Project Period	1/01/2018 - 12/31/2018
Project Location Description (from Proposal)	Manatee and Sarasota Counties, Florida
Project Summary (from Proposal)	Increase the effectiveness of bycatch mitigation activities using more inclusive data sets to rapidly and economically identify critical bycatch interactions with minimal disruption to industry in Florida. Project will result in reduced cetacean bycatch and expand the range of electronic monitoring platforms through a modular, portable piece of equipment to be used interchangeably among shore-based stations, small scale, and medium-sized vessels.

Project Status and Accomplishments

Small to medium-sized fishing vessels (50ft) are often unable to adopt traditional Electronic Monitoring Systems (EMS) as these technologies are costly to implement and maintain, while processing high volumes of video and sensor data can be overwhelmingly complex, which means that creating actionable outputs often remains time consuming and slow. For the purposes of this study, we chose a small-sized fishing vessel that uses a purse-seine net and hydraulic winch system to capture fishes and invertebrates in Sarasota Bay, FL and the Eastern Gulf of Mexico. A two-view FlyWire EMS was successfully installed, tested and validated on this ~28ft fishing vessel during 20 fishing sets in order to demonstrate that this system effectively collects video/GPS data streams, and that allows video reviewers to accurately document catch composition of large (i.e., average 485 fish/set) mixed-species hauls composed of small-sized target and bycatch species. Video review and preliminary analyses were completed chronologically for the first 16 fishing sets and found that 98.3% and 92.7% of all individuals caught were identified by species from the Fish Table and Deck Camera, respectively. Additionally, a video reviewer was able to obtain length measurements from individuals observed on the Fish Table Camera; these fishes ranged in length from 25mm to 480mm with an average of 93mm. The remaining four fishing sets will be used for training newly developed, open-source machine learning algorithms' in order to increase the efficiency of video review, beyond the scope of this report. The FlyWire EMS offers an economical, scalable, and robust system that is easily customized to fit the unique requirements of small to medium-sized vessels. This ability to customize the EMS, coupled with its economic viability, provides industry stakeholders with more flexibility in EM hardware choices and services, thus opening access to fisheries in which EM technology has traditionally proved too costly and logistically challenging to implement.

Continuous video at sites with frequent human-dolphin interactions of concern helps provide more comprehensive, reliable documentation that both reduces observer effects that could alter monitoring accuracy (i.e., people changing their actions due to observer presence) and allows for multiple human observers to later review and confirm events of particular interest which would not be possible with onsite observers only. We installed a two-view EMS at five shore-based locations across Sarasota, Manatee, and Pinellas Counties in Florida, USA. We monitored each of these five shore-based EM Stations to collect video data during four days at each location for a total of 20 days combined from June 19 to July 4, 2018. During video review, marks were made when: (1) a dolphin surfacing event (DSE) occurred, (2) a boat was present, (3) fishers were present, (4) any human-dolphin interactions occurred, and (5) any other marine mammals (e.g., manatees) were present. Due to the overlapping nature of the camera views, which provided an opportunity to view behaviors or activities from multiple angles, the same event may be recorded on multiple cameras at a single location. The preliminary output from this video review was then compiled into activity plots, which show the DSE's, number of interactions, maximum number of vessels, and maximum number of fishers, per hour throughout the observed day. These summary level activity plots offer an easy visualization of general activity throughout the observed day in order to more rapidly identify time periods of interest within the overall data set (i.e., a spike in interactions during a specific hour within a 12-hour continuous video recording). These summary data, including Excel plots of daily activity and review logs coded with types of interactions linked to video clips of the activities themselves are helpful for a rapid sense of overall patterns over time at a site and show promise for providing necessary documentation to direct management and enforcement mitigation efforts. However, the shore stations produce large amounts of data which is time consuming to analyze. Video review for the ~466.5 hours of data collected over 20 days of monitoring took ~402 hours to complete, and resulted in a total of 17,269 marks (i.e., 2,678

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

were human-dolphin interactions). As of now, the efficiency gains of video monitoring on the field side of observations may get lost to an overly time-consuming later review process. For this reason, we recommend development and use of ML tools that will more quickly review the large volumes of data collected by monitoring efforts such as those of this study.

Lessons Learned

Using a FlyWire Electronic Monitoring System (EMS) the project team successfully demonstrated that this system allows video reviewers to accurately identify up to 98.3% of the catch composition at the Fish Table of a large, mixed-species hauls composed of small-sized species. Additionally, these video reviewers were able to accurately measure 93.6% of all fishes that were clearly presented on the Fish Table measuring board. For individual fishes that could not be identified and measured by reviewers many of the problems encountered during the video review process centered around the catch handling protocols for sorting and discarding by the vessel crew. Changes in catch handling protocols were not made during data collection as video review was completed after the fishing effort was over, thus there was no opportunity to modify aspects of catch handling that facilitate faster and more accurate video review. For example, debris from the net, mainly seagrass, obscured the measuring tape at times which impacted the ability of the reviewer quickly and accurately measure a fish with the Fish Table Camera. Additionally, the heads, hands, arms, and hats of the vessel crew often blocked the fish as people sorted fish on the table to be measured, and some observers that did not pause long enough while measuring each fish in order to let the camera capture a clear view of the species and length measurement. In future trials, we recommend that catch handlers position the fish slightly below the measuring tape, which would allow both the observer and the video reviewer to easily measure the fleshy length of the fish on the Fish Table. For the Deck Camera, the main problem was that each fish was not presented in a consistent manner between catch handlers in which video reviewers could identify the species of each individual before it was discarded. If catch handling and discard protocols are reviewed early on and adjusted, then video review will be able to easily identify species and lengths of fish caught with the caveat being too much time spent on these procedures slows down the processing time which for fishers equates to more money.

The expertise from the Sarasota Dolphin Research Program (SDRP), comprised of over 40 years of dolphin surveys was highly beneficial in narrowing down the locations to be used for shore-based camera stations. A sample of locations were proposed to be monitored as known “hot-spots” where SDRP staff routinely documented interactions between dolphins and humans (i.e., fishers, recreational vessels). The five locations monitored in this study were chosen for: (1) their accessibility to the field team to install and maintain the EMS equipment, and (2) because they were known locations in which human and dolphin activities overlap. During recording, the cameras needed to be serviced and SD cards replaced every two days so access to them was critical. The subset of preferred locations that we used for this study offered a range of dolphin and human activities, and in the future if permissions are obtained from residential property owners, more locations could be monitored.

EM technologies, whether vessel-based or shore-based, offer an easy way to collect large volumes of high-quality unbiased video data compared the difficulties of using human observers. Despite the cost-effectiveness of data collection by deployed EM systems, drawbacks exist in that manual review and management of these data is often time consuming, labor intensive, and costly depending on the level of detail required. In order to better direct human effort, we propose to use machine learning (ML) tools in order to identify sections of the video where activity takes place (e.g., vessels, fishers, dolphins, other Endangered, Threatened, and Protected (ETP) species). Once trained, these ML tools could drastically reduce the review time by accurately identifying and then eliminating the hours of video in which no activities of interest occur. From a management perspective, this may be useful to narrow down a long (e.g., 12 hour plus) video recording into a smaller subsample that needs to be reviewed only where activity occurs. These data could also be used as a tool by fisheries managers to better direct limited resources, such as human observers or law enforcement efforts, towards times of the day when activity is typically higher for a particular location.

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

Activities and Outcomes

Funding Strategy: Planning, Research, Monitoring
Metric: FIF - Monitoring - # of trips monitored
Required: Optional
Description: Number of fishing trips monitored using EM/ER technology over the grant period. In the notes, please specify total number of trips taken.

Starting Value	0.00 # of trips monitored
Value To Date	40.00 # of trips monitored
Target value	40.00 # of trips monitored

Note:

Funding Strategy: Planning, Research, Monitoring
Metric: FIF - Monitoring - # vessels in monitoring program
Required: Optional
Description: Number of vessels directly engaged/participating in monitoring program(s)

Starting Value	0.00 # vessels in monitoring program
Value To Date	5.00 # vessels in monitoring program
Target value	5.00 # vessels in monitoring program

Note:

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

Final Programmatic Report Narrative

Instructions: *Save this document on your computer and complete the narrative in the format provided. The final narrative should not exceed ten (10) pages; do not delete the text provided below. Once complete, upload this document into the online final programmatic report task as instructed.* ***Please note*** *that this narrative will be made available on NFWF's Grants Library and therefore should provide brief context for the need of your project and should not contain unexplained terms or acronyms.*

1. ***Summary of Accomplishments:*** *In four to five sentences, provide a brief summary of the project's key accomplishments and outcomes that were observed or measured. This can be duplicative to the summary provided in the reporting 'field' or you can provide more detail here.*

The goal of the project was to assess whether a low-cost, portable electronic monitoring system (EMS) could accurately and repeatably generate: (1) fine-scale fisheries catch data from a small vessel with large, mixed species hauls of small sized fish, and (2) high-value cetacean-fisheries interaction data sets from shore-based monitoring stations in a coastal recreational fishery. We found that the fisheries dataset generated by the FlyWire EMS/Video Review (VR) process was comparable to the vessel-based paper log (PL) in terms of fish abundance, species richness, and mean fish size. This work suggests that the FlyWire EMS is an adaptable, cost-effective, and portable system for small vessels that is capable of generating fine-scale fisheries observer datasets in fisheries that have not thus far been able to be monitored electronically. The FlyWire EMS/VR process was also able to capture fine-scale bycatch interactions between humans and marine mammals in a coastal recreational fishery, such as dolphins depredating the pole and line gear of recreational anglers. This preliminary work suggests that the FlyWire EMS platform may be a valuable and accessible tool to conduct rapid assessments and long-term monitoring of such cetacean-human interaction "hot-spots," as well as to collect actionable data for law enforcement and resource management agencies.

2. Project Activities & Outcomes

A. Activities: *Describe the primary activities conducted during this grant and explain any discrepancies between the activities conducted from those that were proposed.*

Activity 1: Testing a vessel-based, two-view portable electronic monitoring system (EMS)

We tested the effectiveness of a two-view modular EMS on a small-sized vessel in order to determine if this system allows video reviewers to accurately document the catch composition of a large mixed-species haul composed of small-sized target and bycatch species. The Sarasota Dolphin Research Program's (SDRP) *R/V Flip* was chosen as a test vessel due to its small size (28ft) and long-tern use as a platform for standardized multispecies fish surveys using purse-seine techniques. A two-view EMS was installed to capture complete and detailed views of all fishing activities on vessel (See Image 1). The primary view (Deck Camera) was positioned on the Port side of the vessel in order to capture the activity on the deck while the net was deployed, and then hauled on vessel, as well as the catch sorting and discarding by the onboard observers (See Image 2). The secondary view (Fish Table Camera) was positioned over the fish sorting and measuring board in order to document fine-scale resolution of catch sorting activities, including species ID and length measurements (See Images 3 and 4). The net itself measured 183m x 6.6m with a 2.5cm diamond mesh. This fishing vessel and up to seven crew members conducted surveys primarily within Sarasota Bay, FL, USA from 7:30AM to 5:00PM EST during June and July 2018 in shallow estuarine waters. The vessel Captain, Deck Boss, Observer(s) (interns/volunteers), and FlyWire Technician(s), were present during and assisted with fishing activities. Fish were brought onboard, sorted, measured, counted and released/discarded by SDRP staff, interns, and volunteers (collectively referred to as onboard observers) within Sarasota Bay, FL. Onboard observers maintained a detailed Paper Log (PL) of all fishing activities conducted, which included species ID, fleshy length measurements of the first 100 of every species, fish counts, and set location data. These onboard observers varied in their levels of experience with fish identification - with SDRP staff members having 15+ years of experience identifying fishes within the Gulf of Mexico, while the interns and volunteers they managed on vessel were typically inexperienced.

WearWare, Inc. (2019) - Confidential

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

The goal of the project was to assess whether FlyWire EMS/VR process could accurately and repeatedly generate fine-scale catch composition data from large hauls of small-sized, multi-species catch. This included species level identification as well as length estimates for the first 100 individuals of each species per set (replicating existing SDRP sampling protocol). Video Review (VR) from both Deck and Fish Table Camera views was completed in chronological order for the first 16 of 20 fishing sets monitored by two independent observers who have between one and four years of expertise in identifying fishes from Sarasota Bay, FL. The last four sets will be analyzed to train and test a machine learning algorithm to be incorporated in future software upgrades. These videos were reviewed and analyzed using FlyWire Analysis Software. During VR of the Fish Table Camera, a mark was taken for each individual fish, elasmobranch, shrimp and squid that came across the fish table to be identified and measured. For each mark, the reviewer noted the species and length for each individual fish that observers placed on the fish board's measuring tapes. The fish table had two measuring tapes that allowed two onboard observers to measure fish simultaneously (See Images 3 and 4). The Fish Table Camera was oriented with one measuring tape at the top and the second at the bottom of the field-of-view so that the location of the fish (top or bottom), species and length (using 5mm increments) was recorded. The reviewer specifically commented when the view of a fish was obstructed, which limited their ability to obtain species ID and/or length measurements. After 100 individuals of a given species were measured, the remaining individuals of that species were counted and discarded without measurement. During VR of the Deck Camera, a mark was taken for each discard event with identification of species and count noted. SDRP catch handling procedures were also modified during the project to facilitate the review. Typically, all fish are released/discarded directly after being measured and counted however for this study, observers were instructed to present all fish to either the Fish Table Camera or the Deck Camera so that the video reviewer could identify the species and the count of each discard (See Images 2 and 4). The Deck and Fish Table Camera VR process for 16 fishing sets took 126.5 hours to complete and a total of 6,642 marks were made.

Activity 2: Testing a shore-based, portable, two-view electronic monitoring system (EMS)

In order to evaluate the applicability and effectiveness of a portable, multi-view EMS to generate high-value cetacean-fisheries interaction data sets, we installed a two-view EMS shore station at five locations across Sarasota, Manatee, and Pinellas Counties in FL, USA (See Images 5, 6, and 7). These five monitoring locations were chosen for their accessibility to the field team to install and maintain the EMS equipment, and they are known locations in which human and dolphin activities overlap with a variety of adverse human-dolphin interactions that occur. The project team experienced some difficulty attaining access to additional locations of interest due to the lack of availability or consent of property owners in those areas. Future monitoring of such locations may be possible if permissions are granted.

Each EM station was programmed to collect video data continuously each day from 7:30AM to 7:00PM EST. Camera views were setup to overlap with a combined 290-degree field of view which allowed us to better capture the presence of dolphins, fishers, vessels, and human-dolphin interactions within each area during these rapid assessments. Two EM stations were installed in Pinellas County at a public recreational fishing pier, which was a known "hot-spot" of interactions between recreational fishers and dolphins brought to the SDRP's attention by their colleagues at the NOAA Southeast Regional Office. Because of past outreach efforts at this location, the Pier Managers were highly interested in using a video monitoring system to target staff effort on the pier in order to more effectively and efficiently manage enforcement and education activities pertaining to adverse human-dolphin interactions in this Gulf of Mexico recreational fishery (e.g., depredation, illegal provisioning, gear entanglement/ingestion/hooking injuries). This recreational fishing pier is 1000+ ft in length, oriented East to West directly off the southern tip of a peninsula and is open to the public from 7:00AM to 11:00PM EST daily. Each EM station was positioned at opposite ends of the pier with one view that faced away from the pier towards the South in order to capture close-up activities, while the second view faced directly down the length of the pier in order to capture activity across the length of the pier. Cameras were installed on the South side of the pier due to the presence of an underwater reef that attracts fish, and therefore dolphins and fishers. Two EM stations were installed in Manatee County at a privately owned, gated condo association located on a piece of land that was open to both the Intracoastal Waterway (ICW) as well as an entrance to a boat basin for surrounding private residences, including recreational fishers. Recent human observer assessments by the SDRP indicated that dolphin activity was high along the seawall as individuals use the wall as a barrier to capture fish. The proximity of this location to boat rental

WearWare, Inc. (2019) - Confidential

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

facilities, tour group boats, and recreational vessel traffic lends itself to a high probability of human-dolphin interactions. One recording location captured a view of the boat basin and along the seawall of the canal. The second recording location captured the mouth of the private canal out to the ICW. One EM station was installed in Sarasota County just East of New Pass where vessel traffic is often high, including recreational fishers, as people navigate between Sarasota Bay, FL and the Gulf of Mexico. In addition, fishing activity often occurs from shore at the small public park located to the East. At this EM station, one view was focused to the North in order to capture activity moving to and from New Pass, while the second view was focused to the East in order to capture activity along the seawall towards the public park.

B. Outcomes: *Describe progress towards achieving the project outcomes as proposed and briefly explain any discrepancies between your results compared to what was anticipated. Provide any further information (such as unexpected outcomes) important for understanding project activities and outcome results.*

Outcome - Activity 1: Testing a vessel-based, two-view portable electronic monitoring system (EMS)

Twenty fishing sets were monitored during June and July 2018, in which a two-view EMS collected a total of 103.5 hours of video data. The EMS/VR and PL datasets were then compared to determine the accuracy and reliability of using this EMS/VR process for large volume, mixed-species hauls of small-sized individual fish. Over the survey period, species richness was calculated to be 53 distinct species in both EMS/VR and PL datasets (Table 1). Onboard observers recorded a total of 8,052 fish on the PL, resulting in an average of 503 fish caught per set (Table 2). The VR generated a total of 7,760 fish and an average of 485 fish per set, a difference of 292 fewer fish (3.69%), or 18 fewer fish per data set (3.64% per set) (Table 2). Fish abundance ranged from 94 to 1,199 and 94 to 1,183 fish per set in the PL and VR, respectively. Discards that occurred out of view of the Deck Camera, such as (1) when an individual fish jumped out of the net outside of the camera view, (2) when an individual fish escaped from the net while observers maneuvered the net onboard, or (3) when observers discarded fish with their backs to the camera, comprised the majority of the count discrepancies between methods. Menhaden, Mojarra, Puddingwife, and Shrimp were not identified at the species level by the SDRP observers or by the video reviewers (Table 2). Additionally, there were four groups of fish that could not be consistently identified to the species level during video review including: (1) the Emerald Parrotfish (*Nicholsina usta*) and Puddingwife (*Halichoeres radiatus*), (2) the Northern and Southern Puffer (*Sphoeroides maculatus* and *S. nephelus*), (3) the Gulf and Southern Flounder (*Paralichthys albigutta* and *P. lethostigma*), and (4) the Atlantic Thread Herring (*Opisthonema oglinum*) and Scaled Sardine (*Harengula jaguana*). Reflective glare and poor catch handling by onboard observers made it difficult to distinguish unique identifying characteristics of these similar species. If a fish could not be identified it was coded as unknown.

For our preliminary analysis, we measured the level of agreement between the SDRP onboard observers and our independent video reviewers in order to compare their accuracy and measured the distribution of agreement levels between the two observation methods in order to quantify their precision. We also present box plots as standardized way to visually display the distribution of key data elements, such as the number, mean length (mm), and standard deviation of length (mm) of individuals caught per set, per species and/or species group that were compared between both VR and PL observation methods (Figure 1). Since pinfish (*Lagodon rhomboides*) and pigfish (*Orthopristis chrysoptera*) accounted for the majority of the total catch, specifically 64.3% of all individuals caught, key data element distributions were compared between observation methods for pinfish for the purposes of this report (Figure 1). For pinfish, in order to visually compare the key data elements, by observation method across all 16 data sets, we present three groups of paired box plots (Figure 2). These paired box plots incorporate data from the Fish Table Camera only and include: (1) a left-hand column that represents data recorded on PL, and (2) a right-hand column that represents data recorded by VR for each of three key data elements (Figure 2). Additionally, these three key data elements compared across all 16 data sets include: (1) a left-hand pair of box plots that shows the distributions of fish counted on the fish table, (2) a middle-left pair of box plots that compare the distributions of average fish length (mm), (3) a middle-right pair of box plots that compare the distributions of standard deviation of the measured lengths of all fish (mm) per set, and (4) a right-hand box plot that shows the distribution of the percentage of fish that could be measured using the EMS/VR observation method per fishing set.

WearWare, Inc. (2019) - Confidential

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

As part of this preliminary analysis we also quantified the level of agreement between the onboard observers and the video reviewers, we first isolated each pair of observations, for each species/species group, for each set comprising a total of 928 paired sets. We then normalized the ratio of fish count and individual length measurement values between the PL and VR observation methods on a scale of -1 to 1 for each paired set. For example, a value of -1 or 1 occurred when the VR method documented or measured a number of a fish species in a given set, and the PL method counted zero fish of that species/species group in that set. A negative value represented a data pair in which the VR method observed more of a given species/species group or measured longer length values (mm). A positive value represented a data pair in which the PL recorded larger values. A value of zero represented a data pair with no disagreement between VR and PL methods. Values of -1 and 1 occurred most regularly due to a disagreement in species identification or when onboard observers handled fish out of view of the camera or blocked the camera view. In total across all 16 fishing data sets, we found that the PL and VR fell within +/- 10% of each other on: (1) the total number of individuals counted, per species, per set in 95.4% (885/928) of all paired samples, (2) the mean length (mm) of all individuals measured, per species, per set in 97.0% (900/928) of all paired samples, and (3) the standard deviation of measured lengths (mm) of all individuals measured, per species, per set in 92.5% (858/928) of all paired samples (Figure 3 and Table 3).

List of Species Caught					
1	Atlantic needlefish, *Strongylura marina*	21	Grass porgy, *Calamus arctifrons*	41	Sand perch, *Diplectrum formosum*
2	Atlantic spadefish, *Chaetodipterus faber*	22	Gulf flounder, *Paralichthys albigutta*	42	Scaled sardine, *Harengula jaguana*
3	Atlantic stingray, *Dasyatis sabina*	23	Gulf toadfish, *Opsanus beta*	43	Scrawled cowfish, *Lactophrys quadricornis*
4	Atlantic thread herring, *Opisthonema oglinum*	24	Hardhead catfish, *Arius felis*	44	Sheepshead, *Archosargus probatocephalus*
5	Barbfish, *Scorpaena brasiliensis*	25	Inshore lizardfish, *Synodus foetens*	45	Shrimp *spp.*
6	Bay anchovy, *Anchoa mitchilli*	26	Ladyfish, *Elops saurus*	46	Silver perch, *Bairdiella chrysoura*
7	Bay scallop, *Argopecten irradians*	27	Lane snapper, *Lutjanus synagris*	47	Southern flounder, *Paralichthys lethostigma*
8	Black drum, *Pogonias cromis*	28	Leatherjack, *Oligoplites saurus*	48	Southern puffer, *Sphoeroides nephelus*
9	Black sea bass, *Centropristis striata*	29	Lined sole, *Achirus lineatus*	49	Southern stingray, *Dasyatis americana*
10	Blackcheek tonguefish, *Symphurus plagiusa*	30	Lookdown, *Selene vomer*	50	Spanish mackerel, *Scomberomorus maculatus*
11	Bluefish, *Pomatomus saltatrix*	31	Mangrove (gray) snapper, *Lutjanus griseus*	51	Spot, *Leiostomus xanthurus*
12	Bluntnose stingray, *Dasyatis say*	32	Menhaden, *Brevoortia spp.*	52	Spottail pinfish, *Diplodus holbrooki*
13	Bonnethead shark, *Sphyrna tiburo*	33	Mojarra *spp.*	53	Spotted seatrout, *Cynoscion nebulosus*
14	Common snook, *Centropomus undecimalis*	34	Northern sennet, *Sphyraena borealis*	54	Striped (black) mullet, *Mugil cephalus*
15	Crevalle jack, *Caranx hippos*	35	Permit, *Trachinotus falcatus*	55	Striped burrfish, *Chilomycterus schoepfi*
16	Florida blenny, *Chasmodes saburrae*	36	Pigfish, *Orthopristis chrysoptera*	56	Striped mojarra, *Diapterus plumieri*
17	Florida pompano, *Trachinotus carolinus*	37	Pinfish, *Lagodon rhomboides*	57	Unknown
18	Fringed filefish, *Monocanthus ciliatus*	38	Planehead filefish, *Monocanthus hispidus*	58	White grunt, *Haemulidae plumieri*
19	Gafftopsail catfish, *Bagre marinus*	39	Puddingwife *spp.*		
20	Gag grouper, *Mycteroperca microlepis*	40	Red drum, *Sciaenops ocellatus*		

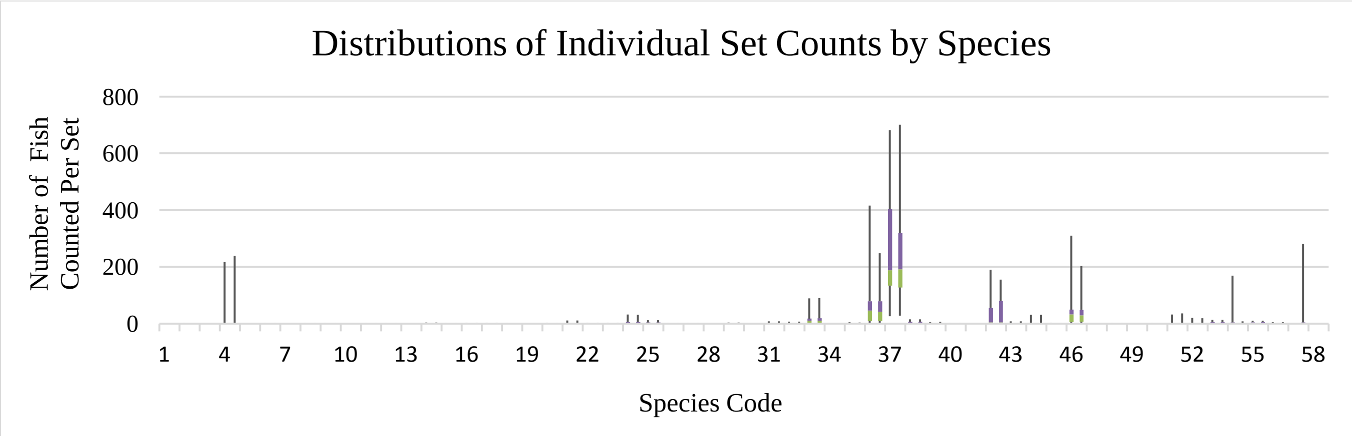
Table 1. Complete list of all species and species groupings identified by onboard observers and/or video reviewers during the 16 fishing data sets analyzed.

Month (2018)	**Number of Sets Video Reviewed**	**Video Review**	**Paper Log**
June	10	3,665	3,872
July	6	4,095	4,180
TOTAL	**16**	**7,760**	**8,052**

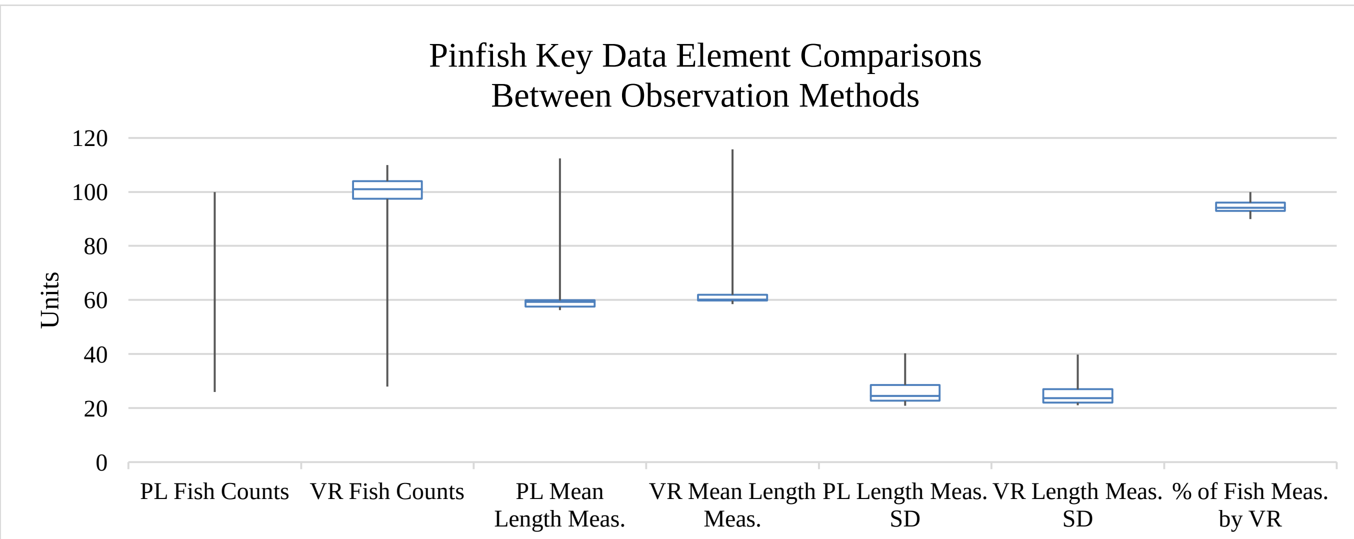
Table 2. Total fish counts as recorded by video review (VR) and paper log (PL) methods from 16 fishing data sets during June and July 2018, in Sarasota Bay, FL.

WearWare, Inc. (2019) - Confidential

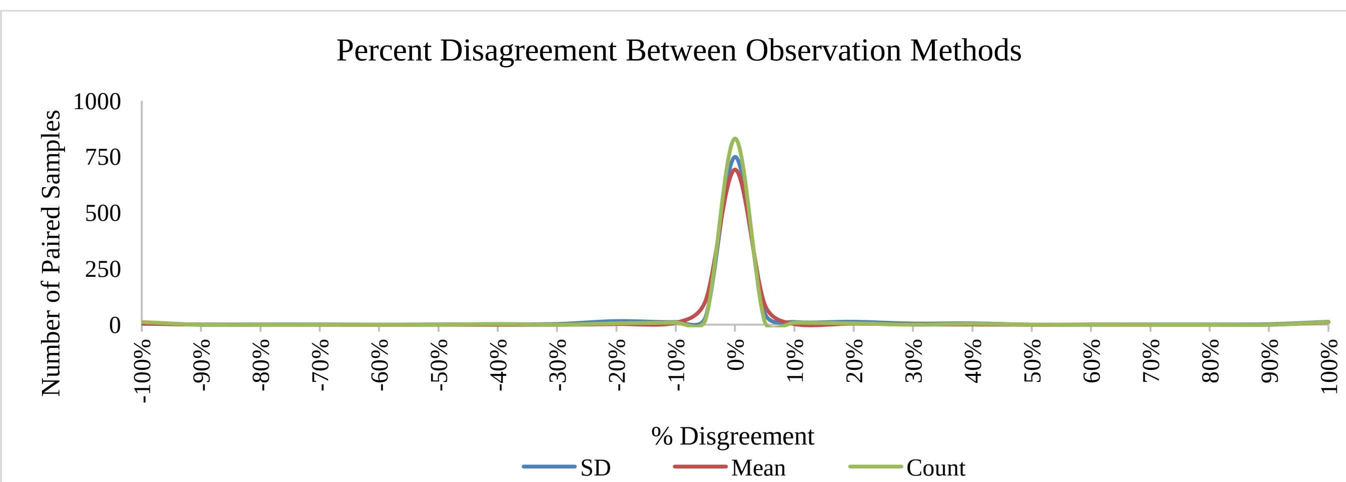
The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.



<u>Figure 1.</u> Paired box plot columns that compare fish counts collected from onboard observers on paper logs (PL) (left column) and EM reviewers during video review (VR) (right column) for the 16 fishing data sets reviewed and analyzed. Note: The x-axis represents the species code reflected in Table 1 above.



<u>Figure 2.</u> Preliminary analyses of onboard observer and video reviewer agreements visualized with box plot for pinfish (*Lagodon rhomboides*) in order to visually compare the following key data elements between paper logs and video reviewers: (1) number of fish counted per set (left pair), (2) mean length (mm) of all fish measured per set (middle pair), (3) standard deviation (mm) of all measured fish lengths per set (right pair), and (4) the percent of fish measured by video reviewer per set. Note: The percent of fish measured in paper logs was always 100%.



<u>Figure 3.</u> Agreement between observation methods as expressed by the number of paired sets of observations per percentage of disagreement between methods for fish count, mean length measurement (mm), and the standard deviation of all length measurements. A negative value represented a data pair in which the video reviewer observed more of a given species/species group or measured longer length values (mm). A positive value represented a data pair in which the onboard observer recorded larger values. A value of zero represented a data pair with no disagreement between VR and PL methods. A value of -1 or 1 occurred when one method (i.e., video reviewer or onboard observer) counted or measured a number of a fish species in a given set, and the other method counted zero fish of that species/species group in that set.

WearWare, Inc. (2019) - Confidential

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

Disagreement % (+/-)	Fish Counts		Mean Length		Standard Deviation of Length Measurements	
	# of Paired Sets	% of Paired Sets	# of Paired Sets	% of Paired Sets	# of Paired Sets	% of Paired Sets
0%	831	89.5%	692	74.6%	749	80.7%
5%	35	3.8%	196	21.1%	85	9.2%
10%	19	2.0%	12	1.3%	24	2.6%
20%	12	1.3%	8	0.9%	29	3.1%
30%	0	0.0%	1	0.1%	8	0.9%
40%	7	0.8%	1	0.1%	8	0.9%
50%	0	0.0%	0	0.0%	1	0.1%
60%	0	0.0%	1	0.1%	0	0.0%
70%	0	0.0%	0	0.0%	2	0.2%
80%	0	0.0%	0	0.0%	2	0.2%
90%	0	0.0%	0	0.0%	3	0.3%
100%	24	2.6%	17	1.8%	17	1.8%
Total	928	100.0%	928	100.0%	928	100.0%

Table 3. Complete listing of the number of paired sets and percentage of paired sets per percent disagreement.

Outcome - Activity 2: Testing a shore-based, portable, two-view electronic monitoring system (EMS)

We monitored EM Stations at five shore-based locations in order to collect video data during four days each for a total of 20 days combined in June and July 2018. At the public recreational fishing pier in Pinellas County, we monitored each EM Station at two locations for four, semi-continuous days from June 19 to July 4, 2018, in which approximately 97 and 93 hours of video data were collected for both camera views combined at each location. At the private residential property in Manatee County, we monitored each EM station at two locations for four, primarily non-continuous days from June 21 to June 27, 2018, in which approximately 90 and 92 hours of video data were collected for both camera views combined at each location. At the private dock in Sarasota County, we monitored an EM station at one location for four, non-continuous days from June 20 to June 28, 2018, of which approximately 94.5 hours of video data were collected from both camera views combined. These shore-station videos were reviewed by two independent human observers that were experienced in observing marine mammals, turtles, and fisheries. VR of the shore-based EM Station data was completed using FlyWire Analysis Software to mark when: (1) a dolphin surfaced, (2) a boat was present, (3) fishers were present, (4) any human-dolphin interactions occurred, and (5) any other marine mammals (e.g., manatees) were present. For the purposes of this study, we defined an interaction as any time a dolphin was observed within approximately 50ft of a vessel and/or human. Human-dolphin interactions ranged from dolphins simply surfacing near a vessel or fishers on the pier to dolphins intentionally approaching and then removing bait from recreational hook and line gear (see Image 8 and 9). For the purposes of this video review, we defined a Dolphin Surfacing Event (DSE) as any time a dolphin was visibly above water, which could include its dorsal fin, head, back, flukes, and/or pectoral fins.

We aimed to review these data in a manner consistent with that of what a machine learning (ML) algorithm would produce as this would be the primary means to decrease the cost and increase the efficiency of reviewing large volumes of shore-station data. We chose to review each EM station view individually rather than simultaneously during this preliminary analysis as ML typically processes video streams sequentially. Two independent video reviewers spent a total of approximately 402.5 hours to review approximately 466.5 hours of video data in which a total of 17,269 marks were made. A total of 2,678 human-dolphin interactions were identified by reviewers across all five EM stations for 20 days using both camera views. The overlapping camera views at shore-based monitoring stations allowed reviewers the opportunity to view observations from multiple angles which may be useful to characterize behaviors and/or activities as well as to help direct management resources at "hot-spot" locations to mitigate human-dolphin interactions. This overlapping view across cameras at the same location unfortunately creates multiple entries of the same event, for

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

example, the same dolphin surfacing may be counted in two camera views during VR. These duplicated entries may be misleading in quantifying the total number of interactions or surfacing events we are reporting, however closer inspection of these interactions was beyond the scope of this project. Although we could clearly identify both Interactions and DSEs both near and far away from the EM station, these images were not fine-scale enough for individual photo identification using traditional methods, therefore we had no way of knowing the total number of individual dolphins observed during this study. The shore-based stations also successfully documented other marine mammals, such as manatees, and their interactions with recreational fishers and vessels (See Image 8). Reviewers were also able to identify characteristics of recreational vessels as they passed by the shore-stations in order to collect information, such as vessel name, company logos, company name, and gear on the vessel, which could be helpful to management and law enforcement agencies.

Once each day of data was reviewed for each view of each station, the raw output from the FlyWire Analysis Software was organized into a series of Activity Plots that show the number of DSE's, number of interactions, maximum number of vessels, and maximum number of fishers, per hour throughout the observed day (Figure 4). This summary level plot offers an easy visualization of general activity throughout the observed day in order to more rapidly identify time periods of interest within the overall data set (i.e., a spike in interactions during a specific hour within a 12-hour continuous video recording). Once time periods of interest were identified on the activity plots, screen capture images produced by the FlyWire Analysis Software (See Image 9), were easily reviewed in order to identify specific interactions of concern (e.g., dolphins that intentionally take bait from anglers and/or anglers that actively fish when dolphins are present rather than removing their gear). With those images linked to the underlying video, a clip of the exact interaction of interest could be recalled in order to provide an objective account of the interaction in proper context.

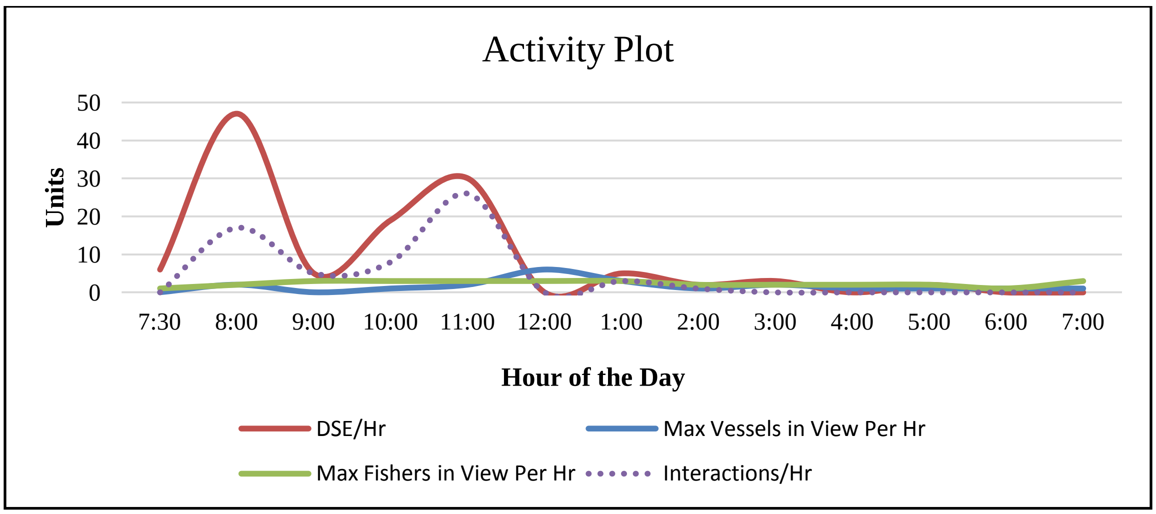


Figure 4. Public Recreational Fishing Pier Activity Plot Location #2, Camera View #2 on June 25, 2018 shows the: (1) number of dolphin surfacing events (DSE's), (2) number of human-dolphin interactions, (3) maximum number of vessels, (4) maximum number of anglers per hour of the day.

3. ***Lessons Learned:*** *Describe the key lessons learned from this project, such as the least and most effective conservation practices or notable aspects of the project's methods, monitoring, or results. How could other conservation organizations adapt similar strategies to build upon some of these key lessons about what worked best and what did not?*

The FlyWire EMS/VR process accurately identified up to 98.3% of the catch composition and accurately measured 93.6% of all fishes clearly presented at the Fish Table of a small vessel with large, mixed species hauls of small-sized fish. For individual fishes that could not be identified and measured by video reviewers many of the problems encountered centered around the catch handling protocols for sorting and discarding by the vessel crew. For example, debris from the net, mainly seagrass, obscured the measuring tape at times which impacted the ability of the reviewer quickly and accurately measure a fish with the Fish Table Camera. Additionally, the heads, hands, arms, and hats of the vessel crew often blocked the fish as people sorted fish on the table to be measured, and some observers that did not pause long enough while measuring each fish in order to let the camera capture a clear view of the species and length measurement. For the Deck Camera, the main problem was that each fish was not presented in a consistent manner between catch

WearWare, Inc. (2019) - Confidential
The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

handlers in which video reviewers could identify the species of each individual before it was discarded. Changes in catch handling protocols were not made during data collection as VR occurred after the fishing effort was completed, thus there was no opportunity to modify these protocols to facilitate faster and more accurate VR. In future trials, we recommend that catch handlers position the fish slightly below the measuring tape, which would allow both the observer and the video reviewer to easily measure the fleshy length of the fish on the Fish Table. If catch handling and discard protocols are reviewed early on and adjusted, then video review will be able to easily identify species and lengths of fish caught with the caveat being too much time spent on these procedures slows down the processing time which for fishers increases operating costs.

The expertise from the SDRP, comprised of over 40 years of dolphin research was highly beneficial in narrowing down the locations to be used for shore-based camera stations. A sample of locations were proposed to be monitored as known "hot-spots" where SDRP staff routinely documented interactions between dolphins and humans (i.e., fishers, recreational vessels). The five locations monitored in this study were chosen for: (1) their accessibility to the field team to install and maintain the EMS equipment, and (2) because they were known locations in which human and dolphin activities overlap. During recording, the cameras needed to be serviced and SD cards replaced every two days so access to them was essential. The subset of preferred locations used for this study offered a range of dolphin and human activities, and in the future if permissions are obtained from additional residential property owners and private pier owners, more locations could be easily monitored.

EM technologies, whether vessel-based or shore-based, offer an easy way to collect large volumes of high-quality unbiased video data when compared the difficulties of using human observers. Despite the cost-effectiveness of data collection by deployed EM systems, drawbacks exist in that manual review and management of these data is often time consuming, labor intensive, and costly depending on the level of detail required. In order to better direct human effort, we propose to use machine learning tools in order to identify sections of the video where activity takes place (e.g., vessels, fishers, dolphins, and other Endangered, Threatened, and Protected species). Once trained, these machine learning tools could drastically reduce the review time by accurately identifying and then eliminating the hours of video in which no activities of interest occur. From a management perspective, this may be useful to narrow down a long (e.g., 12 hour plus) video recording into a smaller subsample that needs to be reviewed only where activity occurs. These data could also be used as a tool by fisheries managers to better direct limited resources, such as human observers or law enforcement efforts, towards times of the day when activity is typically higher for a particular location.

4. *Dissemination:* *Briefly identify any dissemination of project results and/or lessons learned to external audiences, such as the public or other conservation organizations. Specifically outline any management uptake and/or actions resulting from the project and describe the direct impacts of any capacity building activities.*

These results have not been disseminated during this Project Timeline (January-December 2018), but the project team plans to present the findings from this study to stakeholders beyond the scope of this project's timeline in 2019.

5. *Project Documents:* *Include in your final programmatic report, via the Uploads section of this task, the following:*

- *2-10 representative photos from the project. Photos need to have a minimum resolution of 300 dpi. For each uploaded photo, provide a photo credit and brief description below;*
- *Report publications, Power Point (or other) presentations, GIS data, brochures, videos, outreach tools, press releases, media coverage;*
- *Any project deliverables per the terms of your grant agreement.*

We have included nine representative photos via the Uploads section. The following is a list of these nine images and their associated captions.

Image 1: FlyWire EMS installed on fishing vessel. The Deck Camera is in the background (small red circle) and the Fish Table Camera is in foreground (large yellow circle).
Image 2: Screen capture from the Deck Camera of the crew discarding pinfish (*Lagodon rhomboides*).

WearWare, Inc. (2019) - Confidential
The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.

Image 3: Screen capture from the Fish Table Camera of onboard observers measuring pinfish (*Lagodon rhomboides*) at both the top and bottom measuring tapes on the measuring board.
Image 4: Screen capture from the Fish Table Camera of the crew discarding pinfish (*Lagodon rhomboides*), and measuring a pigfish (*Orthopristis chrysoptera*) at the bottom measuring tape.
Image 5: Shore-based EM Station at a public recreational fishing pier in Pinellas County (red oval).
Image 6: Shore-based EM Station at a private dock in Sarasota County (red oval).
Image 7: Shore-based EM Station in Manatee County – Residential canal view (red circles).
Image 8: Screen capture of interactions between two manatees and anglers at the fishing pier in Pinellas County.
Image 9: Screen capture of interaction between dolphin and anglers at the fishing pier in Pinellas County.

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the National Fish and Wildlife Foundation.