Plaster and Chambers, 2018). The presence of an elasmobranch correlates with previous studies, which report the effectiveness of baited cameras for attracting predatory species which may otherwise avoid divers (White *et al.*,2013).

Additionally, the species assemblage included important food sources for juvenile seabirds, i.e. *A.tobianus*. This is a particularly pertinent finding, as Alderney and the surrounding islets host a vital breeding population of Atlantic Puffins (*Fratercula articula*), a species which has declined dramatically over the last 100 years within the English Channel (Sanders, 2008). Similarly, Alderney is home to an internationally important colony of Northern Gannets (*Morus bassanus*) (Wawick-Evans *et al.*,2016). Therefore it is important to understand the prevalence and distribution of their food sources. Both the ray and flatfish were unable to be identified to species level due to obscuration by sand, but likely species of ray include the blonde ray (*Raja brachyura*), small-eyed ray (*Raja microocellata*), thornback ray (*Raja clavata*) and undulate ray (*Raja undulata*), whilst potential flatfish species include plaice (*Pleuronectes platessa*), dover sole (*Solea solea*) and European flounder (*Platichthys flesus*) (Plaster and Chambers, 2018). Repeated surveys within the Platte Saline area may provide additional clearer records of these species. No significant difference in species richness was found between the survey years, a finding which may be attributed to the change in deployment locations and consequent variable habitats surveyed, which may hide real temporal changes. The results of this study are similar to previous Seasearch surveys which also found pollock to be abundant and widespread around Alderney and encountered multiple wrasse species, particularly *L. bergylta* (Wood, 2007). Similarly, both seabass and the two-spotted goby have been previously recorded, as has the lesser sand eel. The absence of corkwing wrasse (*Symphodus melops*) and rock cook wrasse (*Centrolabrus exoletus)* in this study, which were recorded on numerous occasions by Seasearch divers, may be due to their similarities to juveniles or females of other wrasse species which could potentially have caused identification errors.

The intention of this study was to increase knowledge on both fish and shellfish diversity within Alderney's territorial waters; however only 1 shellfish species was observed (a crustacean, Isopoda sp). Numerous shellfish species are known to inhabit the Channel Islands and so this finding is surprising but could perhaps be attributed to an unattractive choice of bait. Additionally, as highlighted by Devine *et al.,* (2019), BRUVs may not be appropriate for capturing benthic species on the seabed due to the positioning of the camera. Setting the camera at a lower position could perhaps enable higher levels of invertebrate detection. However, previous Seasearch surveys also reported low numbers and diversity of shellfish (Wood, 2007). Therefore, fishery-dependent methods may be necessary for sampling invertebrates in the future (Devine *et al.*, 2019).

Compared to the 2018/19 Seasearch dives, the number of species recorded by the BRUVs is low, suggesting that the method is missing species which are known to be present in the area. It is perhaps surprising that the Seasearch methods, as a form of UVC, would detect more species than BRUVs, when many advocates of remote video monitoring praise their ability to overcome the limitations of dive surveys (Schramm *et al.*,2020). Studies by Ghazilou *et al.*,(2019) and Goetze *et al.*,(2015) for example report that BRUVs record comparable levels of diversity to UVC methods. However in contrast, UVCs have also been shown to outperform BRUVs when recording species richness (Colton and Swearer, 2010). In a study by Lowry *et al.*, (2012) for example, BRUVs only identified ~46% of the species observed by UVCs and performed particularly poorly in identifying cryptic species, which may only be spotted by divers searching through complex habitats. This study corroborates that finding, as many of the species observed in the 2018-2019 Seasearch surveys in Longis and Clonque Bay i.e. those in the goby genus *Pomatoschistus* and weever family *Trachinidae*, often hide within the seabed substrate and so may have been present within the BRUV survey sites and missed by the camera. Previous studies have also suggested that BRUVs may miss territorial species, if the system is placed outside of their range, and that the species assemblage viewed on camera will be dependent upon inter and intra specific species interactions (Cappo *et al.*,2004). For example, some species, i.e. wrasses, are highly territorial and therefore any agonistic behaviour around the unit may have repelled other species (ibid.). Nevertheless, it is difficult to make direct comparisons between the results of the AWT's BRUV surveys and the Seasearch dives due to variations in sampling effort, as the BRUV surveys have a variable sampling area, dependent on the dispersal of the bait plume, whereas seasearch dives, as a visual census, generally have a more defined area (Cappo *et al.*,2007).

When drawing conclusions, some limitations must be noted. The clarity of water and the presence of dense kelp at multiple sites resulted in an inability to identify some fish which were hence excluded from analysis. There is therefore potential for additional species to have been discounted from the study and for misidentifications, especially of species which look similar at various lifecycle stages. Therefore species richness within the footage may have been underestimated. In the future this level of error could be reduced by validating identification with a second observer. Similarly, the measures of relative abundance may be an underestimation. Whilst Max N is the most common method for estimating abundances from video footage it is known to be a conservative measure, reporting only the minimum known abundance and simulations have shown that at high abundances, MaxN can underestimate population sizes (Campbell *et al.*,2015;Schobernd *et al.*,2014). Potentially additional measures of abundance could be implemented, like MeanCount, although these come with their own flaws (Whitmarsh *et al.*,2016).

<u>Recommendations and Conclusion</u>

Whilst the increased knowledge of the species present will be highly valuable to the AWT, this study has highlighted areas for improvement within the current BRUV methodology. For example, the use of bait is intended to increase the number of fish sampled, by attracting into the field-of-view both consumers who follow the bait plume looking for a food source and curious herbivorous species (Taylor *et al.*,2013). Previous studies have reported significant effects of bait type upon species assemblages e.g. Wraith *et al.*,(2013), and as only one species (*S.stellaris*) is shown in this study to actively feed upon the bait, it may suggest that either the current bait choice, whiting, is not optimal for attracting fish/shellfish or the method of bait dispersal is failing to generate an olfactory stimulus. This low level of bait interaction contrasts with a study of the Great Barrier Reef where Cappo *et al* reported that 58% of species touched the bait canister (2004). There the bait choice was crushed pilchards (*Sardinops neopilchardus*), a species which has been used frequently due to its oily nature which aids scent dispersal into the water column (Cappo *et al.*,2004; Harasti *et al.*,2015).Crushing bait has also been recommended as it maximises oil diffusion (Langois et al.,2010). Whiting is known to be a less oily whitefish species within the *Gadidae* family, similar to cod (Bayliss, 1996). Therefore in the future, it would be useful for the AWT to test different bait varieties to determine if an oily species (perhaps pilchards or sardines) increases fish counts. Whilst there was no significant difference in species richness between the two years, based on previous studies it is recommended that the bait container employed in 2019, a mesh bag, is more suitable than the plastic container used in 2018, due to the increased ability of fish to access the bait (Whitmarsh *et al.*,2016). It is also recommended in the literature that approx. 1kg of bait is used e.g. Langois *et al.*,(2018), although studies suggest that bait quantity has limited impact upon the species assemblage.

Furthermore, the soak time of the BRUV units varied greatly in length, from 26 minutes to over 98 minutes, largely due to weather conditions and available battery power (Pers comms, Broadhurst-Allen, 2020). A variety of deployment times have been used in previous BRUV studies, and it is known that soak time is one of the principal variables to impact diversity and abundance estimates (Gladstone *et al.*,2012). The general consensus in the literature however is that a deployment time of 60-90 minutes is most effective for recording all species (Langlois *et al.*,2018). The results of the BRUV trial, where one video only lasted for 26 minutes, suggest that standard deployment times are required for the AWT, to ensure an equal sampling effort across all deployments so that all footage can be included in comparisons. Furthermore, as at multiple sites new species arrived after the 50-minute cut-off point, with a new species arriving at one site after 65 minutes, the results suggest that longer soak times would result in capturing a greater number of species. The AWT should ensure that there is sufficient battery power to deploy the camera for at least 60 minutes and preferably up to 90 minutes, after a 5-minute adjustment period (Unsworth *et al.*, 2014).

In the future, to make meaningful conclusions regarding temporal changes in species diversity and abundance, the AWT should sample the same locations each year to limit the effect of. changing depths and habitats on the species assemblage. Furthermore, replications of the BRUV deployments should be conducted within multiple, smaller sampling locations, as the current layout of deployment sites across a large range of Alderney's territorial waters prevents them from acting as replicates due to the >2km distance, which will likely allow for changes in habitat features between sites (Whitmarsh *et al.*,2019). For example the survey design could consist of four survey locations around the island, both inside and outside of the RAMSAR site, each containing 4-6 randomly generated BRUV deployment sites (Andradi-Brown *et al.*,2016), (Appendix 2). Previous studies suggest that replicate deployments should be separated by either 2-hour intervals or 200-500m to prevent overlap of the bait plume, to ensure replicates are independent (Whitmarsh *et al.*,2016; Langois *et al.*,2018). This would allow for future studies comparing species assemblages over time, across different habitats and between protected and unprotected areas.

In conclusion, whilst the results from the Alderney Wildlife Trust's trial BRUV project provide an indication of the species present within the island's territorial waters, which is highly beneficial in data-deficient sites, there are concerns over the current methodological approach and its ability to effectively represent the true marine biodiversity of the area. It is recommended that the AWT adjust the survey design to allow for increased repetitions at each sample site and therefore broaden the opportunities for statistical analysis, ensure there are longer, standardized soak times to capture all species and choose an oily bait to optimise scent dispersal into the water column and the attraction of species into the field-of-view. With these improvements, BRUV surveys may be a highly successful monitoring method for the Alderney Wildlife Trust, providing a visual insight into the local marine environment.

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Appendix 1: Habitat Types shown by screenshots from BRUV footage.