Refining Rapid Recompression Techniques in Gulf of Mexico Red Snapper Using a Unique Acoustic Telemetry Approach

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REFINING RAPID RECOMPRESSION TECHNIQUES IN GULF OF MEXICO RED SNAPPER USING A UNIQUE ACOUSTIC TELEMETRY APPROACH

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II. ABSTRACT

The success of catch-and-release as a management strategy depends directly on fish experiencing high post-release survival. For some demersal deep-water species such as Red Snapper, this may be difficult to achieve as post-release survival may be severely compromised by pressure-related injuries caused by the rapid ascent to the surface associated with fishing activity. This project examined the use of rapid recompression strategies using fish descender devices to increase survival of discarded Red Snapper. Additionally, we partnered with a number of stakeholder groups that were able to provide fishery-dependent data on the feasibility for use of descender devices in the recreational fishery and its utility for reducing discard mortality. Red Snapper were captured from a series of depths and tagged with acoustic transmitters that provided evidence of survival or delayed mortality hours to days after the fish was released. Using these unique profiles, we were able to generate survival estimates along a depth gradient and assess the benefits of rapid recompression strategies. There was a strong influence of depth on survival: fish tagged at 30 meters experienced over 90% survival, while fish tagged at 80 m experienced less than 10% survival regardless of the method of release. Rapid recompression devices performed better than vented or nonvented surface released fish at shallower depths but did not perform any better than these other release methods at the deeper depths. This suggests that there are diminishing returns with using these devices at deeper depths, where catastrophic decompression likely will cause mortality in fish no matter how they are released. The majority of recreational anglers had a very positive perspective on the benefits associated with using descender devices to release regulatory discards experiencing barotrauma. Anglers believed more fish survive long-term when released with a descender device than when released after venting and exhibited a willingness to use descender devices to release fish afflicted with barotrauma. These results provide valuable evidence that recreational anglers are on board with descending fish to improve catch-and-release survival, and this stakeholder buy-in is critical if these devices are to be integrated into fishery management.

III. EXECUTIVE SUMMARY

In the Gulf of Mexico (GOM), recreational fisheries make up nearly two-thirds of total landings, the largest proportion for any region in the U.S. This figure conceivably may be much higher, because this estimate does not incorporate catch-and-release, which has become increasingly prevalent as a management tool and conservation strategy in recreational fisheries. The success of catch-and-release as a management strategy clearly depends directly on fish experiencing high post-release survival; thus, there is a critical need to assess and maximize post-release survival for fish captured by recreational anglers. One example of such a fishery that experiences high numbers of recreational discards is the Red Snapper fishery in the GOM, which has been undergoing a strict rebuilding plan over the last decade. Short recreational fishing seasons and strict bag limits have resulted in large numbers of discarded fish with a high risk of post-release mortality primarily due to barotrauma. Because of the depth preferences of these fish, individuals commonly experience reduced survival from a variety of factors including barotrauma-related injuries, release strategy, and environmental conditions. Finding effective release strategies that minimize injury, mortality, and sub-lethal effects, and maximize the chance of post-release survival is a key parameter in the rebuilding of the stock.

Two major techniques have been developed to reduce the damage resulting from decompression: rapidly recompressing a fish by returning it to depth (“rapid recompression”); and, puncturing the fish with a hollow needle (“venting”) to release the pressure resulting from overexpansion. Post-release mortality estimates remain far from conclusive due to the substantial variability in survival across depth, temperature, release method, fishing sector, and other factors. Venting practices for Red Snapper have received mixed results, while rapid recompression treatments using descender devices have shown promise for increasing post-release survival of barotrauma-afflicted fish, but require further refining and replication before being considered for implementation into the recreational fishery.

Integration of descender devices through management action also necessitates support from stakeholders (i.e., “buy-in”) in the management process. To determine the feasibility of implementing fish descender devices into the recreational fishery, we partnered with a number of stakeholder groups that were able to test descender devices during actual fishing practices. Despite increasing popularity among recreational anglers, no studies have examined angler perceptions or their willingness to use descender devices in specific fisheries. Filling this data gap is an absolute necessity if managing entities eventually wish to require anglers to recompress discarded fish experiencing potentially fatal barotrauma symptoms.

The primary goal of this study was to determine if rapid recompression using forced decent or venting could effectively reduce barotrauma and increase year-round survival of Red Snapper in the northwestern GOM. Using well-designed experimental studies and fishery-dependent surveys targeting recreational anglers, the specific objectives of this project were to: (1) determine the effectiveness of rapid recompression strategies using descending devices for increasing survival of discarded Red Snapper; (2) link barotrauma impairment to release condition to predict fate of discarded fish and how barotrauma severity influences mortality; and (3) assess the potential for integrating descending devices into the recreational fishery. Even though these devices show high promise in reducing mortality, the actual reduction in large-scale fishing mortality is dependent on their wide-scale use by fishermen. Thus, a key aspect of this research project involved input from the GOM recreational fishing industry to help develop the most effective and efficient practices to reduce discard mortality and maximize the use in the fishery.

Red snapper were externally tagged with ultrasonic coded acoustic transmitters containing built-in motion and pressure (i.e., depth) sensors to monitor post-release survival. Using these unique acoustic profiles, we could classify the fate of discarded fish as survivors or delayed mortality. These profiles then allowed us to compare rates of survival across a depth gradient and among various methods of release. There was a strong influence of depth on survival: fish tagged at 30 meters experienced over 90% survival, while fish tagged at 80 m experienced less than 10% survival regardless of the method of release. The proportional risk of death increased along each level of depth, with fish tagged at the deepest 80-m site showing the highest risk of mortality at 36 times the risk of fish tagged at the 30-m site. Rapid recompression strategies using fish descending devices performed better than vented or nonvented surface released fish at shallower depths but did not perform any better than these other release methods at the deeper depths. This suggests that there are diminishing returns with using these devices at deeper depths, where catastrophic decompression likely will cause mortality in fish no matter how they are released.

We developed a strong partnership with the organization FishSmart, a science-based program that promotes catch-and-release and mortality-reducing methods of fishing, to examine recreational angler perceptions regarding the use of descender devices to reduce discard mortality of offshore reef fish in the GOM. To determine how anglers perceive the utility and effectiveness of descender devices to reduce discard mortality in offshore reef fish, participating recreational anglers received a free SeaQualizer and were subsequently required to complete an online survey about their perceptions of the device and to what extent they might use them on an everyday fishing excursion. A total of 538 out of 1,062 (51% response rate) SeaQualizer recipients took the survey sent via email. The majority of recreational anglers had a very positive perspective on the benefits associated with using descender devices to release regulatory discards experiencing barotrauma. Anglers believed more fish survive long-term when released with a descender device than when released after venting and exhibited a willingness to use descender devices to release fish afflicted with barotrauma. Moreover, 70% of survey respondents changed their preference from venting to descending by the end of the study. Despite requiring more time and effort to deploy a descender device, recreational anglers perceived their benefit to outweigh the time saved by venting. These results provide valuable evidence that recreational anglers are on board with descending fish to improve catch-and-release survival. If managers wish to implement future regulations requiring the possession of descender devices on vessels fishing for reef fish in federal waters, this study contributes to the prerequisite knowledge required to successfully promulgate such a rule – that is, they are well-received by all sectors of the recreational fishery. These results provide valuable evidence that recreational anglers are willing to use fish descending devices to improve catch-and-release survival, and this stakeholder buy-in is critical if these devices are to be integrated into fishery management.

IV. PURPOSE

A. Description of the Problem

World fisheries have received much attention over the past several decades because of over-exploitation that has left many stocks overfished worldwide (Jackson et al. 2001, Pauly et al. 2002, Myers and Worm 2003, Worm et al. 2006). Historically, the majority of this attention has focused on large commercial fisheries and the impacts of stock depletion (Thrush and Dayton 2002). Recently, however, substantial increases in recreational fishing effort have driven an increase in the proportion of total harvest from the recreational sector for 71% of marine species in the U.S. (Sutinen and Johnston 2003, Ihde et al. 2011). Additionally, there are pronounced regional differences across the U.S. in the proportion of recreational to commercial landings. For example, in the Gulf of Mexico (GOM), recreational fisheries make up 64% of total landings, the largest proportion for any region (Coleman et al. 2004). This figure conceivably may be much higher, because this estimate does not incorporate catch-and-release, which has become increasingly prevalent as a management tool and conservation strategy in recreational fisheries (Cooke and Suski 2005). Thus, there is a need to assess and maximize post-release survival for fish captured by recreational anglers.

The success of catch-and-release as a management strategy depends directly on fish experiencing high post-release survival (Bartholomew and Bohnsack 2005, Cooke and Schramm 2007, Arlinghaus et al. 2007). For some demersal, deep-water species, this may be difficult to achieve as post-release survival may be severely compromised by pressure-related injuries caused by the rapid ascent to the surface associated with fishing activity (Rummer 2007). A prime example of this problem is presented by Red Snapper (Lutjanus campechanus) in the GOM, where short recreational fishing seasons and strict bag limits result in large numbers of discarded fish with a high risk of post-release mortality. Because of the depth preferences of these fish, individuals commonly experience reduced survival from a variety of factors including barotrauma-related injuries, release strategy, and environmental conditions (Curtis et al. 2015). Finding effective release strategies that minimize injury, mortality, and sub-lethal effects, and maximize the chance of post-release survival is critical to the rebuilding of the stock.

Red Snapper is considered the most economically important reef fish species in the Gulf of Mexico. The Red Snapper fishery has been heavily exploited for decades and was first classified as overfished in 1988 (Goodyear 1988, Hood et al. 2007). Recent estimates from the Southeast Data Assessment and Review (SEDAR) show that the stock is no longer overfished or undergoing overfishing, and is dramatically rebounding (SEDAR 2018). While this is good news, this increase in stock biomass has resulted in larger fish being captured and high catch-per-unit-effort, which ironically, has resulted in shorter recreational fishing seasons, as annual catch limits are more quickly attained. Though they have improved slightly, SEDAR (2013) estimates were high and showed more than a 2:1 ratio in discards to total landings. In addition, new smartphone electronic reporting (i.e., "iSnapper") indicates even during the season approximately 56% of Red Snapper are discarded (Stunz et al. 2016). Understanding that the fate of these regulatory discards is accurately documented is certainly essential for accurate estimates in the stock assessment process.

Discard mortality studies for Red Snapper in the GOM have been widespread and well-documented (see Campbell et al. 2014); yet, post-release mortality estimates remain far from conclusive, due to the substantial variability in survival across depth, temperature, release type, fishing sector, and other factors. Using a meta-analytic approach, Campbell et al. (2014) determined significant increases in mortality by depth, but acknowledged that fundamental biases in the various approaches for estimating discard mortality make estimating the other parameters much more complex. This includes assessing the potential benefits of rapid recompression strategies versus nonventing or venting practices that release fish at the surface. Venting practices for Red Snapper have received mixed results (Wilde 2009), while rapid recompression treatments using descender devices have shown promise for increasing post-release survival of barotrauma afflicted fish (Drumhiller et al. 2014, Curtis et al. 2015), but require further refining and replication to withstand robust statistical testing before being considered for implementation into the recreational fishery.

This project built upon our highly successful, previously funded BREP (funded in 2014) project to examine techniques to reduce discard mortality of GOM Red Snapper and provide definitive management advice for their use. Our use of acoustic telemetry has proven to be an extremely useful tool in providing estimates of total discard mortality by including delayed mortality estimates, and enables us to compare discard mortality rates between surface-released and descended fish. Our results from this ongoing research have shown that rapid recompression strategies using fish descending devices can indeed increase survival of discarded Red Snapper; however, their effectiveness may be limited to certain fishing depths, and results may vary based on season. This remains a key knowledge gap in our understanding of discard morality dynamics for GOM Red Snapper. For example, in this previous work, we found that fish released using a SeaQualizer fish descending device at 40 m had much greater survival than vented or non-vented fish released at the surface, but when the fishing depth was increased to 60 m, rapid recompression strategies did not perform any better than surface release treatments, presumably due to catastrophic decompression at this greater depth. We hypothesize that the benefits of rapid recompression are extremely depth-dependent, and there may be an unknown threshold depth negating the benefits of rapid recompression that would be very informative for management. Thus, the inclusion of additional depth treatments at 30, 50, and 80 m to complement our existing results performed at 40 and 60 m has allowed us to refine the variable benefits of rapid recompression along a depth gradient. This information will provide fishery managers with empirical decision making criteria (i.e., depth, season, etc.) where rapid recompression strategies using descending devices can be successful for enhancing survival of discarded Red Snapper.

To determine the feasibility of implementing fish descender devices such as the SeaQualizer into the recreational fishery, we partnered with a number of stakeholder groups that were able to test descender devices *in situ*. Despite increasing popularity among recreational anglers, no studies have examined angler perceptions or their willingness to use descender devices in specific fisheries. Filling this data gap is an absolute necessity if managing entities eventually wish to require anglers to recompress discarded fish experiencing potentially fatal barotrauma symptoms. Dick (2017) interviewed fishery specialists, scientists, and managers to determine various challenges involved with the devices and to what extent mandating their use in the South Atlantic Red Snapper fishery would be possible. Study participants raised concerns with mandated use due to a lack of scientific research, limited survey data, and the issue with the multispecies complex in the South Atlantic reef fish fishery. Most participants also discussed the importance of angler involvement in the regulatory process and that trust between managers and stakeholders in the fishery would be vital for moving forward. Although Dick (2017) identified many of the issues presented by scientists and managers, the opinions and attitudes of offshore reef fish anglers from the GOM and South Atlantic have yet to be addressed.

A key metric to understanding the utility of descending devices is angler perception. Distributing surveys to users and stakeholders has shed light on previous issues in fisheries management (Scyphers et al. 2013), and understanding angler attitudes towards a tool that may serve as a key ingredient in solving the discard mortality issue is essential. A key fishery to test the perception of these devices is the GOM Red Snapper. Red Snapper anglers in the South Atlantic and GOM have been faced with increasingly shorter summer seasons despite the fisheries having improved dramatically in recent years. Substantial reductions in access and loss of major economic drivers could be curbed if these devices were used in the fishery. Thus, surveying angler opinions and attitudes concerning future regulations can aid in stakeholders regaining confidence in the entities built to provide users the opportunity to target offshore reef fish recreationally. Thus, the third goal of this project was to assess the perceptions and opinions of recreational anglers from North Carolina to Texas surrounding the use of descender devices in the offshore reef fish fishery using survey data and scientist observer trips.

B. Objectives of the Project

The specific objectives of this study were to:

1. Determine the effectiveness of rapid recompression strategies using descending devices for increasing survival of discarded Red Snapper.

2. Link barotrauma impairment to release condition to predict fate of discarded fish and how barotrauma severity influences mortality.

3. Assess the potential for integrating descending devices into the recreational fishery.

V. APPROACH

A. Description of the Work Performed

Objective 1: Determine the effectiveness of rapid recompression strategies using descending devices for increasing survival of discarded Red Snapper.

Previous Laboratory Studies

Our previous BREP experiment included a laboratory component where we measured tag retention and determined the most effective acoustic transmitter settings for answering our field objectives. Our test determined that the vendor Lotek Wireless provided the best tag technologies for the goals of this project. Acoustic transmitters provided by Lotek do not incur tag collisions, which allowed for greater numbers of fish to be tagged in a small area without signal interference. Furthermore, rapid transmission rates associated with Lotek tags provided more usable data during the initial post-tagging period. These two characteristics provided by Lotek tag technologies were much better suited towards answering our objectives regarding post-release mortality. These initial trials tested the new tag sensor technologies, determined the necessary tag size for an appropriate fish to tag weight ratio, and modified our external tagging protocol accordingly. Fish responded favorably to the tagging process and attachment of transmitters, exhibiting normal feeding behavior and movement post-tagging (**Figure 1).** We experienced 100% tag retention for the duration of the trials, which was 30 days in duration, which was more than adequate to cover the estimated 17-day battery life for the transmitters. We also tested different acoustic tag parameters to determine which settings would be the most effective for answering our field objectives. These in-lab trials became the basis for the design of the acoustic transmitters used for both the previous and most recent BREP field trials. These acoustic transmitter models and sensor settings remained unchanged between the two BREP funded projects.

Figure 1. Hatchery tank where preliminary tagging trials occurred to determine tag retention of the transmitter attachment methods. A subset of Red Snapper were tagged with a variety of transmitters of varying size and specifications. Acoustic receivers (seen towards back of tank) recorded acoustic detections from the tagged fish and transmitters fixed to stationary poles. There was no tag shedding for the entire month-long duration of these in-lab tagging trials, and battery life of transmitters expired after 17 days.

Study Sites and Acoustic Array Design

Field trials occurred in the northwestern GOM off the mid-Texas coastline with field sites ranging from approximately 20 to 50 nautical miles from Port Aransas, Texas. This area contains predominantly soft, mud benthic habitat with small areas of isolated natural hard-bottom substrate. The major source of hard structure is provided by artificial reef habitats comprised of standing and reefed oil and natural gas platforms. Our field trials occurred at various reef habitats that we are currently monitoring with Texas Parks and Wildlife’s Artificial Reef Monitoring Project. Previous BREP studies were successfully conducted at similar nearby artificial reefs at 40 m and 60 m depths (**Figure 2**; circled in black). Our current study design complemented these sites with three additional sites for the current study at 30, 50, and 80 m depths (**Figure 2**; circled in blue). Previous sampling efforts at each of these three sites had successfully captured Red Snapper using both vertical longline and single hook-and-line sampling methods, and are scuba dive accessible; thus, these sites will be ideal for our proposed acoustic tagging operations for this project.

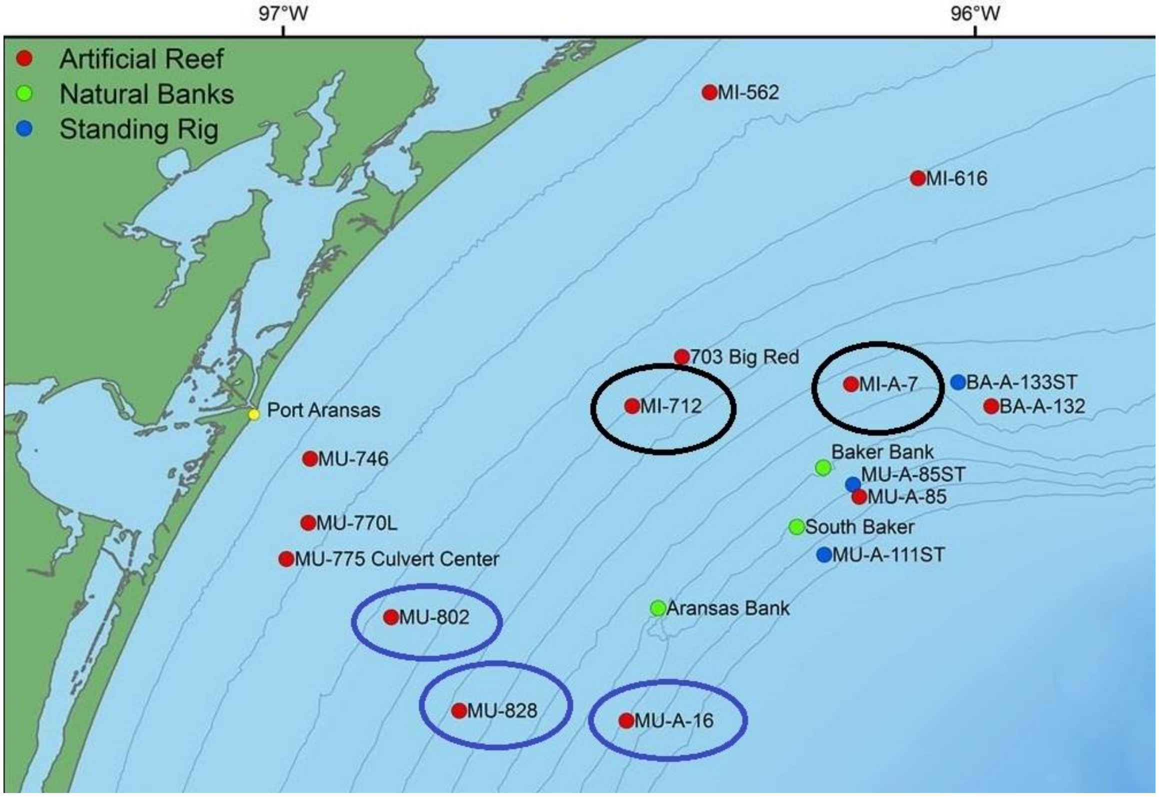

Figure 2. Map of the study sites in the Gulf of Mexico off the South Texas coast used for tagging trials for this project. Black circled sites were completed as part of the BREP2014 funded project. Site MI-712-A resided at 40 m and MI-A-7 at 60 m water depth. Blue circled sites were the additional sites completed for the BREP2016 funding cycle. Site MU-802 resided at 30 m, site MU-828 at 50 m, and site MU-A-16 at 80 m water depth.

Three Lotek acoustic receivers (model WHS3250) were placed on each of these three structures by scuba divers prior to the date of fish tagging. Once tagging was complete and acoustic tags had expired after approximately 17 days, these receivers were then retrieved by scuba divers. Acoustic studies, particularly in the offshore environment, can have very difficult logistical challenges, but the reward is high for the type of data collected. We have refined our acoustic array and tagging designs based on previous federally funded project results to provide the most optimal configurations using the best available technologies to answer our objectives. To minimize impacts of a thermocline on detection patterns (Westmeyer et al. 2007) we strategically placed our receivers as close to the bottom as possible within our scuba limitations. In addition, we moored stationary “sentinel" control tags (one per site) within our array to continuously document receiver performance (i.e., detection ability) during the monitoring period (Payne et al. 2010), and account for environmental variability in detection efficiency.

Acoustic Tagging

Red snapper were caught at the three study sites with single hook-and-line sampling gear using 5/0 circle hooks baited with squid (*Loligo sp.*) or rough scad (*Trachurus lathami*). Data recorded during fishing operations included hooking time, landing time, and release time allowing us to calculate overall fight time and handling time for each fish. Once landed, fish were measured for total length (mm) and assessed (presence/absence) for six externally visible barotrauma symptoms: everted stomachs, swollen and hard abdomen, exopthalmia (eyes forced from orbits), intestines protruding from the anus, formation of subcutaneous gas bubbles, and bleeding from the gills (Diamond and Campbell 2009). A barotrauma impairment score (scale: 0-1) was calculated by the sum of visible symptoms divided by the total number of possible symptoms (six). Fish that appeared moribund from severe barotrauma, foul, or deep hooking were not tagged.

Red snapper were externally tagged with Lotek dual-mode MR-series ultrasonic coded transmitters (Lotek Wireless, Inc., series MM-MR-11-45-PM, 46x9 mm, 76 kHz, ping interval: 3s, estimated battery life: 17 days) containing built-in motion and pressure (i.e. depth) sensors. Tag specifications (e.g. tag size, motion sensitivity, ping interval, etc.) were chosen based on preliminary laboratory studies conducted prior to field tagging. These tags are capable of rapid transmission rates (3/sec), but most importantly, do not incur tag collision issues, and can be programmed with pressure and motion sensors to monitor depth and activity of fish upon release. Depth is calculated by an algorithm that converts pressure sensors to a depth value (max depth <100 m). Since one goal of our study was to explore survival under a variety of release treatments, fish were rapidly (<3 min) tagged externally without anesthesia to best replicate recreational fishing practices and minimize artifacts associated with tagging related surgeries (i.e. venting and use of only survivors; IACUC protocol #13-14). To prevent unavoidable venting associated with traditional incision and suture internal tag implantation, we developed, and validated through in-lab trials, a protocol to attach tags to fish externally, and have successfully used this protocol in previous studies (Curtis et al. 2015; Johnson et al. 2015), including the previous BREP project. Lab trials showed that tag presence did not impair fish behavior and that tag retention using our external attachment method was 100% for the month-long study duration. Tags were positioned below the anterior (3rd-6th) dorsal spines approximately 2-3 cm below the dorsal edge. Fish were punctured between pterygiophores below the anterior dorsal spines using a sterile stainless steel hollow surgical needle. Tags were positioned below the anterior dorsal spines and attached with a plastic “cinch-up” external Floy® tag that is attached to the acoustic transmitter and passed between the 4th and 5th pterygiophores and secured. During the tagging procedure, fish were held in a tagging cradle with gills submerged in oxygenated water (

Figure 3**).**

Figure 3. Red Snapper positioned in tagging/measuring cradle with Lotek ultrasonic acoustic transmitter (MM-MR-11-45-PM) using external tagging procedures

Release treatments

Prior to tagging, fish were randomly assigned to one of three release treatments: (1) nonvented surface release (control), (2) vented surface release, and (3) descended release. Vented surface released fish were punctured in the abdomen posterior to the pectoral fin using a venting tool (Team Marine USA pre-vent fish venting tool – industry partner in the study) to allow escape of excess gas built up in the swim bladder. Once all residual gas had been vented, these fish were tagged and released at the surface. Nonvented surface release fish were not vented prior to tagging and then released at the surface, and acted as a control for venting and descending treatments. To descend fish, we used the SeaQualizer^{TM} (our other industry partner), a new forced descent tool that combines the utility of a low-impact (i.e., no penetrating hook necessary) “fish-grip” design with pressure-sensitive gauges that can disengage the grips at a pre-determined depth setting (~ 15, 30 or 50 m; Figure 4). After a fish is captured, it is transferred to a separately dedicated rod and reel bearing a SeaQualizer device attached to a bottom weight. The SeaQualizer device is attached to the lower jaw of the fish and at the desired depth, a spring automatically opens the grips and releases the fish. This setup is one of several rapid recompression tools, which all attempt to return the fish to depth quickly to counteract the effects of barotrauma through rapid recompression of the swim bladder and without venting. The deepest setting allowable based on the site depth was used to release fish using the SeaQualizer. We attached GoPro HD cameras in-line with the SeaQualizer release devices to document the recompression process and the fate of the fish upon release from the device. Videos were saved to the internal SD card and then downloaded back at the lab. Video was reviewed and the release condition of each fish was documented, as well as any depredation events that occurred upon release by surrounding predators.

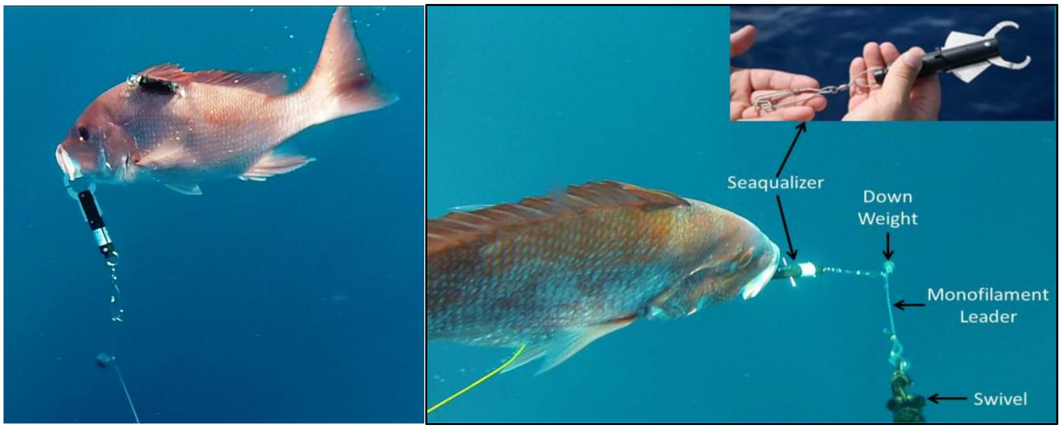

Figure 4. Pictures of acoustically tagged Red Snapper being descended to depth on a weighted line using the SeaQualizer fish descender device. Insert on the right panel is a close-up of the SeaQualizer in its ‘open’ configuration.

Experimental design

Three tagging trials at three distinct depths occurred over the summer season for the second BREP trials: 30-m, 50-m, and 80-m site depths. These depths were selected to complement the previous BREP project that included site depths of 40 m and 60 m; thus, filling out the range of depths necessary for examining depth induced mortality along a continuous gradient. Unlike the previous BREP experiment, in which we tested the seasonal effects by including a winter season, we only included the summer season for this project, when mortality was determined to be greatest. Thirty-one fish at each of the three sites were acoustically tagged and released using one of the three experimental treatments: nonvented, vented, and descended, with ten replicates being performed for the vented and nonvented release treatments, and eleven for the descended release treatment (Figure 5).

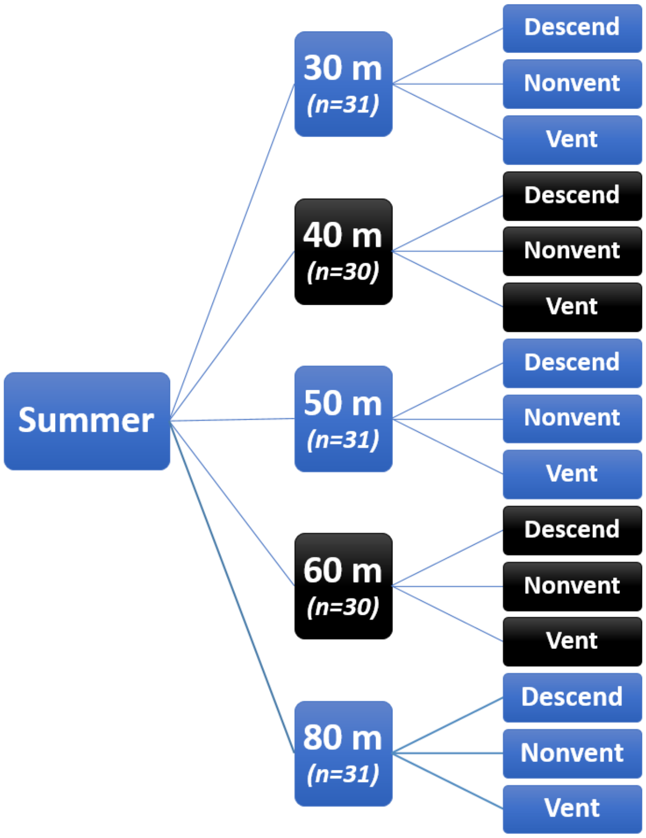

Figure 5. Experimental design of field tagging trials over both BREP2014 and BREP2016 field experiments. Thirty fish were tagged during the summer season at the 40-m and 60-m sites during BREP2014. Thirty-one fish were tagged at the 30-m, 50-m, and 80-m sites during BREP2016. Ten fish were replicated at each treatment level: vented, descended, and control (nonvented) within each depth, with one additional descended fish at each site for BREP2016.

Fate classification

Acoustic receivers were retrieved from study sites approximately one month after acoustic tags expired and data were uploaded to Lotek WHS Host software and then exported into the statistical program R for analysis (R Development Core Team 2016). Motion and depth profiles for each fish plotting these values over time were generated using tag sensor data. Using these unique acoustic profiles, the fate of each individual was classified into one of two categories: survival or delayed mortality. Fish classified as survivors exhibited continuous detections after release, with frequent changes in vertical depth movements in the water column. Delayed mortality events were classified by initially active motion and depth movements followed by a sudden drop-off to depth equal to the seafloor bottom. In our previous BREP trials, we had a third category: emigration, whereby fish did not remain in the acoustic array for sufficient duration of time to be informative with high confidence for fate classification, and were subsequently removed from the dataset for calculating survival estimates. However, based on the review of acoustic profiles from the previous experiments, coupled with the video analysis of release condition and underwater fate, we had additional information to make the fate classification binary: survival or mortality. In essence, fish that did not show patterns indicative of survival were considered mortality events.

Statistical analysis

Percent survival was calculated using the binomial distribution for two outcomes: survival and mortality. Survival estimates ($\hat{S}$) were calculated following equations in (Pollock and Pine 2007):

$$\hat{S} = \frac{x}{n}$$

with a standard error of:

$$SE(\hat{S}) = \sqrt{\frac{\hat{S}(1-\hat{S})}{n}}$$

where x is the number of survivors, and n is the total number of tagged fish minus the fish classified as emigrants for each treatment level.

The probability of survival post catch-and-release was calculated using the product limit estimate (Kaplan and Meier 1958) built into the ‘survival’ package in R (Therneau and Grambsch 2000). At each time interval (day), survival probability is calculated by dividing the number of survivors (x_i) by the number of individuals at risk (n_i). The Kaplan-Meier estimate of total survival probability ($\widehat{K}$) is calculated by multiplying all probabilities of survival at all time intervals preceding the time interval of interest:

$$\widehat{K}(i) = \prod_{i=1}^{j}(1 - x_i/n_i)$$

To determine the most influential variables in predicting survival and the relationship among experimental treatments, a multiple logistic regression generalized linear model (GLM) was performed using the following variables as predictors of survival: release treatment, capture depth, barotrauma impairment scores, fish total length, fight time, and handling time on deck. The full model containing all components was compared with the null model, and the most parsimonious model was selected using a combination of stepwise regression (Venebles and Ripley 2002), and the dredge and relative variable importance (RVI) function from the ‘MuMin’ package in R (Barton 2016). Variables determined to be influential based on results of the logistic regression were included in downstream analysis.

The Cox proportional hazards model (Cox 1972), also built into the ‘survival’ package in R (Therneau and Grambsch 2000), was used to examine the relationship between survival and multiple explanatory variables. This model has been used extensively in public health studies but has only recently been applied to survival analysis in fisheries (Sauls 2014; Curtis et al. 2015). The Cox model is a semi-parametric regression method for survival data. It provides an estimate of the treatment effect on survival after adjustment for other covariates in the model and gives an estimation of the hazard ratio (in this case the proportional risk of death) among levels within each of these explanatory variables. For survival analysis, this method is advantageous over logistic regression models because it can account for survival times and censored data, whereas regression models do not. Additionally, hazard ratios between covariates may be estimated without needing to specify the underlying baseline hazard, which may not be known. The Cox proportional hazards model is given by:

$$h(t) = h_0(t)\exp(\textstyle\sum_{i=1}^{p} \beta_i X_i)$$

where $h_0(t)$ is an unspecified function representing the baseline hazard, β_i are regression coefficients, and X_i are the explanatory variables or covariates in the model.

Objective 2: Link barotrauma impairment to release condition to predict fate of discarded fish and how barotrauma severity influences mortality.

Barotrauma assessment

Taking advantage of a long-term dataset from our Artificial Reef Monitoring Project, we were able to obtain barotrauma impairment scores for a large sample size across a wide depth gradient to complement the scores obtained during acoustic tagging experiments. This enabled us to construct an index of barotrauma impairment across multiple depths. We used standardized vertical longline (VLL) gear (a.k.a. handline, or bandit gear) to rapidly target and collect red snapper to assess the extent of barotrauma impairment related to depth and temperature. Vertical longline sampling allows for direct quantification of fish (via catch) and is a method already extensively used by many GOM SEAMAP partners to develop long standing time series of catch data. Additionally, vertical longline represents the most common harvest gear in the commercial fishery for Red Snapper, so impairment scenarios encountered by our VLL sampling would be reflective of barotrauma impairment experienced in the fishery. Our VLL sampling design follows the SEAMAP protocol and uses multiple hook sizes to capture various size classes of reef fish, with Red Snapper being the most commonly caught species (>90% of catch). We have been conducting VLL surveys since 2013 as part of a concurrent fishery-independent sampling and monitoring program funded by the Texas Parks & Wildlife Department, and have been collecting barotrauma impairment data along with these sampling events that we will use to assess depth related effects on barotrauma impairment and discard mortality. Similar to the acoustic tagging procedures, captured fish were assessed (presence/absence) for the six externally visible barotrauma symptoms: everted stomachs, swollen and hard abdomen, exopthalmia (eyes forced from orbits), intestines protruding from the anus, formation of subcutaneous gas bubbles, and bleeding from the gills. A barotrauma impairment score (scale: 0-1) was then calculated by the sum of visible symptoms divided by the total number of possible symptoms (six).

Objective 3: Assess the potential for integrating descending devices into the recreational fishery.

Engagement with the recreational fishing community

To examine recreational angler perceptions regarding the use of descender devices to reduce discard mortality of offshore reef fish in the South Atlantic and GOM, partnerships and collaborations were formed with various sportfishing entities to distribute descender devices to recreational anglers. During this project we developed a strong partnership with the organization FishSmart, a science-based program that promotes catch-and-release and mortality-reducing methods of fishing. This organization donated over one-thousand SeaQualizers for distribution to recreational anglers with the assumption that each recipient would complete a survey addressing their opinions of the devices. The target population consisted of offshore recreational anglers of the GOM and South Atlantic that targeted reef fish. The sampling frame was identified by targeting SeaQualizer recipients at fishing tournaments, dockside creel stations, and online at www.takemefishing.org. All three subsectors of the federal recreational fishing sector (private anglers, charter captains/owners/operators, and headboat captains/owners/operators) were targeted for SeaQualizer distribution. In addition to the free SeaQualizer, participating anglers received a best-use practices pamphlet discussing proper fish handling, mortality-reducing release procedures, and instructions on how to operate the SeaQualizer. Graduate student Alex Tompkins was weighmaster and scorekeeper for the Corpus Christi Big Game Fishing Club (CCBGFC), a private offshore fishing club that hosts summer fishing tournaments in Port Aransas, TX. These CCBGFC banquets, tournaments, and get-togethers were attended and used as an essential outlet to distribute SeaQualizers to Texas offshore recreational anglers. Additional devices were distributed at meetings held by the Port Aransas Boatmen's Association, an entity comprised of both private anglers and offshore charter captains. Various fishing club banquets and dinners were also attended to distribute and promote descender devices and disseminate best-use practices for catch-and-release fishing of offshore reef fish. Similar to focus groups, SeaQualizer distributors conversed with recipients to determine what potential survey questions would provide researchers with optimum data regarding descender device perceptions.

To determine how anglers perceive the utility and effectiveness of descender devices to reduce discard mortality in offshore reef fish, participating recreational anglers that received a free SeaQualizer were required to complete an online survey about their perceptions of the device and to what extent they might use them on an everyday fishing excursion. Participants were informed they would be sent the survey via email between December 2016 and February 2017. Survey development was a collaborative effort between the Florida Fish and Wildlife Conservation Commission (FWC), FishSmart, and the Harte Research Institute (HRI). Participants were required to classify themselves as belonging to one of the three subsectors of the federal recreational fishing sector: a private recreational angler; charter boat captain, owner, or operator; or a headboat captain, owner, or operator. Participants were questioned about their previous knowledge concerning descender devices and what barotrauma symptoms and signs they use to determine when a discard needs to be vented or descended instead of simply released at the surface. Participants were asked how often they used their free SeaQualizer and how many Red Snapper and other reef fish species they released since acquiring the device. Estimates of the number of fish released by anglers using a descender device during this study were calculated by extrapolating survey responses. Key questions addressed the participant perceptions regarding the success of the SeaQualizers. These questions asked anglers what percent of fish they believe survive long-term after being released with a descender device and to what extent they will use the device on their vessel in the future. Participants were also asked how successful they believe descender devices would be in reducing discard mortality in the Red Snapper fishery.

Due to the variety of data collected from diverse answer categories, statistical analyses were performed on a question by question basis. A major question in this study was defining differences in perceptions and attitudes about descender devices based on what recreational subsector respondents identified. Therefore, analyses assessing significant differences among subsectors were performed. Due to the low amount of respondents in the headboat category (6 respondents) statistical analyses were only performed between private anglers and charter captains, owners, and operators. Ordinal logistic regression (OLR) was performed when answer categories were on an ordinal scale, chi-squared test of independence was performed when answers were nominal, and Kruskal-Wallis test was performed when respondents chose a percentage of 0 to 100% using a slide bar. All tests were performed using the statistical package R (R Core Team 2017). A full copy of the survey is attached to this document as an appendix.

B. Project Management

Gregory W. Stunz, Ph.D., Endowed Chair - Fisheries and Ocean Health, Director at Center for Sportfish Science and Conservation, and Professor of Marine Biology, was Principal Investigator of the project. Dr. Stunz was in charge of overall project oversight, dissemination of findings, and coordination between TAMU-CC and cooperative partners on this project. He co-authored all progress reports and the final report.

Judson M. Curtis, Ph.D., Assistant Research Scientist at Center for Sportfish Science and Conservation was the project's lead scientist, and was in charge of executing day-to-day operations for all field tagging experiments, training students, analysis of results, and dissemination of findings including submitting manuscripts to peer-reviewed scientific journals. He co-authored all progress reports and the final report.

Alex Tompkins, M.S., was responsible for assisting with field tagging experiments. He also was instrumental in the partnerships with the fishing community by engaging recreational anglers, gathering feedback on the use of descender devices by recreational anglers, and development of the angler survey and analysis of survey results.

Monitoring of Project Performance:

Greg Stunz, Ph.D. monitored the project performance throughout the award period and submitted semi-annual progress reports to the NMFS program officer Derek Orner as required. Performance and financial administration was also conducted by the Office of Sponsored Research Administration at Texas A&M University-Corpus Christi.

VI. FINDINGS

A. Actual Accomplishments and Findings

Objective 1: Determine the effectiveness of rapid recompression strategies using descending devices for increasing survival of discarded Red Snapper.

Field Tagging

Red Snapper from the previous BREP2014 experiment that were tagged in the summer season were combined with the fish tagged for the BREP2016 experiment (also tagged in the summer season) to increase the observed sample size, cover a more continuous depth gradient, and provide a more robust dataset for statistical analysis. Between both experiments, 153 Red Snapper were acoustically tagged and released during the summer season using one of three release treatments: nonvent, vent, and descender device. We measured barotrauma impairment scores for each fish prior to tagging to determine the effect of barotrauma on survival estimation. The most typical symptoms exhibited were hard abdomen, followed by an everted stomach. These two symptoms seem to be the least harmful and most reversible. More severe symptoms including exopthalmia or gas bubbling from scales were usually followed by quick mortality on deck or upon release at the surface. These fish were not used for tagging experiments, as the focal point was obtaining delayed mortality information using various release treatments. Furthermore, any fish that were not hooked in the side of the mouth were discarded without tagging to control for latent hook related mortality. Therefore, all mortality that occurred did so after fish had "successfully" re-submerged unassisted, only detected through the use of acoustic telemetry, thus representing delayed mortality. Mean (± SE) fight time, handling time, total length, and barotrauma impairment scores among all depth groups are summarized in **Table 1.** The total length of fish across all five depth groups (30m, 40m, 50m, 60m, and 80m) was plotted in a 50-mm binned histogram grouped by release treatment (**Figure 6**). Only two fish fell outside of the range between 350-700 mm. These fish were 786 mm and 826 mm.

Table 1. Summary statistics for collected data variables at each of the five depths. Values represent the mean ± standard error (*n = 153*).

Depth	Fight Time (s)	Handling Time (s)	Total Length (mm)	Barotrauma Impairment
30m	37.6 ± 3.36	152 ± 6.98	410 ± 6.1	0.301 ± 0.012
40m	42.8 ± 2.24	117 ± 3.52	543 ± 8.02	0.317 ± 0.018
50m	76.1 ± 6.2	151 ± 7.31	551 ± 20.3	0.382 ± 0.024
60m	69.7 ± 2.85	149 ± 5.35	526 ± 9	0.244 ± 0.024
80m	80.8 ± 6.13	144 ± 7.5	442 ± 17.4	0.409 ± 0.039

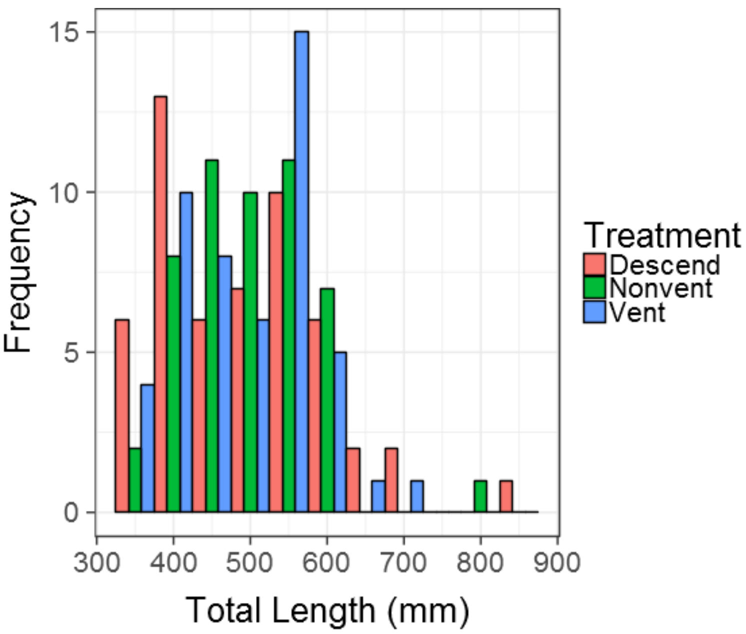

Figure 6. Histogram of total length (mm) of tagged Red Snapper from all five sites (binwidth = 50 mm) grouped by release treatment. There was not a significant difference in total length among the release treatments.

Total length, fight time, handling time, and barotrauma impairment were compared among release treatment and depth using a two-way fixed analysis of variance (ANOVA, α=0.05). There was a significant difference in total length among depths (F = 12.11, $p < 0.001$), with the 30-m and 80-m depth groups showing smaller mean total length than the 40-m, 50-m, and 60-m depths per Tukey's test of multiple comparisons of means (**Figure 7)**. There was no difference in total length among release treatments at each depth (F = 0.37, p = 0.68). The longest mean total length was observed at the middle depth zone of 50 m. There was a significant difference in fight time among depths (F = 7.69, $p < 0.001$), but not between release treatments. Predictably, fight times became longer with increasing depth as it takes longer to reel fish up from deeper waters. There was a significant difference in handling time among depths ($F = 7.71$, $p < 0.001$), but not between release treatments, with the 40-m depth having a quicker handling time than all the rest of the depth groups. There was not a significant difference in barotrauma impairment among depths (F = 2.32, p = 0.06) among depths, though it came quite close to threshold α-value. All variables were still included in downstream multiple logistic regression models regardless of the results of analysis of variance.

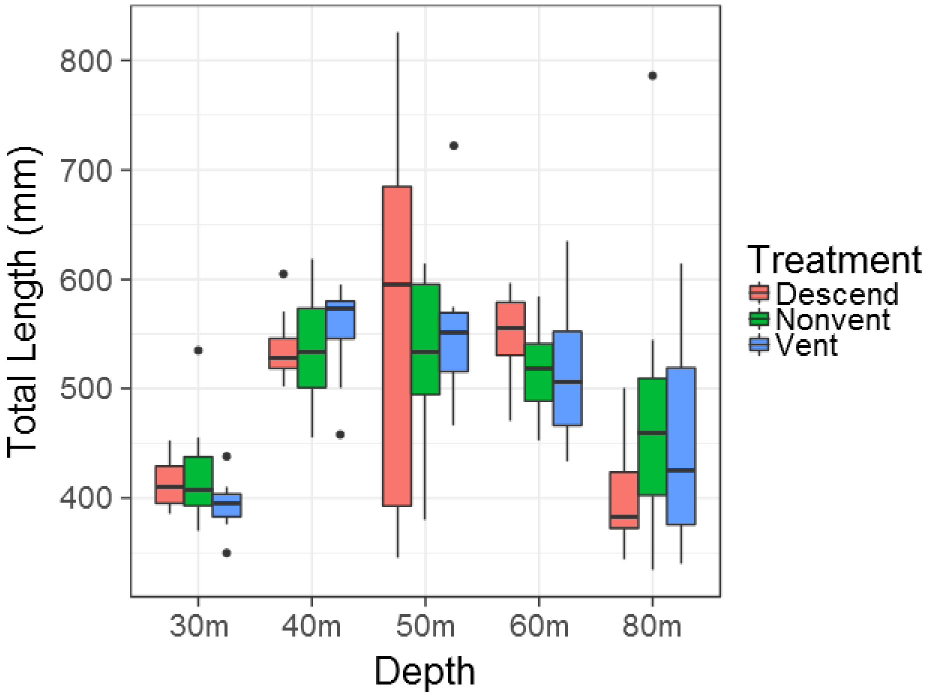

Figure 7. Boxplots showing median total length (mm) of tagged Red snapper for each depth grouped by release treatment. There was a significant difference in total length among depths, with the 30-m and 80-m depth groups showing smaller mean total length than the 40-m, 50-m, and 60-m depths. There was no difference in total length among release treatments at each depth.

Acoustic Detections

After transmitters had expired, receivers were recovered by scuba divers and acoustic data was downloaded. All individuals were detected by acoustic receivers and transmitters' battery life extended for approximately 17 days after the tagging date. The total number of acoustic detections registered at the 30-m site was 10,371,235 detections across all fish (**Figure 9**). The majority of fish at this site detected continuously through the detection period and all the way to the end. The total number of acoustic detections registered at the 50-m site was 6,222,171 detections across all fish (**Figure 10**). Approximately half of the fish at this site detected continuously through the detection period and all the way to the end, with the other half ceasing detections before the midpoint of the 17-day detection period. Lastly, the total number of acoustic detections registered at the 80-m site was 6,146,308 detections across all fish (**Figure 11**). Approximately only one quarter of fish on this site showed detections through the detection period. However, these continuous detections are not necessarily indicative of survival. Depth and motion sensor profiles will determine whether these fish on site had survived or perished and continued pinging long after suffering mortality.

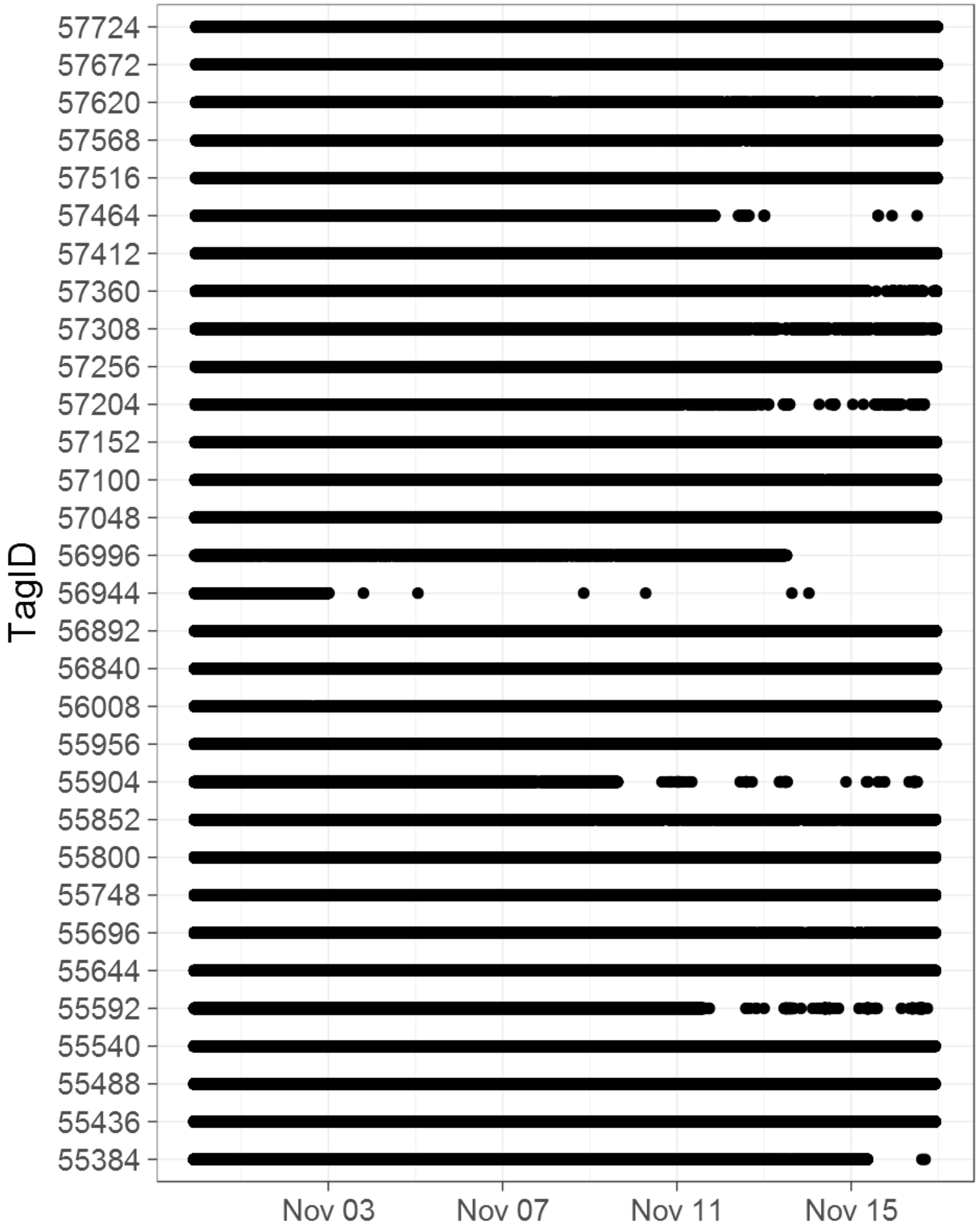

Figure 8. Abycus plot showing the total number of acoustic detections received for all fish (represented by Tag ID) tagged at Site MI-802 (30-m depth). Fish were tagged October 30th and transmitter battery life expired on November 17th.

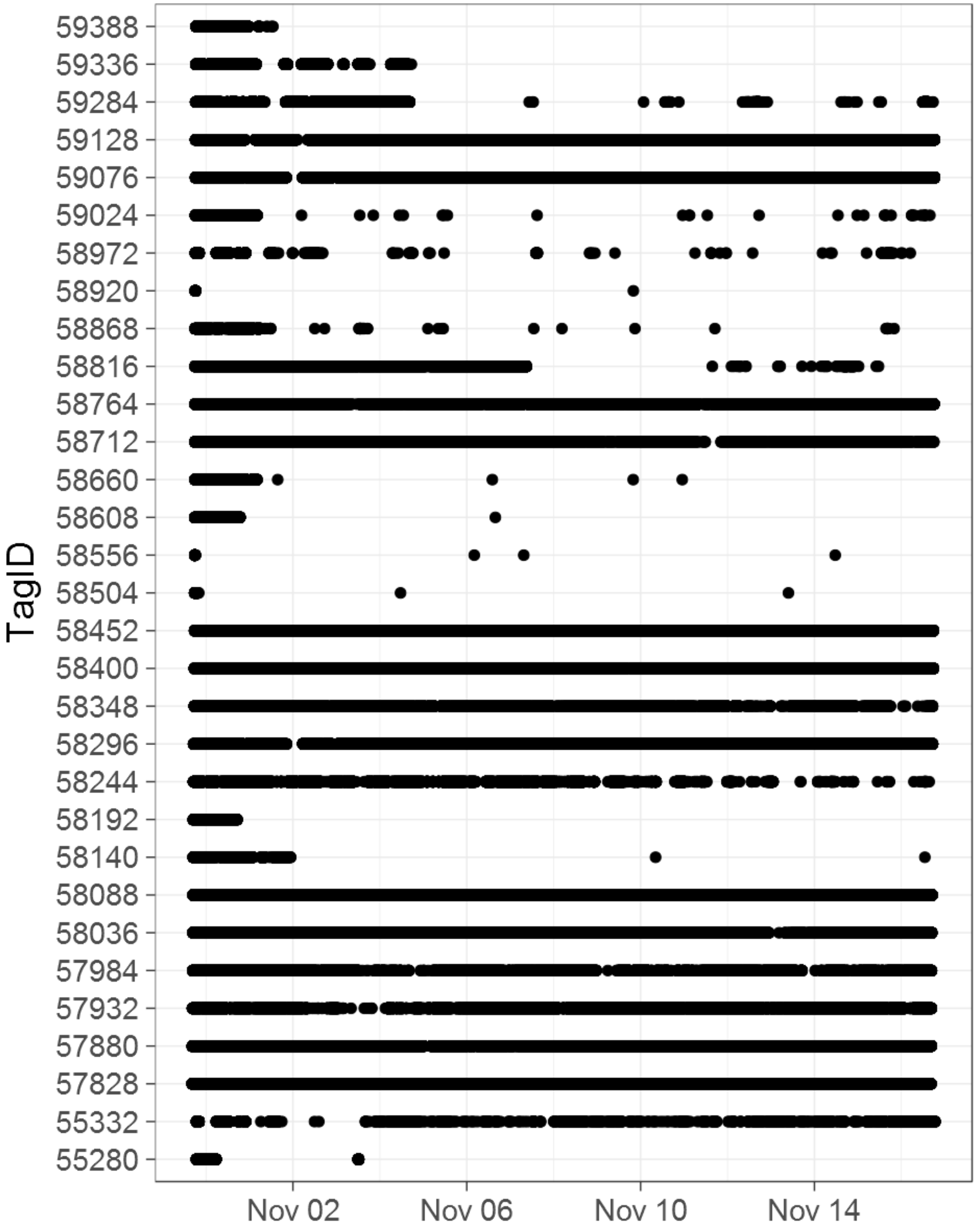

Figure 9. Abycus plot showing the total number of acoustic detections received for all fish (represented by Tag ID) tagged at Site MU-828-A (50-m depth). Fish were tagged October 30th and transmitter battery life expired on November 17th.

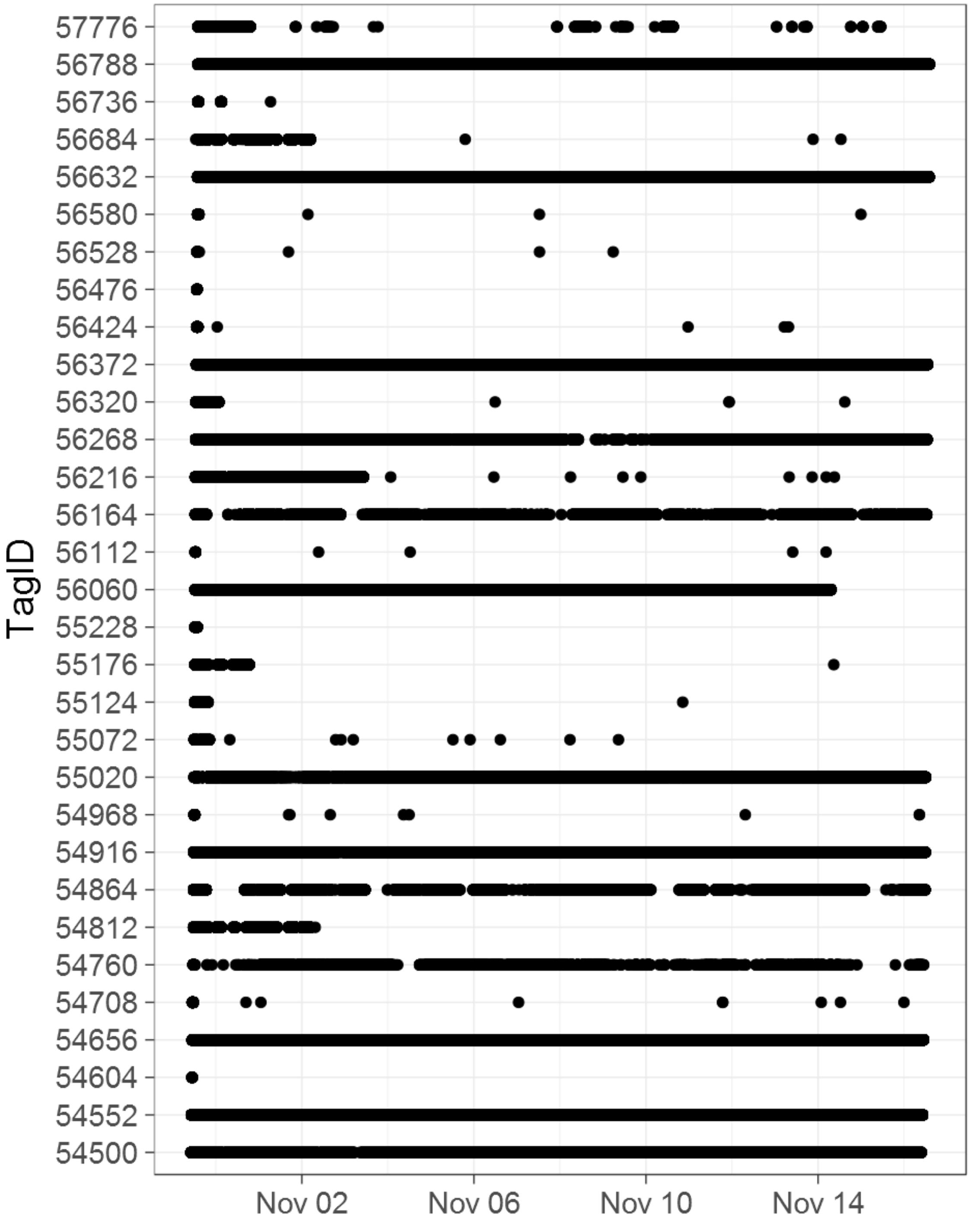

Figure 10. Abycus plot showing the total number of acoustic detections received for all fish (represented by Tag ID) tagged at Site MU-A-16 (80-m depth). Fish were tagged October 30th and transmitter battery life expired on November 17th.

Fate Classification

Using the built-in acoustic sensor data (i.e. pressure and motion) provided by the Lotek transmitters, we were able to better classify the fate of individuals based on their acoustic profiles compared to basic acoustic detections (presence/absence). Unique profiles emerged that represented survival and delayed mortality events. Survivors registered continuous detections for at a minimum five days and had frequent changes in motion and vertical depth movements in the water column (**Figure 11)**. The second profile was indicative of fish experiencing delayed mortality. These fish appeared healthy upon release, and had initial active motion and pressure values detected by acoustic returns, but soon after exhibited a sudden drop-off to zero motion and depth of the seafloor within a period of 3-4 days (**Figure 12**). Acoustic profiles were generated for all 93 fish and their fate was categorized based on the two acoustic profiles that emerged from acoustic motion and pressure sensor data (see Appendix for all fish profiles). Fish profiles from BREP2014 trials were re-examined and re-classified into either survival or delayed mortality signatures only. Emigrants were no longer considered an outcome based on the new information and video evidence.

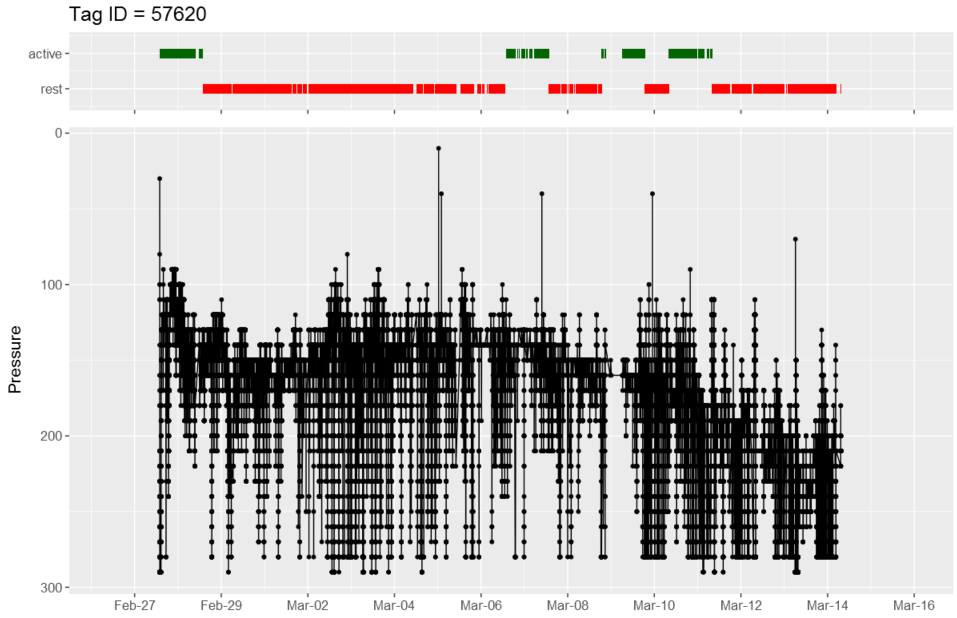

Figure 11. Acoustic telemetry motion (top panel) and pressure (bottom panel) profile of one acoustically tagged Red Snapper classified as a **survivor** post-release (TagID = 57620). Points represent individual acoustic detections and are connected by lines for visualization. Survivors exhibit healthy and active vertical movements in the water column.

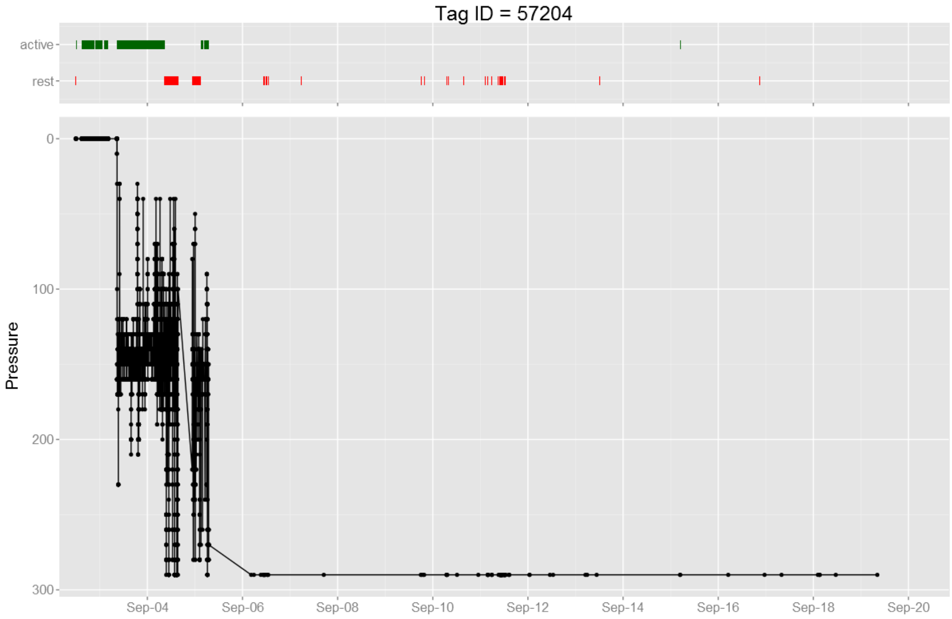

Figure 12. Acoustic telemetry motion (top panel) and pressure (bottom panel) profile of one acoustically tagged Red Snapper classified as a **delayed mortality** event post-release (TagID = 57204). Points represent individual acoustic detections and are connected by lines for visualization. Profile shows that within 2 days the fish is no longer exhibiting any motion or vertical movement, and has fallen to the seafloor and perished.

Survival Analysis

Using the fate classification method based on acoustic sensor data described above, we were able to compare the effects of depth and release treatment on survival and mortality rates for Red Snapper in the field. **Table 3** shows the summary of the results for survival classification based on acoustic profiles by depth and release treatment. Survival estimates and standard errors are derived from equations detailed in the approach section.

Table 2. Summary table of results of Red Snapper experimental trials. *Tagged*: number of fish tagged and released. M*ortality:* fish that exhibited immediate or delayed mortality (perished in < 5 days). *Survive*: fish that exhibited long term (> 5 days) survival. *S^:* survival estimate. *SE(S^)*: standard error of the survival estimate.

	Mortality	**Survive (x)**	**Tagged (n)**	**S^**	**SE (S^)**
			30 m		
Descend	2	9	11	0.82	0.12
Nonvent	1	9	10	0.90	0.09
Vent	0	10	10	1.00	0.00
subtotal	3	28	31	0.90	0.05
			40 m		
Descend	2	8	10	0.80	0.13
Nonvent	6	4	10	0.40	0.15
Vent	6	4	10	0.40	0.15
subtotal	14	16	30	0.53	0.09
			50 m		
Descend	6	5	11	0.45	0.15
Nonvent	9	1	10	0.10	0.09
Vent	7	3	10	0.30	0.14
subtotal	22	9	31	0.29	0.08
			60 m		
Descend	8	2	10	0.20	0.13
Nonvent	8	2	10	0.20	0.13
Vent	10	0	10	0.00	0.00
subtotal	26	4	30	0.13	0.06
			80 m		
Descend	10	1	11	0.09	0.09
Nonvent	10	0	10	0.00	0.00
Vent	9	1	10	0.10	0.09
subtotal	29	2	31	0.06	0.04

Mean percent survival (± SE) across all release treatments was compared among all depths: 30m, 40m, 50m, 60m, and 80m (**Figure 13**). Survival was greatest at the shallowest depth and showed a clear trend of progressively decreasing with increasing depth. Survival among the three different release treatments (descend, nonvent, vent) was also compared among each depth (Error! Reference source not found.).

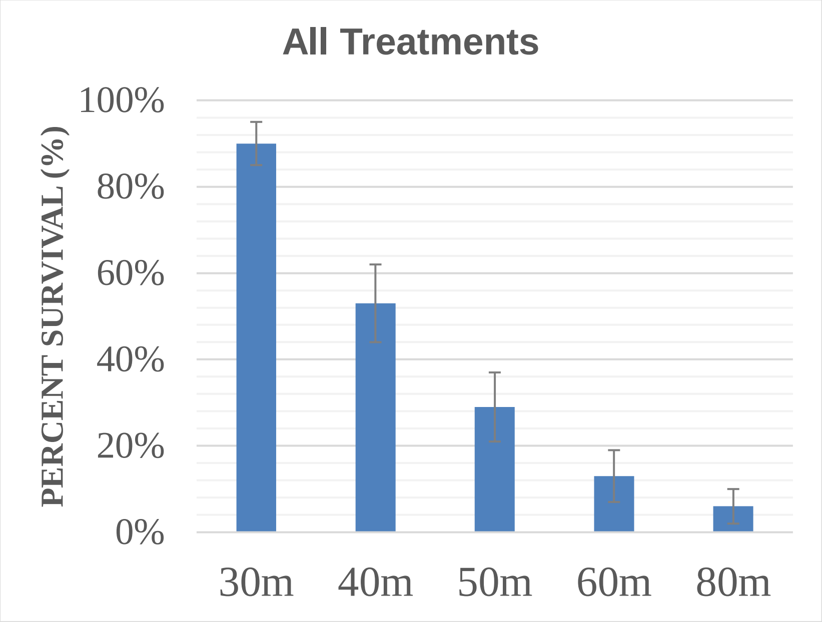

Figure 13. Survival (% mean ± standard error) of Red Snapper at each depth over all release treatments.

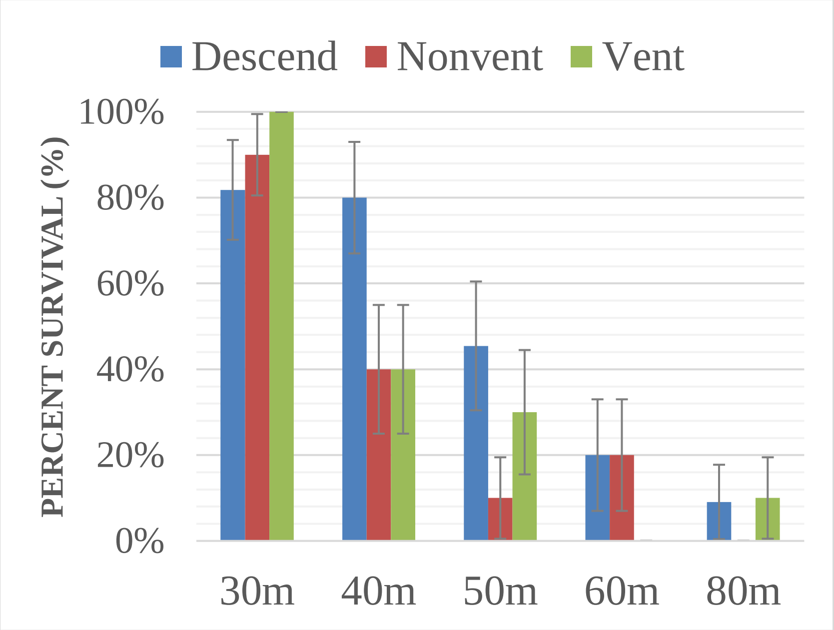

Figure 14. Survival (% mean ± standard error) of Red Snapper grouped by release treatment at each depth.

Survival probabilities were calculated for release treatment and depth explanatory variables based on the Kaplan-Meier product limit estimate (Error! Reference source not found.). The ‘survdiff’ function in the survival package was used to test for differences between two or more survival curves for each level of the explanatory variables using the chi-square statistic for a test of equality. The survival probability did not differ between release treatments ($\chi^2 = 3.7$, *df* = 2, $p = 0.2$). There was a significant difference in the probability of survival for fish tagged and released at different depths ($\chi^2 = 65.8$, *df* = 4, $p < 0.001$): the probability of survival decreased with increasing depth.

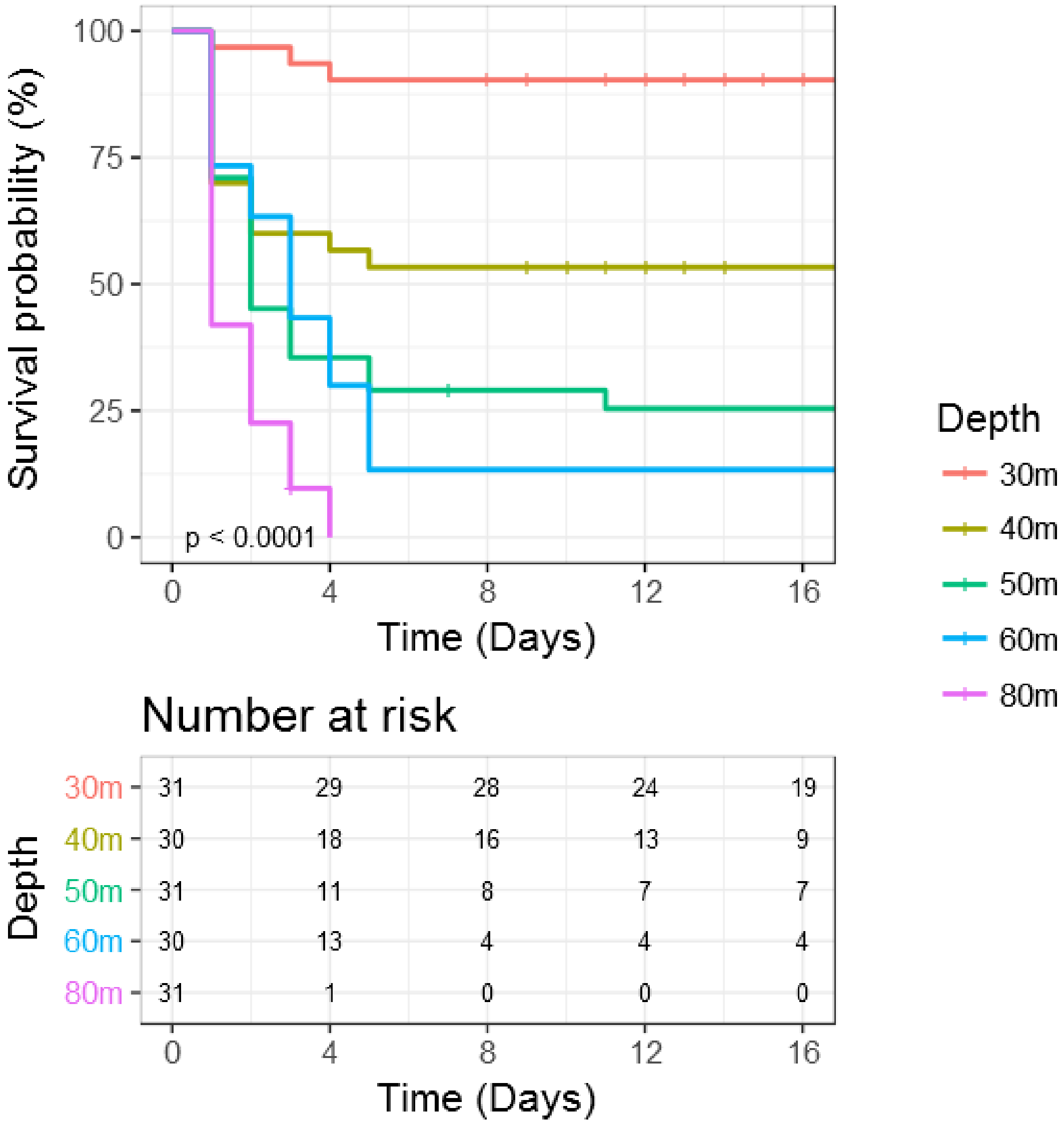

Figure 15. Kaplan-Meier survival curves plotting survival probability over time for each of the depths considered in survival analysis (*n*=153). The bottom panel shows the number at risk at 4-day time intervals taking into account past mortality events and right-censored data of survivors.

Stepwise logistic regression determined that the most important variable in survival prediction was depth, followed by release treatment. Other variables were determined to be unimportant with regards to survival prediction. The dredge and relative variable importance (RVI) function also confirmed that depth and release treatment were the two most influential variables in the model. These variables were retained and inserted into the Cox proportional hazards model to compare the relationship between survival and multiple explanatory variables and compute a hazard ratio, or proportional risk of death, for each covariate level (Error! Reference source not found.). For release method, the descended release treatment experienced the highest probability of survival; thus, was used as the baseline level to which release treatments nonvent and vent were compared. Nonvented fish performed significantly worse in terms of survival than descended fish. Based on the calculated hazards ratio, nonvented fish were 1.9 times, and vented fish 1.2 times as likely to perish as fish descended using SeaQualizer devices, though the test statistic for vented fish was not significantly different than descended treatment. Regarding depth, the 30-m site served as the baseline level to which all other depth groups were compared. The risk of survival was significantly lower at each of the deeper sites when compared with the 30-m site. The hazard ratio or proportional risk of death increased along each level of depth, with fish tagged at the deepest 80-m site showing the highest risk of mortality at 36 times the risk of fish tagged at the 30-m site.

Table 3. Cox proportional hazards model using treatment and depth as covariates. The hazard ratio shows the proportional risk of each level of a particular factor against the baseline risk of mortality (e.g. fish captured and released at 50 m are 14.8 times as likely to perish as fish at 30 m).

Covariate	Coefficient (b)	Hazard ratio (e^b)	95% C.I. for e^b	*P*
Descend	*(baseline)*			
Nonvent	0.6648	1.944	1.1792 - 3.205	< 0.01
Vent	0.2225	1.249	0.0753 - 2.070	0.3879
30m	*(baseline)*			
40m	1.998	7.374	2.1164 - 25.697	< 0.001
50m	2.6926	14.769	4.4130 - 49.430	< 0.001
60m	2.7529	15.688	4.7220 - 52.121	< 0.001
80m	3.6087	36.916	10.9583 - 124.364	< 0.001

Objective 2: Link barotrauma impairment to release condition to predict fate of discarded fish and how barotrauma severity influences mortality.

Barotrauma assessment

We analyzed the influence of depth on barotrauma impairment using the full number of observations (*n* = 1607) from our entire VLL dataset (2013-2018). Sampling events occurred from 20 – 90 m depth and represented all four seasons throughout the year, although the largest proportion of events were conducted in the summer months. For each sampling event, barotrauma impairment scores for each individual fish were averaged and plotted against depth (**Figure 16**). Mean barotrauma impairment across all observations was 0.4 ± 0.01 (mean ± standard error), with the most common barotrauma symptoms being hard abdomen followed by stomach eversion. Barotrauma impairment was modeled with a generalized additive model using a loess smoothing spline. Barotrauma impairment increased with depth, as expected, but reached a maximum value at 55 m. Beyond this depth, barotrauma impairment actually decreased, which was a most unexpected result. The resulting decrease in barotrauma related impairment likely is due to catastrophic decompression events, whereby the swim bladder (and possibly other cavities) has ruptured and released the excess gas built up inside the fish to the environment. We have documented these occurrences at several of our deeper VLL sites using camera footage. The release of these gases creates space inside the fish for internal organs (stomach, intestines) to return to their displaced location prior to capture and the subsequent pressure change that is responsible for expanding the swim bladder, displacing the organs, and making them externally visible. Additionally, catastrophic decompression and the release of excess gas returns the fish to neutral (or negative) buoyancy, which allows the fish to submerge unassisted in many cases when discarded. This may mislead observers to conclude that the fish was healthy and survived the catch-and-release process, when in fact the damage is irreversible and that fish undoubtedly will succumb to delayed mortality hours to days later as indicated by our acoustic telemetry data.

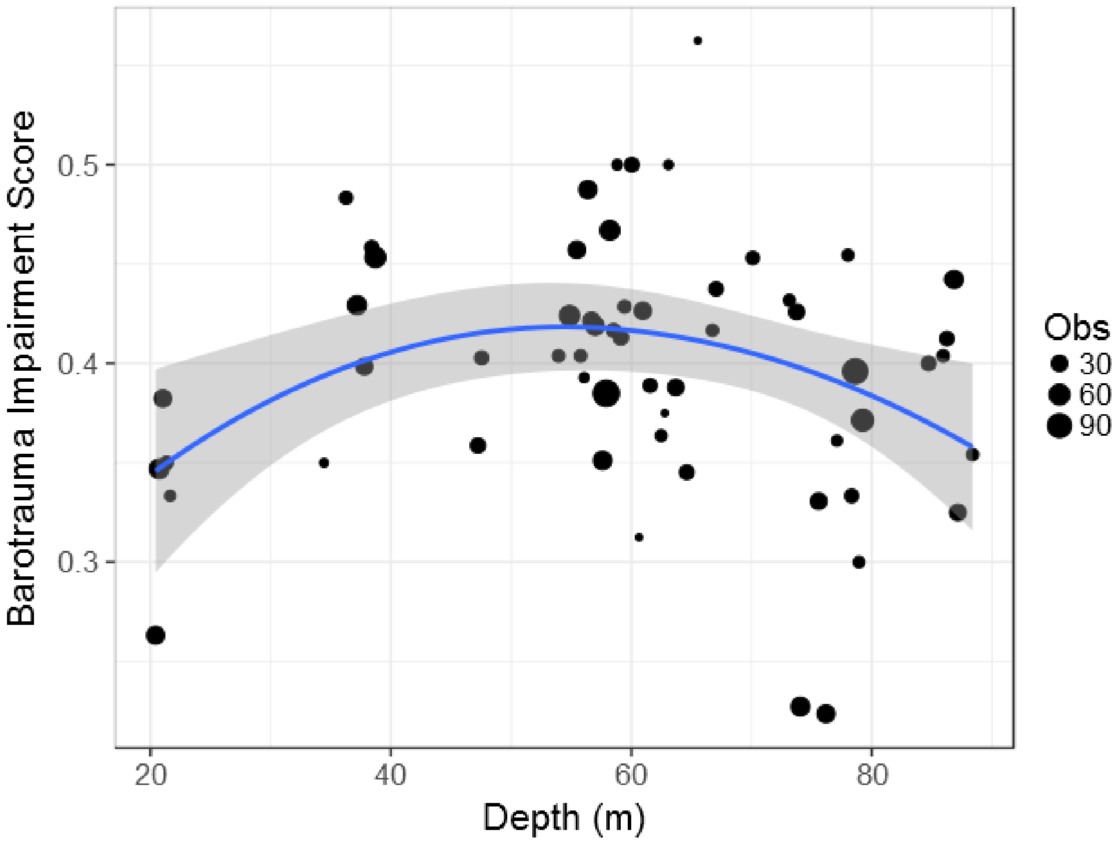

Figure 16. Mean barotrauma impairment score measured at depth ranging from 20 – 90 m. Fish were captured using vertical longline (*n* = 1607). Size of points are relative to the number of observations at each depth sampled. Smoothing spline fit by “loess” generalized additive model.

Objective 3: Assess the potential for integrating descending devices into the recreational fishery.

Engagement with the recreational fishing community and survey results

A total of 1,062 SeaQualizers and best-use practices pamphlets were distributed to recreational anglers from North Carolina to Texas by various state, federal, and private entities. The majority of devices were distributed by state agencies at dockside creel stations and fishing tournaments between March and September of 2016. A total of 80 SeaQualizers were distributed to Texas recreational anglers at dockside creel stations, fishing tournaments, and CCBGFC and Port Aransas Boatmen’s Association meetings and banquets.

A total of 538 SeaQualizer recipients took the survey sent via email (51% response rate). Of those respondents, 23%, 27%, and 28% most commonly fished saltwater in Texas, Alabama, and Florida, respectively (**Figure 17**). All other states were targeted for saltwater fishing by less than 10% of respondents. The most commonly targeted state for saltwater fishing matched almost identically with the respondents' home state determined by zip code. The vast majority of respondents were private recreational anglers (n = 451, 84%), while only 81 (15%) and 6 (1%) identified as charter boat captains, owners, or operators and headboat captains, owners, or operators, respectively (**Figure 17**). On average, respondents owned their SeaQualizer eight months and used it on 15 trips prior to taking the survey. Fifty-five percent targeted water depths between 75 and 125 ft (23 – 38 m), 13% targeted depths less than 75 ft (< 23 m), and the remaining respondents (14%) targeted waters greater than 125 ft deep (> 38 m). Seventeen percent of respondents targeted distances of 10 miles (16 km) offshore or less, half fished 11 to 30 miles (18 – 48 km) offshore, 15% fished 31 to 40 miles (50 – 64 km) offshore, and the 20% fished more than 41 miles (66 km) offshore. Over 95% of participants discussed with and involved other anglers in the use of their free SeaQualizer. Approximately 95% of recipients believed the combinations of materials they received improved their knowledge and skills regarding recognition of barotrauma and proper fish handling and release methods.

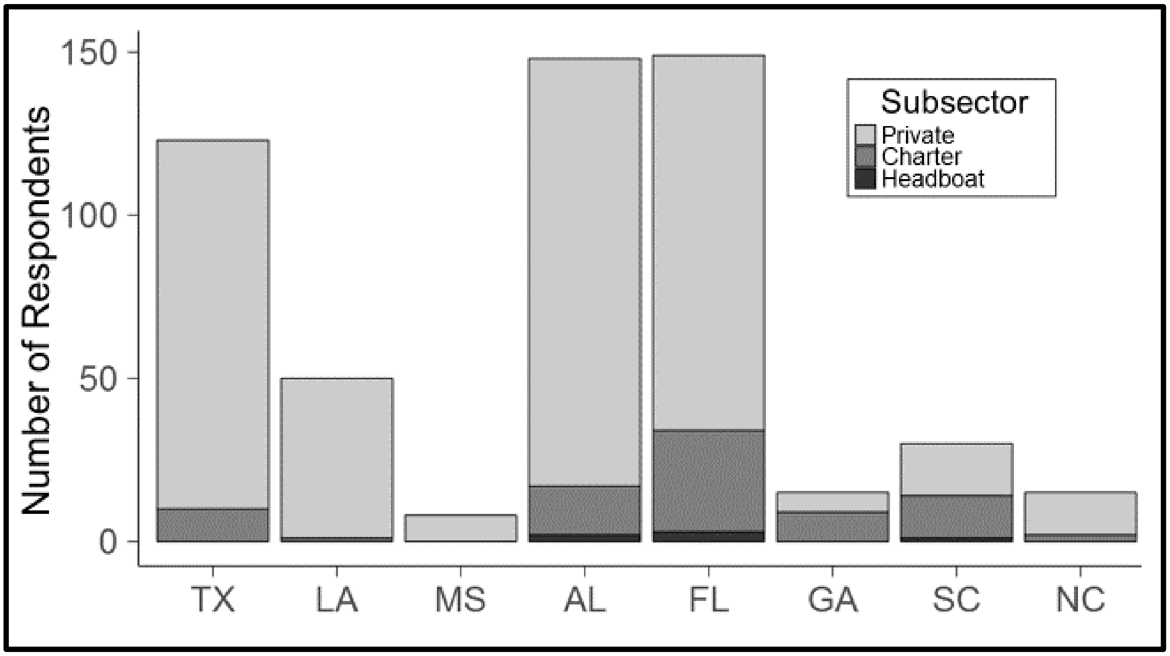

Figure 17. Number of survey respondents from each state broken down by recreational fishing subsector: private anglers, charter captains, owners, or operators, and headboat captains, owners, or operators. The total number of respondents was 538.

Most respondents had used a venting tool at some point in the past (89%). Significantly more charter respondents used vent tools in the past than private anglers (Chi-squared test; χ = 4.314, $p < 0.05$). When employing vent tools in the past, 78% of respondents vented all or most fish when they exhibited signs of barotrauma. When asked what cues anglers used to determine if venting or descending a fish was necessary, anglers considered a protruding stomach, bloated abdomen, inability to submerge, exophthalmia, and sluggishness to be effective cues. Thirteen percent used a venting or descending tool on all fish regardless of symptoms, while 3% never used either.

Sixty-three percent of respondents stated they still used venting tools to release fish exhibiting barotrauma. Responses were not significantly different between private anglers and charter boat captains (Chi-square test; $\chi = 1.758$, $df = 1$, $p = 0.185$). For those that did not currently employ vent tools to release fish, 19% stopped using them because they did not think they work, 17% believed the fish were able to submerge without the help of venting, and 5% stopped using vent tools because they thought they were too time consuming. Sixty-seven percent chose the ‘other’ category and were required to specify their reason. Of those 150 ‘other’ respondents, 66 specifically mentioned they preferred to use a descending device instead of venting. The mean percentage of fish believed to survive the venting process was 57%, and this was not significantly different between private and charter respondents (Kruskal-Wallis test; $\chi = 0.152$, $df = 1$, $P = 0.697$). Mean perceived survival rate after venting for headboats was 62%, similar to the overall mean.

Previous knowledge concerning the use of descender devices was generally low. Seventy-two percent of respondents had little to no knowledge about descender devices prior to acquiring their SeaQualizer. Only 45 of the 517 respondents (< 9%) to the question had a high to very high amount of knowledge prior to receiving their SeaQualizer. Charter boat captains were more likely to possess knowledge on the devices than private anglers (OLR; $\beta = 0.521$, $\chi = 5.365$, $p < 0.05$).

The likelihood of respondents to use a descender device to release fish exhibiting barotrauma was very high (**Figure 18**). Only eight individuals were not likely to use a descender device at all, whereas 33% of respondents were likely to use one to release all fish, 43% to release most fish, and 14% to release approximately half of the fish they catch exhibiting barotrauma. Although there were only six headboat respondents, half of them would not likely release any fish with a descender device. There was no difference in likeliness to use the device between private anglers and charter captains (OLR; $\beta = -0.2095$, $\chi = 0.821$, $p = 0.365$).

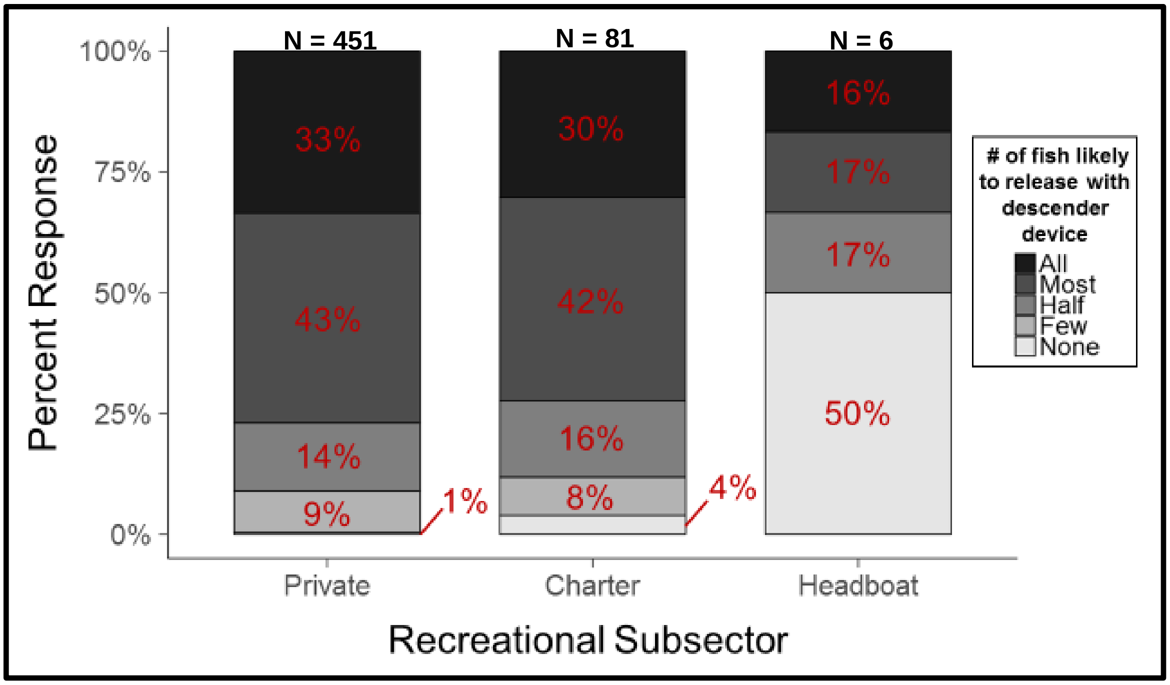

Figure 18. Response of private, charter, and headboat survey participants when asked how likely they were to use a descender device to release fish exhibiting barotrauma. Red percentages correspond to proportional response for that recreational subsector.

The vast majority of respondents (89%) believed descender devices would be at least “moderately helpful” in reducing discard mortality in the Red Snapper fishery (**Figure 19**). Seventy-nine percent believed they would be helpful to very helpful. When answers were compared between private anglers and charter captains, private anglers believed the devices to be only slightly more helpful than charter captains. However, these differences were not statistically significant (OLR; $\beta = -0.407$, $\chi = 2.940$, $p = 0.086$). Three of the six headboat respondents believed the devices would be very helpful, one believed they would be a little helpful, and two believed they would be very little help in reducing Red Snapper discard mortality rates.

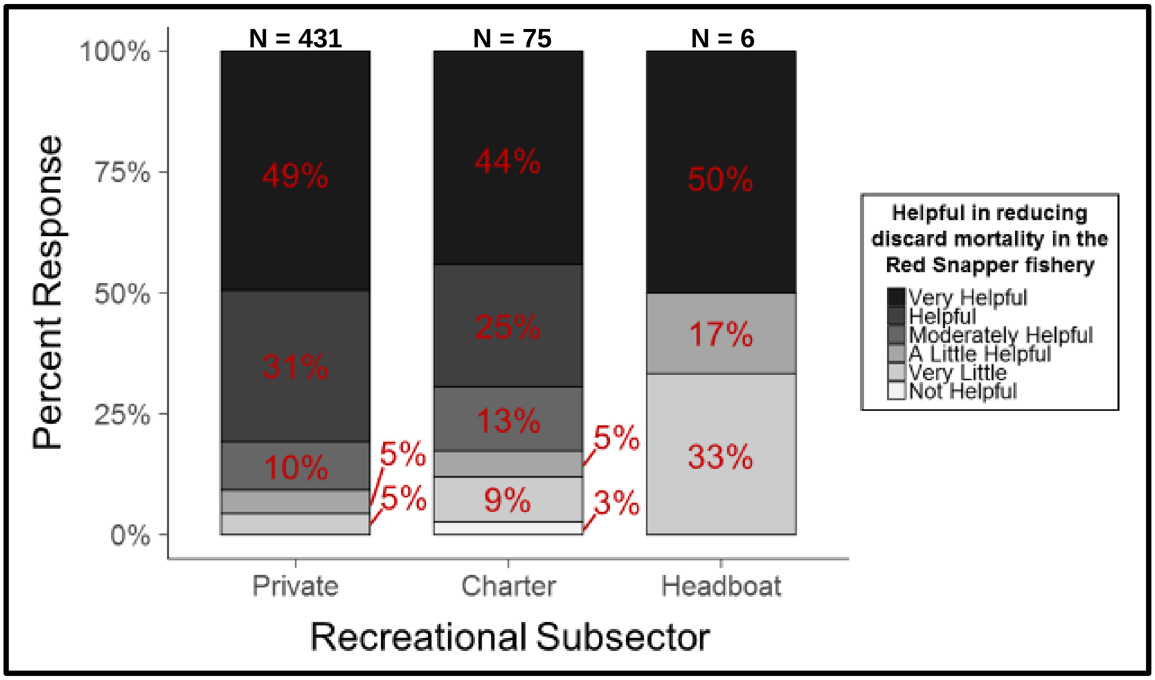

Figure 19. Response of private, charter, and headboat survey participants when asked how helpful they believe descender devices would be in improving discard mortality in the Red Snapper fishery. Red percentages correspond to proportional response for that recreational subsector.

Overall, anglers believed more fish survive long-term when released with a descender device than when released after venting. The mean predicted survival rate of fish released with a descender device was very similar between private anglers and charter captains (80% and 81%, respectively). For headboat respondents, mean predicted survival rate of fish released with a vent tool was identical to the predicted rate when released with a descender device (62%).

A range of the approximate total number of fish released by anglers during this study was calculated by multiplying the number of respondents in one category by the range of the minimum and maximum number of fish released in that category. Anglers who took the survey released a minimum of 7,068 to a maximum of 11,235 Red Snapper and a minimum of 4,316 to a maximum of 6,790 other species of fish during the time period from acquiring their SeaQualizer to taking the survey. On average, charter captains and private anglers released approximately 28 Red Snapper and 16 Red Snapper per person throughout the course of the study, respectively. Similar results occurred for species released other than Red Snapper by charter captains and private anglers. The mean number of Red Snapper and other species released per headboat respondent was 29 and 16, respectively.

After receiving and operating the SeaQualizer, 70% of anglers preferred to use a descender device over a venting tool. Results from the chi-squared test determined significant differences existed in preferred release method between private anglers and charter captains (Chi-squared test; $\chi = 24.567$, $p < 0.001$). After operating the SeaQualizer, seventy-four percent of private anglers preferred to release fish with a descender device. Charter captains were less likely to use the devices, with only 54% preferring a descender device over other methods.

Likewise, 18% of charter captains still preferred venting compared to only 7% of private anglers. More charter captains preferred to employ both methods than private anglers, but no charter captains preferred to use no methods when releasing fish with barotrauma compared to 4% of private anglers.

Survey participants were given the option to complete a secondary portion of the survey that addressed demographic information. Of the original 538 survey participants, 476 agreed to complete the second portion on the survey. To gauge fishing experience of survey participants, anglers were asked how many years they have been fishing for offshore reef fish (**Figure 20**). Fifty-four percent of respondents had been fishing for more than 20 years, 20% for 11 to 20 years, 17% for 5 to 10 years, 9% for 1 to 4 years, and only two respondents had been fishing for less than one year (0.4%). Charter captains were more likely to have greater fishing experience than private anglers (OLR; $\beta = 0.862$, $\chi = 10.404$, $P = 0.001$). Four of the six headboat respondents had been fishing for more than 20 years. When asked how many days they targeted reef fish last year, 41% took more than 20 trips, 24% took 11 to 20 trips, and the remaining 34% took 10 trips or less. Charter captains were much more likely to fish more days in the past year than private anglers (OLR; $\beta = 2.349$, $\chi = 50.219$, $P < 0.001$). All headboat respondents had fished more than 20 days in the past year.

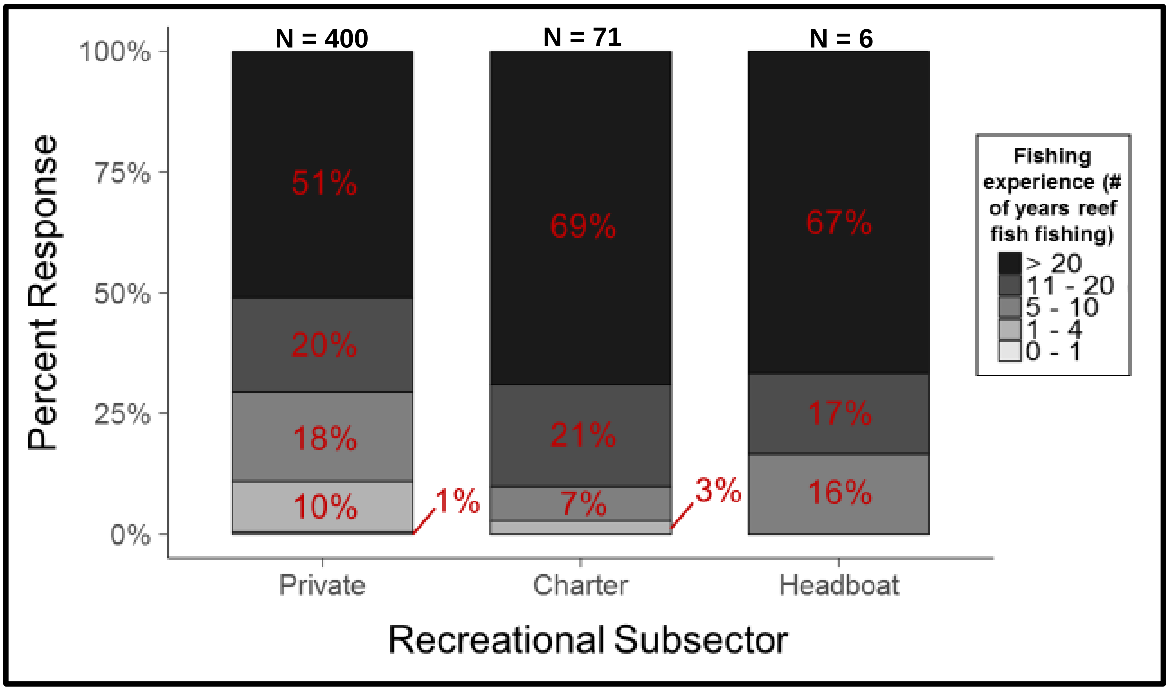

Figure 20. Response of private, charter, and headboat survey participants when asked how many years they have been targeting offshore reef fish.

The majority of survey participants were males (96%) between the ages of 41 and 65 (66%). Fifty-eight percent of respondents' highest level of education was a Bachelor's degree or higher and 66% held a combined household income of at least $75,000. Compared to charter captains, private anglers were more likely to have earned a higher education (OLR; $\beta = -1.192$, χ

= 21.824, $p < 0.001$), and hold a higher household income OLR: $\beta = -0.559$, $\chi = 5.190$, $p = 0.025$,). Headboat respondents held the lowest education level and household income of the three recreational subsectors.

To understand how various demographic characteristics affected anglers' willingness to use a descender device and to what effect they could reduce discard mortality in the Red Snapper fishery, one-way OLR with post-hoc testing was performed. Likelihood ratio tests (LRT) between null models and models including factors of interest were used to determine if variables were significantly correlated with responses. Education was not a significant predictor of either angler willingness to use descender devices (LRT; $p = 0.243$) or of perceived benefit of the devices to reduce discard mortality in the Red Snapper fishery (LRT; $p = 0.123$), nor was fishing experience (LRT; $p = 0.090$ and $p = 0.991$, respectively).

B. Significant Problems

We did not experience any significant problems during the course of this project. We experienced a few minor but typical scheduling setbacks regarding the fieldwork and tagging experiments, but these potential hurdles were anticipated and accounted for during the planning phase. These minor issues did not change our proposed methodology or drastically alter our overall goals and objectives.

C. Need for Additional Work

The work completed in this study contributed to a better understanding of discard mortality estimates that can be applied to stock assessments and red snapper fishery management. Our novel approach using acoustic telemetry to estimate delayed mortality has revealed patterns in survival and mortality otherwise unaccounted for merely using surface observations and can significantly change the estimates of survival. One drawback in using this technology for survival classification is the high expense associated with purchasing acoustic transmitters and receivers, which restricts the number of fish tagged for the study, and therefore the overall sample size. To supplement the low sample sizes associated with acoustic telemetry, simultaneous passive anchor tagging could be used in future experiments. Anchor tags are cheap, easily deployed, and designed for large-volume mark-recapture experiments. Recent analytical methods have been developed to combine both acoustic and passive tag types into a single model for estimating mortality.

The use of cameras and video analysis in concert with the descender devices has proven to be a necessity for accurately classifying the fate of discarded fish. On several occasions, depredation occurred after fish had been successfully released from the SeaQualizer devices. In some instances, acoustic profiles of the released fish become ambiguous based on acoustic returns, but video evidence can confirm whether fish are perishing through depredation.

The use of SeaQualizers or other fish descending devices is only effective for reducing discard mortality for recreationally caught red snapper if recreational anglers use these devices.

This project began gathering information about the use of descender devices in the recreational sector, and explored methods for integrating recreational anglers into the testing of these devices. The partnerships we have established through this project (e.g. FishSmart) resulted in a much larger scale survey and questionnaire than what was previously accomplished, and has allowed us to provide useful fishery-dependent feedback on the utility of these devices for reducing discard mortality of red snapper and other reef fish species in the context of the recreational fishing community. Continuing this involvement with fishery stakeholders in the management process is critical to obtain buy-in from stakeholders seeking to use the descending devices for fishery conservation and management.

VII. EVALUATION

A. Attainment of Project Goals and Objectives

The goals and objectives for this project were fully attained as proposed. There were no modifications made to the project goals and objectives. Using acoustic telemetry, we were able to assess the impacts of discard mortality on red snapper survival and compare behavior and estimate mortality of red snapper experiencing barotrauma in field trials. We also evaluated how differences in depth and release treatment might influence the number of discards. Using fishery surveys coupled with vertical longline data, we established an index of barotrauma impairment, and examined how this impairment may change based on depth. Lastly, we were successful in engaging recreational anglers, disseminating information on fish descender devices, and gathering extremely useful feedback from stakeholders. We gathered useful fishery-dependent data on their utility for reducing discard mortality in the recreational fishery, as well as the preference and feasibility for their use by recreational anglers.

B. Dissemination of Project Results

This project garnered outstanding interest by the general public, recreational anglers, scientists, and the fisheries management community. Scientific output of this work will result in several manuscripts that will be submitted to peer-reviewed scientific journals for publication. These manuscripts are currently in preparation and are anticipated to be submitted next year. Multiple oral and poster presentations have been given at local and national scientific meetings and symposia, including the American Fisheries Society Annual Meetings and local chapters. These scientific forums included: TPWD Artificial Reef program Annual Science and Research Consortium, Texas Chapter of the American Fisheries Society Annual Meeting, 7th Annual Graduate Program in Marine Biology Symposium, 6th Annual Marine Science Graduate Student Organization Student Research Forum, NOAA Educational Partnership Program Eighth Biennial Education and Science Forum, and the 6th Annual Graduate Program in Marine Biology Symposium. The third objective was a primary focus of Alex Tompkins' Master's thesis, which he defended last year and earned his degree from Texas A&M University-Corpus Christi.

Outreach specifically aimed at the recreational fishing community and the wider general public was performed at various non-scientific gatherings comprised primarily of recreational anglers. These gatherings included: CCBGFC fishing tournaments, banquets, fundraisers, and parties, Port Aransas Boatmen’s Association monthly meetings, Coastal Conservation Association – Corpus Christi Chapter weekly banquet meetings, dockside creel stations during the federal open season for Red Snapper, and through social media posts on Facebook and Twitter. Additional educational pamphlets were created by our team describing the benefits associated with rapid recompression devices. These pamphlets were distributed to all SeaQualizer recipients who received their device from one of our team members. Contact information and sources describing best catch-and-release practices were provided in these pamphlets, and these resources continue to be available online.

Finally, PI Stunz serves on the Gulf of Mexico Fishery Management Council and Co-PI Curtis serves as a member of the Reef fish Scientific and Statistical Committee. Thus, these affiliations will help ensure these results are conveyed to the fishery managers during the stock assessment and other management processes. PI Stunz has attended and given presentations to the Council where the results of this and other ongoing studies were the primary subject and a major scientific contribution to the workshop material.

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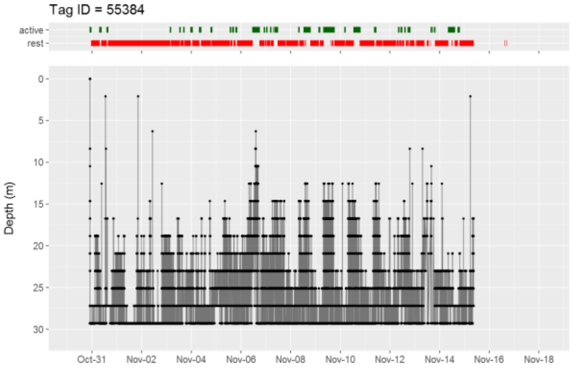
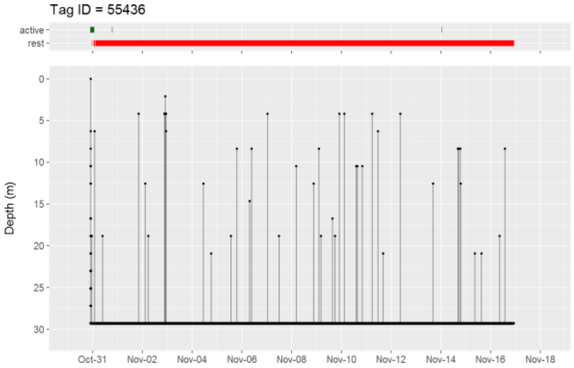
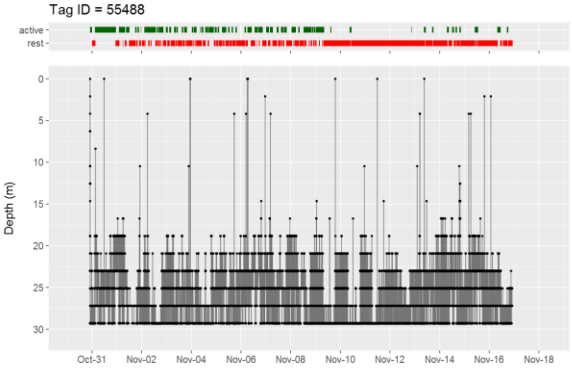
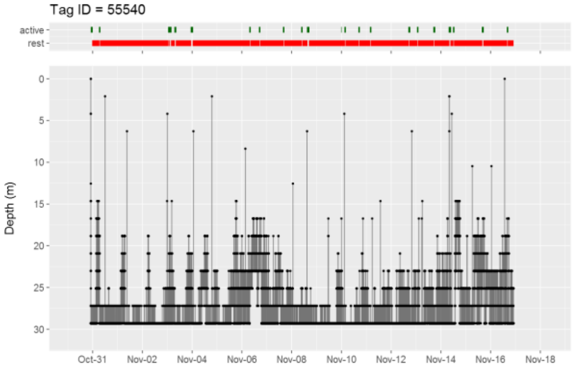
APPENDICES

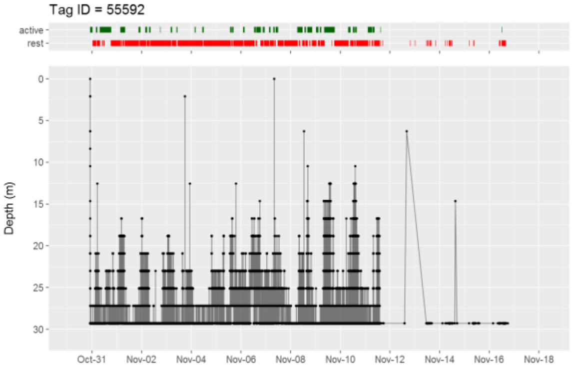
Appendix A: Acoustic Profiles at 30-m site

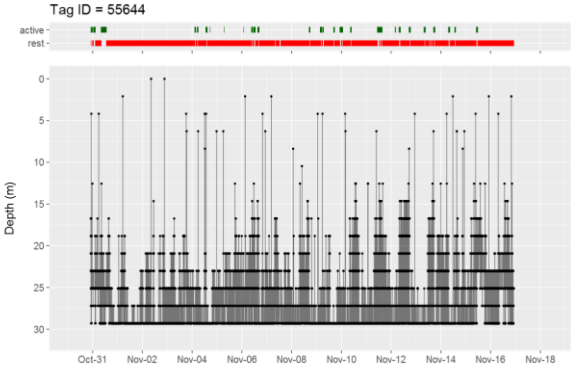


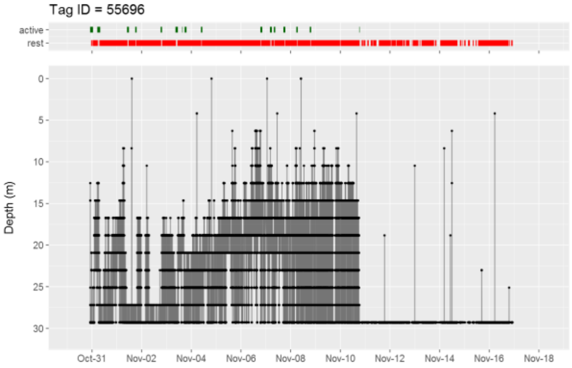


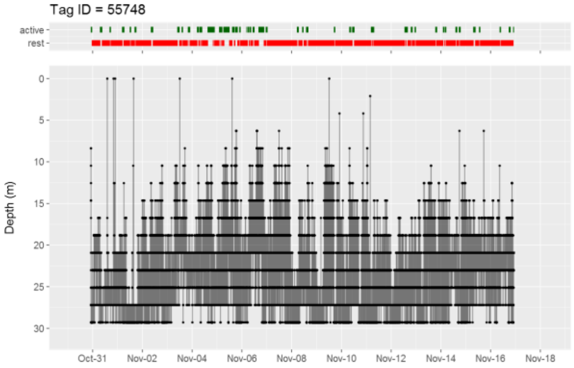


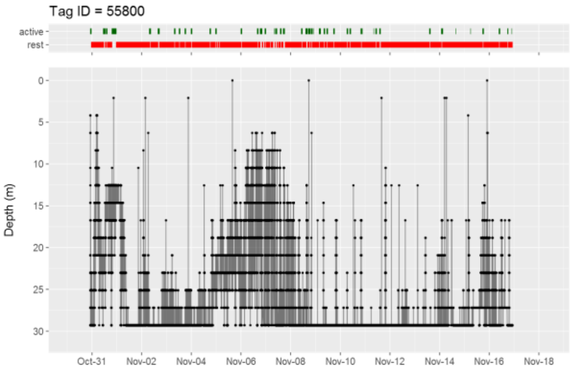








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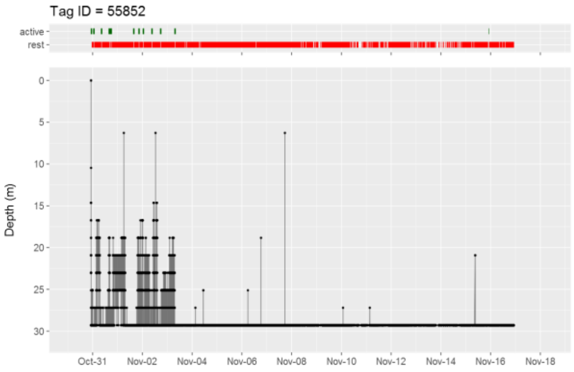
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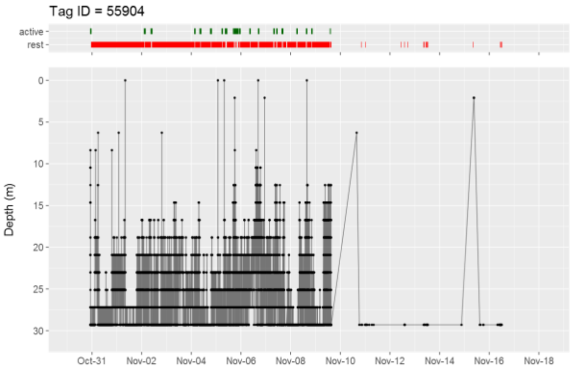
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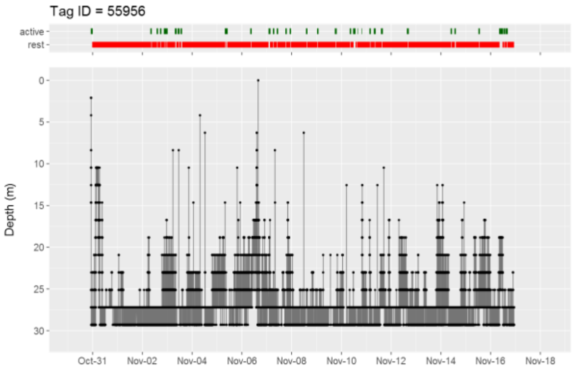
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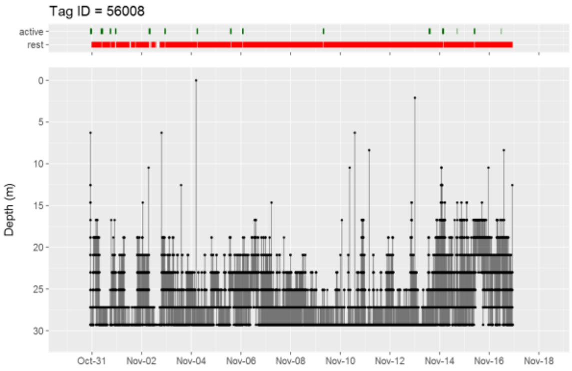
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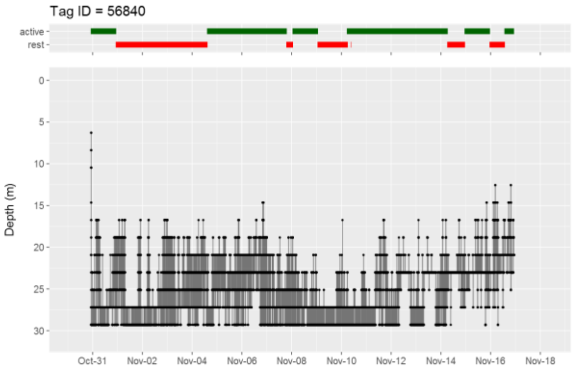
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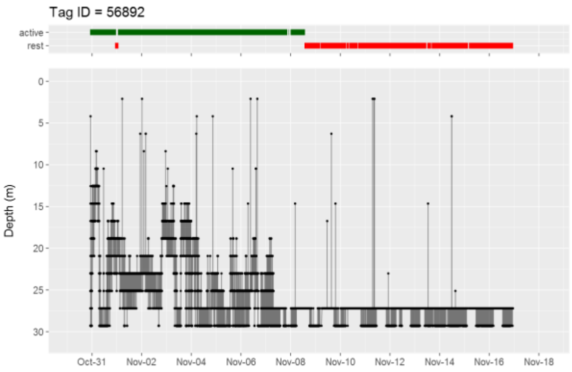
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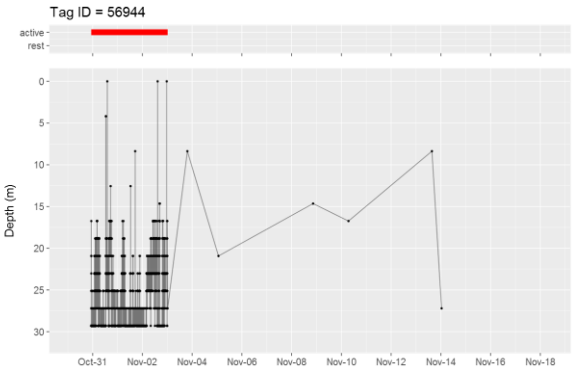
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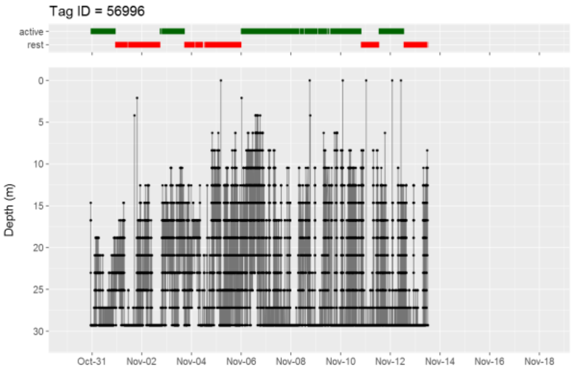
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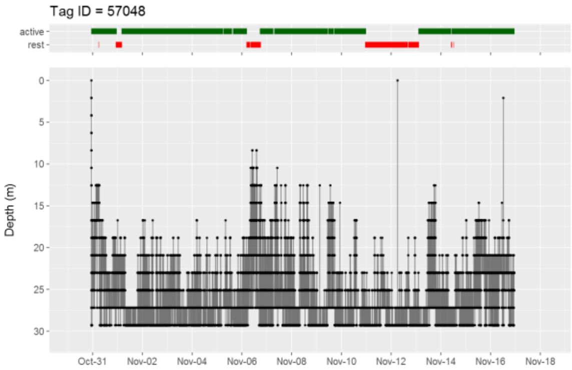
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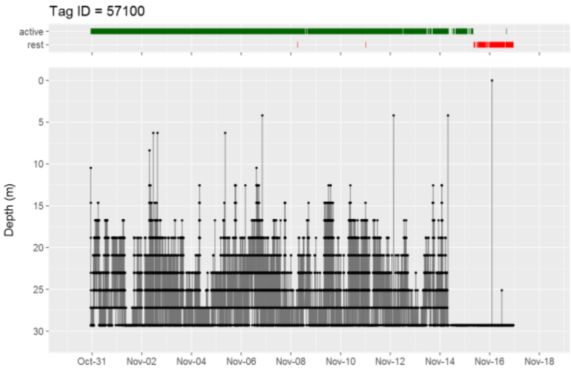
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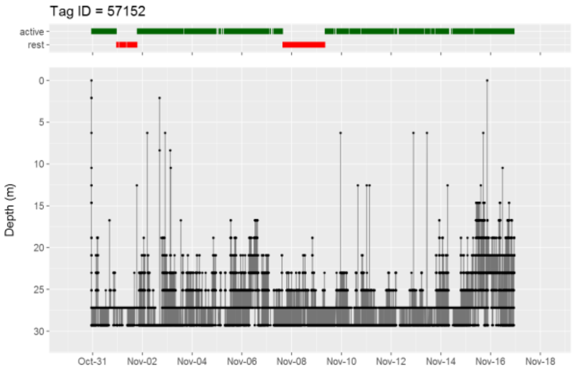
Nov-18


Tag ID = 57152
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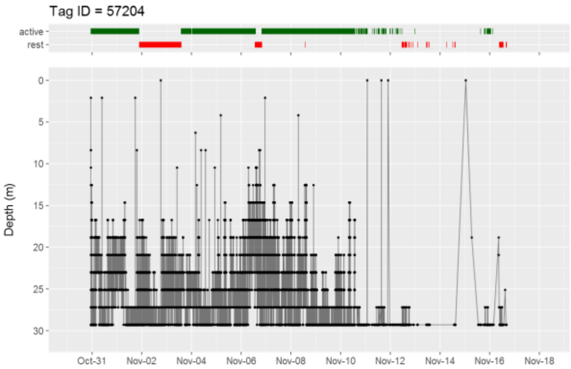
Nov-16
Nov-18


Tag ID = 57204
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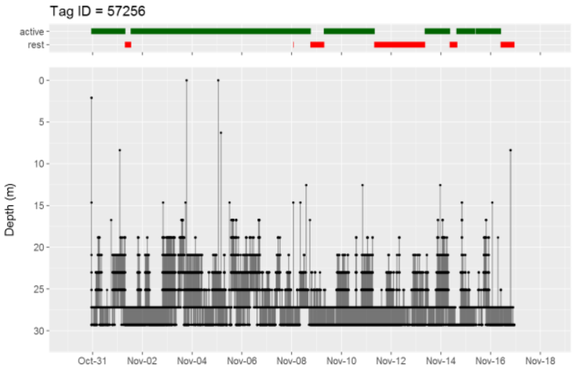
Nov-16
Nov-18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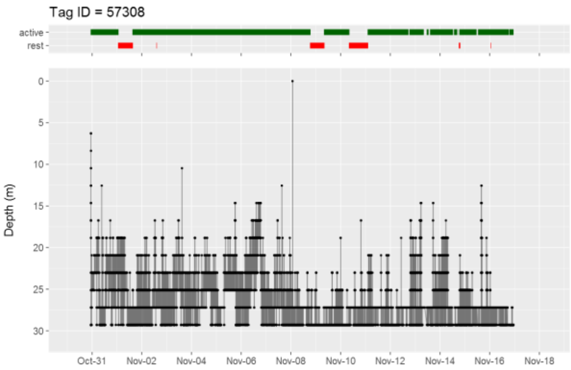
Nov-16
Nov-18


Tag ID = 57308
active
rest
Depth (m)
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Oct-31
Nov-02
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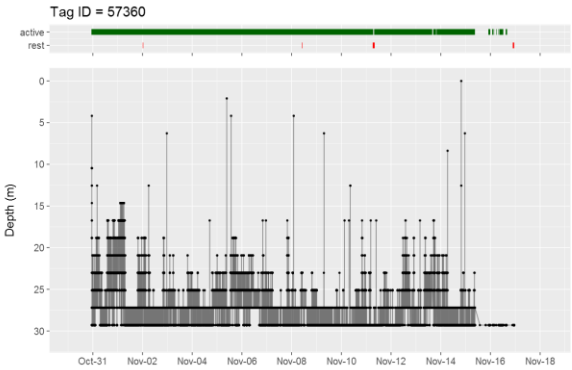
Nov-16
Nov-18


Tag ID = 57360
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rest
Depth (m)
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Nov-02
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Nov-06
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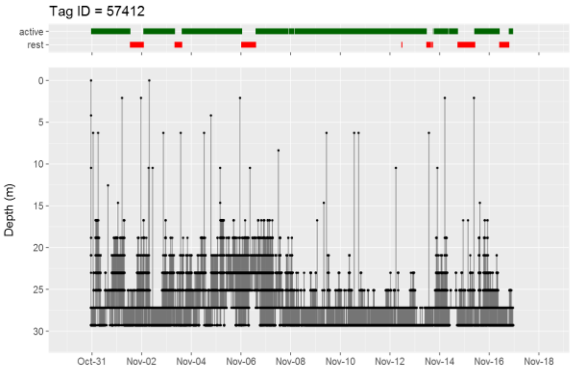
Nov-16
Nov-18


Tag ID = 57412
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Depth (m)
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Nov-02
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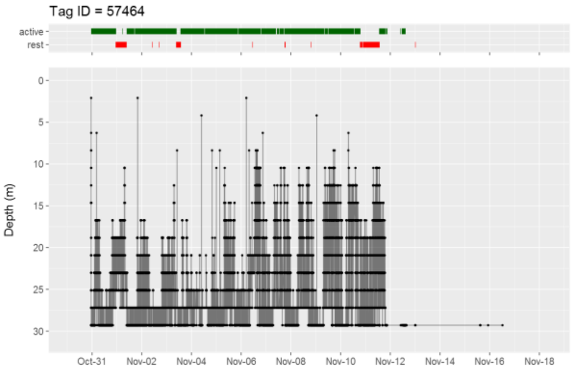
Nov-16
Nov-18


Tag ID = 57464
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rest
Depth (m)
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Oct-31
Nov-02
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Nov-06
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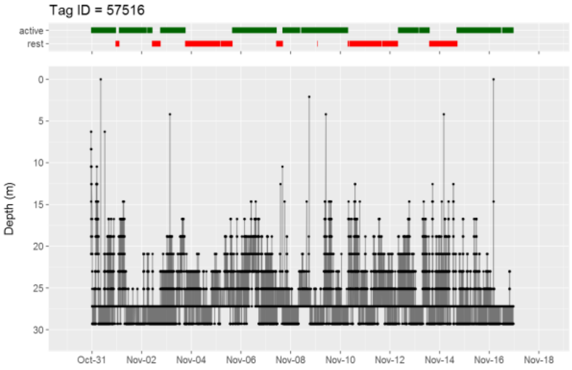
Nov-18


Tag ID = 57516
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rest
Depth (m)
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10
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Oct-31
Nov-02
Nov-04
Nov-06
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Nov-12
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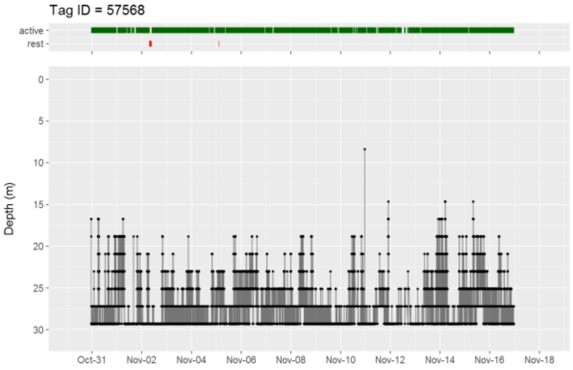
Nov-16
Nov-18


Tag ID = 57568
active
rest
Depth (m)
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10
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Oct-31
Nov-02
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Nov-06
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Nov-10
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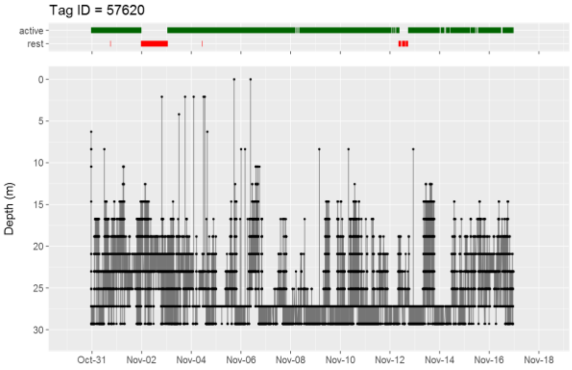
Nov-16
Nov-18


Tag ID = 57620
active
rest
Depth (m)
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10
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25
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Oct-31
Nov-02
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Nov-06
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Nov-12
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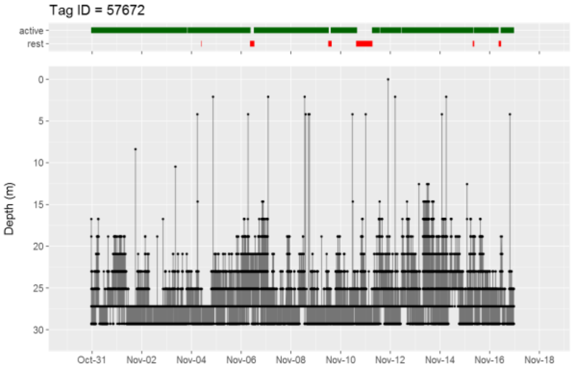
Nov-16
Nov-18


Tag ID = 57672
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rest
Depth (m)
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10
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25
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Oct-31
Nov-02
Nov-04
Nov-06
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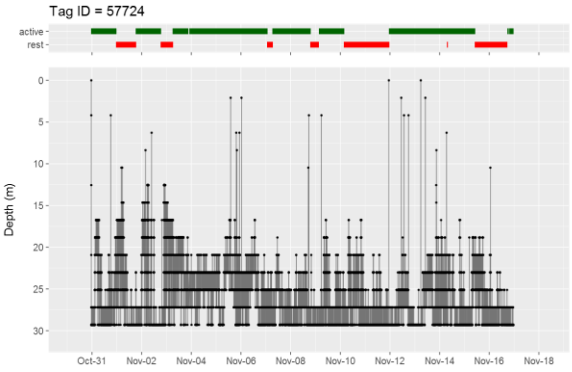
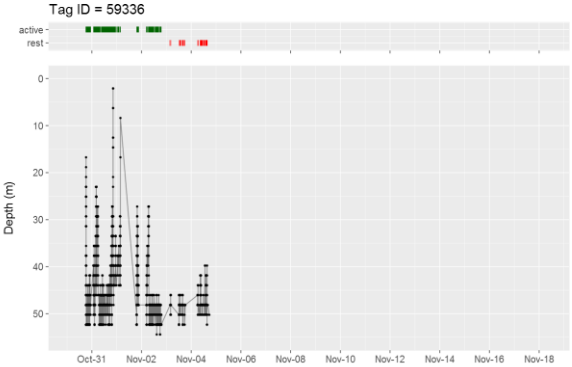
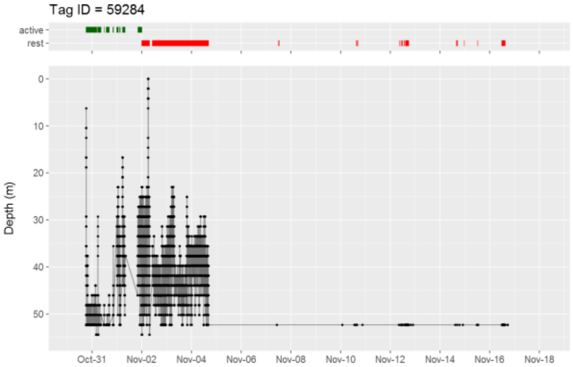
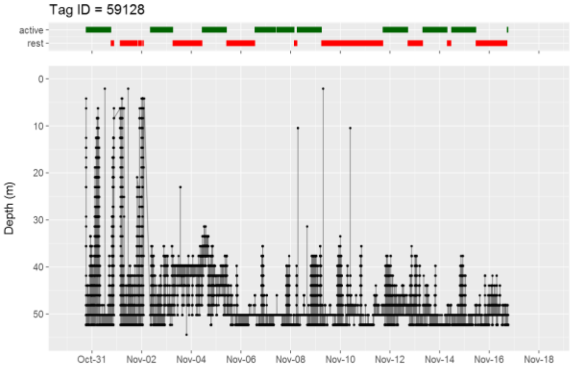
Nov-12
Nov-14
Nov-16
Nov-18

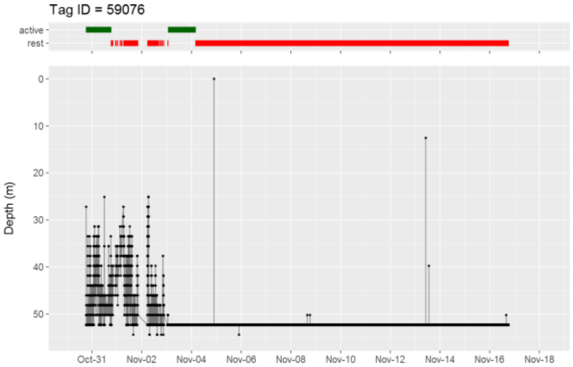

Tag ID = 57724
active
rest
Depth (m)
0
5
10
15
20
25
30
Oct-31
Nov-02
Nov-04
Nov-06
Nov-08
Nov-10
Nov-12
Nov-14
Nov-16
Nov-18

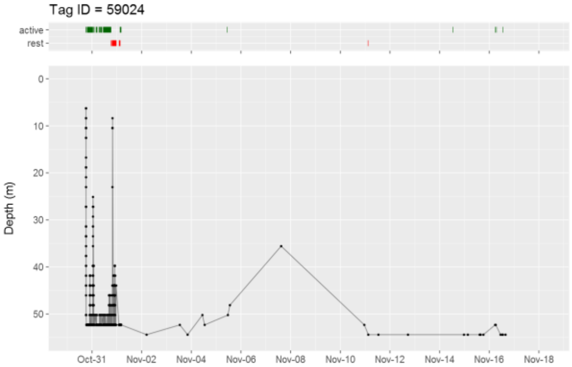
Appendix B: Acoustic Profiles at 50-m site

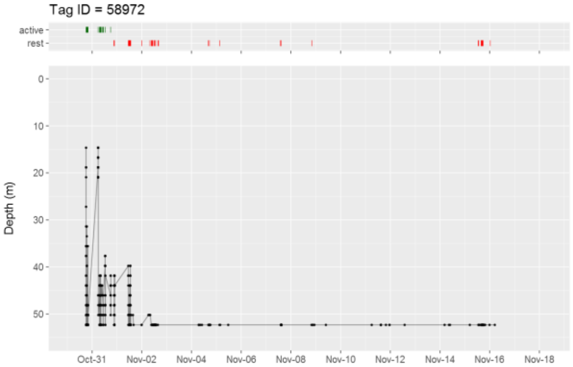

Tag ID = 59336

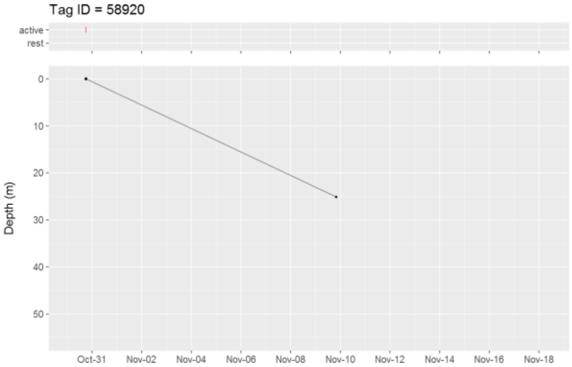

Tag ID = 59284

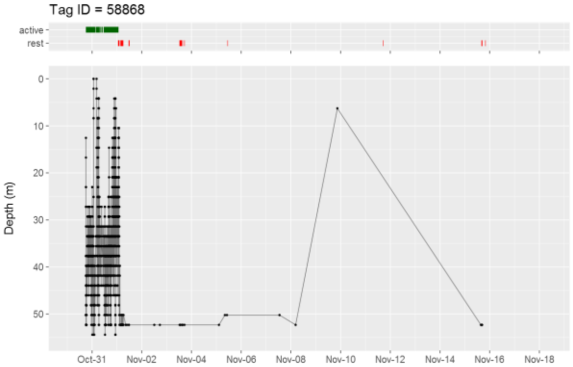

Tag ID = 59128

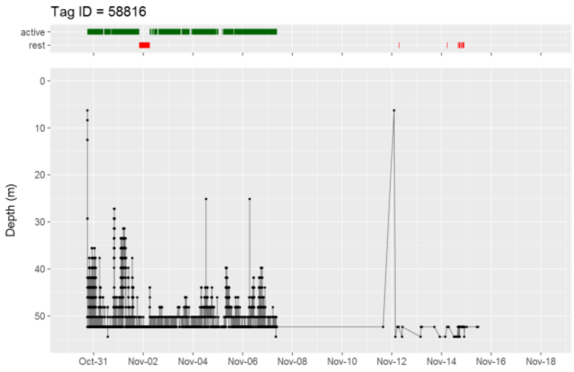

Tag ID = 59076


Tag ID = 59024


Tag ID = 58972


Tag ID = 58920


Tag ID = 58868


Tag ID = 58816
active
rest
Depth (m)
0
10
20
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Oct-31
Nov-02
Nov-04
Nov-06
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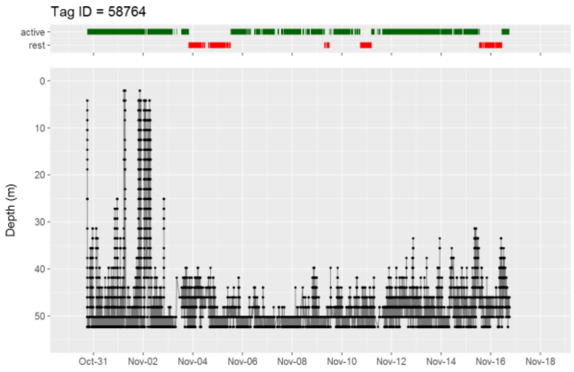
Nov-10
Nov-12
Nov-14
Nov-16
Nov-18


Tag ID = 58764
active
rest
Depth (m)
0
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Oct-31
Nov-02
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Nov-06
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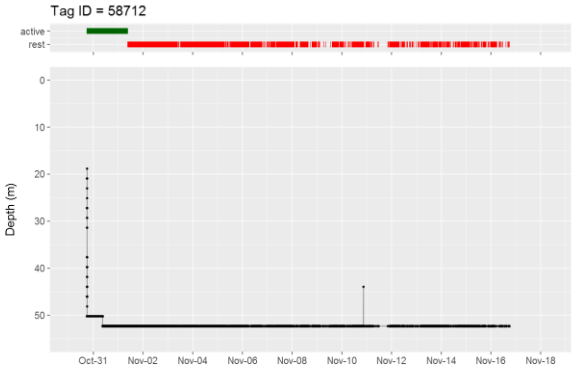
Nov-16
Nov-18


Tag ID = 58712
active
rest
Depth (m)
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Oct-31
Nov-02
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Nov-06
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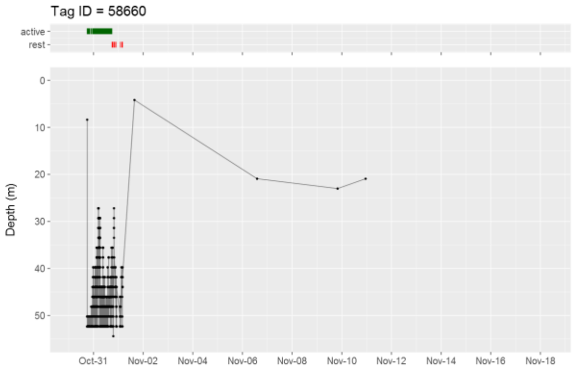
Nov-14
Nov-16
Nov-18


Tag ID = 58660
active
rest
Depth (m)
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Oct-31
Nov-02
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Nov-06
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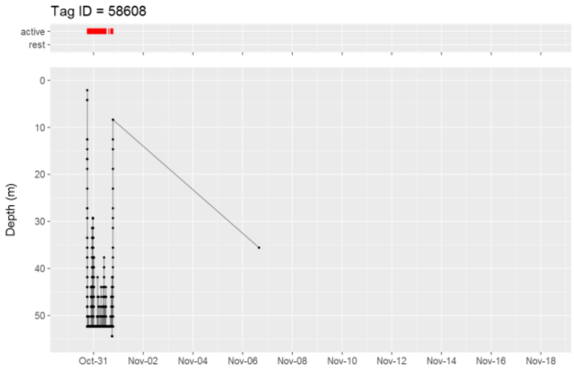
Nov-12
Nov-14
Nov-16
Nov-18


Tag ID = 58608
active
rest
Depth (m)
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Oct-31
Nov-02
Nov-04
Nov-06
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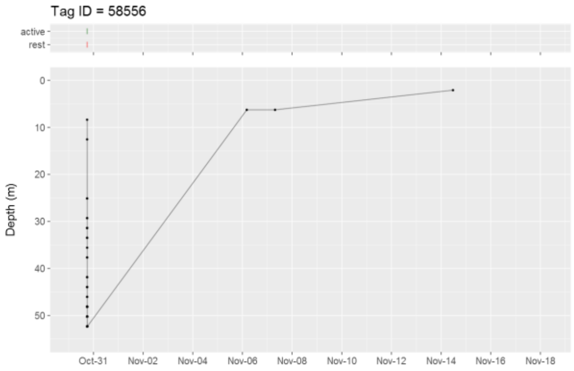
Nov-12
Nov-14
Nov-16
Nov-18


Tag ID = 58556
active
rest
Depth (m)
0
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Oct-31
Nov-02
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Nov-06
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Nov-12
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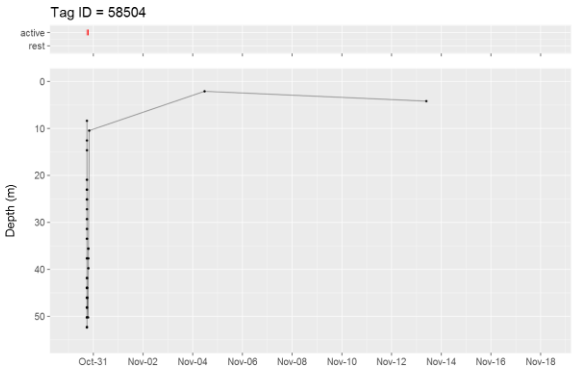
Nov-16
Nov-18


Tag ID = 58504
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rest
Depth (m)
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Oct-31
Nov-02
Nov-04
Nov-06
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Nov-12
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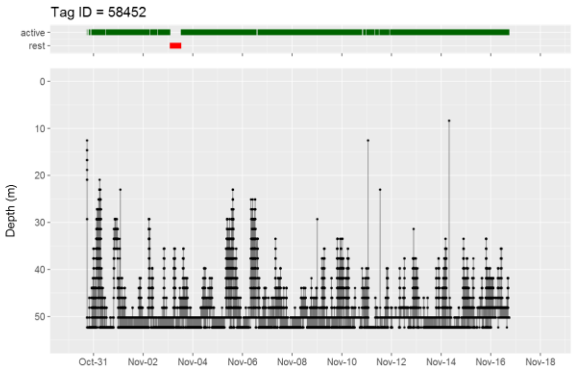
Nov-16
Nov-18


Tag ID = 58452
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rest
Depth (m)
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Oct-31
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Nov-06
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Nov-10
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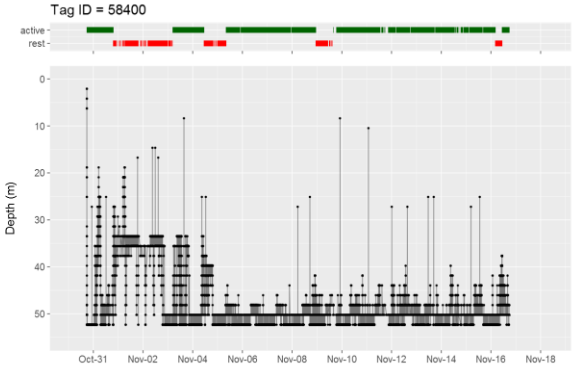
Nov-18


Tag ID = 58400
active
rest
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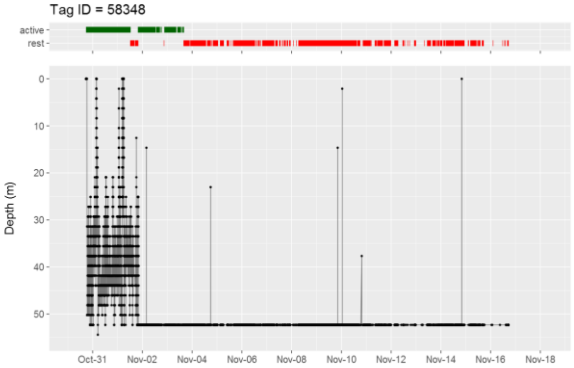
Tag ID = 58348
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Depth (m)
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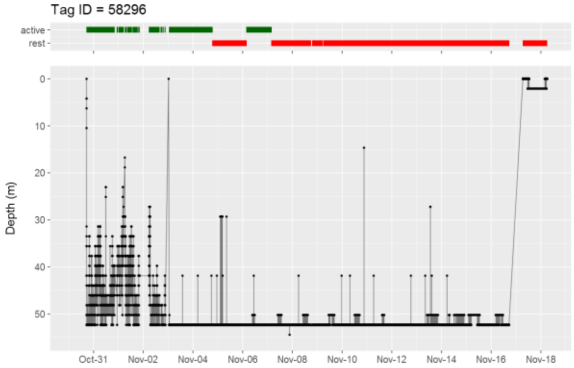
Nov-18


Tag ID = 58296
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rest
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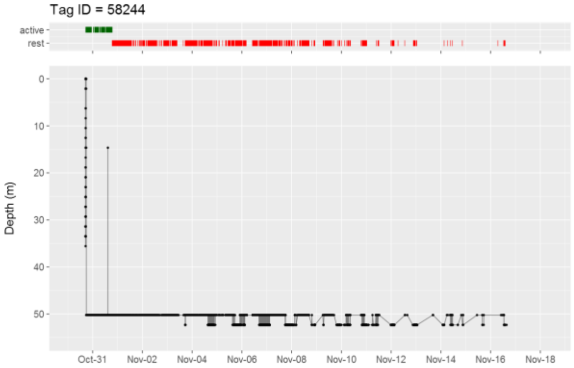
Nov-16
Nov-18


Tag ID = 58244
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Depth (m)
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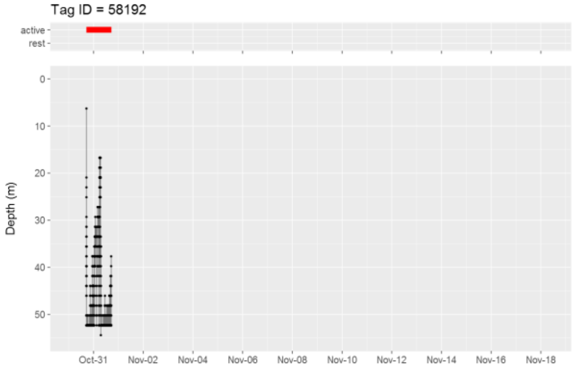
Nov-18


Tag ID = 58192
active
rest
Depth (m)
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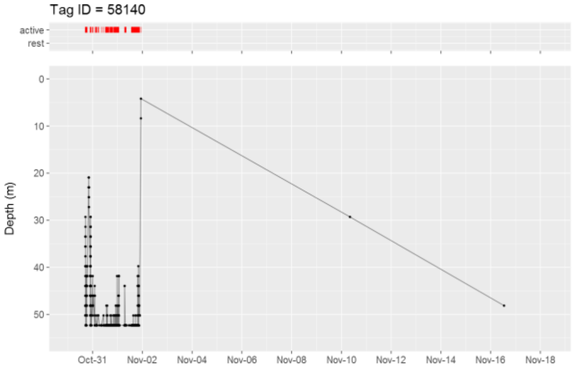
Nov-16
Nov-18


Tag ID = 58140
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rest
Depth (m)
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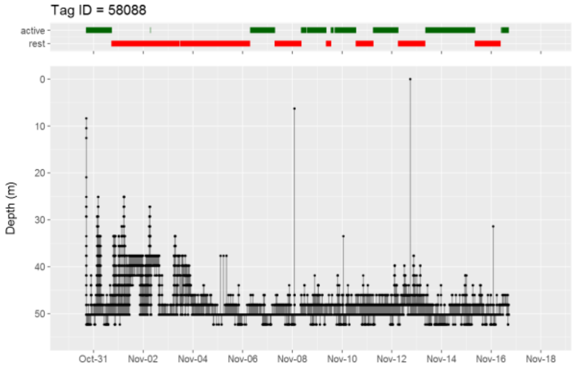
Nov-16
Nov-18


Tag ID = 58088
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rest
Depth (m)
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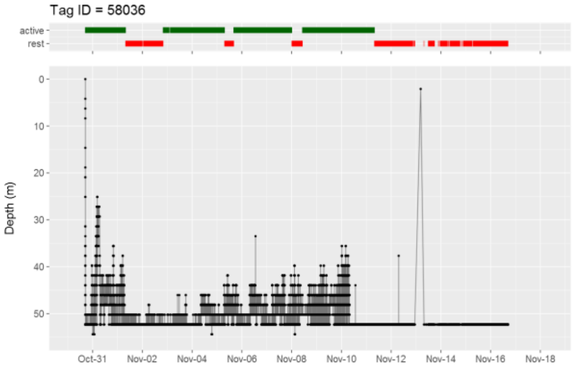
Nov-18


Tag ID = 58036
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rest
Depth (m)
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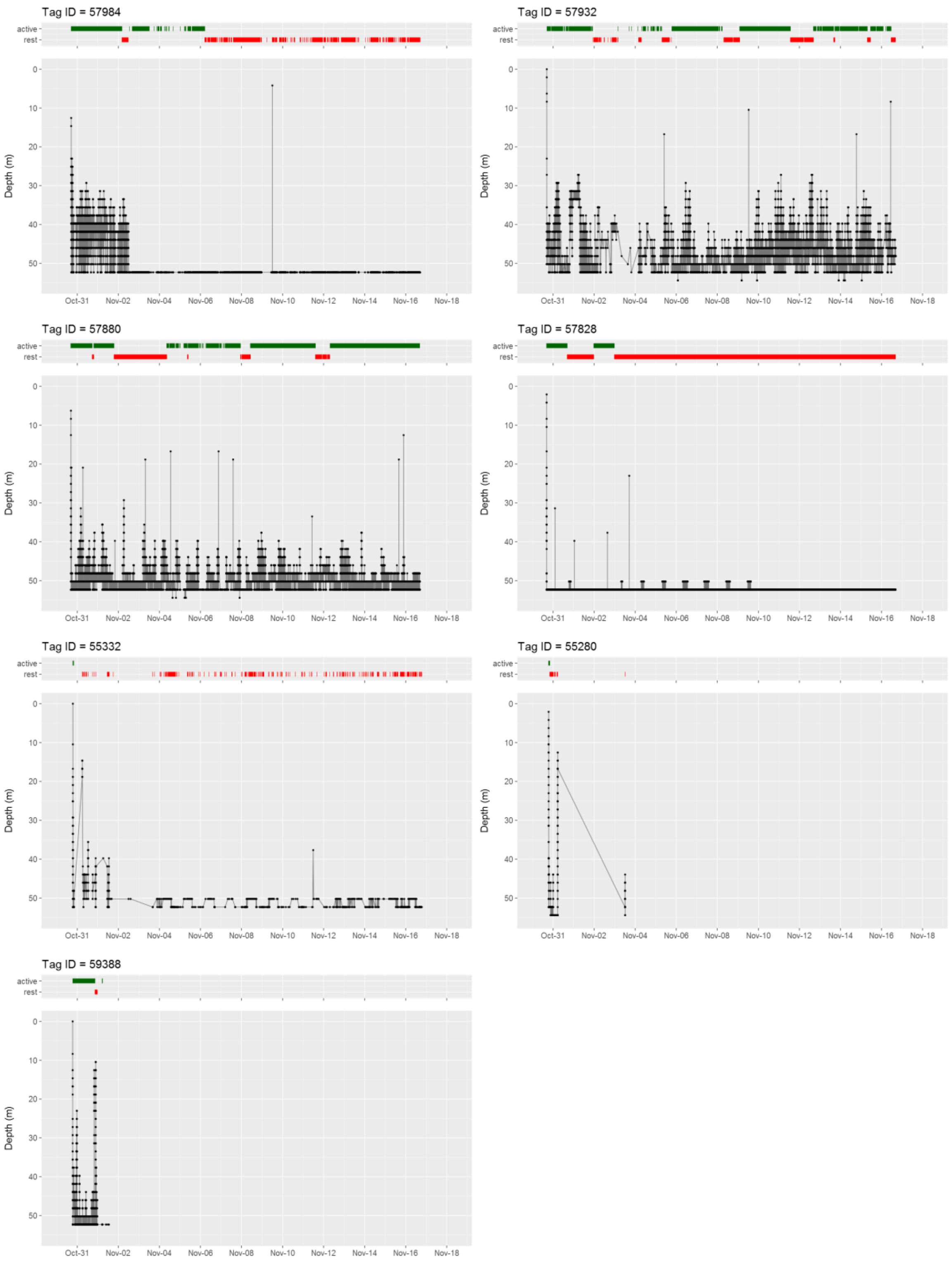
Nov-16
Nov-18


Tag ID = 57984
Tag ID = 57932
Tag ID = 57880
Tag ID = 57828
Tag ID = 55332
Tag ID = 55280
Tag ID = 59388
active
rest
Depth (m)
0
10
20
30
40
50
Oct-31
Nov-02
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Nov-06
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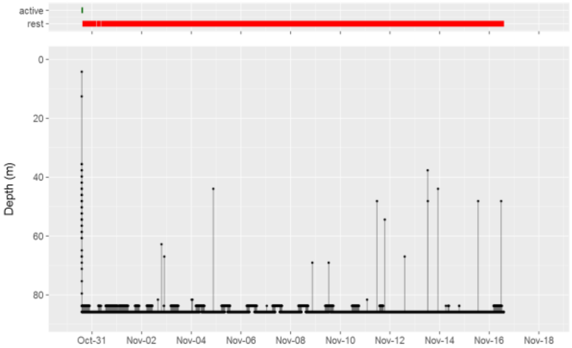
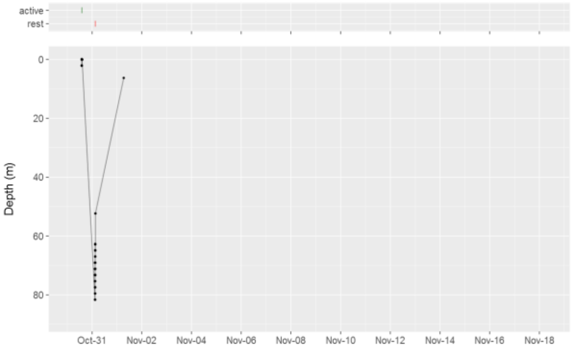
Nov-10
Nov-12
Nov-14
Nov-16
Nov-18

Appendix C: Acoustic Profiles at 80-m site

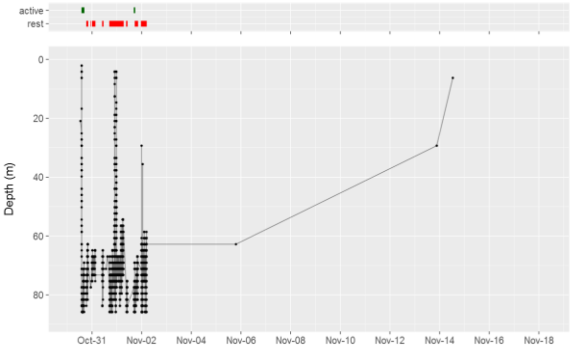
Tag ID = 56788



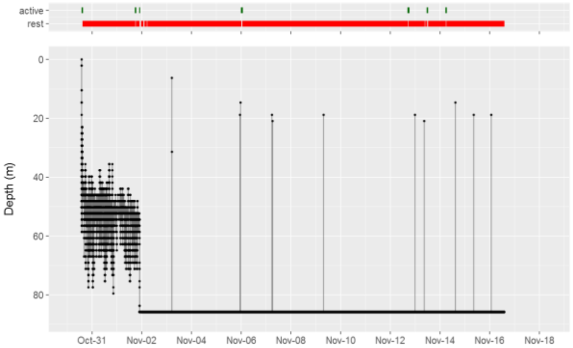
Tag ID = 56736



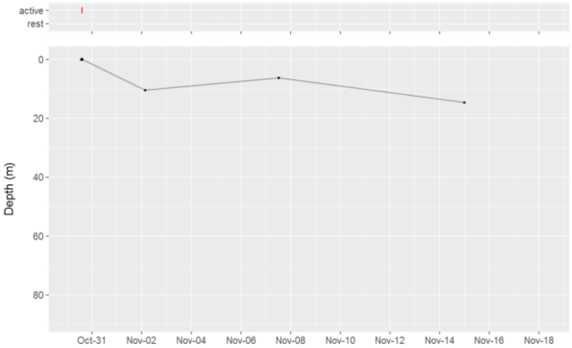
Tag ID = 56684



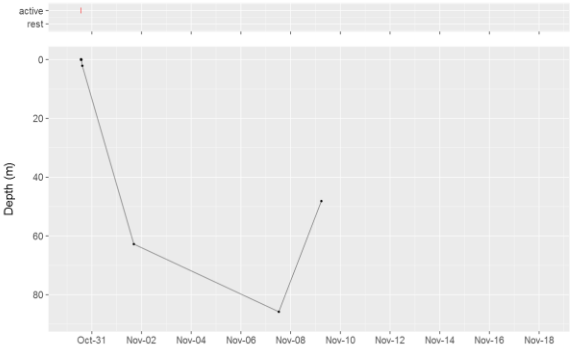
Tag ID = 56632



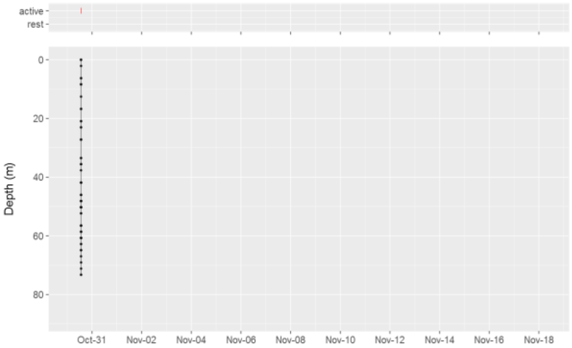
Tag ID = 56580



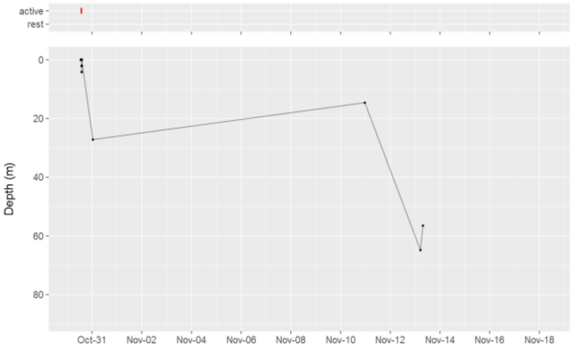
Tag ID = 56528

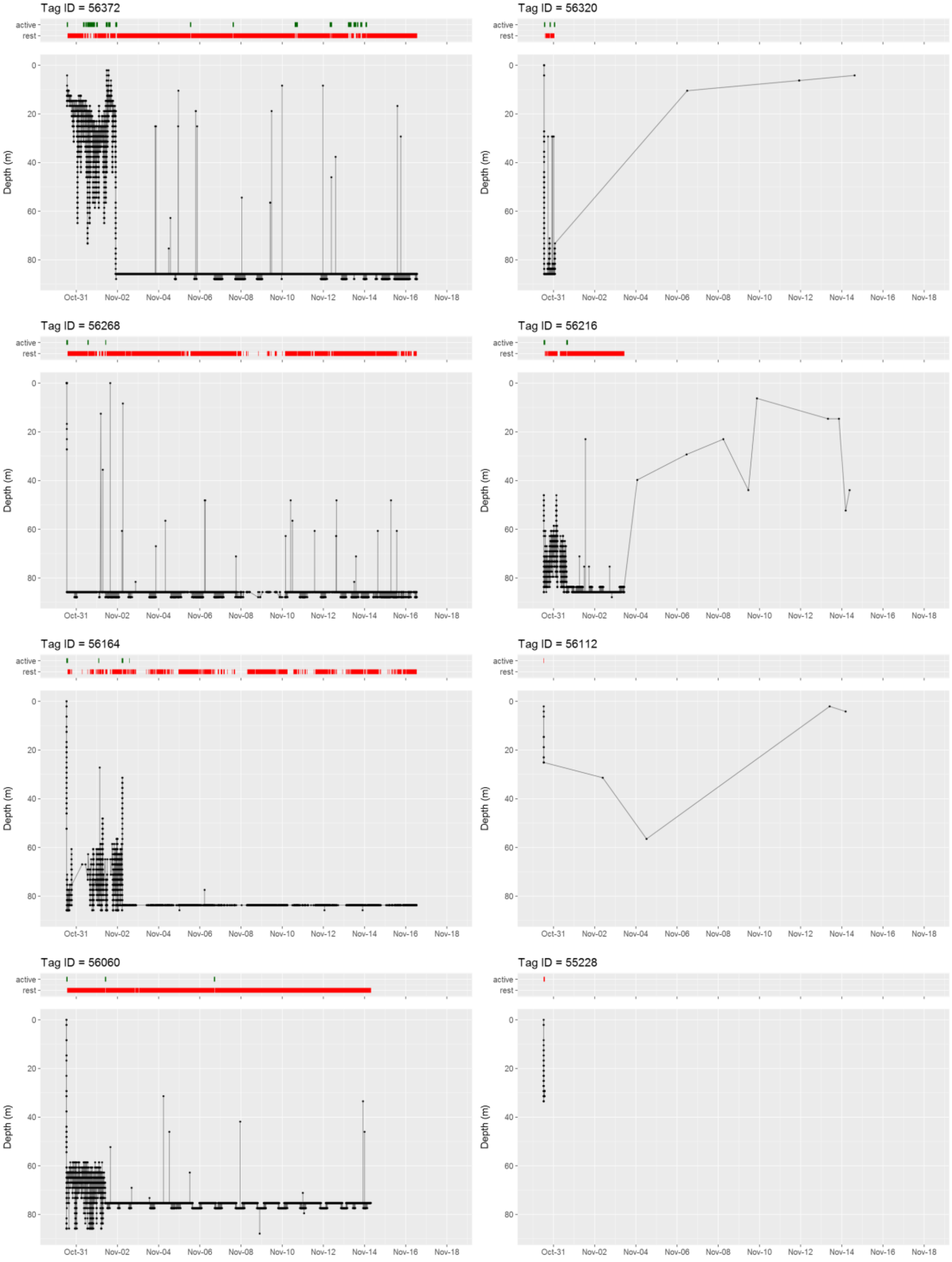


Tag ID = 56476



Tag ID = 56424




Tag ID = 56372
Tag ID = 56320
Tag ID = 56268
Tag ID = 56216
Tag ID = 56164
Tag ID = 56112
Tag ID = 56060
Tag ID = 55228
active
rest
Depth (m)
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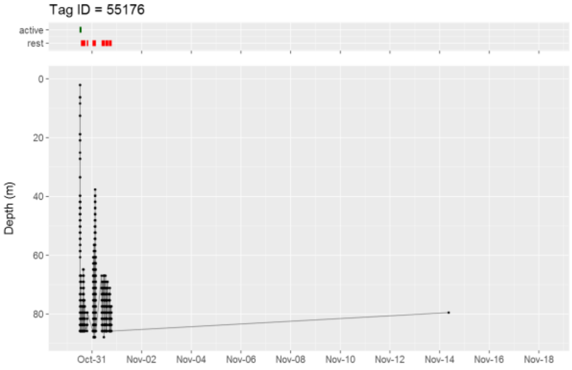
Nov-12
Nov-14
Nov-16
Nov-18


Tag ID = 55176
active
rest
Depth (m)
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60
80
Oct-31
Nov-02
Nov-04
Nov-06
Nov-08
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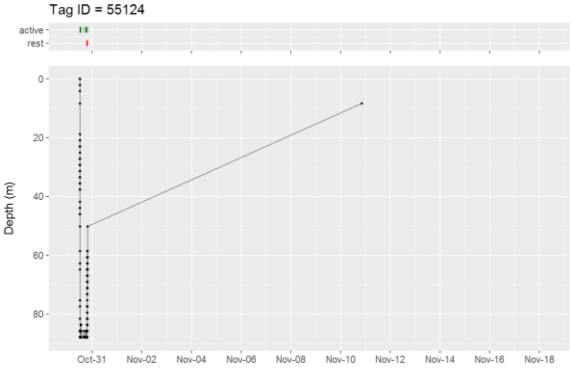
Nov-12
Nov-14
Nov-16
Nov-18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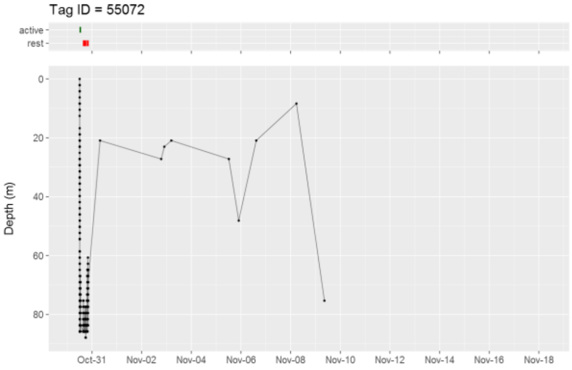
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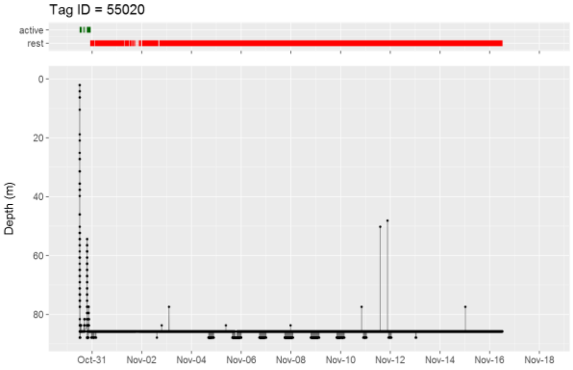
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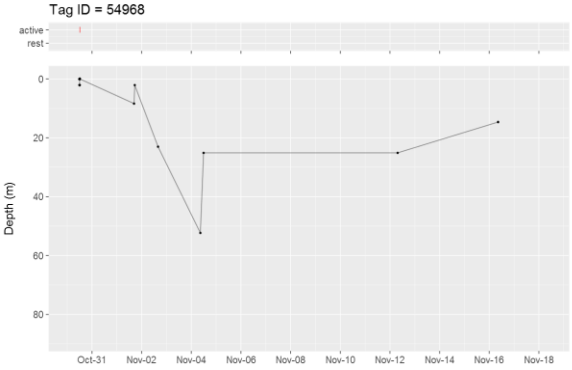
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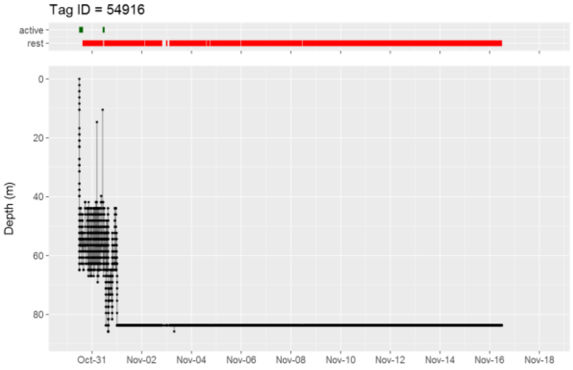
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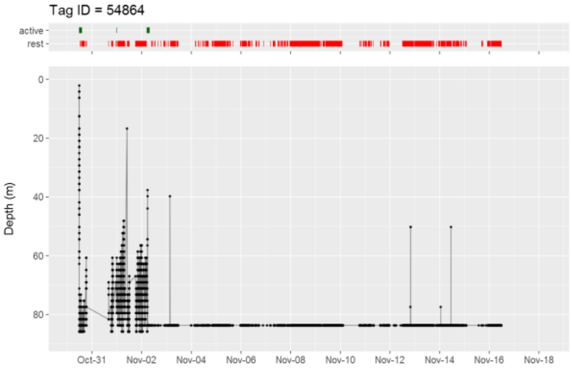
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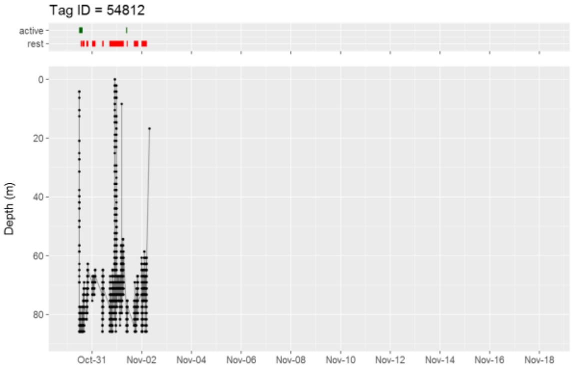
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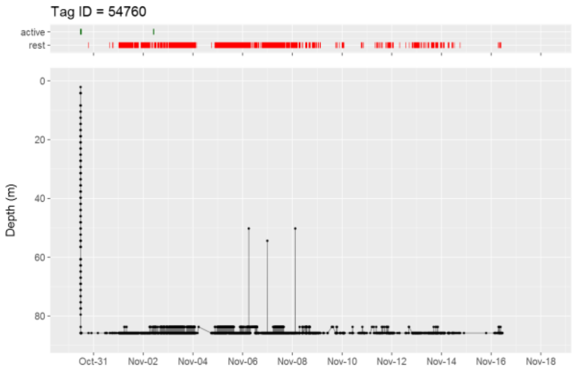
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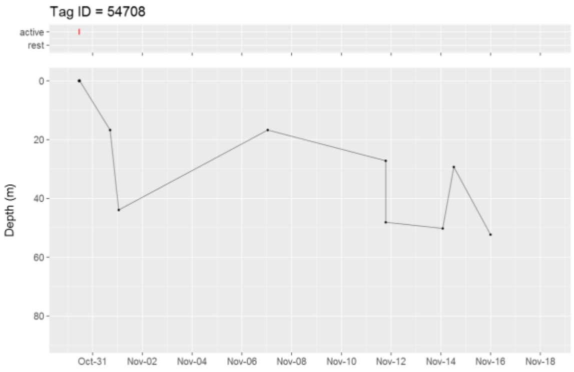
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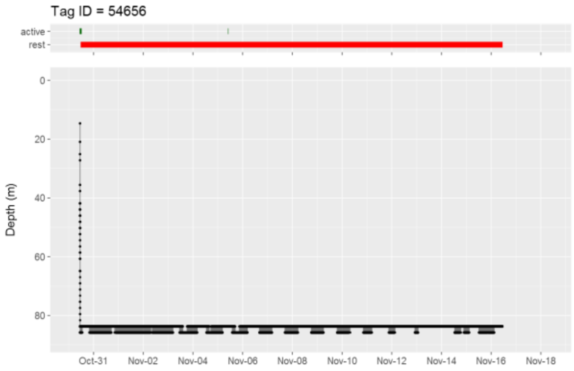
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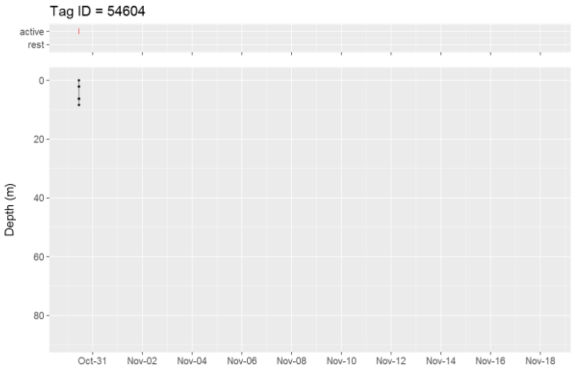
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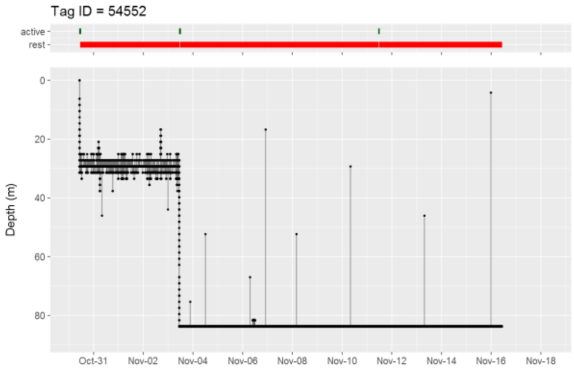
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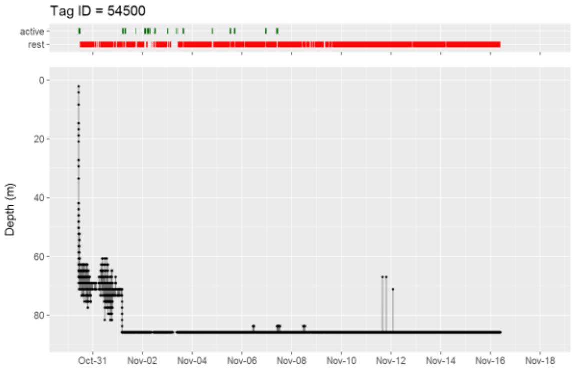
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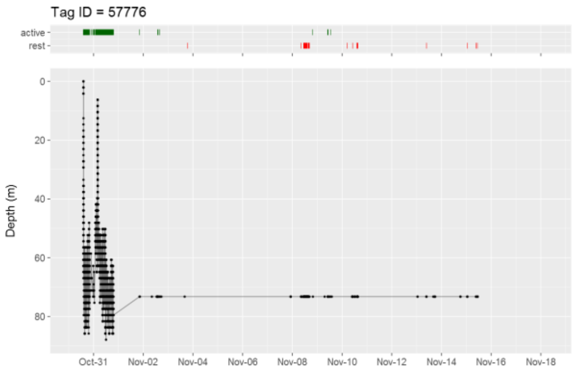
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Nov-16
Nov-18

Appendix D: Survey questions for stakeholder engagement

*1. Are you (check only one):

○ Charter boat captain/owner/operator
○ Head boat captain/owner/operator
○ Private recreational angler

*2. Did you receive your SeaQualizer:

○ Directly from a dockside interviewer
○ Via registration on the web
○ From state agency personnel (other than dockside)
○ Other (please specify)

☐

*3. From which state do you most often fish saltwater (choose only one):

○ AL
○ FL
○ GA
○ LA
○ MS
○ NC
○ SC
○ TX

*4. What material do you remember receiving or viewing when you registered for or received your device? (select all that apply)

☐ FishSmart Best Practices flyer/brochure
☐ "How to Use a SeaQualizer" video
☐ FishSmart Video
☐ I didn't receive or view any materials

Other (please specify) ☐

*5. Which of the following cues do you use on the water to decide when to use a descending tool or venting tool to release a fish (check all that apply):

☐ Fish appears bloated (inflated with air), but otherwise normal
☐ Stomach is protruding from mouth
☐ Eyes are bulging
☐ Fish appears sluggish or unresponsive when brought to the boat

☐ Fish is floating and unable to submerge

☐ I use a venting or descending tool on every fish, even if they exhibit none of the symptoms above

☐ I never use a venting tool or descending tool

☐ Other (please describe)

*6. Have you ever used a venting tool in the past?

○ Yes

○ No

○ I don't know what this is

*7. Why don’t you use a venting tool (check all that apply)?

☐ I don’t think it works

☐ It is too time consuming

☐ Fish are able to swim down without venting

☐ Other (please specify)

8. What percentage of fish do you believe survive the **venting** process? (Use slider bar to adjust percentage)

0 – 100 percent

*9. How much knowledge did you have about **descender** devices in general before acquiring your SeaQualizer?

○ None

○ Very little

○ Little

○ Moderate

○ High

○ Very high

*10. Considering your normal fishing activity, how likely are you to use a descender device to release fish when needed?

○ I would likely use it on all fish
○ I would likely use it on most fish
○ I would likely use it about half the time
○ I would likely use it on very few fish
○ I would not likely use it at all

*11. How helpful do you believe descender devices would be in reducing discard mortality in the Red Snapper fishery?

○ Not helpful
○ Very little
○ A little helpful
○ Moderately helpful
○ Helpful
○ Very helpful

12. What percent of fish do you estimate survive long-term after being released with a descender device (use slider bar to adjust percentages)?

0 – 100 percent

*13. When fishing for reef fish, what is your most common targeted fishing depth?

○ Less than 75 feet
○ 76-125 feet
○ 126-175 feet
○ 176-225 feet
○ 226-275 feet
○ Greater than 275 feet

*14. How many months have you had the SeaQualizer supplied as part of this program? (Use slider bar to indicate months)

0 (less than 1 month) 20 months

*15. On approximately how many trips did you use your SeaQualizer?

0 trips 100 or more trips

*16. Approximately how many fish have you released using the SeaQualizer?

	Red Snapper	Other Fish
None	☐ None Red Snapper	☐ None Other Fish
1-5 fish	☐ 1-5 fish Red Snapper	☐ 1-5 fish Other Fish
6-15 fish	☐ 6-15 fish Red Snapper	☐ 6-15 fish Other Fish

	Red Snapper	**Other Fish**
16-30 fish	☐ 16-30 fish Red Snapper	☐ 16-30 fish Other Fish
31-50 fish	☐ 31-50 fish Red Snapper	☐ 31-50 fish Other Fish
51-75 fish	☐ 51-75 fish Red Snapper	☐ 51-75 fish Other Fish
More than 75 fish	☐ More than 75 fish Red Snapper	☐ More than 75 fish Other Fish
I have no idea	☐ I have no idea Red Snapper	☐ I have no idea Other Fish

*17. After trying out the device, which release tool do you prefer to use for fish exhibiting barotrauma?

○ Descending tool
○ Venting tool
○ Neither
○ Both

*18. How many other people have you talked with about descender devices or have you involved in the use of your SeaQualizer?

	None	**1-5**	**6-10**	**11-15**	**More than 15**
Other Fisherman	○ Other Fisherman None	○ Other Fisherman 1-5	○ Other Fisherman 6-10	○ Other Fisherman 11-15	○ Other Fisherman More than 15
Customers (charter or head boat)	○ Customers (charter or head boat) None	○ Customers (charter or head boat) 1-5	○ Customers (charter or head boat) 6-10	○ Customers (charter or head boat) 11-15	○ Customers (charter or head boat) More than 15
Non-Fisherman	○ Non-Fisherman None	○ Non-Fisherman 1-5	○ Non-Fisherman 6-10	○ Non-Fisherman 11-15	○ Non-Fisherman More than 15

*19. Part 1 is complete and you can choose to enter a drawing to win a Shimano Talica 16II two-speed lever drag reel, or a Shimano Terez extra heavy fast action 6’6” rod.

Would you be willing to answer a few more questions for a chance to win a Shimano Talica 25II two-speed lever drag reel,or a Shimano Tallus roller stripper tip medium heavy fast action 5’9” rod ?

○ Yes
○ No thanks

*20. How many years have you been fishing for reef fish?

○ Less than 1 year

○ 1 - 4
○ 5 - 10
○ 11 - 20
○ More than 20

*21. How many days did you fish for reef fish in the last year?

○ 0
○ 1-5
○ 6-10
○ 11-20
○ More than 20

*22. What distance from shore do you most often fish when fishing for reef fish?

○ 0-10 miles
○ 11-20 miles
○ 21-30 miles
○ 31-40 miles
○ 41-50 miles
○ 51-60 miles
○ 61-80 miles
○ More than 80 miles

The following questions are for statistical purposes only and will not be associated with your name or any other personally identifiable information.

*23. What is your 5-digit zip code?

*24. What is your gender?

○ Male
○ Female
○ Would rather not say

*25. What is your highest level of education?

○ Grammar School
○ High School or equivalent
○ Vocational or Technical School
○ Bachelor's Degree
○ dMaster's Degree
○ Doctoral Degree

○ Professional Degree (MD, JD, etc.)
○ Would rather not say
○ Other (please specify)

*26. What is your age?

○ 25 or under
○ 26 - 40
○ 41 - 55
○ 56 - 65
○ 66 or older
○ Would rather not say

*27. What is your current household income (include total income from all working members in the household)?

○ Under $10,000
○ $10,001 - $25,000
○ $25,001 - $50,000
○ $50,001 - $75,000
○ $75,001 - $100,000
○ $100,001 - $150,000
○ More than $150,000
○ Would rather not say

28. Do you have any comments or thoughts regarding your participation in this program or use of descending devices?