Standard Operating Procedures (4.3): Fish Cameras – Baited Remote Underwater Video

March 2021

Prepared for the United States Environmental Protection Agency

The Bay Foundation
8334 Lincoln Blvd. #310, Los Angeles, CA 90045
(888) 301-2527
www.santamonicabay.org

Standard Operating Procedures:
Fish Cameras –
Baited Remote Underwater Video (BRUV)

SOP Identification: SOP 4.3 Fish Cameras
Date of Original Issue: 29 March 2021
Date of Last Revision: 29 March 2021
Developed by: Christine Whitcraft, California State University, Long Beach
Protocols reviewed by:
Cody Fees, California State University, Long Beach
Jeff Crooks, Tijuana River National Estuarine Research Reserve
Karina Johnston, The Bay Foundation

Suggested citation: CSULB and TBF. 2021. Fish Cameras Standard Operating Procedures. Unpublished protocols. The Bay Foundation, Los Angeles, CA.

Protocol Suitability Evaluation

A habitat suitability table containing appropriate estuarine wetland habitat types (of those evaluated) to implement the fish camera Baited Remote Underwater Video (BRUV) protocol is displayed in Table 1. Some camera trapping may also be appropriate in emergent salt marsh but only at high tides. A comparative assessment of cost, effort, and data quality are shown in Table 2. A matrix of additional detailed categorical evaluations of fish cameras can be found in Appendix 4.3A.

Table 1. Appropriate habitat types for fish camera trap survey protocols.

	Habitat Types					
Survey Protocol	**Tidal Channel**	**Mud/sand flat**	**Emergent salt marsh**	**Non-tidal salt marsh**	**Salt pan**	**'Degraded' / fill**
Fish Camera (BRUV)	X	X				

Table 2. Categorical assessment of cost/effort and data quality for fish beach seine survey protocols.

	Evaluation Metric	Fish Camera (BRUV)	Notes
Time / Effort	Office Preparation Time	30-60 minutes	Gather equipment, site selection
	Equipment Construction Time (one time)	10 minutes	Assemble the bait and camera set up
	Field Time (per station)	2 + hours	Depending on the accessibility, each station may take more than 2 hours of video time
	Laboratory Time (per station)	0 minutes	Not applicable, unless post quality control checks on videos are necessary
	Post-Survey Processing / QAQC Time	Variable	Watching time will depend on the length of video taken and will decrease with experience of the data collector
	Minimum Repetition (site-dependent)	Few Repetitions	As fish are highly mobile and variable, repetitions are encouraged but are often time/effort limited; typically, 2 – 3 video sessions per site per sampling period are conducted
	Relative Cost (equipment and supplies)	> $500	Cameras, housings, SD cards, batteries, PVC, bait, stockings
Survey / Data Quality	Accuracy (at a survey area level)	Medium	----
	Precision (at a survey area level)	Medium	----
	Qualitative-Quantitative Score	Quantitative	----
	Subjectivity-Objectivity Score	Objective	----

Resulting Data Types

The application of the fish camera trap survey protocol will yield quantitative data displayed as counts (MaxN –see discussion below) by species or size frequency distributions across multiple time scales (e.g., seasonally, annually). These data are useful to identify the potential species composition / richness of specific wetlands, sub-areas, or habitats and to potentially identify the uses or functions of a particular wetland area by specific fish species (e.g., nursery). Data can be displayed as size frequency or MaxN abundance graphs, species presence tables, multivariate charts (e.g., MDS or CAP), or at a higher level using diversity indices.

Objective

Defining the fish assemblage of a wetland can be difficult, due to the highly mobile nature of the fauna. Characterizing wetland fish assemblages is often a primary goal of monitoring efforts, but besides the mobility, there are often inherent biases associated with sampling methodologies. Therefore, it is often advantageous to use a variety of methodologies to characterize the fish communities as fully as possible. The primary purpose of this sampling method is to quantitatively assess the distribution, relative abundances, species richness, and diversity of fish in intertidal or subtidal wetland habitats using cameras. Fish cameras are a potentially useful addition to many sampling programs and can be co-deployed with stationary gear such as minnow traps.

Baited cameras are highly effective at attracting scavengers and subsequent predators (Wilson and Smith 1984, Henriques et al. 2002, Davis et al. 2019). Additionally, they are non-extractive, cost-effective, and particularly useful when other forms of sampling are challenging due to uneven substrate (e.g., shell hash or oyster beds), fish handling restrictions, or other reasons (Dorman et al. 2012). Baited video monitoring and MaxN calculation have been successfully used to document fish assemblages within many structured coastal systems (Mallet 2014).

Equipment

Equipment and supplies needed for this survey include:

1. GoPro cameras and battery extenders (Figure 1)
2. Go Pro attachments (Figure 2) and waterproof housings (Figure 1)
3. Micro SD card, 64-GB (4) and adapter
4. PVC supports
    a. PVC pipe, 6 ft, white (4)
    b. PVC pipe, 0.5 m, clear (4)
    c. PVC primer and cement, with T-fitting (4)
5. Stockings or similar mesh material
6. Defrosted bait (fish, shrimp, etc.)
7. Zipties, electrical tape
8. Scissors
9. Screwdrivers to loosen the attachment gear
10. Wetsuit (optional)
11. Neoprene dive/surf booties and gloves

Figure 1. Go Pro camera (bottom left) with the battery extender (top left) and the waterproof case that attached to the PVC apparatus (middle); baited camera PVC T-frame setup (right).

12. Map of sites
13. Buckets and plastic containers for carrying gear
14. Field notebooks or data sheets for recording field notes (see Appendix 4.3B)
15. External hard drive or similar (for video storage)

Figure 2. Go Pro attachment gear to hold cameras onto the PVC structure.

Field Preparation

Site selection for fishing stations will vary with the question being asked. Generally, the placement of BRUVs within an estuary can be more widely spaced than other methods because they sample a broader range of species than many other techniques (e.g., Dorman et al. 2021). Following guidelines in the SONGS protocols for spacing (CCC 2006), it is recommended that multiple BRUV stations per estuary be spaced a minimum of 100 m apart to decrease chances for spatial autocorrelation. The stations should cover the range of tidal conditions of the estuary (e.g., creeks, channels, and/or basins).

Equipment described above should be collected prior to the field shift. BRUV stations should be constructed prior to field deployment. Batteries for all electronic devices should be charged, checked, and replaced as needed, and relevant data sheets should be printed and attached to the clipboards.

Field Methods

While the exact timing will depend on the monitoring objectives or research questions, using cameras at the time of peak fish abundance for the location is recommended. In southern California, this is often June and September as the targeted survey months to coincide with peak fish abundances. Additional survey times (e.g., March or December) may be added by individual site needs or if additional time may be allocated (Zedler 2001). Sampling should not be conducted within 72 hours of a rain event and other constraints may need to be considered (e.g., bird nesting season).

Individual set ups for the camera may vary based on substrate type, flow rates, and gear available. The general goal of the camera set up is to use a horizontal clear support to hold bait a known distance from the camera close to the substrate (if the goal is to capture benthic or demersal fish species). The clear

horizontal support has been demonstrated to be less noticed by fish. A white PVC bar underneath the baited arm may help secure the frame.

An upright support should be visual above the water to help relocate the camera post-deployment. Attachments for the GoPro camera should be set up in a way so the GoPro sits just above the horizontal clear pipe, and its view will be directly parallel with the horizontal clear pipe. If using older units, the GoPros may be paired with extendable battery packs to allow each of the units to collect videos for at least an hour and a half. Newer GoPros have extended battery life and can easily film for two hours.

The bait used for each camera should be store-bought bait or seafood (e.g., large frozen shrimp) placed in a pair of nylon pantyhose then tied to the clear plastic pipe approximately two-thirds down the pipe away from the camera but still clearly in view (Figure 3). The apparatus is inserted into the sediment so that the camera will be just above the bottom in a stable position, and then left out for 1-2 hours at each treatment of each site. Literature suggests collecting at least one hour of videos at each treatment per site per season (four seasons per year) over the course of two years (Bacheler and Shertzer 2015).

Tide selection of deployment will depend on the project needs but should be standardized across the monitoring or research program (e.g., always rising low-to-mid tide when target area is at least minimally covered the entire time) among sampling stations and sampling timing.

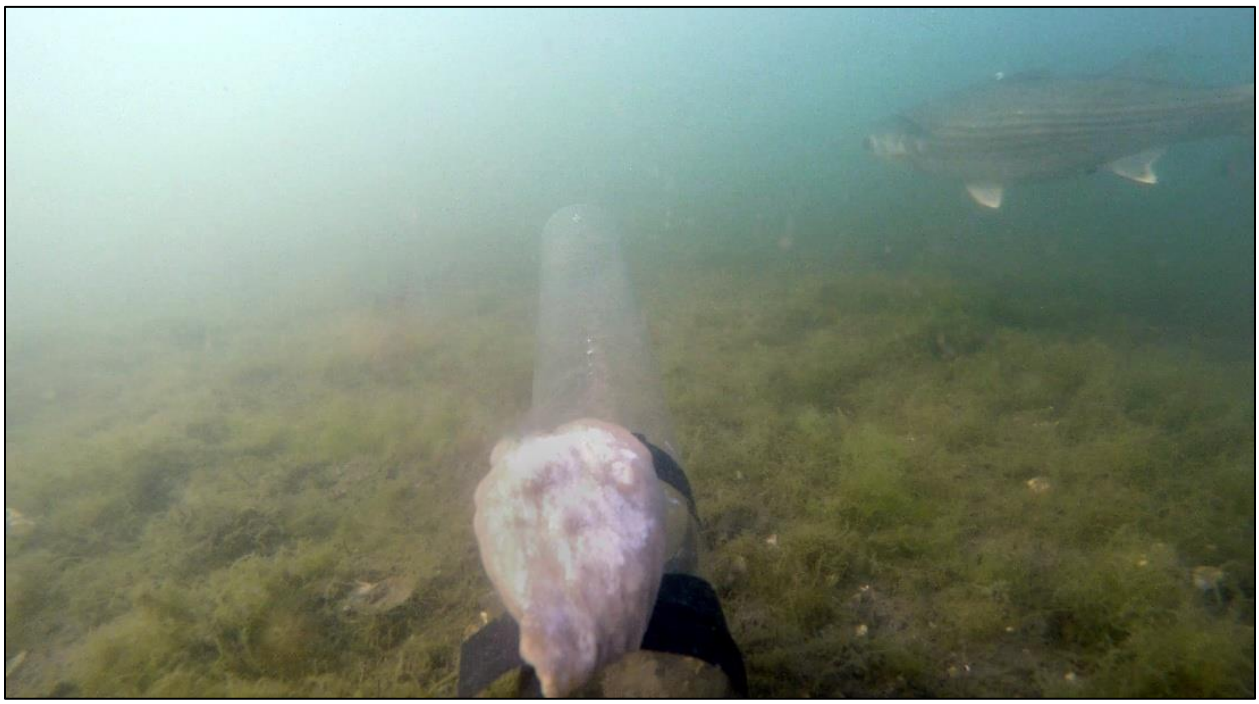

Figure 3. Photograph of mullet in an estuary at a baited BRUV.

Station protocols:

1. Randomly select station locations within the study area (Figure 4).
2. Secure GoPro cameras to PVC T-frames (Figure 1).
3. Fasten GoPro to attachments (base + 1 larger attachment + 1 smaller attachment), and secure camera to the arm of the T-frame using zipties. Cover zipties with electrical tape.
4. Chop shrimp and squid (or other available bait) and place in a bag made of nylon. Place bait approximately 0.3 m from GoPro, ensuring that its position is visible on camera.
5. Samples should be collected at low-to-mid tide when sites are minimally submerged. At each site, place the base of the T-frame into the sediment a fixed distance from the shore, facing away from shore (towards deeper water). Record for 1-2 hours (be consistent), or the maximum recording time with the battery available on the camera or extension pack.
6. Collect deployed cameras. Transfer files to external hard drive using SD card converter. Ensure all cameras are cleared and that both cameras and battery packs are charged before the next sampling date.

Figure 4. Example of camera placement locations from Upper Newport Bay.

Laboratory (Office) Methods

Analyze each video sample using a media player (e.g., VLC media player, open source) at up to 3x speed. For each fish passing through the frame of view (Figure 5), record ID to the lowest taxonomic level possible, and the time it enters and leaves the field of view. Abundance should be estimated by species as MaxNspecies, the maximum number of individuals present in the field of view at one time. Total time on camera for each species, as well as species richness and MaxN should be reported for each sample.

For each data sheet (i.e., each treatment within a site on a specific day, Appendix 4.3B):

- Calculate the amount of time each fish spends on camera (time out of frame – time in frame)
    - Note: Time calculations in Excel may return incorrect results depending on the format of the cells. They should be formatted as a time (Format cells > Custom > h:mm:ss).
- Add up quantities: (1) by species and (2) total
- Total number of different species observed = species richness (S)
- Total number of individuals observed = abundance (N)
- Additionally, calculate total amount of time used by each species as a different metric (Note: abundance may not be "true" abundances because the individual may re-enter the frame multiple times).
- Compare average and standard error by treatment

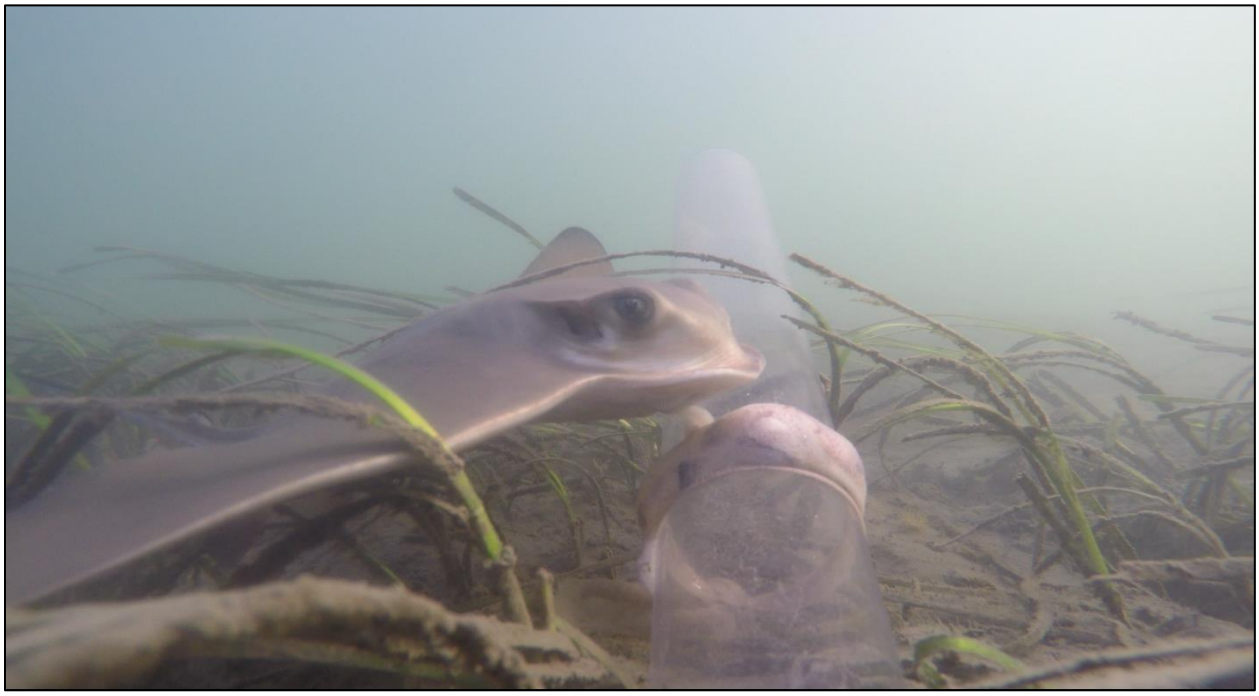

Figure 5. Bat ray appearing in a frame from a BRUV in Upper Newport Bay (credit: Marjorie Howard).

Data Entry and QAQC Procedures

Data should be entered in the field in a field notebook as described above. Back in the laboratory or office, data should be entered using the appropriate database (e.g., Appendix 4.3C). All required fields should be completed in full, and the data recorder should assign their name at the top of the document(s). Data should be transferred to the appropriate electronic database within three days, and the hard copies filed in labeled binders. Electronic copies of all data and videos should be housed on an in-house dedicated server and backed up to a cloud-based or off-site server nightly. Hard copies should be saved for five years. Electronic copies should be saved indefinitely.

Quality Assurance and Quality Control (QAQC) procedures should be conducted on all data. QAQC procedures should be conducted by the QA Officer and include a thorough review of all entries, double checking of all formulas or macros, and a confirmation that all data sheets, Chain-of-Custody forms, and field notes are filed appropriately with electronic back-up copies available. QAQC should verify that the entered data match the hard copies of the field data sheets. Any discrepancies should be corrected, and the initial data entry technician notified.

Data Analyses

After data have been entered, corrections made, and QAQC procedure completed, data can be used in multiple analyses. Examples include abundances by MaxN within site (Figure 6) or multivariate community analysis (Figure 7). Figure 7 displays a CAP analysis, with each point representing a sampling point and all the fish seen in the associated video. Distance between points corresponds to differences among community composition.

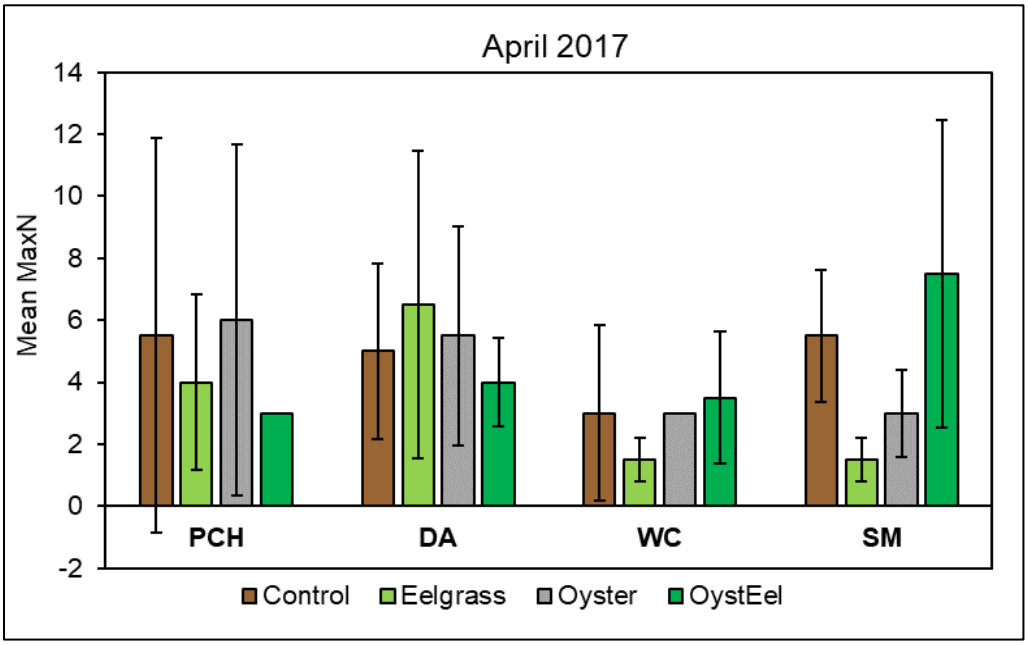

Figure 6. MaxN per site and treatment (replicated from Howard et al. 2019).

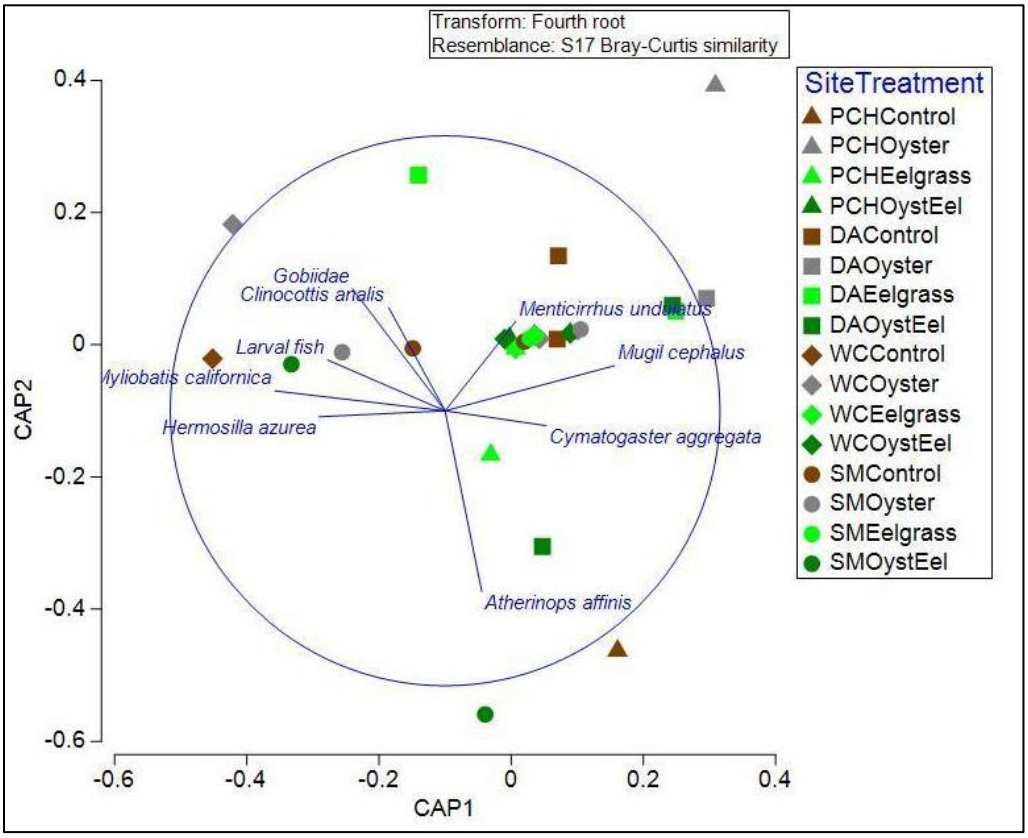

Figure 7. CAP multivariate plot of fish communities among treatments and locations (replicated from Howard et al. 2019).

Health and Safety Precautions

Care should be taken when setting up the cameras as deploying involves walking in habitats that have species with spines (e.g., sculpin, stingrays) or sharp terrain (e.g., shells or rocks). Additionally, appropriate attire and clothing should be worn for comfort and warmth in exposure to cold water for extended periods of time, e.g., wetsuit.

References and Applicable Literature

Bacheler, N. M., and Shertzer, K. W. (2015). Estimating relative abundance and species richness from video surveys of reef fishes. *Fishery Bulletin*, *113*(1), 15-26. https://doi.org/10.7755/FB.113.1.2

(CCC) California Coastal Commission. 2006. Monitoring Plan: The S.O.N.G.S. Wetland Mitigation Program. California Coastal Commission, San Francisco, CA. 21pp. + app.

Davis, J., C. Valle, M. Haggerty, and H. Gliniak. 2019. Comparing video and visual survey techniques for Barred Sand Bass in rocky reef ecotone habitats. California Fish and Game 105(4):233-253.

Dorman SR, Harvey ES, Newman SJ. 2012. Bait Effects in Sampling Coral Reef Fish Assemblages with Stereo-BRUVs. PLoS ONE 7(7): e41538. doi:10.1371/journal.pone.0041538

Henriques C, Priede IG, Bagley PM .2002. Baited camera observations of deep-sea demersal fishes of the northeast Atlantic Ocean at 15-28° N off West Africa. Mar Biol 141: 307–314.

Howard M., D. Zacherl, C. Fees, K. Nichols, and C.R. Whitcraft. 2019. Impacts of paired Olympia oyster (*Ostrea lurida*) and eelgrass (*Zostera marina*) restoration on fish and infaunal communities in Upper Newport Bay, CA. CSU Long Beach.

Mallet, D. 2014. Archimer Underwater video techniques for observing coastal marine biodiversity: A review of sixty years of publications (1952 – 2012). 154 (June), 44–62.

Wilson RR Jr, Smith KL Jr. 1984. Effect of near-bottom currents on detection of bait by the abyssal grenadier fishes *Coryphaenoides* spp., recorded in situ with a video camera on a free vehicle. Mar Biol 84:83–91

Zedler, J.B., ed. 2001. *Handbook for Restoring Tidal Wetlands.* Baton Rouge: CRC Press.

Contact Information

Christine Whitcraft, California State University, Long Beach
christine.whitcraft@csulb.edu

APPENDIX 4.3A

	Evaluation Metric	BRUV	Notes
	Correlation to L2 CRAM	Attribute 2	Hydrology-dependent
Personnel Requirements	Specialty Equipment or Clothing Required	Many Specialty Items	Cameras, supports, wetsuits, etc.
	Ease of Transport (amount or weight of supplies)	Many or Heavy Items / Difficult	See above; much less challenging than fish seines
	Ease of Implementation	Moderate	Time consuming and a high level of coordination is required for successful implementation
	Expertise / Skill Level	Some Technical Knowledge	Familiarity with species identifications is required
	Number of Personnel	2	Depends on number of sites
	Training Requirements	None	----
	Seasonality of Survey Time	Spring and Fall	Both seasons are required to capture the breadth of fish activity and species diversity
	Suggested Frequency	Semi-annual	Or more frequent, project-dependent
Survey / Data Quality	Type of Output	Numerical	----
	Active or Passive Monitoring Style	Active	----
	Specialty Computer Software Required	Yes	Video player or video editing software
	Availability of Online / External Resources	Many	----
Potential Limitations	Wetland Type Applicability	Bar-built and Estuarine	Must have tidal influence or prolonged water exposure
	Images or Multi-Media Required	Images Required	Videos are the data product
	Degree of Impact / Disturbance	Low Disturbance	Walking to deploy and retrieve cameras will disturb sediments
	Vegetation Height Limitation	Not Applicable	----
	Appropriate for Tidal / Wet Habitats	Yes	----
	Tide Height	Medium to High Tide Only	Implementation within flood and ebb tides may be possible in full tidal environments
	Regional or Broad Implementation *	Sometimes Used	----
	Potential for Hazards / Risk	Medium Risk	----
	Restrictions	Special Status Species	Although no collection occurs, special status species may still be present in survey area

** based on monitoring literature review*

APPENDIX 4.3B

	Timepoint 1: Time on camera							
	Date 1	Date 2	Date 1	Date 2	Date 1	Date 2	Date 1	Date 2
Species	**Control**		**Oyster**		**Eelgrass**		**Paired**	
Species 1								
Species 2								
Species 3								
…								
…								
…								
Total	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00
Mean	**0:00**		**0:00**		**0:00**		**0:00**	
St Dev	**0**		**0**		**0**		**0**	

	Timepoint 1: MaxN							
Species	**Control**		**Oyster**		**Eelgrass**		**Paired**	
Species 1								
Species 2								
Species 3								
…								
…								
…								
Total	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00
Mean	**0:00**		**0:00**		**0:00**		**0:00**	
St Dev	**0**		**0**		**0**		**0**	

	Timepoint 1: Species Richness							
	Control		**Oyster**		**Eelgrass**		**Paired**	
S	0	0	0	0	0	0	0	0
Mean	**0**		**0**		**0**		**0**	
St Dev	**0**		**0**		**0**		**0**	

APPENDIX 4.3C

Site Shellmaker
Treatment
Date 6/1/2019
Camera # Lowe 5
Total run time SUM(B8:B#)

File name	Total Video Clip Length (min)	Fish ID	Time in frame	Time out of frame	Time on camera (sec)	MaxN	Notes
GOPR####		round ray	7:15	7:24	9	1	
		round ray	7:25	8:23	58		
		round ray	8:28	8:51	23		

Species	Time on camera		Time (min)	MaxN
round ray		90	8.88	1
Species 2	SUM(F#,F#,F#...)		...	MAX(MaxNsp2)
Species 3	SUM(F#,F#,F#...)		...	MAX(MaxNsp3)
...	...		...	...
...	...		...	...
...	...		...	...