Using underwater video to observe aquaculture gear in Long Island Sound- A Citizen Science Guide

Gillian Phillips, Dylan Redman, Renee Mercaldo-Allen, and Julie M. Rose

NOAA Fisheries, Northeast Fisheries Science Center, Milford Laboratory

Milford, CT 06460

Contacts: Gillian Phillips, Dylan Redman, Renee Mercaldo-Allen, Julie Rose

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GoPro Team Members: Paul Clark, Mark Dixon, Erick Estela, Yuan Liu, Lisa Milke, Renee Mercaldo-Allen, Gillian Phillips, Dylan Redman, Julie M. Rose, Barry Smith

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Introduction

A team of scientists at the NOAA Fisheries NEFSC Milford Laboratory are studying interactions between aquaculture gear and the environment. We are using video from field-of-view cameras to document how off-bottom oyster cages provide habitat for fish in Long Island Sound. Fish may utilize oyster cages as a food source, for shelter, refuge from current flow or protection from predation. Shellfish farms with many cages add habitat and structure to the seafloor and may act as an artificial reef, attracting greater numbers of fish than found on bare bottom. Our study compares fish interactions with oyster cages to fish activity adjacent to natural structure on a rock reef.

To collect video, we chose point of view cameras because they are inexpensive, easy to use, provide good quality video, and are widely available. To observe fish activity, two cameras were mounted to each oyster cage, providing top and side views of the cage structure. To collect video across varying current and light conditions over a 12 hour tidal cycle, we used a timer compatible with the cameras that allowed us to conduct underwater recording at 8 minute intervals every hour. We also developed a minimal “t-platform” frame system for mounting cameras that allows us to collect video near boulders and at other natural habitats without adding more structure.

Our study has demonstrated the utility of GoPro™ cameras as a tool for observing aquaculture gear in Long Island Sound and other marine environments. This guide, which builds on our experiences, describes how to capture, edit and view underwater video images and is intended for those familiar with digital cameras.

A list of specific materials and brands we tested are included in this document. NOAA and the NEFSC do not endorse GoPro™ or other branded products described here.

Cameras

Model considerations: GoPro is a widely recognized brand designed to be used in ways traditional cameras are not. GoPro Hero 3+ and Hero 4 cameras can be used underwater by adding a waterproof dive case (choose 40 or 60 meters depths). Cameras require a battery, data or SD card and access to the internet for programming. The Hero 3+ is less expensive than newer models but has similar utility. Newer models are waterproof and do not require an underwater dive case.

Pictured above is a Hero 3+ Silver camera in a 40 m dive case.

Updating firmware: The process for updating camera firmware is similar for all camera models and is accomplished at the GoPro Website

The first five steps apply to all camera models:

1. Go to the GoPro Website and create a free GoPro account
2. From the GoPro home page, click 'Support' on the top navigation bar on the right side
3. Select the 'Product updates' box
4. Click 'Product updates' on left navigation bar
5. Select 'Hero 3+' or your correct camera

The following instructions are specific to the 'Hero 3+' and steps for other models may be different:

6. Select 'Update manually'
7. Enter GoPro serial number (located in the battery area of the camera), enter email address and click next
8. Select update type and click next step
9. It is best to set up WiFi and Firmware the first time you update cameras. Setting up WiFi information makes it easier to use the GoPro App and tell multiple cameras apart
10. Follow directions for entering a camera name and password for WiFi set up. Select Next Step

11. Follow the prompts to continue
12. Wait for the ‘Download’ button to become blue and click to download
13. Open your “downloads” folder. Unzip folder by right clicking on the file folder and selecting ‘Extract All’ and designating where you would like to save it
14. Insert a microSD card from the camera to the computer via a microSD card reader/writer. We used the Vivitar Ultra Slim SDHC Card Reader/Writer.
15. Move the extracted folder to the USB drive and eject drive once transfer is complete
16. Put SD card in camera
17. Turn camera on and the update will automatically begin
18. The camera will flash ‘Updating’ before it turns off. As long as you do not get a ‘Camera Update Failed’ message then the update is successful. If you are unsure the version number will show on the camera as you turn it on.

Free software/apps to control cameras and view/manage video files: GoPro offers two desktop computer apps and a tablet app for managing and editing video and programming cameras.

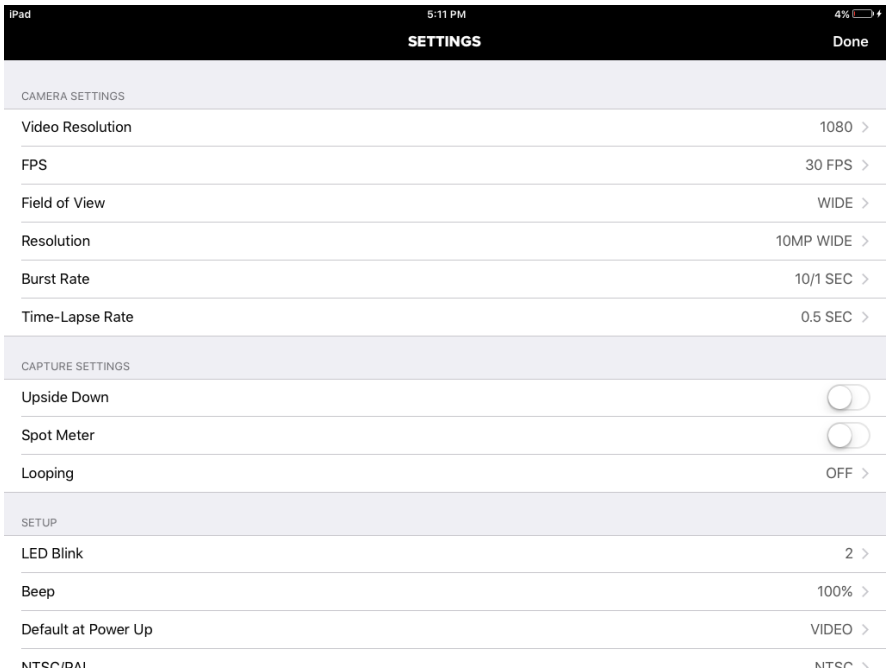
GoPro Quik desktop computer program:
Allows you to take clips and still photos from your video. You can also rotate videos in this app. Rotations applied within the app are saved but this process may alter the sizing. If rotating 90 degrees the field of view is reduced, as seen in the figure below. For this reason, we recommend mounting cameras to capture the desired view instead of altering the video file afterward.

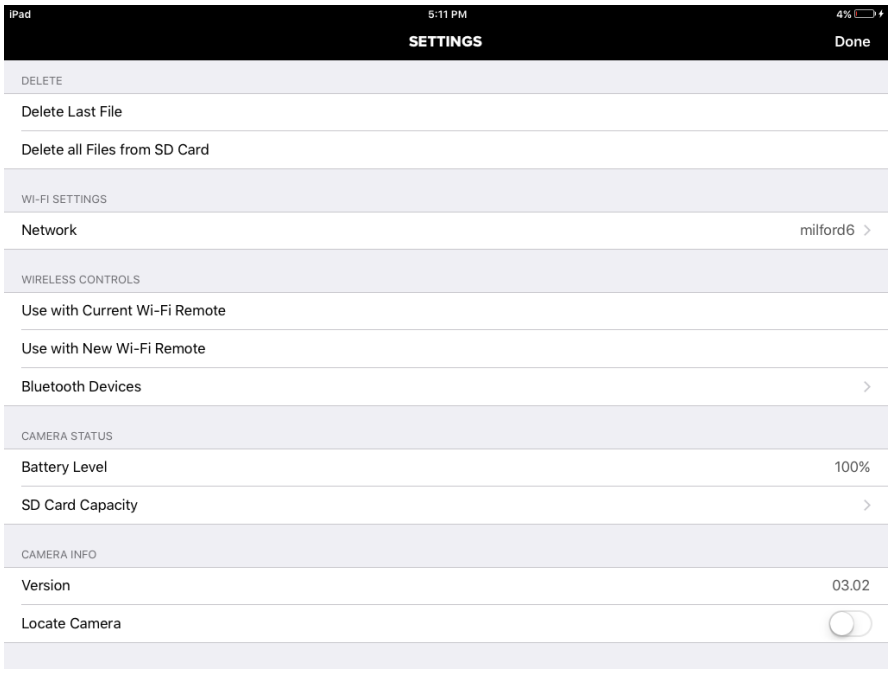
Pictured left above is the correct orientation of an oyster cage. The picture on the right has been rotated 90 degrees and much of the field of view is lost.

GoPro Fusion Studio desktop computer program:
This program provides more advanced video editing than the GoPro Quik program, including clipping and playback speed, as well as alterations to the videos themselves such as color, volume, balance, contrast, and others. Using this app will create multiple copies of your video during the editing process. These copies increase your storage capacity needs. An alternative would be choosing a different image/video software, such as Adobe Photoshop. We have not explored other options, but note that alternative software may require additional cost and/or knowledge.

GoPro Mobile/Tablet app:
This app can be used with a smartphone or tablet. Both Apple and Android versions are available. We found this app useful for checking camera settings, syncing times, ensuring WiFi is on/off, monitoring battery level, and clearing SD cards. Before connecting the camera to this app, update the camera firmware and enable custom WiFi settings, especially if using more than one camera (see step-by-step directions above under "Updating Firmware")

To connect camera to the app:
1. Download and open the GoPro App on device
2. Enter your GoPro App username and password. If you have updated the firmware on your camera (see step-by-step directions above under "Updating Firmware"), the login you created is also used in the mobile/tablet app.
3. Click "Connect to Camera"
4. Select "Add New"
5. Select Camera Type and follow prompts
6. Turn on Camera
7. Turn on WiFi, wait to connect. If camera and WiFi doesn't immediately pair or prompt you for the camera password then press continue. This will take you to the device WiFi page to connect directly
8. Once connected return to the GoPro app, which should automatically take you to the camera view. On this page you can take pictures or videos using the app, look at media on the camera or change camera settings:





9. To change settings click on the wrench icon
10. Use the Time and Date setting if you have multiple cameras to ensure that all cameras are synced to the same time
11. Once you connect cameras to the app on WiFi, then you can use the app in the field via WiFi or cellular connection.

Our camera settings: Camera settings can be easily changed using the GoPro mobile app for smartphones and tablets.

Resolution refers to the pixel dimensions within the video captured by the camera. Higher resolution yields better video quality, but also creates larger video files. We used 1080, 10MP WIDE for the video resolution in our project.

Field of View refers to the portion of the camera sensor that is used to capture video. The larger the field of view, the more of the scene in front of the camera is captured. We used the Wide setting. Other settings may result in distortion, and it's worth testing your camera to optimize this setting prior to deployment.

FPS or Frames per Second refers to the number of frames captured each second by the camera. Higher frame rates produce better quality slow motion video. We have found that slowing video playback can be useful when identifying fish in suboptimal light conditions. However, higher frame rates also increase file sizes. We used 30 FPS in our project.

Additional note: We also turned off the "LED Blink" and "Beep." Because we are looking at fish behavior we wanted to minimize the potential effects of a noise when the camera turned on and off as well eliminate the blinking red light while recording. In order to do this on the GoPro App click "LED Blink" and select "Off to turn the light off. To turn off noise, select "Beep" and select "Off"

Tips for putting a camera underwater:
WiFi will not work once the camera is underwater so all camera setup should be done before deployment!

Dive cases:
Two case options are currently available for this camera model, which are waterproof to either 40 or 60 meters. When purchasing additional products it is important to note which case style you purchase for to ensure compatibility.

The images above show the front view of dive cases rated to 40 m depth (left) and 60 m depth (right)

The images above show the top view of dive cases rated to 40 m depth (left) and 60 m depth (right)

Lubricant provides additional waterproofing and camera protection:
Use silicone or synthetic lubricant to protect metal parts, seawater is very corrosive. Add a small amount of lubricant to dive case O-rings to ensure a tighter seal and protect cameras from water

damage. Add a small amount of lubricant to any metal fittings exposed to seawater (i.e., GoPro thumb screws) to prevent seizing of the metal, prevent rusting and increase product life.

Camera troubleshooting and other helpful tips:
Check to see if a firmware update is available: Check that you are using the most recent camera firmware. Older cameras are less likely to be updated but should checked periodically. If you are running into issues such as camera turning off, not recording or changing settings then re-download the firmware and update.

Battery troubleshooting: Ensure battery is fully charged and not damaged in any way. Batteries will have reduced recording capacity underwater when water temperatures are low.

SD card: SD cards must be formatted to be compatible with the camera. The SD card that comes with the camera will already be formatted. If you are running into recording problems, you may need to reset the SD card. Back up any files from the SD card first. Insert card into the camera. Open the GoPro Mobile app, connect it to WiFi, then select "Delete all SD Files". The app will ask to "Format SD card" which will correctly set up the card for new GoPro files.

Camera Waterproofing tips:

1. Check that O-ring seals are present and intact as this keeps the case waterproof. Grease O-ring seals with silicone lubricant to aid in secure sealing of the case.
2. Check for cracks in cases. Check that the clip holding the case together is tight fitting and not cracked or otherwise broken.
3. Ensure a tight fit: Camera should not be able to move around in the case. Change the backing if necessary.
4. Water-test a case without a camera in a bucket of water. Although this does not reflect the increased pressure experienced at depth, it is a good place to start.
5. If cameras are deployed in the intertidal zone, the sudden temperature changes that occur when the tide comes in and covers the case/camera may cause leakage. Proper lubrication of O-rings is especially important in these situations.
6. Silica gel packs placed with cameras during storage can help absorb water and prevent water damage

Camera Accessories

Magenta Filter: Acts to balance the color and reduce green tones or cast in video and/or photos, reducing the need for post-processing. We used the PolarPro GoPro Magenta Filter – Hero4, which is compatible with Hero 3, 3+, and 4 cameras. Separate filters are sold for the 40 vs. 60 m dive case.

Although effectively correcting for green water coloration, filters considerably reduce the amount of light entering the camera. Therefore, magenta filters are most effective in shallow water (<20 feet). Lower light availability at greater depth may require use of post-processing rather than filter correction.

Post-processing refers to manual editing of video using software (see above section on camera software available from GoPro) and can include balancing video color by adding red back into the video to reduce green coloration. This process requires creation of multiple copies of the same video file, which increases storage requirements. Additionally, converting and editing video files is very time consuming.

In the above photo, the camera on the left is a 40 m dive case with no filter, and the photo on the right is the same case with a PolarPro GoPro Magenta Filter-Hero 4

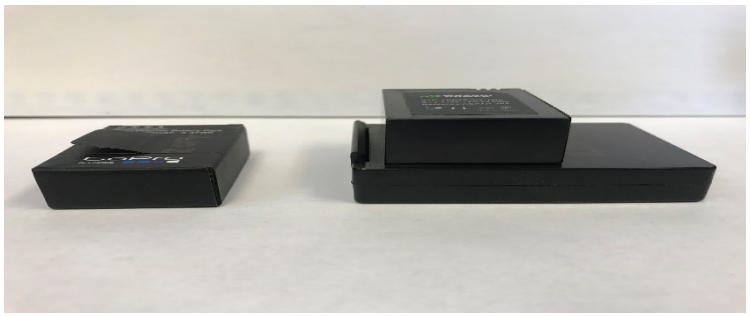
In the above photo, the image on the left was taken using a camera with no filter, and the image on the right was taken using a camera with the magenta filter

Extended backdoor attachment for the GoPro underwater case: BacPac for GoPro is an extension of the GoPro dive case, which allows space for other camera accessories that also need to be kept waterproof. We used the Vicdozia Waterproof BacPac Back Door Case that is compatible with the GoPro Hero 4/3+ Standard Housing Case.

The photo above is a top-down view of the standard dive case (left) and the dive case after the addition of the BacPac (right)

The photo above is a side view of the standard dive case (left) and the dive case after the addition of the BacPac (right)

Extending battery life through use of a second battery: If length of video is limited by battery life and not memory card capacity, the addition of a second battery can increase recording time. Using a second battery underwater requires the addition of the extended backdoor attachment to the standard dive case (see above). Water temperature greatly affects battery life, with lower temperatures reducing recording time. Important note: when a battery is removed the time and date is reset on the GoPro! Keep in mind if using multiple synced cameras in your project!



The photo above shows a single battery on the left, and a double battery on the right

Blink Timers: Blink by CamDo is a programmable timer that can be used with GoPro cameras to automatically record for set intervals of time after deployment. The Blink attaches directly to the back of the GoPro camera, uses the GoPro battery to operate and is programmed using a cellular- and WiFi-enabled device. Use of a Blink requires the addition of an extended backdoor attachment on the GoPro dive case (see above). Once removed from the camera, the Blink must be reset. Blinks turn the camera on and off at preset times. We have used Blinks for two primary functions in our project: 1) To delay the onset of recording in order to allow fish communities time to recover from the disturbance of camera deployments, typically 18-24 hours; and 2) To extend the battery life by recording short video intervals over a much longer time period than would be possible by continuous video recording. Our project records 8 minute videos over 12 hours, in order to capture video from most of daylight hours and over a full tidal cycle.

All setup and troubleshooting documents are available for download on the CamDo website. Step by step instructions are provided on the website, including pictures of the set-up process.

We do recommend updating the software to the latest version upon purchase of the Blink as well as checking frequently for updates. Because the setup of the Blink timers is connected through a WiFi connection, if the device used is set up on a cellular network it will allow for easier configuration.

If the Blink software is updated after use then select “Clear All” the next time you go to use it. If not, the Blink will not operate properly.

The extended backdoor attachment that we used (BacPac, see above) provides enough space for either a second battery or a Blink, but not both!

Fisheye Lens: We tested the Inon® UFL-G140 SD Underwater Semi-fisheye Conversion Lens attachment by Backscatter to increase the field of view captured by the GoPro cameras. Specifically, we tested a method to look down at the top horizontal surface of our oyster cages. The semi-fisheye lens does provide a wider field of view than the standard GoPro lens. Unfortunately, the curved lens wasn’t compatible with the flat magenta filter that was used to remove the green color from video (see above). The lens was also quite heavy, requiring construction of a PVC frame to support its attachment to the buoy lines. The video captured by the lens was also somewhat distorted at the edges. For these reasons, we ultimately did not use this accessory in our project.


HERO3+

Camera Field Deployment

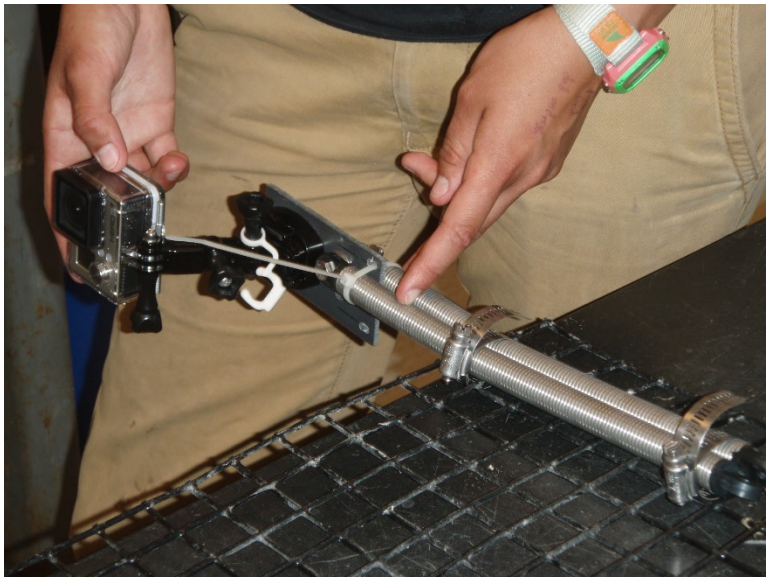
Altering video orientation using GoPro software: *Upside down* is a camera setting that allows you to capture video in the opposite orientation of your field of view. This option reduces the need to fix camera positioning through post-processing, which is time consuming and can result in large video files.

Changing height and direction of cameras: Pivot arms can be used to change the height and direction of cameras:

A variety of mounting pieces are offered by GoPro as well as other aftermarket producers. Some pieces are available in both aluminum and plastic. Some pieces are curved. Some attach by clips or thumb screws or both. Combining these accessories with the pivot arms allow adjustment of camera angle and direction to obtain the desired view.
Examples are shown in the photo below:

Attaching cameras to gear: We used materials that are readily accessible from local hardware stores whenever possible. Some examples include the following:

The above picture shows the mount we used to attach a camera to a corner of the oyster cage. The mount is constructed from ½ inch PVC pipe covered by ⅞ inch marine reinforced water hose, secured with hose clamps. A GoPro quick release flat surface adapter buckle base is attached to a piece of PVC cut in half at the end to allow for mounting the base. The marine reinforced water hose has some flexibility, allowing the camera to hang down from the top of the cage and provide a view of two sides and also the cage-seafloor interface. This view of the cage-seafloor interface has been effective in capturing fish activity in our videos.

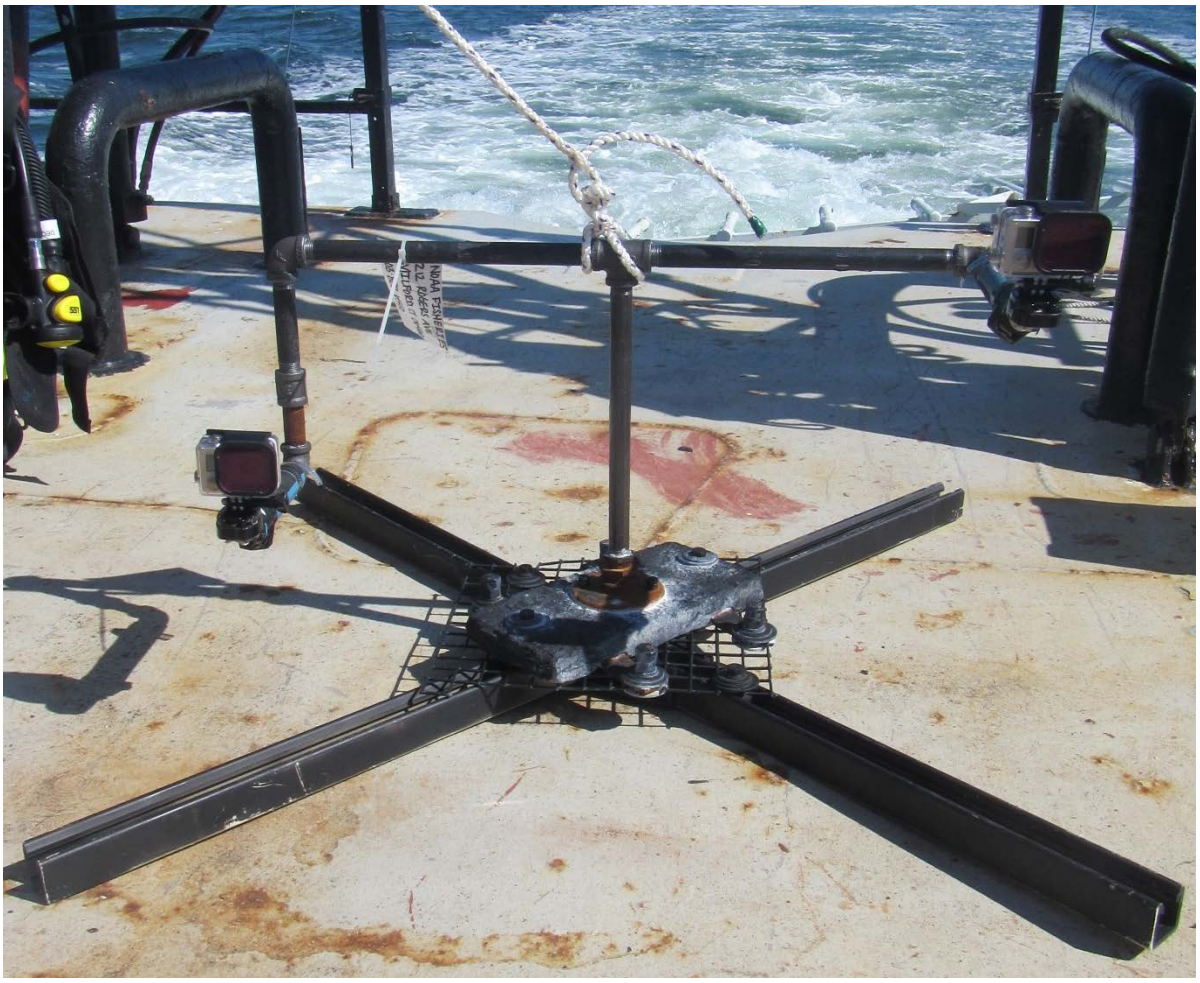


The above picture shows an early prototype mount that we tested but ultimately did not use. This spring attachment placed at a corner of the cage provided more flexibility than the marine reinforced water hose, but unfortunately resulted in too much camera motion during deployments.

This photo shows the periscope style mount we used to view across the top of the oyster cages. We cut ½ inch PVC pipe to the height of the cage. We used a PVC 90 degree elbow to obtain the proper camera orientation. A GoPro quick release flat surface adapter buckle base was attached to a piece of PVC cut in half at the end to allow for mounting of the base.

Pictured above is a PVC bridle with 1 in. mesh that was created to support the weight of the Semi-Fisheye Lens.

Construction of a "t-frame" to mount cameras adjacent to natural structured habitat:
Pictured below is a minimal-structure camera mounting system that provides similar views across the top and along one side of a boulder. Boulders within the Charles Island Rock Reef are the control habitat that we are using for comparison to the fish interactions with the oyster cages.



In the photo above, the X base was constructed of ½ inch Aickinstrut fiberglass strut with 90 degree brackets. One inch mesh was screwed on top of the struts, and a 5x10 zinc plate was screwed on top of the mesh to provide weight. A ½ inch floor flange was attached to the top of the zinc pipe. Interchangeable threaded pipe was used to create custom heights needed based on the dimensions of each replicate boulder. The base was painted black to better blend in with the seafloor.

A few simple tips for optimizing video collection in the field:

Water depth: areas in shallower water will yield better video due to higher light availability. We found that depths < 20 feet depth (mean high water) produced the best quality video in Long Island Sound.

Tidal cycle: Lower tide will allow for better light penetration. Slack tide may be a time of low current speed and higher quality imaging

Weather: Sunny days result in higher light availability. Days immediately following large rain events can have turbid/cloudy water, which reduces video quality.

Data Management

Increase speed of file transfer: When transferring files, it is faster to use the same SD card reader used to transfer files on to a computer instead of using the USB cord provided with the camera.

Create a logical folder system to organize and store videos on your computer: Create a system for storing videos so you know when and where they were recorded. This will make it much easier to find specific videos later. Start this process early before you have a bunch of videos and it becomes confusing. DO NOT RELY on the "date modified" associated with a file to record when video was taken, because depending on the way a computer folder is set up, clicking on a file could change the date modified.

Continuous video recording: If you record a continuous video file, GoPro will separate those videos into multiple video files for management. This helps when downloading and playback of videos.

Video files are large – be prepared! How much storage you need will depend on how much video and at what quality you record. As you increase video quality, the files produced will be larger. Video quality is controlled by the camera settings (see camera section of this document). Increasing frames per second and resolution will result in larger file sizes. The camera settings we describe in this document produce a 900 mb (0.9 gigabyte) file for each 8 minute interval of video that we record.

If possible, it is a good idea to have your video in two places in the event of a technology mishap: External hard drives can be used to back up video separately from your primary computer

Video Analysis

What to do with video you create? Video clips can be great outreach tools, can be used for development or just enjoy the views!

Basic analysis
Using common computer applications such as Excel you can keep track of the fish observed in the video.

Free software exists to help you track and record what you observe in your videos:
Behavioral Observation Research Interactive (BORIS) is a free downloadable behavior analysis software that allows you to set up your own analysis framework specific to your study. You can use it to keep records of fish abundance of multiple individual species that you observe in your videos. You can also create variables for each of these individual species, so you can record activities such as feeding, moving in and out of the cage, etc. This software will require a time investment to set up a project and learn the software.

Scan QR code for Project Website