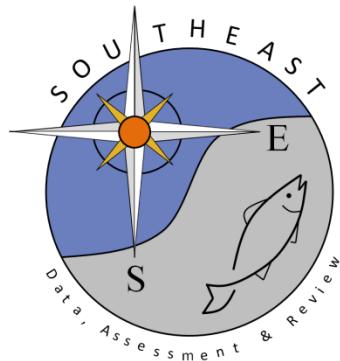


# A cage release method to improve fish tagging studies

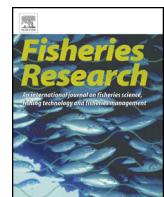
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## Short communication

## A cage release method to improve fish tagging studies

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## ABSTRACT

The return and survival of tagged fish to their depth of capture has proved difficult due to barotrauma and predation in previous telemetry studies. Tagging stress can slow and disorient the fish upon release, and reduce the ability to return to depth, relocate their home habitat site, and evade predators. To reduce these initial tag and release artifacts we designed and tested a remotely opening cage for use with reef fish in the northern Gulf of Mexico. Our objectives were to quickly return transmitter tagged fish to depth (20–30 m) in close proximity (<10 m) to their capture site, and to increase survival by providing predator protection during an initial recovery period. This cage release method proved successful for both red snapper (*Lutjanus campechanus*;  $n=62$  out of 71, 87%) and all gray triggerfish (*Balistes capriscus*;  $n=24$ ) that were tagged and released on artificial reefs. All tagged fish were released from November 2012 to September 2014, no initial tag induced mortalities were observed, and after tagging fish were successfully tracked for extended periods (for the entire 2 year study period).

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## 1. Introduction

In both conventional and acoustic tagging studies, increased stress, emigration, and mortality of fish after tag and release has been reported for several different release methods (Szedlmayer, 1997; Starr et al., 2000; Humston et al., 2005; Szedlmayer and Schroepfer, 2005; McDonough and Cowan, 2007; Westmeyer et al., 2007; Topping and Szedlmayer, 2011b, 2013; Piraino and Szedlmayer, 2014). Immediate and prolonged tagging mortalities due to barotrauma and stress from the tagging procedure have been examined in multiple species (Parrish and Moffitt, 1992; Davis, 2002; McGovern et al., 2005; Jarvis and Lowe, 2008; Diamond and Campbell, 2009; Pribyl et al., 2009; Campbell et al., 2010; Sumpton et al., 2010; Hannah and Rankin, 2011; Hannah et al., 2012; Pribyl et al., 2011). These studies showed increased stress due to the rapid change in pressure, substantial changes in water and air temperature, fish handling, and time spent on the surface (Parrish and Moffitt, 1992; Davis, 2002; Jarvis and Lowe, 2008; Diamond and Campbell, 2009; Campbell et al., 2010).

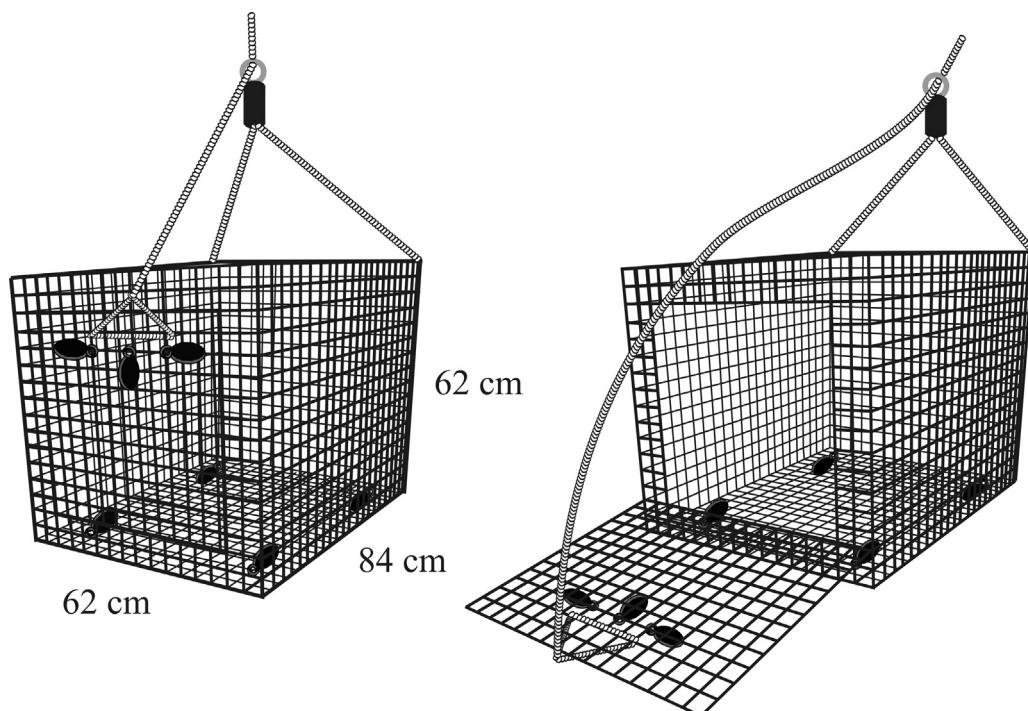
While the effects of barotrauma stress have been examined, the effects of different release methods on tagged fish were rarely reported. Methods of release include surface release (Fable, 1980; Szedlmayer and Shipp, 1994; Gitschlag and Renaud, 1994;

Patterson et al., 2001; McDonough and Cowan, 2007; Hannah and Rankin, 2011), drop weights (Szedlmayer and Schroepfer, 2005; Topping and Szedlmayer, 2011a, 2011b; Piraino and Szedlmayer, 2014), underwater tagging and release by SCUBA divers (Tong, 1978; Gitschlag, 1986; Parrish and Moffett, 1992; Szedlmayer, 1997; Starr et al., 2000; Sigurdsson et al., 2006), surface tagging and underwater release by divers (Szedlmayer, 1997; Nemeth et al., 2007), and surface tagging, caging, and delayed release by divers (Piraino and Szedlmayer, 2014).

In most cases, studies of release methods have not considered predator protection, but have focused on cost, time, training, and fish condition (e.g., surface release, drop weights, underwater tagging). For example, the drop weight release method was quick, inexpensive, and returned fish to their depth of capture (Szedlmayer and Schroepfer, 2005; Topping and Szedlmayer, 2011a, 2011b; Piraino and Szedlmayer, 2014). However, during descent tagged fish were not protected against predators. This protection may be extremely important following tagging, because even fish with little sign of barotrauma can still have loss of equilibrium and reduced mobility (Tytler and Blaxter, 1977; Gitschlag and Renaud, 1994; Cooke and Philipp, 2004; Danylchuk et al., 2007; Jarvis and Lowe, 2008; Campbell et al., 2010; Raby et al., 2013). The early escape of disoriented fish during decent at mid-depths can substantially increase emigration and predation. In an effort to reduce predation effects, cage release methods were tested for transmitter tagged red snapper (*Lutjanus campechanus*; Piraino and Szedlmayer, 2014). The cages were lowered to the bottom near the capture reef site, and after ~2 h, SCUBA divers opened the cage

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**Fig. 1.** Vinyl coated wire mesh cage (16 gauge wire, 3.8 cm mesh size) with individual 0.25 kg weights fastened to the bottom of the cage and to the outside of the cage door. A nylon rope (1.5 cm diameter) is attached to the inside of the door and runs through a stainless steel ring over the top of the cage. This ring is attached to a small buoy (black; 10 cm) to keep the rope suspended above the cage.

doors on the bottom and released the fish close (2–3 m) to the reef. This cage release method required more time and training, but successfully reduced tag induced emigrations and predation mortality of tagged red snapper from 85% to 8%.

A release method that provides protection from predators is especially important in regions with a high abundance of predators. In recent years shark abundances have apparently increased based on SCUBA diver encounters 20–50 km south of Dauphin Island, AL. For example in 2014, SCUBA diver fish surveys on artificial reefs had frequent encounters (~45%) with large (>2 m) Carcharhinid sharks, while past diver surveys (>1000) over 20 years prior to 2010 only had rare (<10) shark encounters (unpublished data Szedlmayer, S.T.). These larger sharks include many species that commonly occur in our study area (10–40 m), for example, blacktip shark (*Carcharhinus limbatus*), bull shark (*C. leucas*), sandbar shark (*C. plumbeus*), spinner shark (*C. brevipinna*), nurse shark (*Ginglymostoma cirratum*), scalloped hammerhead (*Sphyrna lewini*), and tiger shark (*Galeocerdo cuvier*; Drymon et al., 2010). Thus, in our study area with substantial shark populations, the use of SCUBA divers to release tagged fish from submerged cages became difficult due to safety considerations.

In the present study, we further examined cage release methods to reduce predation and tag induced early emigrations with an untested species, gray triggerfish (*Balistes capriscus*) as well as continued studies with red snapper. Importantly, we developed a remote release method that eliminates the use of SCUBA divers and the risk of shark encounters.

## 2. Methods

The cage and release method was tested from November 2012 to 2014 on transmitter tagged red snapper and gray triggerfish 20–50 km south of Dauphin Island, AL in the northern Gulf of Mexico. Tagging methods followed Topping and Szedlmayer (2011a,b). Temperature and dissolved oxygen levels were

measured at depth prior to tagging. If the dissolved oxygen values were lower than 2.5 mg/L fish were not tagged. If surface temperatures were higher than temperatures at depth of capture we chilled both the anesthesia container and the recovery container with ice. Fish were captured by hook and line, weighed, measured, and anesthetized on the research vessel in a 70-L container of seawater and tricaine methanesulfonate (150 mg tricaine methanesulfonate/L seawater for 2.5 min). Fish were tagged internally with an acoustic transmitter and externally with an anchor tag. During the tagging procedure the swim bladder was punctured for easy insertion of the transmitter. After tagging, fish were held until they showed signs of recovery (active fin and gill movements) and then placed in the release cage. The tagging procedure was complete in <10 min.

The release cage (84 × 62 × 62 cm) was constructed of vinyl coated wire mesh (16 gauge, 3.8 cm mesh), and fastened with stainless steel connectors (Fig. 1). Four 0.25 kg lead weights were attached to the bottom corners of the cage and three weights to the cage door. A nylon rope (1.5 cm diameter) was attached to the inside of the door and passed through a stainless steel ring over the top of the cage, which allowed opening and closing of the cage door. This ring was attached to a 10 cm buoy to keep the rope suspended above the cage (Fig. 1). Initial testing without fish was observed by SCUBA divers and confirmed that the cage descended to the seafloor and opened correctly.

Once a tagged fish recovered from anesthesia it was placed into the release cage and held at the surface (1 m depth), and observed for about 10–20 s to confirm that the fish was upright and actively swimming. After confirming normal swimming behavior, the caged fish was lowered to the bottom (20–30 m). As the cage was lowered to the bottom the tension was maintained on the line to keep the release door closed. Once the cage reached the seafloor the line was released which allowed the cage door to open. The weights on the cage door passively caused the door to fall open. The cage door weights continued to keep the door open until retrieval and allowed the tagged fish to leave on its own initiative (Fig. 2). Cages



**Fig. 2.** A transmitter red snapper (*Lutjanus campechanus*) exiting the cage. The camera was attached to the bottom of the cage and is facing towards the opened cage door.

were retrieved after allowing at least 10 min for gray triggerfish and 15 min for red snapper to leave the cage. The cage was retrieved by hand or winch. If a tagged fish remained in the cage after this release period it was not released and removed from the study. Video cameras (GoPro Inc., San Mateo, California, USA) were attached to a subset ( $n=6$ ) of the cage releases to visually assess fish releases.

All tagged fish were released on artificial reefs surrounded by an acoustic array (VEMCO, VR2W Positioning System, Vemco Ltd, Nova Scotia; [Piraino and Szedlmayer, 2014](#)) and their fine-scale positions (~1 m accuracy) were monitored for extended time periods (up to 2 years). Survival was evaluated based on the fine-scale movements of tagged fish within the VPS array. If a tag showed movement within the array, it was assumed that the fish was alive. However, if a tag was stationary it was defined as a mortality. Emigrations were detected when a fish made progressive movements away from the center of the reef ([Piraino and Szedlmayer, 2014](#)). Some emigrations were confirmed by detections on additional VR2W receivers on nearby reefs (~1 km). In addition, diver observations of active “normal” swimming behavior of tagged fish provided further survival validations in later months.

### 3. Results

We used this new cage release method with tagged red snapper and gray triggerfish on artificial reef habitats (22–35 m depths) in the northern Gulf of Mexico. Video recordings confirmed that the cage door successfully opened onto the seafloor for all the recorded releases ( $n=6$ ; [Fig. 2](#)). Most tagged red snapper ( $n=62$  out of 71, 87%) and all tagged gray triggerfish ( $n=24$ ) left the cage of their own initiative. Based on video recordings red snapper and gray triggerfish left the cage within 1–14 min.

We identified mortality and emigration based on fine scale (1 m) fish position data within VPS arrays ([Piraino and Szedlmayer, 2014](#)), and broader scale movements based on detections at single receivers 1 km from the release site. After fish left the cage, no mortalities were detected within the VPS arrays during an initial 4 d post release recovery period. At the single receivers, we detected three (27%) emigrations of tagged red snapper and one (33%) emigration of a tagged gray triggerfish, among fish that left their release site within the recovery period. These emigrating red snapper remained at their new reef sites for extended periods (>30 days). After this initial 4 d recovery period most red snapper (82%) and gray triggerfish (83%) remained on the release site for extended periods. For example, one tagged red snapper remained

at its release site for 559 days, and was subsequently caught and reported by a private fisher. After the initial 4 days recovery period, no natural mortalities were recorded for red snapper, while one mortality was detected in a gray triggerfish 8 d after release. Emigrations were detected 6–367 days after release for red snapper, and 21–563 days after release for gray triggerfish.

### 4. Discussion

The present cage release method provides several advantages (e.g., less training and greater predator protection) over past release methods and has proved successful for both red snapper and gray triggerfish. Several telemetry studies have observed a substantial percentage of tagged fish emigrating shortly (<8 days) after release presumably due to the tagging stress: e.g., 15%, 8 out of 54 fish ([Szedlmayer and Schroepfer, 2005](#)), 16%, 14 out of 87 ([Topping and Szedlmayer, 2013](#)), and 35%, 7 out of 20 fish ([McDonough and Cowan, 2007](#)). In the present study, red snapper emigrations (18% 11 out of 62) and gray triggerfish emigrations (17%, 4 out of 24) during the initial 4 days recovery period were similar to these previous studies.

We detected no mortalities in tagged fish immediately following release ( $\leq 4$  days), but identified a single mortality in a gray triggerfish 8 d after release. This mortality occurred shortly after the post-release recovery period and may have still been related to tag and release effects. [Topping and Szedlmayer \(2013\)](#) reported a low mortality (2%, 2 out of 87 fish) for tagged red snapper within 6 days of release. In contrast [Piraino and Szedlmayer \(2014\)](#) reported a high release mortality (39%, 13 out of 33 fish) within 4 days of release.

The high mortality reported by [Piraino and Szedlmayer \(2014\)](#) was likely caused by shark predation. In the present study, SCUBA divers frequently encountered 1–3 large (>2 m) sandbar and bull sharks on the same artificial reefs used by [Piraino and Szedlmayer \(2014\)](#) and diver release of tagged fish from cages was discontinued for safety considerations. We then developed the present cage release method and continued tagging on the same sites that showed this high predation level and detected no predation and reduced emigration of transmitter tagged fish.

In the present study, red snapper had similar emigration rates compared to earlier telemetry studies in the Northern Gulf of Mexico when predation effects were less apparent ([Szedlmayer and Schroepfer, 2005](#); [Topping and Szedlmayer, 2013](#)). [Piraino and Szedlmayer \(2014\)](#) attributed 39% of lost tagged fish to predation using the drop weight release method. They also detected a high (45%) loss to emigration that may include additional predation. During the present study, the video recording showed the presence of predators *Carcharhinus sp.*, and bottlenose dolphin (*Tursiops truncatus*) around the cages, confirming the continued predation risk. However, the high survival (100%) observed in the present study showed that the cage release method protected the tagged fish from predation.

A review of the camera videos showed that tagging recovery time varied from 1 to 14 min. The longest recovery time was for a red snapper confirming that this post-release protection provided by the cage may be particularly important for this species. The cage provided protection for a minimum of 15 min and allowed red snapper to recover from tagging stress and exit on their own initiative. A recompression study on Pacific rockfish that used similar methods (hook and line and cage release) found that the degree of impairment due to barotrauma varied by species, increased with depth of capture (greatest >40 m depth), and that observations of barotrauma made while the fish was on the surface poorly predicted the degree of behavioral impairment observed underwater ([Hannah and Matteson, 2007](#)). Similarly, in the present study there

were no detectable differences in fish recovery behavior observed at the surface before lowering the cage among tagged fish that took 1–14 min to exit the cage.

In the future, cameras should be used to record all cage releases. The recordings in the present study were valuable in showing not only the threat of predation, but also the importance of maintaining tension on the line while lowering the cage. In addition, it showed that the cage functioned correctly with the cage door opening after it reached the seafloor. The future use of camera recording would allow evaluations of all releases and potentially identify any difficulties.

In the present study, the cage was dropped close to the reef (<10 m). The close proximity of the caged fish to the reef site likely allowed the fish to quickly swim from the cage to the reef to avoid predation. We suggest that the combination of the cage protection and longer term predator protection of the reef site substantially contributed to the high survival of tagged fish in the present study.

The present cage release method was successfully used to release transmitter tagged fish on artificial reefs at depths up to 30 m in the northern Gulf of Mexico. In the northern Gulf of Mexico, there is little natural reef habitat (Parker et al., 1983; Dufrene, 2005) and artificial habitats are typically surrounded by flat sand or mud bottom. Therefore, there were few obstructions around the reef that would prevent the cage door from opening. The success of the present cage release method on natural habitats may be reduced due to the increased complexity of the reef surface that may impede the cage door from opening. In addition, this method was used in relatively shallow waters ( $\leq 30$  m), and it is unclear how the cage would function at deeper depths.

## 5. Conclusion

The cage release in the present study provides an effective method that improved the survival and residency estimates of reef-associated fish. The cage was designed to release fish at depth, and increased predator protection for tagged fish immediate (~15 min) after release. We also suggest that release of fish within close (<10 m) proximity of their capture site also provided longer term predator protection. The advantages of the present cage release methods are: (1) it can be made with readily available and inexpensive materials (wire mesh, rope, and floats), (2) it reduces effort by eliminating the need for SCUBA divers, and (3) it only releases fish in good condition as fish exited the cage on their own initiative. This method was successful for the release of transmitter tagged red snapper and gray triggerfish, but may also be successful with other species in the northern Gulf of Mexico.

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