Cooperative Research Program Final Report: Estimating Gulf of Mexico Gray Triggerfish Release Mortality and Its Mitigation with Three-Dimensional Acoustic Telemetry

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Executive Summary

High-resolution three-dimensional (3D) acoustic telemetry was utilized to estimate gray triggerfish discard mortality in a 24.6 km^2 acoustic array (n = 59 receivers) deployed around a series of artificial reefs (n = 7) at approximately 30 m depth in the north central Gulf of Mexico (GOM). Fish were captured with standard hook-and-line gear, tagged externally with Innovasea V13P acoustic tags, and released at the surface, at the surface following venting, or at depth with a descender device. Experimental fishing and fish tagging occurred in winter and summer 2021, with 60 gray triggerfish captured and released in each season. Tags were programmed to transmit data every 1 to 3 minutes, with transmission timing randomized to minimize potential tag collisions. The maximum number of detections of a given tag within the acoustic array was 23,083, and the maximum number of days a tag was tracked was 242. However, both of those tags were estimated to have become detached from fish much earlier than the total days tracked. The longest time period a fish was tracked alive and swimming in the array was 115 days at 18,678 detections. Geoposition data from individual gray triggerfish demonstrated a consistent pattern of limited movement and nearly fixed depth from around midnight to 8 a.m., which was important to recognize when assigning fate to tagged fish. Estimated speed and depth differential between sequential detections suggested it took up to a month for fish to fully recover from catch and release, although it is unclear how much the tagging process added to recovery time.

Fate of released fish was assigned by examining movement patterns, speed, and depth profiles of acoustic tags, with potential fates including fish being alive in the array, dead on the seabed, consumed by a predator, emigration out of the array, tag loss, harvest, or tag failure. Cox proportional hazards modeling indicated there was no significant effect of release method on gray triggerfish mortality, with the most parsimonious model (evaluated with ΔAICc) including season (winter versus summer), fish length, time out of water, and condition as independent variables. Winter discard mortality (± 95CI) was estimated to be 5.8 (± 5.2) % after 48 hours and 7.1 (± 6.2) % after 14 days. The same estimates for summer were considerably higher, at 34.7 (± 11.8) and 41.1 (± 12.2) %, respectively. Nearly all the mortality suffered by acoustically tagged fish was due to being eaten by large predators (i.e., sharks and dolphins), which was based on direct observation or examination of acoustically tracked movement dynamics of released fish versus positive (live) or negative (dead) controls tagged on the seafloor. It is unclear what affected the presence of large

predators in summer versus winter, but when present predators had a substantial effect on gray triggerfish discard mortality irrespective of release method.

Attempts to simulate the effects of higher discard mortality on the gray triggerfish stock assessment were unsuccessful. Our proposed plan was to utilize the SEDAR 62 GOM gray triggerfish stock assessment model as an operating model and then conduct simulations with the R package *SS3sim* to test the effects of different discard mortality rates on estimates of stock productivity and status. Unfortunately, the SEDAR 62 process was terminated following the assessment workshop stage due to data issues and structural issues with the assessment model, hence the assessment was never completed. Therefore, we attempted to conduct discard mortality simulations with the SEDAR 43 (2015) gray triggerfish assessment model, but discovered structural issues also exist with that model which precluded its use for simulation testing. An update SEDAR GOM gray triggerfish stock assessment is scheduled for 2024 to evaluate and revise the SEDAR 43 base model. Included in the terms of reference is examination of the effects of revised discard mortality estimates on the model.

Introduction

Marine fisheries bycatch is a significant global issue that is anathema to efficient utilization of fishery resources, as well as counter to principles of ecosystem-based fisheries management. Globally, calls to address and minimize bycatch have resonated for more than two decades (Crowder and Murawski 1998; Hall et al. 2000; Francis et al. 2007), and in the U.S. minimizing bycatch and the mortality of bycatch, to the extent practicable, are among the National Standards of the Magnuson-Stevens Fishery Conservation and Management Act. While progress has been made in this respect, until recently bycatch issues in commercial fisheries received much greater attention in the scientific literature and among marine fisheries management agencies than those related to recreational fishing. This is partly due to the fact that commercial fisheries are implicated more often than recreational fisheries in the bycatch of non-targeted megafauna, such as marine turtles, birds, mammals, or elasmobranchs (Lewison et al. 2004; Read et al. 2006; Mandelman et al. 2012). However, it may also stem from an historic underestimation of the effect of recreational fisheries on targeted fishes and on marine ecosystems in general (Post et al. 2002; Cooke and Cowx 2004; Arlinghaus et al. 2007; Kerns et al. 2012; Raby et al. 2013). For example, Coleman et al. (2004) estimated that recreational fisheries' impacts in the northern Gulf of Mexico (nGOM) rivaled and even surpassed those of commercial fisheries, especially among species of concern, and many of the species of concern highlighted by Coleman et al. (2004) are depleted reef fishes, such as gray triggerfish.

Reef fishes in the nGOM are particularly prone to discard mortality given the substantial increase in regulatory discards in recent years (SEDAR 43), and the fact that these physoclistous fishes often suffer significant barotrauma associated with being caught at depth and brought to the surface rapidly. Red snapper, *Lutjanus campechanus*, has received the greatest amount of attention with respect to discard mortality estimates (Campbell et al. 2014; Bohaboy et al. 2020), which is perhaps unsurprising given its importance to the nGOM reef fish fishery and the number of conventional and acoustic tagging studies that have been performed on red snapper. Among published studies, red snapper discard mortality estimates vary widely, which reflects myriad factors, such as time of year, depth of capture, and means of observation (Campbell et al. 2014). For example, fish placed in cages, thus protected from predators, or those only observed at the surface following release, produced the lowest estimates of discard mortality.

Most recently, large-scale (20 km^2) three-dimensional (3D) acoustic telemetry produced estimates of red snapper discard mortality for surface-released fish that were among the highest yet reported for that species (Bohaboy et al. 2020). However, the authors also reported return-to-depth tools, also known as descender devices, decreased red snapper discard mortality by approximately 50%. Utilizing a large-scale telemetry array in which fish geoposition (latitude/longitude) could be estimated, coupled with depth data from acoustic tags with pressure sensors, enabled fish to be tracked three-dimensionally, thus fate could be assigned more accurately to released fish. For example, in earlier acoustic telemetry studies red snapper that left the region of detection within 48-96 hours were censored from the data as émigrés. Bohaboy et al. (2020) reported most red snapper that rapidly disappeared from arrays deployed at 30 m or 60 m depths off Pensacola, FL or Orange Beach, AL were in fact consumed by large predators, such as sharks or dolphins. They were able to estimate that particular fate (predation) by tracking acoustically tagged bull sharks in study acoustic arrays that demonstrated large predators moved at mean speeds of ~1.5 m/sec, while red snapper typically moved at <0.5 m/sec. Furthermore, while red snapper moved among reefs located in study arrays, they typically stayed with ~100 m of a given reef. Large pelagic predators did not display a similar affinity for reef structure. Collectively, these results indicate large-scale 3D telemetry is an effective tool to examine reef fish movement and fate, including post-release fate (Donaldson et al. 2008; Raby et al. 2013), and previous approaches likely greatly underestimated the amount of predation mortality suffered by discarded red snapper (Bohaboy et al. 2020).

Gray Triggerfish

Gray triggerfish, *Balistes capriscus*, is frequently captured along with snappers, groupers, and other reef fishes in mixed reef fisheries of the nGOM and US Atlantic. Historically, gray triggerfish was not a targeted species, but increasing regulations on other species, such as red snapper and gag, *Mycteroperca microlepis*, and a growing appreciation for quality of gray triggerfish meat, caused it to become increasingly targeted in the 1990s and early 2000s. The GOM stock was estimated to be overfished and undergoing overfishing in 2006 via an integrated assessment model with data through 2004 (SEDAR 2006). A rebuilding plan (RF 30A) was implemented for the stock within the Reef Fish (RF) Fishery Management Plan by the Gulf of Mexico Fishery Management Council (GMFMC) in July 2008. Seasonal closures in the recreational fishery were first implemented through a revised rebuilding plan (RF 37) in May 2013 in response to an updated assessment that indicated a lack of recovery in the GOM gray triggerfish stock (SEDAR 2011). A 12-fish commercial trip limit was also instituted as part of RF 37. A subsequent stock assessment continued to fall shore of recovery targets established in the GOM gray triggerfish rebuilding plan (SEDAR 2015). In 2018, the passage of RF 46 increased the commercial trip limit to 16 fish, reduced recreational bag limit to 1 fish per person day, and increased the recreational minimum size limit to 15” fork length.

There are several sources of uncertainty that complicate assessment, hence management, of GOM gray triggerfish. Recruitment dynamics do not appear to be well estimated in the Stock Synthesis (SS) assessment model, given most of the adult biomass is estimated to occur in the eastern GOM, while most of the recruitment is estimated to occur in the western GOM (SEDAR 2015). Another issue is the traditional method of ageing gray triggerfish with dorsal spines underestimates age for age-5+ fish (Patterson et al. 2019), with underestimation becoming progressively worse with age (Chamberlin 2022). Chamberlin (2022) demonstrated through stock assessment simulations that underestimating age causes overestimation of growth, stock productivity, and spawning stock biomass, as well as underestimation of fishing mortality. Lastly, recent evidence suggests the historical assumption of 5% discard mortality for gray triggerfish regulatory discards is likely to be inaccurate. For example, Bohaboy et al. (2020) employed 3D acoustic telemetry to estimate surface-released gray triggerfish captured at approximately 30 m in the nGOM suffered 26.7% mortality, although small sample size (n = 16) in a study focused on red snapper imparted considerable uncertainty in that estimate (e.g., 95CI: ±22.3%). Even greater uncertainty exists in their estimate of discard mortality for gray triggerfish (n = 10) returned to depth with a descender device (60.7 ± 30.4%), which was higher but not significantly different than their surface release estimate. Runde et al. (2019) estimated the mean discard mortality rate of conventionally tagged gray triggerfish was approximately 65% (± 25%) in U.S. Atlantic waters off North Carolina and Florida despite fish often lacking obvious external symptoms of barotrauma. However, necropsies performed on sacrificed fish indicated extensive internal organ damage was often present despite a lack of external symptoms, such as the presence of exophthalmia, a distended esophagus, or a prolapsed intestine.

The dramatic difference between the previously assumed discard mortality estimate utilized in GOM gray triggerfish stock assessments (5%) versus the new estimates produced by Runde et al. (2019) and Bohaboy et al. (2020) take on greater importance given recent trends in gray triggerfish landings versus discards. Quotas and seasonal closures have curtailed landings in recent years, but this has also caused a substantial increase in the percentage of captured gray triggerfish that are returned to the sea as discards. For example, nearly all of the gray triggerfish commercial catch and >75% of the recreational catch is discarded (SEDAR 2015). Therefore, if discard mortality estimates are as high as 30-60%, then assuming a discard mortality rate of 5% would substantially underestimate annual fishery removals from the GOM gray triggerfish stock.

The goal of this study was to estimate gray triggerfish discard mortality with high-resolution 3D telemetry in the nGOM, as well as test the efficacy of different approaches to mitigate discard mortality. Specific study objectives were to 1) employ 3D acoustic telemetry to estimate the fate (e.g., survival, mortality, depredation, emigration, etc.) of gray triggerfish captured with standard recreational fishing gear in the nGOM; and, 2) estimate the efficacy of descender devices or venting to mitigate discard mortality. A third proposed objective was to conduct stock assessment simulations to examine the effect of higher (study estimates versus the current assumption of 5%) discard mortality on the SEDAR 62 gray triggerfish stock assessment scheduled for 2019-20. However, that assessment was abandoned due to data and model structural issues, and preliminary model runs with the previous (SEDAR 43) assessment model indicated structural issues existed with that model as well.

Methods

Acoustic Array

We deployed an acoustic array consisted of 59 Innovasea VR2 Tx receivers with inter-receiver spacing of 424 m (Fig. 1). This spacing was based on range testing and post-tagging analysis conducted by Bohaboy et al. (2020). The array was deployed on January 13-14, 2021 in the Escambia East-Large Area Artificial Reef Site (EE-LAARS). The center receiver was approximately 32 km south-southeast of Pensacola Bay Pass, Florida, and the water depth range in the array was 28-32 m (Fig. 1). The benthic habitat within the array area is characterized primarily by fine sand and shell rubble bottom and included 11 known artificial reefs, some of which were deployed by the Florida Fish and Wildlife Commission in 2003. Other undocumented private artificial reefs are also likely present in the southeast portion of the array area (Bohaboy et al. 2020).

Each receiver was attached to the top of a 2-m tall PVC support pipe that was set in a 36-kg cement anchor (Fig. 2). Several grab lines were attached between the cement anchor and the riser that could be used as hoist points during deployment and retrieval. All receiver bases had a line attached to a syntactic foam buoy approximately 2 m above the receiver to increase visibility to sonar (Fig. 2c). A HOBO U26-001 dissolved oxygen sensor was deployed on the receiver riser at the center of the array approximately 1 m above the seabed.

Array deployment and retrieval were conducted onboard the *F/V Intimidator* out of Orange Beach, Alabama with study cooperator, Captain Johnny Greene, and his crew. The array remained on the seabed through two rounds of tagging in winter and summer 2021, as well as tagging positive and negative control fish in fall 2021. The array was then removed from the water between October 25 and November 13, 2021. A line was attached to each receiver with the ROV-mooring hook method described by Tarnecki and Patterson (2020), and then was winched to the surface. All study receivers were successfully retrieved from the seabed.

Tagging

Tagging events occurred during winter and summer 2021 to test the effect of season on gray triggerfish discard mortality. Gray triggerfish and other reef fishes were captured with two-hook (3/0 to 5/0 Mustad model 39945BLN) rigs at artificial reef sites within the study area (Fig. 1), with hooks baited with cut squid or mackerel scad. Each gray triggerfish was held in a silicone-lined V-shaped measuring board, measured to the nearest mm fork length (FL), and tagged with an Innovasea V13P high output (153 db) acoustic tag and a Floy dart tag, with the latter advertising a $50 reward and toll-free phone number to report tagged fish. External symptoms of barotrauma (exophthalmia, everted esophagus or stomach, or prolapsed intestine), degree of abdominal rigidity (1 = fully pliable to 5 = stiff and inflexible), and total time out of water for dehooking and tagging were recorded.

A logistic regression was computed to test the effect of fish FL on the probability of observing external barotrauma symptoms. A one-factor ANOVA was computed to test the effect of fish size class (250-350, 350-450, and 450-550 mm FL) on abdominal rigidity score. And, a student's t-test was computed to test the effect of season on time out of water. All analyses were computed in R (R Core Team, 2021).

Acoustic tags transmitted a unique acoustic ID code and pressure value at random intervals between 1 and 3 minutes. As configured, Innovasea estimated the battery life of these tags at 468 days. Tags were attached to fish externally to ensure rapid tagging and the least intrusive tagging process possible. There were two different tag attachment methods used in this study, with method-I being utilized in winter (March 3rd and 4th) 2021 and method-II being utilized during summer (July 22nd and 27th) 2021. In method-I, tags were attached to Domeier dart heads that are constructed of a soft polymer and Dacron® surgical polymer fibers that are designed to heal into the muscle tissue of tagged fish. These dart heads have been used to quickly attach acoustic or satellite tags to tunas (Domeier et al. 2005), sharks (Rogers et al. 2013), and reef fishes (Bohaboy et al. 2020; Angela Collins, pers. comm.), thus minimizing handling time. Each V13P tag was attached to a medium-sized Domeier dart head with approximately 3 cm of polymer coated braided stainless steel fishing line. Marine heat-shrink tubing was applied over the V13P tag cap to reduce movement and friction against the side of the fish (Fig. 3a).

Two of three winter-tagged fish were harvested and reported by fishers in mid-May 2021, with only the Floy tag remaining in the fish. We had no way to estimate the extent of tag loss among all samples, and our plan was to wait until fall 2021 to retrieve receivers. Therefore, for summer 2021 tagging we switched to the tag attached approach reported by Bohaboy et al. (2020)

since we had earlier success acoustically tagging gray triggerfish with that approach. With this second attachment method, a tag was secured to an American National Standards Institute size 2 (approximately 2 mm diameter) threaded stainless steel rod with a nylon-insert 6.35-mm stainless steel hex nut. The stainless steel rod was sharpened on one end and inserted through the fish's dorsal pterygiophores and secured on the opposite side of the fish with a second 6.35-mm stainless steel hex nut behind a 3.2-mm thick polyethylene disk. Silicon disks (2.4−3.2 mm thick) were placed behind the tag and the polyethylene disk to minimize abrasion (Fig. 3b).

Once tagged, fish were released with one of three methods: at the surface, at the surface following venting with an Angler's Choice FVT-001 venting tool, or returned to depth with a Seaqualizer descender device (Fig. 3b). A downward looking GoPro Hero5 camera was mounted above the descender device to record fish fate during descent and release to evaluate the performance of the descender device, behavior of released fish, and possible predator interactions. Fish released at the surface were assessed for release condition following Patterson et al. (2001): condition-1 = fish immediately oriented to the bottom and swam down rapidly; condition-2 = fish oriented to the bottom and swam down slowly or erratically; condition-3 = fish remained on the surface; and condition-4 = fish was apparently dead at the surface, including from predation. Condition for fish released at depth with the descender device were estimated to be in condition-1.

Gray triggerfish were also captured near the seabed adjacent to study reefs by divers with nets on October 7, 2021. Fish were measured to FL, tagged with the Domeier attachment method, and either allowed to swim freely after tagging or were sacrificed by pithing and left on the seabed. Fish that swam freely served as positive controls of live gray triggerfish swimming behavior, while sacrificed fish were intended to mimic fish that died and were lying on the seabed following catch and release. A 1-m tall stainless steel camera rig with a GoPro Hero5 camera mounted in an underwater housing was positioned on the seabed a approximately 5 meters from and facing the artificial reef for 2 hours to record any interactions of the sacrificed fish with predators.

Fates Assignment and Discard Mortality Estimation

Detection data were uploaded from study receivers in November 2021 and sent to Innovasea for geolocation estimation. Position estimates with horizontal position error in the upper 5th percentile of the data were excluded from further analysis (Smith, 2013; Bohaboy et al. 2020).

This filtering eliminated uncertain geoposition estimates from the data, as well as those that likely resulted from false detections. Sequential geoposition estimates separated by less than 10 min (600 s) were used to estimate swim speeds of tagged fish. The average swim speed (v) in m/s of a tagged fish as it moved from position 1 with coordinates (Lat_1, Lon_1) at time t_1 to position 2 with coordinates (Lat_2, Lon_2) at time t_2 was calculated as

$$v = \frac{2r * arcsin\sqrt{sin^2\left(\frac{Lat_2 - Lat_1}{2}\right) + cos(Lat_1)cos(Lat_2)sin^2\left(\frac{Lon_2 - Lon_1}{2}\right)}}{(t_2 - t_1)} \quad , \qquad \text{equation 1}$$

where coordinates are in radians and $r = 6.371 \times 10^6$ m is the assumed mean radius of the Earth.

Following geoposition data processing, changes in depth over time and estimated speed were used to infer the fate of each tagged fish over three time periods: immediate (within 48 hours of release), short-term (48 hours to 14 days after release), and long-term (greater than 14 days after release). The parameter *Δdepth* was calculated as the absolute value of estimated depth between two sequential tag detections. Fish movement behavior (v and *Δdepth*) was then utilized to assign fate to each tagged gray triggerfish (see below), with potential fates being alive in the array, dead on the seabed, predation, emigration, tag loss, harvest, or tag failure.

Acute discard mortality ($\widehat{M_a}$) was estimated as the percentage of tagged fish with estimated fates (n) that suffered from mortality within 48 hours of release. Chronic discard mortality ($\widehat{M_c}$) was estimated as the percentage of tagged fish with estimated fates (n) that suffered from mortality within 14 days of release. Ninety-five percent confidence intervals on discard mortality estimates were computed from standard error (SE) following Pollock and Pine (2007):

$$SE(\widehat{M}) = \sqrt{\frac{\widehat{M}(1-\widehat{M})}{n}}\text{, and 95CI} = 1.96 * SE(\widehat{M}). \qquad \text{equation 2}$$

The effect of release method (i.e., surface, vented, or descended), season (winter versus summer), fish FL, presence/absence of external barotrauma symptoms, abdominal rigidity, release condition, and time out of water on the probability of acute or chronic discard mortality were tested with nonlinear regressions with the *glm* function in R (R Core Team 2021). Mortality was coded as 1 (dead) or 0 (alive until the next time period) for each individual, with overall discard mortality modelled as a function of the explanatory variables listed above. Release method, season, presence or absence of barotrauma, and abdominal rigidity were coded as categorical variables in the model. Fish FL and time out of water were continuous variables in the model and were scaled to have mean = 0 and variance = 1. Candidate models were evaluated for parsimony with the small sample Akaike Information Criterion (AICc) (Burnham and Anderson 1998).

Lastly, we computed a Cox proportional hazards model to estimate the risk of mortality for significant factors in the regression model (Cox and Oakes, 1984). The model was fitted and its performance evaluated with the *survival* package in R (Therneau and Lumley 2019; R Core Team 2021). Goodness of fit was evaluated with pseudo-R^2, while the effects of significant factors in the model were evaluated as the proportional reduction in the sum of squared residuals from the null (intercept only) to the final (with covariables) model.

Results and Discussion

Tagging

Sixty gray triggerfish were tagged in winter 2021, and an additional 60 fish were tagged in summer 2021 (Table 1). Mean ± 95% CI FL of tagged gray triggerfish was 375.1 ± 21.3 mm in winter and 356.2 ± 11.9 mm in summer. There was no significant difference in FL between release method (ANOVA, $p = 0.947$), seasons (ANOVA, $p = 0.129$), or their interaction (ANOVA, $p = 0.831$). Therefore, while mean FL was nearly 20 mm larger in winter versus summer, the lack of significant difference between seasons was driven by the slightly greater range in FL observed during winter (Fig. 4). Within seasons, mean FL and its variance was consistent among release methods (Fig. 4).

External barotrauma symptoms were present in 25.8% of gray triggerfish and included everted esophagus and prolapsed anus (Table 1). There was a significant relationship between the probability of observing external barotrauma symptoms and fish FL (logistic regression; $p < 0.001$; $R^2 = 0.24$), with the probability increasing with fish size (Fig. 5). Abdominal rigidity scores ranged from 1 to 5, but were mostly in the range of 3 to 5 (Table 1). There was a significant effect of gray triggerfish size class on rigidity score (ANOVA; $p < 0.001$), with estimated abdominal rigidity increasing with fish FL (Fig. 6). While scoring abdominal rigidity is subjective, only a single tagger (WFP) was utilized among all fish, thus minimizing any potential variance that could occur among different rigidity evaluators. Moreover, abdominal rigidity scores mirror barotrauma symptom trends with FL. They are also consistent with reports by Runde et al. (2019) that necropsies revealed gray triggerfish often displayed internal organ displacement without displaying external barotrauma symptoms, given that 41.7% of fish in the current study had an abdominal rigidity score of 5 and another 37.5% had a score of 4, yet only 25.8% displayed external barotrauma symptoms. There was a significant difference in the mean rigidity score of fish displaying external barotrauma symptoms (4.52 ± 0.31) versus those not displaying external symptoms (4.04 ± 0.25) in the current study, but 63% of fish with rigidity scores of 5 displayed no external barotrauma symptoms.

There was no significant difference in time out of water for fish tagged in winter (69.0 ± 9.2 s) versus summer (78.9 ± 5.6 s) 2021 (Fig. 7). Therefore, the approach utilized to attach external tags did not have a significant effect on time out of water given the approach differed between winter- and summer-tagged fish. There was also no significant difference in time out of water for fish released with different release methods (ANOVA; $p = 0.088$), thus obviating a potential confounding factor in our analysis of factors affecting discard mortality.

Tag Detections and Water Parameter Data

Tag transmissions were received from all but two tags deployed on gray triggerfish (Table 1; Fig. A1). The range in detections per fish was 2 to 23,083, and the range in days detected was <1 to 242. Overall, 652,746 tag detections existed in the data from array receivers, but data filtering removed 43,828 detections. The mean ± 95% CI number of receivers that detected each tag transmission was 4.47 ± 0.004, while the mean number of receivers utilized to triangulate fish x-y position was 4.22 ± 0.003. While we relied on tag range detection and drift tests performed by Bohaboy et al. (2020) to inform receiver spacing, detection data confirm receiver spacing was optimized to achieve the largest array areal coverage while maintaining our ability to estimate tag geoposition given each transmission must be detected by at least 3 receivers to accomplish that.

Dissolved oxygen and temperature measured 1 m above the seabed within the acoustic array were within the range of expected values, with dissolved oxygen mostly ranging from approximately 5 to 10 mg/l and temperature ranging from approximately 18 to 29 °C (Fig. 8). However, there were brief periods of hypoxic (<2 mg/l) water observed in late March, the middle of July, and early August. It is not unusual to see episodic low dissolved oxygen on the shelf in late summer when the nGOM seasonal thermocline is often the strongest (Patterson 1999), but its unclear what caused the brief occurrence of hypoxia in late March.

Fate Assignment

Mortality estimation and analysis first required establishing an algorithm to assign fate to tags or tagged fish. We first examined the video samples and fish movement data of negative (GT-121 to GT-123) and positive (GT-124 to GT-126) controls. All three of the negative controls, which were sacrificed and left on the seabed, were consumed by large (~2 m) bull sharks within 12 min of being left on the seabed (Fig. 9). We also observed sharks and dolphins in video recorded with GoPro cameras mounted on the line above the descender device when returning acoustically tagged fish to depth (Fig. 10), although they were never observed removing a fish from a descender device. Estimated speed data of our positive controls indicated gray triggerfish typically swim approximately 0.1 to 0.2 m/s (Figs. 11&12). They do at times move at speeds >1 m/s, but that is rare and typically observed when fish transit between adjacent reefs, as evidenced by geoposition data (Fig. A2). Speed estimated from tags attached to negative control fish consumed by bull sharks was consistently much faster than positive controls (Fig. 12). However, positive control fish GT-124 demonstrated a marked change in speed around detection number 2,300, which was accompanied by movement back and forth across the array. Such movement was typical of tags attached to negative control fish that had been consumed by bull sharks (Figs. 11, 12, A2). Therefore, we infer fish GT-124 was alive and swimming in the array for 9 days, and then was consumed by a large predator, likely a shark, on day 10. The tag for GT-124 was sporadically detected for during each of the next 9 days, and then was no longer detected within the array (Fig. 13).

Based on movement data for negative controls, as well as GT-124 after day-10 post-tagging, we estimate large predators typically move at speeds of >0.6 m/s (Fig. 12). However, sharks are not the only large predators in the nGOM shelf ecosystem capable of consuming an adult gray triggerfish. Bohaboy et al. (2020) inferred that dolphins were also likely consuming tagged reef fishes during their study due to the fact some tags periodically transmitted depth data indicated they were at or near the surface, which cetaceans must visit to breathe. We saw similar evidence of this surfacing pattern among some of our tagged fish during periods when their speed estimates increased substantially above typical gray triggerfish speeds (Fig. 14).

Fish GT-034 and GT-035 were reported as harvested by recreational anglers on May 16, 2021 and May 23, 2021, respectively (Table 1, Fig. A1). Both fish were reported as only having the Floy dart tag, hence had suffered tag loss prior to fishery recapture. Tag speed and depth profiles indicated a shift in mean v to < 0.02 m/s, and $\Delta depth$ dropped to nearly zero, following tag loss. These patterns were utilized to determine the occurrence of tag loss in other fish, such as GT-005, which was estimated to lose its telemetry tag on March 22, 2021 (Fig. 15). However, closer inspection of the data from individual fish revealed time of day must be considered when evaluating whether patterns in v or $\Delta depth$ are indicative of tag loss. This is due to a consistent pattern of limited movement that occurred among all tagged fish between approximately 00:00 and 08:00. For example, in the week following tagging fish GT-016 moved very little from 00:00 until 08:00, but its movement was greater during other times of the day (Fig. 16). Therefore, determination of tag loss had be done later in the day than 08:00.

During the non-morning hours, it is also apparent from the GT-016 data that its v and $\Delta depth$ increased steadily across the first four weeks post-tagging (Fig. 16). Greater variance in v observed after week 4 corresponds to greater movements away from the nearest artificial reef. Therefore, not only do the data for GT-016 demonstrate the pattern of limited movement between 00:00 and 08:00, they also suggest it took approximately one month for GT-016 to fully recover from the catch and release (and tagging) process. Greater exploration of the data among all tagged gray triggerfish is required to evaluate whether this is a general pattern among them, as well as whether movement data from control fish tagged at depth may enable the effects of catch and release versus tagging to be distinguished. However, initial inspection of the data for other individuals suggests this pattern may be persistent throughout the overall dataset, hence further demonstrating the power of 3D telemetry to estimate fish movement dynamics and infer physiological or ecological processes.

Movement data among tagged GT, especially those with known fates, such as recaptures reported by fishers without telemetry tags, enabled us to create a decision tree to assign fate to individual fish in our dataset (Fig. 17). For example, a fish was estimated to surfer tag loss if its $\Delta depth$ was consistently <0.05 m outside of the 00:00 to 08:00time period and its tag speed was <0.6 m/s (and mostly well below 0.6 m/s). Alternatively, if a tag was estimated to consistently have a $\Delta depth$ < 0.05 m outside of the 00:00 to 08:00 time period, but its tag speed later increased to >0.6 m/s, that was indicative of a fish that had suffered mortality and was subsequently scavenged by a larger fish or mammal. Fish that were directly consumed by predators while alive had *Δdepth* > 0.05 m (and mostly well above 0.05 m) and *v* > 0.6 m/s. If the tag consistently traveled to the sea surface following consumption by a predator, then the predator was most likely a dolphin. Otherwise, the predator was likely a shark. If a tag had *Δdepth* consistently >0.05 m (and mostly well above 0.05 m) but *v* < 0.6 m/s (typically well below 0.6 m/s), and detections did not cease, then the tagged gray triggerfish was estimated to be alive within the acoustic array. If the same conditions existed but detections ceased while the fish was detected near or just outside the edge of the array, then that fish was estimated to have emigrated out of the array. If the same conditions existed but the fish was not near the edge of the array when detections ceased, then that indicated tag failure or harvest. Most harvested fish were reported by fishers, but there was one instance where a tag (GT-94) moved toward the surface then was no longer detected within the array, but with no evidence of having been consumed by predators. We inferred these movement dynamics were indicative of an unreported fishery recapture.

Fate of Tagged Fish

Our fate assignment algorithm (Fig. 17) was utilized to assign fate to 116 of 120 fish. Fate could not be assigned to 4 fish, which was likely due to tag failure for at least two fish (GT-117 and GT-118) which were never detected within the array. For the other two fish (GT-102 and GT-105), their tags were detected 6 and 13 times, respectively, on the day they were tagged. There is no evidence these fish were consumed by predators and left the array inside predator stomachs. However, their tags could have failed due to predator bite force. Unfortunately, the lack of movement data and related information means fate of these fish is coded as unknown in the dataset (Table 1).

Two winter-tagged gray triggerfish were estimated to die and their carcasses subsequently scavenged by predators, while 3 fish were estimated to be be directly consumed by predators within the first 2 days post-tagging (Table 1). An additional fish was estimated to be eaten by a predator on day-12. Following day-14, 5 fish were harvested by recreational anglers, 11 were estimated to emigrate away from the array, and 37 fish (65%) were estimated to lose their tags. The range in days until tag loss was 19-124 (mean = 58.2 days), thus all fish retained their tags during the initial 14-day period over which chronic discard mortality was estimated. The range in time until harvest for fish recaptured by anglers was 73-152 days, with a mean of 95.6 days. No fish tagged during winter 2021 were estimated to be alive in the array by the end of the study.

Much higher mortality was observed for fish tagged in summer 2021 (Table 1). Within the first 48 hours post-tagging, 2 fish were estimated to have died and then their carcasses scavenged, while 16 fish were estimated to have been directly consumed by predators. One fish was harvested on the second day post-tagging. By day-14, an additional 3 fish succumbed to predators. Throughout the rest of the study, 4 additional fish were eaten by predators, 21 emigrated out of the array, 6 suffered tag loss, 1 tag suffered failure, and 1 additional fish was harvested.

The two most difficult fates to distinguish were harvest and tag failure. In both cases, tags disappeared from the array with out moving out of the array, either slowly (like typical gray triggerfish movement indicating emigration) or quickly (like in the stomach of a predator). Harvest was typically (6 of 7) reported by anglers, but in one case that was estimated to be a harvest the tag went to the surface within the array and then disappeared. Two of four tags estimated to experience failure (GT-117 and GT-118) were never detected within the array, thus we are reasonably confident in the inference of tag failure, hence an unknown fate of the tagged fish.

For the two other fish with unknown fate (GT-105 and GT-108), only 6 and 13 tag transmissions were detected immediately after tagging. Those two fish were tagged on site G in summer 2021 when 6 of 19 tagged fish were estimated to be consumed by predators within hours of being tagged. It is possible those fish were also consumed by predators, with predator bites disabling tags. However, we have no evidence that actually occurred, thus coded those fish as having an unknown fate in the data.

Mortality Estimation

The most parsimonious regression model fit to release fate data included the factors season, fish length, and time out of water (Table 2). However, there was not a significant difference (ΔAICc < 2) between that model and one that also included release condition, so release condition was also included in the Cox proportional hazards model. That model had a pseudo R^2 value of 77.0%, with season ($p < 0.001$) and fish length ($p = 0.014$) being the only significant factors in the model.

Estimated discard mortality was 5.8% after 48 hours and 7.1% after 14 days in winter, and 34.7% after 48 hours and 41.1% after 14 days in summer. A model run with seasons modeled jointly produced discard mortality estimates of 13.9% and 16.9% for 48 hours and 14 days, respectively. For the season-specific model, the hazards ratio indicated discard mortality was 7.2 times more likely in summer than winter.

Stock Assessment Simulations

Our original plan was for study co-PI Dr. Jeff Isley to run stock assessment simulations with different discard mortality scenarios utilizing the SEDAR 64 Gulf of Mexico gray triggerfish stock assessment base model as the operating model. That assessment was scheduled to be completed by 2020. However, data issues and model structural issues caused that assessment process to be terminated prior to model completion, and Dr. Isley left NOAA Fisheries shortly thereafter. In an attempt to move forward with planned stock assessment simulations, Dr. Derek Chamberlin, a post-doctoral scholar in Dr. Patterson's laboratory, obtained the SEDAR 43 Gulf of Mexico gray triggerfish Stock Synthesis control and data files from Dr. Katie Siegfried, the Chief of the Gulf and Caribbean Branch of the Sustainable Fisheries Division of the Southeast Fisheries Science Center. The assessment model was loaded in the *SS3sim* package in R (Taylor et al., 2014) and attempts were made to run simulations with discard mortality scenarios of 25% and 50%, utilizing the base SEDAR 43 model as the operating model and changing discard mortality in two different estimation models. Neither of those two models resulted in any appreciable difference in biomass or fishing mortality estimates. That did not seem plausible given the fact that nearly 80% of recreational catch in the terminal year of the SEDAR 43 assessment was discarded. Further diagnostics were explored, as well as the data input files. It became apparent that no length composition data were utilized in the model and it was not clear on what retention and discard mortality parameters were operating. It was concluded that running discard mortality simulations with the SEDAR 43 base model was not possible and any simulation work would have to wait until the SEDAR 43 update model has completed in 2024.

Conclusions

Overall, our 3D telemetry results suggest gray triggerfish discard mortality are likely considerable higher than the 5% currently assumed in the GOM stock assessment. However, the high (~40%) discard mortality we estimated in summer 2021 was due almost entirely to predators. No predators were observed consuming tagged fish at the surface or taking tagged fish off descender devices on the way to the seabed, be we did make direct observation of bull sharks consuming negative controls that were sacrificed and left on the seabed and have the 3D movement data from those fish as well as tagged sharks that moved through the arrays deployed by Bohaboy et al. (2020). Combined, data from those fish provided compelling evidence of what movement tracks look like when large predators consume tagged fish.

It is unclear why the estimated amount of predation in winter 2021 was so much lower than summer 2021. Several of the movement tracks of apparently consumed fish in summer appeared to suggest dolphin predation given tags were repeatedly recorded at or near the surface prior to exiting the arrays. Bottlenose dolphins often travel in groups of several individuals and it is possible that consumption of our tagged fish in summer 2021 resulted from a group or groups of dolphins. For-hire and private recreational fishers have provided public testimony at GMFMC meetings in recent years about the perceived increase in the consumption of discards by large predators, namely sharks and dolphins. Our data provide clear evidence of that source of discard mortality for tagged gray triggerfish, as did Bohaboy et al. (2020). However, in the Bohaboy et al. (2020) study, most gray triggerfish were (opportunistically) tagged in early spring, yet still suffered substantial mortality due to predators.

Gray triggerfish were not the target species in the Bohaboy et al. (2020) study, hence their low sample size (n = 26) and the resulting high variance in gray triggerfish discard mortality estimates. However, their overall gray triggerfish discard mortality estimate of approximately 40% was still comparable to the summer estimate in the current study and well below the estimate reported by Runde et al. (2019) for Atlantic gray triggerfish. Runde et al. (2019) utilized conventional tagging and employed Cox proportional hazards modeling to estimate discard mortality of surface-released fish referenced to return rates of positive controls tagged at depth by divers on SCUBA. Their mean discard mortality rate was 65%, which is much greater than the assumed discard mortality rate in the Atlantic or GOM stock assessments. However, it is unclear how much site fidelity versus emigration may have affected their estimates of fish fate or release mortality.

Fish captured with hook-and-line, tagged with external telemetry tags, and released at the surface in the current study appeared to take ~4 weeks to fully recover from the catch-and-release and tagging process. Afterwards, gray triggerfish showed limited site fidelity as most individuals visited numerous reefs within our acoustic array, and most of the fish that retained their tags for more than two months eventually emigrated out of the array. If control fish tagged at depth in the Runde et al. (2019) were less likely to move away from reefs surveyed in their study area than were fish tagged and released at the surface, then apparent mortality would have been higher than actual discard mortality. However, reefs in their study system were up to 10 m deeper than those in the current study, thus depth may also may have been an important factor driving their higher discard mortality estimates.

Some uncertainty exists with respect to the causes of differences in gray triggerfish discard mortality estimates among the Bohaboy et al. (2020), Runde et al. (2019), and the current study. However, discard mortality estimates from all three studies are considerably higher than the current estimates utilized in GOM and Atlantic stock assessments. The red snapper discard mortality estimates reported by Bohaboy et al. (2020) were produced from 3D telemetry arrays in 30 and 60 m of water, with depth being a significant factor in their models of discard mortality. Likewise, Runde et al. (2019) estimated discard mortality to increase with depth for Atlantic gray triggerfish. Therefore, it seems evident that gray triggerfish would benefit from a 3D telemetry assessment of discard mortality in deeper waters of the GOM to bracket the range of depths typically utilized by recreational and commercial fishers targeting this species or catching it as bycatch when targeting other ones.

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Table 1. Descriptive data of gray triggerfish acoustically tagged at artificial reef sites in the north central Gulf of Mexico during 2021. Site locations are provided in Figure 1. FL = fork length. Baro is external barotrauma symptoms: ES = everted esophagus; PA = prolapsed anus. Release condition and rigidity scores are indicated in the text. Temperature is °C. Fate assignment methods provided in text.

Fish	Site	Date	Seaon	Time	Sec out	FL mm	Floy tag	Innovasea tag	Baro	Condition	Rigidity	Release	Air temp	Bottom temp	Fate 48-hr	Fate 14-day	Day died	Post day 14 fate	Total dections	Days tracked
1	E	3/3/2021	Winter	10:40	33	314	487	13334	PA	1	3	surface	8.9	19.32	alive	alive		tag loss 4/25/21	23,083	212
2	F	3/3/2021	Winter	10:55	94	520	488	13349	PA	1	5	vented	9.0	19.32	alive	alive		tag loss 5/2/21	15,443	170
3	F	3/3/2021	Winter	10:57	132	535	489	13341	PA	2	4	surface	9.0	19.32	alive	alive		emigration 8/5/21	15,667	155
4	F	3/3/2021	Winter	11:00	140	503	490	13347	PA	1	5	descender	9.2	19.32	alive	alive		emigration 7/26/21	11,678	145
5	D	3/3/2021	Winter	12:14	61	287	491	13343	PA	1	4	vented	8.7	19.32	alive	alive		tag loss 3/22/21	2,131	76
6	D	3/3/2021	Winter	12:16	79	290	492	13351		1	3	descender	8.7	19.32	alive	alive		tag loss 5/4/21	6,160	169
7	D	3/3/2021	Winter	12:19	34	370	493	13344		1	4	surface	8.7	19.32	predation	predation	1		97	1
8	D	3/3/2021	Winter	12:21	46	338	494	13345		1	3	vented	8.7	19.32	alive	alive		emigration 5/9/21	6,482	66
9	D	3/3/2021	Winter	12:22	82	295	495	13350		1	4	descender	8.7	19.32	alive	alive		emigration 4/20/21	2,761	47
10	D	3/3/2021	Winter	12:22	150	307	496	13346	PA	1	3	surface	8.7	19.32	alive	alive		emigration 5/31/21	7,933	89
11	D	3/3/2021	Winter	12:25	49	273	497	13348		1	3	vented	8.7	19.32	alive	alive		tag loss 4/21/21	4,077	174
12	D	3/3/2021	Winter	12:26	46	310	498	13355		1	3	surface	8.7	19.32	alive	alive		tag loss 4/4/21	7,545	198
13	D	3/3/2021	Winter	12:26	52	300	499	13354		1	3	descender	8.7	19.32	alive	alive		tag loss 4/10/21	5,001	163
14	D	3/3/2021	Winter	12:31	50	304	500	13353		1	5	vented	8.7	19.32	alive	alive		tag loss 7/5/21	11,949	238
15	D	3/3/2021	Winter	12:31	49	323	501	13335		1	3	descender	8.7	19.32	alive	alive		tag loss 6/23/21	13,869	226
16	D	3/3/2021	Winter	12:36	49	408	502	13342	PA	1	4	surface	8.7	19.32	alive	alive		tag loss 7/17/21	15,867	164
17	D	3/3/2021	Winter	12:37	30	340	503	13352		1	4	descender	8.7	19.32	alive	alive		tag loss 3/27/21	1,562	161
18	D	3/3/2021	Winter	12:46	35	305	504	13359		1	2	vented	8.7	19.32	alive	alive		emigration 5/30/21	8,285	88
19	B	3/3/2021	Winter	13:11	51	323	505	13358		1	3	surface	8.6	19.32	alive	alive		tag loss 5/20/21	14,110	234
20	B	3/3/2021	Winter	13:12	37	315	506	13357		1	4	vented	8.6	19.32	alive	alive		tag loss 5/25/21	13,733	232
21	B	3/3/2021	Winter	13:12	73	375	507	13356		2	3	surface	8.6	19.32	alive	alive		emigration 7/29/21	8,425	147
22	B	3/3/2021	Winter	13:20	106	322	508	13363		1	2	descender	8.6	19.32	alive	alive		tag loss 7/2/21	20,577	242
23	B	3/3/2021	Winter	13:26	45	322	509	13339		1	4	surface	8.6	19.32	alive	alive		tag loss 4/30/21	18,744	237
24	B	3/3/2021	Winter	13:26	93	505	510	13338	PA	1	5	descender	8.6	19.32	alive	alive		tag loss 5/15/21	13,741	238
25	B	3/3/2021	Winter	13:43	53	457	511	13360		1	5	vented	8.6	19.32	alive	alive		tag loss 4/5/21	10,670	226
26	B	3/3/2021	Winter	13:43	55	321	512	13361		1	2	surface	8.6	19.32	alive	alive		tag loss 5/23/21	10,174	234
27	B	3/3/2021	Winter	13:44	53	405	513	13362	PA, ES	1	4	descender	8.6	19.32	alive	alive		tag loss 4/21/21	9,662	174
28	C	3/3/2021	Winter	14:34	40	515	515	13336	PA	2	5	surface	8.6	19.32	alive	alive		tag loss 5/2/21	16,230	60
29	G	3/3/2021	Winter	15:15	92	470	516	13337	PA	1	5	vented	9.7	19.32	alive	alive		tag loss 5/11/21	7,843	144
30	G	3/3/2021	Winter	15:16	152	475	517	13365	PA	1	5	descender	9.7	19.32	alive	alive		emgration 7/8/21	3,874	127

Table 1 continued. Descriptive data of gray triggerfish acoustically tagged at artificial reef sites in the north central Gulf of Mexico during 2021. Site locations are provided in Figure 1. FL = fork length. Baro is external barotrauma symptoms: ES = everted esophagus; PA = prolapsed anus. Release condition and rigidity scores are indicated in the text. Temperature is °C. Fate assignment methods provided in text.

Fish	Site	Date	Seaon	Time	Sec out	FL mm	Floy tag	Innovasea tag	Baro	Condition	Rigidity	Release	Air temp	Bottom temp	Fate 48-hr	Fate 14-day	Day died	Post day 14 fate	Total dections	Days tracked
31	G	3/3/2021	Winter	15:19	60	522	518	13340	PA	1	5	vented	10.0	19.32	alive	alive		tag loss 4/20/21	6,580	212
32	G	3/3/2021	Winter	15:20	96	498	519	13392		1	5	descender	10.0	19.32	alive	predation	12		4,672	106
33	G	3/3/2021	Winter	15:21	48	360	520	13391		1	3	surface	10.0	19.32	alive	alive		harvested 5/16/21	2,378	74
34	G	3/3/2021	Winter	15:28	98	500	522	13397		1	5	descender	10.0	19.32	alive	alive		harvested 8/2/21	6,924	163
35	A	3/3/2021	Winter	16:23	42	403	523	13390	PA	1	5	vented	10.0	19.32	alive	alive		harvested 5/23/21	10,382	242
36	A	3/3/2021	Winter	16:28	154	490	525	13364	PA	1	5	surface	10.0	19.32	dead	dead	1		325	2
37	D	3/4/2021	Winter	8:42	61	278	526	13366		1	4	vented	14.6	19.34	alive	alive		emigrated 9/17/21	16,641	177
38	D	3/4/2021	Winter	8:43	83	325	527	13367		1	3	surface	14.6	19.34	alive	alive		tag loss 4/29/21	4,161	105
39	D	3/4/2021	Winter	8:46	31	325	528	13389		1	3	descender	14.6	19.34	alive	alive		tag loss 3/30/21	4,236	236
40	D	3/4/2021	Winter	8:49	39	390	529	13388	PA	1	4	descender	14.6	19.34	alive	alive		tag loss 4/7/21	7,667	175
41	D	3/4/2021	Winter	8:50	51	285	530	13384		1	3	surface	14.6	19.34	alive	alive		tag loss 4/17/21	5,025	174
42	D	3/4/2021	Winter	8:50	154	347	531	13385	PA	1	5	descender	14.2	19.34	alive	alive		tag loss 3/27/21	4,627	170
43	D	3/4/2021	Winter	8:54	86	306	532	13386		1	4	descender	14.2	19.34	alive	alive		tag loss 4/24/21	3,893	77
44	D	3/4/2021	Winter	9:05	29	363	533	13387	PA	1	4	vented	14.2	19.34	alive	alive		tag loss 4/1/21	3,939	231
45	D	3/4/2021	Winter	9:10	34	324	534	13380		1	5	surface	14.2	19.34	alive	alive		tag loss 3/31/21	3,395	160
46	D	3/4/2021	Winter	9:10	44	275	535	13381	PA	1	4	descender	14.1	19.34	alive	alive		tag loss 4/3/21	5,808	175
47	F	3/4/2021	Winter	9:29	34	540	536	13382	DA	1	5	vented	14	19.34	dead	dead	1		168	6
48	F	3/4/2021	Winter	9:40	91	518	537	13383	PA	1	5	surface	13.9	19.34	alive	alive		harvested 5/16/21	6,877	111
49	F	3/4/2021	Winter	9:42	94	408	538	13376		1	5	surface	13.9	19.34	alive	alive		predation 4/1/21	4,907	161
50	G	3/4/2021	Winter	9:54	143	394	539	13377	PA	1	5	vented	13.8	19.34	alive	alive		harvested 6/10/21	12,883	98
51	G	3/4/2021	Winter	9:58	73	465	540	13378	PA	1	5	surface	13.8	19.34	alive	alive		emigrated 4/26/21	4,437	53
52	G	3/4/2021	Winter	10:06	101	460	541	13379	PA	1	5	descender	13.8	19.34	predation	predation	1		98	1
53	B	3/4/2021	Winter	10:38	73	335	542	13372	PA	1	4	descender	13.7	19.34	alive	alive		tag loss 4/13/21	3,306	169
54	B	3/4/2021	Winter	10:40	49	340	543	13373		1	5	surface	13.7	19.34	alive	alive		tag loss 5/1/21	12,228	233
55	B	3/4/2021	Winter	10:49	46	344	544	13368		1	1	surface	13.8	19.34	predation	predation	1		25	0
56	B	3/4/2021	Winter	10:49	60	325	545	13375	PA	1	4	vented	13.8	19.34	alive	alive		tag loss 4/26/21	2,905	70
57	B	3/4/2021	Winter	10:54	45	353	546	13374	PA	1	5	vented	13.8	19.34	alive	alive		tag loss 5/7/21	6,390	77
58	B	3/4/2021	Winter	10:56	33	282	547	13369	PA	1	4	vented	13.8	19.34	alive	alive		tag loss 6/26/21	20,444	183
59	B	3/4/2021	Winter	10:58	37	312	548	13370		1	5	vented	13.8	19.34	alive	alive		emigrated 5/21/21	7,759	78
60	B	3/4/2021	Winter	10:58	90	313	549	13371		1	3	vented	13.8	19.34	alive	alive		tag loss 4/18/21	12,218	237

Table 1 continued. Descriptive data of gray triggerfish acoustically tagged at artificial reef sites in the north central Gulf of Mexico during 2021. Site locations are provided in Figure 1. FL = fork length. Baro is external barotrauma symptoms: ES = everted esophagus; PA = prolapsed anus. Release condition and rigidity scores are indicated in the text. Temperature is °C. Fate assignment methods provided in text.

Fish	Site	Date	Seaon	Time	Sec out	FL mm	Floy tag	Innovasea tag	Baro	Condition	Rigidity	Release	Air temp	Bottom temp	Fate 48-hr	Fate 14-day	Day died	Post day 14 fate	Total dections	Days tracked
61	D	7/22/2021	Summer	8:35	108	360	551	11650		1	4	surface	28.7	25.48	alive	alive		tag loss 8/3/21	2,058	25
62	D	7/22/2021	Summer	8:38	98	392	552	11651		1	5	descender	28.7	25.48	alive	alive		predation 9/1/21	2,472	41
63	D	7/22/2021	Summer	8:40	71	353	553	11652		1	4	vented	28.7	25.48	alive	alive		alive in array	18,678	115
64	D	7/22/2021	Summer	8:41	107	312	554	11653		1	4	surface	28.7	25.48	alive	alive		emigration 8/30/21	4,783	39
65	D	7/22/2021	Summer	8:43	103	312	499	11646		1	4	descender	28.7	25.48	alive	alive		tag loss 8/9/21	2,557	37
66	D	7/22/2021	Summer	8:46	80	327	556	11647		1	4	vented	28.7	25.48	alive	alive		tag loss 8/19/21	2,225	37
67	D	7/22/2021	Summer	8:47	66	327	557	11648		1	4	descender	28.7	25.48	alive	alive		emigrated 8/15/21	1,785	24
68	D	7/22/2021	Summer	8:50	58	322	558	11649		1	4	surface	28.7	25.48	alive	alive		emigrated 9/2/21	3,942	41
69	D	7/22/2021	Summer	8:54	68	343	559	11642		1	4	descender	28.7	25.48	alive	alive		tag loss 8/9/21	2,258	37
70	D	7/22/2021	Summer	8:55	111	420	561	11643		1	5	vented	28.7	25.48	alive	alive		tag loss 8/9/21	1,765	18
71	B	7/22/2021	Summer	9:31	108	315	562	11656		1	4	descender	28.6	25.48	alive	alive		predation 10/1/21	14,703	71
72	B	7/22/2021	Summer	9:32	68	346	563	11638		1	4	surface	28.6	25.48	alive	alive		harvested 8/30/21	6,370	39
73	B	7/22/2021	Summer	9:34	65	335	564	11639		1	4	vented	28.6	25.48	predation	predation	1		2	<1
74	B	7/22/2021	Summer	9:36	68	338	565	11645		1	4	descender	28.6	25.48	predation	predation	1		46	<1
75	B	7/22/2021	Summer	9:37	61	340	566	11640		1	4	surface	28.6	25.48	predation	predation	1		7	<1
76	B	7/22/2021	Summer	9:40	114	415	567	11680	PA	1	5	descender	28.6	25.48	dead	dead	1		32	<1
77	B	7/22/2021	Summer	9:41	108	382	568	11644		1	5	surface	28.6	25.48	predation	predation	1		4	<1
78	B	7/22/2021	Summer	9:46	78	315	560	11657		1	4	descender	28.6	25.48	predation	predation	1		3	<1
79	B	7/22/2021	Summer	9:47	72	337	569	11665		1	4	descender	28.6	25.48	predation	predation	1		10	<1
80	B	7/22/2021	Summer	9:48	63	490	570	11655		3	5	surface	28.6	25.48	predation	predation	1		7	<1
81	B	7/22/2021	Summer	9:52	116	312	571	11654		1	4	vented	28.6	25.48	alive	alive		emigrated 10/7/21	11,664	77
82	F	7/22/2021	Summer	12:39	119	442	538	11658		1	5	descender	28.7	25.48	alive	alive		tag failed 7/27/21	1,873	4
83	G	7/22/2021	Summer	13:05	72	343	573	13404		1	5	surface	28.7	25.48	alive	alive		emigrated 10/8/21	4,924	114
84	G	7/22/2021	Summer	13:12	93	387	574	13405		1	5	vented	28.7	25.48	predation	predation	1		170	8
85	D	7/22/2021	Summer	13:41	98	320	575	13409		1	3	surface	28.7	25.48	alive	predation	7		3,978	54
86	D	7/22/2021	Summer	13:42	65	347	576	11661		1	4	descender	28.8	25.48	alive	alive		tag loss 8/6/21	2,243	24
87	D	7/22/2021	Summer	13:51	73	352	577	11660		1	3	vented	28.8	25.48	alive	alive		emigration 8/31/21	3,113	39
88	B	7/22/2021	Summer	14:12	125	294	578	11659		1	5	vented	28.8	25.48	alive	alive		emigration 8/16/21	3,755	24
89	B	7/27/2021	Summer	8:27	79	335	579	13399		1	5	surface	29.3	25.52	alive	alive		emigration 9/4/21	4,621	39
90	B	7/27/2021	Summer	8:28	62	313	580	13395		1	3	vented	29.3	25.52	alive	alive		emigration 9/18/21	8,556	86

Table 1 continued. Descriptive data of gray triggerfish acoustically tagged at artificial reef sites in the north central Gulf of Mexico during 2021. Site locations are provided in Figure 1. FL = fork length. Baro is external barotrauma symptoms: ES = everted esophagus; PA = prolapsed anus. Release condition and rigidity scores are indicated in the text. Temperature is °C. Fate assignment methods provided in text.

Fish	Site	Date	Seaon	Time	Sec out	FL mm	Floy tag	Innovasea tag	Baro	Condition	Rigidity	Release	Air temp	Bottom temp	Fate 48-hr	Fate 14-day	Day died	Post day 14 fate	Total dections	Days tracked
91	B	7/27/2021	Summer	8:29	62	359	581	13393		1	5	surface	29.3	25.52	predation	predation	1		11	1
92	B	7/27/2021	Summer	8:31	79	352	583	13396	PA	1	4	descender	29.3	25.52	predation	predation	1		130	3
93	B	7/27/2021	Summer	8:37	78	353	584	13394		1	5	surface	29.3	25.52	dead	dead	1		41	<1
94	B	7/27/2021	Summer	8:42	60	335	585	13415		1	4	vented	29.3	25.52	harvest	harvest			336	2
95	B	7/27/2021	Summer	8:45	78	353	586	13413		1	5	descender	29.3	25.52	alive	alive		emigration 9/2/21	3,333	38
96	B	7/27/2021	Summer	8:51	64	317	587	13414		1	4	descender	29.3	25.52	predation	predation	2		166	3
97	B	7/27/2021	Summer	8:55	56	355	582	13398		1	4	surface	29.3	25.52	alive	alive		emigration 9/14/21	5,496	49
98	D	7/27/2021	Summer	9:12	93	296	588	13411		1	4	descender	29.3	25.52	alive	alive		predation 9/14/21	3,931	49
99	D	7/27/2021	Summer	9:13	40	301	589	13416		1	4	surface	29.3	25.52	alive	alive		emigration 9/6/21	1,119	41
100	G	7/27/2021	Summer	9:59	64	434	590	13410		1	5	vented	29.3	25.52	alive	predation	9		679	34
101	G	7/27/2021	Summer	10:02	69	400	591	13400		1	3	vented	29.4	25.52	alive	alive		emigration 9/8/21	711	101
102	G	7/27/2021	Summer	10:03	65	382	592	13407		1	4	vented	29.4	25.52	unknown	unknown			6	<1
103	G	7/27/2021	Summer	10:06	70	355	593	11664		1	4	vented	29.4	25.52	alive	unknown			41	2
104	G	7/27/2021	Summer	10:07	48	363	595	13412		1	5	descender	29.4	25.52	alive	alive		emigration 8/29/21	776	32
105	G	7/27/2021	Summer	10:11	64	363	596	13408		2	5	surface	29.4	25.52	unknown	unknown			13	1
106	G	7/27/2021	Summer	10:13	57	370	594	13403		1	5	vented	29.4	25.52	alive	alive		predation 8/28/21	739	95
107	G	7/27/2021	Summer	10:15	59	388	597	13406		1	5	descender	29.4	25.52	alive	alive		emigration 10/10/21	1,910	75
108	G	7/27/2021	Summer	10:16	72	376	598	11662		2	4	vented	29.4	25.52	predation	predation	1		15	2
109	G	7/27/2021	Summer	10:17	80	296	599	13402		1	3	surface	29.4	25.52	alive	alive		emigration 9/6/21	346	56
110	G	7/27/2021	Summer	10:19	63	253	600	13401		1	3	surface	29.4	25.52	alive	alive		emigration 9/21/21	413	40
111	G	7/27/2021	Summer	10:21	62	372	601	11663		1	5	descender	29.4	25.52	predation	predation	1		311	55
112	G	7/27/2021	Summer	10:24	64	376	602	11641	PA	1	5	vented	29.4	25.52	predation	predation	2		47	4
113	G	7/27/2021	Summer	10:26	81	366	603	11675		1	4	descender	29.4	25.52	alive	alive		emigration 8/14/21	330	99
114	G	7/27/2021	Summer	10:27	145	348	604	11678		1	4	surface	29.4	25.52	predation	predation	2		192	7
115	G	7/27/2021	Summer	10:29	121	484	605	11672		1	5	descender	29.4	25.52	alive	alive		emigration 8/26/21	540	30
116	G	7/27/2021	Summer	10:42	70	336	606	11667		1	5	descender	29.4	25.52	alive	alive		emigration 10/23/21	11,603	96
117	G	7/27/2021	Summer	10:43	91	480	607	11668		2	5	surface	29.4	25.52	unknown	unknown			0	<1
118	G	7/27/2021	Summer	10:45	68	338	608	11673		3	5	vented	29.4	25.52	unknown	unknown			0	<1
119	F	7/27/2021	Summer	11:05	76	378	609	11669		1	5	surface	29.4	25.52	alive	alive		emigration 8/16/21	5,965	23
120	F	7/27/2021	Summer	11:06	58	364	610	11666		3	5	vented	29.4	25.52	predation	predation	1		4	<1

Table 2. Regression models computed to estimate the effect of measured parameters on gray triggerfish post-release survival. -LL is the negative log likelihood of each model. AICc is Akaike's Information Criterion with correction for small sample size and ΔAICc is the difference between a given model's AICc and the lowest AICc value. Season = winter or summer. Length = fish fork length. Time = time out of water while attaching external acoustic telemetry and dart tags. Rigidity is abdominal rigidity score (1 = flaccid to 5 = completely rigid). Barotrauma = presence (1) or absence (0) of external barotrauma symptoms (e.g., everted esophagus, prolapsed anus). Release = release type: surface, vented, or descended. Condition = apparent condition based on swimming: 1 = swam down vigorously, 2 = oriented to bottom but swam down slowly, 3 = alive at surface but struggled to submerge, and 4 = apparently dead at surface.

Parameters included in model	n	k	-LL	AICc	ΔAICc	Rank
β_0	116	1	64.11	130.25	19.15	8
β_0 + *season*	116	2	57.03	118.16	7.05	6
β_0 + *season* + *length*	116	3	53.36	112.93	1.82	3
β_0 + *season* + *length* + *time*	115	4	51.37	111.10	0	1
β_0 + *season* + *length* + *time* + *condition*	115	5	50.94	112.43	1.32	2
β_0 + *season* + *length* + *time* + *condition* + *rigidity*	115	6	50.75	114.28	3.17	4
β_0 + *season* + *length* + *time* + condition + *rigidity* + *barotrauma*	115	7	50.73	116.50	5.40	5
β_0 + *season* + *length* + *time* + condition + *rigidity* + *barotrauma* + *release*	115	8	50.73	118.81	7.71	7

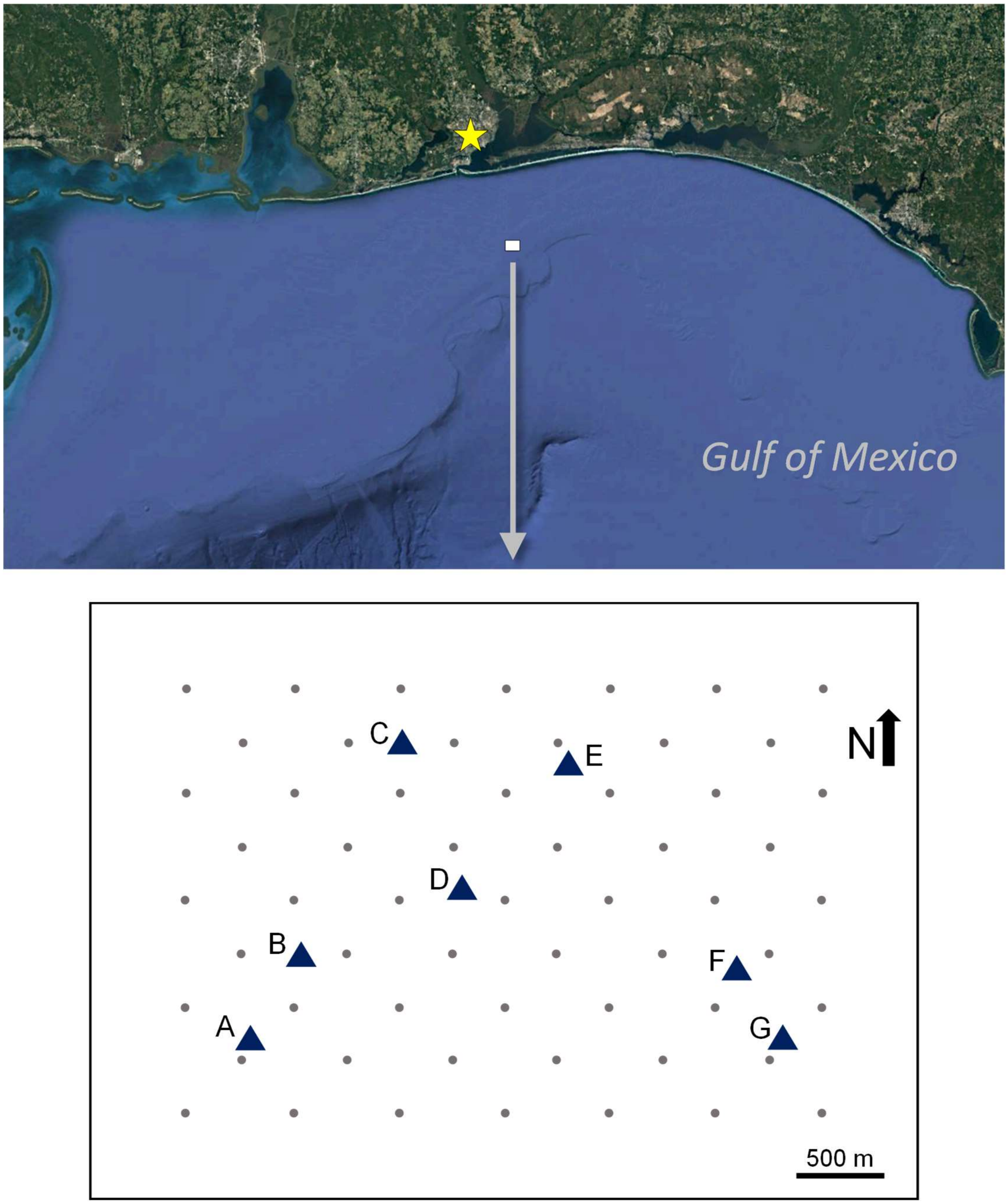


Figure 1. Map of the north central Gulf of Mexico indicating the location (white polygon) of the acoustic array deployed off Pensacola, Florida (yellow star) at depths of 28.1 to 31.8 m. Receiver (dark gray circles) and artificial reef (blue triangles) locations are indicated in bottom map.

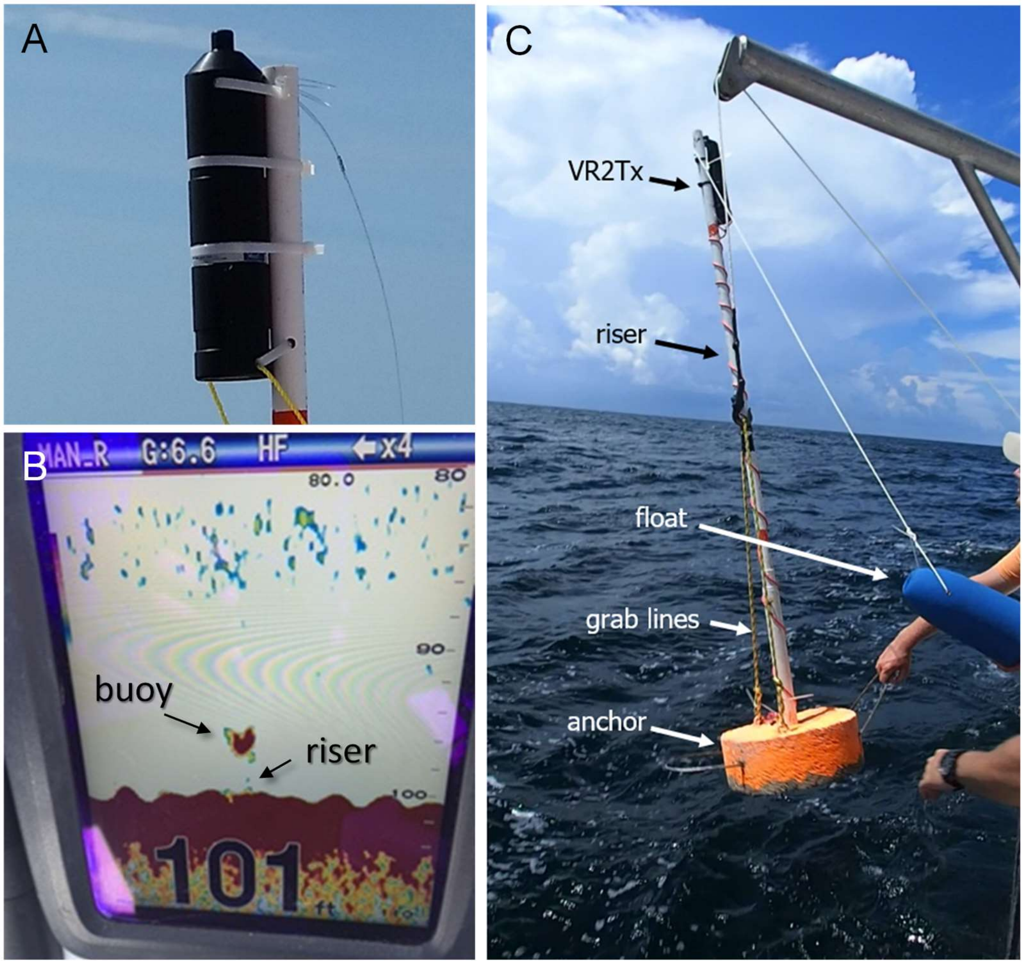


Figure 2. A) Innovasea VR2-Tx receiver attached to the top of a 2-m riser consisting of 2” PVC anchored in a 36-kg concrete base. B) An entire receiver base with syntactic foam buoy (float) readied for deployment to the seabed. C) Sonar image of the buoy suspended above the riser facilitating locating the receiver and its base upon a return trip offshore.

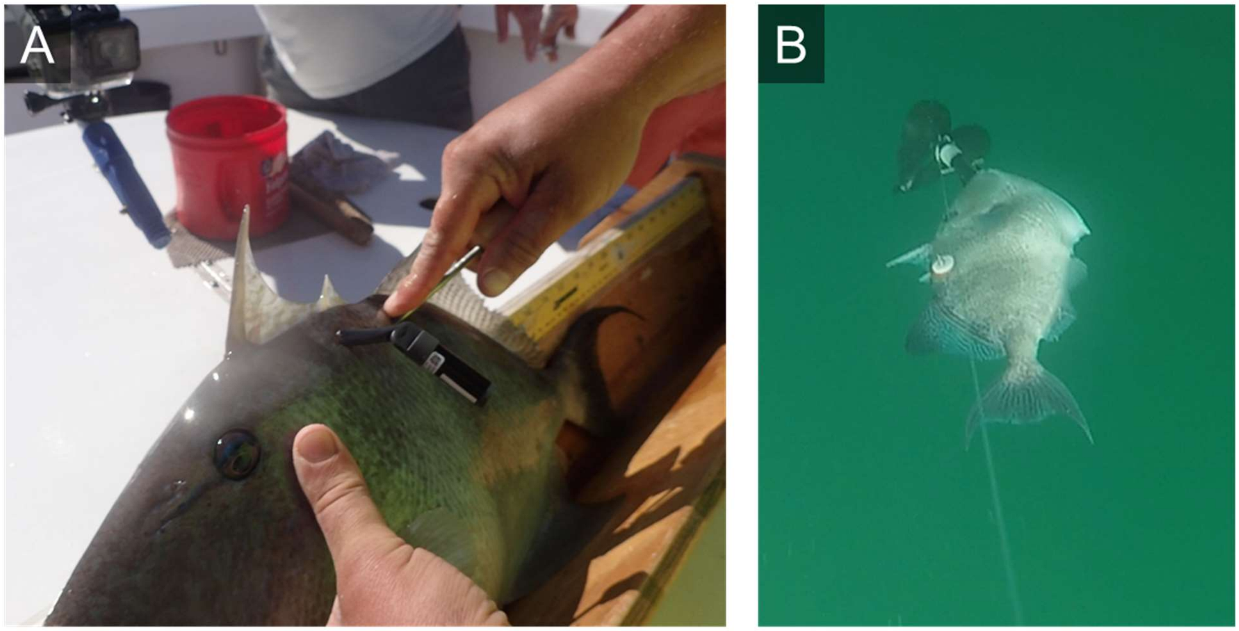


Figure 3. A) An adult gray triggerfish externally tagged with a Innovasea V13P acoustic tag applied with the Domeier anchor method. A Floy stainless steel dart tag is being applied to the fish before release. B) An adult gray triggerfish tagged with an Innovasea V13P acoustic tag applied with the Bohaboy et al. (2020) threaded stainless steel rod method. The fish is being descended to depth for release with a Seaqulizer return-to-depth tool.

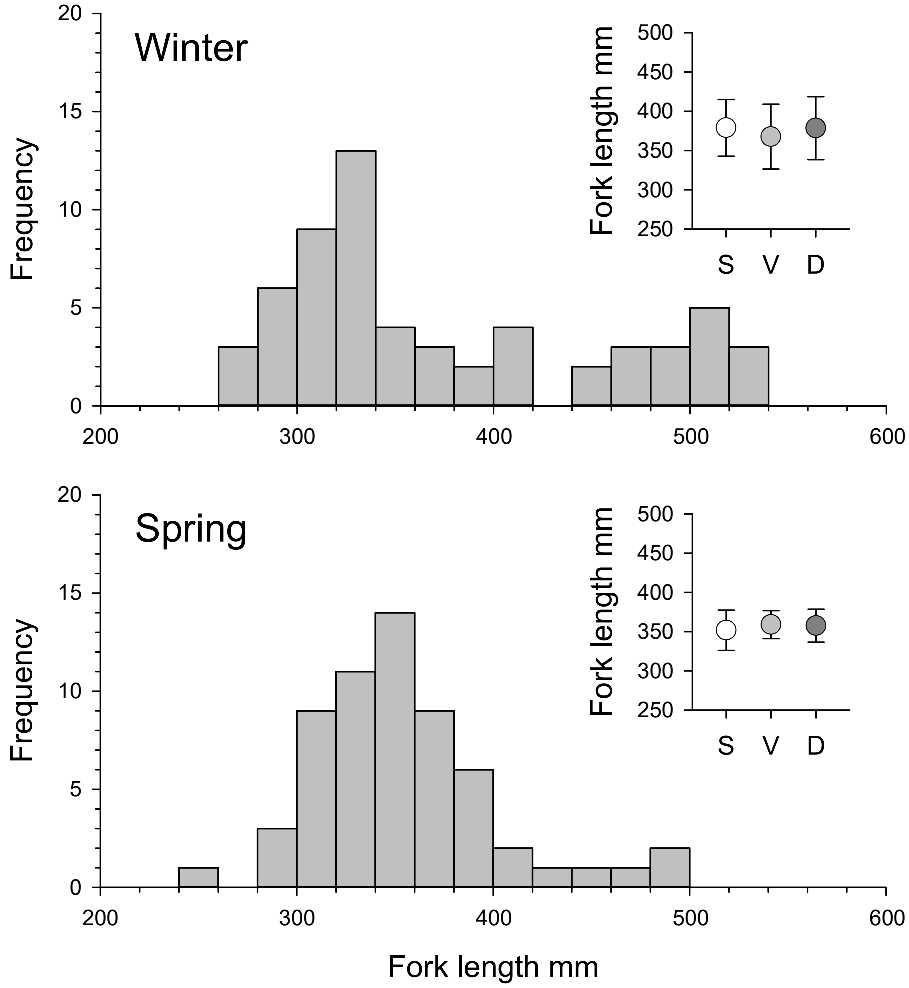


Figure 4. Overall winter (top) and summer (bottom) gray triggerfish fork length distributions for fish captured with hook and line, tagged externally with Innovasea V13P acoustic tags, and released at the surface (S), vented and released at the surface (V), or released at depth with a Seaqualizer descender device (D). Inset panels indicate season-specific mean ± 95% CI for each release treatment.

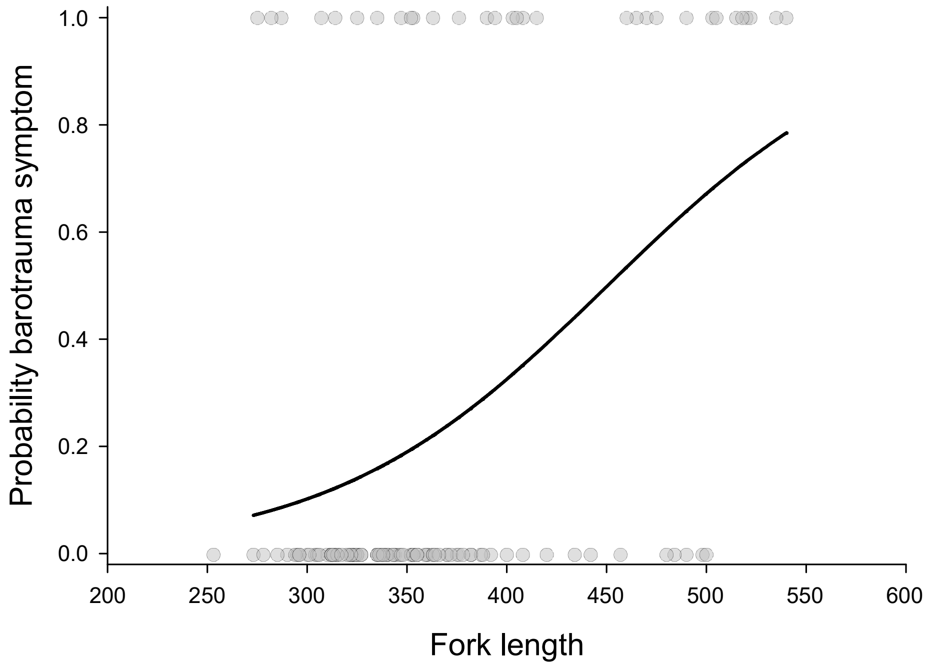


Figure 5. Probability of gray triggerfish experiencing external barotrauma symptoms (e.g., everted esophagus or prolapsed anus) as a function of fork length. Data were coded as 1 if symptoms were observed, and 0 for no external barotrauma symptoms. Fitted line is the logistic regression predicting barotrauma symptoms (FL = 6.51 - 0.014*FL; $p < 0.001$; pseudo $R^2 = 0.24$).

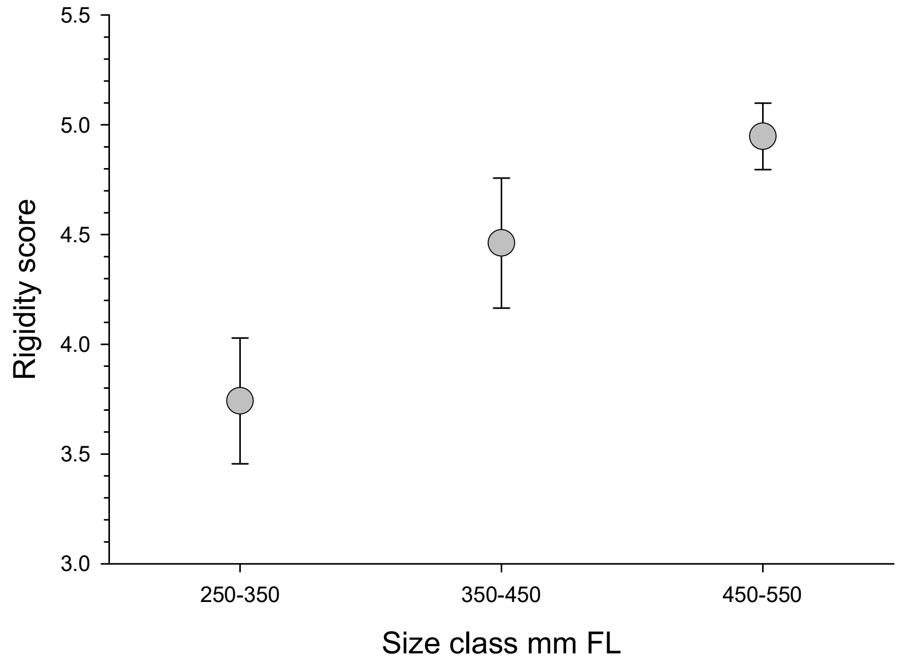


Figure 6. Mean (± 95% CI) rigidity score for gray triggerfish size classes.

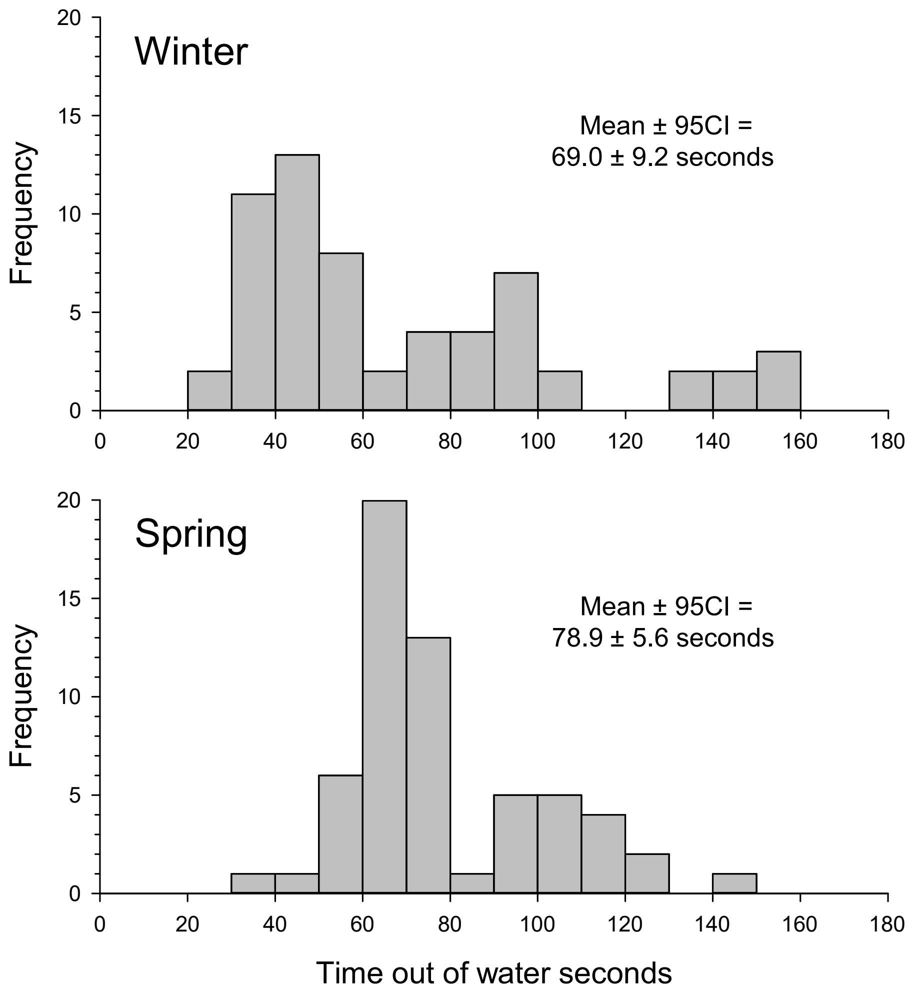


Figure 7. Winter (top) and summer (bottom) distributions of time out of water to tag gray triggerfish externally with Innovasea V13P acoustic tags and a Floy stainless steel dart tag. Sample size was 60 in each season.

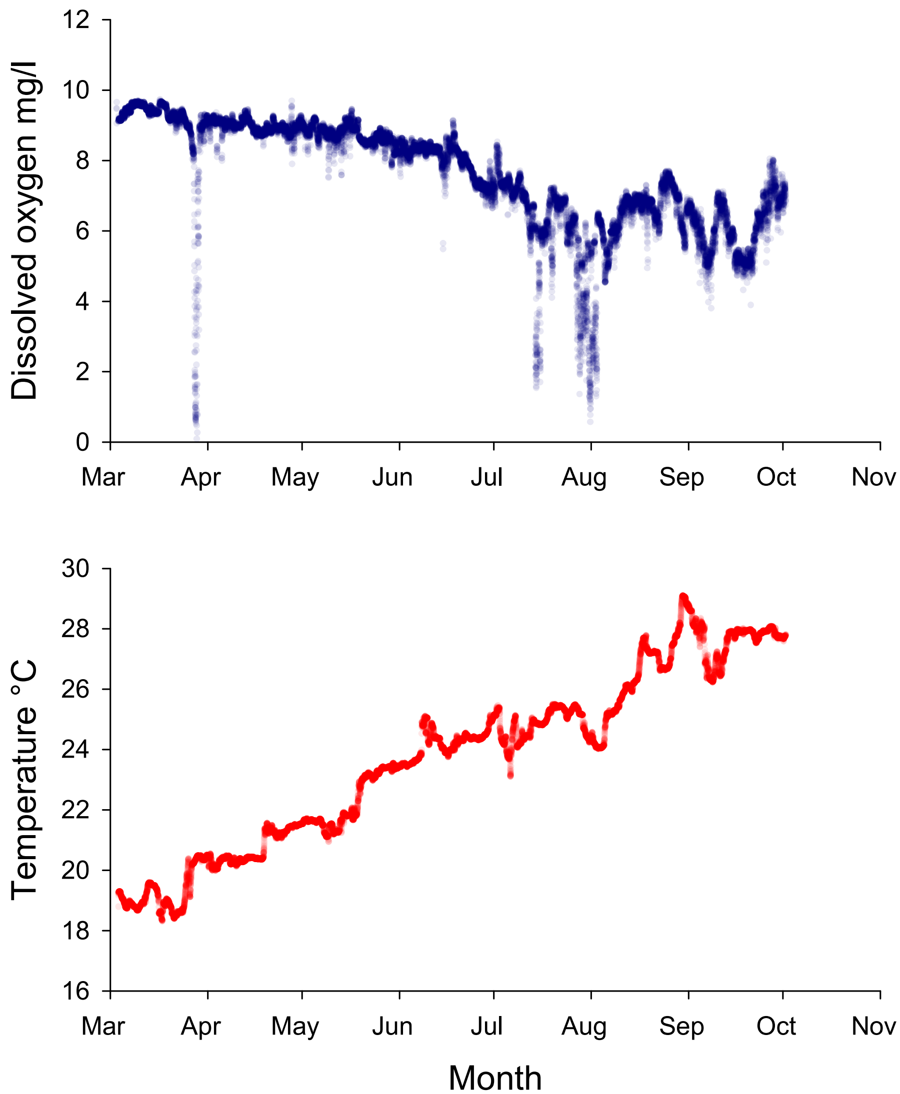


Figure 8. Dissolved oxygen (top) and water temperature (bottom) measured with a HOBO U26-001 dissolved oxygen sensor attached to a telemetry receiver PVC pole approximately 1 m above the seabed in the center of the telemetry array.

Figure 9. A) Fish GT-123 externally tagged with an Innovasea V13P acoustic tag on the seafloor and then sacrificed via pithing to render it dead. B) Same fish consumed by a bull shark which then swam away with the gray triggerfish and attached telemetry tag in its gut.

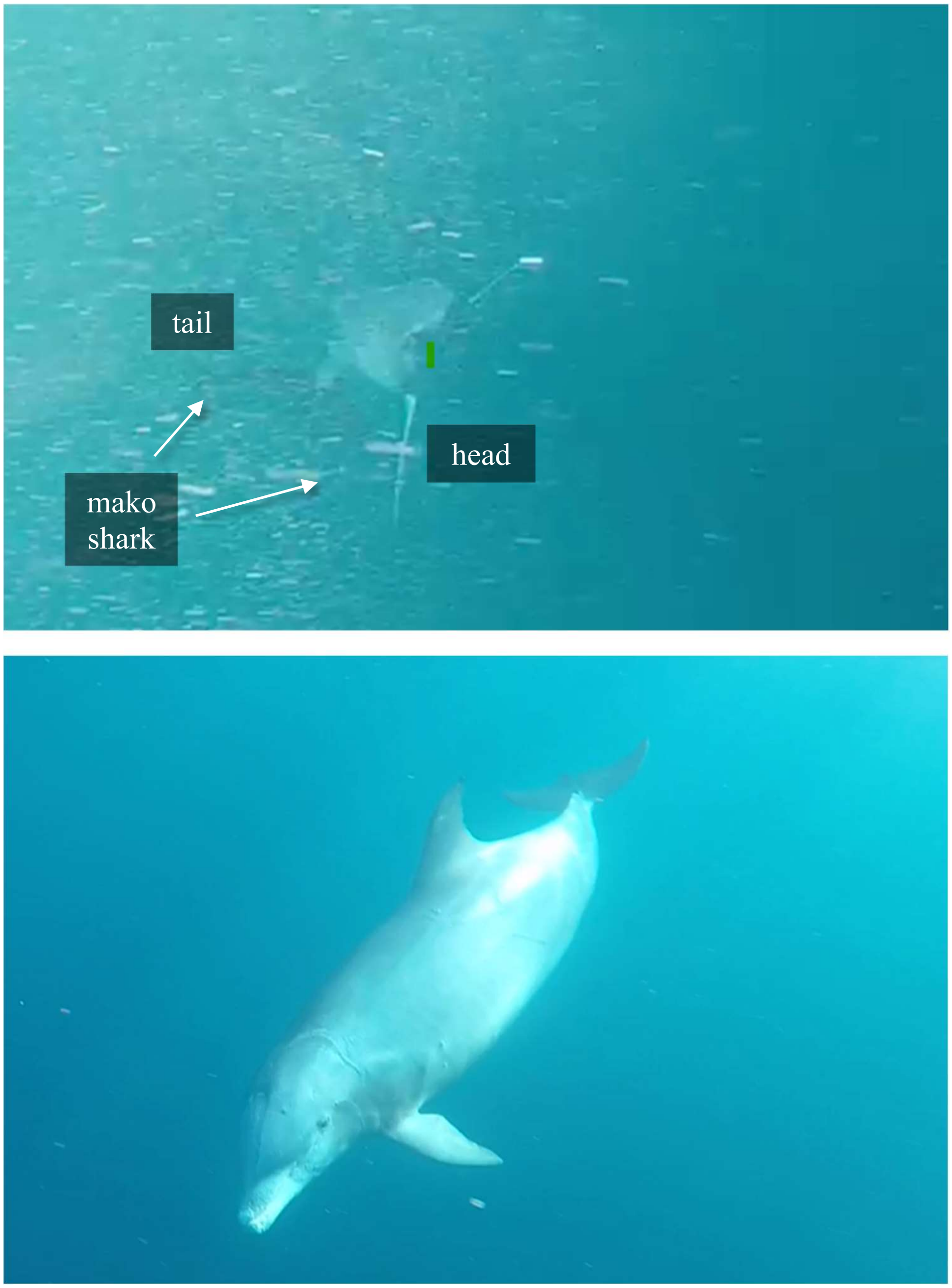


Figure 10. Digital images of a shortfin mako shark (top) and a bottlenose dolphin (bottom) that were present on tagging artificial reefs and followed acoustically tagged triggerfish as they swam back or were descended to reefs from the surface.

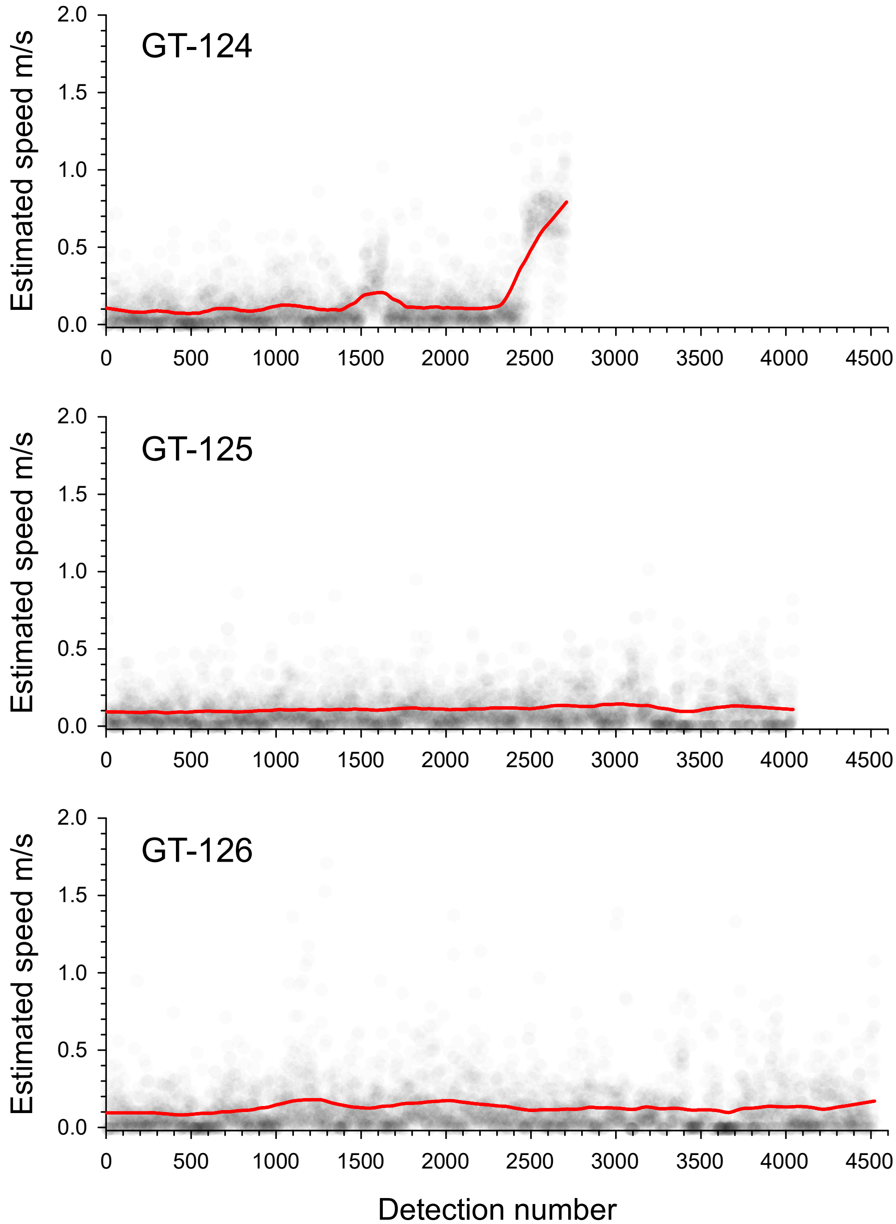


Figure 11. Estimated speed versus detection number for three adult gray triggerfish captured with nets near the seabed and externally tagged with Innovasea V13P telemetry tags. Red lines are loess regressions fitted to the data. These fish serve as positive controls of the general trend and variance observed in live gray triggerfish movement. Fish GT-124 subsequently appeared to be consumed by a predator at approximately detection 2,300, after which its speed profile changed substantially.

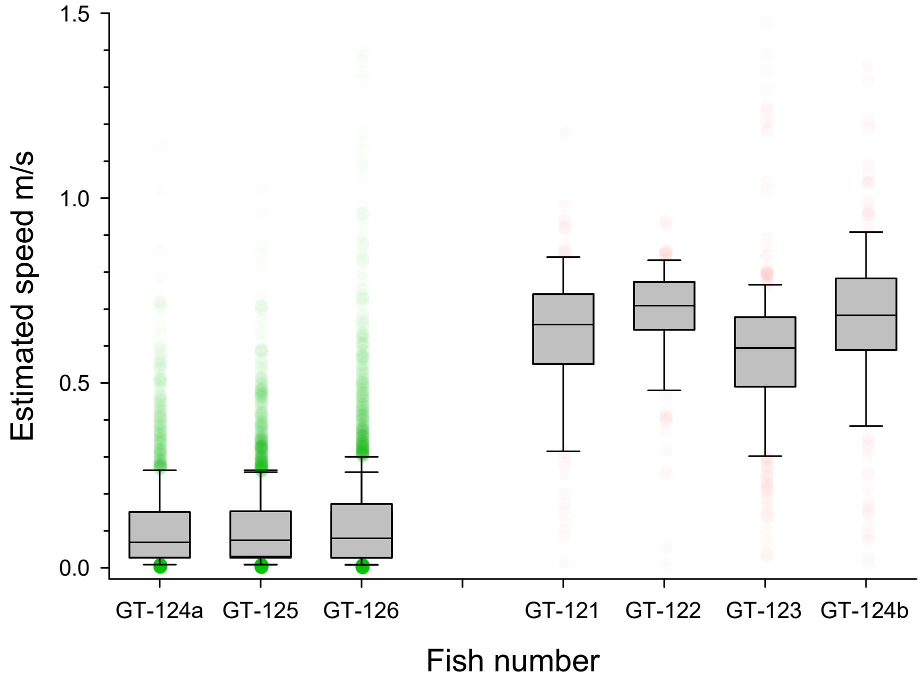


Figure 12. Estimated speed box plots for positive (green) and negative (red) gray triggerfish controls captured and tagged on the seabed. The negative controls were subsequently sacrificed via pithing. Fish 124 is plotted with both groups to indicate the time period prior to being consumed by a predator (124a) versus after being consumed (124b). Upper and lower sides of boxes indicate the upper and lower quartiles of the data, while horizontal lines indicate the median. Extended bars indicate 5^{th} and 95^{th} percentiles, with green or red circles indicating data beyond those percentiles.

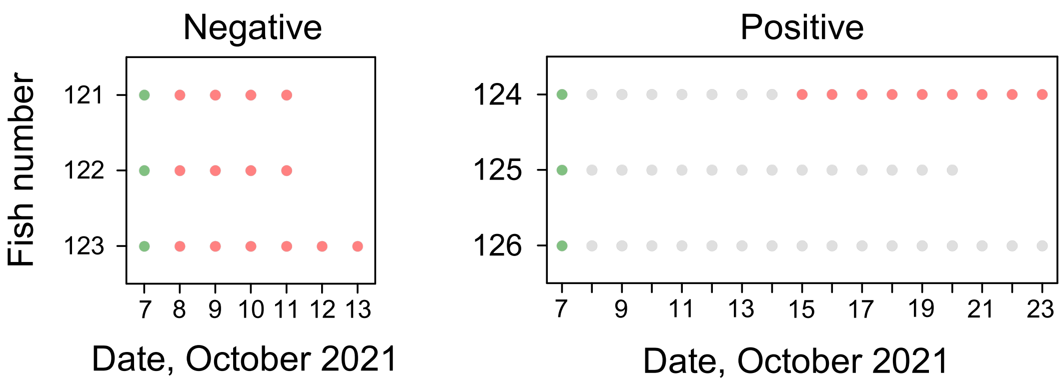


Figure 13. Detections over time of sacrificed (negative controls) and live (positive controls) gray triggerfish externally tagged with Innovasea VP-13H acoustic tags on the seafloor in the north central Gulf of Mexico during 2021. Green circles indicate date of tagging. Red circles indicate predation events or predator tracking.

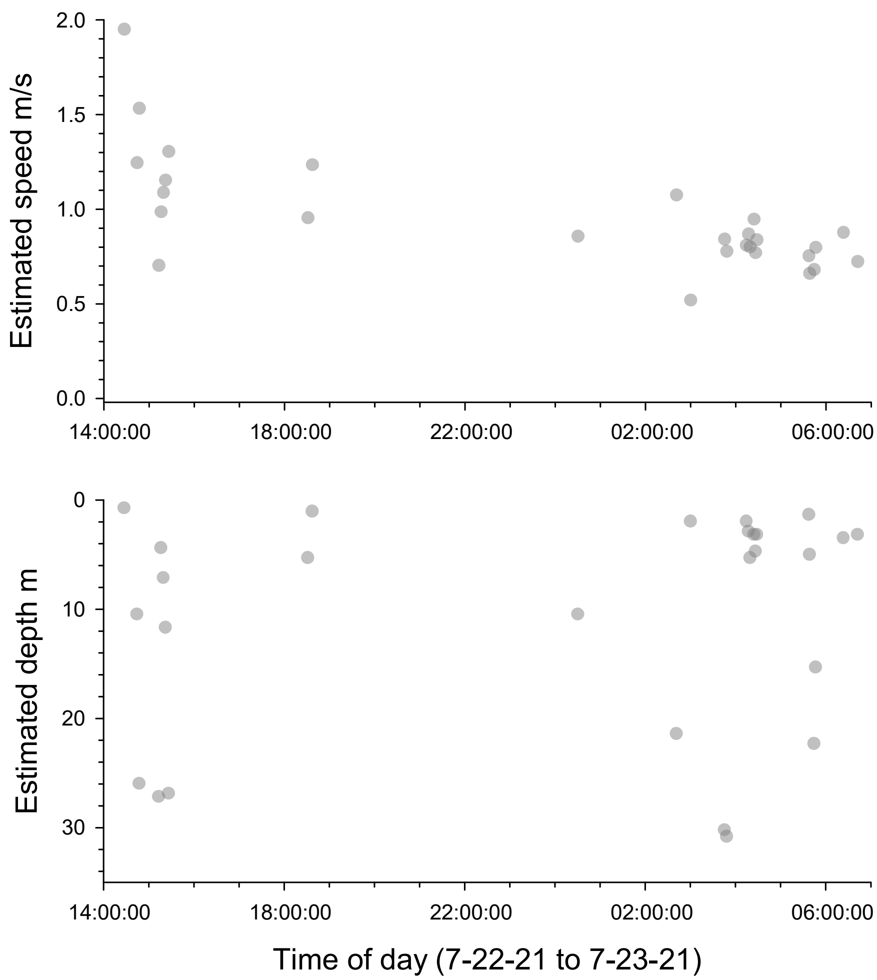


Figure 14. Estimated speed and depth of tagged fish GT-070, which was tagged on 7/22/21 and consumed by a predator almost immediately after release. Repeated movements toward to the surface suggest a marine mammal was the consumer, most likely a bottlenose dolphin, *Tursiops truncatus*.

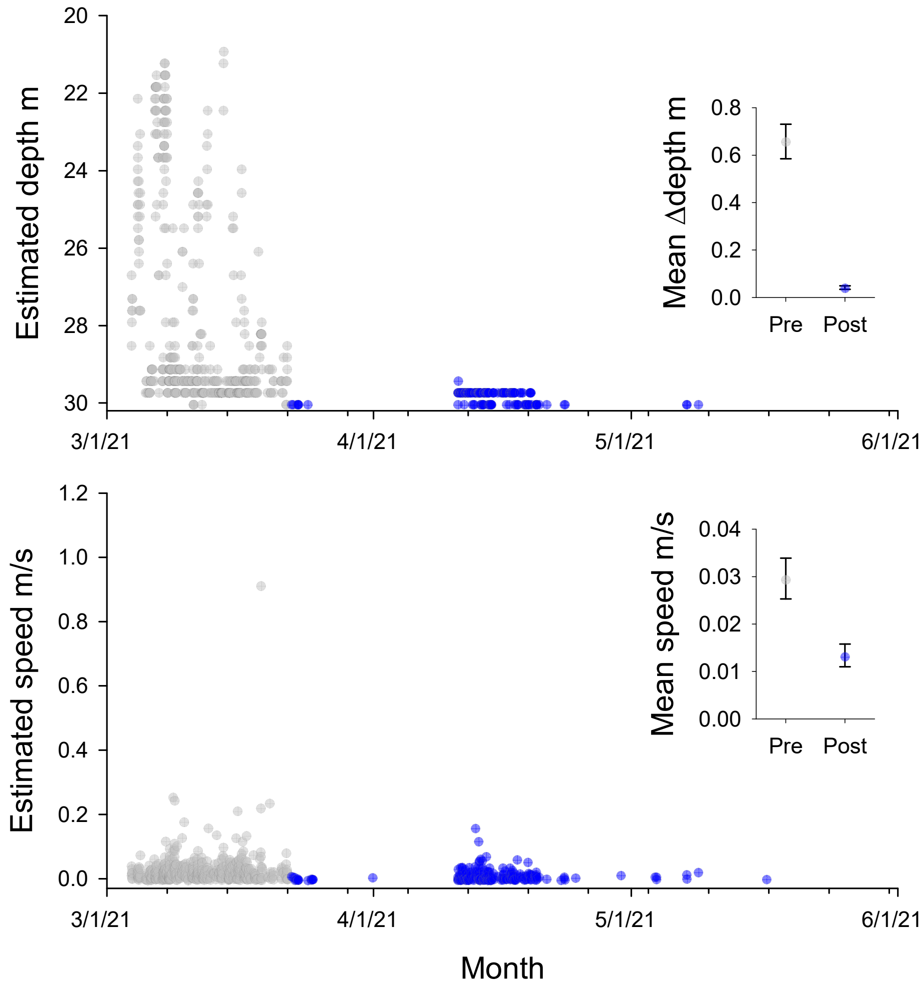


Figure 15. A) Estimated depth and B) speed of an Innovasea V13P tag that was attached to Fish GT-005. The near-constant depth and limited speed estimates indicate the tag became detached from the fish on March 22, 2021 (blue circles) but periodically was detected on the seabed until May 18, 2021, after which it either became covered in sediment or otherwise stopped transmitting. Inset panels indicate mean ± 95% CI for Δdepth (above) or speed (below) during pre- versus post-tag loss periods.

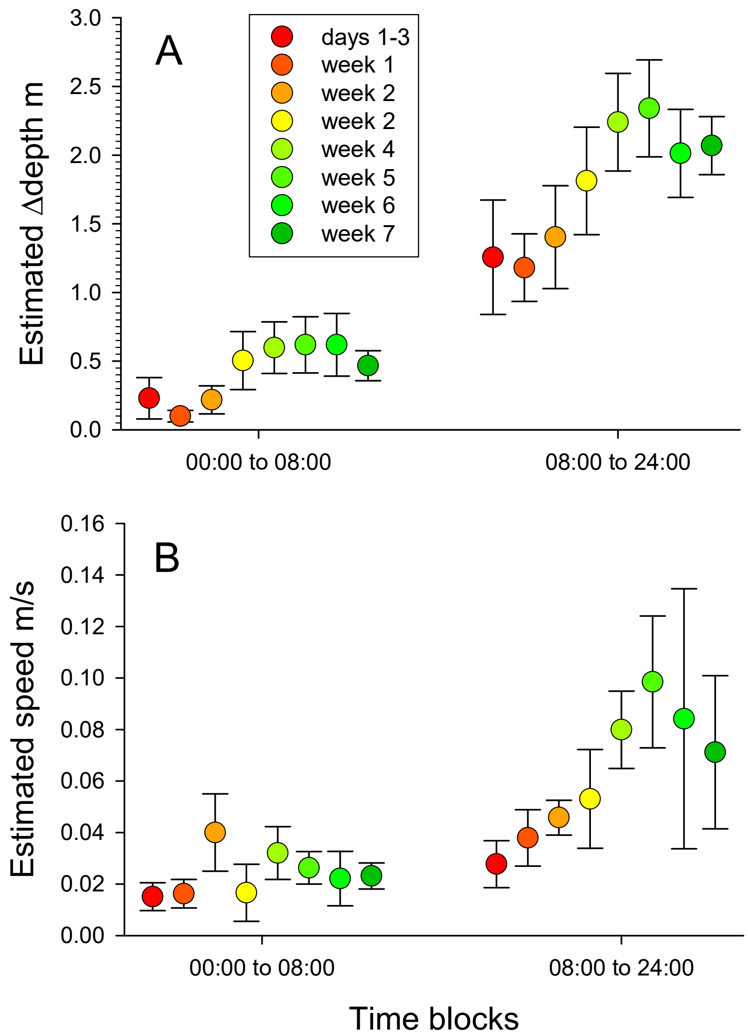


Figure 16. Estimated A) depth differential and B) speed (mean ± 95% CI) for gray triggerfish GT-016 tracked with acoustic telemetry. Depth differential is the absolute value of the difference in depth between two sequential detections.

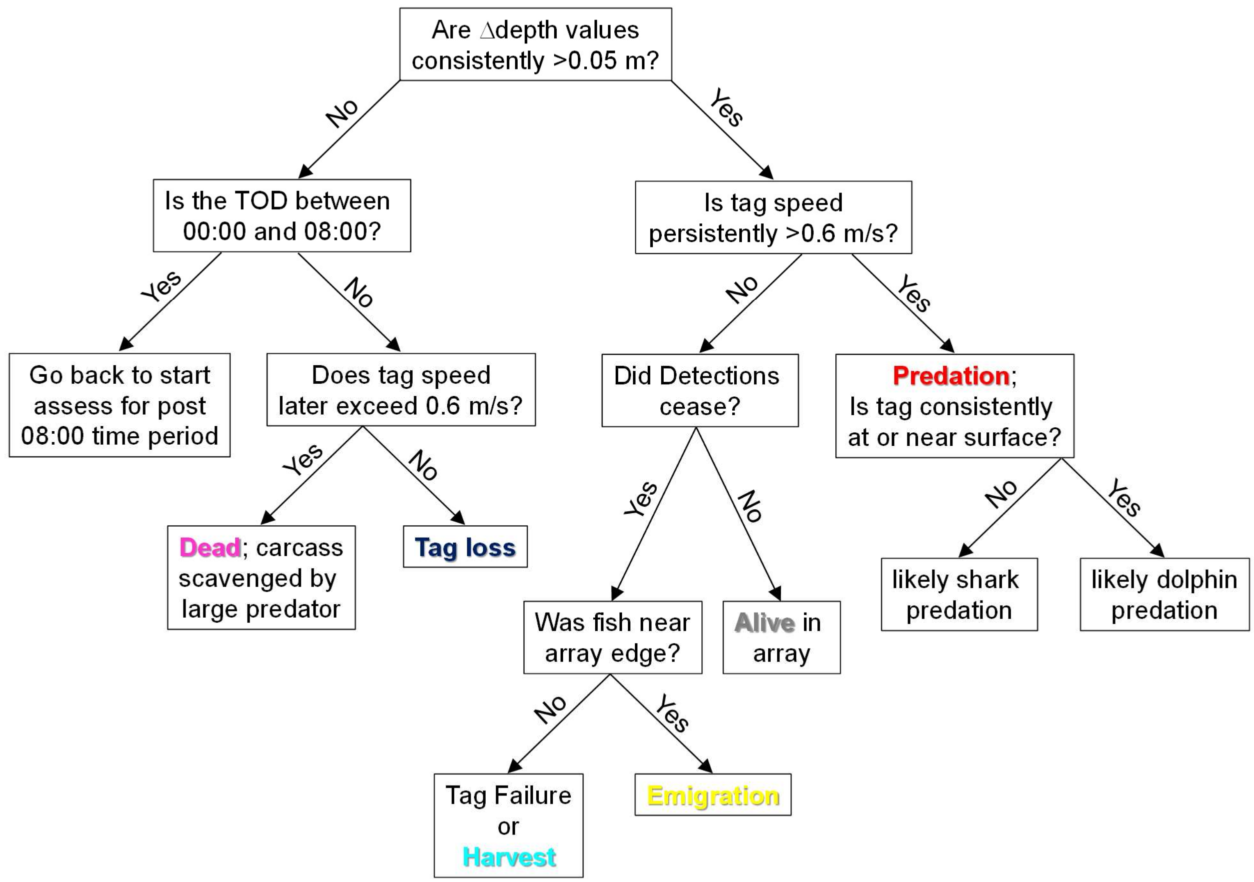


Figure 17. Decision tree constructed to assess the fate of acoustically tagged gray triggerfish based on movement behavior. Δdepth is the absolute value of the difference in estimated depth between two sequential detections of a given acoustic tag. TOD = time of day.

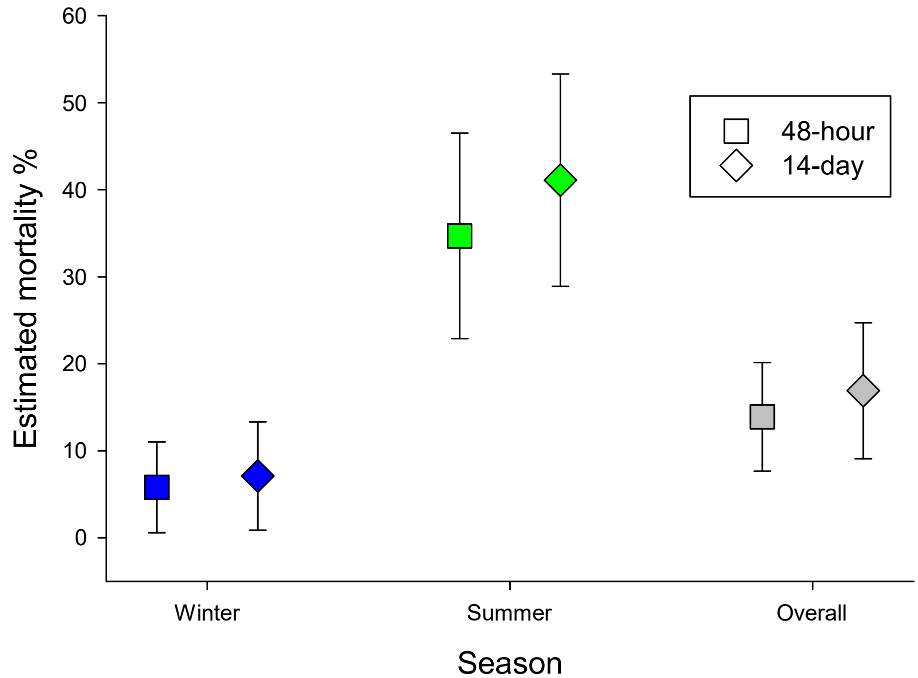


Figure 18. Season- and time-specific estimated gray triggerfish mortality for the most parsimonious model presented in Table 2. Error bars indicate 95% CI computed as 1.96*SE following Pollock and Pine (2007). Sample size was 60 for winter and 56 in summer due to 4 fish with unknown fate in summer.

Appendix 1

Figure A1. Detections over time of gray triggerfish tagged externally with with Innovasea VP-13H acoustic tags in the north central Gulf of Mexico during 2021.

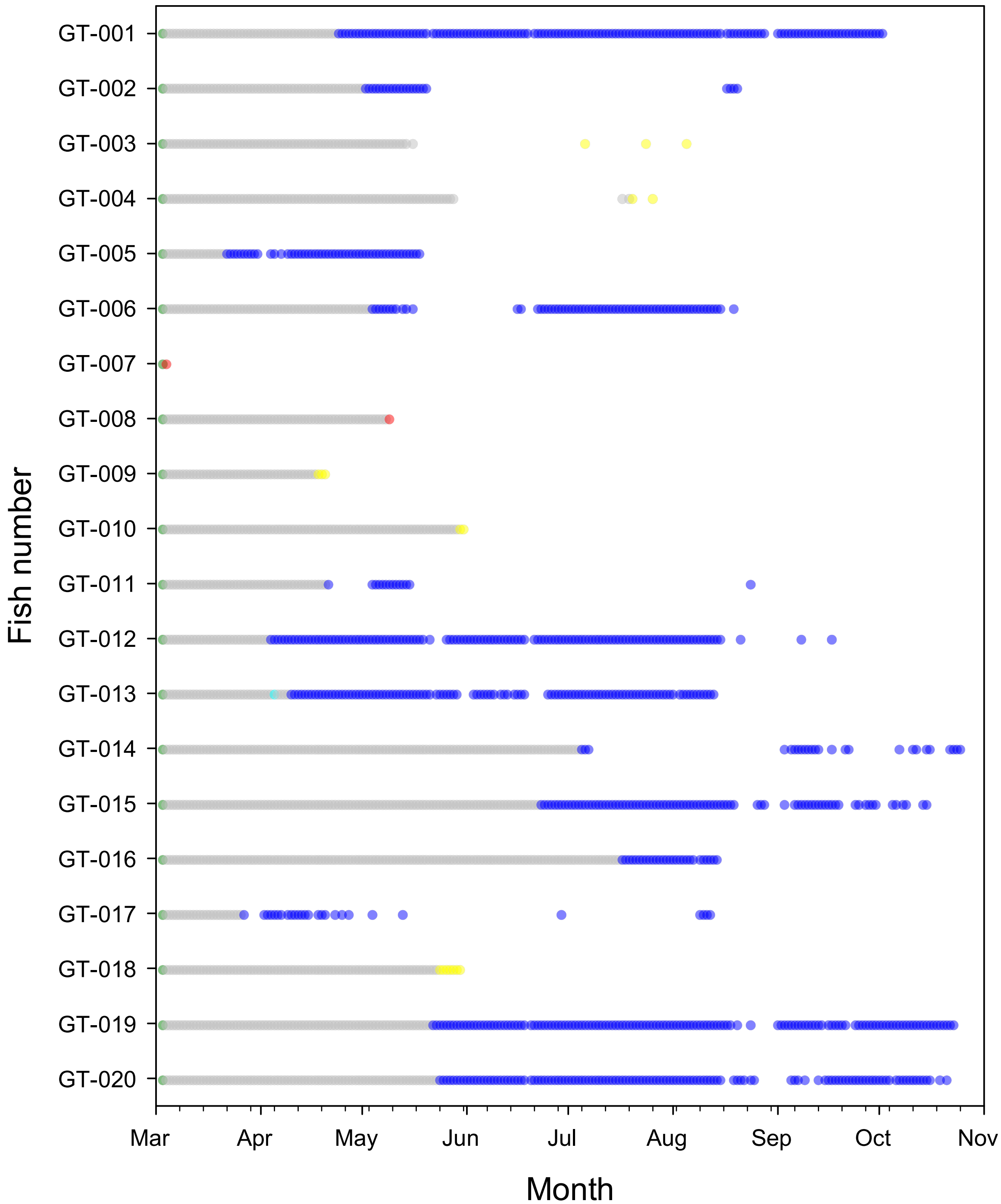


Figure A1. Detections over time of gray triggerfish externally tagged with Innovasea VP-13H acoustic tags in the north central Gulf of Mexico during 2021. Green circles indicate date of tagging. Gray circles indicate fish detected within telemetry array. Pink circles indicated release mortality without predation. Red circles indicate predation events and subsequent predator tracking. Orange circles indicate scavenging events and subsequent tracking. Dark blue circles indicate tag loss and transmission on bottom. Light blue circles indicate fishery harvest. Yellow indicates emigration from array. Minor tick marks on x-axis indicate weeks since March 1, 2021.

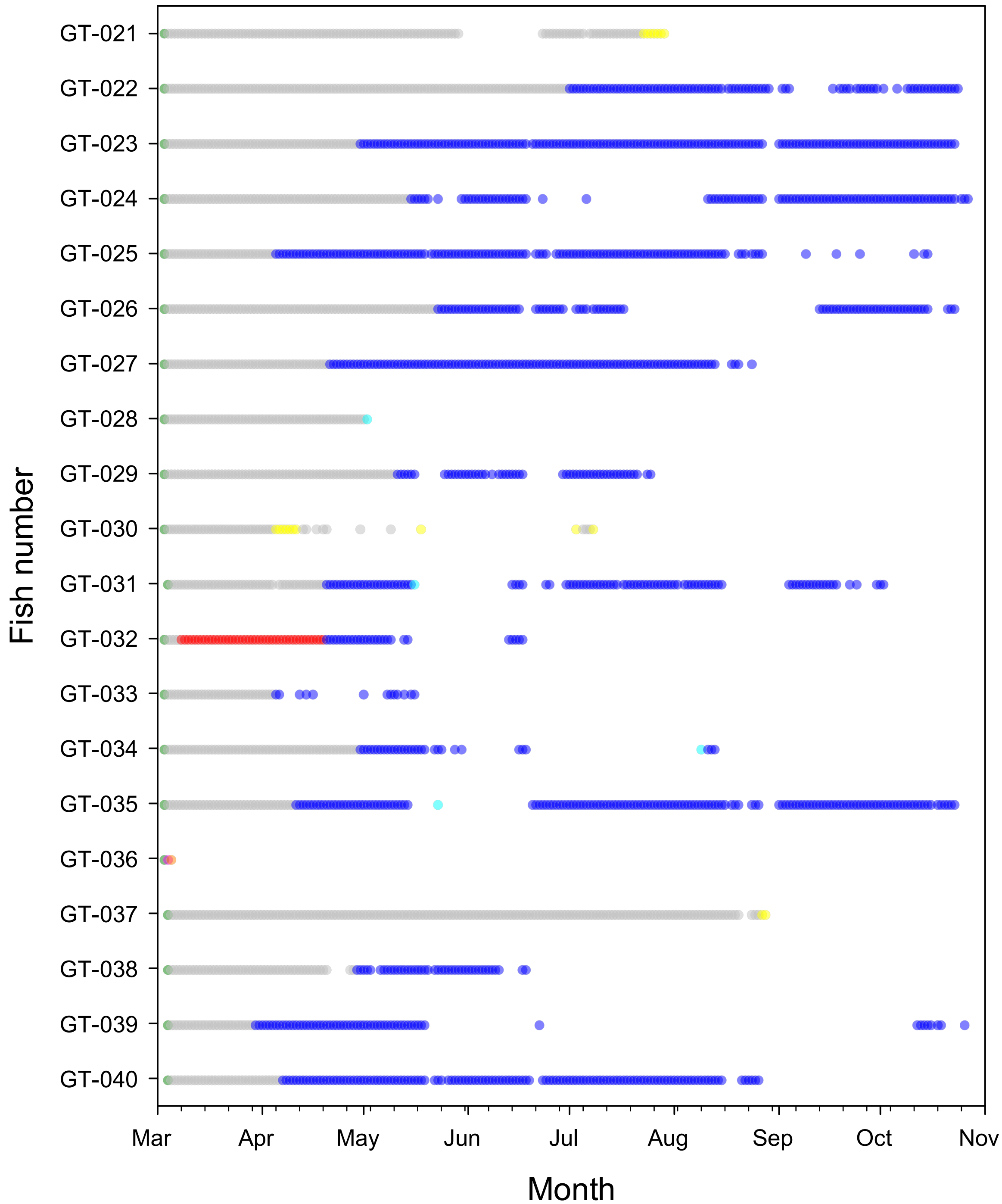


Figure A1 cont. Detections over time of gray triggerfish externally tagged with Innovasea VP-13H acoustic tags in the north central Gulf of Mexico during 2021. Green circles indicate date of tagging. Gray circles indicate fish detected within telemetry array. Pink circles indicated release mortality without predation. Red circles indicate predation events and subsequent predator tracking. Orange circles indicate scavenging events and subsequent tracking. Dark blue circles indicate tag loss and transmission on bottom. Light blue circles indicate fishery harvest. Yellow indicates emigration from array. Minor tick marks on x-axis indicate weeks since March 1, 2021.

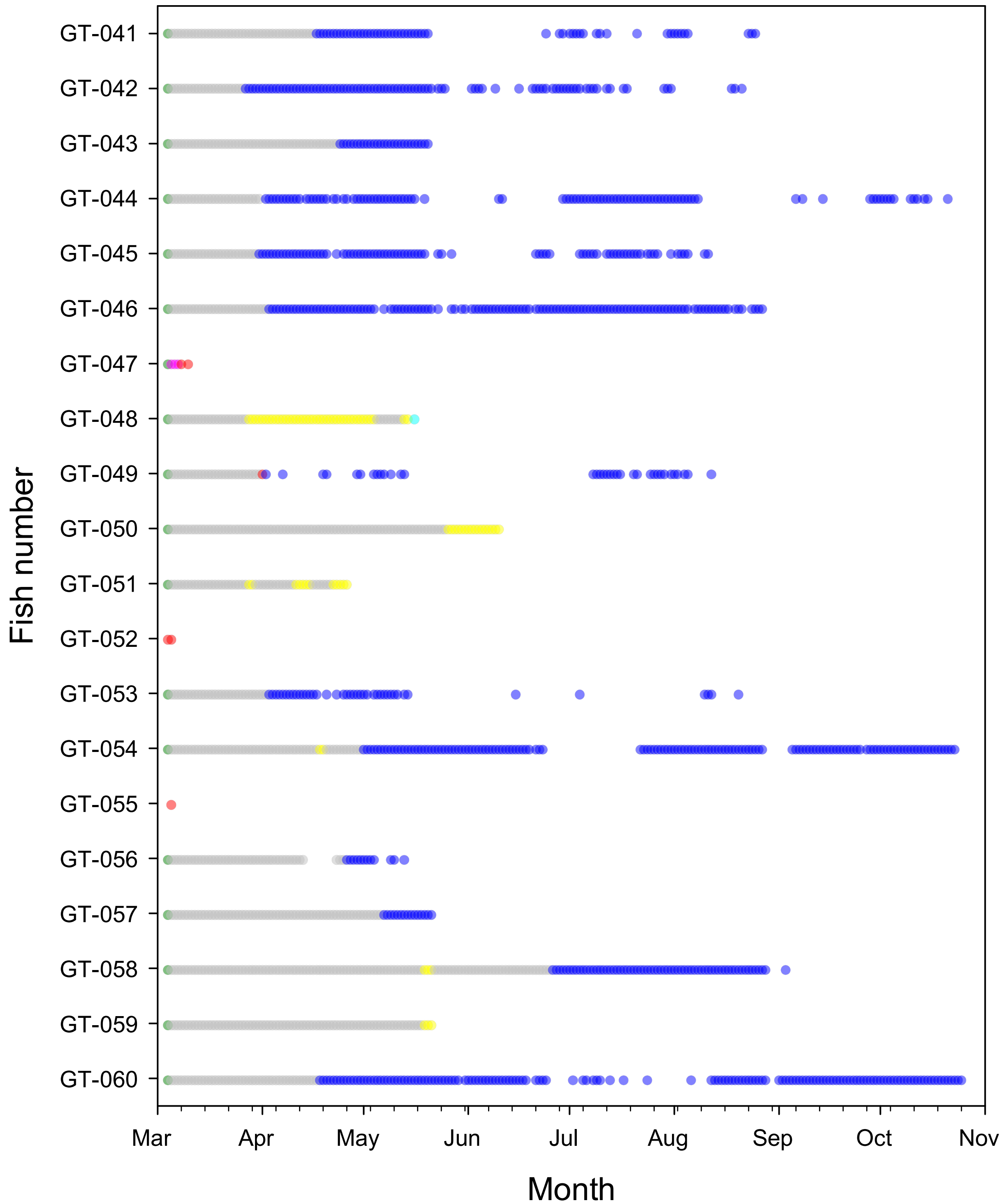


Figure A1 cont. Detections over time of gray triggerfish externally tagged with Innovasea VP-13H acoustic tags in the north central Gulf of Mexico during 2021. Green circles indicate date of tagging. Gray circles indicate fish detected within telemetry array. Pink circles indicated release mortality without predation. Red circles indicate predation events and subsequent predator tracking. Orange circles indicate scavenging events and subsequent tracking. Dark blue circles indicate tag loss and transmission on bottom. Light blue circles indicate fishery harvest. Yellow indicates emigration from array. Minor tick marks on x-axis indicate weeks since March 1, 2021.

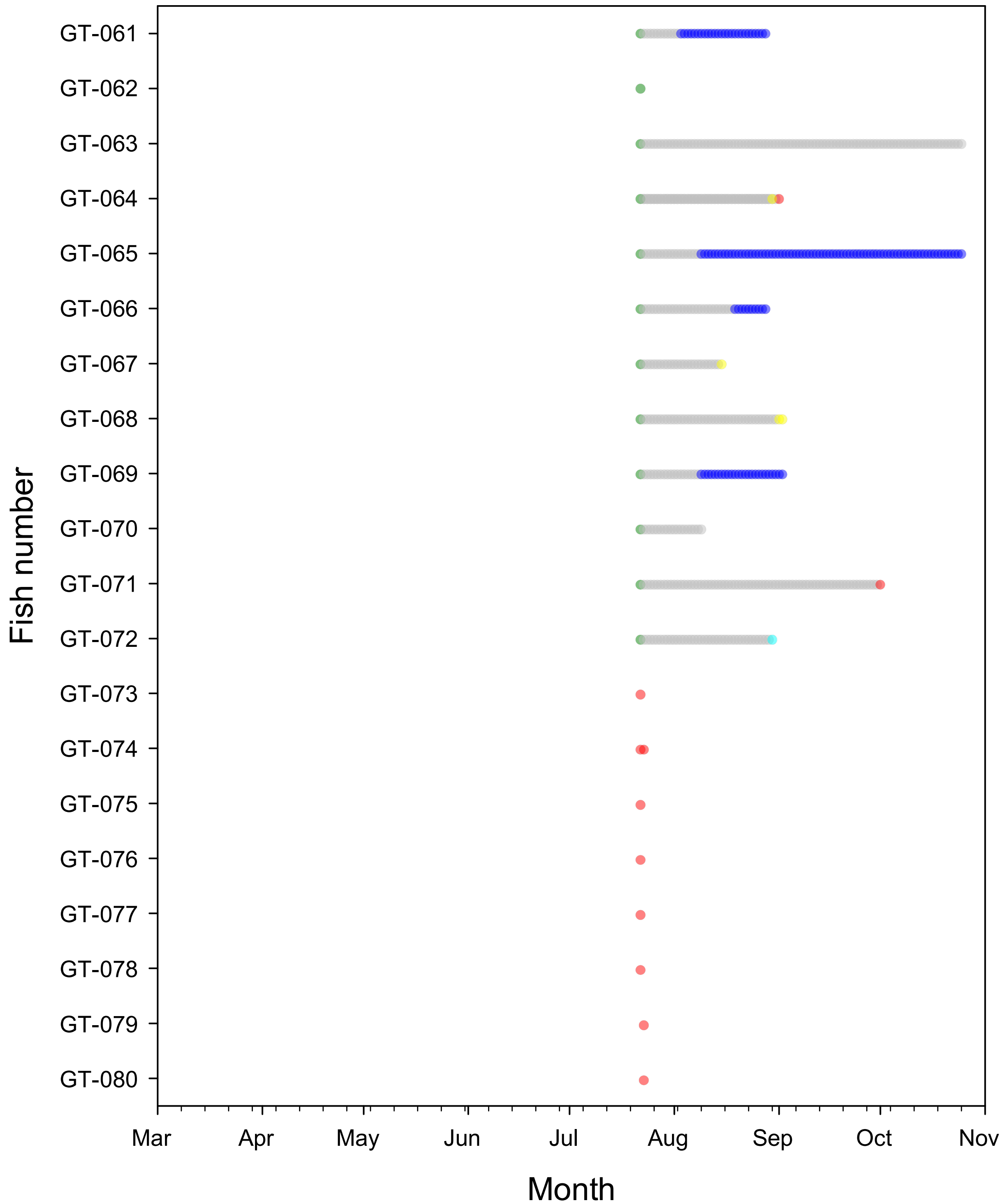


Figure A1 cont. Detections over time of gray triggerfish externally tagged with Innovasea VP-13H acoustic tags in the north central Gulf of Mexico during 2021. Green circles indicate date of tagging. Gray circles indicate fish detected within telemetry array. Pink circles indicated release mortality without predation. Red circles indicate predation events and subsequent predator tracking. Orange circles indicate scavenging events and subsequent tracking. Dark blue circles indicate tag loss and transmission on bottom. Light blue circles indicate fishery harvest. Yellow indicates emigration from array. Minor tick marks on x-axis indicate weeks since March 1, 2021.

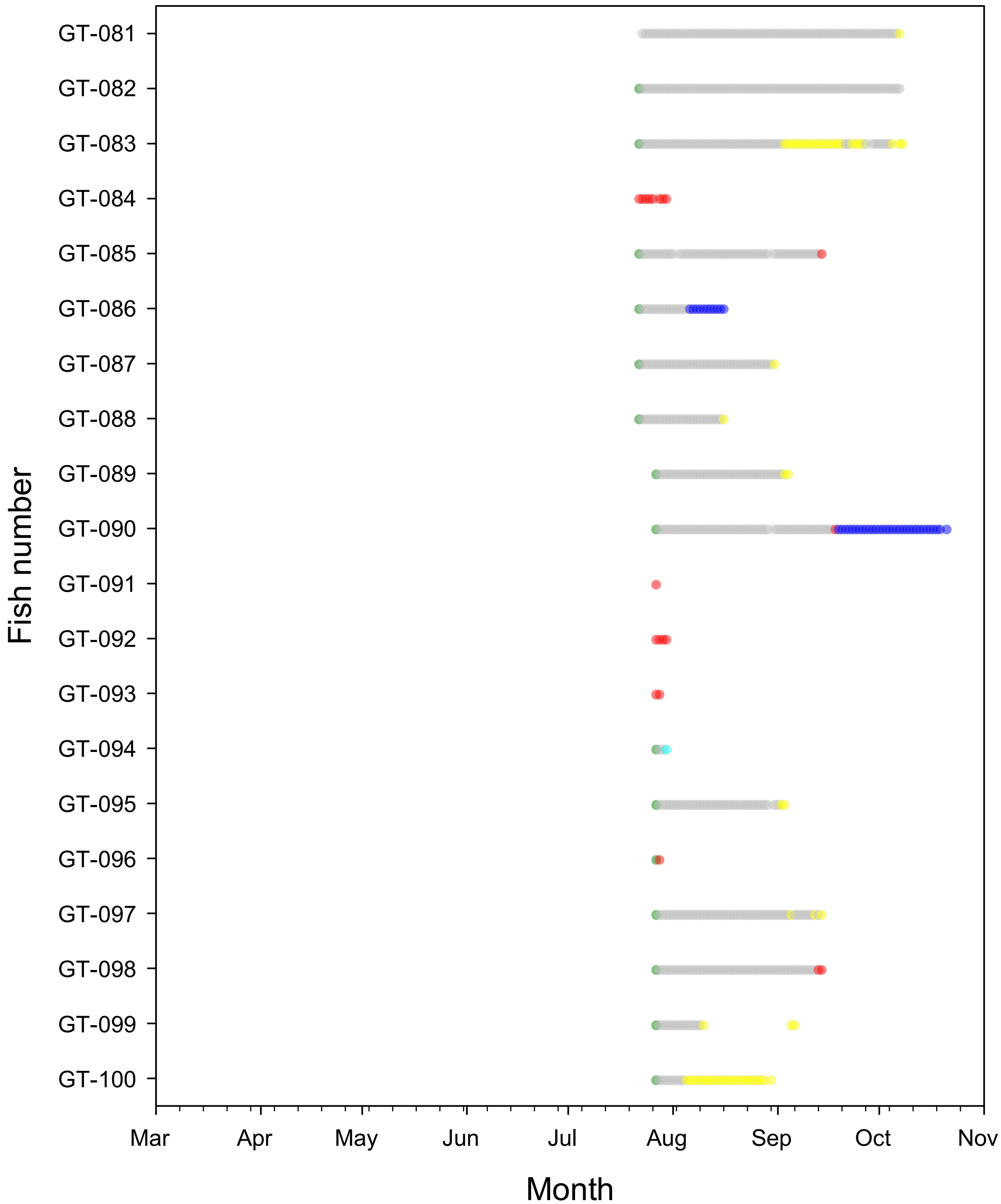


Figure A1 cont. Detections over time of gray triggerfish externally tagged with Innovasea VP-13H acoustic tags in the north central Gulf of Mexico during 2021. Green circles indicate date of tagging. Gray circles indicate fish detected within telemetry array. Pink circles indicated release mortality without predation. Red circles indicate predation events and subsequent predator tracking. Orange circles indicate scavenging events and subsequent tracking. Dark blue circles indicate tag loss and transmission on bottom. Light blue circles indicate fishery harvest. Yellow indicates emigration from array.

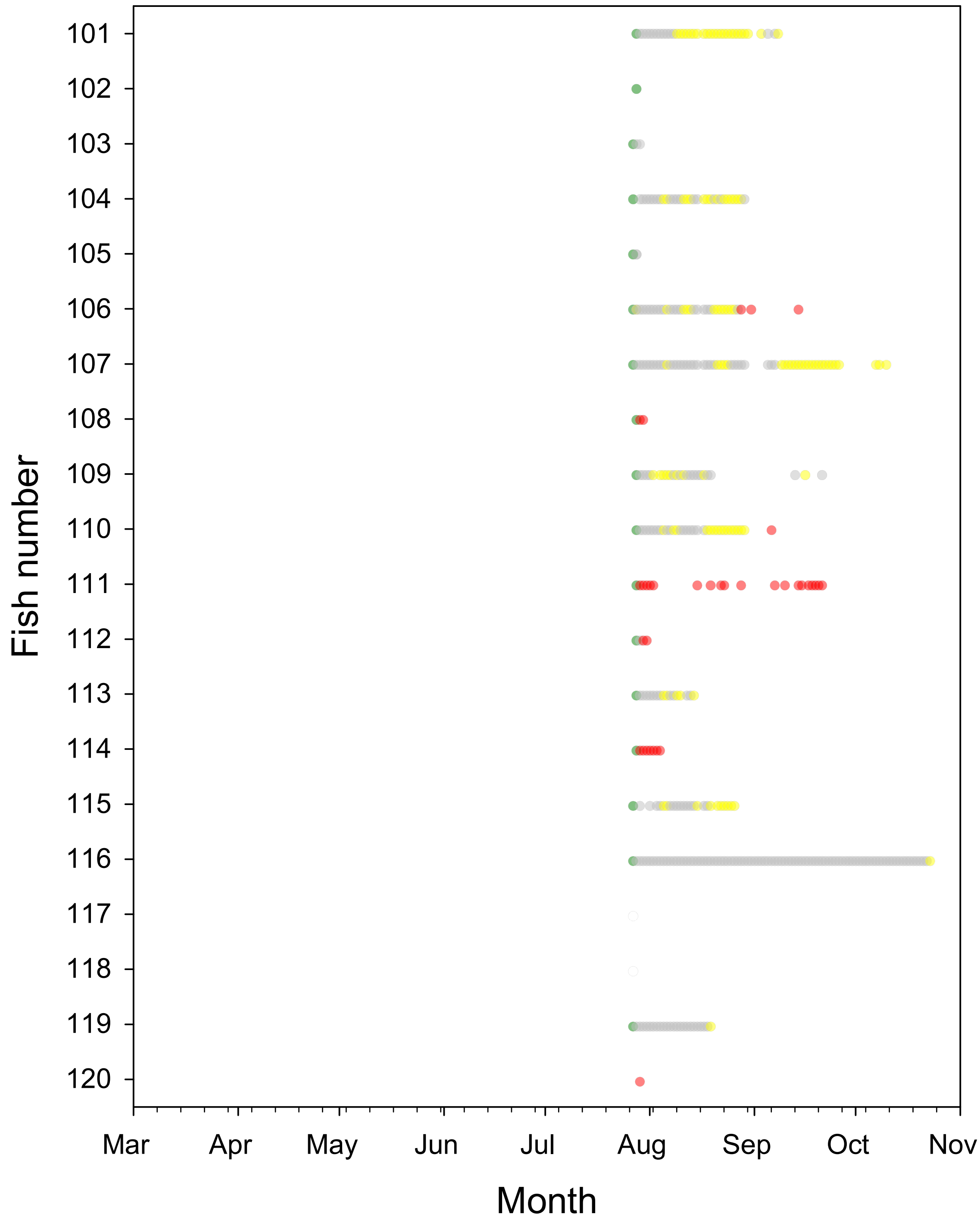
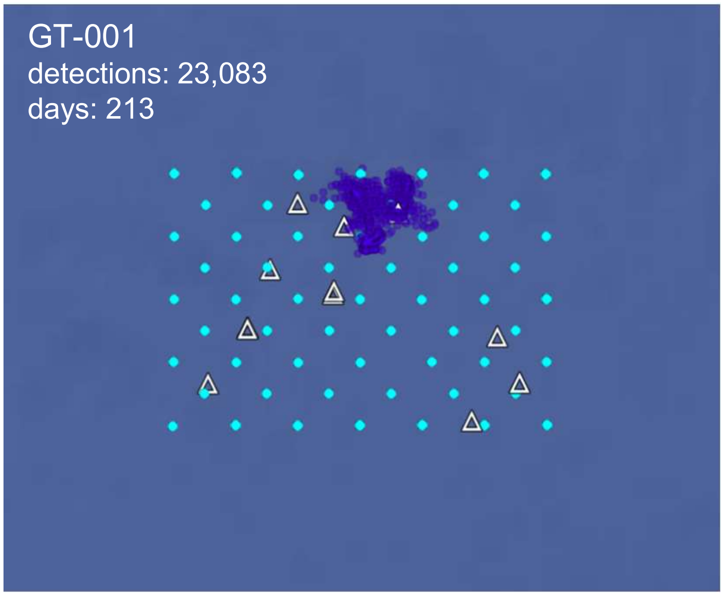
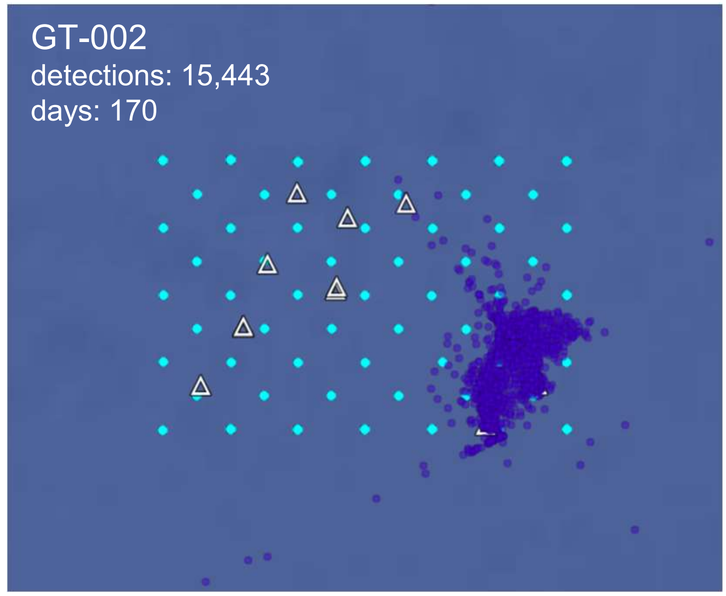


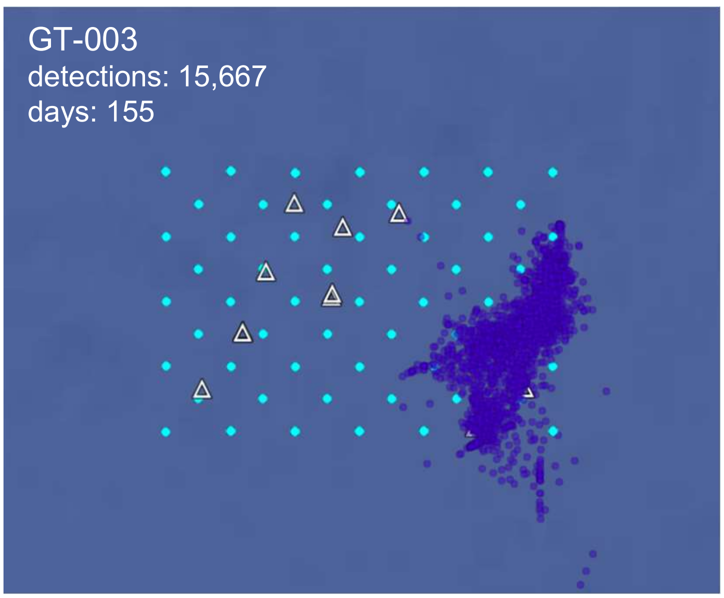
Figure A1 cont. Detections over time of gray triggerfish externally tagged with Innovasea VP-13H acoustic tags in the north central Gulf of Mexico during 2021. Green circles indicate date of tagging. Gray circles indicate fish detected within telemetry array. Pink circles indicated release mortality without predation. Red circles indicate predation events and subsequent predator tracking. Orange circles indicate scavenging events and subsequent tracking. Dark blue circles indicate tag loss and transmission on bottom. Light blue circles indicate fishery harvest. Yellow indicates emigration from array.

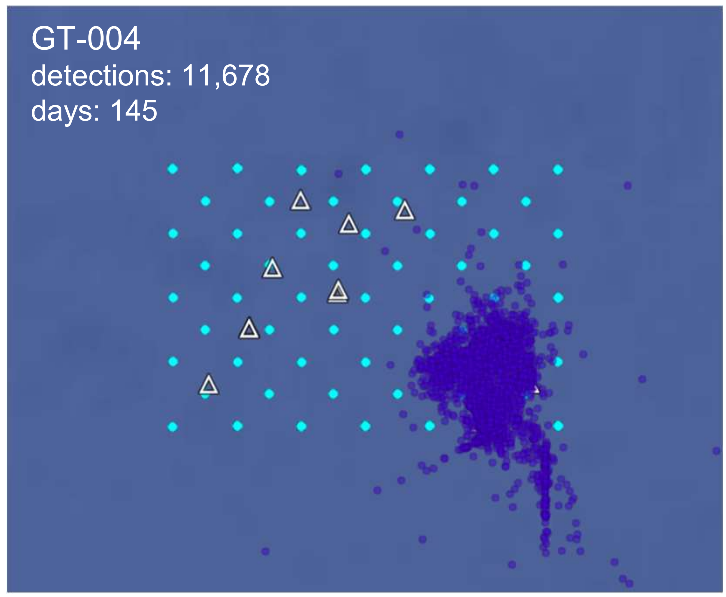
Appendix 2

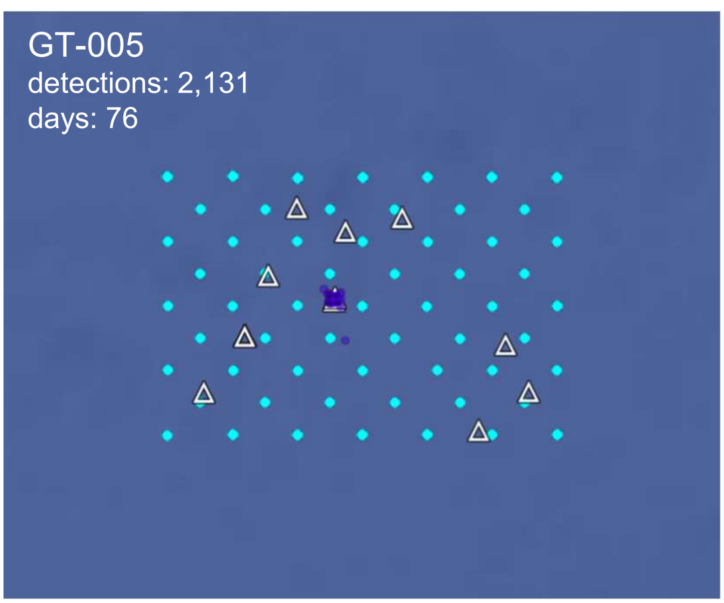
Table A2. Movement maps of acoustically tagged gray triggerfish in an acoustic array deployed approximately 32 km south southeast of Pensacola Pass, Florida (array midpoint: 30.081N 87.104W) in the Escambia East Large Area Artificial Site. Acoustic receivers locations indicated by light blue circles. Triangles indicate locations of known artificial reefs. Dark blue circles indicate fish geoposition estimates. Number of detections and total days tracked o is provided on each sample-specific map.

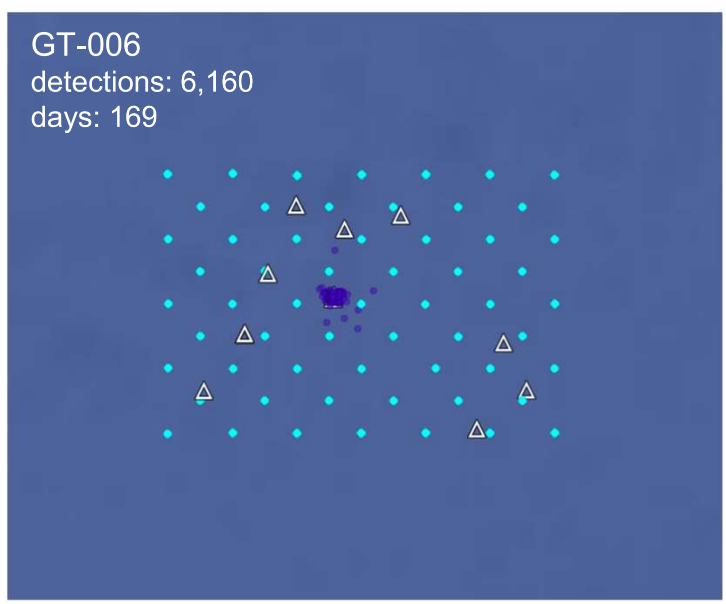

GT-001
detections: 23,083
days: 213

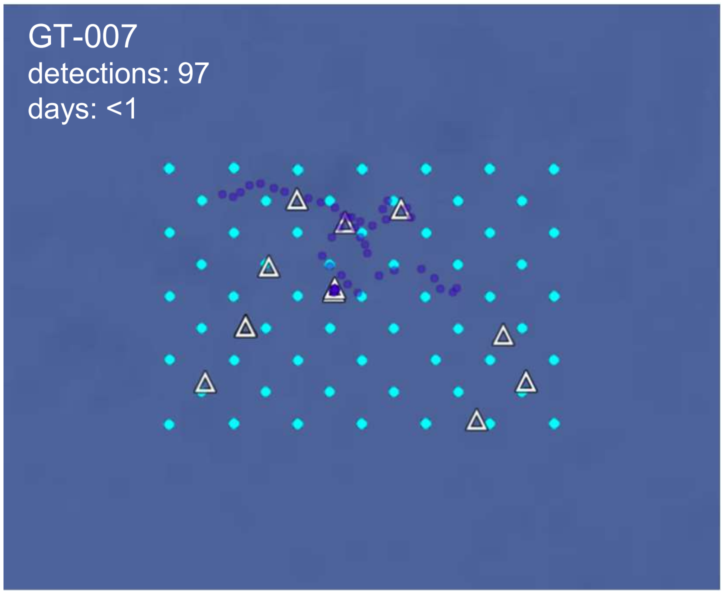

GT-002
detections: 15,443
days: 170

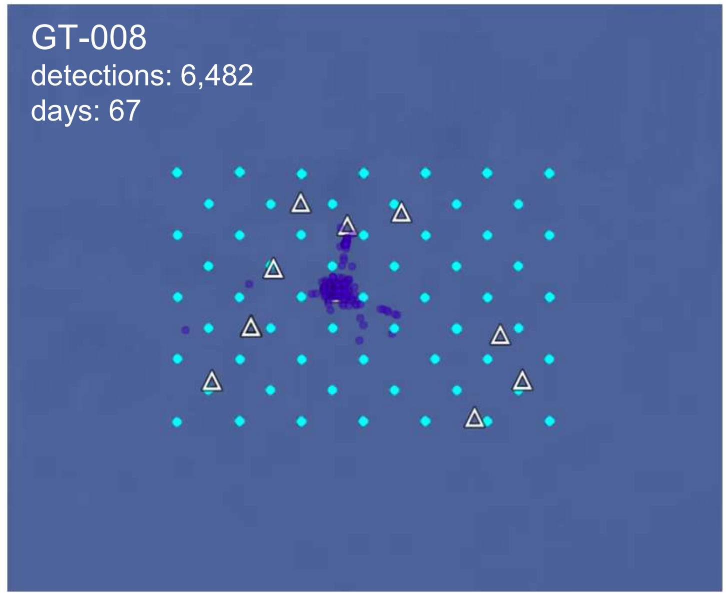

GT-003
detections: 15,667
days: 155

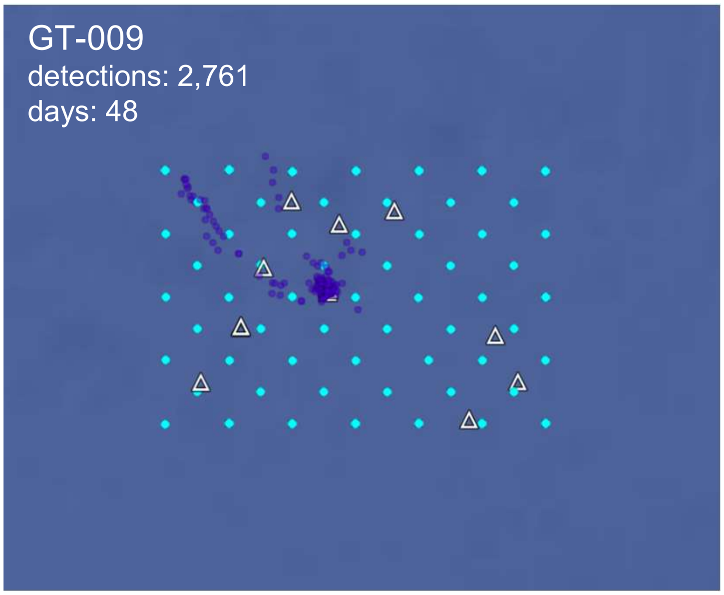

GT-004
detections: 11,678
days: 145

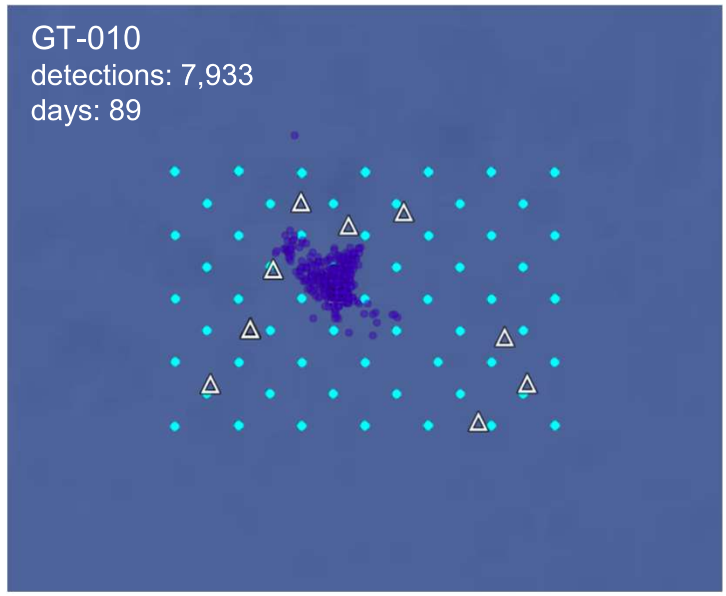

GT-005
detections: 2,131
days: 76

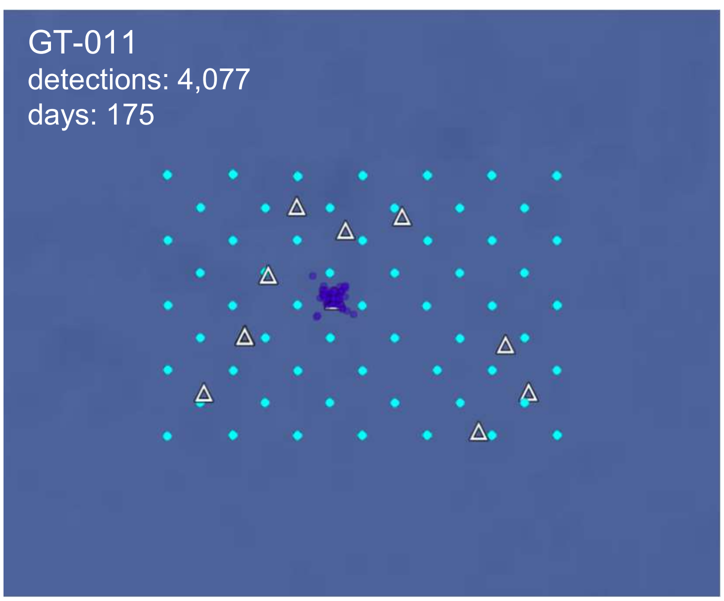

GT-006
detections: 6,160
days: 169

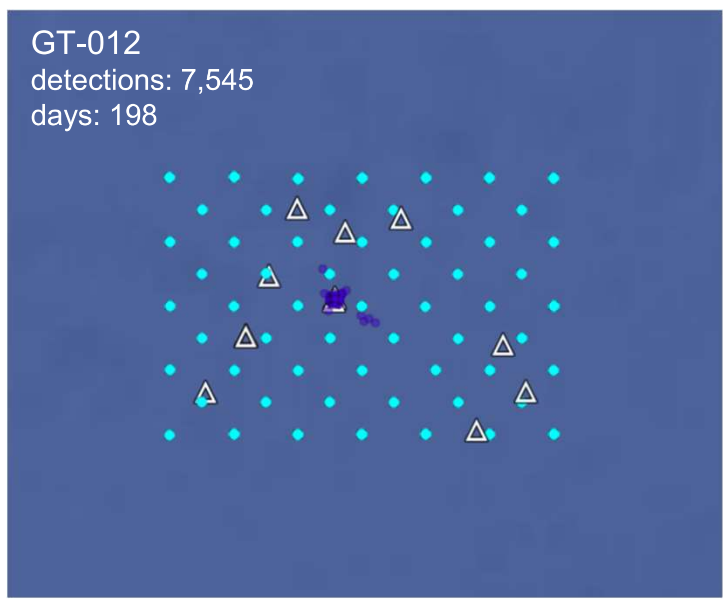

GT-007
detections: 97
days: <1

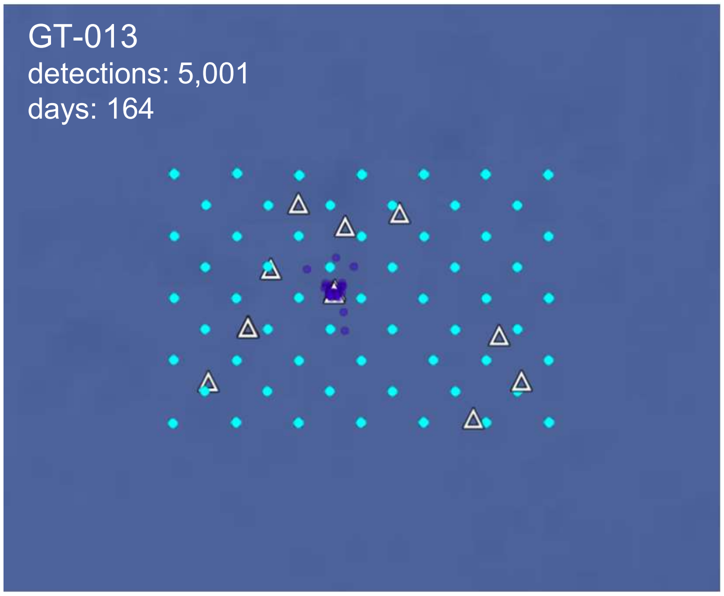

GT-008
detections: 6,482
days: 67

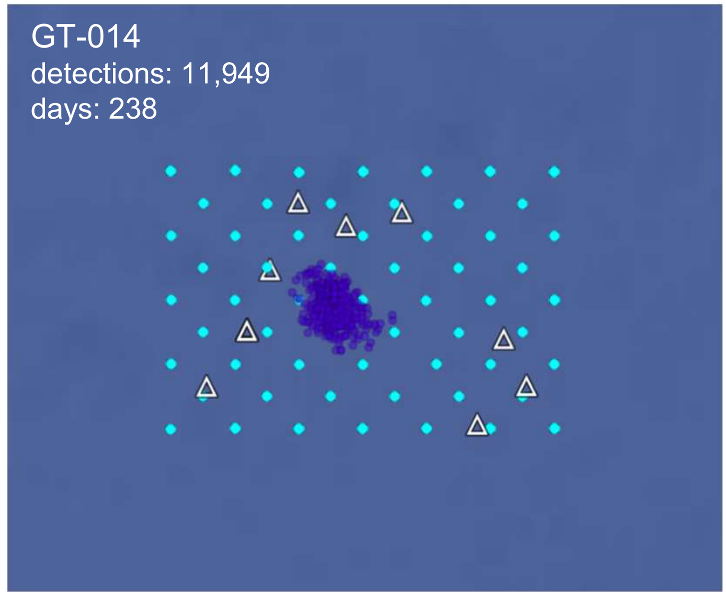

GT-009
detections: 2,761
days: 48

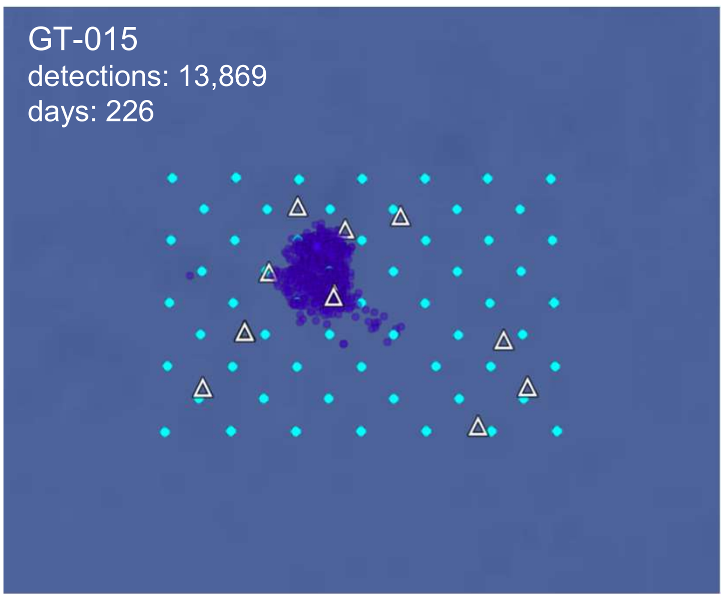

GT-010
detections: 7,933
days: 89

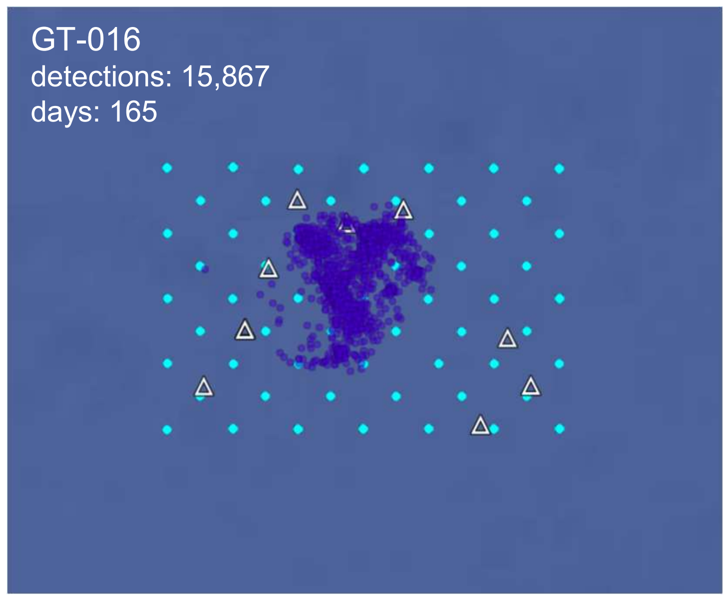

GT-011
detections: 4,077
days: 175

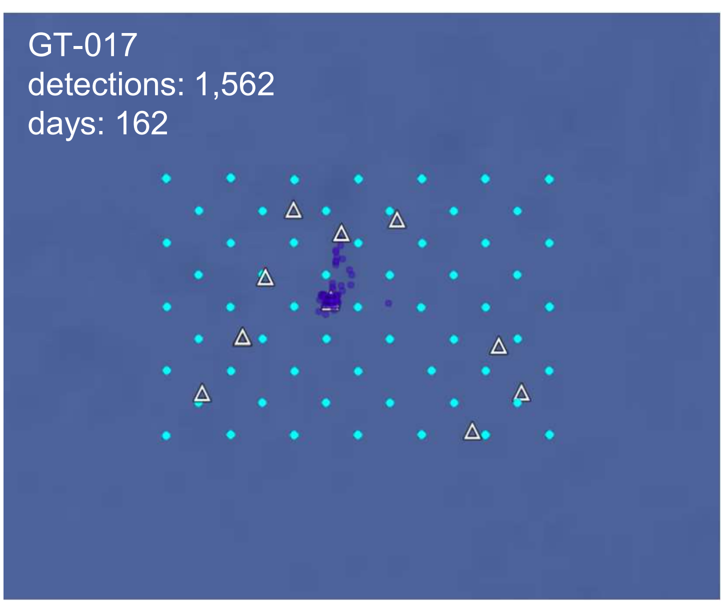

GT-012
detections: 7,545
days: 198

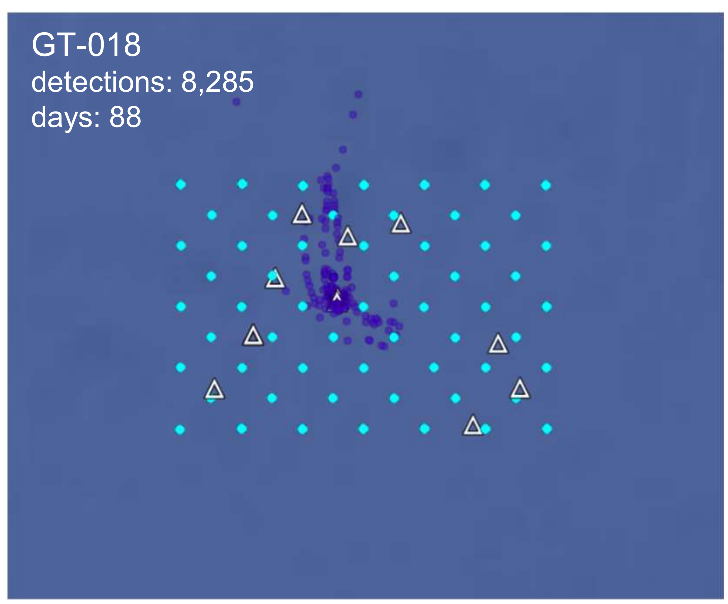

GT-013
detections: 5,001
days: 164

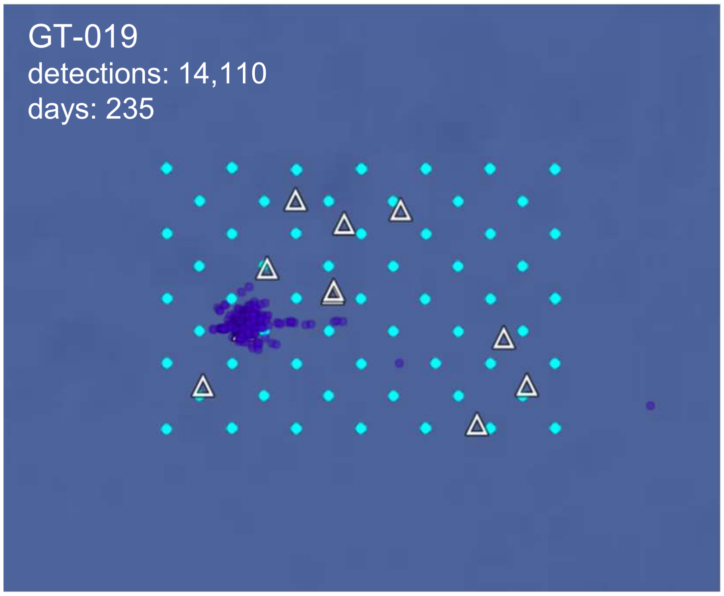

GT-014
detections: 11,949
days: 238

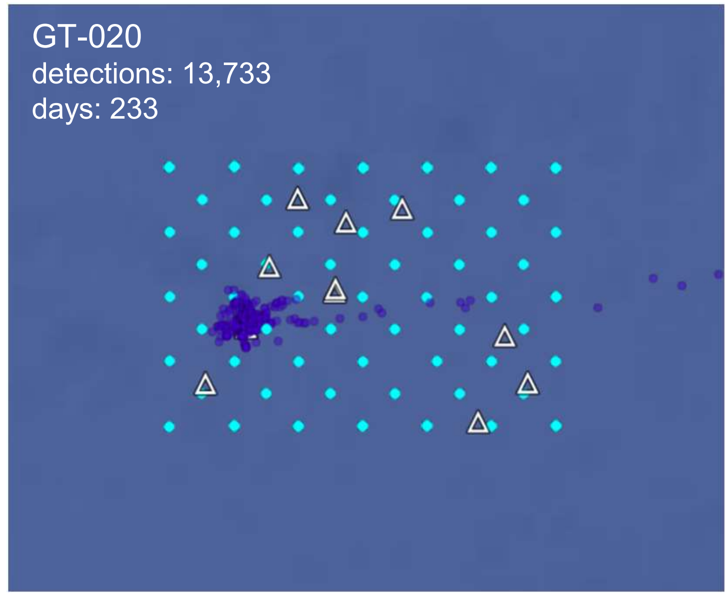

GT-015
detections: 13,869
days: 226

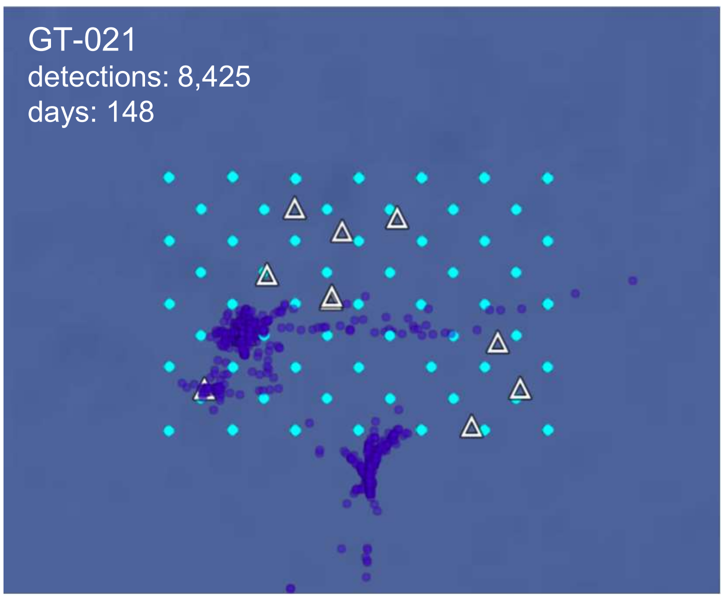

GT-016
detections: 15,867
days: 165

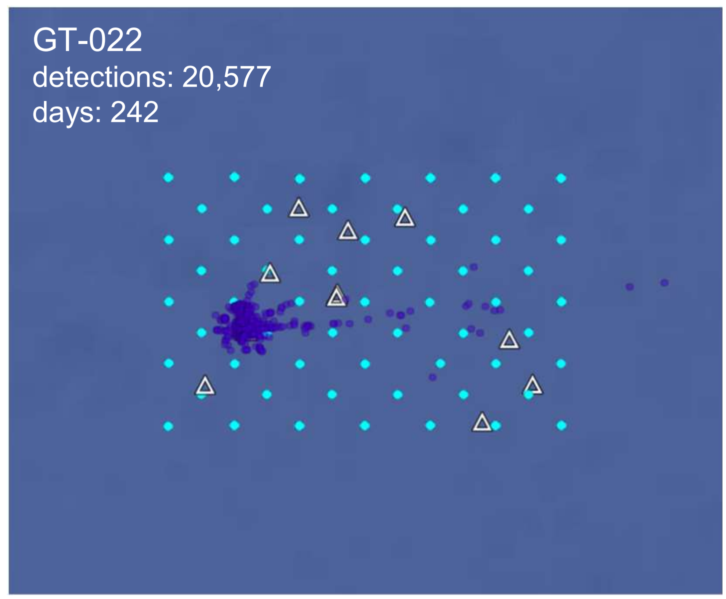

GT-017
detections: 1,562
days: 162

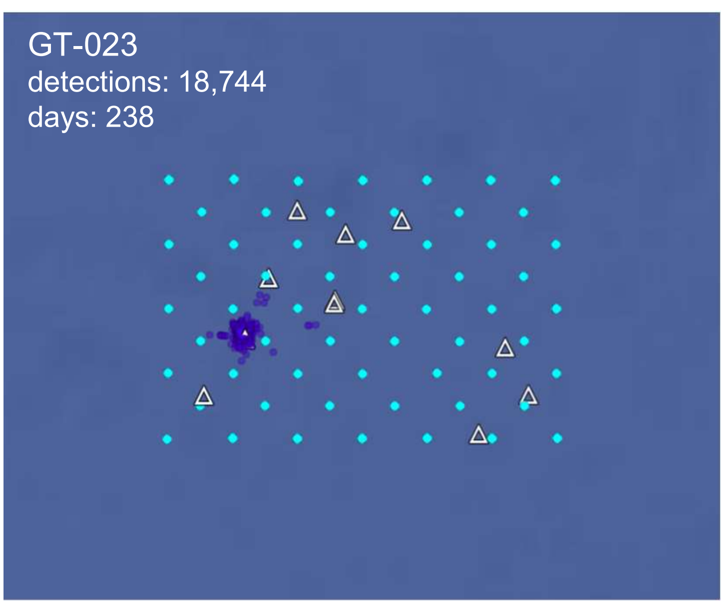

GT-018
detections: 8,285
days: 88

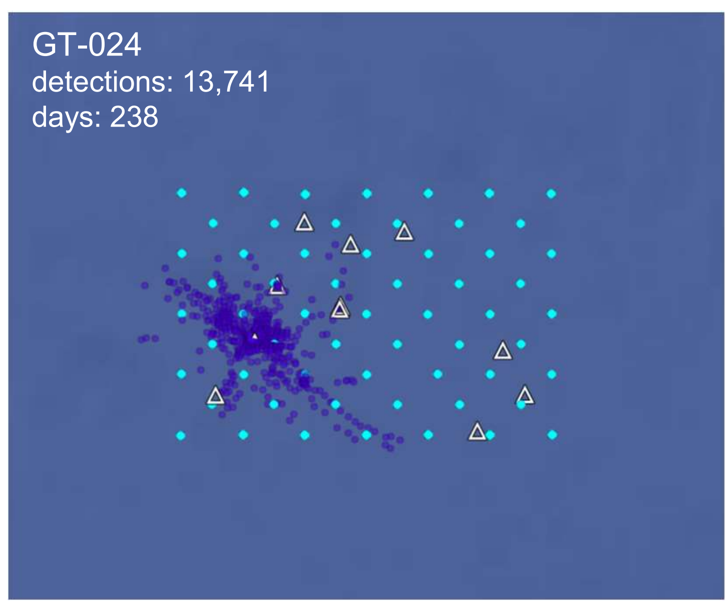

GT-019
detections: 14,110
days: 235

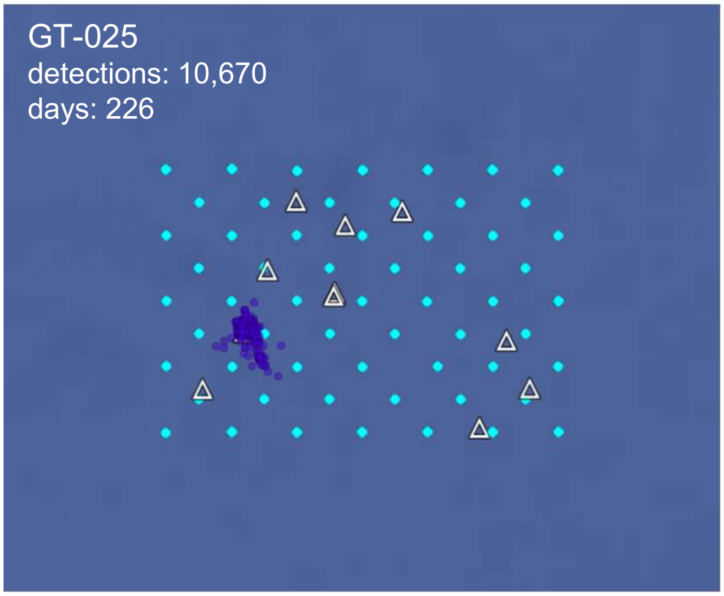

GT-020
detections: 13,733
days: 233

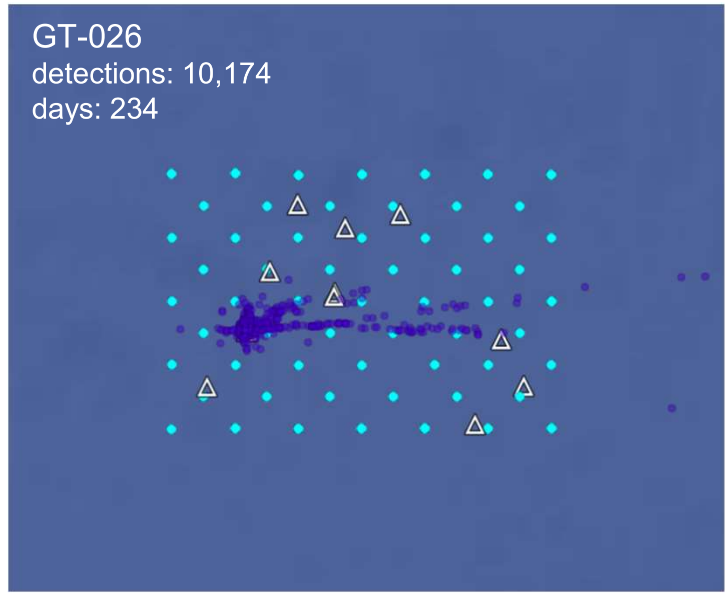

GT-021
detections: 8,425
days: 148

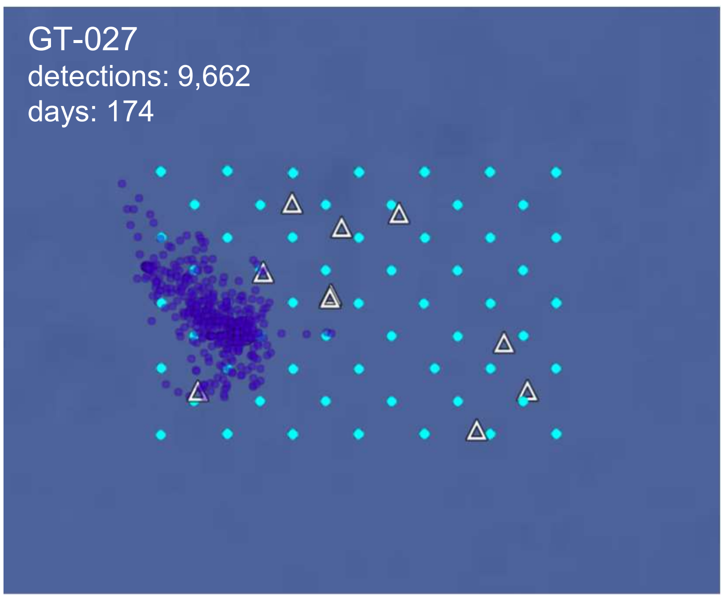

GT-022
detections: 20,577
days: 242

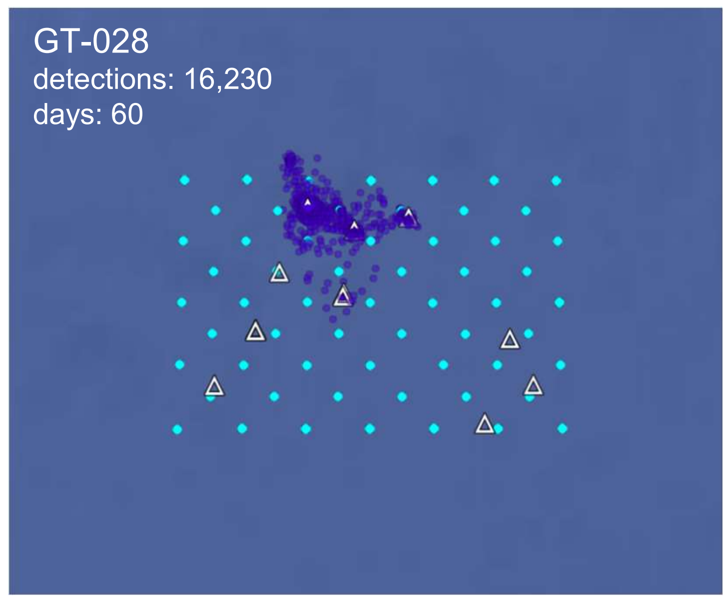

GT-023
detections: 18,744
days: 238

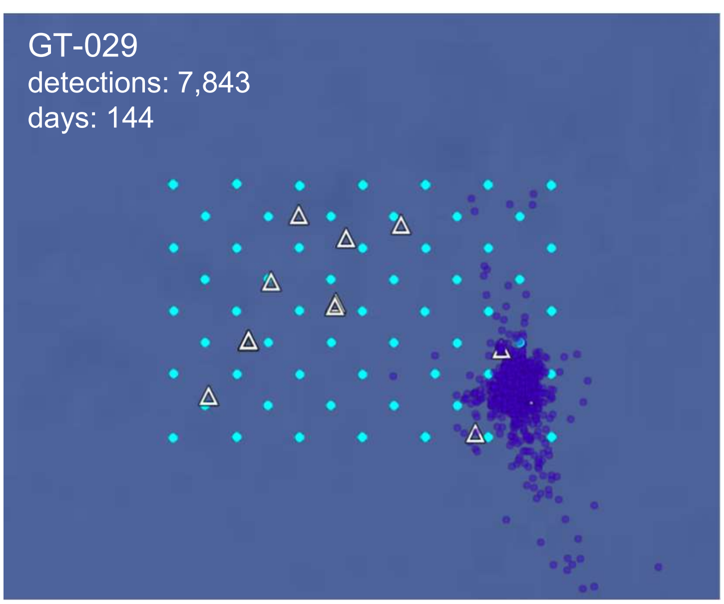

GT-024
detections: 13,741
days: 238

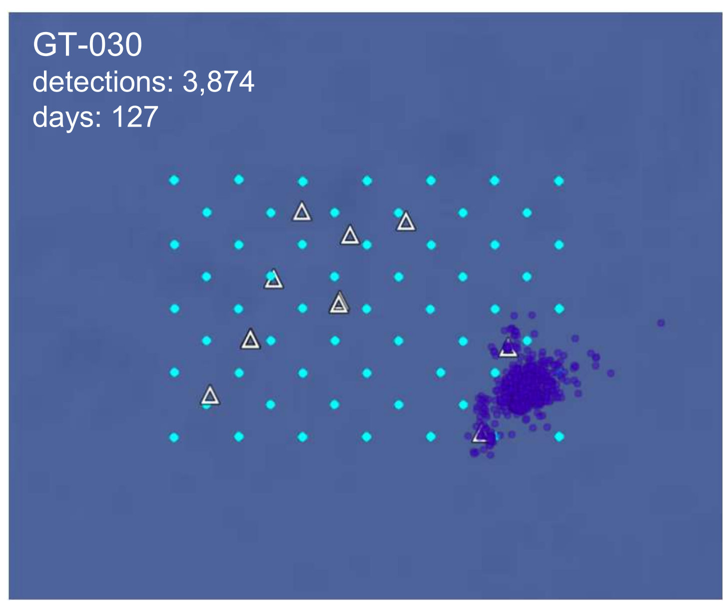

GT-025
detections: 10,670
days: 226

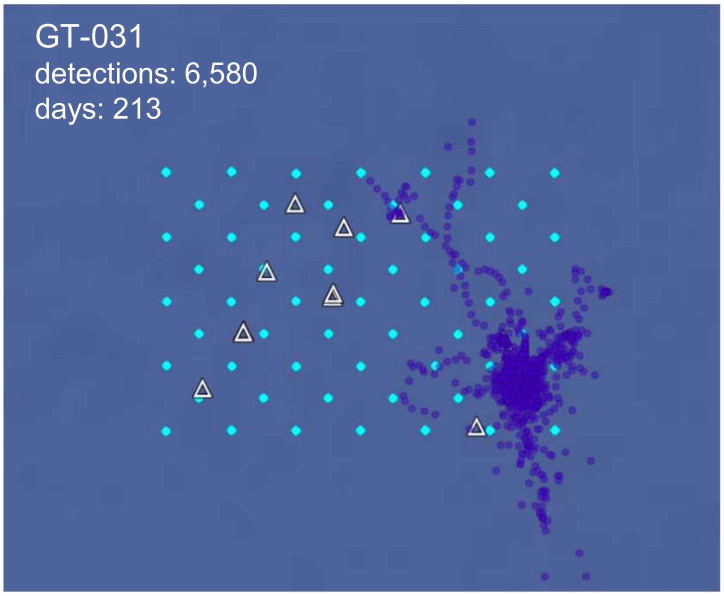

GT-026
detections: 10,174
days: 234

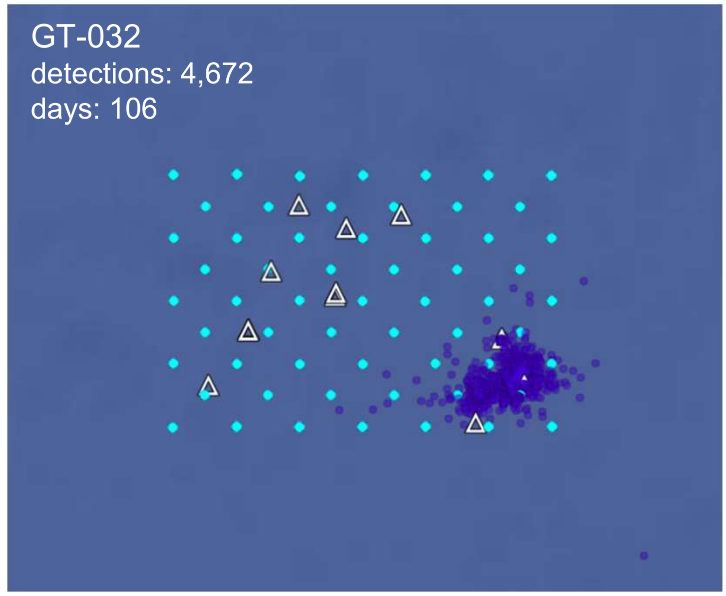

GT-027
detections: 9,662
days: 174

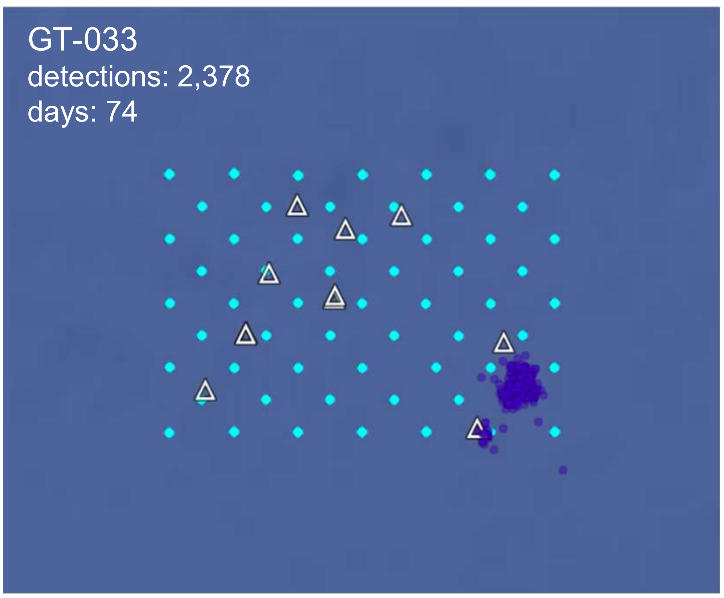

GT-028
detections: 16,230
days: 60

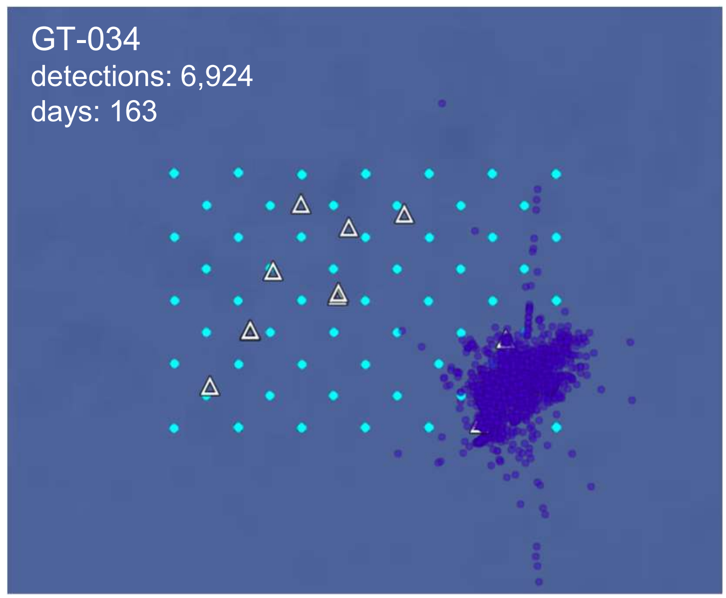

GT-029
detections: 7,843
days: 144

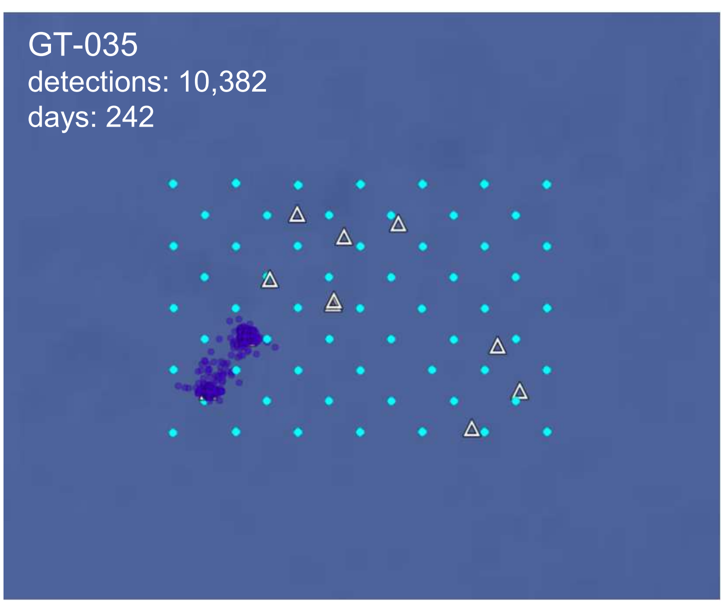

GT-030
detections: 3,874
days: 127

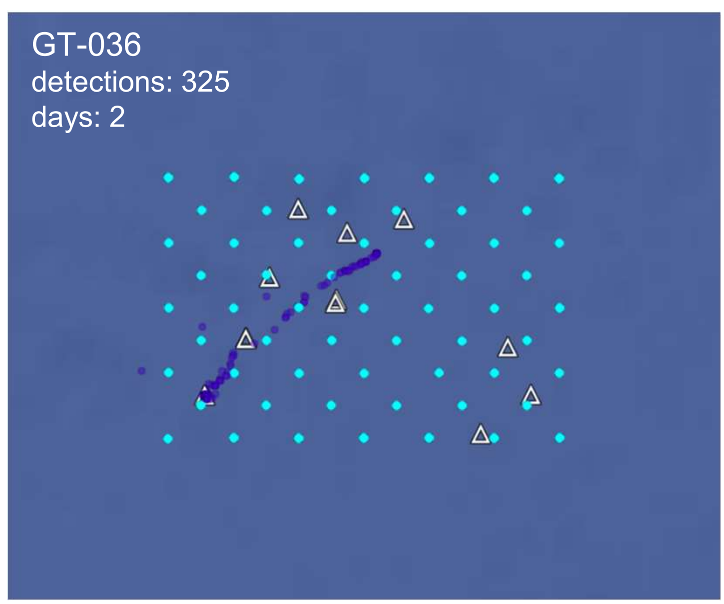

GT-031
detections: 6,580
days: 213

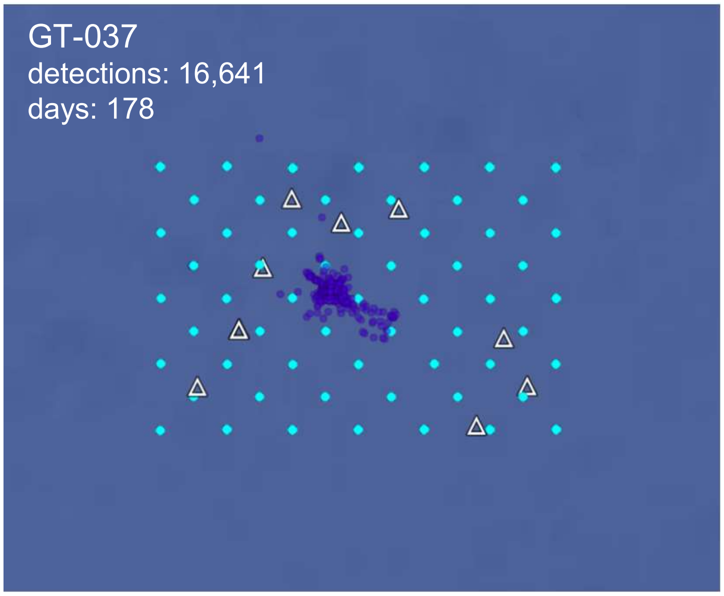

GT-032
detections: 4,672
days: 106

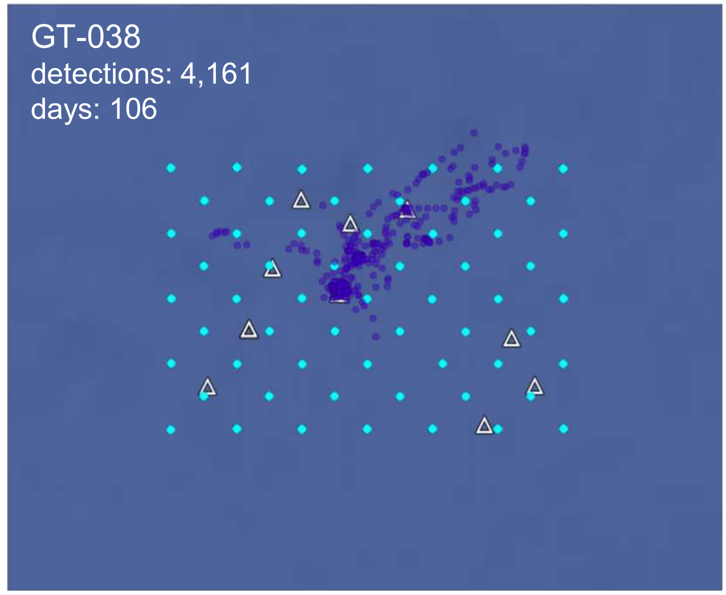

GT-033
detections: 2,378
days: 74

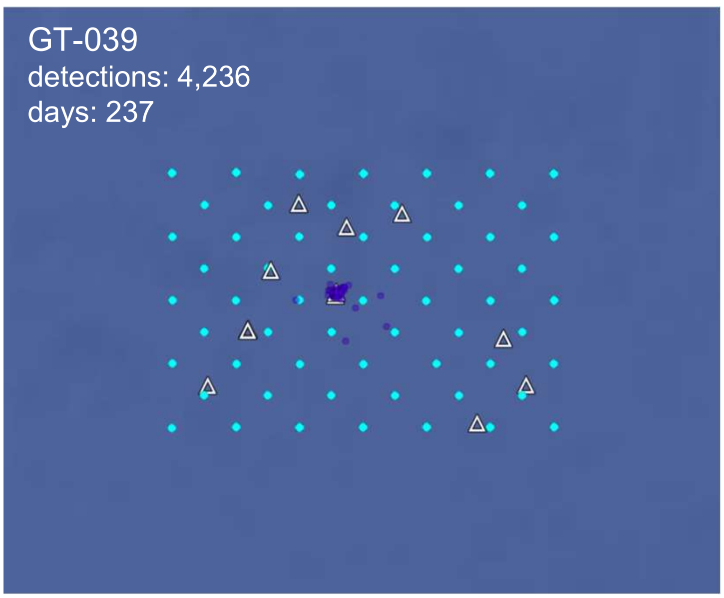

GT-034
detections: 6,924
days: 163

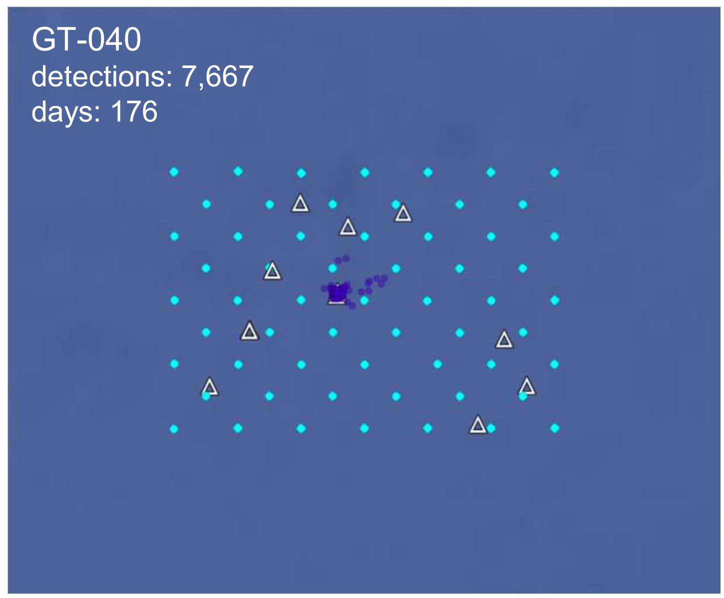

GT-035
detections: 10,382
days: 242

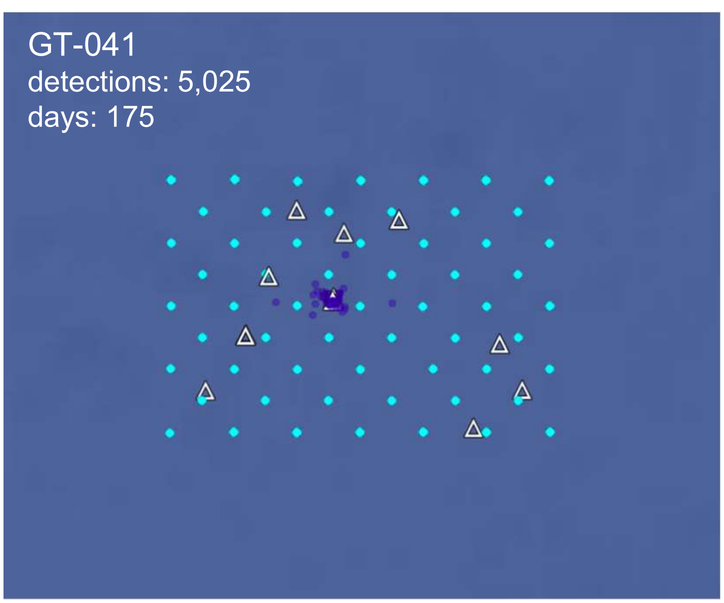

GT-036
detections: 325
days: 2

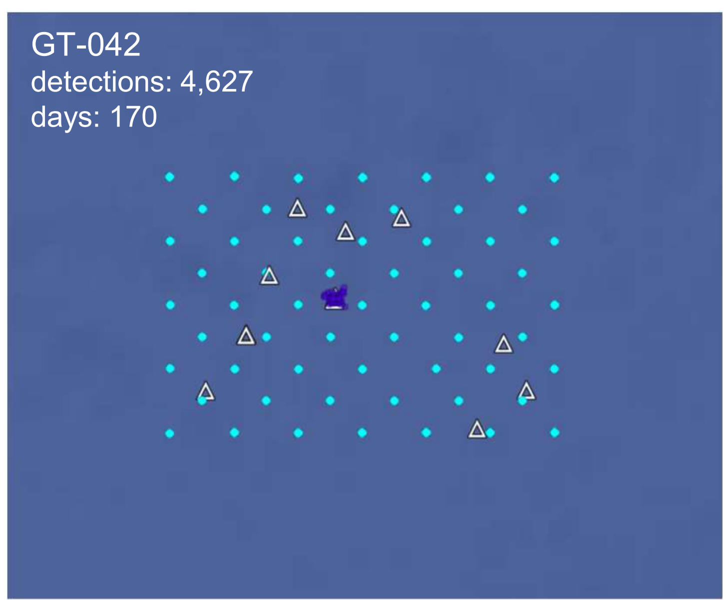

GT-037
detections: 16,641
days: 178

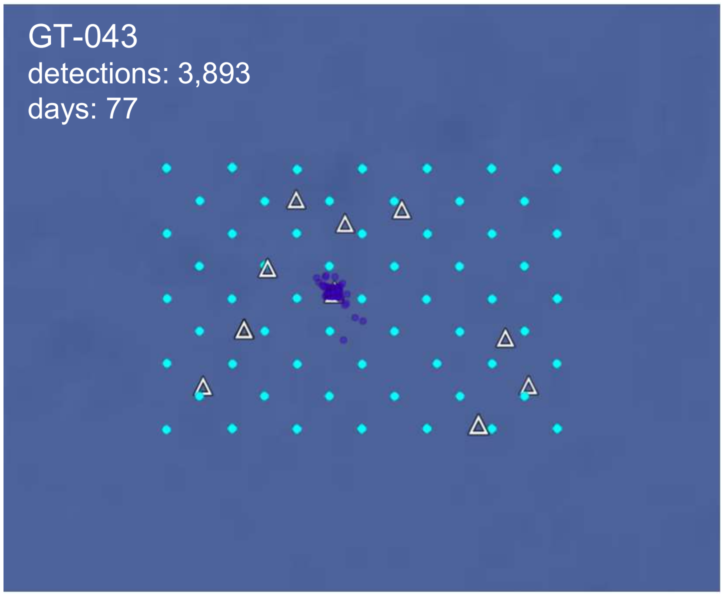

GT-038
detections: 4,161
days: 106

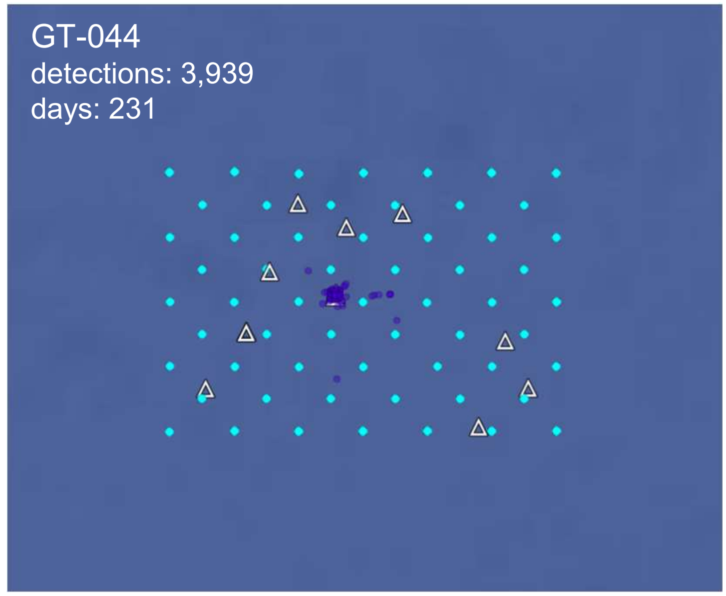

GT-039
detections: 4,236
days: 237

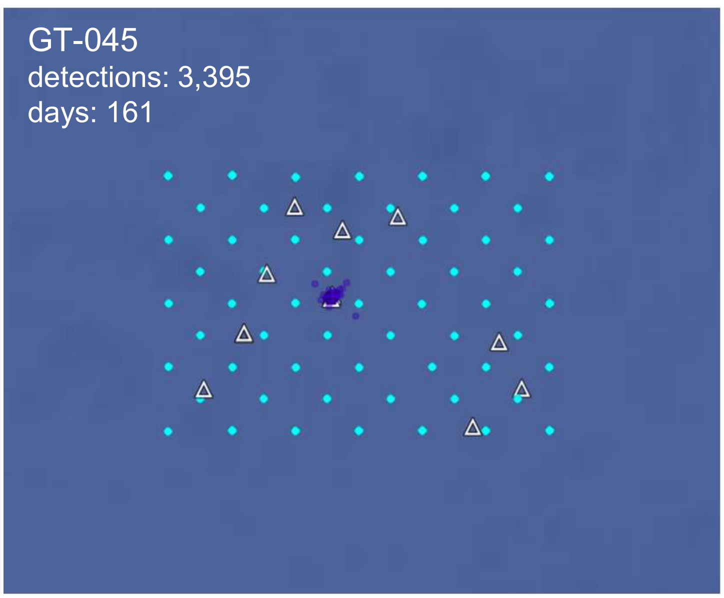

GT-040
detections: 7,667
days: 176

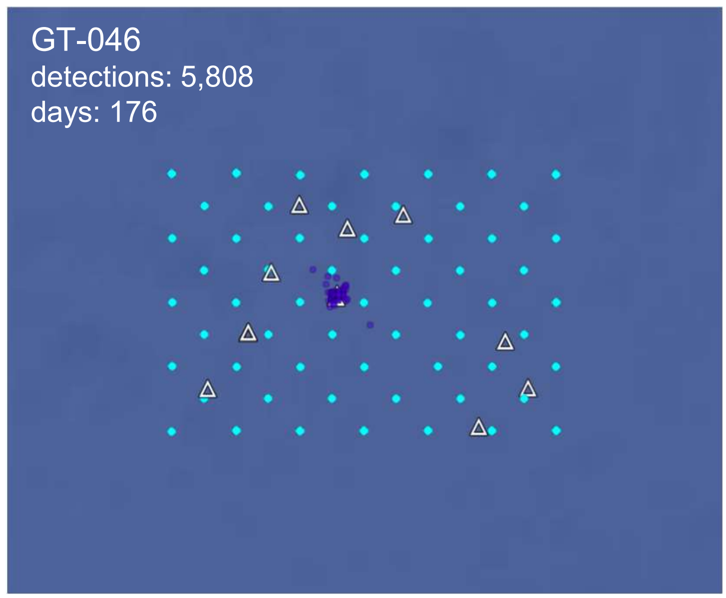

GT-041
detections: 5,025
days: 175

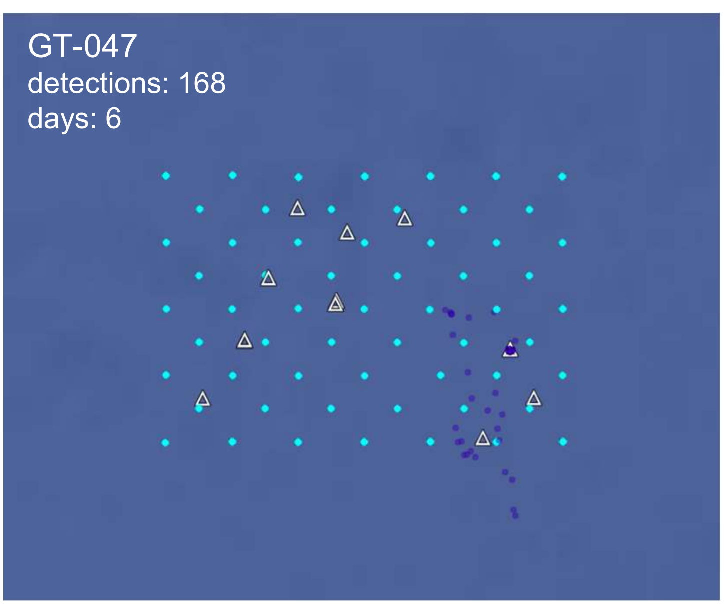

GT-042
detections: 4,627
days: 170

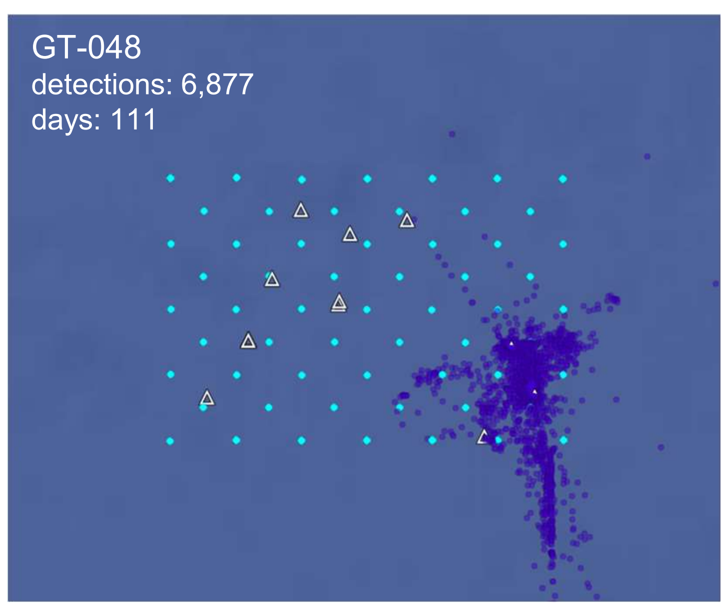

GT-043
detections: 3,893
days: 77

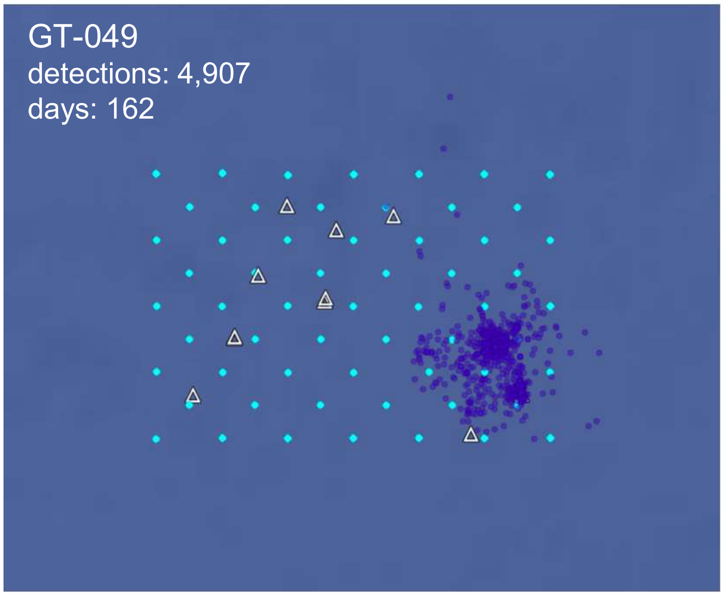

GT-044
detections: 3,939
days: 231

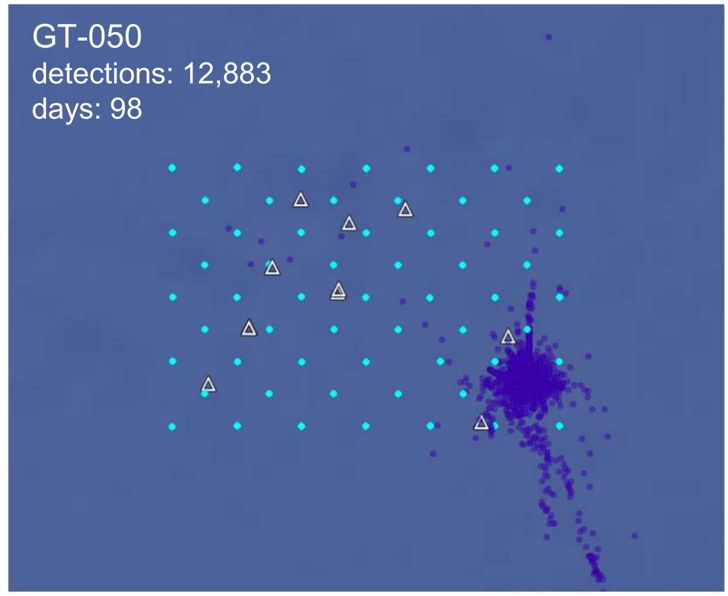

GT-045
detections: 3,395
days: 161

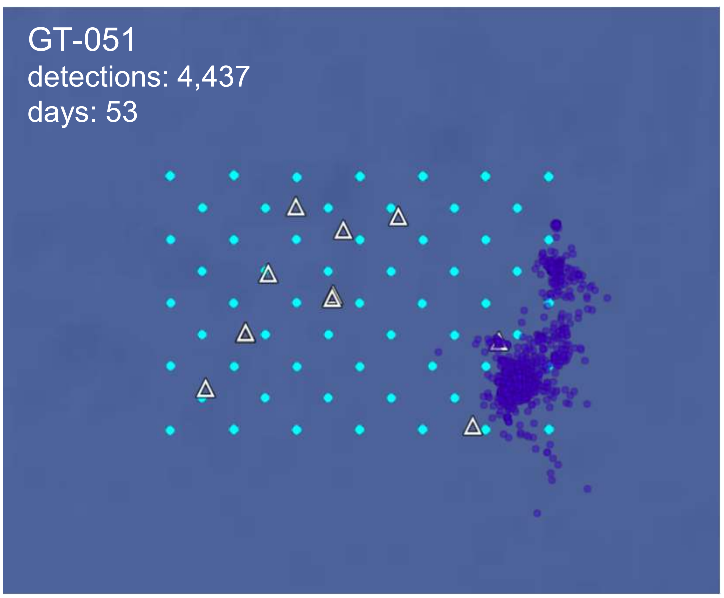

GT-046
detections: 5,808
days: 176

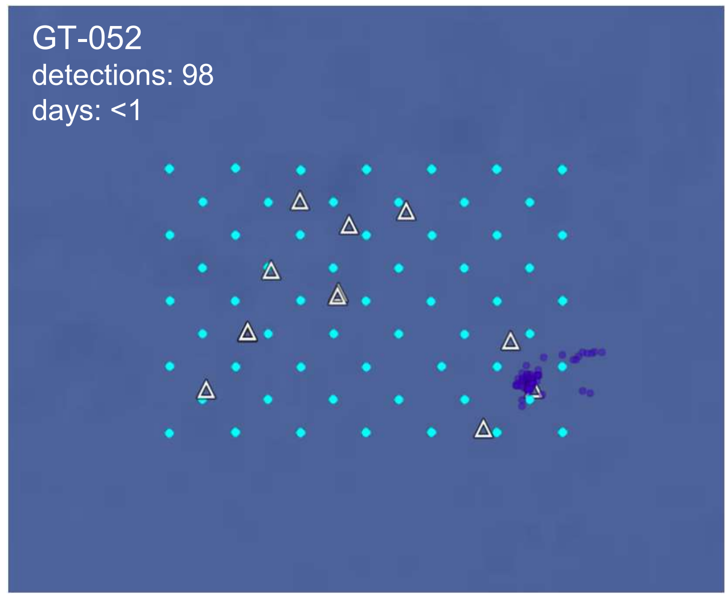

GT-047
detections: 168
days: 6

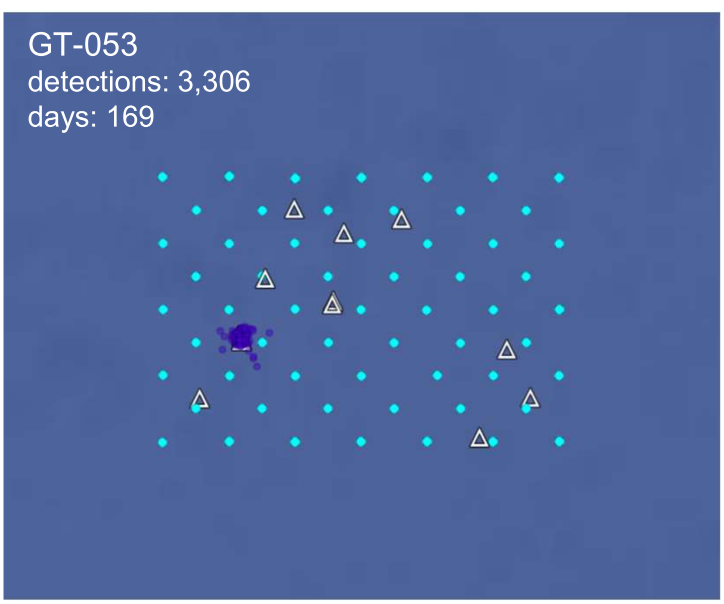

GT-048
detections: 6,877
days: 111

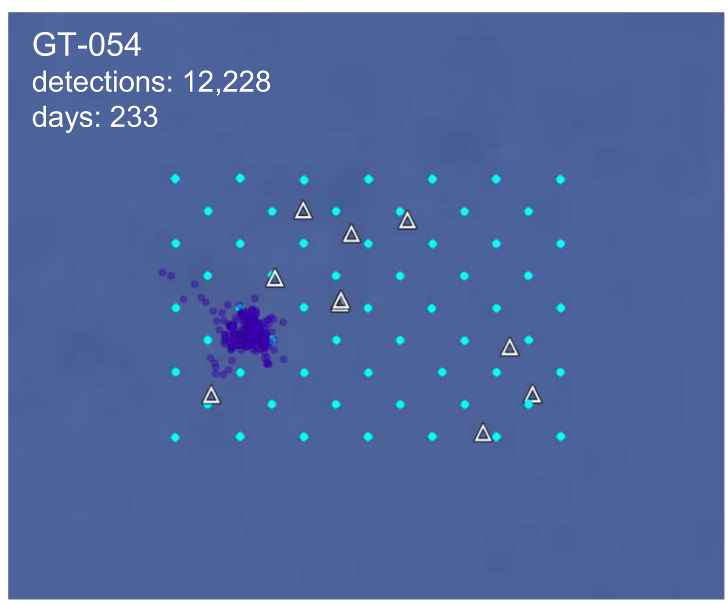

GT-049
detections: 4,907
days: 162

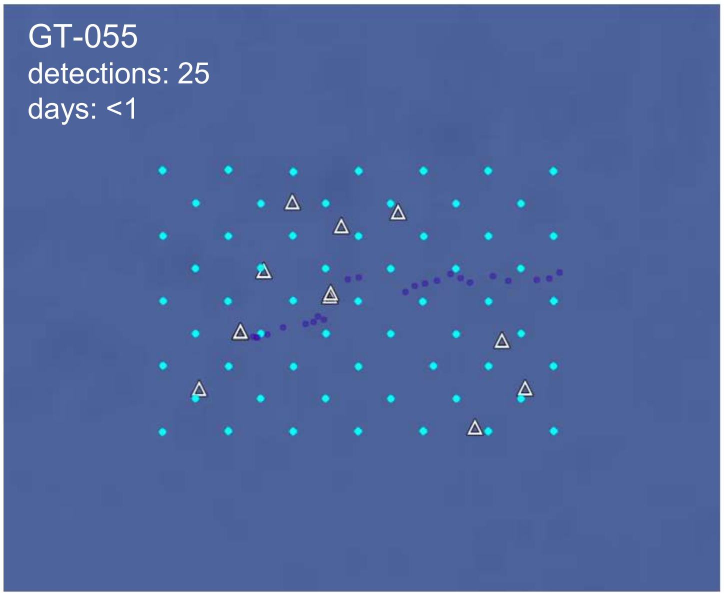

GT-050
detections: 12,883
days: 98

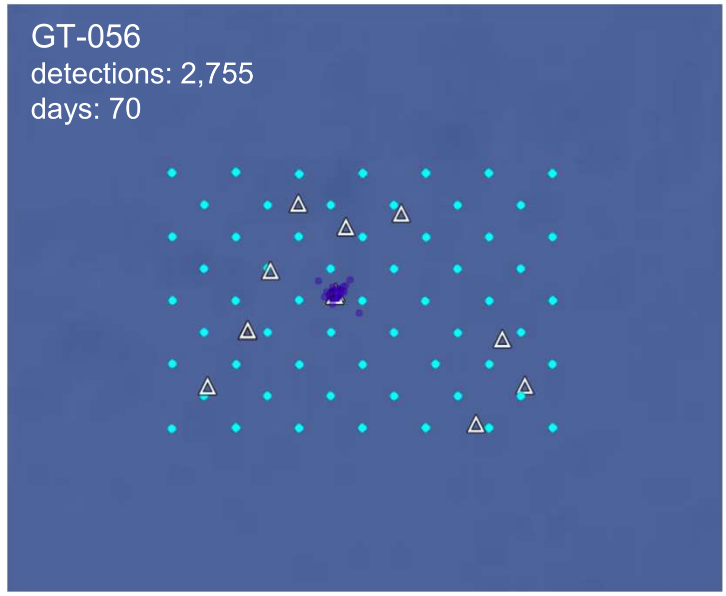

GT-051
detections: 4,437
days: 53

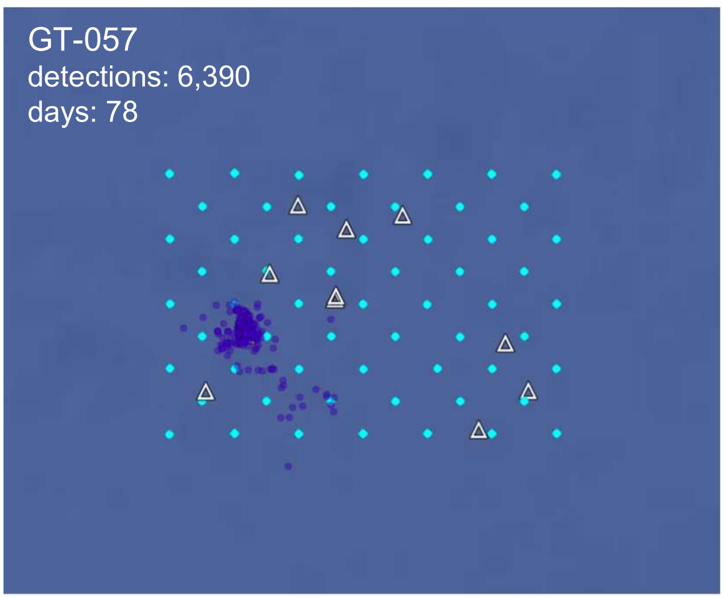

GT-052
detections: 98
days: <1

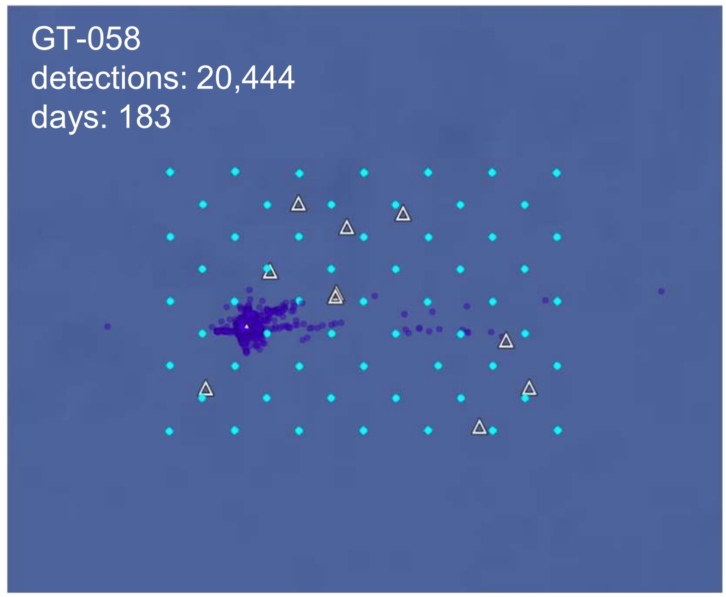

GT-053
detections: 3,306
days: 169

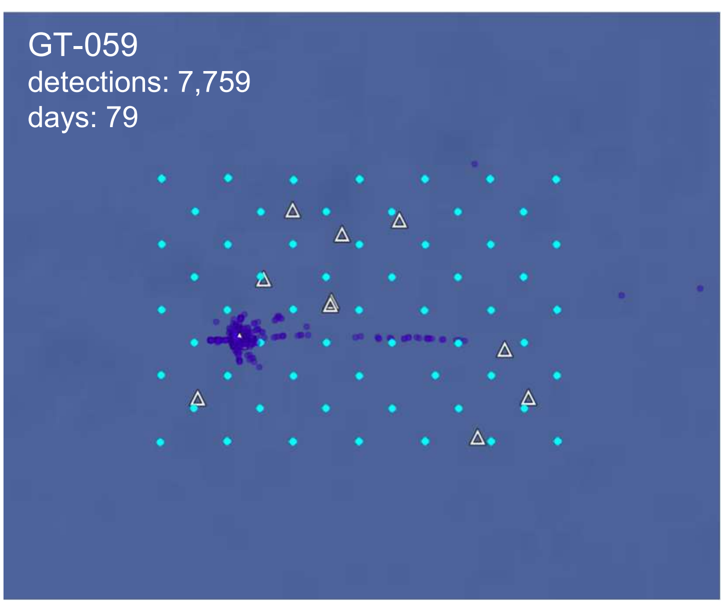

GT-054
detections: 12,228
days: 233

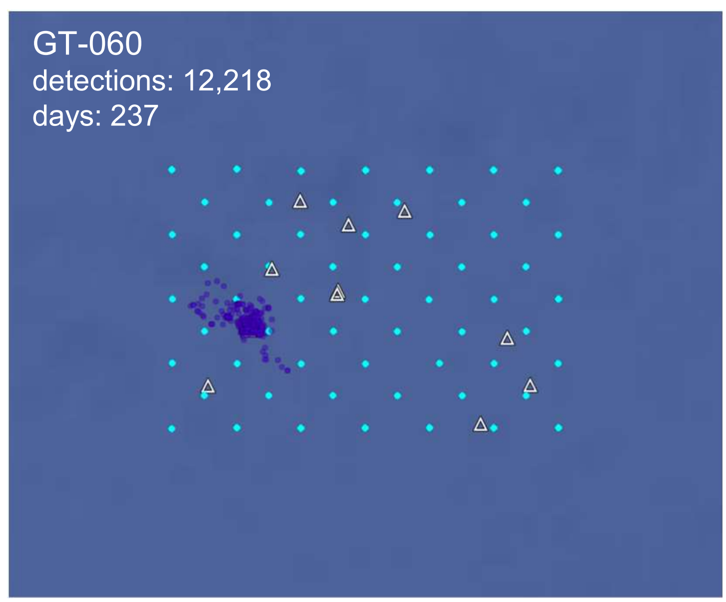

GT-055
detections: 25
days: <1

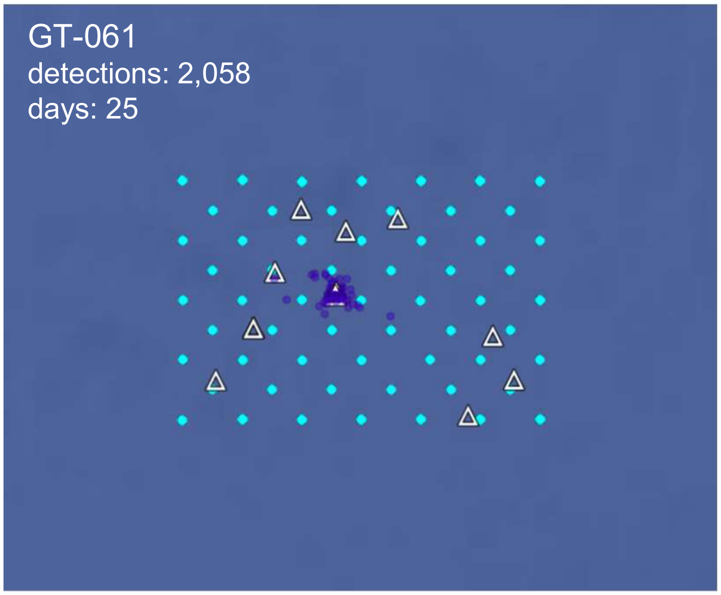

GT-056
detections: 2,755
days: 70

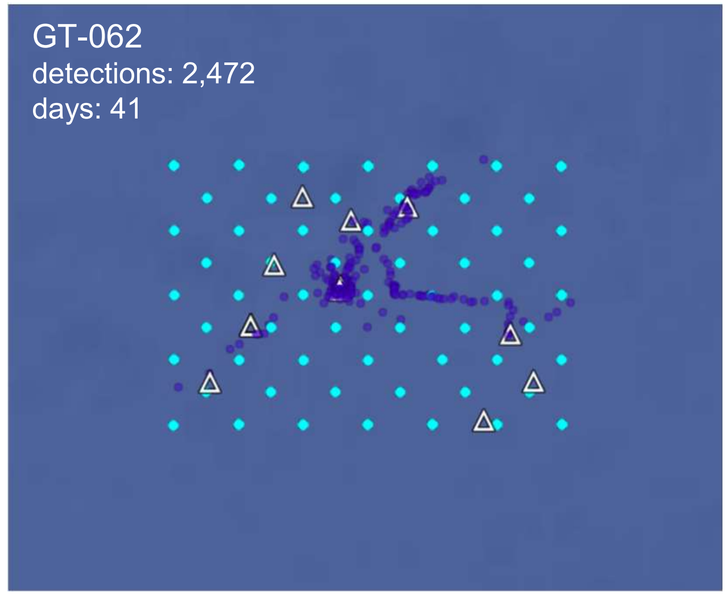

GT-057
detections: 6,390
days: 78

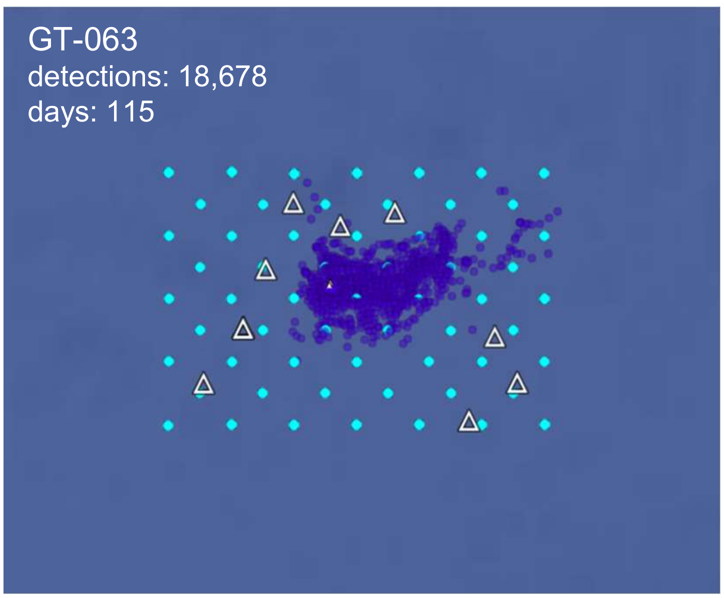

GT-058
detections: 20,444
days: 183

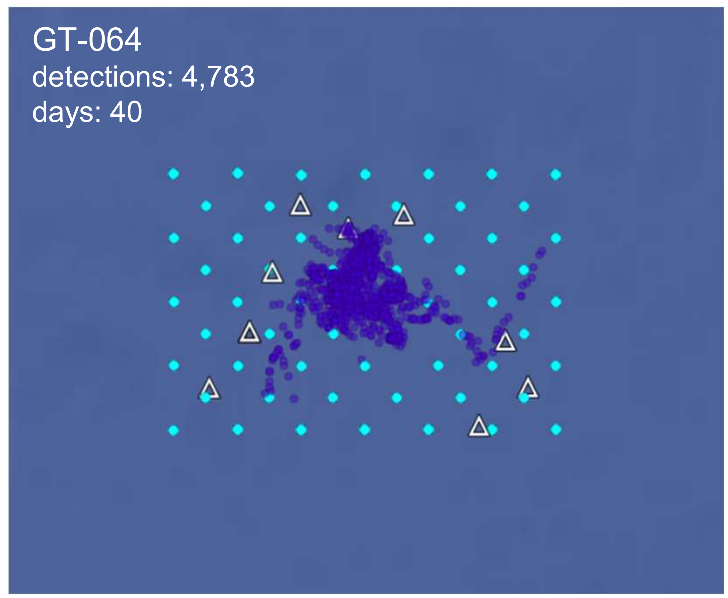

GT-059
detections: 7,759
days: 79

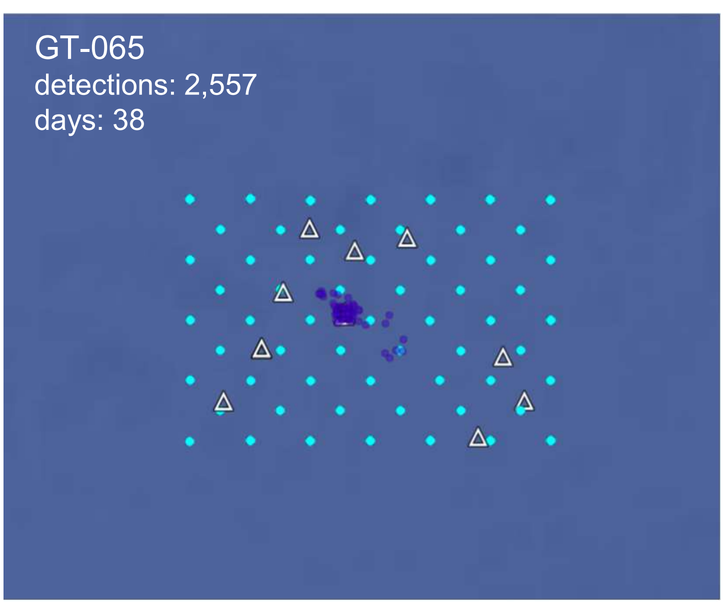

GT-060
detections: 12,218
days: 237

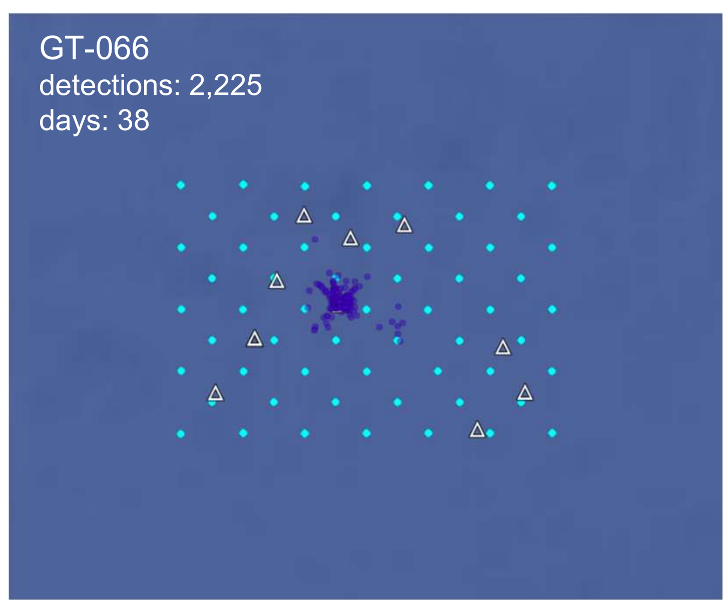

GT-061
detections: 2,058
days: 25

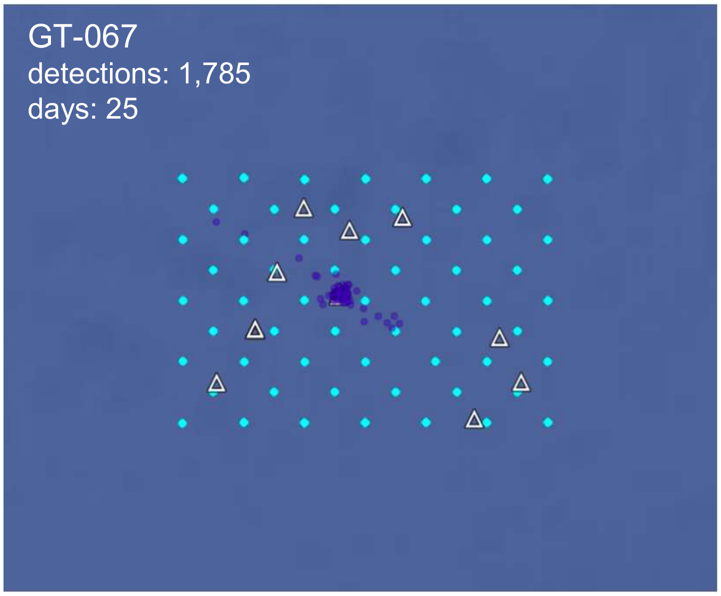

GT-062
detections: 2,472
days: 41

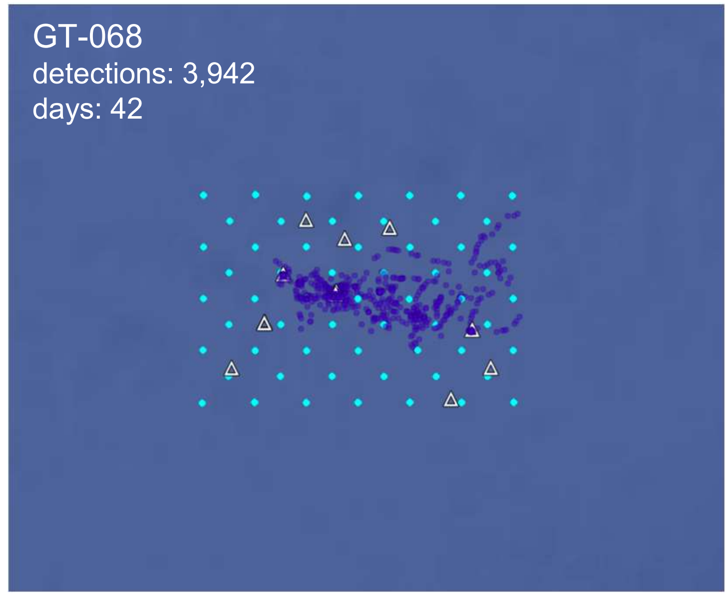

GT-063
detections: 18,678
days: 115

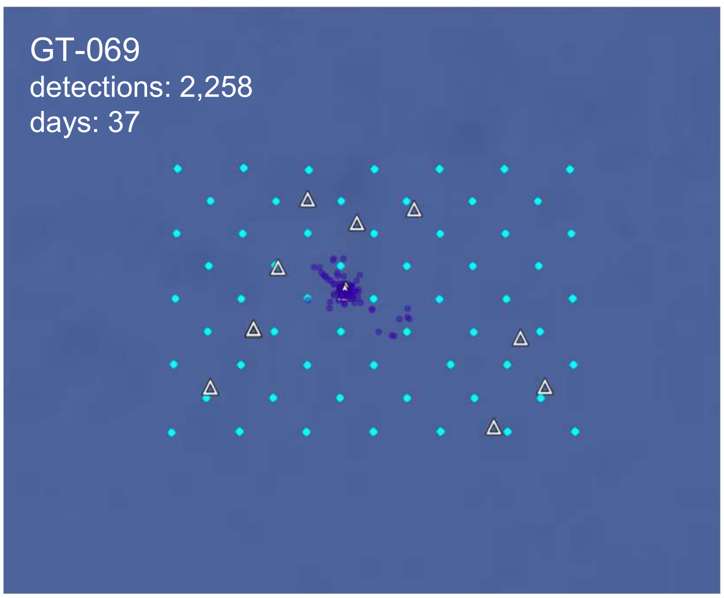

GT-064
detections: 4,783
days: 40

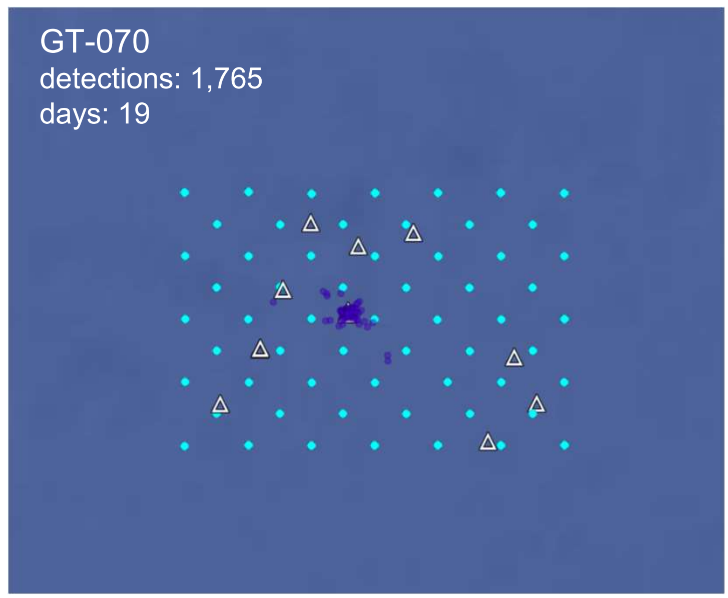

GT-065
detections: 2,557
days: 38

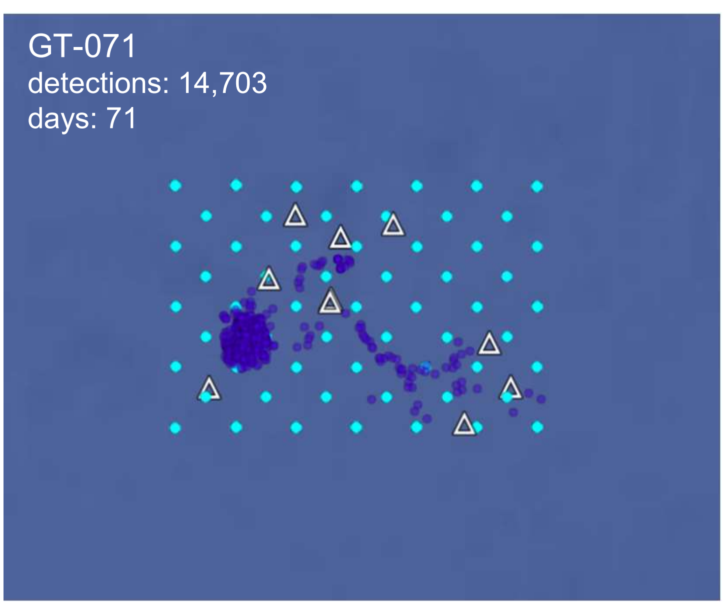

GT-066
detections: 2,225
days: 38

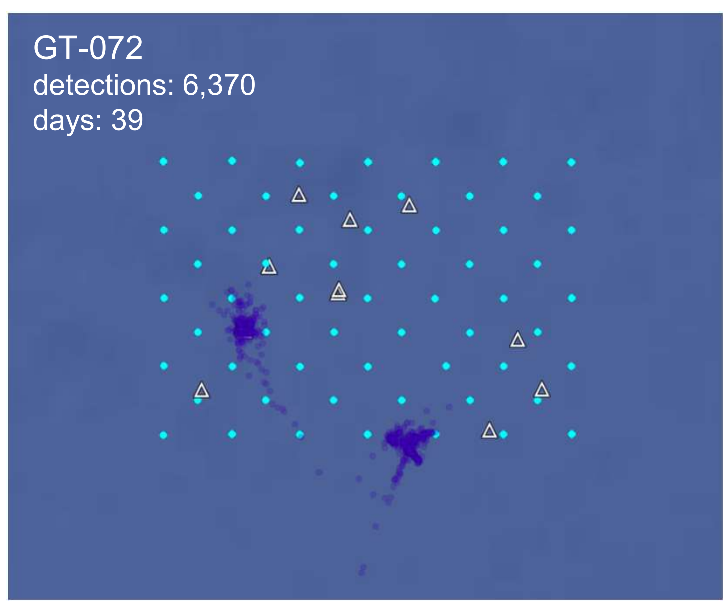

GT-067
detections: 1,785
days: 25

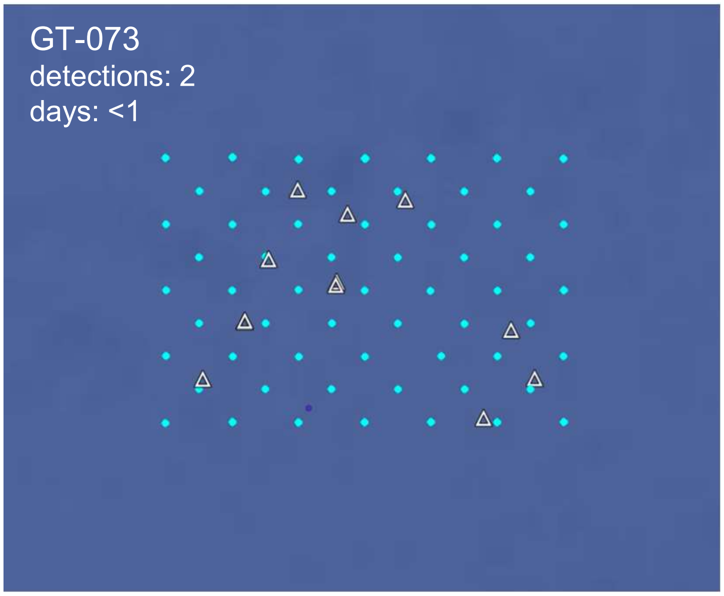

GT-068
detections: 3,942
days: 42

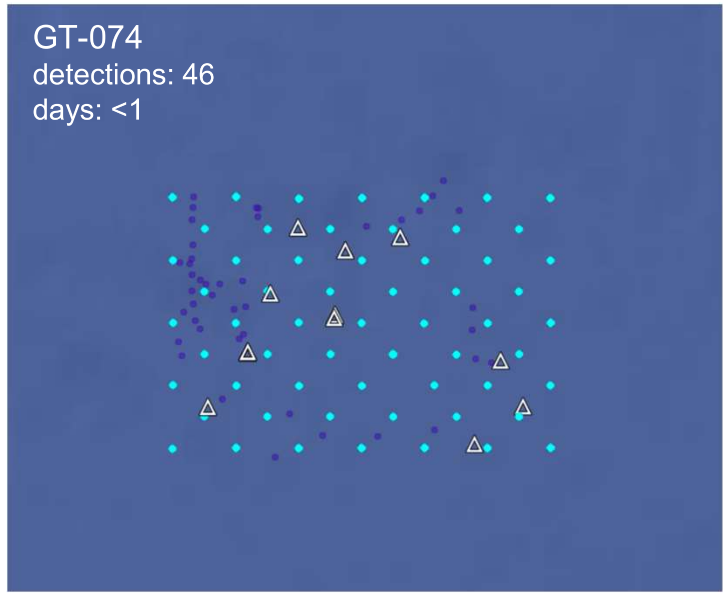

GT-069
detections: 2,258
days: 37

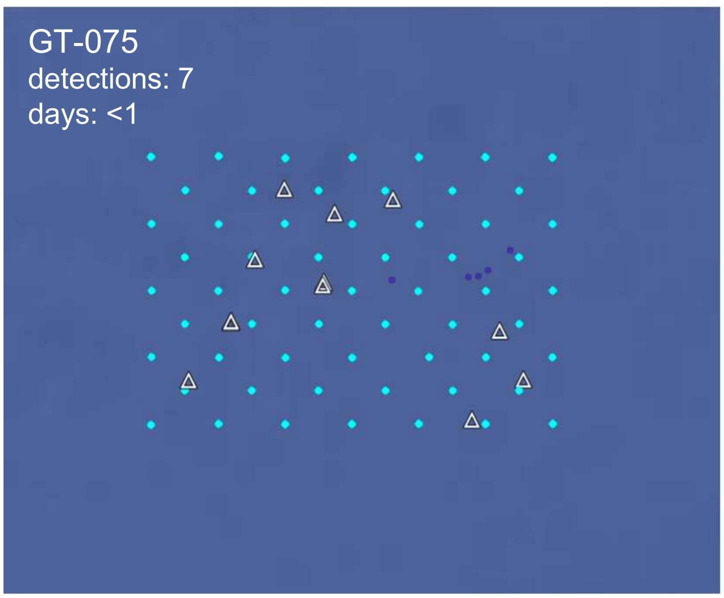

GT-070
detections: 1,765
days: 19

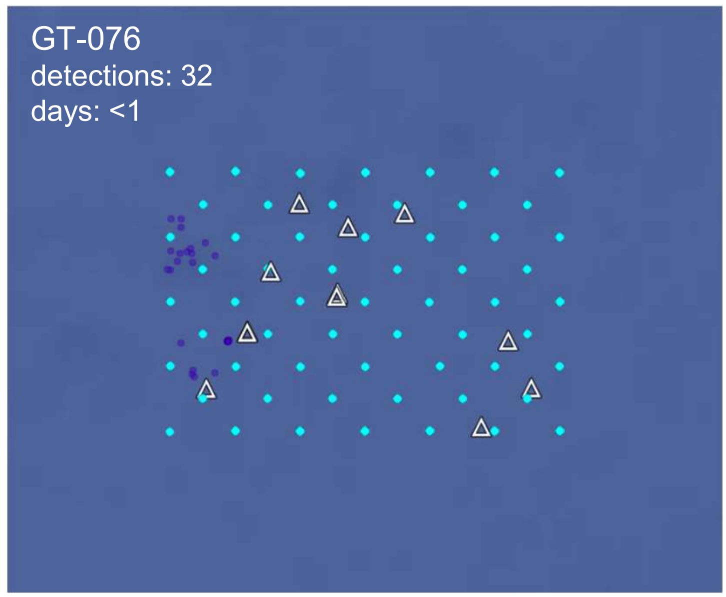

GT-071
detections: 14,703
days: 71

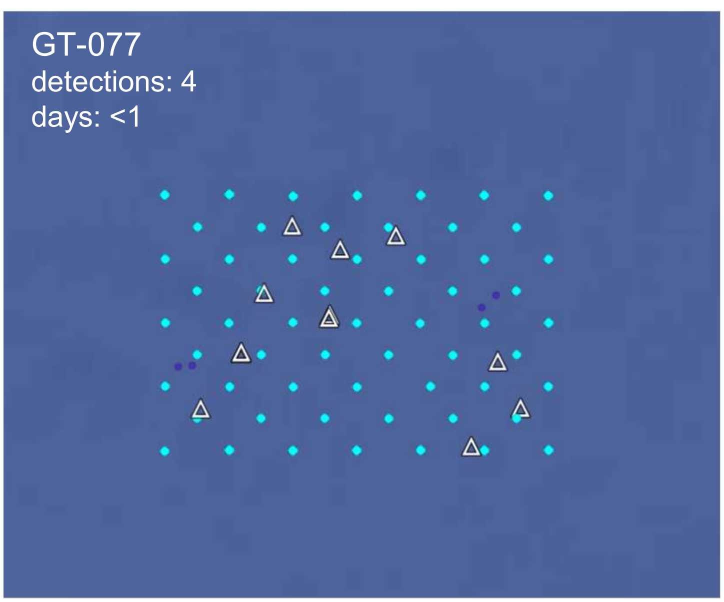

GT-072
detections: 6,370
days: 39

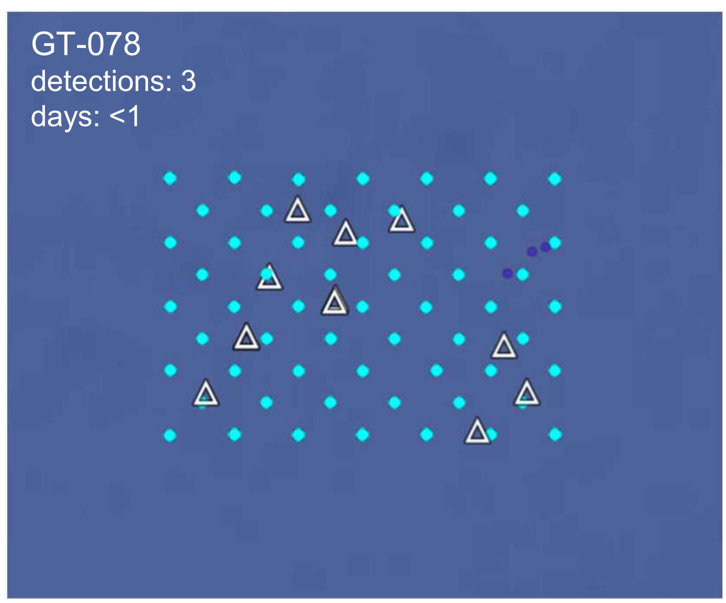

GT-073
detections: 2
days: <1

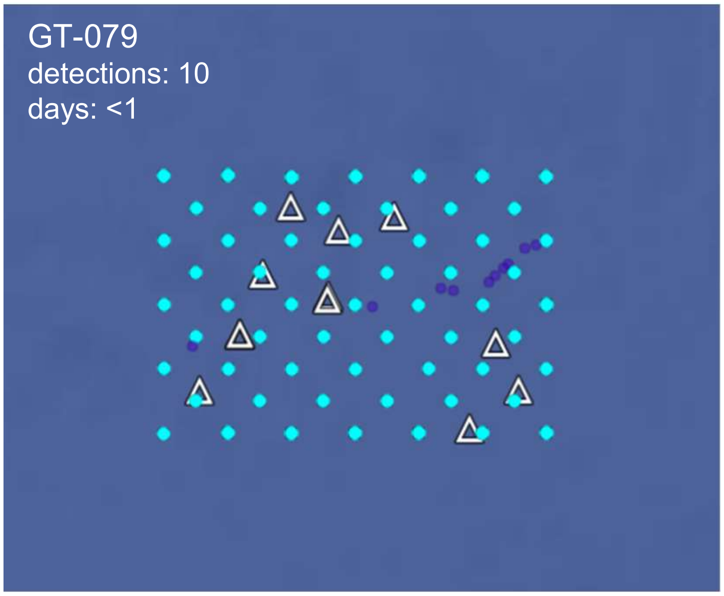

GT-074
detections: 46
days: <1

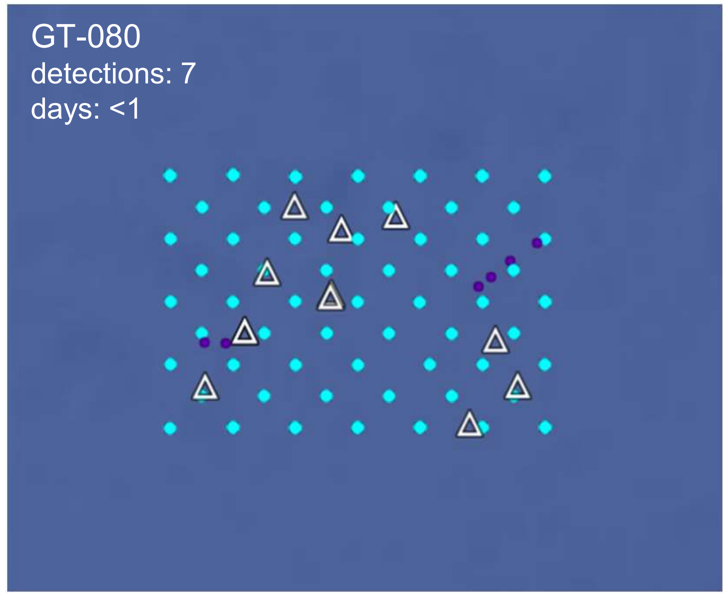

GT-075
detections: 7
days: <1

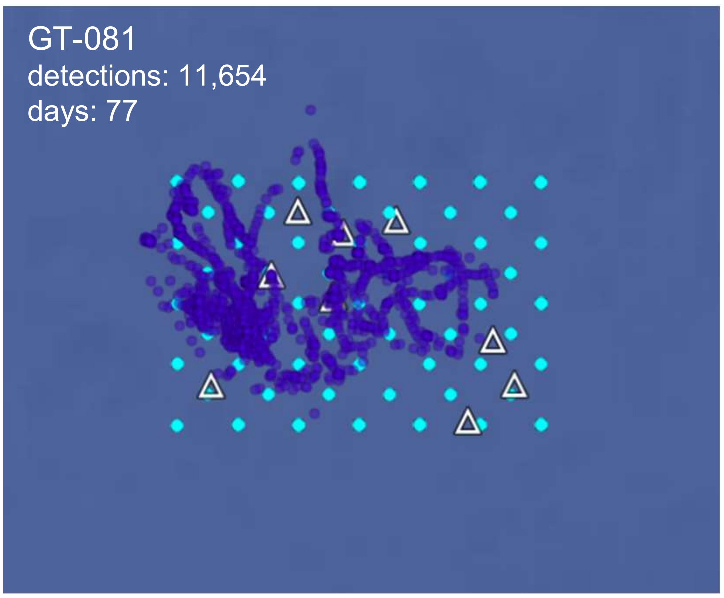

GT-076
detections: 32
days: <1

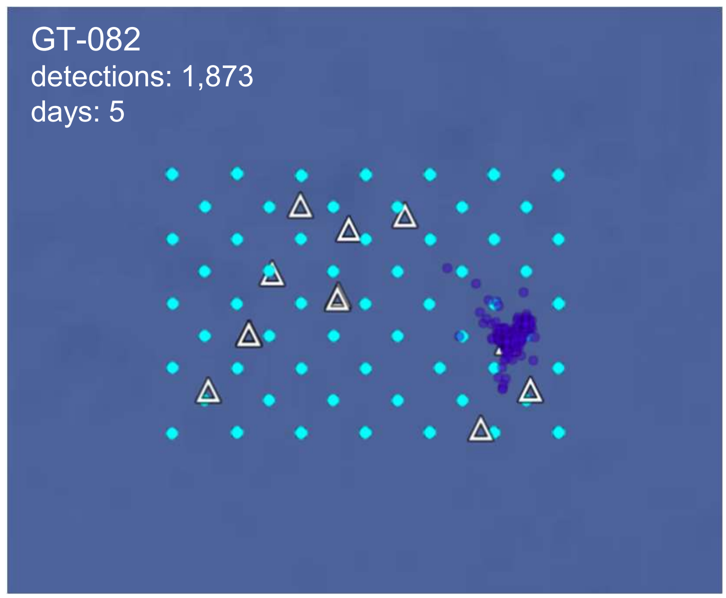

GT-077
detections: 4
days: <1

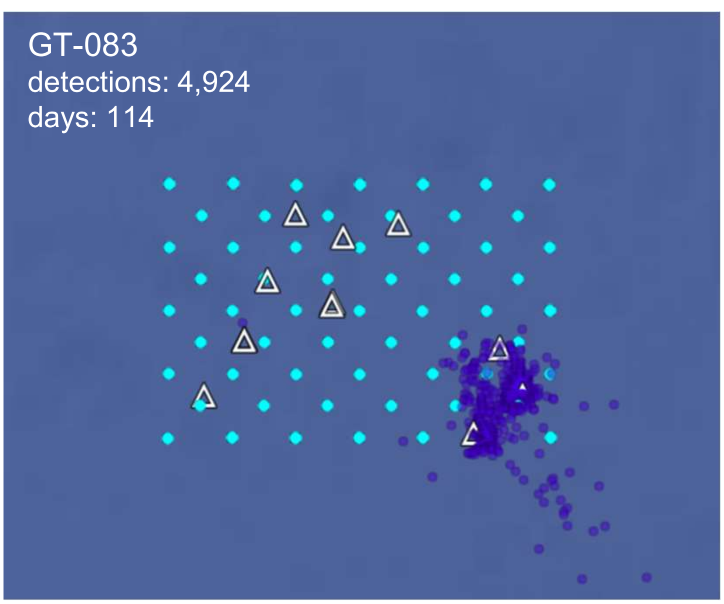

GT-078
detections: 3
days: <1

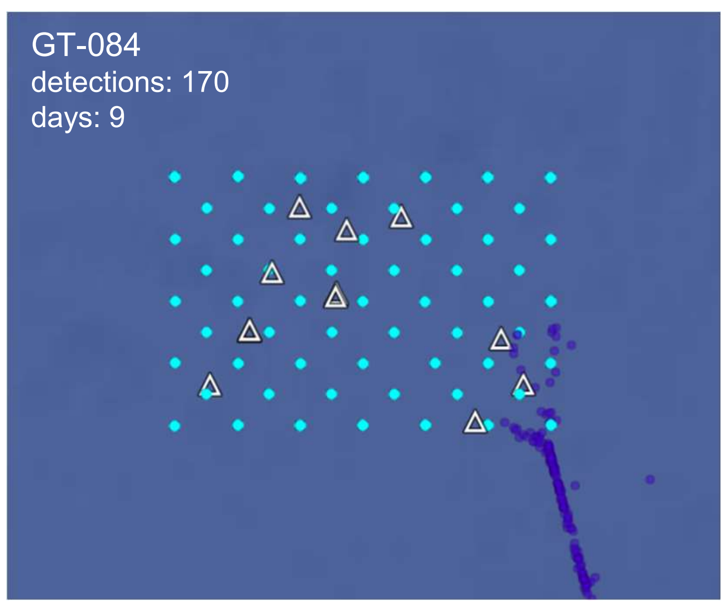

GT-079
detections: 10
days: <1

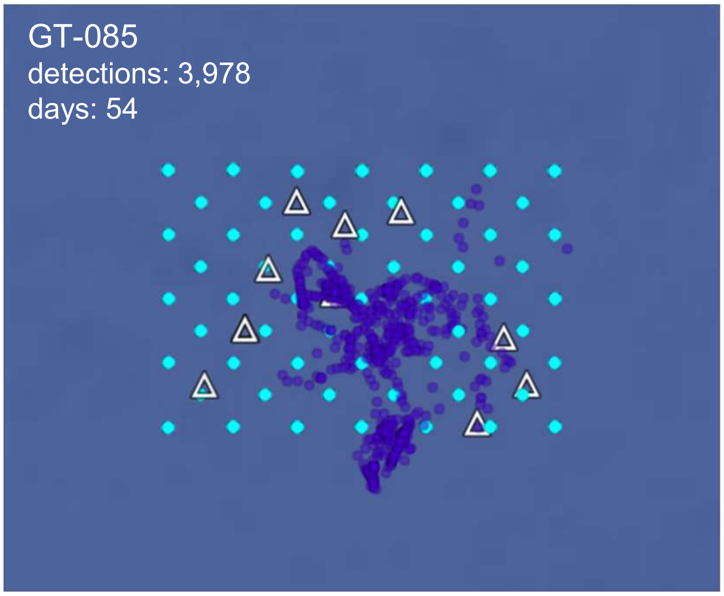

GT-080
detections: 7
days: <1

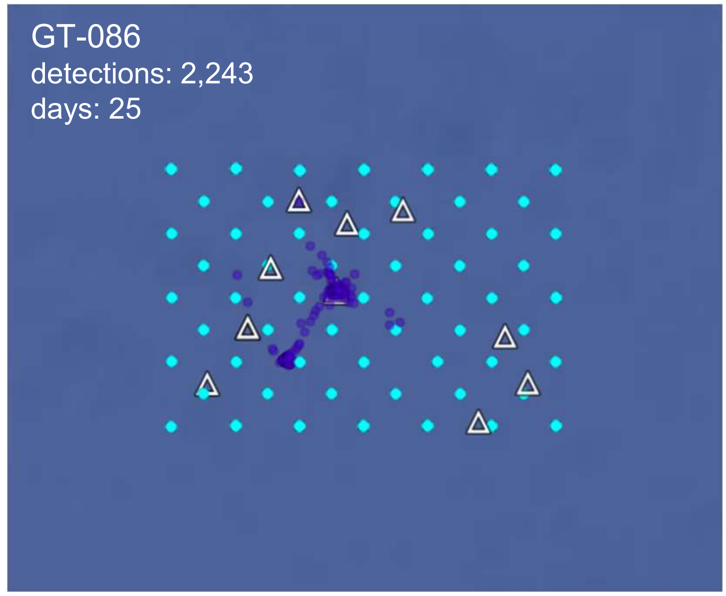

GT-081
detections: 11,654
days: 77

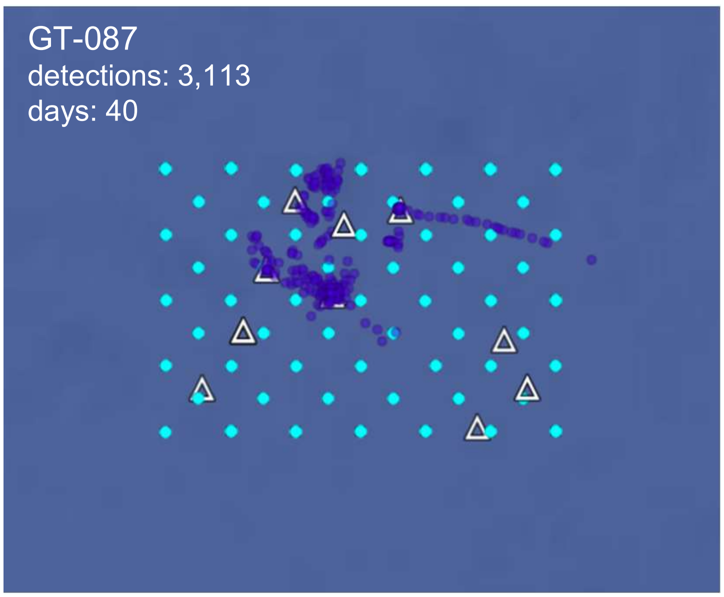

GT-082
detections: 1,873
days: 5

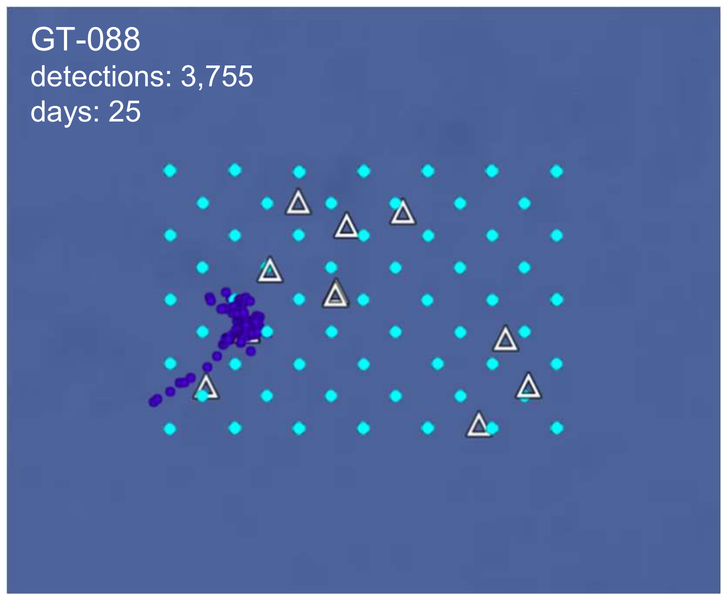

GT-083
detections: 4,924
days: 114

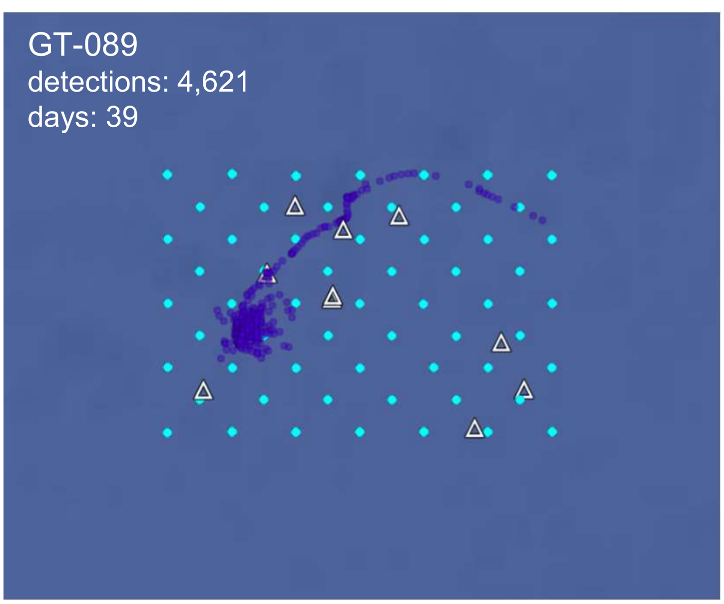

GT-084
detections: 170
days: 9

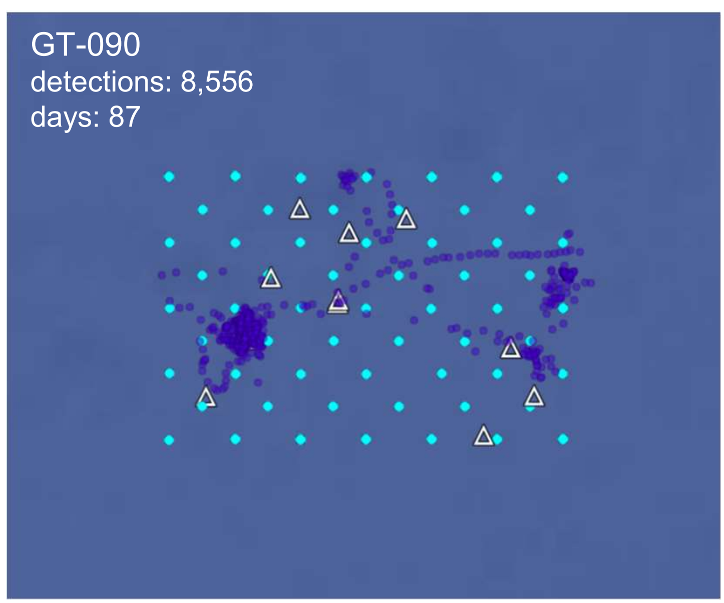

GT-085
detections: 3,978
days: 54

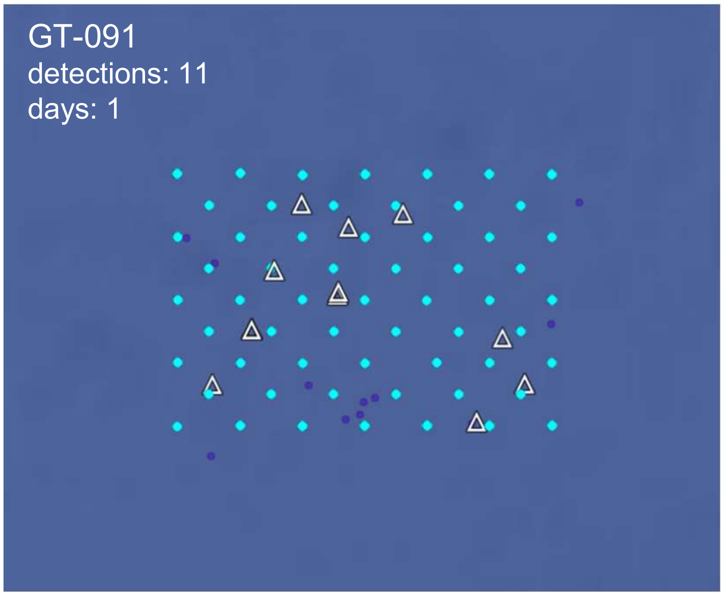

GT-086
detections: 2,243
days: 25

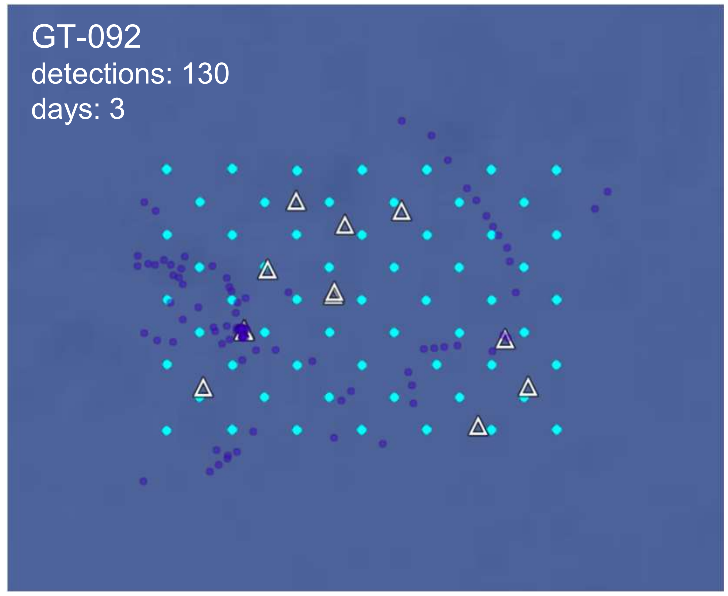

GT-087
detections: 3,113
days: 40

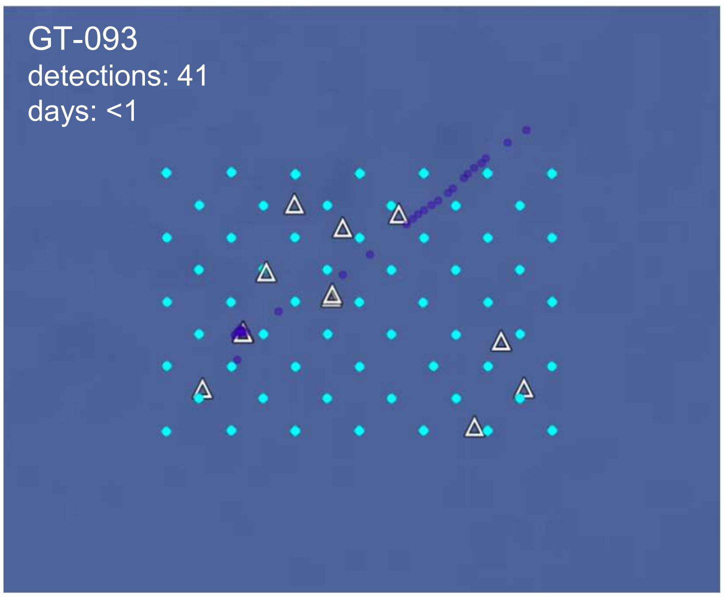

GT-088
detections: 3,755
days: 25

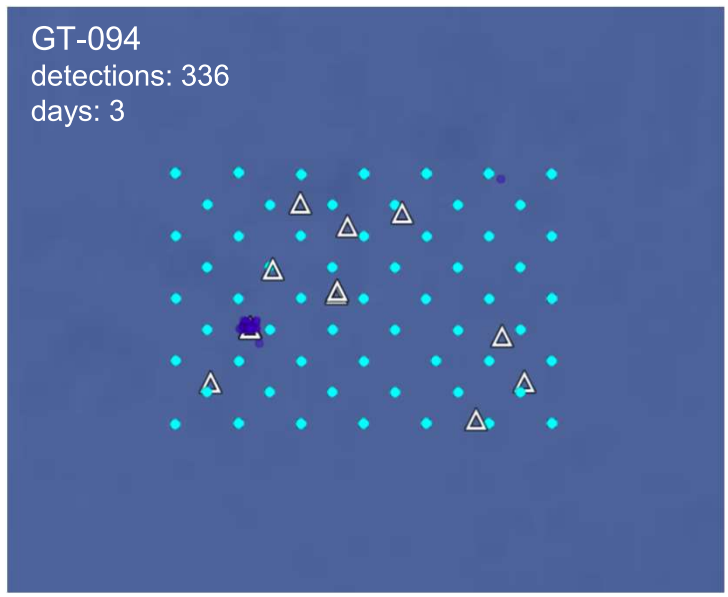

GT-089
detections: 4,621
days: 39

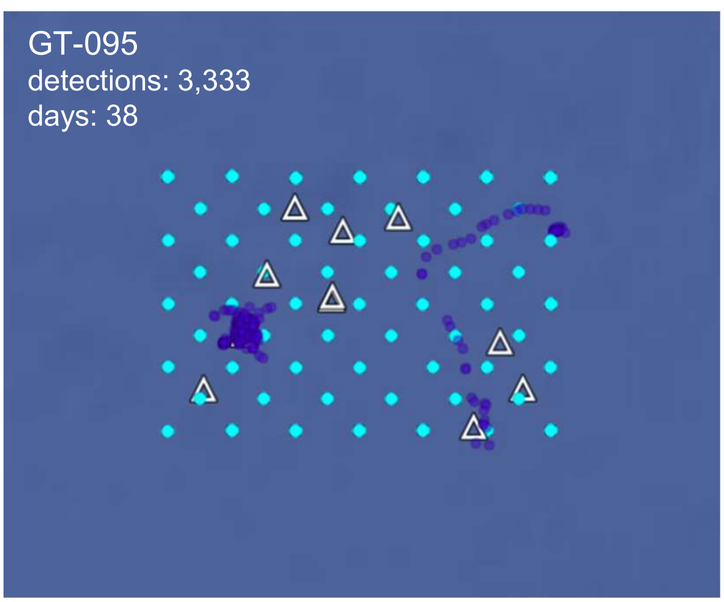

GT-090
detections: 8,556
days: 87

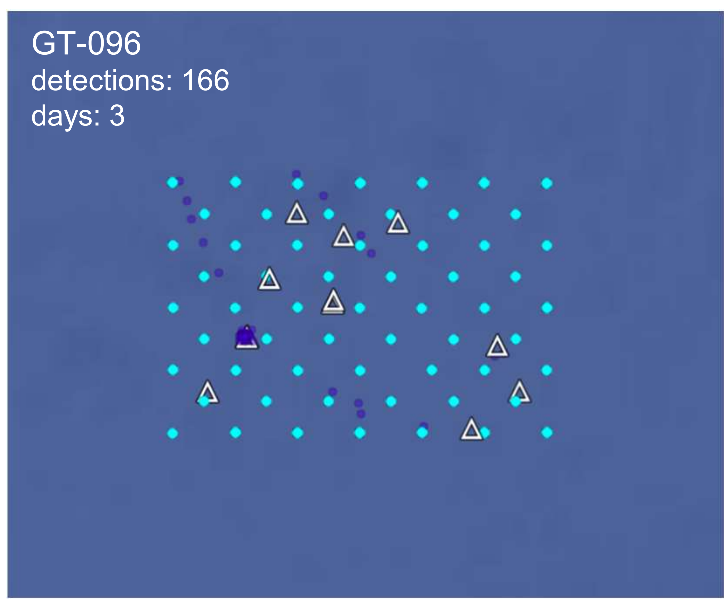

GT-091
detections: 11
days: 1

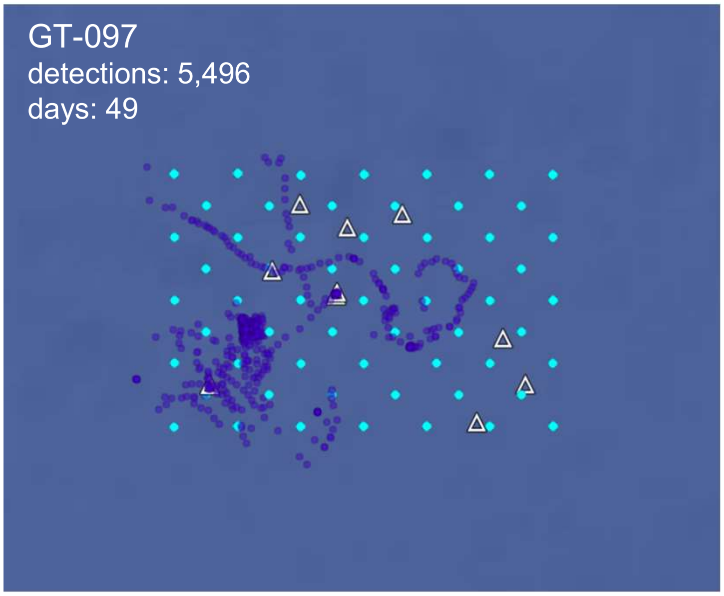

GT-092
detections: 130
days: 3

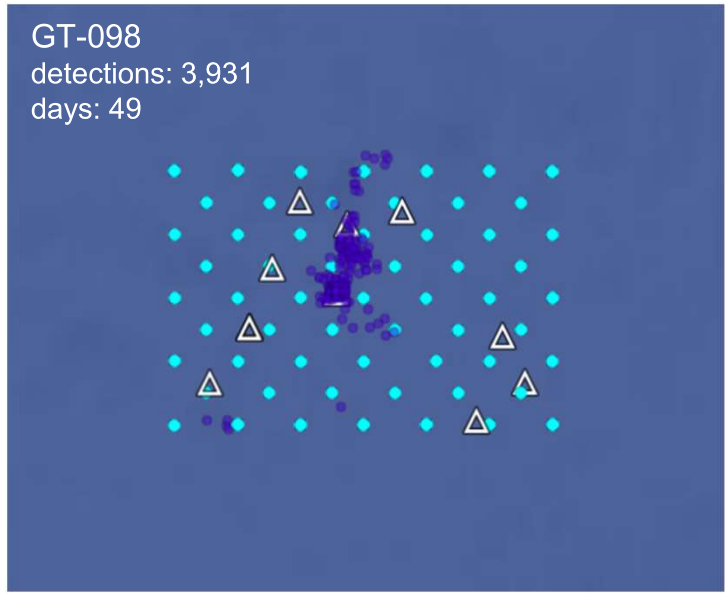

GT-093
detections: 41
days: <1

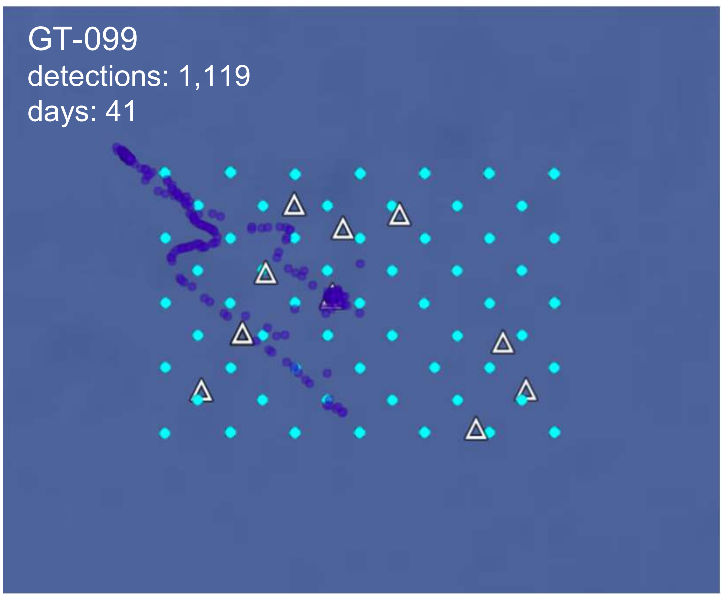

GT-094
detections: 336
days: 3

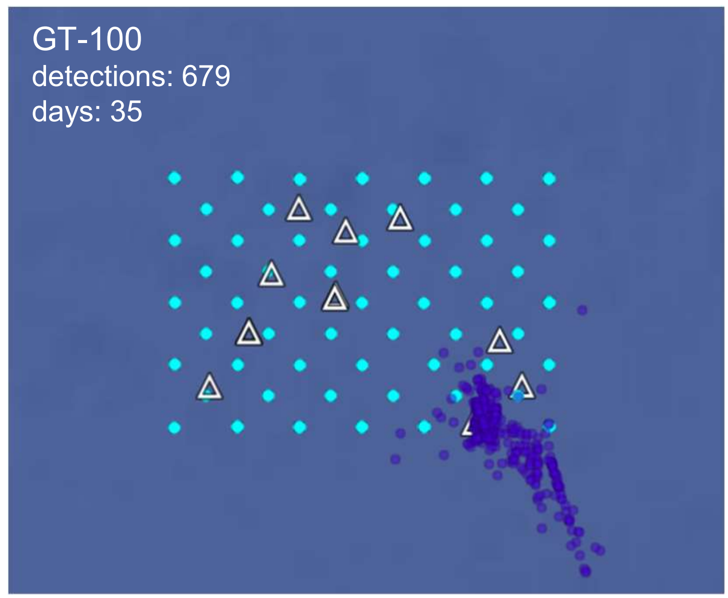

GT-095
detections: 3,333
days: 38

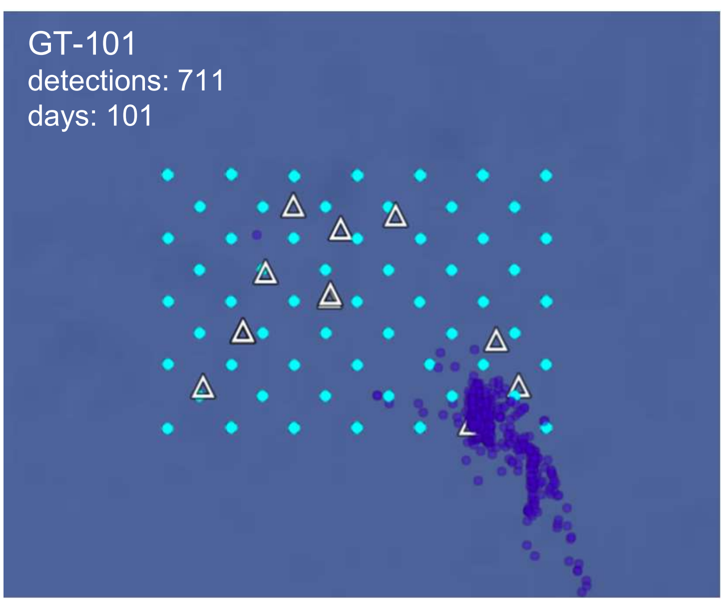

GT-096
detections: 166
days: 3

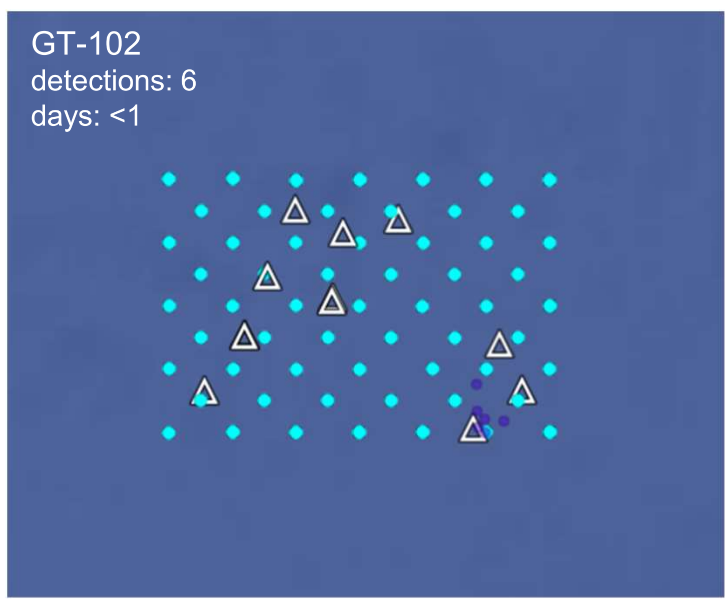

GT-097
detections: 5,496
days: 49

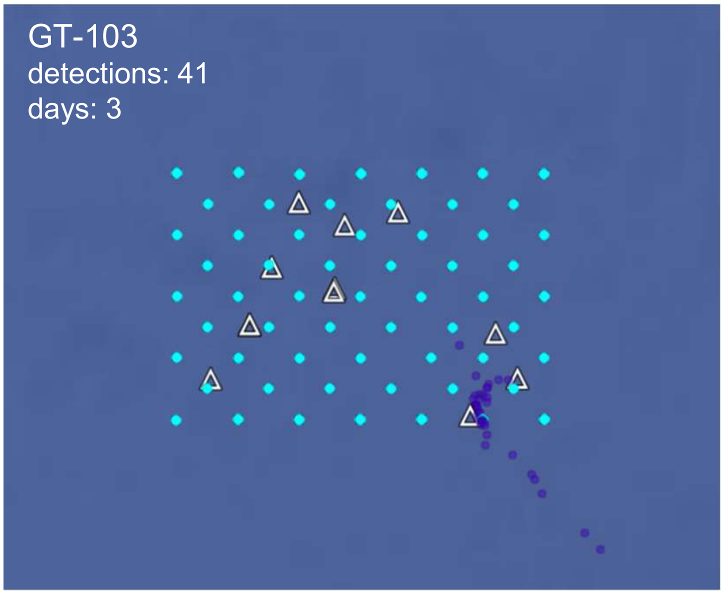

GT-098
detections: 3,931
days: 49

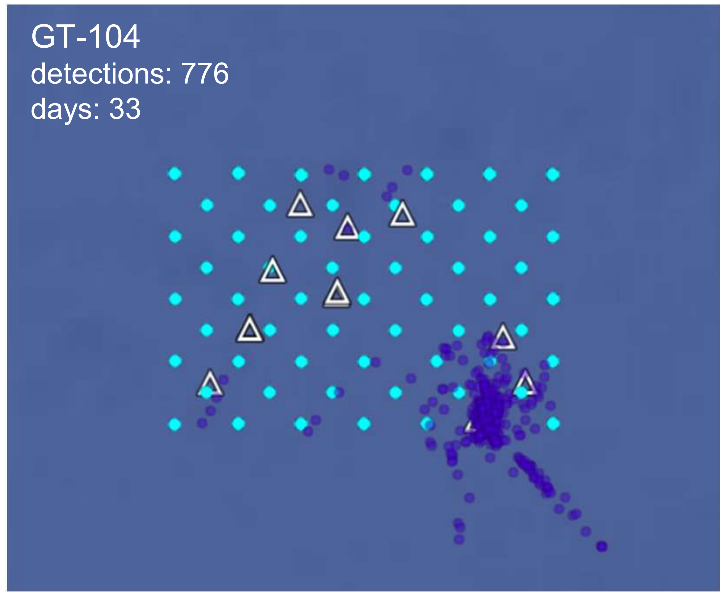

GT-099
detections: 1,119
days: 41

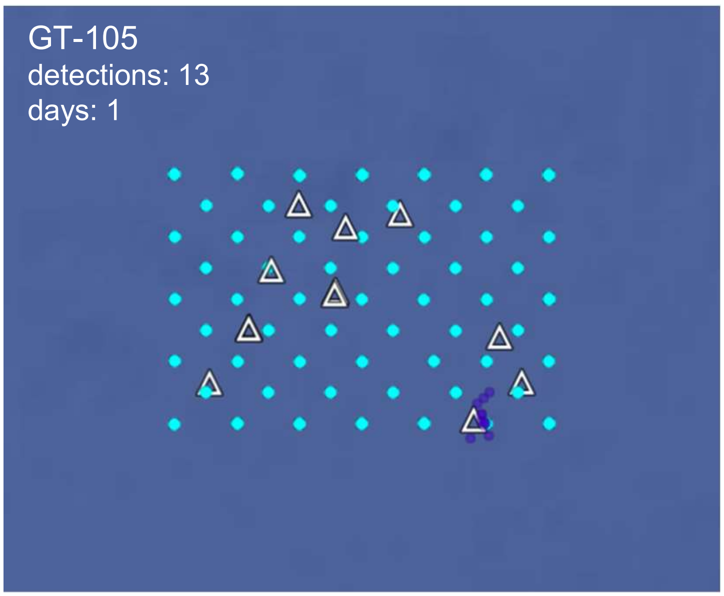

GT-100
detections: 679
days: 35

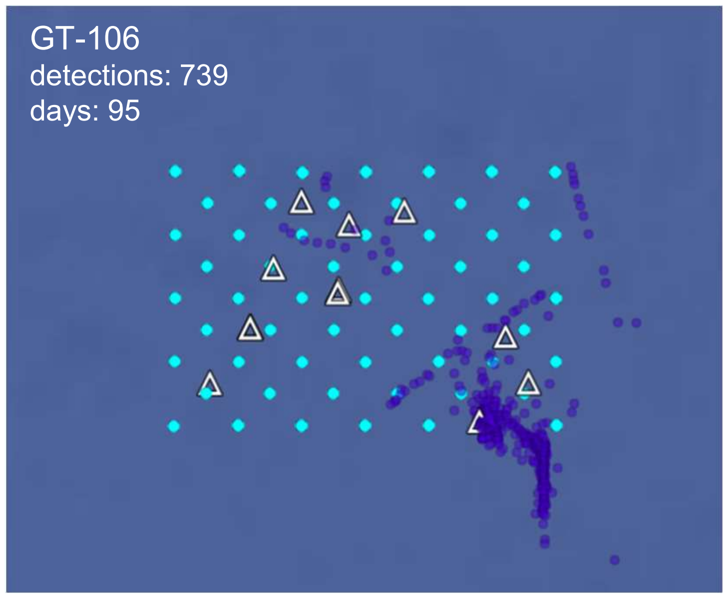

GT-101
detections: 711
days: 101

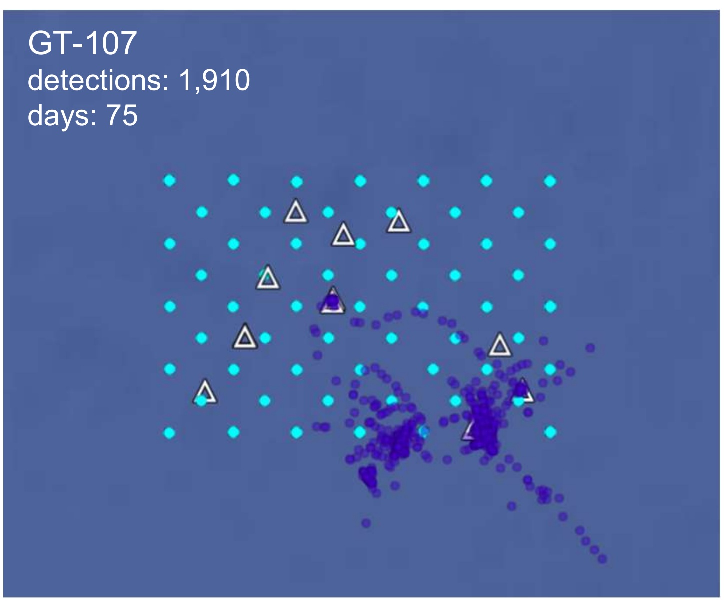

GT-102
detections: 6
days: <1

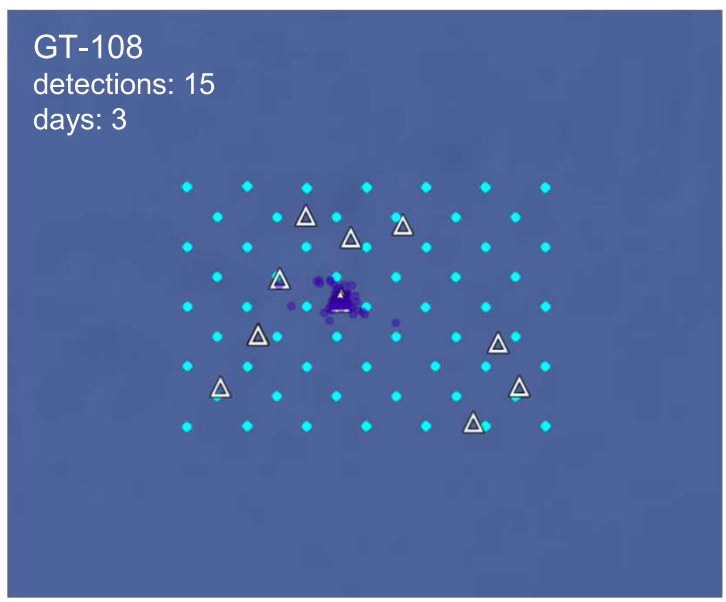

GT-103
detections: 41
days: 3

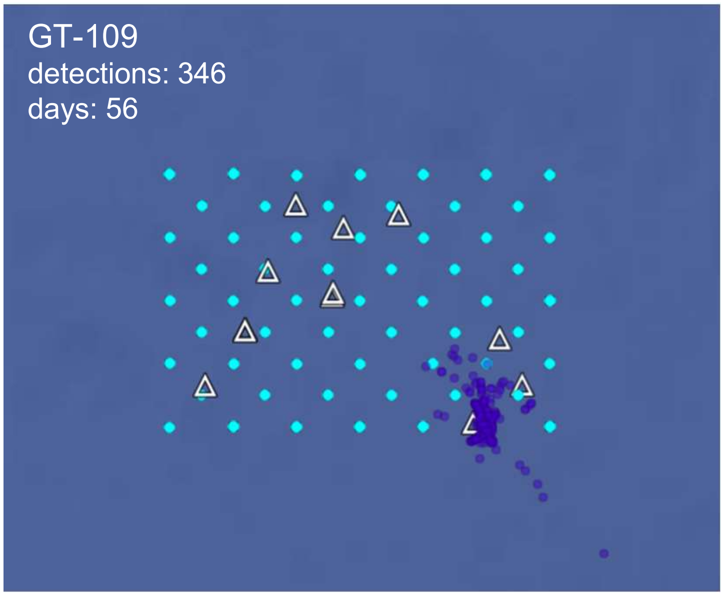

GT-104
detections: 776
days: 33

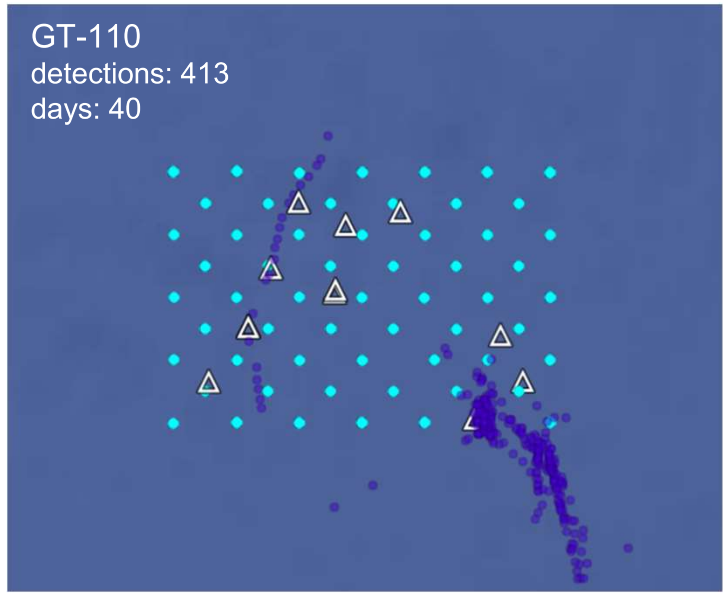

GT-105
detections: 13
days: 1

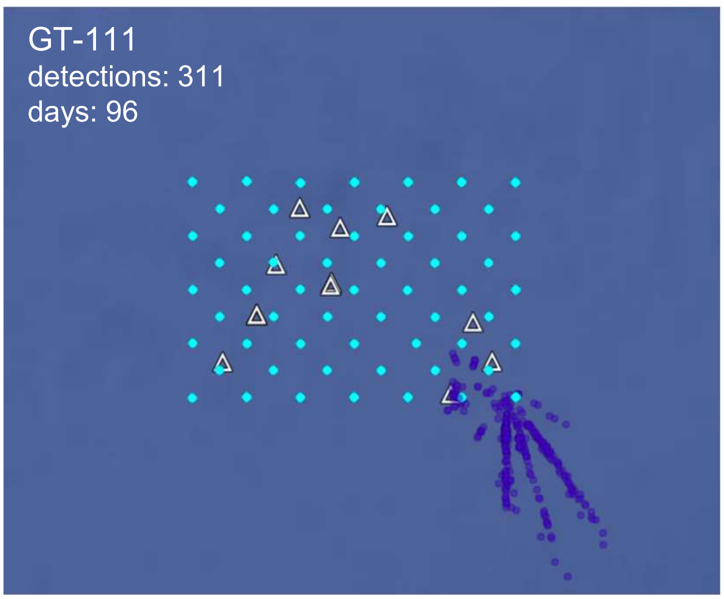

GT-106
detections: 739
days: 95

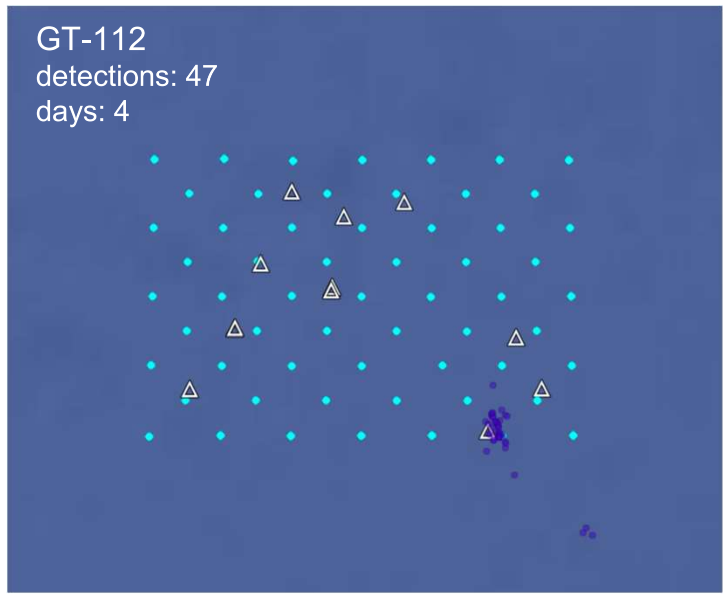

GT-107
detections: 1,910
days: 75

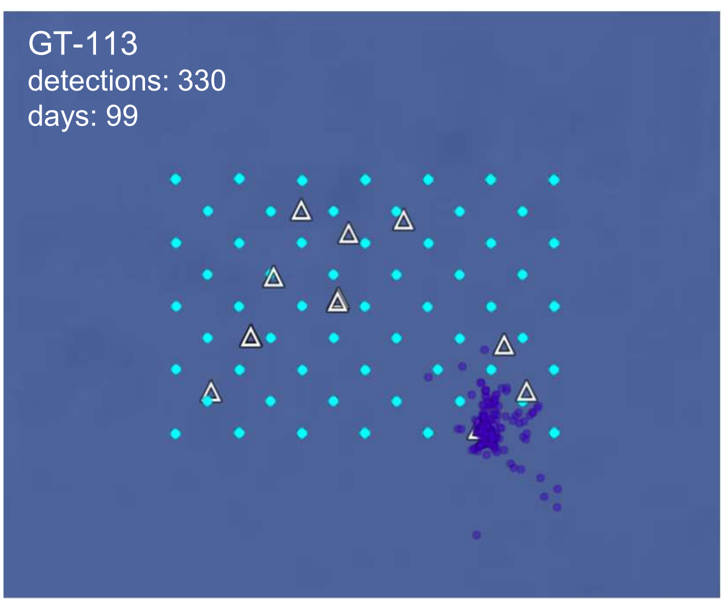

GT-108
detections: 15
days: 3

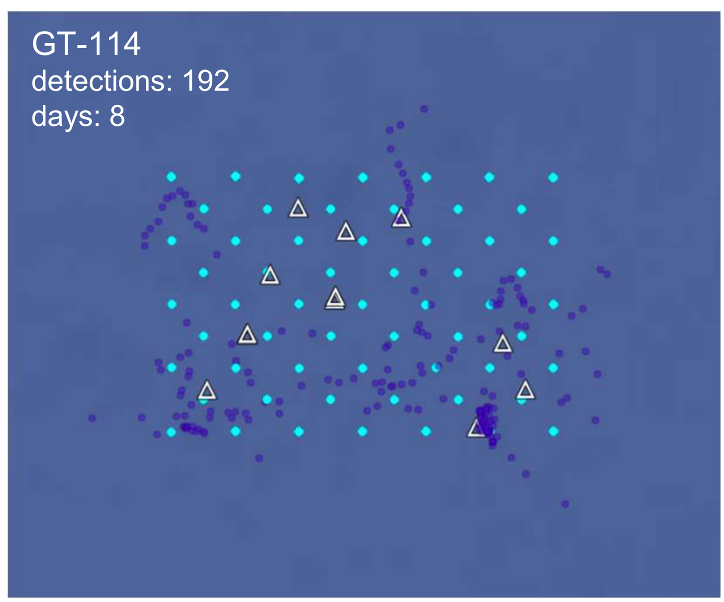

GT-109
detections: 346
days: 56

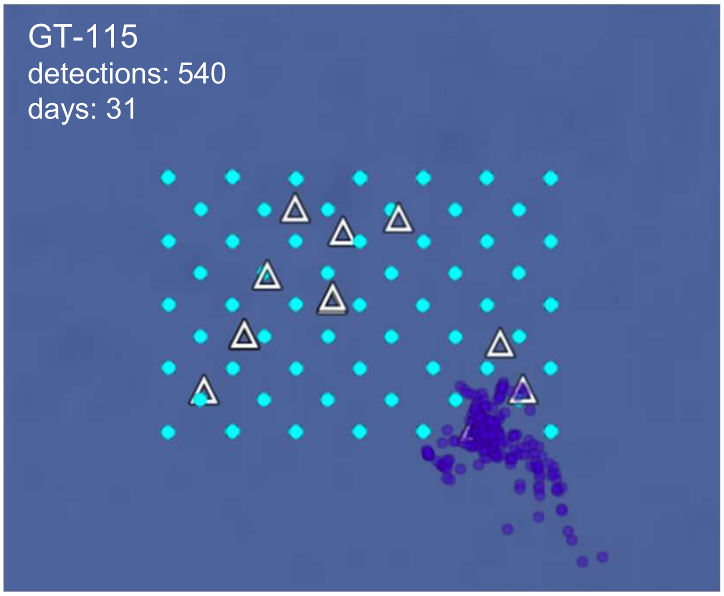

GT-110
detections: 413
days: 40

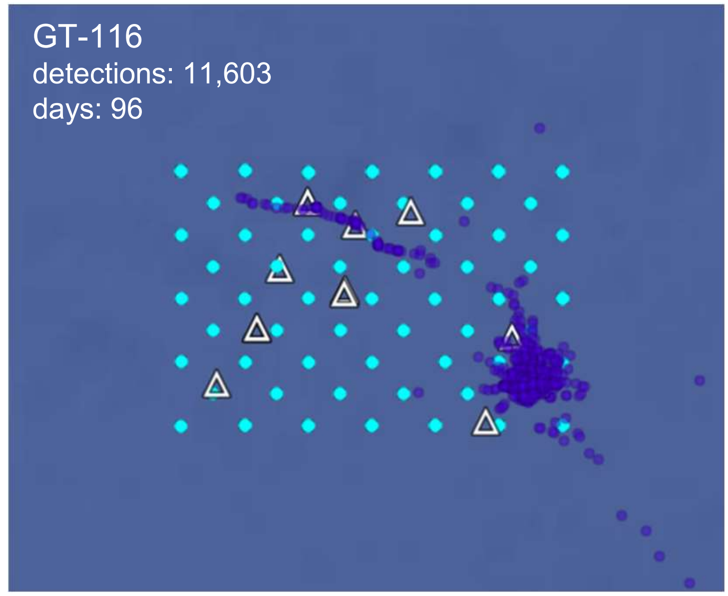

GT-111
detections: 311
days: 96


GT-112
detections: 47
days: 4


GT-113
detections: 330
days: 99

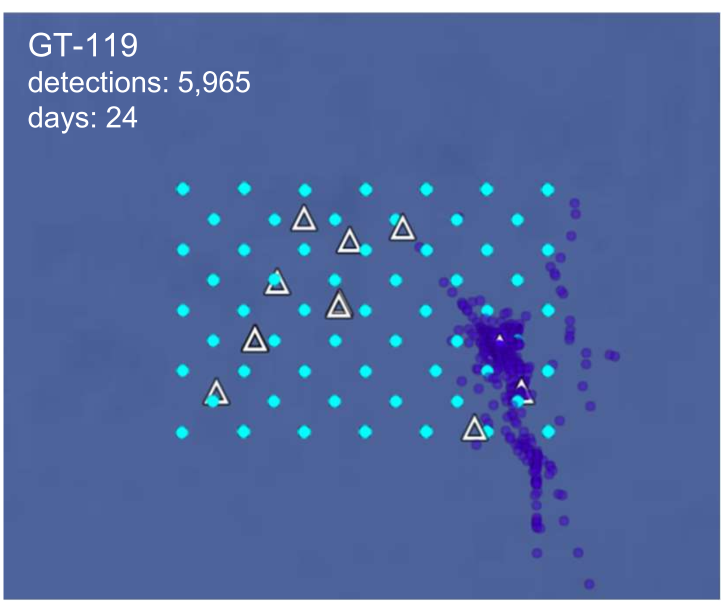

GT-114
detections: 192
days: 8

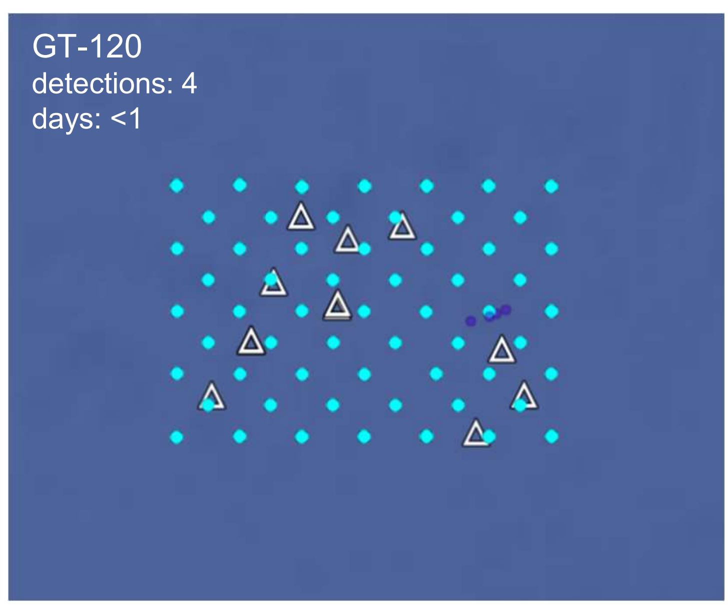


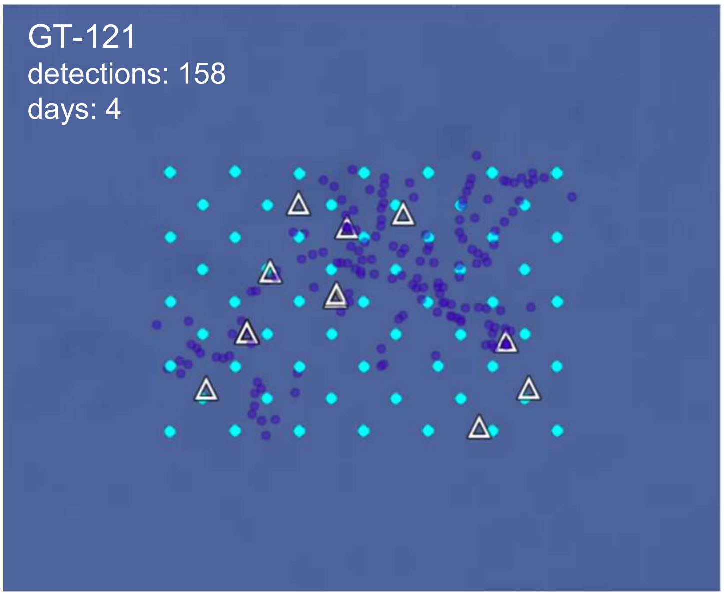


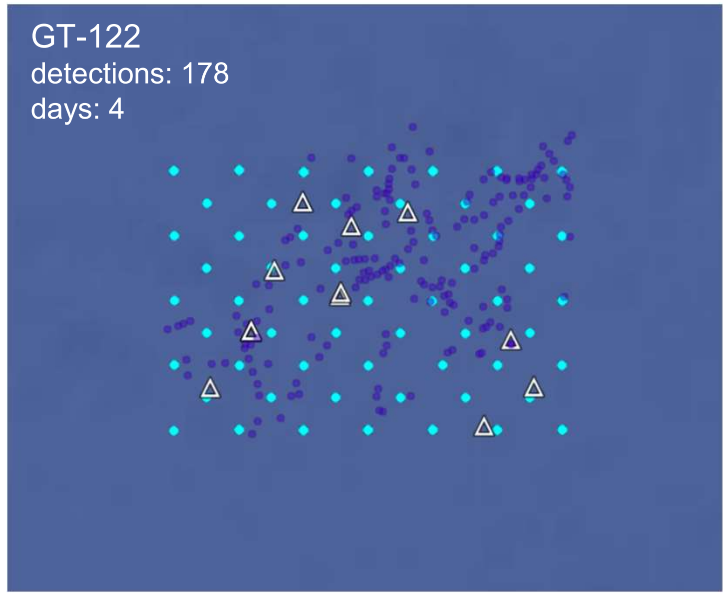
GT-117
No Data

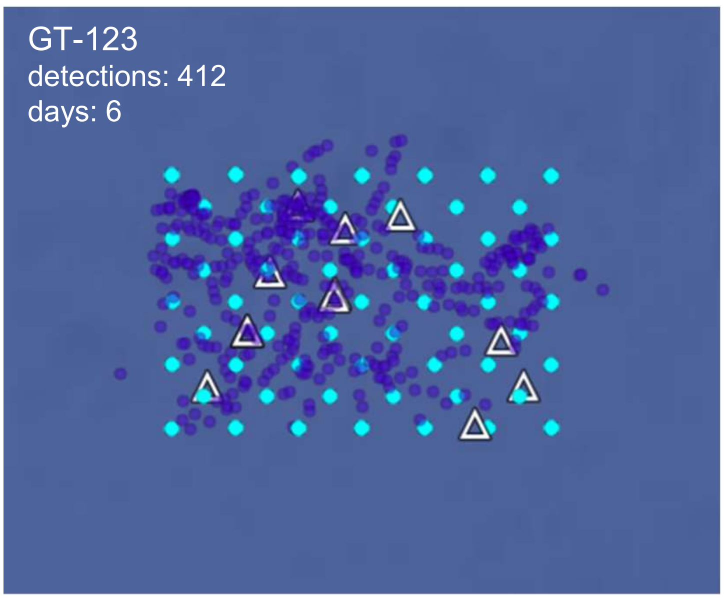
GT-118
No Data

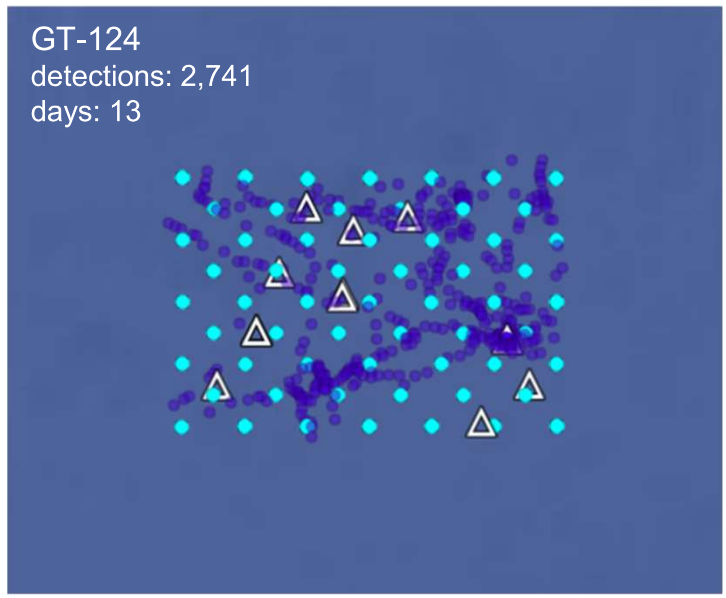


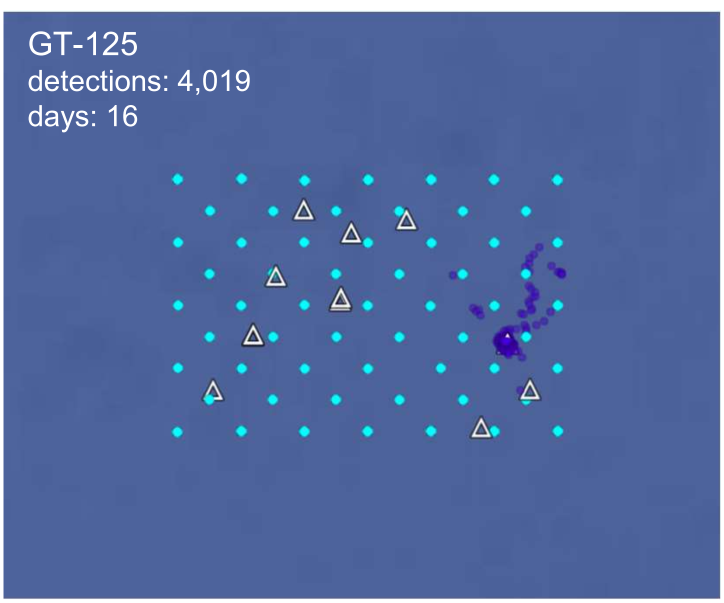


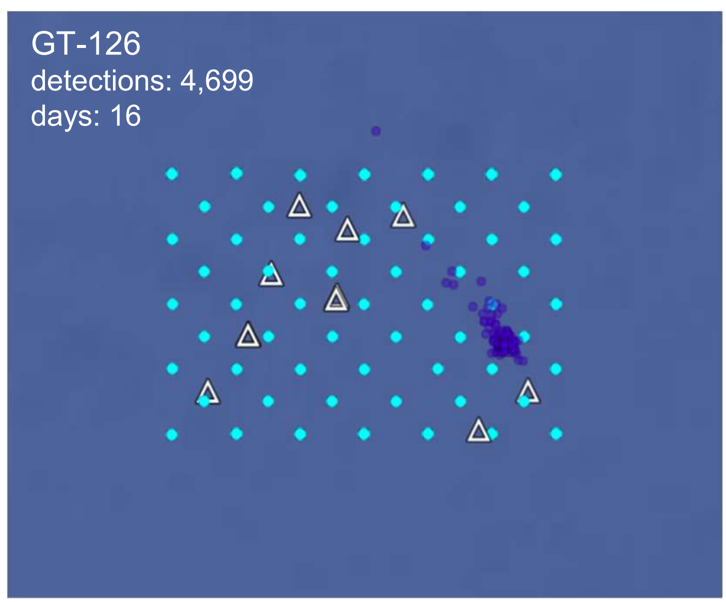

GT-121
detections: 158
days: 4


GT-122
detections: 178
days: 4


GT-123
detections: 412
days: 6


GT-124
detections: 2,741
days: 13


GT-125
detections: 4,019
days: 16


GT-126
detections: 4,699
days: 16