DIDSON Steelhead Population Viability Monitoring in

Santa Barbara and Ventura County, California

2012-2014

Report for the California Department of Fish and Wildlife

Fisheries Restoration Grants Program (Project Number: P1050004)

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Table of Contents

List of Tables

List of Figures

Abstract

Dual Frequency Identification Sonar (DIDSON) cameras were operated in three high priority watersheds, designated "Core 1" by the National Marine Fisheries Service (2012), in Santa Barbara and Ventura Counties from 2012 to 2014. DIDSON cameras were deployed in response to storm events occurring during the spawning season (January to May) to gather quantitative data on steelhead abundance. Cameras remained in operation as long as adequate flows were maintained. Persistent drought conditions inhibited steelhead passage in all monitored systems; this resulted in no adult steelhead trout being observed. A number of challenges to effective DIDSON monitoring indicative of Southern California systems—flashy, high turbidity, low flow, species identification—were addressed and surmounted by this project. These challenges were first addressed during a rigorous site selection process where site suitability was assessed by a number of parameters found to impact DIDSON image quality (i.e. substrate type, channel profile and wetted width). Site specific DIDSON mounts were then developed to ensure optimal DIDSON functionality while addressing mobility, security and staff safety concerns. Species identification was improved by obtaining footage of sympatric species for comparison with *Oncorhynchus mykiss* in addition to exploring the efficacy of acoustic shadows in species differentiation. This multi-faceted approach led to the development of robust methodology specific to DIDSON monitoring operations in the Southern California region.

Acknowledgements

Funding for this work was provided by the California Department of Fish and Wildlife Fisheries Restoration Grants Program. Many individuals contributed to the data collection and analysis process including: Chris Lima (CDFW); Heidi Block, Patrick Riparetti, Tom van Meeuwen, Patrick Saldana, Ben Lakish, Karissa Willits, Megan Meyers, Jackie Patt, Tobias Moyneur, Jamie Hoffman and Gaytha Morningstar (Pacific States Marine Fisheries Commission); Mary Larson (CDFW); and David Gottesman, Kayti Christianson, Carrie Fong and Tessa Reeder (California Conservation Corps – Watershed Stewardship Project). We gratefully acknowledge the landowners, whose cooperation and willingness to work with our staff made this project possible.

Introduction

Southern California steelhead trout (*Oncorhynchus mykiss)* populations have undergone sharp declines throughout Southern California. This has resulted in populations occupying the area from the Santa Maria River to the Tijuana River at the U.S.-Mexico border being placed under protection by the U.S. Endangered Species Act (ESA). ESA mandates require implementation of a recovery plan to manage and recover the species. The recovery plan produced by NMFS in 2012 prioritizes streams by recovery potential. The highest priority systems receive a "Core 1" designation. Obtaining abundance data for these systems is a crucial component of adopting appropriate management strategies (NMFS 2012). However Southern California conditions (e.g., flashy streams, high turbidity) combined with steelhead's behavioral plasticity present a number of challenges to traditional enumeration techniques.

To address these challenges, the NMFS Southern California Steelhead Recovery Plan and the California Coastal Salmonid Monitoring Plan (methods described in Adams et al. 2011) recommend the use of dual frequency identification sonar (DIDSON) to obtain population assessment data. DIDSON cameras, developed by Sound Metrics, produce near video-quality imagery and allow for data collection under conditions where more traditional optical systems would fail, including at night and periods of high turbidity. Furthermore, DIDSON allows for the passive collection of data, which avoids altering steelhead behavior or causing harm to a listed species. DIDSONs have been successfully used to gather abundance data for salmon populations under a multitude of conditions in various locations throughout the state (Larson 2013, Metheny 2014, Pipal et al. 2010, Pipal et. al 2012).

In 2012, the Department of Fish and Wildlife's California Coastal Monitoring Program (DFW-CCMP) began to use DIDSON cameras to estimate steelhead escapement in two Southern California Core 1 systems–Salsipuedes Creek (a tributary to the Santa Ynez River) and the Ventura River (Figure 1). A third core 1 watershed was added in 2014, with the inclusion of a site on Carpinteria Creek (Figure 1). All systems have maintained historical steelhead populations and exhibit characteristics indicative of Southern California systems—flashy, high turbidity, low flow–that prevent standard escapement monitoring methods from being feasible which makes them ideal candidates for a DIDSON monitoring program. Additional supplemental deployments were carried to refine methodologies, gather comparative data, test equipment and for training purposes. This report will summarize operations and findings from 2012 through 2014.

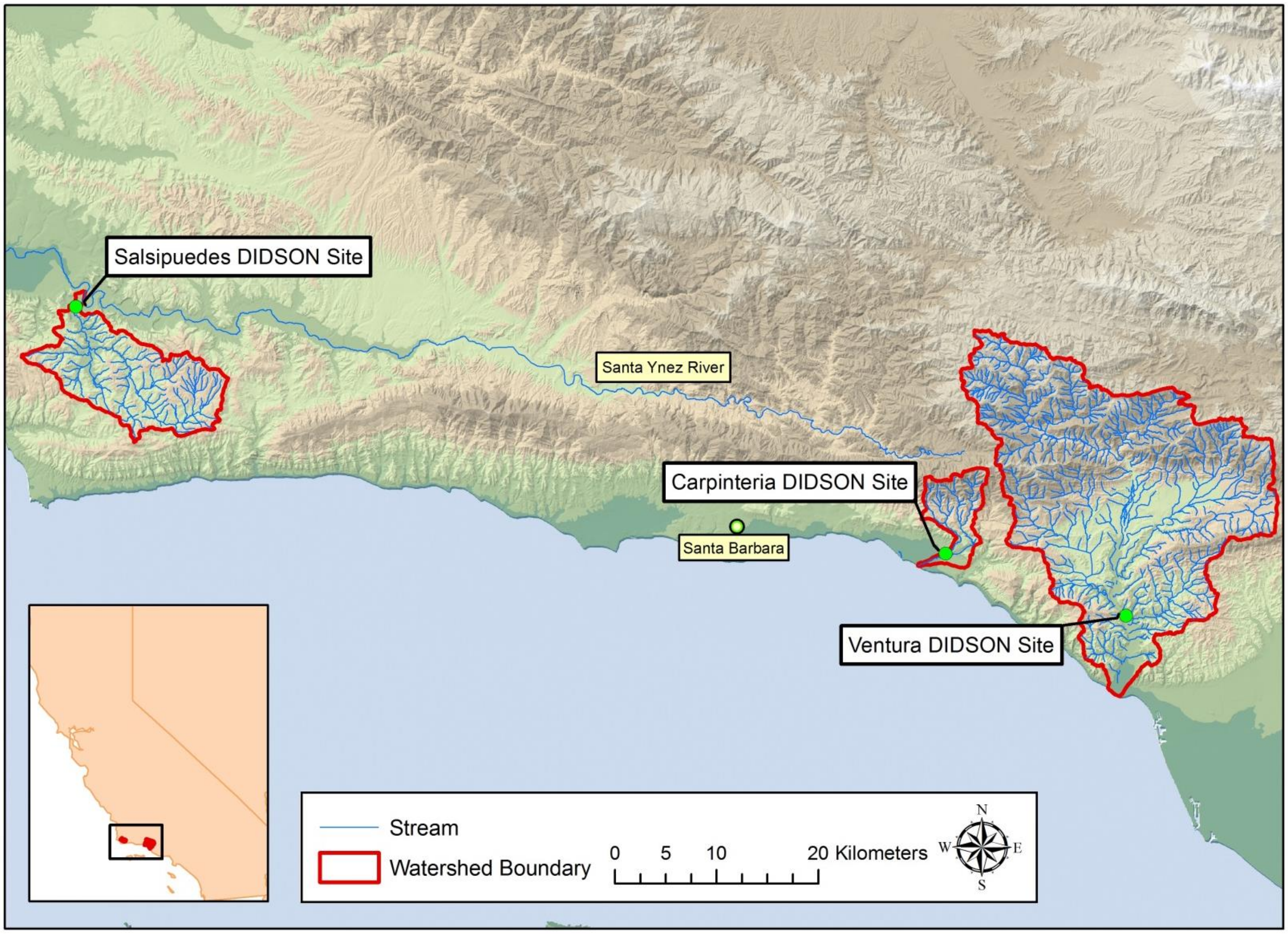

Figure 1. An overview of the three DIDSON-monitored watersheds.

Study Sites

Salsipuedes Creek

Salsipuedes is located southeast of the city of Lompoc in Santa Barbara County, California. Salsipuedes Creek is the largest tributary to the lower Santa Ynez River and drains approximately 47.1 square miles (Santa Ynez River Technical Advisory Committee 2000). Salsipuedes Creek is 10 miles long; its confluence with the Santa Ynez River is located approximately 16.1 stream miles from the Pacific Ocean.

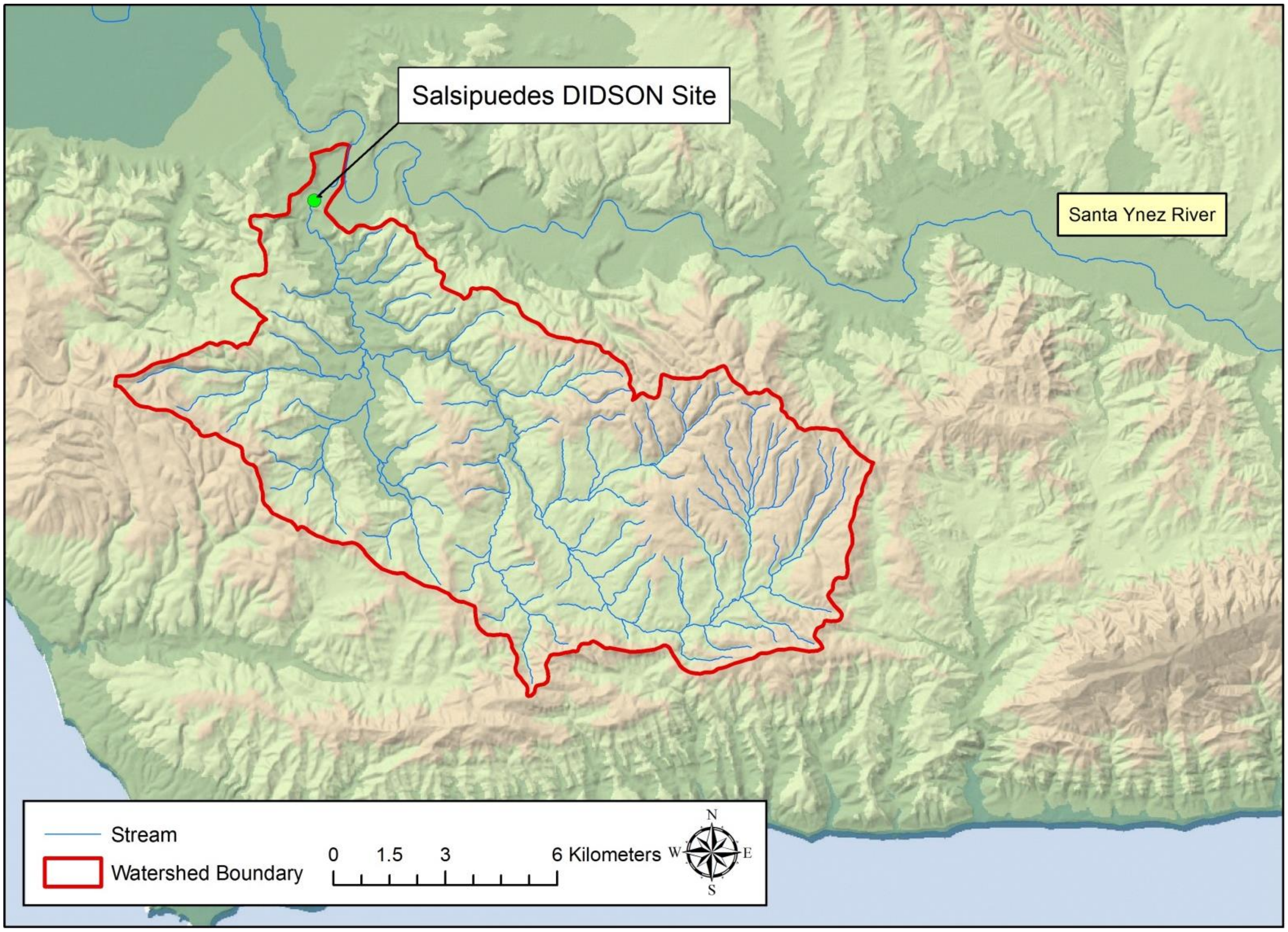

Figure 2. Map of the Salsipuedes Creek watershed showing the location of the DIDSON site.

A 1997 draft report by the U.S. Forest Service concerning steelhead habitat in the Santa Ynez basin states that, "Of the tributaries to the lower Santa Ynez, Salsipuedes Creek currently has the highest potential for steelhead spawning and rearing" (USFS 1997).

It is important to note that the Santa Ynez River experiences a seasonal sandbar under low flow conditions which disconnects the river from the ocean. In low water years the sandbar will remain intact for the entire year, as was the case for the 2014 season. While in place, the sandbar prevents anadromous fish from entering the system.

The Santa Ynez basin is home to numerous fish species in addition to *O. mykiss*. The native species that occur in tributary streams, such as Salsipuedes Creek, are Three-spined Stickleback (*Gasterosteus aculeatus*), Arroyo Chub (*Gila orcutti*), and Prickly Sculpin (*Cottus asper*). Non-native species that occur in Santa Ynez tributaries are bass (*Micropterus* spp.); sunfish (*Lepomis* spp.); crappie (*Pomoxis* spp.), Black Bullhead (*Ameiurus melas*); Western Mosquitofish (*Gambusia affinis*); and Fathead Minnow (*Pimephales promelas*) (Santa Ynez River Technical Advisory Committee 2000).

Carpinteria Creek

Carpinteria Creek flows through the city of Carpinteria located in Santa Barbara County, California. It drains approximately 17 square miles and contains approximately 7 miles of anadromous waters. Quality spawning habitat exists in the upper watershed; however access is limited to times of the year when adequate flow is maintained.

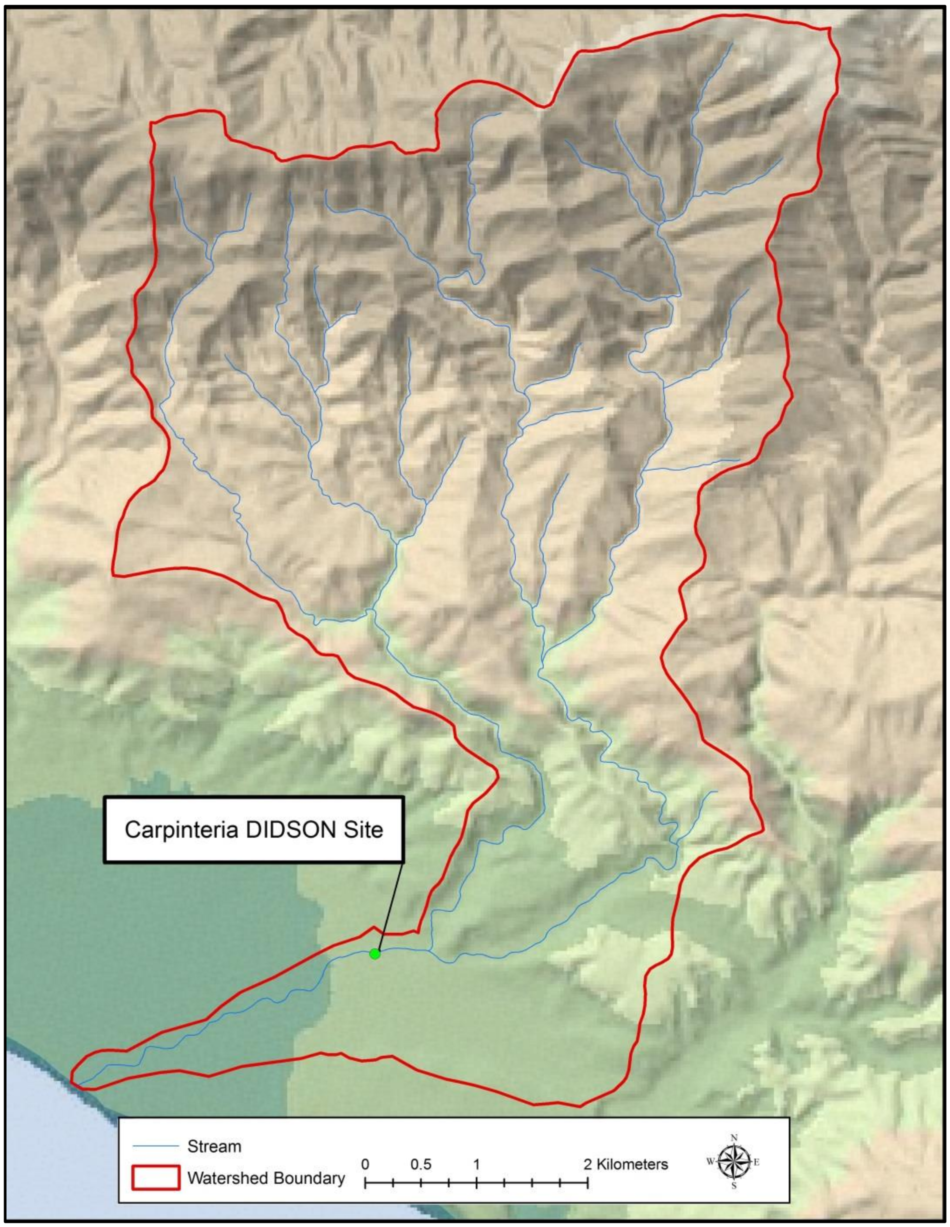

Figure 3. Map of the Carpinteria Creek watershed, showing the location of the DIDSON site.

Fish species present in Carpinteria Creek main stem in addition to *O. mykiss,* include Western Mosquitofish (non-native), and Three-spined Stickleback (Padre and Assoc. 2002 and Ecology Consultants, Inc. 2004).

As is the case with many Southern California systems, Carpinteria Creek experiences a seasonal sandbar. Access by anadromous fish is limited to when the bar is breached.

Ventura River

The Ventura River flows through the cities of Ojai, Casitas Springs and Ventura in Ventura County, California. It drains approximately 227 square miles and contains approximately 35 miles of anadromous waters (California Department of Forestry and Fire Protection 1999).

Suitable spawning habitat exists in the lower basin, primarily within San Antonio Creek, a tributary located approximately 8 stream miles from the Pacific Ocean. High quality spawning habitat exists in the upper watershed, but is located behind the Robles Diversion. The diversion is located on the main stem approximately 14.5 stream miles from the Pacific Ocean. This diversion, operated by the Casitas Municipal Water District under regulation of the Bureau of Reclamation, redirects water to the Casitas Lake Reservoir when sufficient surface flows are generated. The diversion operates a fish way allowing steelhead passage when requisite flows are met.

The Ventura River Basin contains many fish species in addition to *O. mykiss*. The native species observed by Pacific States Marine Fisheries Commission and CDFW staff carrying out biological surveys in the Ventura River main stem are Three-spined Stickleback, Arroyo Chub, and Prickly Sculpin. Non-native species observed are Western Mosquitofish, Common Carp (*Cyprinus carpio*), Fathead Minnow, Largemouth Bass (*Micropterus salmoides*), Green Sunfish (*Lepomis cyanellus*), and Black Bullhead.

As with our other sites, the Ventura River forms a seasonal sandbar, preventing access by anadromous fish from the ocean until it is breached.

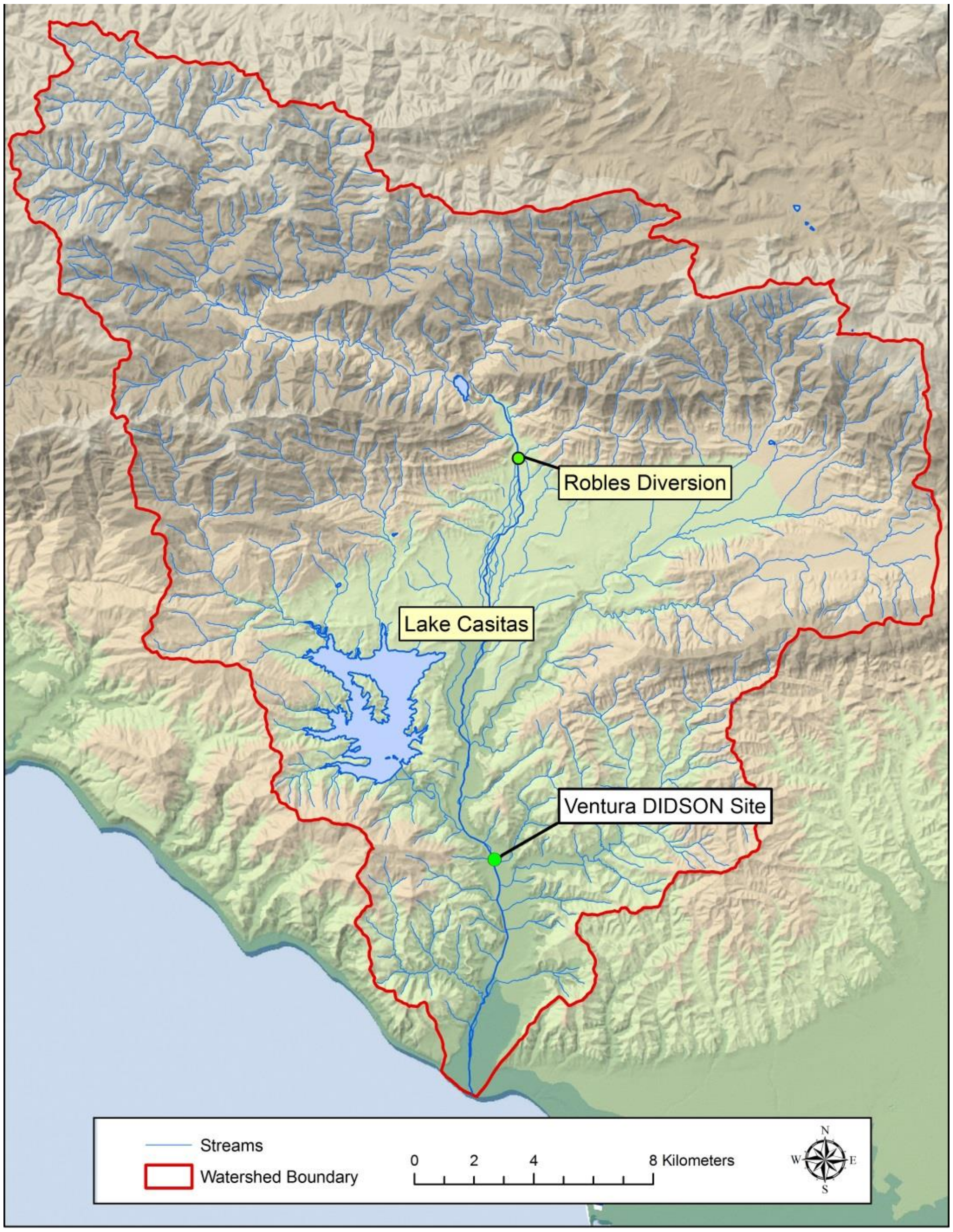

Figure 4. Map of the Ventura River watershed, showing the location of the DIDSON site and Robles Diversion Dam.

Methods

2013

Data Collection

Salsipuedes Creek—The deployment site is located 0.6 stream miles upstream of the confluence with the Santa Ynez River (Figure 2). This site is located downstream of spawning habitat and acts as a migration corridor as it provides limited holding habitat. The site also serves as a smolt trap site for the

Cachuma Operation and Maintenance Board (COMB); this allows for comparisons between DIDSON and trap data (Figure 7).

DIDSON units were deployed in response to storms events forecasted to produce enough precipitation to generate flows sufficient to connect spawning habitat to the ocean and allow for fish passage.

A standard DIDSON unit, operating in high frequency mode (1.8 MHz, 96 beams), was used for all deployments. The camera was installed bankside in a side-facing orientation aimed perpendicular to flow. This allows for maximum channel coverage and results in fish passing more or less perpendicular the DIDSON's beam, resulting in the best possible imagery (Burwen et al. 2007). The camera was housed in a silt box—a plastic box with a window for the lens manufactured by Sound Metrics to protect the camera while keeping the lens free from sediment—as well as an in-house fabricated aluminum box to protect the camera from larger debris (a "debris box"), following plans developed by Pipal et al. (2010).

The camera was mounted using an "A-frame" configuration for all 2013 deployments. The A-frame consists of two steel sleds connected by a crossbar with at post at its center and is anchored in place by gravel bags weighting down the sleds. A ram-mount ball joint is affixed to both the top of the aluminum debris box and the center-post of the A-frame (Figure 5, Key feature (A)), joining these two pieces together. This allows for manual aiming of the DIDSON camera by loosening the joint, rotating the camera to obtain the desired field of view and then tightening the joint to lock it in place (Larson 2013).The sleds were secured by tether to earth anchors anchored 40 in. into the stream bank substrate. A flange on the debris box allows for the attachment of a padlock from which a tether made from 1/8" diameter, 7x7 strand core galvanized steel aircraft cable is run to the largest tree in the vicinity. This tether acts as both a security measure against theft and as a precaution against the camera being swept away during high flows.

Figure 5. Salsipuedes Creek DIDSON site in 2013 viewed from the opposite bank. Key features are labeled. (A) A-frame mount anchored by gravel bags; (B)DIDSON camera housed in both a silt and debris box; (C) security tether; (D)Earth Anchor.

The DIDSON camera communicates with the topside laptop via a 60 m long cable manufactured by Sound Metrics. The cable runs from the camera up to a weatherproof job-box located safely outside the floodplain where additional topside electronics are housed as suggested by Pipal et al. 2010. The job-box was hardwired into existing site power by a contracted electrician. An uninterruptible power supply was used to ensure sustained data collection during storm events when power outages are common in the surrounding area. Additional topside components consisted of the Sound Metrics topside box, which supplies the DIDSON with power and a means to communicate with the laptop, and an external hard drive to hold the large files being generated during DIDSON recording (1-1.5 GB/h). Footage was recorded continuously for the duration of the deployment in 20 minute files to ensure minimal data loss if individual files became corrupted.

Recording settings were set at the start of each deployment. Frequency and frame rate were set to adjust automatically. Frequency remains in the “high frequency mode” for window lengths $\leq$10 m, as was the case for our entire deployment. Window length was set to 10m under high flows and 5m under low flow conditions. Frame rate was optimized by the software and remained between 8-10 frames/second for the 2014 deployment. The camera mount required the camera to be upside down so display controls were set to “reverse” in order to accurately convey flow direction. Threshold and intensity and settings were left at their default values of 0 dB and 90 dB, respectively. This decibel range encompassed all observed acoustic returns.

Ventura River— The deployment site is located approximately 4.8 stream miles from the Pacific Ocean (Figure 4). The site is located on property owned by the Ojai Valley Sanitary District and provides some site security in the form of a perimeter fence and locked gate. In addition to being close to a major metropolitan area, a significant homeless population has inhabited this area for the duration of the project. These factors lead to elevated security concerns. As a result, staff remained on site for all periods of deployment.

A standard DIDSON unit operating in high frequency mode (1.8 MHz, 96 beams) was used for all deployments. Concerns over persistent low flow conditions lead to a test of Sound Metrics manufactured concentrator lenses prior to the deployment season. The concentrator lenses are designed to allow DIDSON beams to travel further and to cut down on interference caused by reflection of the surface and substrate (Sound Metrics 2015) by compressing the vertical component of the beam from 14° to 3° and 8° respectively. The test found there to be no discernible improvement in image quality with either lens and suggested that concentrator lenses lead to increased crosstalk (crosstalk occurs when an overly bright return is picked up by neighboring beams, resulting in an object looking distorted and blurred) for close proximity targets as a consequence of increased beam strength. Subsequently, standard 14° lenses were used for all deployments.

DIDSON units were deployed in response to storms events forecasted to produce enough precipitation to generate flow capable of connecting spawning habitat to the ocean and allowing for fish passage.

The camera was situated in close proximity to the bank aiming perpendicular to flow. The DIDSON was housed in both a silt box and debris box before being attached to an H-mount using a RAM double socket ball joint (Figure 6). The H-mount was constructed of aluminum pipes and fittings as described by Larson et al. 2013. Camera height was adjusted by raising or lowering the crossbar to which DIDSON was fastened.

As with other sites, the DIDSON was connected to topside electronics via a 60m cable. However topside site infrastructure differed from the site previously described. Due to increased security concerns, it was necessary for staff to remain on site for the full duration of the deployment. This required a suitable structure to house both personnel and equipment for an extended period of time. To meet this need an 8 ft x 8 ft x 10 ft shipping container was put into place—safely outside of the floodplain and 60m from the camera—and hardwired into power provided by the Ojai Valley Sanitary District. Software and hardware settings were the same as previously described for other sites.

Figure 6. Ventura River DIDSON site in 2013 as viewed from the river left bank. Key features are labeled. (A) H-mount; (B) DIDSON camera housed in both a silt and debris box; (C) security tether.

2014

Data Collection

Salsipuedes Creek—A standard DIDSON unit was used, operating in high frequency mode (1.8 MHz, 96 beams), for the duration of the deployment from February 27, 2014 to March 13, 2014.

Depending on flow and water depth, the camera was mounted in one of two ways. Under low flow conditions, the camera was mounted to an A-frame (Figure 7). Fish were prevented from swimming behind the camera by a gravel bag berm placed at shallow angles relative the bank. The berms also served to keep fish from swimming too close to the lens (within 1 m) where images would suffer from near-field effects (Doehring et al. 2011).

Figure 7. Salsipuedes Creek DIDSON site viewed from downstream. Key features are labeled. (A) A-frame mount anchored by gravel bags; (B)DIDSON camera housed in both a silt and debris box; (C) security tether; (D) gravel bag berm; (E) COMB trap.

Under high flow conditions, the camera was mounted to a track system (Figure 8)**.**The track is 30 ft in length and follows the banks profile down to the low flow channel's edge. The track is mounted to steel legs that have been buried in the substrate. Further stability is achieved by cross-bracing the structure using airline wire under tension (Figure 8, Key Feature (E)). The void space between the track and the bank was filled with gravel bags to prevent fish from passing below or behind the camera. The DIDSON is affixed to a pan/tilt rotator, called an X2, manufactured by Sound Metrics for use with DIDSON cameras. The X2 is controlled by the DIDSON topside software, allowing for remote aiming of the DIDSON. The DIDSON and X2 are then mounted to an aluminum sled using hardware produced by Sound Metrics. The sled is then placed on the track where it can be raised and lowered by a winch tethered to the sled by airline cable. This allows for the camera to be adjusted in response to changing flow and depth conditions without having to physically enter the water when conditions may be unsafe.

In both low and high flow conditions, the DIDSON camera was aimed using the topside image as a guide. Tilt was adjusted until the entire channel was fully ensonified. Camera angle changed with track height, but was most often a shallow grazing angle which directs the beam into the substrate. Beam height accommodated the entire water column under low flow conditions. Under higher flow conditions, we anticipated adult steelhead to minimize energy expenditure by swimming close to the bottom where water velocities are decreased (Quinn 2005), so a shallow grazing angle ensonifying the lower portion of the water column was maintained.

Figure 8. Salsipuedes Creek DIDSON site viewed from across the channel. Key features are labeled. (A) track; (B) DIDSON housed in silt box and mounted to a sled via an X2 rotator; (C) winch used to adjust camera height; (D) gravel bag berm; (E) cross-bracing cables; (F) security tether.

Carpinteria Creek – The deployment site on Carpinteria Creek is located 1.95 stream miles from the Pacific Ocean (Figure 3). The site is located in a migration corridor and is downstream of spawning habitat to limit the potential for milling behavior. The site is on private property with limited access owned by the US Forest Service Rincon Station. As with other sites, a tether was installed to prevent against theft and potential loss of equipment to high flow.

A long range unit operating in high frequency mode (1.2 MHz, 48 beams) was used from February 28, 2014, to March 2, 2014. A test deployment was completed to ascertain whether or not a long range unit could serve as a viable substitute for a short range (Appendix B). Images produced by the long range unit were found to be of sufficient quality to identify *O. mykiss* in the Carpinteria Creek watershed as O. *mykiss* represent the only fish species present, making finer detail unnecessary.

The unit was mounted to a tethered A-frame as previously described, with the addition of gravel bags used to weigh down the A-frame's sleds. The camera was initially positioned close to the bank, facing perpendicular to flow and manually aimed, as detailed above for the A-frame configuration used at the Salsipuedes Creek site. The camera was connected to topside electronics located in a weatherproof job-box further up the bank via a 60m cable. Topside components mirrored those used at the Salsipuedes site. Equipment was powered by an extension cord running from the job-box to an adjacent residence. Software and hardware settings were identical to those used at Salsipuedes with the exception of window length. Unlike Salsipuedes where window length was changed in response to variable flow, Carpinteria Creek never exceeded a wetted channel width of 5m. Consequently, window length remained constant at 5m. The A-frame had to be positioned further out into the channel to maintain acceptable depth as flows receded. This new camera location created wetted space behind the camera where fish could pass undetected. This required a guidance weir, constructed of large woody debris found in the immediate area, to be put into place on the downstream side. On March 2nd the site no longer met depth requirements (0.3m) and the camera was removed.

Figure 9. Carpinteria Creek DIDSON site viewed from upstream. Key features are labeled. (A) DIDSON camera housed in a silt box and debris box; (B) A-frame mount anchored by gravel bags; (C) security tether.

Ventura River – The deployment site remained the same as used during the 2013 data collection season.

An A-frame was selected to replace the H-frame and was tethered to the largest available tree; gravel bags were placed over the frame's sleds to better anchor it. Four foot-square deflection panels constructed out of PVC and aquaculture mesh were used to keep fish from passing behind or too close to the camera. Three panels per side (upstream and downstream) were installed by affixing them to t-posts using zip ties and anchored by gravel bags placed along the bottom edge of the panels .

Given the potential size overlap of the target species and resident Common Carp, a shadow board was installed on the bank opposite the DIDSON to aid in species identification. The shadow board was installed once flow had stabilized, following a peak of 3180 ft^3/s. The shadow board served as a projection surface to capture acoustic shadows (Figure 10) which have been used with success to distinguish between species of overlapping size under lab conditions (Langkau et. al 2012).

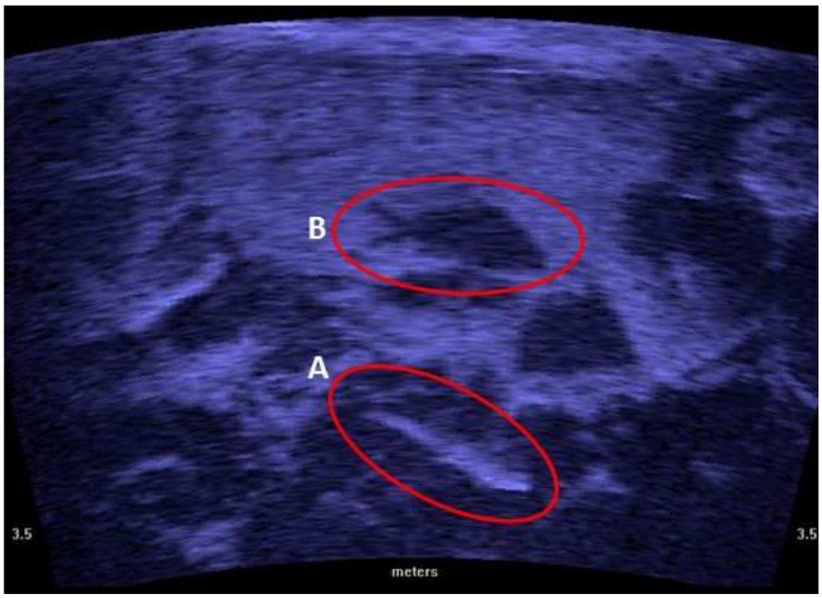

Figure 10. An image taken from footage of a Common Carp (A) showing its acoustic shadow (B). Note the clear depiction of body and tail shape.

The board was constructed of 3/8 in plywood and measured 4 ft x 5 ft. Plywood was chosen for its low cost and propensity for absorbing sound waves as determined by preceding experimental deployments where alternative materials were tested (Appendix D). The board was placed 45° relative to the Y-axis angle of the DIDSON, which was found in previous studies to be the optimal orientation (Langkau et al. 2012). The board was placed at a distance of 4.4 m from the DIDSON lens and covered an area ranging to 4.7m. The board's support frame was anchored using gravel bags, which also functioned to keep fish from passing behind the board (Figure 11C**)**. The board's placement allowed for the DIDSON window length to be dropped from 10m to 5m, further increasing image resolution and the potential for observations of morphological features through the acoustic shadow. When fish passed at the proper angle and range, silhouette of the fish in profile was projected on the shadow board providing further insight into species identification by making distinctive morphological features evident.

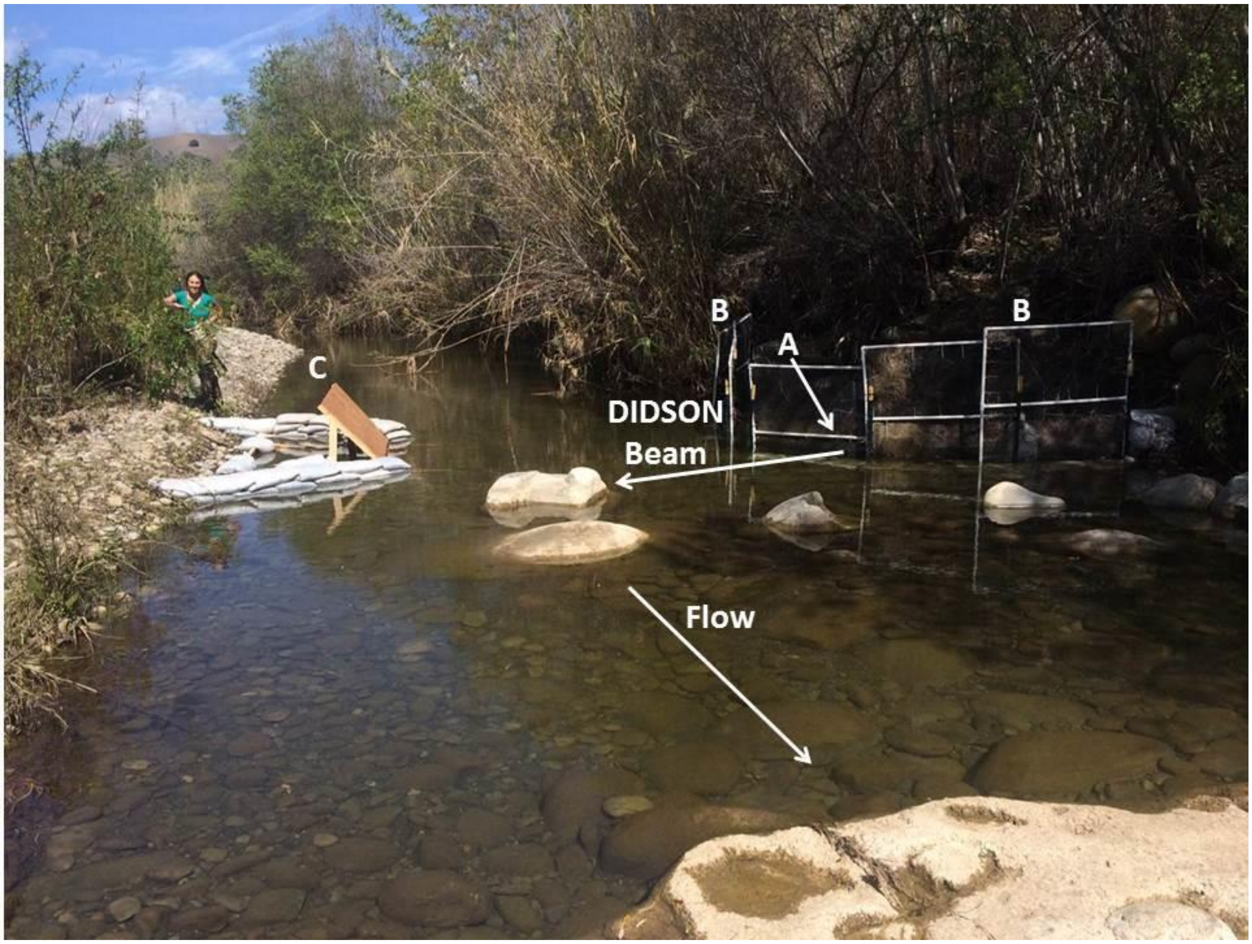

Figure 11. Ventura River DIDSON site viewed from downstream. Key features are labeled. (A) The DIDSON mounted to an A-frame; (B) deflection panels constructed from PVC and aquaculture mesh; (C) shadow board anchored by gravel bags.

Data Analysis

The DIDSON software's echogram function was used to analyze each 20 minute file. Software settings followed those suggested by Sound Metrics to locate rare events with some modifications made to optimize settings specific to site and day. This allowed for expedited file viewing by enabling the viewer to see 800 frames at once and hone in on motion events contained within those frames. Viewers were trained to look for objects that exhibited changes in direction or swimming behavior to differentiate between fish and debris or other aquatic species.

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Figure 12. Data fields logged for each detection event as well as the relevant header metadata associated with each observation.

Fish observations were classified as *O. mykiss,* Common Carp, or unidentified fish species. This was determined by a combined consideration of length, body morphology and behavior. Fish >16 cm in length were designated as either *O .mykiss* or Common Carp, as these are the only two species present able to reach these lengths. Footage of positively identified Common Carp and adult steelhead of known sizes was obtained over the course of several supplemental deployments (Appendix C and E). Imagery of a positively identified Southern California steelhead trout was obtained by taking footage of a mature adult that became temporarily trapped below a low-flow barrier in the Goleta Slough Complex for the spring and summer of 2013 (Figure 13) .

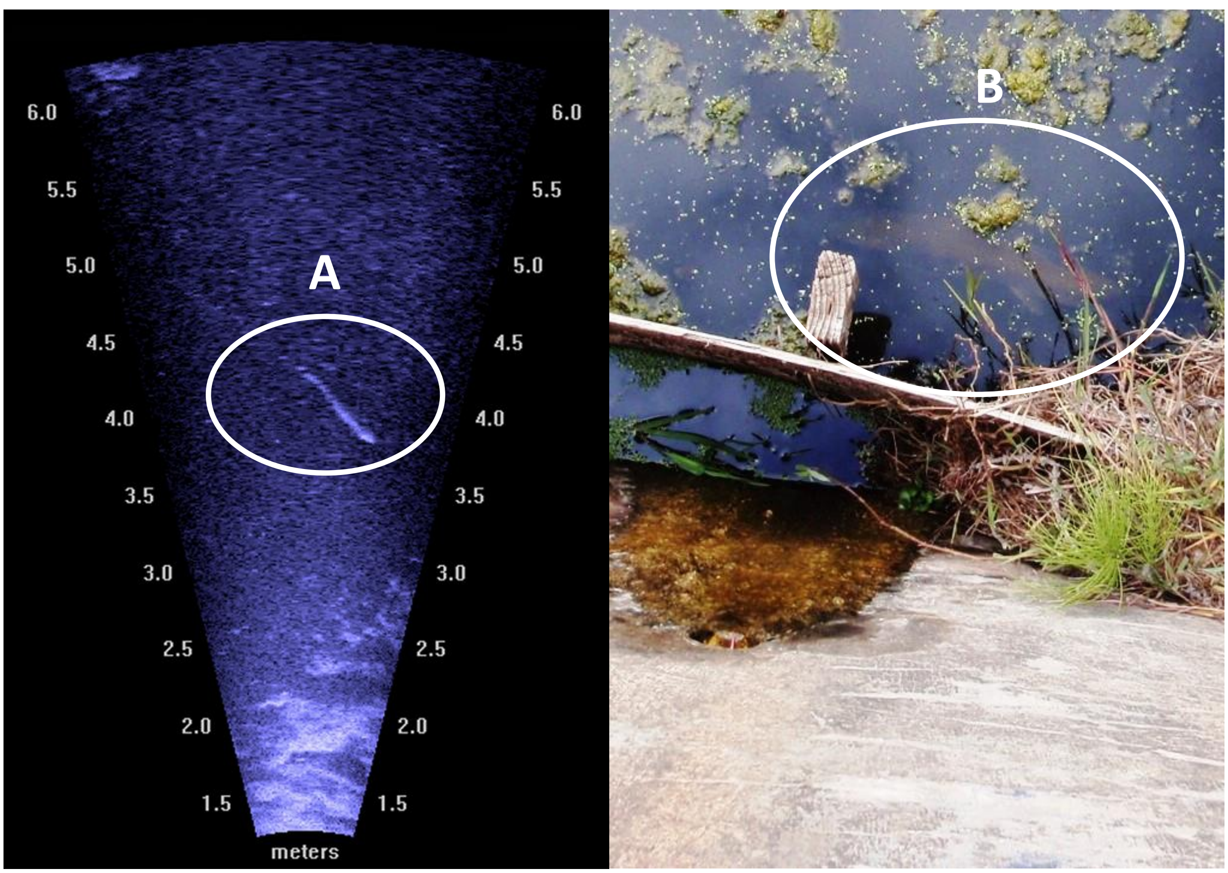

Figure 13. A seasonally trapped adult steelhead as viewed by DIDSON (A) and at the water's surface (B).

This footage was used to train new staff on measurement procedures in addition to providing opportunity for in depth comparison of swimming behavior and morphology. Further distinctions between the two species were made by evaluating behavioral cues, swimming motion, body shape and morphological features garnered from acoustic shadows in the case of the Ventura River site's 2014 deployment season. A particularly informative behavioral cue was carp feeding behavior, which involves foraging head down in the substrate. With regard to swimming behavior, there were several characteristics looked for. Carp fins tend to present greater surface area than *O. mykiss* while swimming, making them more easily discerned by DIDSON cameras. Certain aspect angles, relative to DIDSON center, yield better views of different sets of fins. This becomes more evident when combined with Carp's tendency to travel bank to bank while moving through the ensonified zone. Furthermore, this behavior contradicts steelhead which have been found to swim more directly in the bearing of travel when migrating. *O. mykiss* also exhibit more of a sinusoidal swimming motion than Carp. When considering body shape, body depth was the primary focus with Carp being the deeper bodied of the two. When analyzing acoustic shadows, fin shape was the primary focus. Carp have more deeply forked caudal fins and a more prominent dorsal fin than steelhead of similar size.

Length was taken using the box method available in the DIDSON software. When possible, three measurements were taken using the three best quality frames to obtain an average length. Observational data was reviewed by an experienced biologist or technician before entry into a database to verify species identification and recorded length.

All other wildlife detections were recorded and classified as Red Swamp Crayfish (the only observed crayfish species in the area), frog spp., turtle spp., waterfowl spp., mammal spp. or unknown. Direction of travel was recorded as upstream, downstream, upstream/downstream or downstream/upstream. The latter two options describe detections where the target didn't fully cross the DIDSON beam, and exited the field of view from the same side they entered. The "Quality of frames" played a role in observational confidence and served as a means for initial viewers to call attention to observations requiring verification by the biologist. All other recorded fields are shown in Figure 12 above**.**

Results

2013

Salsipuedes Creek

None of the 2013 storm events monitored by DIDSON precipitated a significant flow response in the Salsipuedes Creek watershed (Table 1).

Table 1. Salsipuedes Creek DIDSON deployment dates for the 2013 season. (*)Flow data unavailable.

Deployment Dates	Peak Flow
January 24-28	*
February 7-11	*
March 7-9	6.5 ft^3/s

Continual low flow conditions resulted in barriers that would normally be considered seasonal (i.e. the lagoon's sand berm and beaver dams) persisting for the entire spawning season. These obstacles effectively prevented *O. mykiss* upstream migration. Evidence of beaver activity can be seen in the number of DIDSON detections recorded throughout the three deployment events. (Tables 2- 4).

Intermittent, short-term power outages were common throughout the season. These outages caused issues early in the season prior to the implementation of an uninterruptible power supply.

A total of 237 detections were recorded over the course of three deployments, including 29 *O. mykiss* detections. *O. mykiss* observed ranged in size from 17 cm to 21 cm. The nearly equal amount of upstream and downstream detections— combined with the relatively small measured lengths and the presence of instream migration barriers—suggests that all observed *O. mykiss* were milling individuals of a resident population. No adult Steelhead trout were observed.

Table 2. Salsipuedes Creek DIDSON detections January 24, 2013 to January 28, 2014.

Species	Downstream	Upstream	Downstream/Upstream	Upstream/Downstream	Totals
North American Beaver	59	59	0	1	**119**
Fish spp.	4	11	0	0	**15**
O. mykiss	0	1	0	0	**1**
Totals	**63**	**71**	**0**	**1**	**135**

Table 3. Salsipuedes Creek DIDSON detections February 7, 2013 to February 11, 2014.

Species	Downstream	Upstream	Downstream/Upstream	Upstream/Downstream	Totals
North American Beaver	5	1	2	0	**8**
Red Swamp Crayfish	0	1	0	0	**1**
Fish spp.	2	7	1	4	**14**
O. mykiss	0	0	2	1	**3**
Waterfowl spp.	0	2	0	0	**2**
Totals	**7**	**11**	**5**	**5**	**28**

Table 4. Salsipuedes Creek DIDSON detections March 7, 2013 to March 9, 2014.

Species	Downstream	Upstream	Downstream/Upstream	Upstream/Downstream	Totals
North American Beaver	24	23	0	0	**47**
O. mykiss	11	11	1	2	**25**
Waterfowl spp.	1	1	0	0	**2**
Totals	**36**	**35**	**1**	**2**	**74**

Ventura River

Monitored storm events resulted in relatively low peak flows (Table 5). Connectivity between spawning habitat and the ocean was limited, making opportunities for adult steelhead migration into the Ventura River watershed few and far between.

Table 5. Ventura River DIDSON deployment dates for the 2013 season.

Deployment Dates	Peak Flow
March 30- April 1	.87 ft^3/s
April 15-17	.96 ft^3/s

A total of 131 detection events were recorded over the course of two deployments, including 36 *O. mykiss* detections (Tables 6 and 7). The majority of detections consisted of milling adult Common Carp, averaging 52 cm in length. Carp were visually observed throughout the deployment season occupying a large pool approximately 30 m upstream. This likely served as the source population for observed individuals.

Observed *O. mykiss* ranged in size from 12 cm to 27 cm. The nearly equal amount of upstream and downstream detections— combined with relatively small measured lengths—suggests that all observed *O. mykiss* were resident individuals exhibiting milling behavior. No adult Steelhead trout were observed.

Table 6. Ventura River DIDSON detections March 30, 2013 to April 1, 2013.

Species	Downstream	Upstream	Downstream/Upstream	Upstream/Downstream	Totals
Common Carp	4	5	49	0	**58**
Fish spp.	1	1	0	0	**2**
O. mykiss	2	4	2	0	**8**
Turtle spp.	**0**	**1**	**0**	**0**	**1**
Waterfowl spp.	**2**	**2**	**0**	**0**	**4**
Totals	**9**	**13**	**51**	**0**	**73**

Table 7. Ventura River DIDSON detections April 15, 2013 to April 17, 2013.

Species	Downstream	Upstream	Downstream/Upstream	Upstream/Downstream	Totals
Common Carp	1	0	26	0	**27**
O. mykiss	9	13	4	2	**28**
Turtle spp.	**0**	**1**	**0**	**0**	**1**
Waterfowl spp.	**1**	**1**	**0**	**0**	**2**
Totals	**11**	**15**	**30**	**2**	**58**

2014

Salsipuedes Creek

During peak flows of 158 ft^3/s (U.S Geological Survey 2015), turbidity levels increased, reducing image quality and image range (<2m), rendering footage taken during the night of February 28, 2014 unusable. Flow decreased quickly following peak values as is typical of Southern California flow regimes. Wetted channel width contracted from >10m to <5m, where it remained for the greater part of the deployment period. The resulting channel profile was deepest within the first 2m of the DIDSON's field of view. Consequently, targets were consistently passing closer to the transducer than was ideal, with an average distance to target of 0.86 m. This leads to image distortion caused by crosstalk. As a result, confidence in species identification was low for fish measuring <16 cm when interspecific size overlap is most likely to occur. A total of 777 detection events were recorded; including 28 *O. mykiss*—ranging in size from 16 cm to 29 cm—and 370 fish of unidentified species (see Appendix A for a full list of detections). Additionally, 329 detections were designated as unknown due to poor image quality. No adult Steelhead trout were observed.

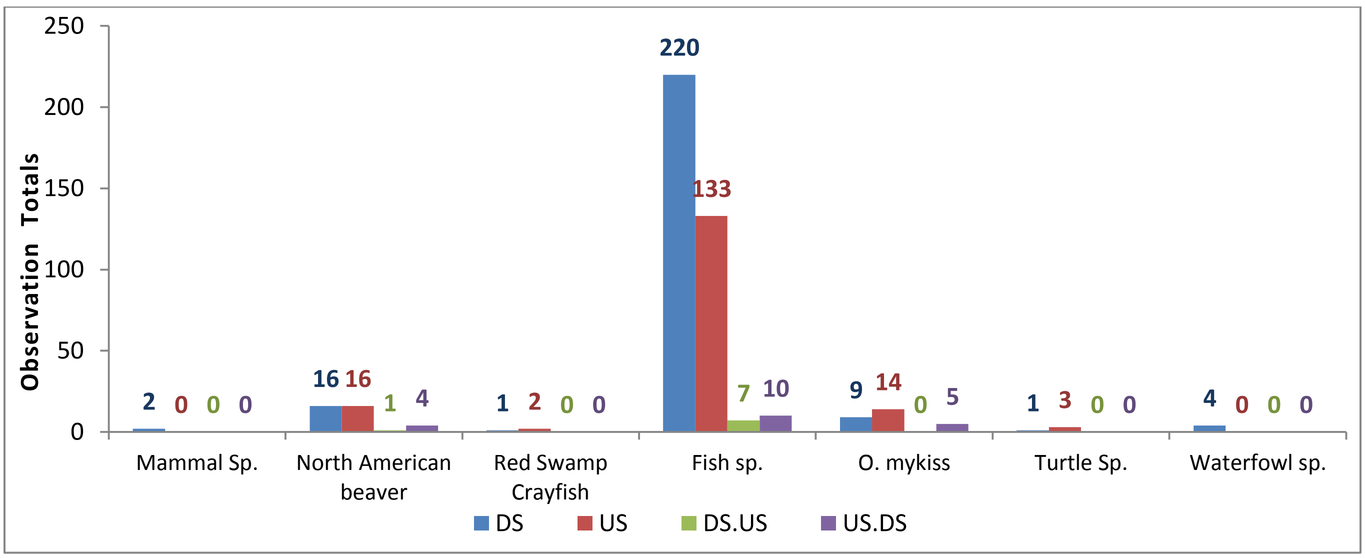

Figure 14. Salsipuedes Creek species observation totals for detection events captured from February 27, 2014 through March 13, 2014.

Carpinteria Creek

Maximum recorded flow for the event that took place from February 28, 2014 to March 2, 2014 was 37 ft^3/s. Wetted width remained <5 m. Two fish detections were recorded and classified as Southern California steelhead trout based on size and swimming behavior (Appendix A). These detections are believed to be the same individual for the following reasons: direction of travel was upstream with the first detection (0140 on March 2, 2014) and downstream for the second detection (0440 on March 2, 2014); average length was measured at 27 cm in both instances; and the degree of confidence was high in both instances due to the high quality of associated footage.

Ventura River

Peak flow for the event that took place from February 27, 2014 to March 25, 2014 was recorded on March 1 at 3180 ft^3/s (U.S. Geological Survey 2015). As with Salsipuedes Creek, flows descended quickly following peak values, returning to conditions similar to those observed pre-storm over the course of two days. Extreme turbidity associated with this period of peak flow lead to a decrease in imaged range similar to Salsipuedes Creek. This rendered footage collected between 1320 on March 1, 2014 to 0430 on March 2, 2014 unusable. Footage collected for the remainder of the deployment was of consistently high quality. Consequently, confidence in species identification was also high. A total of 717 detection events were recorded, including 33 *O. mykiss* detections (Appendix A). *O. mykiss* observed ranged in size from 16 cm to 34 cm. No adult Steelhead trout were observed.

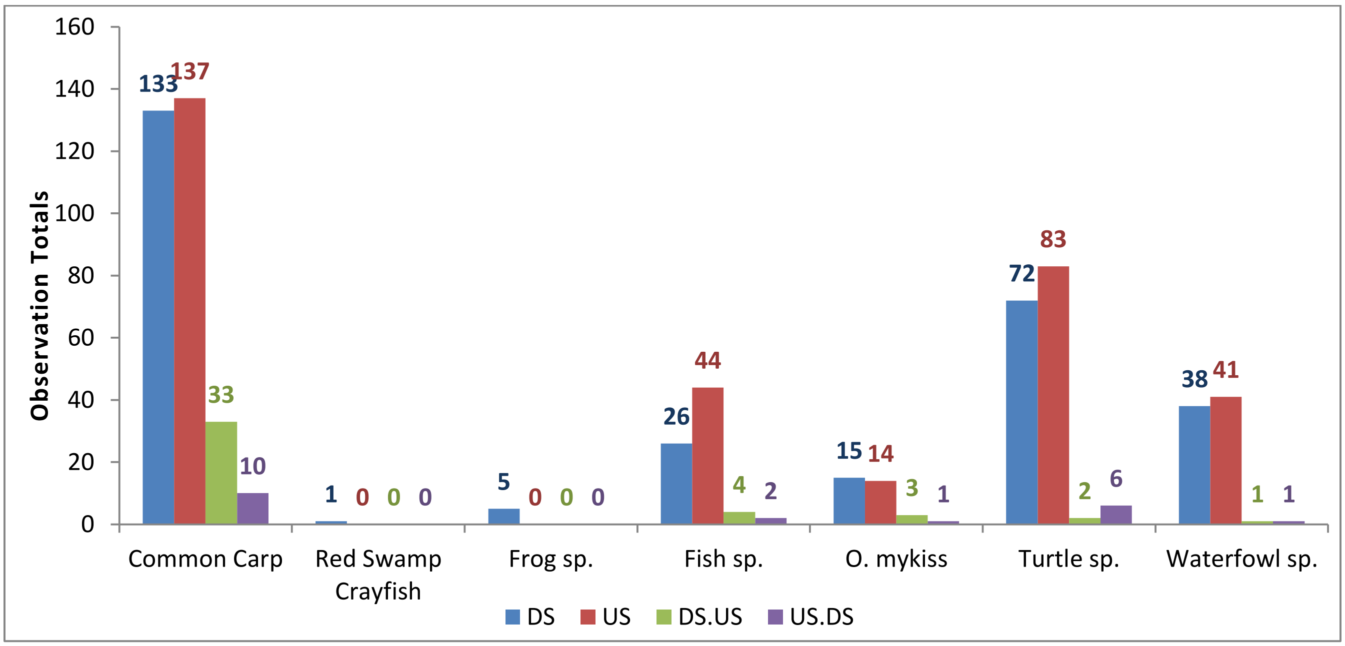

Figure 15. Ventura River species observation totals for detection events captured from February 27, 2014 through March 25, 2014.

Discussion

Drought Conditions

The 2013 and 2014 DIDSON sampling seasons were severely limited by drought conditions (Figure 16). For a historical perspective, 2012 through 2014 represent the three driest consecutive water-years on record for Santa Barbara County dating back to the early 1900's (County of Santa Barbara 2014).

The 2013 season failed to produce any storm events capable of generating flows capable of allowing anadromous adults to migrate upstream and past our DIDSON stations to spawning habitat. This trend continued through 2014, with the exception of single storm event that took place at the end of February 2014 (Table 1). This represented the only opportunity for anadromous fish to enter the monitored systems, with the exception of Salsipuedes Creek, where the berm never breached. Given the relatively short amount of time where flows met migration flow requirements, the lack of adult steelhead trout observations is not surprising.

Table 8. Deployment dates for the 2014 DIDSON season.

Site	Deployment Dates	Peak Flow
Salsipuedes Creek	Feb 27 - March 13	158 ft^3/s
Carpinteria Creek	Feb 28 - March 2	37 ft^3/s
Ventura River	Feb 27 - March 25	3180 ft^3/s

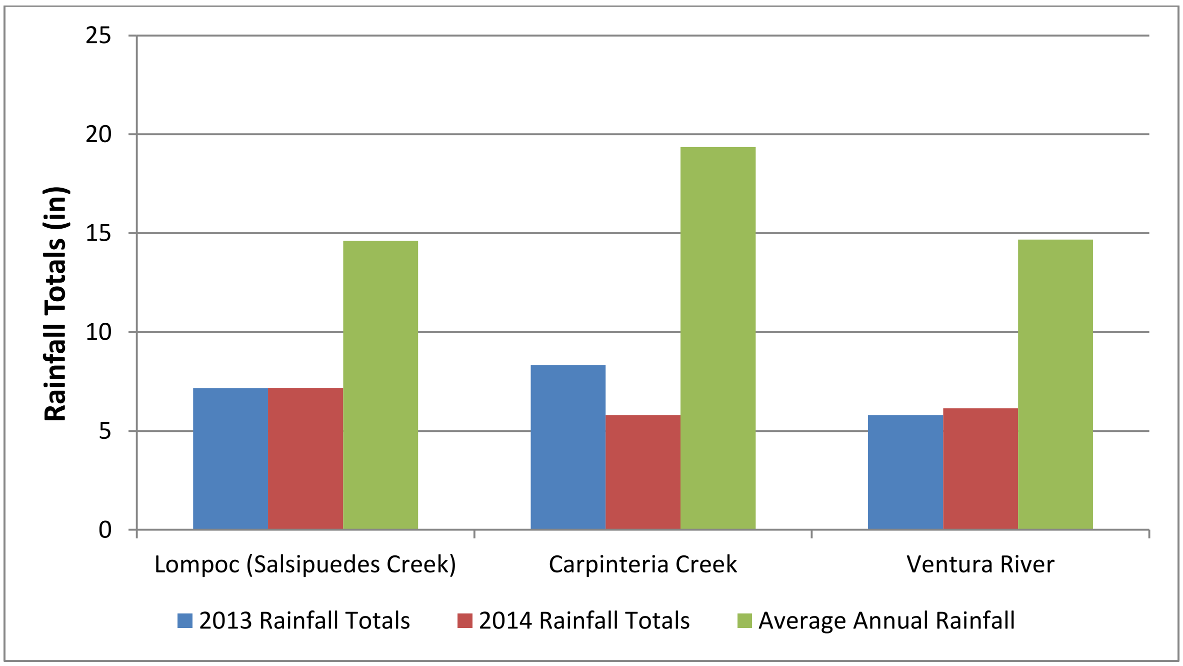

Figure 16. 2013 and 2014 rainfall totals compared to average annual rainfall.

Species Identification

Species determination represents the most significant challenge encountered during DIDSON footage analysis. This rings particularly true for the Ventura River site where, as expected, the ranges in recorded lengths for Common Carp (30-68 cm) were similar to those expected for adult *O .mykiss*. Moreover, the greatest number of upstream detections for *C. carpio* occurred during flow velocities when steelhead trout migration could occur (Figure 17). Several of the initial *C. carpio* upstream detections were visually observed by onsite staff. These positive identifications combined with *C. carpio* and adult *O. mykiss* footage obtained from previous deployments (Appendices C and E) served as comparative examples to help determine species identification in ambiguous cases. Comparison between footage of adult *C. carpio* and *O. mykiss* added valuable information needed to assess several parameters (body shape, swimming behavior, etc.) used for improved accuracy in species determination. Accuracy in species identification has increased throughout the 2014 season with the incorporation of the shadow board at the Ventura River site and by identifying more specific metrics for analysis of swimming motion, behavior and morphology. Staff will gain proficiency and effectiveness through continued experience. Improvements in training materials and methodologies will also be continually improved upon in hopes of decreasing the initial learning curve.

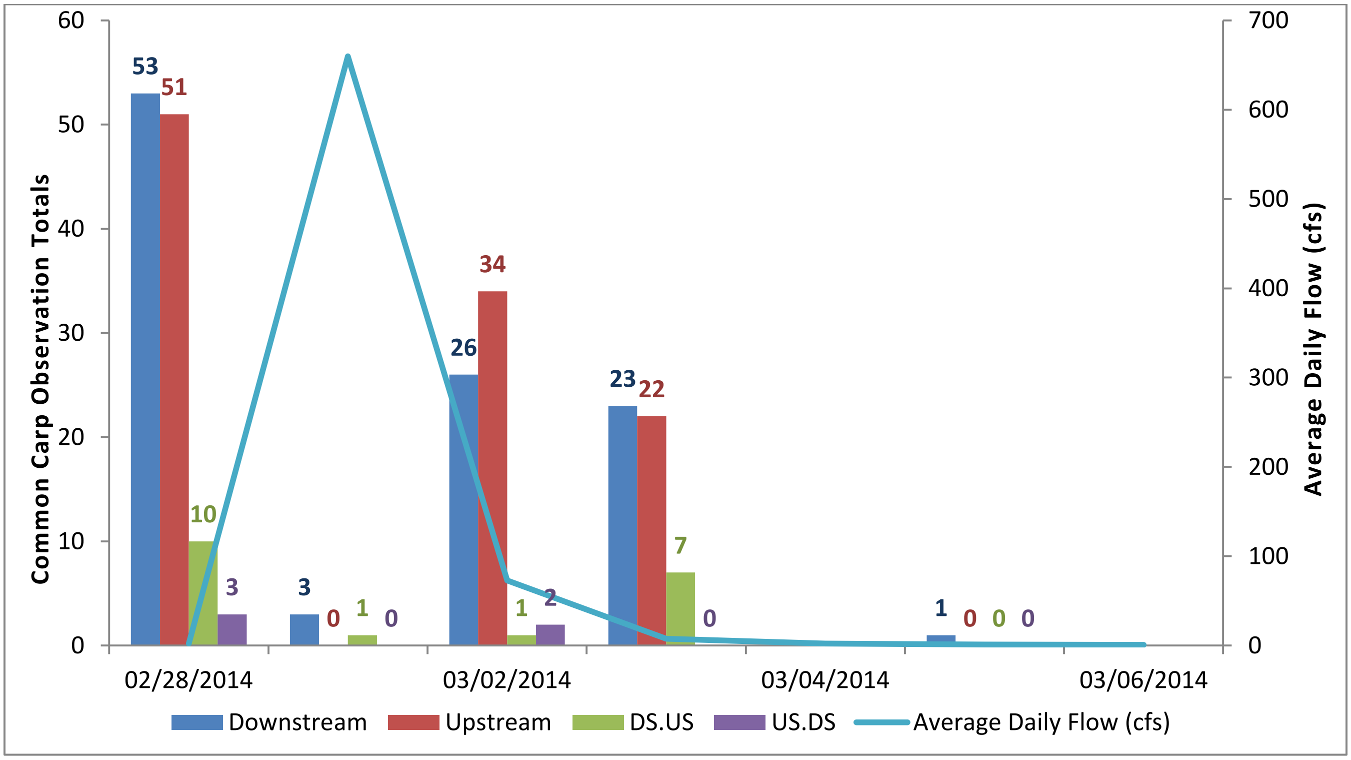

Figure 17. Common Carp detections for February 28, 2014 to March 6, 2014 shown alongside daily average flow in the Ventura River.

Milling

Milling behavior was commonplace at all three sites. Assigning individual fish ID's using DIDSON imagery is a challenging proposition, but must be addressed to avoid double counting. To move away from a best guess approach, a decision support tool was developed by Pipal et al. (2010) to deal with complicated steelhead trout in-stream movement. This approach applies a point system to ascertain whether each observed fish is the same or different than the previous fish (Pipal et. al 2010). Given that no adult steelhead were observed over the course of our deployments, and the time-intensive nature of applying the decision support tool, individual fish ID's were not assigned during our 2013 or 2014 analysis. Future seasons will make use of a modified decision support tool when it becomes necessary.

Site Infrastructure

Site selection, development and maintenance are all critical components of successful DIDSON operation and data collection. Our sites had to meet a number of parameters prior to selection. The first of these parameters involved the evaluation of the substrate and channel profile. The combination of substrate and channel morphology should be such that the DIDSON beam ensonifies the entire field of view without obstructions. Large substrate or deeper sections of channel will result in “dead zones” where target species could be allowed to pass undetected resulting in inaccurate counts. Ideal sites exhibit uniform substrate and a consistent shallow angle reflective of the DIDSON beam shape. Attention must also be paid to habitat type. DIDSON sites should be situated along a migration corridor free of holding habitat so fish are actively swimming as they pass by the camera to avoid complications associated with milling behavior. If possible, DIDSONs should be installed in areas of reduced water velocity relative to the thalweg. This limits potential for damage caused by debris or being swept away by high flow.

Once a site has been selected; site power, access, security needs and type of DIDSON camera mount must be addressed. Sites require continuous power for extended periods of time. All DIDSON sites operated by this project were either hardwired into the power grid or connected by extension cord to an adjacent powered, permanent structure. In the absence of nearby access to a power grid, alternative power sources (i.e. solar, deep cycle batteries, etc.) would have been required. Site access required trails to be cut at all three sites. These trails had to be wide and even to allow staff to safely carry valuable equipment from the vehicle to the camera’s final location. Steep banks required the installation of steps. The mode of camera mount selected was dictated by site conditions. Mounts were all “A-frame” configurations as detailed above, with the exception of the high flow track mount system at Salsipuedes Creek. Site security measures were determined by site specific risk assessments. The Salsipuedes Creek and Carpinteria Creek sites are both located on private property with the only access to the camera itself being via the stream channel. In these cases a heavy duty security tether was sufficient to allay theft and high flow concerns. The Ventura site is in close proximity to a former large transient encampment. While this encampment has been removed, small encampments persist throughout the surrounding area. These factors result in a higher potential for theft and vandalism. Consequently, a regular presence was maintained by keeping staff on site for the entire deployment duration. This required a substantial allocation of personnel and transportation resources. More cost effective alternatives to around the clock staffing—such as theft insurance and a more robust security tether system—are being evaluated for future deployments.

Operational Improvements

DIDSON cameras are unable to effectively image targets that pass within 1 m of the transducer. Targets occupying this range will appear blurred and blown out. This was the case for many detection events associated with the Salsipuedes Creek site and several at our Carpinteria Creek site. To address this issue, deflection weirs were proposed and implemented—with input and approval from California Department of Fish and Wildlife engineers and streambed alteration biologists— following the sampling season for both Salsipuedes and Carpinteria Creek. These structures were designed to function under low flow conditions when the wetted channel constricts and there is a higher likelihood that targets will pass too close to the camera. At Salsipuedes Creek, a series of modified live willow siltation baffles were installed. These types of baffles are typically used in restoration to rebuild degraded banks. Their design suited our needs because we required a structure that would guide fish away from the bank without causing scour leading to bank failure.

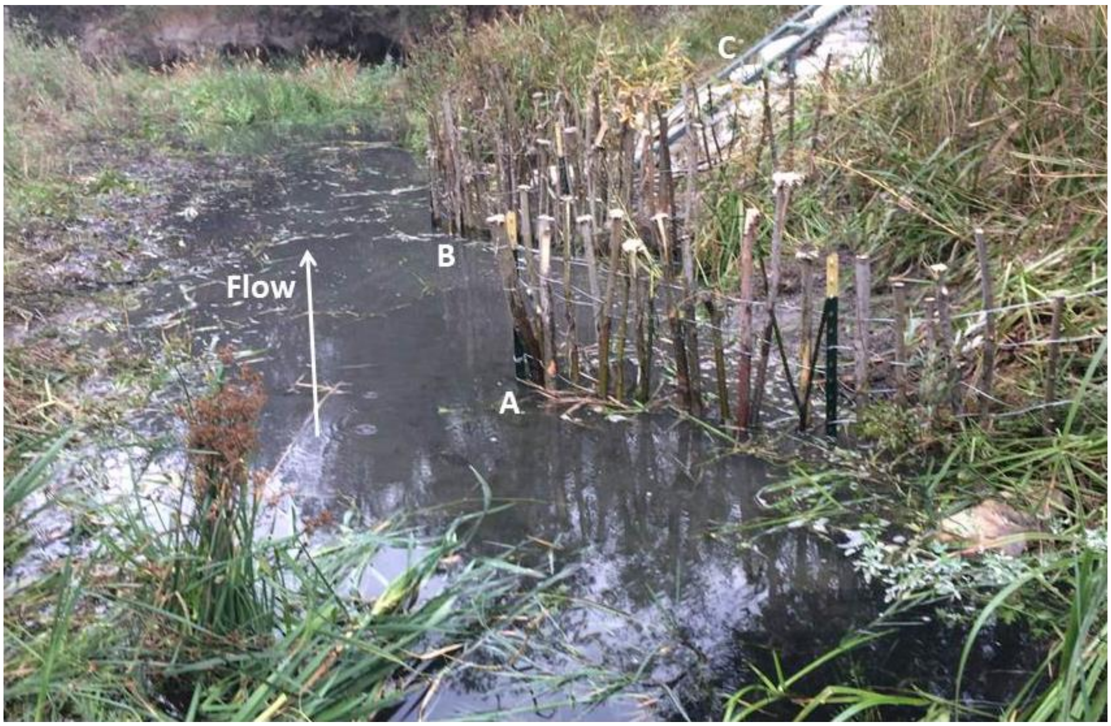

Figure 18. Willow baffles being used to direct fish to an optimal DIDSON imaging range at Salsipuedes Creek. Key features are labeled. (A and B) Upstream willow baffles; (C) High flow DIDSON track.

The guidance weir for Carpinteria Creek was composed of native cobbles and boulders. Design and construction followed guidelines similar to those used in restoration work, but on a smaller scale. Carpinteria Creek has historically exhibited relatively low peak flows and base flows (U.S. Geological Survey 2015); therefore, only a small berm was required on the upstream side with a downstream weir consisting of large woody debris that has been enhanced and reinforced by native cobbles and boulders.

Figure 19. Berms composed of native materials being used to direct fish to an optimal DIDSON imaging range at Carpinteria Creek. Key features are labeled. (A) Upstream berm composed of large cobbles and small boulders; (B) Downstream berm composed of woody debris reinforced with cobbles and boulders.

Future Development

DIDSON monitoring in Southern California is an evolving process. Maximizing this powerful tool's utility will require adaptive protocols and operational ingenuity. Gaining a better understanding of DIDSON's performance limitations—specifically with regards to turbidity's effects on DIDSON imaging range— is one example of an area warranting further research. Another way to increase a DIDSON counting station's monitoring value will be to couple it with efforts to monitor additional life history stages to achieve a Life Cycle Monitoring station as outlined in Fish Bulletin 180 (Adams et al. 2011). The Salsipuedes Creek site operated immediately downstream of migrant traps operated by the Cachuma Operation and Maintenance Board. This presented the opportunity to assess DIDSON size estimate accuracy by comparing size estimates of individuals with in hand measurements as well as allowing for an evaluation of trapping efficiency by comparing DIDSON detections with the number of fish caught.

The benefits of DIDSON technology to Southern California steelhead monitoring far outweigh its cost and challenges and it remains the best option for gathering reliable count data under Southern California conditions.

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Appendix A

Table 1. Salsipuedes Creek DIDSON detections from February 27, 2014 to March 13, 2014.

Species	DS	US	DS.US	US.DS	Total
Mammal Spp.	2	0	0	0	**2**
North American beaver	16	16	1	4	**37**
Red Swamp Crayfish	1	2	0	0	**3**
Fish spp.	220	133	7	10	**370**
O. mykiss	9	14	0	5	**28**
Turtle spp.	1	3	0	0	**4**
Waterfowl spp.	4	0	0	0	**4**
Unknown	302	24	1	2	**329**
Totals	**555**	**192**	**9**	**21**	**777**

Table 2. Carpinteria Creek DIDSON detections from February 28, 2014 to March 2, 2014.

Species	DS	US	DS.US	US.DS	Totals
O. mykiss	1	1	-	-	**2**
Unknown	5	1	0	0	**6**
Totals	**6**	**2**	**0**	**0**	**8**

Table 3. Ventura River DIDSON detections from February 28, 2014 to March 27, 2014.

Species	DS	US	DS.US	US.DS	Totals
Common Carp	133	137	33	10	**313**
Red Swamp Crayfish	1	0	0	0	**1**
Frog spp.	5	0	0	0	**5**
Fish spp.	26	44	4	2	**76**
O. mykiss	15	14	3	1	**33**
Turtle spp.	72	83	2	6	**163**
Waterfowl spp.	38	41	1	1	**81**
Unknown	16	19	8	0	**43**
Totals	**306**	**338**	**51**	**20**	**715**

Appendix B

September 10, 2013 Long Range vs. Short Range DIDSON Field Test

Summary

On September 10, 2013 both a long range and short range DIDSON were deployed at the Ventura River DIDSON site, located in Ventura County, on to compare image quality. This was done to ascertain whether the long range model can serve as a substitute for the short range in the upcoming field season.

Methods

Both units were deployed in the same location and under the same conditions with regards to water clarity, placement, camera position and sonar settings.

Results

Image quality varied noticeably between the two models (Figure 1). Images produced using the long range models were consistently too bright and less defined. This is due to the differences in operating parameters between the two cameras (Table 1). Reduced image resolution in the long range is a result of a decreased operating frequency combined with fewer beams used to create the image resulting in a larger pixel size. The increase in brightness is likely caused by more intense returns resulting from the long range's increased sonar pulse length. Brightness can be compensated for by using the sonar controls to adjust "receiver gain". DIDSON units always transmit at maximum power, so adjusting the receiver gain is the only way to adjust the return signal strength. Figure 2 shows a side by side comparison of long range images before and after gain reduction.

Discussion

Over all, results were as expected with the short range producing a noticeably sharper image than that of the long range. While the brightness problem caused by the long range unit can be countered by adjusting receiver gain, we have concerns that a duller overall image may lead to greater difficulty in seeing fish movement. This would be particularly problematic for small fast moving fish, such as out-migrating smolts.

There are also concerns about increased sizing errors due larger cross range pixel size (Table 1). With a 10m window length the short range unit has a cross range pixel size of 5cm, while the long range unit has a cross range pixel size of 10cm. This could lead to substantial overestimation of fish sizes from DIDSON images.

Table 1. Short range and long range DIDSON operating parameters

Specifications	Short Range	Long Range
Operating Frequency	1.8 MHz	1.2 MHz
Beam width	0.3° wide by 14 ° tall	0.5°wide by 14° tall
Number of Beams	96	48
(Extended) Window Start	0.42m to 12.92m in 0.42m steps	0.42m to 12.92m in 0.42m steps
(Extended) Window Length	1.25m, 2.5m, 5m, 10m	1.25m, 2.5m, 5m, 10m
Pixel width (relative to window length)	0.75cm, 1.25cm, 2.5cm, 5cm	1.5cm, 1.5cm, 5cm, 10cm
Pulse Length (relative to window length)	4.5μs, 9μs, 18μs, 36μs	6.7μs, 13μs, 26μs, 54μs

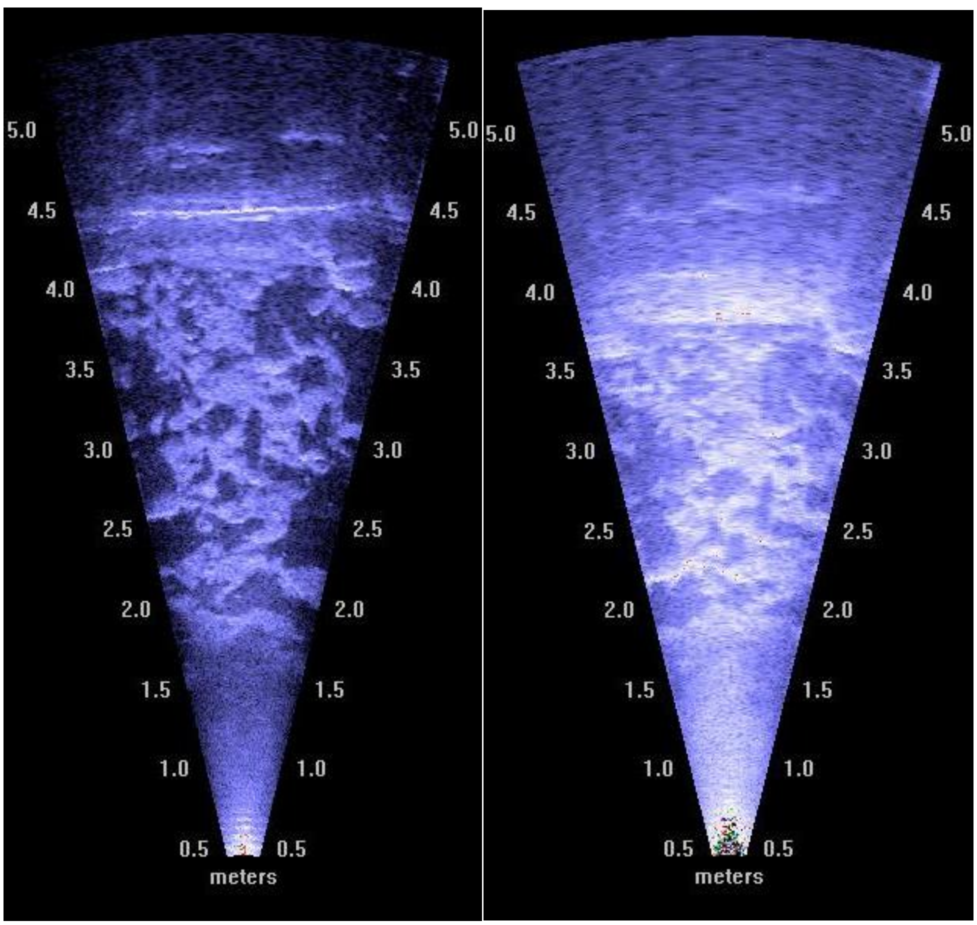

Figure 1. The image on the left was captured on the short range. The right is captured using the long range.

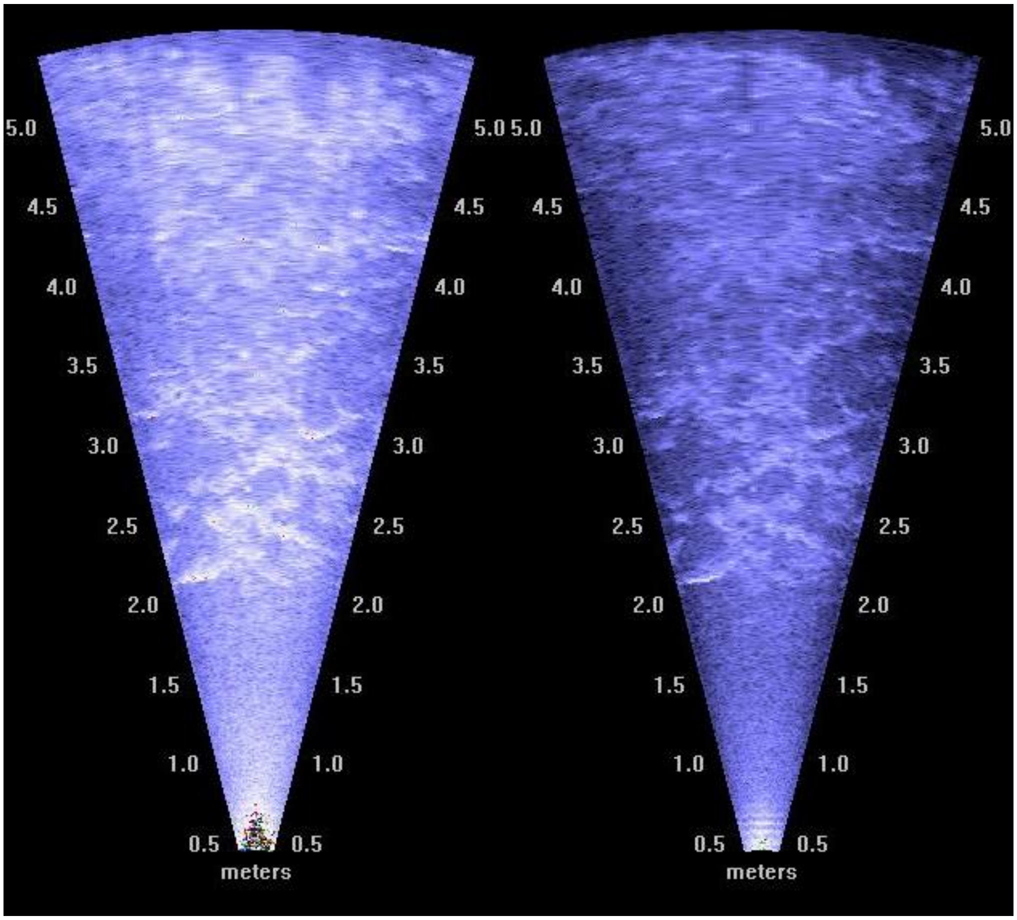

Figure 2. The image on the left is taken from footage set to the default receiver gain value of 40 db. The one on the right is set to 22 db.

Appendix C

October 1, 2014 Matilija Creek DIDSON Sizing Experiment

Summary

On October, 2014 a standard DIDSON unit was deployed in Matilija Creek, a tributary to the Ventura River located in Ventura County, CA, to gather footage of tethered fish of known sizes. This will be used to train new staff on measurement procedures used when analyzing DIDSON footage.

Methods

A number of fish were captured along a short section of Matilija Creek below Matilija dam. Only fish exceeding ≥15 cm were considered for tethering. This represents the expected lower size limit for our target species, *Oncorhynchus mykiss*, during our field deployment season. All individuals of acceptable size were Largemouth Bass, *Micropterus salmoides* with the exception of a single Green Sunfish, *Lepomis cyanellus.*

Both total length and fork length was taken for each fish prior to being tethered (Table 1) . Fish were tethered by monofilament line running from a fishing pole to a clasp swivel affixed to the corner of their mouth. Fish were guided through the center of the DIDSON's field of view, where image quality is best, until sufficient footage was obtained. Time stamps and other pertinent data were recorded to allow for easy comparison during analysis (Table 1).

The DIDSON's settings and positioning were chosen to reflect those typically used during actual deployments (Figure 1).The site was chosen for its regular streambed topography and narrow channel width which allowed for a short DIDSON window length. Shorter window lengths are desirable as they result in higher resolution and overall image quality. The X2 rotator control was employed to allow for ease of adjustment throughout the exercise.

Results

Footage was of high quality and software measurements were typically within 2 cm of recorded total length. As expected, total length is more reflective of size estimates obtained using DIDSON software.

Discussion

This deployment's findings will be useful by providing images to compare against footage captured during actual deployments. This footage will be particularly useful in providing opportunity for development of species differentiation techniques. It will also be used to develop training protocols for sizing methodology.

Table 1. Deployment data.

Start	End	Filename	Species	FL (cm)	TL (cm)
1247	1253	124632	Green Sunfish	18.5	19
1256	1306	125604	Largemouth Bass	24.7	25.1
1308	1322	130815-132000	Largemouth Bass	26.7	27.7
1325	1341	132502-134000	Largemouth Bass	30	31.8

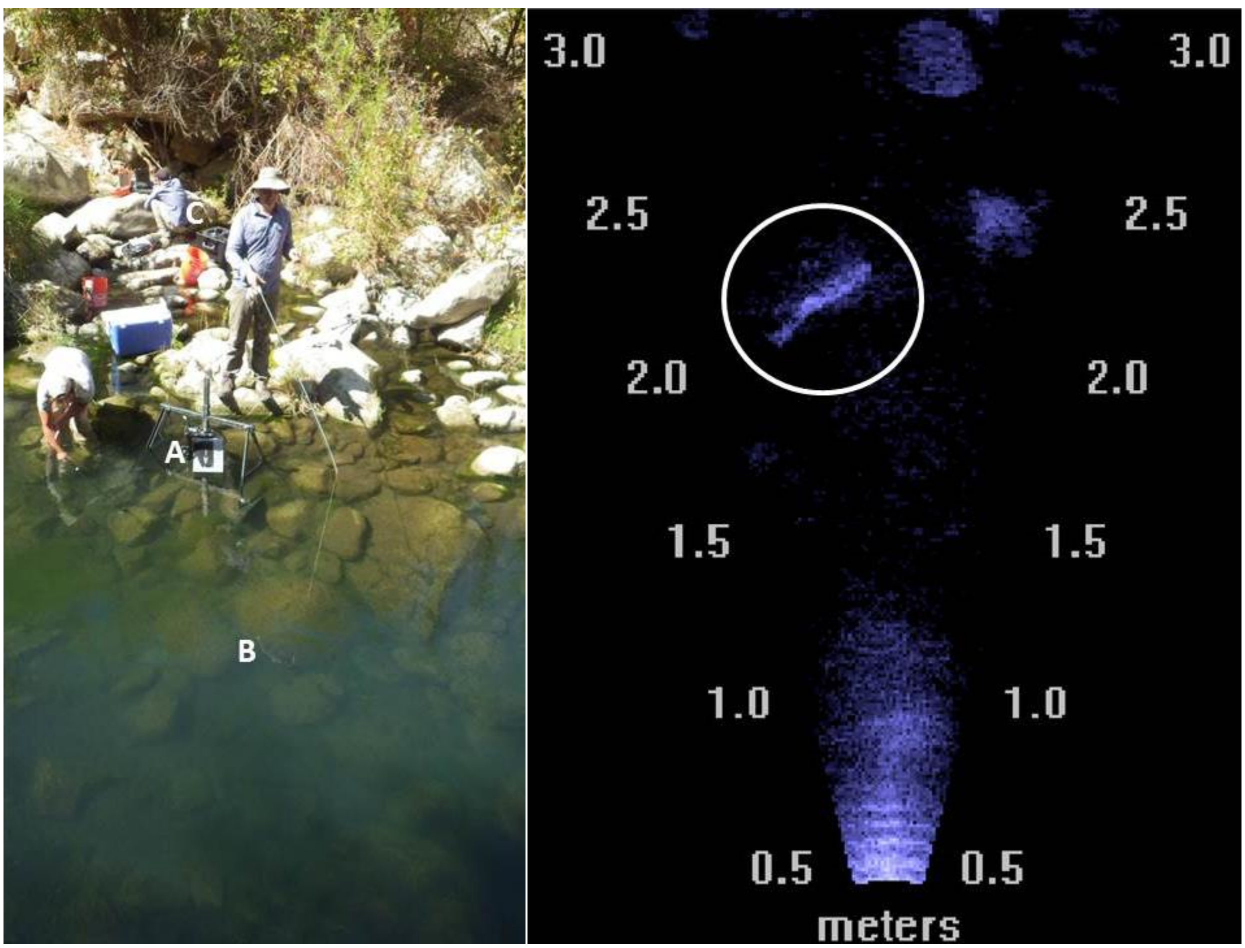

Figure 1. (Left)Key features are labeled. Using DIDSON (A) to gather imagery of a tethered bass (B) while using topside equipment (C) to adjust settings. (Right) A Largemouth Bass as seen by DIDSON.

Appendix D

August 8, 2013 Ventura River Shadow Board Test

Summary

On August 8, 2013 a test deployment was carried out water at our Ventura River DIDSON site to determine whether a descriptive shadow could be produced using a DIDSON and an angled surface following guidelines presented in Langkau et al. 2012.

Methods

Repurposed shelving was used to create a small scale shadow board. This shelving was constructed out of metal and measured 41.5 cm wide and 91.5 cm tall.

The shelf was placed in approximately 0.6 m of water at a distance of 2.7 m from the DIDSON. The shelf was angled at approximately 45 degrees.

A rubber, model trout was used as a test target. The target was moved back and forth between the DIDSON and shelf to determine the effects of range on shadow clarity and distortion.

Results

The metal shelf was not able to produce a useful shadow initially. We found that the metal produced a mirroring effect (Figure 1). In attempt to resolve this problem on site, the metal shelf was covered with cardboard to increase sound absorption. This reduced the mirroring effect, creating distinguishable shadows (Figures 2-4).

Using the cardboard covered shelf, we were able to obtain shadows with enough detail to discern individual fins on the model trout (Figures 2-4). We found that the shadows were clearer with a shorter (2.5m) window length than with a longer (5m) window length (Figure 4). When the model was moved farther away from the shelf, and closer to the DIDSON, the shadow became larger (Figure 3). This created clearly distinguishable shadows up to about 1m in front of the shelf. When the model was moved farther away from the shelf the shadow image would become distorted and faint.

Discussion

We learned several things from this preliminary test. First, it appears that we may be able to use a shadow board at the Ventura River DIDSON site to help to distinguish between carp and trout. The shadow images obtained using suboptimal materials still provided more descriptive detail (e.g. visible fins) than the DIDSON imagery alone (Figures 2-4). Given the quality of shadow imagery obtained during this preliminary test, we would be interested in building a more effective shadow board and gathering imagery of live fish.

We also discovered that we will need to use a material with better sound absorption properties than metal. We used the metal shelf because it was available, and did not foresee this type of problem. Wood has been used as an effective projection surface (Langkau et al. 2012). We believe using wood to create a shadow board would eliminate the mirroring effects seen with the metal shelf, in addition to providing a low cost testing solution.

Finally, it will likely be necessary for fish to swim within a specific area between the DIDSON and the board to create descriptive shadows. We would like to set up deflection fencing at the Ventura DIDSON site to help to position fish between the DIDSON and the board to get the best image possible.

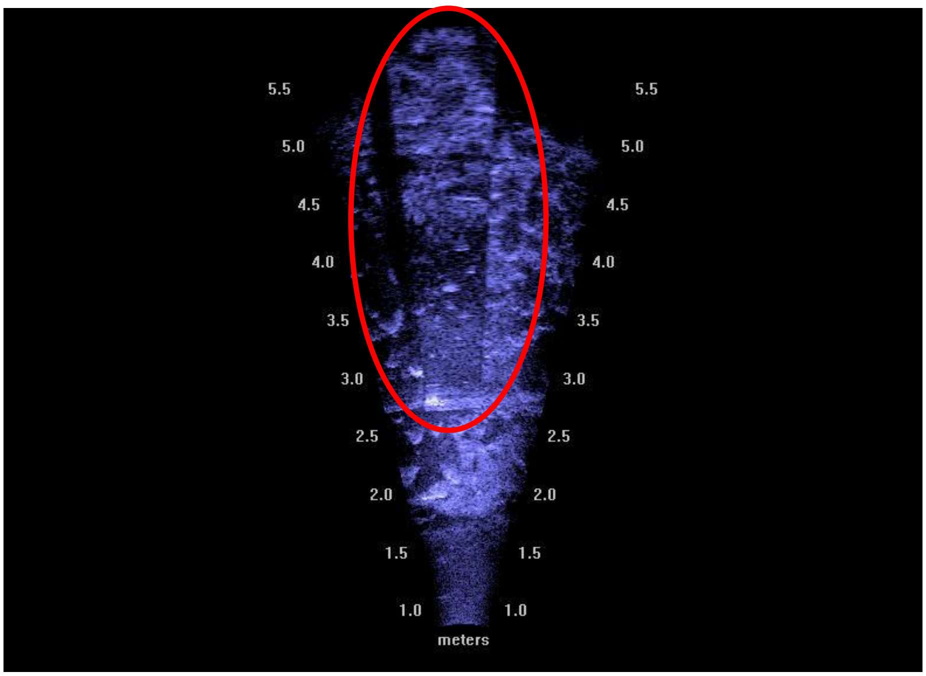

Figure 1. To show the mirroring effect, the shelf (circled in red) was held vertically. Note how the DIDSON projects images of the substrate onto the surface of the shelf.

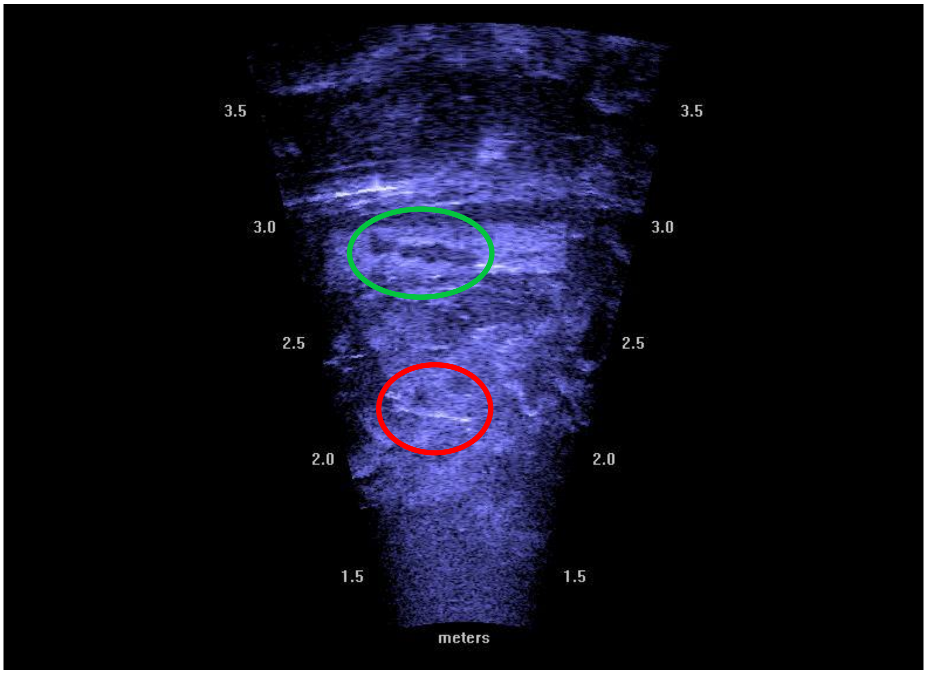

Figure 2. Shadow with a 2.5m window. The fish model is located about 2.2m in front of the DIDSON and 0.5m in front of the shelf. The DIDSON image of the model is circled in red and the shadow is circled in green.

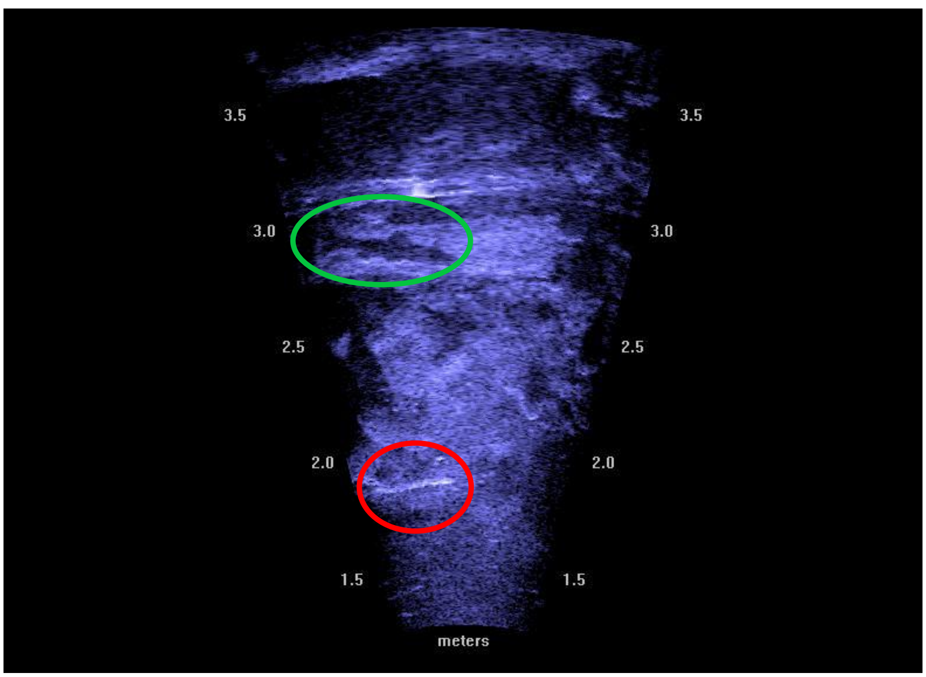

Figure 3. Shadow with a 2.5m window. The model was held approximately 1 meter in front of the shelf. The DIDSON image of the model is circled in red and the shadow is circled in green.

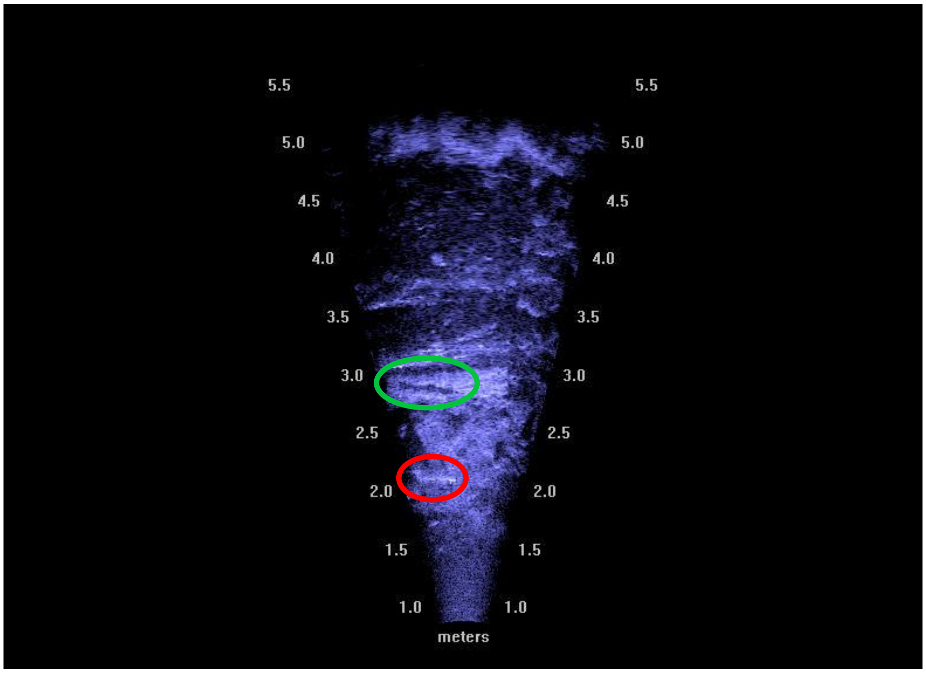

Figure 4. Shadow with a 5 m window length. The model is held approximately 0.5m in front of the shelf. The model is circled in red and the shadow is circled in green.

Appendix E

July 23, 2014 Conejo Creek DIDSON Sizing Experiment

Summary

On July 23, 2014 a standard DIDSON unit was deployed in Conejo Creek, a tributary to Calleguas Creek located in Ventura County, CA, to gather footage of tethered fish of known sizes. This will be used to train new staff on measurement procedures used when analyzing DIDSON footage.

Methods

A number of fish were captured by electrofishing a short section upstream of the DIDSON deployment site. Only fish exceeding $\geq$15 cm were considered for tethering. This represents the expected lower size limit for our target species, *Oncorhynchus mykiss*, during our field deployment season. All individuals of acceptable size were Common Carp, *Cyprinus carpio*, with the exception of a single Largemouth Bass, *Micropterus salmoides.* All Carp were of similar size so only the largest and smallest individuals were used in addition to the single Largemouth Bass (Table 1).

Total lengths were taken for each fish, rather than fork length, as this better corresponds to the top down view provided by DIDSON imagery (Figure 2). Fish were tethered by monofilament line running from a fishing pole to a clasp swivel affixed to the corner of their mouth. Fish were guided through the center of the DIDSON's field of view, where image quality is best, until sufficient footage was obtained. Time stamps and other pertinent data were recorded to allow for easy comparison during analysis (Table 1).

The DIDSON's settings and positioning were chosen to reflect those typically used during actual deployments (Figure 1).The site was chosen for its regular streambed topography, uniform substrate and its width which also approximated typical deployment conditions. The X2 rotator control was employed to allow for ease of adjustment throughout the exercise.

Results

Footage was of high quality and software measurements were typically within 3 cm of recorded total length (Figure 2).

Discussion

This sizing experiment will be useful by providing carp images to compare against imagery captured during actual deployments. It will also be used for training purposes to ensure accurate sizing technique of staff by comparing software generated measurements to field measurements.

As expected, the angle of the fish's body relative to the beam, distance from the lens, and at what point in the fish's tail beat cycle the measured frames are taken can all have a significant effect on measurement accuracy.

Table 1. Deployment data

Start Time	End	Filename	Species	TL (cm)
1455	1505	7-23-145400	Bass	26.4
1508	1516	7-23-150000	Carp	52.7
1522	-	7-23-152000	Carp	45.0

Figure 1. DIDSON deployment setup for sizing experiment in Conejo Creek.

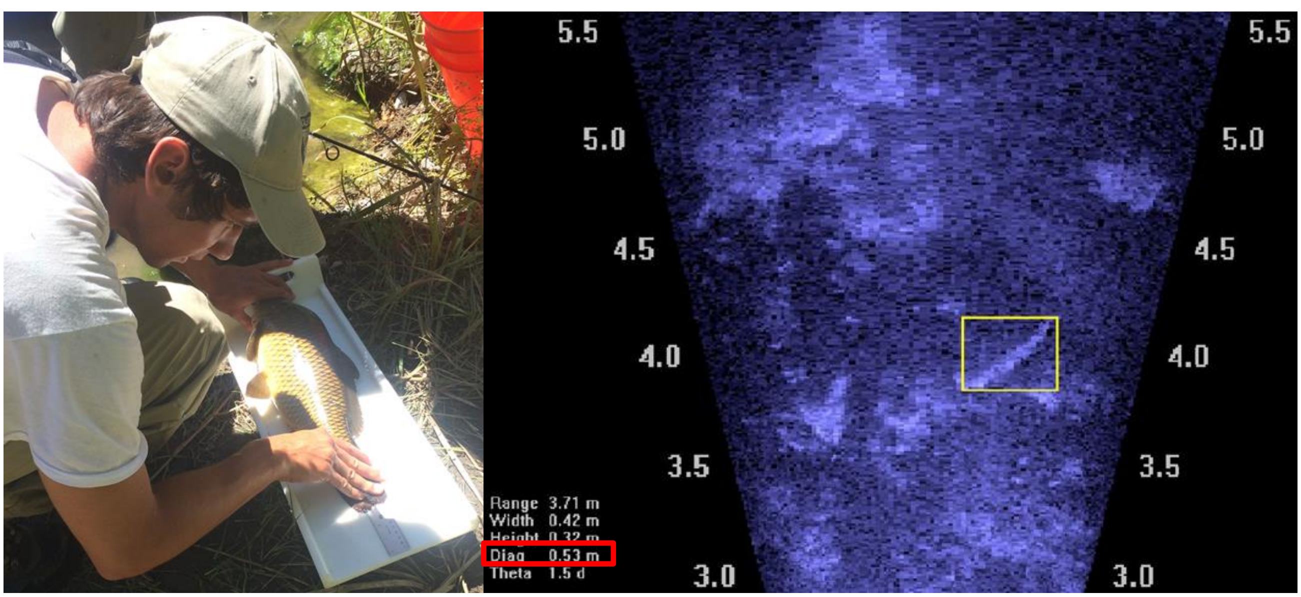

Figure 2. (Left) Carp being field measured to 52.7 cm TL. (Right) The same fish being measured using DIDSON software, resulting in a measurement of 53 cm TL.