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Assessing the performance of a cost-effective video lander for estimating relative abundance and diversity of nearshore fish assemblages

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ABSTRACT

Rocky reefs in the temperate Northeast Pacific constitute a small portion of the nearshore seabed, yet are highly valued as productive habitat for local fisheries. Surveying these structurally complex, untrawlable habitats requires robust gear that can be deployed in rough sea states. Here, a cost-effective, compact video lander was evaluated for its ability to survey the diversity and abundance of nearshore (<40 m), rocky-reef-associated fish populations (e.g. Sebastes, Cottidae, Hexagrammidae). To determine the application and limitations of surveying complex rocky reefs with this new tool, this study sought to (1) determine the frequency of observation of known nearshore fish species, (2) evaluate the influence of baiting the lander on the observed fish assemblage, (3) identify the optimal deployment time to maximize observed species richness and abundance, and (4) evaluate species-specific behavioral responses to the lander characterized *a priori* as attractive, avoidance, or neutral. Seventy percent of lander deployments met established requirements of visibility, view, and habitat. Seventy-seven percent of observed fishes were identifiable to species. The method observed 15 species belonging to 5 families; 5 species were classified as common (observed in >20% of deployments), the remaining rare. Contrary to lander studies in other regions, bait was not found to improve species-specific identification, increase observed species richness or abundance (at the species or feeding guild level), or shorten deployment duration. A deployment time of 8 min on the benthos was determined as optimal for observing maximum species richness and abundance in the nearshore, doubling the previously described lander drop durations evaluated in deeper Oregon, U.S.A., waters. Species-specific behavioral responses to this compact lander were evaluated by viewing trends in species abundance (assessed within 30 s bins) over the deployment duration; no attractive or avoidance behaviors were observed. Results confirm that this simple, cost-effective video lander configuration is suitable for sampling the suite of fish species found in the nearshore, including rockfish species federally designated as "overfished" (*Sebastes pinniger* and *Sebastes ruberrimus*). Furthermore, this study illustrates the importance of evaluating the performance of survey tools in the specific environment in which the tool will be used to determine best-practices from long-term monitoring.

1. Introduction

Successful long-term monitoring strategies hinge on obtaining precise and accurate data on the diversity and abundance of focal populations. In the marine environment, this information can be challenging to obtain due to logistical and technical limitations of surveying underwater. The temperate reef systems in the nearshore Northeast Pacific (<40 m) are an important habitat for commercially and recreationally valuable fish species—including two federally designated overfished species (i.e. *Sebastes pinniger* and *Sebastes ruberrimus*). These structurally complex, untrawlable habitats present a challenge to survey. Yet, marine resource managers acknowledge the growing need for a comprehensive fishery-independent survey that can sample these reef-associated species considered at or below sustainable fishing thresholds (Yoklavich et al., 2007). Video-based techniques are advancing as a non-extractive, fishery-independent approach to monitor fish communities in these habitats. Mobile video camera systems have been designed to be towed behind boats (Knight et al., 2014; Lauth et al., 2004; Williams et al., 2010) and installed on remotely operated vehicles (Johnson et al., 2003). However, these mobile video approaches are frequently both logistically complex and expensive to execute, limiting the frequency of their use. Stationary video landers (i.e. underwater drop cameras) offer a logistically simple, inexpensive alternative that can be particularly useful to survey high-relief, rocky areas (Hannah and Blume, 2012; Langlois et al., 2010).

A growing number of studies have been conducted in recent years to assess the strengths and limitations of various designs of video landers to effectively survey fish communities (Watson et al., 2010; Holmes et

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al., 2013; Hannah and Blume, 2012, 2014; Langlois et al., 2010). While this body of work continues to grow in subtropical and deeper temperate environments, evaluations of lander methods in shallow (<40 m), temperate habitats are more limited (but see Pita et al., 2014). Video lander configurations vary. Some configurations use external lights while others do not. Baited video landers have been shown to increase the diversity of species observed and be more cost-effective compared to underwater visual census approaches (Stobart et al., 2007; Langlois et al., 2010), while other studies have used unbaited landers to effectively capture fish and habitat data (Hannah and Blume, 2012; Easton et al., 2015; Pita et al., 2014). Optimal lander deployment (drop) durations reported in the literature vary widely, from 10 min or less (Hannah and Blume, 2012; Ellis and DeMartini, 1995) to up to 60 min (Colton and Swearer, 2010; Harvey et al., 2007; Langlois et al., 2010). Given this variation in lander configuration and deployment duration, it is essential when developing a robust lander survey approach to evaluate a given configuration's performance in the specific habitats of interest to refine protocols and test limitations of the sampling tool.

Studies evaluating the strengths and limitations of a video lander approach for a given area or fish community are especially valuable to inform long-term monitoring strategies for a given region (Pita et al., 2014; Stobart et al., 2007). Video landers show promise to comprise a key component of the long-term strategy for monitoring nearshore waters and the newly established marine protected areas in California and Oregon, U.S.A. (Langlois et al., 2012, 2006). As such, they have recently been the subject of methodical studies in this region (Hannah and Blume, 2012, 2014). However, we know of only one study using a video lander in shallow (<40 m) nearshore waters in Oregon (Easton et al., 2015). While Easton et al. (2015) used a lander to explore fish–habitat associations in this environment, their study did not evaluate the strengths and limitations of the tool. In the nearshore Northeast Pacific, favorable sea states (including visibility) are limited and the landers themselves are often expensive and bulky to withstand deployment into complex rocky habitats. The size and weight of these lander configurations also often require the additional expense of contracting larger vessels for deployment. Specific fish species common to shallow littoral habitats in the Northeast Pacific may exhibit varied responses to a video lander; introducing uncertainty in detectability that may influence the tool's ability to provide unbiased data. Additionally, the poor-visibility in the nearshore Northeast Pacific may limit the ability to confidently identify fish to species.

Here, a lightweight, cost-effective video lander was designed to be readily deployed off smaller vessels as an alternative to previously used larger lander configurations to sample the diversity and abundance of nearshore fish communities (e.g. Sebastes, Cottidae, Hexagrammidae) in Oregon's nearshore system of marine reserves. Diversity and abundance estimates of these nearshore reef fish assemblages are important metrics when monitoring Oregon's marine reserves. As such, optimizing the collection of these metrics should be considered when assessing this new lander configuration. Specifically, video landers generate relative conservative abundance estimates of the fish inhabiting a given reef. However, the limitation of these relative abundances estimates is that they may underestimate true abundance (Conn, 2011). Thus, it is important when using this newly configured lander to try to limit underestimates of abundance to verify that the highest abundance possible is observed during the drop duration. The Oregon Department of Fish and Wildlife (ODFW), the management agency tasked with monitoring reserve performance, recognized the need to assess the application and limitations of this new lander design within Oregon's nearshore waters to sample the target fish community prior to establishing long-term marine reserve monitoring with this tool. The objectives of this assessment were fourfold: (1) to determine the frequency of observation of nearshore fish species; (2) to determine whether baiting the lander would improve ability to resolve species-specific identification, increase estimates of species richness, increase estimates of abundance, or reduce drop duration needed to observe maximum richness or abundance; (3) to identify the optimal drop duration to maximize richness and abundance in this environment; and (4) to evaluate the *a priori* behavioral responses of species to this lander that could bias data. Evaluating the performance of this cost-effective, compact video lander prior to establishing a long-term monitoring program is essential to inform marine resource managers about the strengths and limitations of this sampling approach to survey the fish community of interest in this environment.

2. Material and methods

2.1. Lander design

The objective of lander configuration presented here was to reduce the size and weight such that it could be readily deployed off smaller vessels frequently owned by management agencies, ameliorating the expense of contracting larger vessels. Additionally, reducing the cost of the lander itself enables replicate landers to be affordably constructed and used simultaneously to maximize sampling during rare weather and visibility windows. Given the shallow depths of Oregon's nearshore rocky reefs and marine reserves, ambient light was deemed sufficient, eliminating the need (and cost) of external lights. To maximize data collection during favorable sea states, the newly configured lander needed to be remote (i.e. without live-feed umbilical to the vessel) to allow multiple lander deployments at a given time from a single vessel. Lastly, the lander needed to be designed to be both rugged and stable for encountering rocky reef habitats in an upright orientation.

The lander frames were constructed of 25 mm ID aluminum pipe in a tripod design with lead leg weights and topped with two 3 mm thick aluminum plates 20 cm in diameter (Fig. 1). Weights were attached to the base of the legs to maintain a low center of gravity to reduce potential for tipping. At the top of the lander was a stainless steel eye bolt for buoy line attachment (Fig. 1). This streamlined tripod configuration was designed to reduce the chance of the lander frame becoming stuck in rocky habitat but strong enough to be able to withstand contact with rocky substrates with limited damage. Three GoPro® Hero 3 + Black Edition HD cameras with magenta filters were mounted 42 cm from the base of the lander (comparable Hannah and Blume, 2012) with 120° separation (Fig. 1). Three cameras maximized the likelihood of obtaining unobstructed video footage on at least one camera. Footage from a single camera per drop was used for analysis. These cameras were chosen based on cost, relatively high image quality in low light conditions, and small size. High-definition video was collected at 1080 × 1920 progressive format at 48 frames per second in the low-

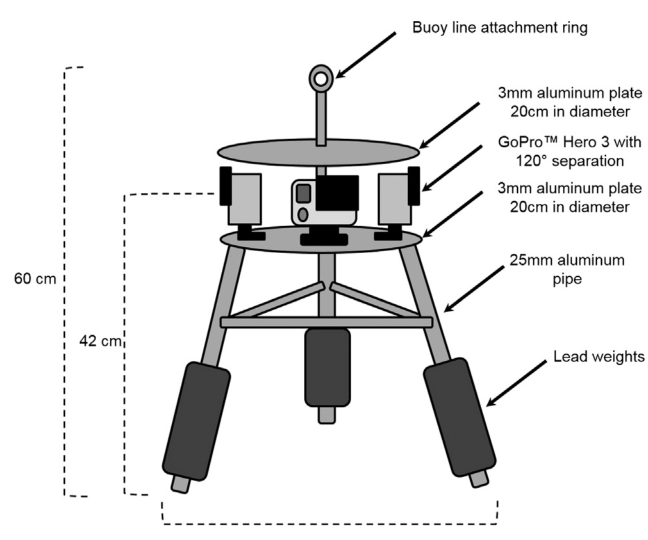

Fig. 1. Schematic of the lander design showing the various components.

light mode with spot meter on and protune off. Fully assembled, the video lander weighed 15 kg and cost $1715 (U.S. dollars). Two identical landers were constructed and used simultaneously during sampling.

2.2. Field methods

Lander surveys were conducted in the nearshore rocky reefs off the Oregon coast. The two identical, remote underwater video landers were deployed in a free descent from the survey vessel, remain stationary on the benthos for the designated drop duration, and then retrieved using an electric pot hauler. When the lander reached the benthos, a spatial position of the deployment was recorded. All video lander deployments were carried out at least 1 hour after sunrise and 1 hour prior to sunset to avoid the crepuscular period.

Bait tests were conducted at two sites within 18.5 km of Newport, Oregon. For baited deployments, an orange mesh bait bag of chopped Pacific sardine (*Sardinops sagax*) and market squid (*Loligo opalescens*) was suspended directly under the cameras. Bait was replaced every three drops. For unbaited deployments, an identical empty bait bag, which was never in contact with bait, was suspended in an identical location. At each of the two sites, a total of 40 points were randomly placed on rocky substrates between 5 and 25 m depths and spaced >250 m apart to minimize the influence of bait on adjacent deployments. Sampling points were randomly assigned as either baited or unbaited and then the reverse treatment applied on a second sampling day to generate 40 baited deployments and 40 unbaited deployments per site. Two rounds of bait tests were completed. For the first bait test, the drop duration was 8 min. For the second test, the drop duration was extended to 20 min to allow additional time for the bait effects to manifest.

After determining that bait had no effect on the fish response variables, drop duration was determined for an unbaited lander only. Hannah and Blume (2012) suggested a 4 min drop duration for deep temperate rocky reefs in Oregon. As one goal for this study was to explore optimal drop duration in the shallow nearshore habitats, drop duration was extended threefold to 12 min. Drops were conducted at numerous sites along the Oregon coast that correspond to marine reserve locations. Drop locations were selected by first constraining the survey area to rocky reef habitats at depths between 3 and 33 m, and then randomly selecting points using a minimum buffer distance of 250 m. In total, 505 drops were completed from Sept. 2014 to Oct. 2015.

2.3. Video review and analysis

For each drop, all three videos were initially reviewed to confirm the lander oriented upright and the benthic environment in view met predetermined conditions of visibility, view, and rocky reef habitat (Table 1). Visibility was scored as an index based on water clarity, while view reflected whether the field of view was obstructed when the lander settled onto the seafloor. Primary habitat was recorded as the most abundant geological habitat in the field of view. Videos with a visibility score of 0 (unusable), with a view score of 0 (poor), or not encountering rocky habitats, have been shown to bias estimates of fish diversity and abundance (Huntington et al., 2014) and were excluded from further analysis. The camera with the highest scores for visibility and view that encountered rocky substrates was selected for analysis. If all three cameras scored equally for a given drop, one was randomly retained for analysis. Of the 505 drops conducted, 70% (n = 353) met habitat, view, and visibility requirements and were reviewed for fish observations.

All fish that could be positively identified to species were scored; individuals unable to be positively identified to species were tallied and excluded from subsequent analysis. The proportion of retained drops in which a given species was observed was calculated. A species that occurred in ≥20% of drops was considered common, while species occurring <20% were considered rare (Stobart et al., 2007). The time at which a species first arrives in the video (i.e. time of first arrival) was recorded in MM:SS. The index of relative abundance per species was quantified as MaxN and recorded, along with the time that MaxN occurred. MaxN is a conservative approach to quantifying abundance that is the most commonly used metric in reef habitats to index fish abundance (Ellis and DeMartini, 1995; Harvey et al., 2007; Watson et al., 2005). While there may be more individuals present in the area than recorded, this metric minimizes the risk of repeatedly sampling the same individuals.

Table 1
Definitions of the metrics used to score lander drops for visibility, view, and primary habitat type.

Metric	Class	Description
Visibility	0—Unusable	View of surrounding substrate completely obscured; ID not possible
	1—Poor	ID ability potentially compromised by visibility
	2—Moderate	View limited by variable turbidity and/or marine snow but ID still possible
	3—Good	View of surrounding substrate is clear; ID readily possible
View	0—Poor	Obstructed or tipped upwards (cannot see benthos); obstruction is <1 m away and >50% of frame
	1—Moderate	Partially obstructed; >1 m away and >50% of frame is obstructed or lander tilted but benthic substrate still visible
	2—Good	Not Obstructed; oriented upright
Primary habitat	Bedrock	Substrate with mostly continuous formations of bedrock
	Bedrock outcrop	Individual rocks or outcrops of bedrock with sizes >4 m in any dimension
	Large boulder	Median gravel size of 1 m to <4.0 m, including angular and rounded blocks
	Small boulder	Median gravel size of 25 cm to <1 m
	Cobble	Median gravel size of 64 mm to <25 cm
	Gravel Pebble	Median gravel size of 2 mm to <64 mm
	Sand	Particles 0.0625 mm to <2 mm in diameter
	Mud	Particles <0.0625 mm in diameter

To evaluate whether bait reduced the number of unidentifiable fishes observed, a generalized linear model (GLM) was conducted on the MaxN of unidentified fishes with bait as a fixed factor. A quasi-Poisson distribution was used to control for over-dispersion common in ecological count data. Next, excluding unidentified fishes, the same GLM approach was used to test whether bait impacted total abundance ($MaxN_{agg}$) and species richness. Multivariate differences in community composition between baited and unbiated drops were evaluated using an analysis of similarity (ANOSIM) based on a Bray–Curtis resemblance matrix of species-specific MaxN. To evaluate whether bait impacted predators differently than prey species, a second ANOSIM was conducted using a matrix of MaxN by feeding guild rather than species. Influence of bait was determined from ANOSIM outputs by reviewing the global R statistics, which ranges from 0 to 1 with higher values (>0.6) indicative of strong clustering of community composition by the factor being tested. Lastly, non-parametric Wilcoxon tests were used to explore whether bait reduced the time of first arrival or time of MaxN for individual species.

The optimal deployment duration was determined in two ways. First, species accumulation curves over the duration of a drop were constructed. The time beyond which no additional species accumulated was noted as an optimal deployment duration. Second, the mean time of first arrival and mean time of MaxN were plotted for each species observed. Both time values were considered to generate a conservative optimal drop duration that would both maximize number of species observed and the greatest abundance of each species.

To evaluate species-specific behavioral response to the lander, a second detailed video review was conducted on a subset of the lander drops that contained the commonly observed species (n = 127).

Three *a priori* behavioral responses to the video lander were hypothesized in this study: attraction, avoidance, and neutrality. An attractive response was defined as species whose abundances increase over the entire duration of the drop suggesting that the maximum abundance for the fish in that area has not been observed. Species displaying an avoidance response to the lander were hypothesized to only be observed immediately upon initial lander settlement on the benthos and not seen again during the duration of the video. Lastly, a neutral response was defined as a species whose abundance fluctuates over the duration of the drop but is neither immediately deterred nor continually attracted to the lander over time. This includes species exhibiting an initial attraction then dissipation in abundance within the drop duration. Video review entailed evaluating MaxN within 30 s bins for each species observed throughout the entire duration of the drop. MaxN was then standardized per drop as follows:

$$\left(\frac{MaxN_{sp^i}}{MaxN_{sp^{max}}}\right) * 100$$

where $MaxN_{sp^i}$ is the MaxN for a given species for each of the 30 s time bin in a single drop, and $MaxN_{sp^{max}}$ is the greatest MaxN for that species observed in any of the 30 s time bin in the drop. Means of these standardized MaxN values were then calculated for each 30 s time bins to evaluate behavioral responses per species over the drop duration.

This standardization allowed for the comparison of species-specific patterns in abundance over the drop duration, acknowledging the potential for variable absolute abundances between drops. The standardized MaxN values were averaged for a given time bin and plotted over the drop duration. Trends in species abundances were then compared to three *a priori* behavioral responses: attraction, avoidance, and neutral. These data were only presented for the commonly observed species as rare species were data limited.

Univariate statistical analyses were conducted using the R statistical package (R Core Team, 2012), and multivariate analyses were conducted using the PRIMER statistical package (Clarke and Gorley, 2006). Plots were created using the gglpot2 package in R (Wickham, 2009).

3. Results

3.1. Frequency of fish observations

Fish were observed in 84% (n = 295) of the lander drops that met the requirements for visibility, view, and habitat. Fifteen fish species were observed with five species (*Sebastes melanops, Sebastes mystinus/Sebastes diaconus, Hexagrammos decagrammus, Embiotoca lateralis,* and *Ophiodon elongatus*) classified as common based on their frequency of occurrence, while the remaining 10 species were classified as rare (Table 2). A maximum of six different species were observed in a single drop (n = 12); however, average species richness was much lower (2.2 ± 0.04 SE). Indeed, 22.7% of drops in which fish were observed consisted of a single species (n = 67). When present, seven species exhibited mean MaxN values of one (Table 2), reflecting solitary and/or territorial life histories. Of all fishes observed, 77% were identified to the species level.

Table 2
Of the drops that met condition of habitat, visibility and view (n = 353), sample size containing that species (n), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present are provided.

Species	n	Frequency	Occurrence	Mean MaxN when present
Sebastes melanops	177	0.5	Common	3
Sebastes mystinus/diaconus	94	0.27	Common	3.76
Enophrys bison	1	<0.01	Rare	1
Scorpaenichthys marmoratus	12	0.03	Rare	1
Sebastes pinniger	13	0.04	Rare	2.15
Sebastes nebulosus	4	0.01	Rare	1
Hexagrammos decagrammus	189	0.54	Common	1.15
Ophiodon elongatus	97	0.27	Common	1.12
Oxylebius pictus	2	0.01	Rare	1
Rhacochilus vacca	67	0.19	Rare	1.42
Sebastes maliger	1	<0.01	Rare	1
Embiotoca lateralis	116	0.33	Common	2.09
Anarrhichthys ocellatus	2	0.01	Rare	1
Sebastes ruberrimus	1	<0.01	Rare	1
Sebastes flavidus	11	0.03	Rare	2.27

3.2. Baited versus unbaited

Contrary to other studies, baiting the lander did not improve the ability to identify fish, alter community composition, or reduce the time of first arrival or MaxN. The number of unidentified fish did not differ between the baited and unbaited drops for either the 8 min or 20 min drop durations (Table 3). Similarly, we detected no difference in total abundance of fish identified to species ($MaxN_{agg}$) or species richness between the baited and unbaited drops for either drop duration (Table 3). Community composition did not differ between baited and unbaited drops at the species level (Fig. 2B; ANOSIM; 8 min: Global R = 0.089, 20 min: Global R = 0.078) or by feeding guild (Fig. 2C; ANOSIM; 8 min: Global R = 0.005, 20 min: Global R = 0.108). Baiting the lander had few significant impacts on the time of first arrival for species in either the 8 or 20 min drop durations. *O. elongatus* arrived significantly later in the baited 8 min drops (Wilcoxon test, p = 0.01). *S. melanops* arrived significantly earlier in the baited 20 min drops (Wilcoxon test, p = 0.001). These were the only two species exhibiting significant response of time to first arrival with bait. Time of MaxN also showed no consistent benefit of bait across the species observed. *O. elongatus* and the *S. mystinus/diaconus* complex reached MaxN later in the baited 8 min drop (Wilcoxon test, $p < 0.05$), but this pattern was not observed in the 20 min duration. In the 20 min drop duration, time to MaxN was significantly reduced for only two species: *S. melanops* and *Rhacochilus vacca* (Fig. 2A).

3.3. Optimal drop duration

The optimal drop duration was determined as the time to achieve maximum species richness and abundance. The number of species observed in a given drop increased with the drop duration until approximately 8 min into the video (Fig. 3). A maximum richness of six species were observed within a single drop (Fig. 3). Despite a species pool of 15 and an average drop duration of over 12 min, additional time beyond 8 min did not yield greater species richness. With the exception of the *Anarrhichthys ocellatus*, both the time of first arrival and the time of MaxN for all species occurred before 8 min (Fig. 4). Hence, 8 min is recommended as the optimal drop duration to maximize both species richness and relative abundance for fishes in Oregon's nearshore waters.

Table 3
Results of quasi-Poisson GLM models evaluating the influence of bait on the abundance of unidentified fishes, identified fishes ($MaxN_{agg}$), and species richness for both 8 min and 20 min drop durations.

Response	Duration (min)	Baited		Unbaited		P-value
		Mean	SE	Mean	SE	
Unidentified MaxN	8	1.32	0.25	1.13	0.23	0.607
	20	1.57	0.69	0.64	0.25	0.158
$MaxN_{agg}$	8	5.73	1.04	4.34	0.54	0.191
	20	4.07	0.76	5.58	0.76	0.168
Species richness	8	2.49	0.26	2.22	0.16	0.347
	20	2.43	0.28	2.92	0.22	0.174

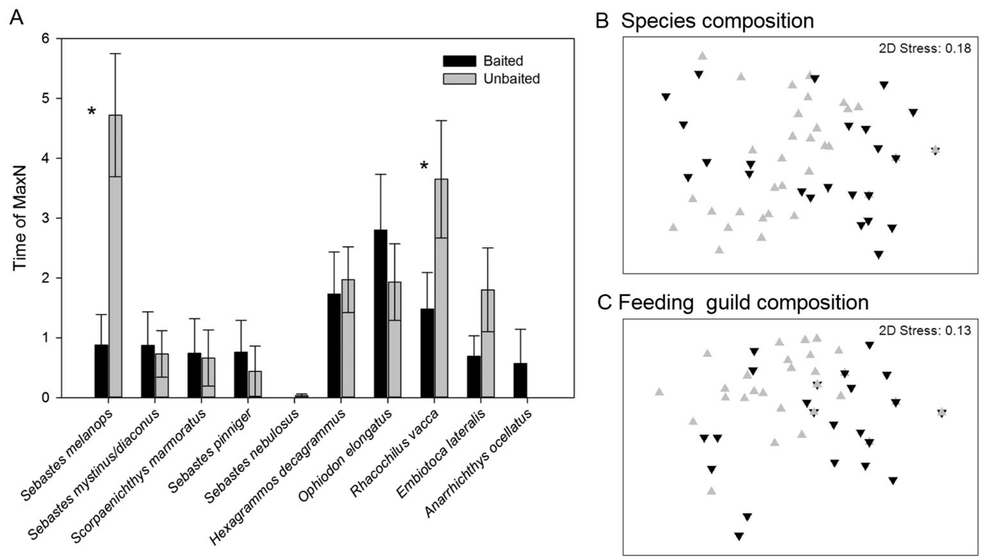

Fig. 2. Impacts of bait during 20 min lander deployments for A) time to MaxN (mean ± SE) by species, B) community composition by species, and C) community composition by feeding guild. * indicate significant difference between baited (black) and unbaited (grey) responses (Wilcoxon test, $p < 0.05$).

3.4. Behavior response

Relative abundance over the drop duration for each of the common species was used to infer attraction, avoidance, or neutrality to the lander. The standardized abundance for the five common species were variable over the drop duration (Fig. 5). *S. melanops* and *S. mystinus/diaconus* showed increases in abundance shortly after the lander contacted the bottom (within 120 s). However, this increase quickly dissipated. No single species exhibited a consistent increase in abundance through time indicative of an attractive response. Likewise, an immediate avoidance response was not observed. Rather, the five species showed fluctuating abundance patterns throughout the duration of the drop consistent with *a priori* predictions of a neutral response to the lander.

4. Discussion

This study refined the use of a lightweight, cost-effective video lander configuration to survey temperate, nearshore fish assemblages. In the Northeast Pacific, there are limited fishery-independent data to characterize abundance of fishes in these rocky reef environments. However, fishery-independent data are increasingly recognized as important to marine resource management decisions including evaluations of fish stocks (Harms et al., 2010), monitoring long-term change in trophic structure (Shackell et al., 2010), and assessing spatial management tools like marine reserves and other restricted fishing areas (Yoklavich et al., 2007). Lander video surveys offer one cost-effective method for increasing the amount of fishery-independent data available. As with any survey tool, these results validate the importance of first addressing the strengths and limitations of the tool within your study region before launching a comprehensive fishery-independent monitoring program.

A component of this lander evaluation was to assess the amount of usable data generated for a given sampling effort within challenging sea states with variable visibility. In the course of completing 505 drops, the video system was undamaged and the lander was never

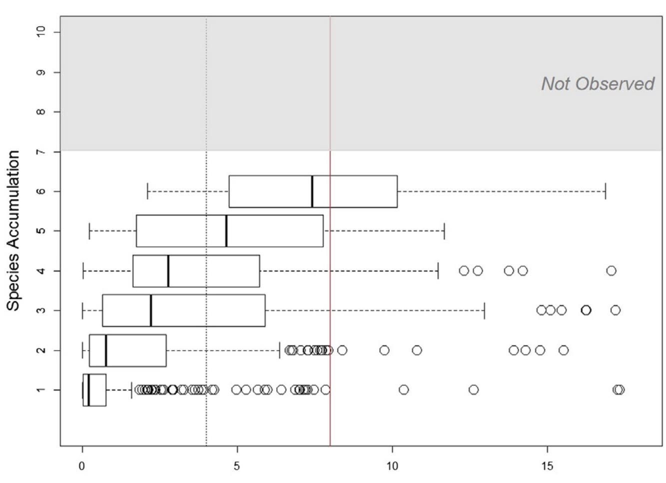

Fig. 3. Species accumulation over the drop duration. No drops contained more than six species despite drop durations in excess of 12 min (grey bar). The vertical black dashed line at 4 min demarks the drop duration recommended by Hannah and Blume (2012). A vertical red line at 8 min demarks the suggested drop duration from this study. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

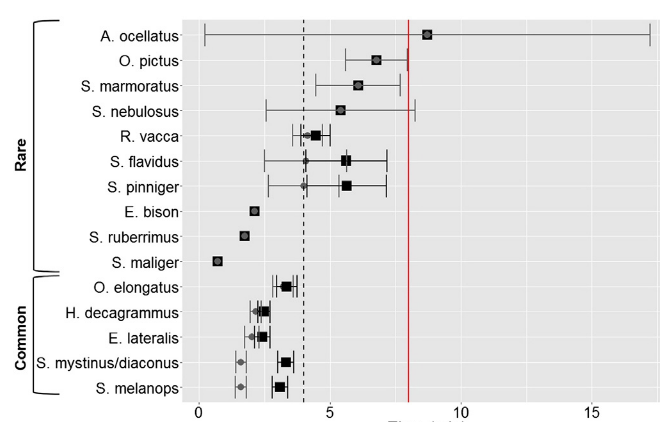

Fig. 4. Mean (±SE) time to first arrival (grey circle) and time to MaxN (black square) for 15 fish species observed. The vertical black dashed line at 4 min demarks the drop duration recommended by Hannah and Blume (2012). A vertical red line at 8 min demarks the suggested drop duration from this study. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

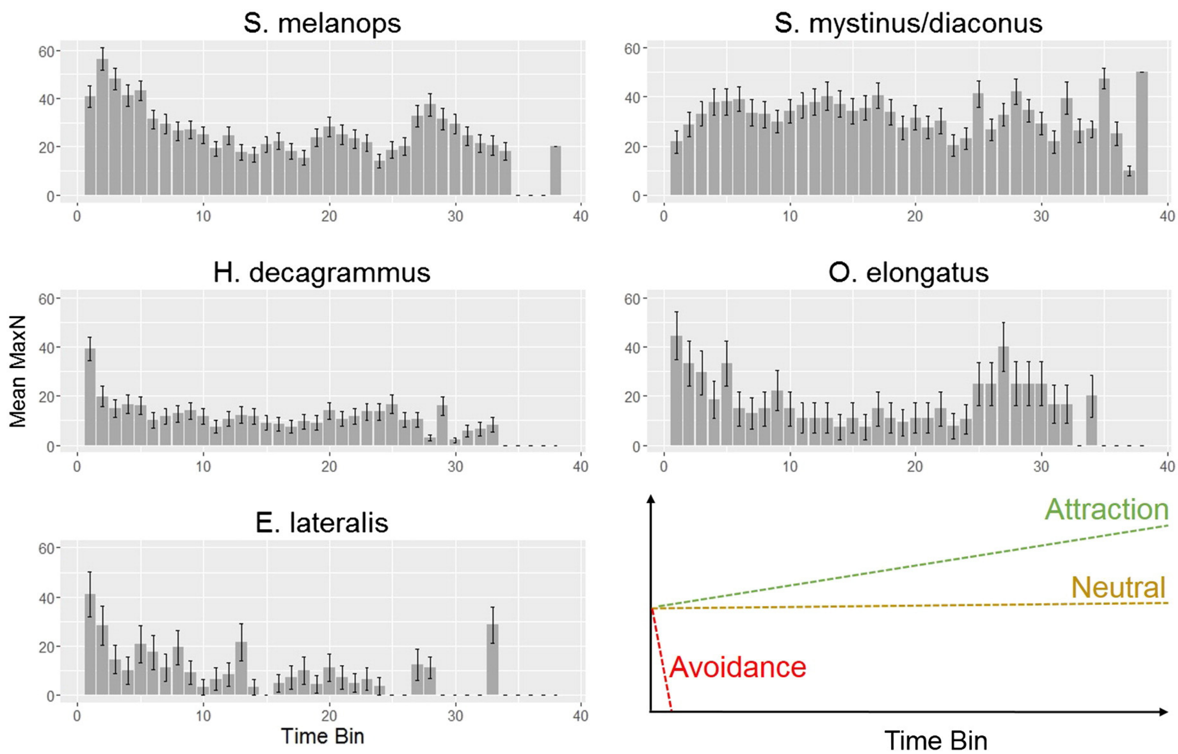

Fig. 5. Standardized mean MaxN (±SE) throughout the duration of the drop for the five common fish species. MaxN was scored using 30 s time bins for the duration of the drop. *A priori* hypothesized responses are shown in the bottom right panel.

irretrievable. The proportion of the lander drops that met *a priori* visibility, view, and habitat requirements (70%) with this new cost-effective configuration was comparable to the 77–82% obtained by Hannah and Blume (2012) from nearshore Oregon waters. These similarities between the proportions of useable drops by these two different configurations attests to this new lander's ability to encounter the target habitat, orient upright, and record useable video at a fraction of the cost. Due to the small size and low cost of these video landers, replicate landers can be affordably constructed and easily mobilized using small vessels to capitalize on short windows of good visibility and favorable sea states that characterize this environment. Indeed, the pair of landers used here enabled upwards of 45 deployments (targeting 8 min drop durations) in an 8 h sampling day.

The lander encountered 15 species known to inhabit the nearshore waters of Oregon – including species important to management such as the Yelloweye Rockfish (*S. ruberrimus*) and Canary Rockfish (*S. pinniger*) – validating this tool's ability to capture species of interest prior to establishing long-term fishery-independent monitoring protocols. While a maximum of only six species were observed within a single drop, these diversity levels are comparable to unbaited lander studies in other temperate systems where species accumulation within a sample was acknowledged to be low (i.e. 12 species observed in the Mediterranean, Stobart et al., 2007). It is worth noting that half of the usable drops contained at least one fish observation unidentifiable to the species level; limiting the ability to generate precise species-specific measures of diversity and abundance. Similarly, abundance estimates were low for many species and zero values were frequent, which can make statistical comparisons of abundance challenging. Yet, this limitation is inherent with conducting visual surveys in the low visibility temperate environments (Stobart et al., 2007), and reflects the solitary, demersal life histories of many of these fishes. Interestingly, the percentage of drops in which fish were observed (84%) with this small, lightweight lander was much higher than a previous study in Oregon's nearshore waters that used a larger unbaited lander with external lights. Easton et al. (2015) only observed fish in 54% of lander drops conducted during the spring, and 63% of drops conducted in the fall, though he did not exclude drops that encountered sand habitat in his analysis where fewer numbers of nearshore demersal fishes are observed (Huntington et al., 2014).

Unbaited deployments performed equally well to the baited deployments for surveying a diverse assemblage of rocky-reef-associated fish species within relatively short deployment times. This finding contrasts to lander studies from warmer water systems evaluating the influence of bait over 60 min drop durations (Watson et al., 2007; Willis and Babcock, 2000; Harvey et al., 2007; Langlois et al., 2010). However, bait impacts have been detected in temperate lander studies using drop durations of <12 min (Watson et al., 2005; Hannah and Blume, 2014), providing support that the 20 min drop durations were sufficient in time to observe effects of bait. Bait was hypothesized to reduce the optimal deployment duration by drawing in individuals more quickly who were attracted to the bait. However, there was no consistent reduction in time of first arrival or time of MaxN for the species observed. Nor did bait improve the ability to resolve observed fish to species. These findings mirror those of video lander tests in the nearshore waters of California where no discernable benefit of bait was found (R. Starr & C. Denny, pers. comm.). Interestingly, the nearshore hook-and-line fishery (both commercial and recreational) in this region relies heavily on unbaited terminal gear indicating that visual cues, rather than bait, are most effective at catching these species. There are potential benefits to using an unbaited approach. Baited landers have biases associated with fluctuating bait plume dispersal in changing ocean conditions and variable fish attraction patterns to bait (Cappo et al., 2004). In contrast, unbaited landers avoid these bait biases and can provide data for exploring fish distributions and species-habitat associations without the confounding influence of bait (Easton et al., 2015), which aid in designation of essential fish habitat (Johnson et al., 2003).

A deployment duration of 8 min was established to maximize species richness and relative abundance for all observed species while minimizing the drop duration to facilitate increased sample sizes. Longer drop durations did not lead to increases in observed species richness, suggesting that high diversity mixed assemblages are uncommon at the scale at which this tool samples the demersal fish community. This 8 min recommendation reflects a doubling of the drop duration identified by Hannah and Blume (2012) from deeper water habitats off Oregon's coast, reiterating the value of testing the performance of a given sampling tool within the specific environment of interest. Similar lander tests underway in the temperate nearshore waters of California also determined 8 min to be optimal for maximizing observed richness and relative abundance (R. Starr & C. Denny, pers. comm.). Species-specific biases towards a sampling tool can limit which target communities can be reliably sampled (Smith, 1989; Stobart et al., 2007). Of the five common species examined in this study, all exhibited a neutral response to the lander's presence over the drop duration. This neutral response may reflect the lack of external lights on the lander which have been shown to influence fish behavior (reviewed by Stoner et al., 2008) or the relatively small size and stationary nature of the lander itself. *S. melanops and S. mystinus/diaconus* exhibited an initial attraction followed by dissipation within the suggested 8 min drop duration. Unlimited increases in abundance are improbable given the finite amount of fish in a given area, therefore only attractive responses continuing over the duration of the suggested 8 min drop would warrant extending the drop time past the asymptote of the attractive response. The short-lived attractive responses of *S. melanops* and *S. mystinus/diaconus* are beneficial in ensuring that the highest MaxN for these species are observed during the drop duration protecting against potential underestimates for these species. The behavioral examinations were limited to the five most abundant species many of which exhibit schooling behaviors. It is possible that the solitary, demersal species which were classified as "rare" in this study may exhibit biases towards this lander. However, more lander deployments encountering these rare species are needed before a similar examination of their behavior can be explored.

5. Conclusion

A growing number of studies are refining the application and use of video landers to assess fish assemblages in locations across the globe (Stobart et al., 2007; Pita et al., 2014; Langlois et al., 2010). While these studies offer tremendous insights in how certain lander configurations might perform in a given system, these results underscore the need to explicitly test the performance of a specific tool in one's ecosystem or habitat of interest in order to refine targets of use (Stoner et al., 2008; Colton and Swearer, 2010). In fishery-independent monitoring studies as well as marine reserve assessments, it is important to employ a standardized method, with known biases (Magnuson, 1991). ODFW seeks to build its cadre of tools capable of cost-effectively and accurately sampling the fish assemblages in Oregon's nearshore waters for application in population monitoring, fishery assessments, and marine reserve evaluation. Expanding these approaches geographically across nearshore waters of the Northeast Pacific can broaden spatial scale of long-term monitoring in this region. We are encouraged that similar video lander tests in nearshore water of California have found similar results when considering drop duration and the usefulness of bait. Establishing consistency among regional video lander protocols allows for comparability between California Current nearshore monitoring efforts and increases the spatial scale at which regional comparisons can be made. There are, however, fundamental differences in the approaches used in temperate nearshore lander surveys in this region to those carried out in more tropical biogeographic regions. As such, global scale comparisons of long-term monitoring efforts will be limited.

Looking forward, ODFW is developing stereo–video capacity to generate length data of observed fishes (Langlois et al., 2012; Hannah and Blume, 2014; Williams et al., 2010). Increases in fish biomass calculated from lengths can be an earlier indicator of marine reserve response (Lester et al., 2009) and will be a valuable addition to long-term monitoring in Oregon's marine reserves. These relatively simple methodological studies are a crucial step toward advancing the use of these survey methods to generate robust data and guide the process of continued refinement of these techniques into the future.

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