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From Plates to Baits: Using a Remote Video Foraging System to Study the Impact of Foraging on Fouling Non-Indigenous Species

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Abstract: Marinas are a gateway for the introduction and establishment of non-indigenous species (NIS). In these habitats, competition and predation are crucial determinants for NIS establishment and invasiveness. However, fish trophic preferences and biotic effects inside marinas are poorly known. This study proposes a novel method that combines the deployment of settlement plates to recruit different assemblages, followed by their use as bait in remote underwater video systems. This combined approach, addressed as a remote video foraging system (RVFS), can record fish foraging behaviour, including feeding choices and their impacts on fouling assemblage composition. An experimental RVFS trial carried out in a marina of Madeira Island, Portugal (NE Atlantic), identified the Mediterranean parrotfish, *Sparisoma cretense*, as the most important fouling grazer in the area. *S. cretense* behaved as a generalist and increased the heterogeneity of fouling assemblages, which can hamper NIS dominance of the fouling and reduce the pressure of propagules from the marina to the natural environment. The RVFS tool was useful to understand the trophic links between foragers and fouling and has the potential to provide relevant information for the management of NIS introductions, establishment and spread.

Keywords: marina; trophic interactions; cascade effect; biotic resistance; RVFS

1. Introduction

The relocation of marine species outside their historical distribution has increased significantly in recent decades [1–4]. When non-indigenous species (NIS) find favourable conditions in their introduced ranges, they may become invasive. Invasive NIS can promote biotope changes, habitat modifications and loss of ecosystem services, leading to severe

environmental, socioeconomic and human health impacts [2,5]. With a growing number of examples around the globe, marine invasions are currently one of the main drivers of biodiversity loss and an important element of global change [6–9]. In this context, understanding the factors underpinning NIS proliferation and success is an important issue for conservation and mitigation of global change.

The proliferation of NIS is often shaped by a complex interaction of compounding factors such as climate change, environmental pollution, local community resilience and habitat degradation [10,11]. Although it is difficult to predict whether a NIS will succeed in a given environment, there are many hypotheses designed to explain invasion success (see Catford et al. [12]). For instance, some particular biological and ecological traits are shared by many invasive species [13]. Invasive species tend to have faster reproductive and growth rates and higher tolerances to extreme environmental conditions than native species [14]. Invasive species also often have traits that favour competition against native species and/or provide enhanced defences against predators, i.e., [11,12,15,16]. Some NIS with invasive traits have allelochemical defences such as toxins and non-palatable compounds that grant them a repulsive smell or taste [17–19], often granting them ecological advantages towards native taxa. In such cases, native consumers (predators and grazers) often reject feeding on NIS and selectively target a native-based diet. This behaviour can facilitate the proliferation and spread of NIS [20–23]. In contrast, local consumers that feed on NIS can control NIS dominance through trophic interactions, exerting a top-down control over potential invaders [24–27]. In this context, consumer–prey interactions can be particularly relevant, as predators may either facilitate or hamper a newly arrived NIS from successfully establishing and/or invading a new region by limiting its ability to spread from a site where it is already established [28–30]. As such, understanding whether local consumers exhibit selective or generalist feeding behaviours that favour or deter NIS dominance may represent a crucial mechanism and an essential piece of the puzzle when assessing resistance and susceptibility of local communities to biological invasions. Moreover, the presence of benthic NIS in the ecosystem can also alter the feeding preferences and foraging intensity of invertebrates and fishes [31]. Therefore, further research on trophic interactions between native and NIS communities and their biotic functional response to current and future climate scenarios is necessary to formulate an effective management strategy against NIS [32–35].

Efforts to better understand trophic interactions between local consumers and NIS communities in shallow coastal areas have primarily relied on indirect methods, such as exclusion experiments, to assess the influence of predators and grazers in shaping communities [36]. These studies manipulate consumer densities among treatments by caging and assessing the effect of predation pressure as a top-down control mechanism for NIS success. This approach does not inform which species are feeding on what, nor does it allow the selective exclusion of predator species to assert the ecological importance of a particular taxon [36]. In this regard, video surveillance methods may be a promising tool for studying trophic interactions in the marine environment, allowing researchers to identify predators and grazers, as well as foraging behaviours and prey selectivity [37]. Among video techniques, the use of baited remote underwater video (BRUV) to attract and quantify various motile taxa could be a powerful tool to study these interactions [38,39]. Oricchio et al. [40] provided an example of how this approach could be used to assess trophic interactions between fish and fouling recruited on caged polyvinyl chloride (PVC) panels. This method allowed identifying main predator species and which fouling species were targeted. Here, we advance this research approach one step further by combining the two methods and use video and imagery analysis for a more detailed assessment of prey–predator interactions. Specifically, we propose to assess how predator exclusion shapes different fouling assemblages (i.e., higher native vs. higher NIS “content”) and offer them as bait on a video setup so that one can inspect the imagery and the plates to identify predators/grazers, study feeding choices and assess the effects of existing preferences on the fouling community structure, diversity and abundances.

Marinas and harbours are considered as hubs for enhanced NIS recruitment, as they are under greater pressure from maritime traffic and human activities than other natural and artificial coastlines [41–43]. These can serve as stepping stones for NIS introduction into local natural habitats since they serve as a refuge for arriving NIS [14,44,45]. It is often in these areas that newly arrived NIS pass through several ecological filters such as prevailing temperature and salinity, pollutants in the water, and pressure from predators or grazers, before taking hold, establishing and being able to disperse to natural habitats in the vicinity [14,46]. With higher NIS diversity and abundance and with the facilitated access, marinas and harbours are often considered as the ground zero for marine biological invasions, where monitoring and early detection is likely to be essential for prevention practices, mitigation activities and adequate NIS management.

In this context, the overall goal of this study is to (1) design, develop and test a combined method that leverages recruitment panels and a remote video foraging system (RVFS), custom designed to study trophic choices of foragers and their effects on fouling assemblages present in marinas and/or harbours; (2) provide guidelines for integrating the use of recruitment panels, RVFS and imagery analysis as a monitoring tool in marinas, and; (3) evaluate the success of RVFS as a tool to detect potential fish consumers that may provide biotic resistance against NIS in the marinas of Madeira.

2. Materials and Methods

2.1. Remote Video Foraging System

We designed and built a custom made remote video foraging system (RVFS), a non-invasive system that avoids any contact or manipulation of the fish, complying with general bioethics in research and with the European Community Council Directive (Directive 2010/63/EU) on the protection of animals used for scientific purposes. The RVFS comes up as a combination of techniques used to study trophic interactions inside marinas: exclusion experiments (Figure 1A) and video experiments (Figure 1B). Exclusion experiments have been used worldwide to investigate the trophic effect of foragers on the fouling composition [36,47,48]. Video experiments can identify foraging species and their trophic choices [37,40]. To this matter, the proposed RVFS would help to investigate trophic choices of the fish foragers among fouling assemblages differing in variables such as fouling species composition and NIS dominance (Figure 1C). The different assemblages offered to the fish can be obtained by deploying plates in different environments or under different predation pressure. Then, plates will be used as bait units to perform the RVFS trials by offering all assemblages in a randomised blocks arrangement using a PVC structure with top and frontal cameras. The RVFS was tested in this pilot study in order to assess its applications and outline guidelines for its use in NIS monitoring and studies.

2.2. Pilot Study

2.2.1. Experimental Setup

This pilot study was carried out in the marina of Quinta do Lorde (32°44.5' N, 016°42.8' W), in Madeira Island, Portugal (Figure 2A), where the most common fish species present inside the marina had been previously catalogued based on sightings during underwater surveys (Table S1). Fouling assemblages used as bait units were recruited by haphazardly deploying 12 settlement plates [49], consisting of polyvinyl chloride (PVC) panels of 14 × 14 cm, grouped in three treatments. These were chosen to manipulate predator pressure and create artefact effects, which would provide three different assemblages. Treatments were: uncaged (T1), caged with 15 mm mesh (T2), and caged with 1 mm mesh (T3) (Figure 2B). Caged with 15 mm mesh was aimed to avoid predation, taking into account that meshes as small as 5 mm did not cause artefact effects in Madeira (see Gestoso et al. [48]), whereas caging with smaller mesh sizes (1 mm mesh) is expected to avoid predation and create an artefact effect that alters the structure of the assemblages [47]. Settlement plates were hung from the marina's pontoons at 1 m depth and facing downwards from May to September 2018. After five months, plates were retrieved, photographed using an Olympus TG4

camera, and checked under a binocular microscope (LEICA S8 APO, Portugal) for detailed identification of the fouling community to produce a taxa inventory. Settlement plates were also weighed individually using a scale (KERN KB 2000-2N, Portugal) (resolution of 0.01 g) after holding them for 30 s in a vertical orientation to allow water to drain. To ensure non-destructive sampling and no loss of live coverage and biomass, the plates were kept separated from each other in tanks and submerged in seawater for less than two hours during this inspection and photo capture period.

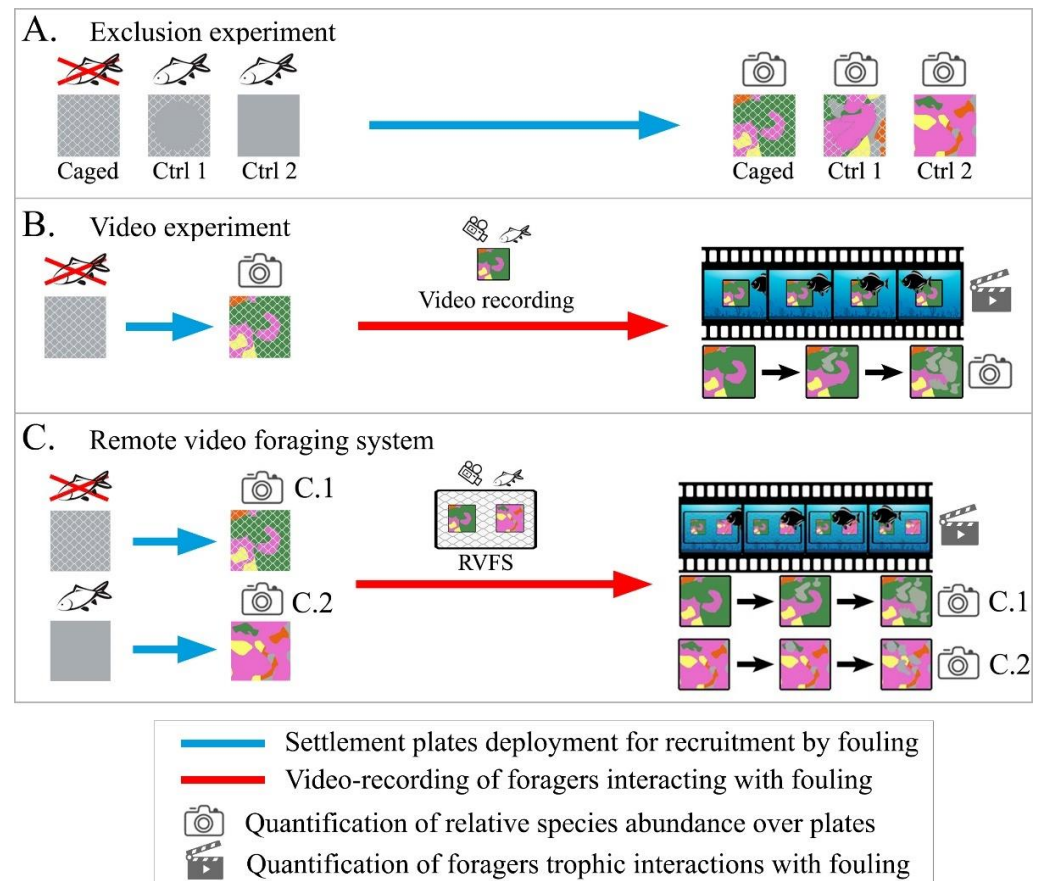


Figure 1. Traditional approaches used to study trophic effects and interactions between fouling and foragers inside marinas (A,B) and the proposed combined method (C). (A) Exclusion experiments study the recruitment and colonisation of settlement plates by fouling assemblages under a caging (predators exclusion) treatment against a procedural control (Ctrl 1), testing possible artefacts caused by the exclusion method (mesh used for caging), and uncaged plates (Ctrl 2). (B) Video experiments record fish trophic interactions with fouling species recruited on plates (e.g., caged settlement plates). (C) Remote video foraging system (RVFS) technique developed and tested in this study is baited with different fouling assemblages (C.1 and C.2) recruited on settlement plates (e.g., caged and uncaged).

For RVFS trials, one randomly selected plate from each treatment (T1, T2 and T3) was offered as bait in a randomised block arrangement. A total of four RVFS trials, of 4 h each, were carried out using a custom-built structure with two Olympus TG-tracker cameras, suspended at 2 m depth from the marina pontoons (see Figure 2B). Cameras were synced and set up in time-lapse mode with 2 s intervals (0.5 frames per second). After each trial, the structure was retrieved, the plates detached, and these were re-weighed and re-photographed for analysis (see the conceptual design of the experiment in Figure 1C). Our RVFS trials were carried out in late September 2018 over a 2-day period, with one trial in the morning and one in the early afternoon. RVFS deployment was at the same location

where water temperature (measured every 4 h using a HOBO temperature data logger) ranged between 23.5 °C and 24.0 °C during the trial period.

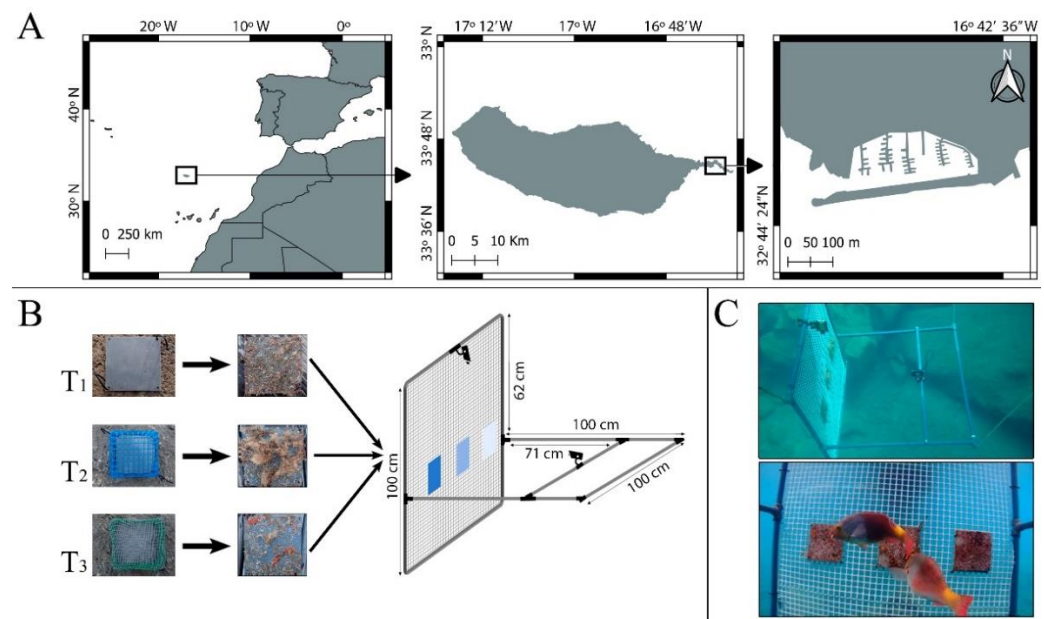


Figure 2. Pilot study experimental setup. (A) The study was conducted in Marina of Quinta do Lorde, Madeira Island, Portugal. (B) The fouling assemblages used as bait were obtained using caging treatments (T1: uncaged, T2: caged 15 mm mesh, and T3: caged 1 mm mesh) and were exposed to foraging in a randomised blocks arrangement on a PVC structure with top and frontal cameras. (C) Structure used for the remote video foraging system (RVFS) (top) and an image taken from the frontal camera during trials (bottom).

2.2.2. Data Acquisition and Treatment

Images of the settlement plates before and after RVFS trials were labelled, colour lens corrected, perspective cropped and resized. Using CPCe V4.1 software (Coral Point Count with Excel extensions, Nova southeastern University, Florida, USA [50]), 99 points were randomly overlaid in a stratified fashion over a 3×3 cell grid (11 points per cell) over each image to quantify taxa relative abundance before and after exposure to predation during video trials. The same 99 hit-point grid was also used to assess which taxonomic categories had been removed from each plate. Point coordinates were maintained by using the same *.cpce file on the cropped and resized images of each plate (prior and after exposure). Image files of the same plate (prior and after exposure) were renamed to match during analysis on CPCe. This strategy allows the same hit points to be sampled before and after exposing the plates to predation in a repeated-measurement sampling strategy. The identified fouling species were classified by major taxa, morphology (encrusting, massive and arborescent) and status (native, cryptogenic and NIS). Species status was assigned based on the existing literature [44,51–67].

The video files obtained during RVFS were visually inspected frame by frame, and the following fish behaviours were annotated by scan sampling [68]: forager presence, forager interest and forager feeding. Forager presence was defined as the occurrence of a fish species within the frontal camera frame range (see Figure 2C). The image frames from the top and frontal cameras were used for recording interest and bites. Forager interest was defined as the percentage of present individuals displaying a curiosity action towards one of the three offered plates (e.g., swimming towards or stopping less than 5 cm from the plate and facing its surface). Forager feeding was defined as the number of bites over each offered plate.

2.2.3. Statistical Analyses

For multivariate analyses, fouling species relative abundance data were square-root transformed and used to calculate a Bray–Curtis similarity matrix (Bray and Curtis, 1957). This matrix was used to test the orthogonal factors: treatment (fixed with three levels: T1 uncaged, T2 caged with 15 mm mesh and T3 caged with 1 mm mesh); and time (fixed with two levels: before and after predation) using permutational multivariate analysis of variance (PERMANOVA). The heterogeneity of multivariate dispersions was tested using permutational analysis of multivariate dispersions (PERMDISP).

Univariate analyses were carried out on fouling assemblage biomass (wet weight), total biotic abundance, native species' relative abundance and NIS relative abundance. These datasets were used to calculate Euclidean distance matrices and tested using the same design as multivariate analyses. Data on fish interest towards plates and number of bites (feeding) from RVFS trials were used to calculate Euclidean distance matrices. These were tested using PERMANOVA on a randomised block design; for details, see Anderson et al. [69] (p. 58), including on factors' treatment (fixed, three levels) and trials (random, four levels). All non-parametric data analyses were carried out with 9999 permutations using PRIMER v7 with PERMANOVA+ add-on (PRIMER-E Ltd., Plymouth, UK) [69,70].

3. Results

The Mediterranean parrotfish *Sparisoma cretense* (Linnaeus, 1758) was almost the only species foraging on the settlement plates during the 16 h of remote video foraging system (RVFS) trials. This species was registered showing interest 1829 times and feeding on the settlement plates 421 times. The only exception to this occurred when a Mugilidae school approached showing interest and fed once from the settlement plates. Overall, fish foragers' interest and feeding on plates were similar across RVFS trials (Table 1). Among treatments, foragers showed a higher interest in uncaged and caged 15 mm over caged 1 mm, although feeding was similar among treatments.

Table 1. PERMANOVA results on foragers' interest and feeding over settlement plates during remote video foraging system (RVFS) trials. df = degrees of freedom; MS = mean square sum; *P* (Perm) = *p*-values for permutation test; Tr = Treatment, 3 levels: uncaged (T1), caged 15 mm mesh (T2) and caged 1 mm mesh (T3); Trial = random: four levels.

Source	df	Foragers Interest			Foragers Feeding			
		MS	Pseudo-F	<i>P</i> (Perm)	MS	Pseudo-F	<i>P</i> (Perm)	
Treatment	2	826.48	70.8584	0.0172 *	541.58	2.8368	0.1381	
Trials	3	155.17	10.4754	0.3144	408.75	2.141	0.1962	
Residuals	6	105.17			190.92			
Pair-wise			(T1 = T2) > T3					

* Statistically significant result.

Regarding the fouling community on the settlement plates, twenty-seven taxa were recorded: six native species, eight cryptogenic species, nine NIS and three taxa unidentified to species level (see Table S2). Annelida and Bryozoa were the most abundant phyla, while the most abundant morphologies were massive and arborescent (Figure 3). Overall, the structure of fouling assemblages was unique for each treatment, which confirms that different choices of fouling were offered to the fish during RVFS trials (Figures 4 and S2).

The foraging activity of *Sparisoma cretense* reduced mean fouling biomass by more than 10% and its relative abundance by more than 40% (see Figure S2). Wet biomass among treatments was different before but equal after RVFS, while relative abundance was similar among treatments before and after RVFS (see Table 2). Similarly, the relative abundance of NIS and native species decreased after RVFS (Figure S1; Table S3). However, native species

were more abundant at the uncaged treatment (T1) before and equal to the other treatments after RVFS, while NIS abundances were similar among treatments before and after RVFS.

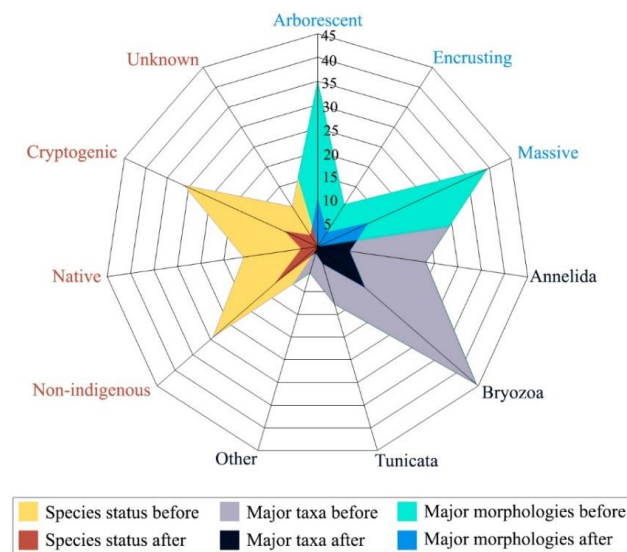


Figure 3. Mean relative abundance over settlement plates before and after remote video foraging system (RVFS) trials, biogeographic status and functional morphologies for the main phyla. Other includes taxonomic categories with a relative abundance lower than 5% (Porifera, Arthropoda and Macroalgae). Unknown includes taxa that could not be identified to the species level (uncertain biographic status). Massive: domed or flat-topped shape; Encrusting: encrusting plate-like shape; Arborescent: erect branching shape.

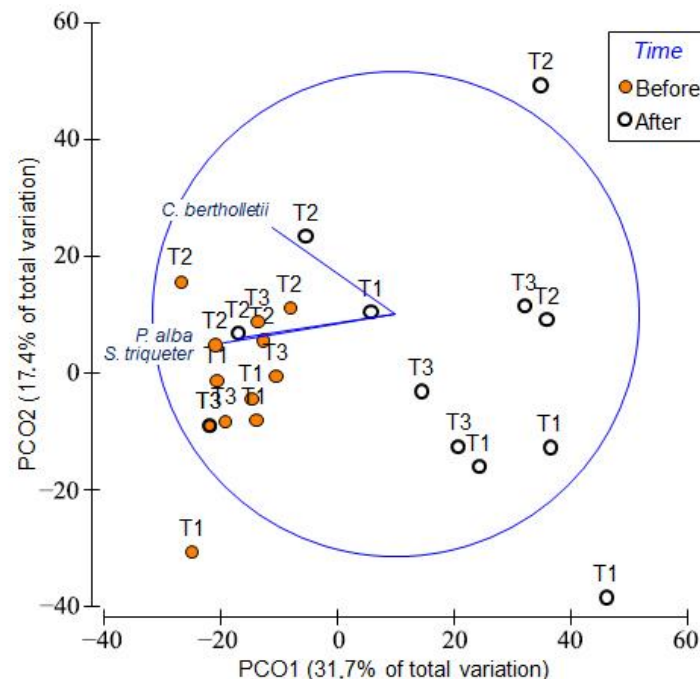


Figure 4. A principal coordinates ordination (PCO) for an exploratory tool of the structure of the assemblages (taxa relative abundance) to understand the components of multivariate variation. The PCO displays 49.1% of variation and, using the blue vectors, those variables with a mean relative abundance higher than 10% before remote video foraging system (RVFS) trials and Pearson correlation coefficient (Pr) higher than 0.7 with any of the ordination axes. Vector’s length indicates the Pr value, with the maximum value (Pr = 1) highlighted by blue circumference. T1 = uncaged, T2 = caged 15 mm mesh and T3 = caged 1 mm mesh.

Table 2. PERMANOVA results for the relative abundance and wet biomass. Tr = Treatment, 3 levels: uncaged (T1), caged 15 mm mesh (T2) and caged 1 mm mesh (T3); Ti = Time, 2 levels: before and after remote video foraging system (RVFS) trials. df = degrees of freedom; MS = mean square sum; P (Perm) = *p*-values for permutation test.

Source	df	Relative Abundance			Wet Biomass		
		MS	Pseudo-F	P (Perm)	MS	Pseudo-F	P (Perm)
Treatment	2	180.54	0.4924	0.6376	1.7689	7.4793	0.0059 *
Time	1	22083	60.23	0.0001 *	23.764	100.48	0.0001 *
Tr × Ti	2	351.04	0.9575	0.419	1.9138	8.092	0.0032 *
Residuals	18	366.64			0.2365		
Pair-wise			Before > After			Before: T2 > (T1 = T3) After: T1 = T2 = T3	

* Statistically significant result.

Foraging activity modified the structure of the fouling assemblages, although without having a homogenising effect across treatments at the level of species composition (Figure 4, Table 3), major taxa or morphologies (Figure 3). However, in terms of multivariate dispersions, the heterogeneity of the assemblages increased after RVFS, particularly for the treatment caged with 15 mm mesh (Figure 4, Table 3). Overall, the variables with a higher contribution to the multivariate dissimilarities were: the cryptogenic bryozoan *Cradoscrupocellaria bertholletii* (Audouin, 1826), the NIS bryozoan *Parasmittina alba* Ramalho, Muricy and Taylor, 2011, and the native annelid *Spirobranchus triqueter* (Linnaeus, 1758). These species had 24.9%, 10.8% and 10.2% mean relative abundance before RVFS trials, respectively (see Table S2).

Table 3. Results for the multivariate PERMANOVA and PERMDISP on fouling assemblage structure. Tr = Treatment, 3 levels: uncaged (T1), caged 15 mm (T2) and caged 1 mm (T3); Ti = Time, 2 levels: before and after. df = degrees of freedom; MS = mean square sum; P (Perm) = *p*-values for permutation test; Tr = Treatment, 3 levels: uncaged (T1), caged 15 mm mesh (T2) and caged 1 mm mesh (T3); Ti = Time, 2 levels: before and after RVFS trials; res. df = residual degrees of freedom for the PERMDISP test.

Source	df	PERMANOVA			df	PERMDISP		
		MS	Pseudo-F	P (Perm)		res. df	F	P (Perm)
Treatment	2	4224.8	3.3431	0.0007 *	2	21	1.555	0.4229
Time	1	7617.8	6.028	0.0001 *	1	22	19.836	0.0002 *
Tr × Ti	2	1219.8	0.9652	0.4983	2	18	24.108	0.0001 *
Residuals	18	1263.7			18			
Pair-wise			Treatment: T1 ≠ T2 ≠ T3				Before: (T1 = T3) > T2 After: T1 = T2 = T3	

* Statistically significant result.

4. Discussion

The integration of novel technological tools in ecological studies is paramount for enhancing current capability in collecting and processing qualitative and quantitative data needed to increase the understanding of marine systems [71]. This is the case when integrating underwater video technology and imagery analysis tools in trophic and behavioural studies. Regarding this matter, the use of a remote video foraging system (RVFS) in a new enhanced method developed for this study allowed us to record fish foragers' feeding choices and gather knowledge on their effect on non-indigenous species (NIS) establishment and proliferation inside marinas [72]. Furthermore, the RVFS allowed us to study foragers' preference between and within different fouling assemblage structures that can be manipulated and pre-selected. This could be relevant, as fish can visually identify and memorise different patterns in fouling and express interest towards a whole assemblage

structure (food patches) rather than a single species [73]. The data output of RVFS can be further enhanced by integrating other tools such as macro photography (i.e., high-resolution photomosaics), machine learning (e.g., automated species abundance/biomass estimation in plates, foraging behaviour and species identification in videos), environmental DNA (for plate species composition) and stable isotope analysis (e.g., to validate trophic links) (Figure 5). Additionally, the collection of samples of tissue and stomach content from identified foragers could also help to better understand their feeding behaviour and the effect of the inclusion of NIS in their diets [73]. Even though it was not the case during this pilot study, this may be of particular interest if NIS present in the study area have allelochemical defences (e.g., *Caulerpa* spp. Algae) which can promote adverse effects in native foragers' health, fitness and behaviour, as well as the accumulation of toxic compounds in their tissues, which can ultimately pose risks to human health [74–76]. Regarding data workflow, RVFS outputs can be analysed in multiple ways. For example, cluster analysis and discriminant methods such as SIMPROF can assign fouling assemblages into different groups post-settlement, before their deployment as bait. Before and after foraging, univariate measures (e.g., total abundance or biomass, diversity index, behavioural metrics) can be analysed using repeated measures ANOVA or t-tests (or their non-parametric alternatives), while the multivariate species composition of fouling assemblages can follow a similar approach to what was used in this pilot study (Figure 5).

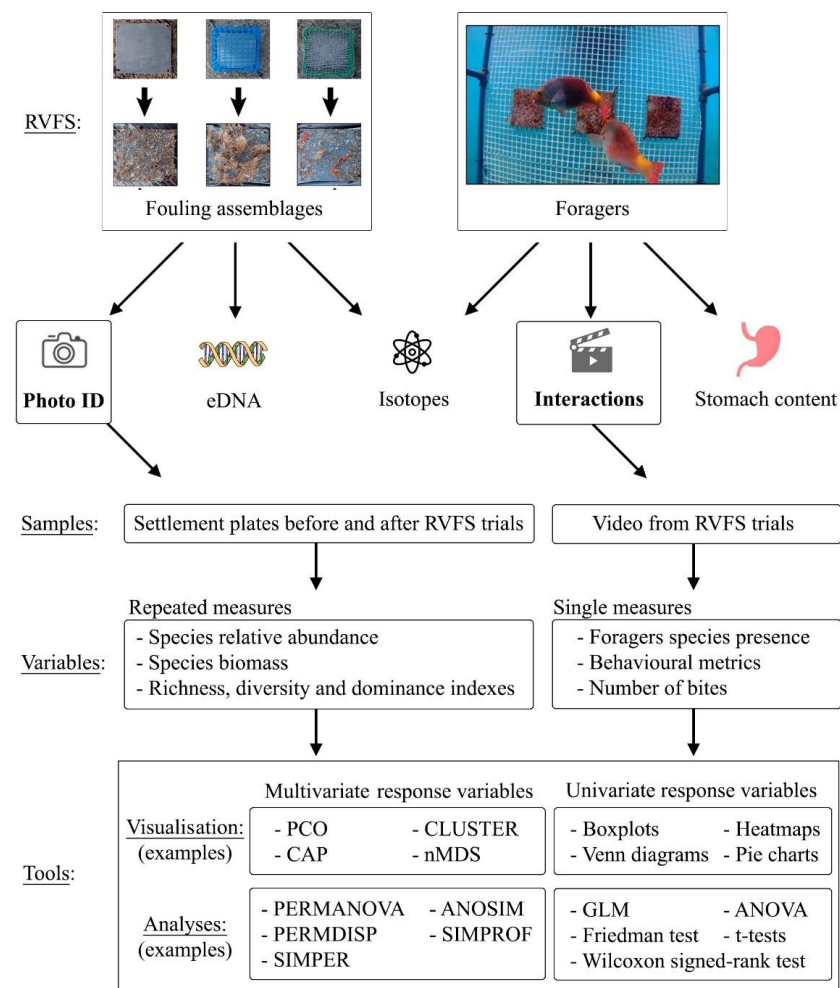


Figure 5. Summary of techniques compatible with remote video foraging system (RVFS), highlighting the pathway followed in this study. The section Tools includes additional tools that can be used to segregate the fouling assemblages used as bait before RVFS and for the visualisation and analysis of the final RVFS data output.

The RVFS pilot study identified the Mediterranean parrotfish *Sparisoma cretense* (Linnaeus 1758) as the main fouling consumer in the study area. This is an edible fish of high ecological and commercial relevance and the only parrotfish in the Mediterranean and North-East Atlantic regions [77–79]. To some extent, the diversity of fish foragers identified during this pilot study has likely been conditioned by the daytime period and or by the two-day duration of the trials. As a pilot study, findings demonstrate the use of RVFS, however, future use of this new combined method should consider daytime activity patterns and seasonality when assessing forager diversity and behaviour. *S. cretense* is a territorial daytime grazer, predominantly herbivorous in the Eastern Mediterranean and omnivorous in the Atlantic Ocean [80–87]. In the Madeira Archipelago, *S. cretense* is abundant from the surface to 50 m depth and constitutes an important fraction of coastal fish biomass [88]. Along with *Thalassoma pavo* (Linnaeus 1758), *Boops boops* (Linnaeus 1758) and *Chromis limbata* (Valenciennes 1833), *S. cretense* is one of the most common fish grazers [88] and thus plays an important ecological role by influencing the structure of fouling and shallow sessile communities in Madeira [89,90]. In this pilot study, the role played by *S. cretense* in the marina of Quinta do Lorde during RVFS trials matches this pattern and corroborates its importance in shaping fouling communities. However, further research is needed to better understand this species' functional role in artificial coastal habitats and to what extent it affects fouling and sessile communities at a broader spatial scale (i.e., beyond the marina infrastructure).

Foraging fish can be attracted to novelty [73], and the PVC structure used for RVFS trials could have attracted foragers feeding over plates. Methodologically, this effect could be minimised by pre-deploying the RVFS structure before the beginning of the experiment, so it is not perceived as a novelty for the fish. However, the intense feeding registered over plates could have been influenced by the structure of the fouling assemblages. The settlement plates were hung facing downwards during recruitment and vertically during RVFS trials, which would increase illumination over plates and make the fouling noticeable to the foraging fish.

Overall, *Sparisoma cretense* showed a generalistic feeding behaviour with a “bulldozing” effect (*sensu* Flecker et al. [91]) on the fouling assemblage. This feeding behaviour increases the heterogeneity of fouling assemblages and can reduce the dominance of species, including NIS and cryptogenic species [30,91,92]. Due to this apparent lack of preference, *S. cretense* can play an important regulatory role in marine ecosystems, particularly in oceanic islands with relatively low diversity but high endemism [29,30,93,94]. Therefore, coastal ecosystems in oceanic islands exert lower biotic resistance against NIS than their counterparts in continental coastlines [95]. Biotic resistance is particularly relevant in artificial structures, where native competition is lower than in natural areas, which can facilitate NIS success and impacts [23,26,96–98]. Ultimately, a low horizontal competition can increase the relative importance of consumers (grazers and predators) in the biotic resistance exerted by the ecosystem. Regarding this matter, the foraging on fouling can promote a more heterogeneous fouling assemblage, whether the total NIS and cryptogenic species abundance in the fouling community may decrease, increase or remain the same [48,89,99,100]. In other words, the empty patches created by the foraging activity can be re-colonised by NIS and cryptogenic species [11]. However, the increase in heterogeneity and lower community dominance by a single species will reduce its propagation capacity. Thereby, a better understanding of the functional trophic role of *S. cretense* in artificial areas can improve our ability to manage NIS proliferation and spread to nearby areas, such as natural habitats and boat hulls [42,101–104].

The RVFS tool created and tested in this study constitutes, to our best knowledge, the first in situ study of trophic interactions in the marinas of the Macaronesia region. Furthermore, there are still major knowledge gaps regarding trophic interactions in coastal marine systems, mainly when dealing with NIS-dominated fouling assemblages inside marinas. A better understanding of the functioning of the trophic web inside marinas could be beneficial, as local fish populations with a significant trophic role should be considered

when planning management actions against NIS [105,106]. Against that backdrop, in situ experimental approaches such as the one proposed can serve as a tool to improve knowledge in these topics.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/jmse10050611/s1>, Figure S1: Mean relative abundance over settlement plates for the main phyla, biogeographic status and functional morphologies, and for each treatment: T1, T2 and T3, before and after remote video foraging system (RVFS) trials. Other includes taxonomic categories with a relative abundance lower than 5% (Porifera, Arthropoda and macroalgae). Unknown includes taxa that could not be identified to the species level (uncertain biographic status); Figure S2: Relative abundance and wet biomass for each treatment before and after remote video foraging system (RVFS) trials. T1: uncaged; T2: caged 15 mm mesh; T3: caged 1 mm mesh; Table S1: Fish species sighted inside the marina of Quinta do Lorde; Table S2: Fouling taxa and their mean percent coverage on each treatment before and after being exposed to foraging during the remote video foraging system (RVFS) trials, including the references used for their identification and previous records for the archipelago of Madeira. Species status was assigned using the most updated list [52]. C = Cryptogenic species; N = Native species; NIS = Non-indigenous species; U = Unresolved taxa; T1 = Treatment 1 (uncaged); T2 = Treatment 2 (caged with 15 mm mesh); T3 = Treatment 3 (caged with 1 mm mesh); Bef = Before predation; Aft = After predation; Table S3: PERMANOVA results on the relative abundance of NIS and native species among treatments before and after Remote Video Foraging System (RVFS) trials. Tr = Treatment, 3 levels: uncaged (T1), caged 15 mm (T2) and caged 1 mm (T3); Ti = Time, 2 levels: before and after Remote Video Foraging System RVFS trials.

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