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TECHNICAL NOTE

The first deployments of pop-up satellite archival tags on black sea bass (*Centropristis striata*)

Samir H. Patel[1] | **Ricky Alexander**[1] | **Farrell Davis**[1] | **Luisa Garcia**[1] | **Natalie Jennings**[1] | **William Pappas**[2] | **Nathan Shivers**[1] | **Nicole Trenholm**[3]

[1]Coonamessett Farm Foundation, East Falmouth, Massachusetts, USA

[2]Playin Hookey Charters, Virginia Beach, Virginia, USA

[3]Ocean Research Project, Annapolis, Maryland, USA

Correspondence
Samir H. Patel, Coonamessett Farm Foundation, 277 Hatchville Road East Falmouth, MA 02536, USA.
Email: spatel@cfarm.org

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Abstract

Black sea bass (*Centropristis striata*; BSB) are a commercially managed species with an increasing population in the Northwest Atlantic Ocean. Understanding their movement ecology can be difficult due to their wide distribution and ability to inhabit both inshore and offshore reef habitats. BSB have been studied using a range of tagging techniques, and here we present the results of the first deployments of pop-up satellite archival tags (PSAT) on this species. During 2019 and 2021, we conducted four fishing trips within the southern Mid-Atlantic Bight region of the NW Atlantic and tagged a total of 30 fish with T-bar tags and external data loggers, of which 4 received a PSAT and the rest received a Star-Oddi conductivity–temperature–depth (CTD) archival tag. All PSATs transmitted some data, with short attachment durations (8–32 days) relative to the programmed release of 250 days, and we did not recover a Star-Oddi tag. External tag attachment techniques need to be examined and improved before continued deployment of larger data loggers on BSB.

KEYWORDS
acoustic telemetry, fish tagging, Northwest Atlantic Ocean, satellite telemetry

1 | INTRODUCTION

Black sea bass (*Centropristis striata*; BSB) are widely distributed along the U.S. east coast, ranging from the Bay of Fundy to the Gulf of Mexico (Drohan et al., 2007), and are known to congregate around benthic structures, such as reefs, shipwrecks and pilings (Able et al., 1995; Steimle et al., 1999). BSB found north of Cape Hatteras, North Carolina (NC), are a distinct genetic population from those in the Southern Atlantic Bight and in the Gulf of Mexico (Roy et al., 2012). All stocks support commercial fisheries, and recent data indicate that the north of Hudson Canyon BSB catch has substantially increased while remaining stable (Atlantic State Marine Fisheries Commission [ASMFC], 2021) or declining (National Oceanographic and Atmospheric Administration [NOAA], 2022) in the southern end of their range.

Researchers have studied BSB using tagging and mark–recapture techniques for ~50 years (Parker, 1990). Several state-run tagging programmes exist, and a large federal effort from the National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) to tag BSB from NC to Massachusetts occurred from 2002 to 2004 (Moser & Shepherd, 2009). These tagging programmes primarily used passive tags and obtained supplemental data from a fewer number of deployments of electronic tags that also needed to be recovered (Moser & Shephard, 2009). In nearshore waters, tag returns tend to be higher due to concentrated fishing activity compared to offshore locations; however, returns are still relatively low and vary based on preferred fishing sites. In Virginia (VA), the average tag return rate is 24.5% (Musick & Gillingham, 2022), whereas in offshore waters (i.e. federal waters), the rate tends to be lower, with Moser and Shephard (2009) recording 17.4% of traditional tags returned and only 5% of electronic tags returned.

Advances in acoustic telemetry have led to a much higher likelihood of recovering data from fish equipped with electronic tags and have increased understanding of fish movement ecology (Hockersmith & Beeman, 2012). This technique can be logistically complicated, requiring both the tagging of animals and the use and maintenance of either mobile or stand-alone acoustic receivers for data recovery (Ng et al., 2007). Fabrizio et al. (2013) conducted a large acoustic telemetry study of BSB in the New York Bight region, tagging 129 fish and deploying 72 stationary receivers. This led to high data recovery (95% of tags) and a relatively long-term data set, with tags transmitting within the receiver array for several months (Fabrizio et al., 2013). Smaller scale studies on BSB, like the one conducted by Secor et al. (2021), have also yielded a substantial amount of data over a long period, though this was highly dependent on the environmental conditions and seasonality of fish movement in and out of the receiver array. For marine species, these studies emphasize the value of releasing fish with acoustic tags within established receiver arrays to understand localized movement within a predefined area. This is particularly important in offshore regions where oceanographic conditions may be more dynamic (increased current and wind speeds), resulting in lower detection probability (Reubens et al., 2019) and where receivers are generally scarce and typically located nearshore or at intersections between bodies of water like the mouth of the Chesapeake Bay (Secor et al., 2020).

For studying more-mobile species, especially larger marine vertebrates like sea turtles, marine mammals, sharks and tuna, satellite telemetry has been an effective technology (Costa et al., 2010). Compared to other electronic data loggers (i.e. Star-Oddi conductivity–temperature–depth [CTD]) or acoustic tags, satellite tags do not require recovery or additional deployed equipment to download location, dive and temperature data due to the existing satellite network. This makes these devices ideal for animals that are far offshore, away from receiver arrays and unlikely to be recaptured. For animals that rarely or never breach the surface to allow for the satellite tag to transmit opportunistically, researchers specifically use pop-up satellite archival tags (PSATs). These tags are meant to remain on the animal for a pre-set number of days, release, then float to the surface and transmit collected data through the satellite network. Some limitations include the cost of tags (~$2500–$5500/tag), the size of the animal that can retain the tag (typically <5% of tag to body mass ratio for fish), tag retention, and the accuracy of the location data while on the animal (light level location data compared to Argos or GPS) (Jepsen et al., 2015; Musyl et al., 2011; Teo et al., 2004). However, recently, PSATs have been successfully tested and deployed on smaller fish (~45 cm fork length; Naisbett-Jones et al., 2023). For BSB, we deployed PSATs on similarly sized individuals (≥44 cm total length [TL]) to assess their ability to retain the tag and transmit data. We tested two additional external attachment techniques using the Star-Oddi tags to help assess retention times while fish were released at sea.

2 | METHODS

To conduct this research on a commercially managed species, we received an Exempted Fishing Permit (#20071) from the U.S. NMFS and a Scientific Collection Permit (#19-038) from the State of VA. Handling methods were based on the guidelines on the use of fish in research published by the American Fisheries Society, the American Institute of Fishery Research Biologists and the American Society of Ichthyologists and Herpetologists (Use of Fishes in Research [UFR] Committee, 2013).

In April and August, during both 2019 and 2021, we conducted fishing trips in the southern Mid-Atlantic Bight to capture and tag BSB. Each trip consisted of 3 days of fishing at various in- and offshore sites with known BSB presence (Figure 1). For all trips, we departed from Rudee Inlet, VA Beach, aboard the F/V Playin Hookey, captained by William Pappas. Sites were selected based on previous knowledge of the region and the likelihood of capturing fish appropriate for each tagging technique. No sampling occurred in 2020 due to logistical constraints associated with the Covid-19 pandemic.

Each site was fished using rod and reel rigged with <20 lb-test monofilament line, a small weight (2 oz) and two or three 3/0 circle hooks baited with pieces of crab (*Callinectes sapidus*) or squid (*Loligo* sp.). Once on board, fish were placed into a live well for a recovery period (>15 min). If barotrauma was observed, a hypodermic needle (16 ga) was immediately inserted into the abdominal region behind the pectoral fin to vent the swim bladder prior to placing the animal in the live well (Rudershausen et al., 2020; Zemeckis et al., 2020). A tagging station was created next to the live well, consisting of a measuring board, a V-shaped holding container and a towel drenched in sea water to help hold the fish in place. The TL of each fish was recorded prior to tagging. All fish received a T-bar tag and then the appropriately sized fish received at most one electronic tag. Techniques established by Moser and Shephard (2009) and Fabrizio et al. (2013) were followed to attach passive T-Bar tags.

We deployed Star-Oddi CTD tags (13 g in water) (Table 1) using both a saddle attachment technique ($n = 10$; fish >31 cm TL; Figure 2a) (Mellas & Haynes, 1985) and a simplified loop technique ($n = 16$; fish >23 cm TL; Figure 2b) (Runde et al., 2022; Sweezey et al., 2020). The simplified loop technique used in this research was modified from Capizzano et al. (2016). We threaded nylon monofilament (8 lb test) through the tag, then the muscle anterior of the dorsal fin, which left the tag dangling from the fish above the operculum. We avoided placing the loop over the dorsal fin to avoid damage to this appendage, as documented by Naisbett-Jones et al. (2023). The monofilament was secured using a single-barrel aluminium sleeve (size 0.8), and once crimped, the sleeve was clipped to reduce its profile. This technique took ~1 min to complete. We performed all loop attachments on the final day of the fourth trip in August 2021, when sea surface temperature (SST) was 26.6°C and air temperature on land was 32.8°C.

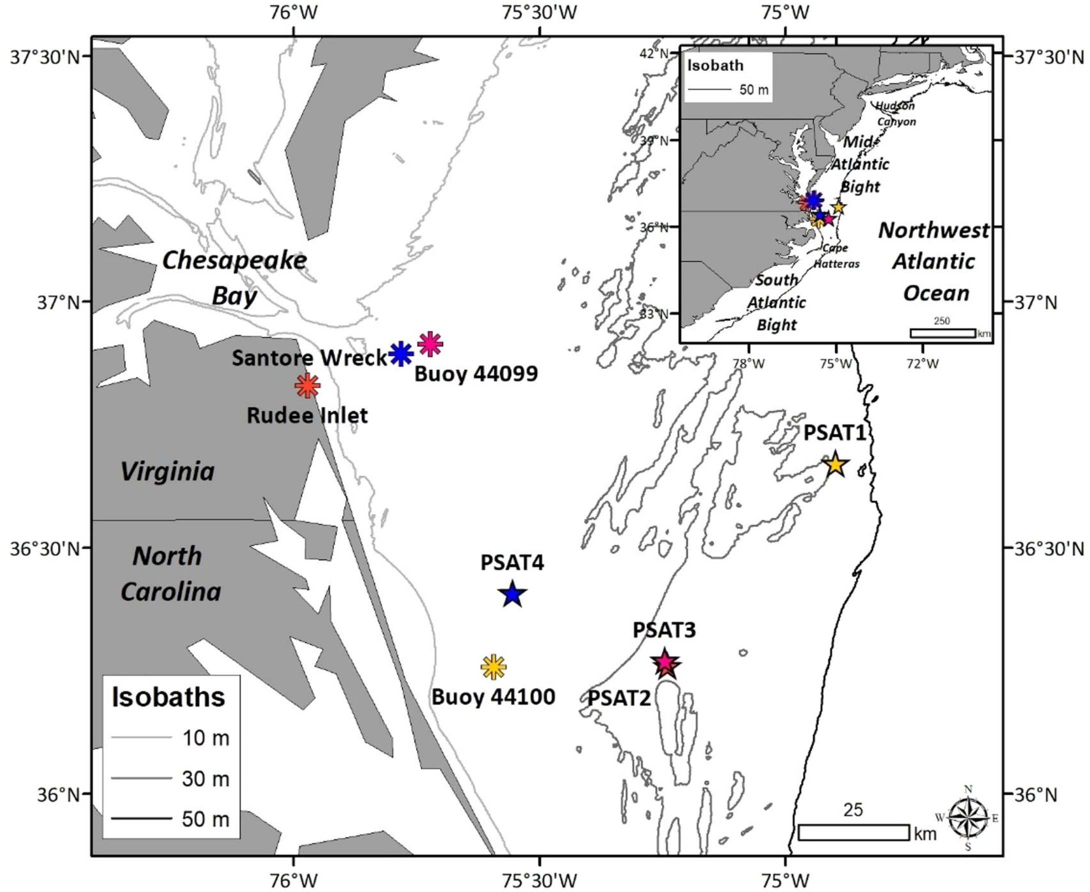

FIGURE 1 Map of the study site, pop-up satellite archival tag (PSAT) deployment locations (stars) and National Oceanic and Atmospheric Administration (NOAA) buoys used for ocean temperature data.

TABLE 1 Summary data for deployments of the Star-Oddi conductivity–temperature–depth (CTD) tags.

Tag type	Trip #	Sample size	TL (mean ± SD)	TL range
Star-Oddi CTD	1	6	40.2 ± 3.2 cm	37–44 cm
	3	2	32.0 ± 1.4 cm	31–33 cm
	4	18	26.7 ± 3.0 cm	23–32 cm
Total		26	30.3 ± 6.4 cm	23–44 cm

Abbreviation: TL, total fish length.

The saddle technique was the option provided by Star-Oddi for the external attachment of the CTD tag. This method followed the process described in Mellas and Haynes (1985) and was tested in many studies (e.g. Naisbett-Jones et al., 2023; Økland et al., 2013). We used a plastic housing to hold the tag, soft silicon pads on either side of the dorsal fin and thin (0.6 mm thickness) stainless-steel wire threaded through the muscle and then twisted to secure the tag to the animal (Figure 2a). Excess wire was then clipped, and the twisted portion was bent down to lower its profile. Prior to fishing, tags were secured in the housings with stainless steel wire threaded through predrilled holes and twisted tight. The process of attaching it to the animal took ∼1–2 min. We performed this method during the April fishing trips when air temperature on land was higher than SST (high of 23.3°C air temperature and 17.6°C SST in 2019 and 22.8° air temperature and 14.5°C SST in 2021) and during the first day of the fourth trip, occurring in August 2021, when air temperature on land was 29.4°C and SST was 25.1°C.

Fish 44 cm TL or larger were considered for a PSAT (MiniPAT, manufactured by Wildlife Computers, 61 g in air and positively buoyant) (Table 2). Based on Wuenschel et al. (2013), these fish were likely >1000 g. The PSAT, outfitted with a small titanium anchor (45 mm length × 14 mm width × 1.3 mm thickness) designed by Wildlife Computers, was attached under the skin using a tag applicator and placed

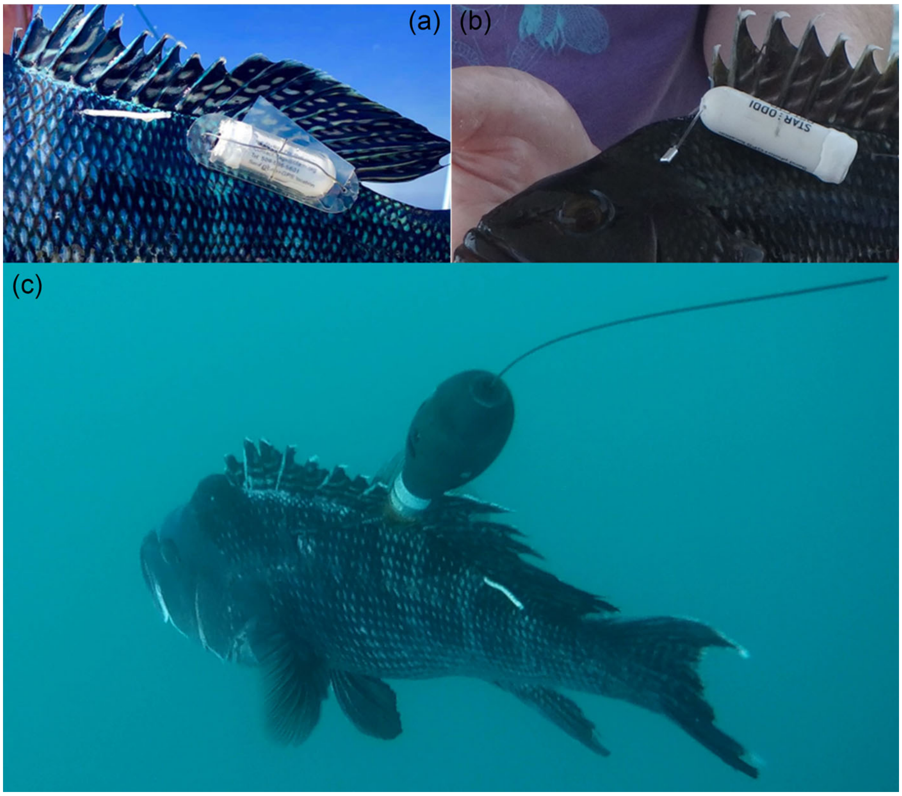

FIGURE 2 (a) Saddle attachment technique used for the first 10 Star-Oddi conductivity–temperature–depth (CTD) tag deployments. White thin line anterior of the Star-Oddi is a T-bar tag. (b) Simplified loop technique used to attach the Star-Oddi CTD for the final 16 deployments. (c) Deployment of the first pop-up satellite archival tag (PSAT1) on a male black sea bass as part of this study. The large black item is the PSAT, and the small white line posterior of that is a T-bar tag.

TABLE 2 Summary data for pop-up satellite archival tag (PSAT) deployments throughout the study.

Tag	Deployment date	Trip ID	TL (cm)	Popoff date	Days at large	Data recovered (%)
PSAT1	4/25/2019	1	46	5/28/2019	32	89
PSAT2	4/27/2021	3	44	5/5/2021	8	52
PSAT3	4/27/2021	3	48	5/9/2021	11	89
PSAT4	4/27/2021	3	46	5/19/2021	22	90

Abbreviation: TL, total fish length.

superficially into the muscle at the base of the dorsal fin. Fish were released immediately to avoid interactions between tags and other fish within the live well. Tagged fish were released as close to the capture location as possible.

PSATs were programmed to continuously record temperature and depth at 10-min intervals for a scheduled 250 days. Tags were programmed not to release while at a constant depth due to the behaviour of BSB, which resides at the ocean floor with minimal movement through the water column (Secor et al., 2021). Tags were programmed to immediately begin transmission once they reached the surface and to transmit temperature and depth time series, time at temperature histograms (bin upper limits (°C) = 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33), time at depth histograms (for 2019 bin upper limits (m) = 10, 20, 40, 70, 100, 200, 300, 400, 500, 700, 1000, and for 2021 bin upper limits (m) = 5, 10, 15, 20, 30, 40, 50, 75, 100, 150, 200), Argos quality locations after pop-off, temperature through depth at 8 m increments, summary information on battery life and condition of the tag and other versions of compiled temperature and depth information. Depth bins in 2019 were broader to account for both shallow and very deep excursions considering the proximity of the fishing location to the shelf edge (~25 km–1000 m isobath and ~90 km–10 m isobath); however, after receiving data from the fish tagged in 2019, we adjusted the bins to focus more on shallower depths. Tags also recorded light level for geolocation estimation; however, we did not incorporate this into the results due to the lack of other data used to inform models for generating accurate locations (Teo et al., 2004). Depth changes were subtle and deployments were generally short, and so the resolution of these locations estimated from parameters like light level, depth and temperature is not realistic for species with small home ranges (<1° latitude and longitude) like BSB (Secor et al., 2021; Teo et al., 2004).

Fishing sites that led to captures of large BSB and PSAT deployments varied in depth but were generally the farthest offshore. In total, we attempted to equip five fish with a PSAT; however, only four were released with the tag. Our first tagging attempt occurred during Trip #1 on a fish that was 50 cm TL. The fish did not respond well to the anchor, and it was removed. We most likely placed the anchor too deep, impacting a larger portion of the muscle and likely impeding swimming ability. After removing the tag, this fish was monitored in the live well before being released alive. Later during Trip #1, PSAT1 was successfully deployed on a fish 46 cm TL and at a site ~125 km southeast of VA Beach that had a depth of 33 m and SST of 14.4°C (Figure 1). The attachment process went well, and we were able to film the individual swimming towards the seafloor using an action camera attached to a long pole (Figure 2c). This gave us confidence that swimming behaviour had not been impaired. During Trip #3, we deployed PSAT2 and PSAT3 on fish measuring 44 and 48 cm TL, respectively. These tags were deployed at a fishing site ~120 km southeast of VA Beach and to the southwest of the PSAT1 deployment. The depth was 30 m, and the SST at deployment was 13.1°C. During the same fishing day, we stopped at a site ~80 km southeast of VA Beach and deployed PSAT4 on a fish measuring 46 cm TL. This site was 23 m deep, and SST was 13.2°C.

We used data from US National Oceanic and Atmospheric Administration (NOAA) buoy station 44,099, located ~24 km offshore from the mouth of the Chesapeake Bay, to obtain SST for the region during the deployment of PSAT1. We used NOAA buoy station 44,100, located ~17 km east of the NC coastline, to obtain SST during deployments of PSATs 2–4, as this location was closer to those release areas. We overlayed tide data from Rudee Inlet with transmitted depth data from the PSATs to simply determine if the consistent and repeated depth change corresponded with tidal cycles or BSB movement.

3 | RESULTS

In total, we tagged 30 fish: All received a T-bar tag, 26 also received a Star-Oddi (Table 1) and 4 were also equipped with a PSAT (Table 2). As of December 2023, we received three T-bar tag returns from fish that had electronic tags. These three recovered tags were all caught at Santore Wreck in early September 2021, after having been tagged at the same site during Trip #4. Two fish measured the same as when we caught them (30.5 and 32.0 cm), and one fish was 2.0 cm larger when measured at recapture (28.0–30.0 cm). All three of these fish had been equipped with a Star-Oddi tag attached using the simplified loop technique. However, upon recovery, which was 26 days after the deployment, none of the fish had retained the Star-Oddi, and there were no clear signs of where the tag had been attached, likely indicating the tags had fallen off days earlier and the attachment site had time to heal.

PSAT retention duration was short relative to the scheduled release. PSATs 1–4 remained on the fish for 32, 8, 11 and 22 days, respectively. The fish tagged with PSAT1 remained at a depth of ~35 m throughout the duration of the deployment, with an occasional ascent in the water column, ~2–3 m (Figure 3a). Water temperature steadily rose by ~1°C, from 9 to 10°C, through the duration of the tag deployment (Figure 4a). Based on the bottom depth at the capture site, we suspect that this fish remained at the same site throughout the duration of the PSAT deployment.

From PSAT2, we received a small portion of the total tag data. This fish remained in the deepest water, 37.5–39.5 m, which was deeper than the release site (30 m), likely indicating that this fish moved to a new site immediately after tagging (Figure 3b). The temperature experienced by the fish at the start of the deployment was 12.5°C and rose to 16.3°C just prior to the tag releasing from the fish (Figure 4b). The fish with PSAT3 was released approximately 1 h later and at the same site as PSAT2. This fish consistently remained between 33 and 35 m depth, which was slightly deeper than the bottom depth at the release site (30 m), also indicating that this individual may have swum to a new site (Figure 3c). For the first few days of the deployment, water temperature was under 13°C; however, this fish either ventured into warmer water, or a warm water intrusion moved through the region, as water temperatures at depth warmed to 16°C for 2 days (May 4–6, 2021), as similarly recorded by PSAT2, before returning to and remaining at ~13°C until the transmitter was released from the fish (Figure 4c). This corresponded to a mini-heat wave in VA Beach, where air temperature (recorded at the Norfolk International Airport) rose ~5°C from May 3 to May 4, before dropping again on May 6. Buoy 44,100 also recorded a rise in SST from May 4–6.

Data recovered from PSAT4 indicated that the fish relocated to a new site after release, with bottom depth at the deployment site being shallower (~23 m) than recorded from the tag (26–28 m) (Figure 3d). Tidal depth change for this region is 1–2 m, confirming that the fish likely moved to a new site as the depth difference recorded by the PSAT is consistently 3–5 m deeper compared to the deployment site. Water temperature experienced by the fish increased by ~1°C through the duration of the deployment from 12.5 to 13.5°C (Figure 4d). Unlike the other two tags deployed on the same day (PSAT2 and PSAT3), this fish did not record the rise in water temperature on May 4–6, even though the warm conditions likely overlapped its location. All PSATs seemed to document depth changes of ~0.5–2 m in a cyclical pattern. After overlaying the Rudee Inlet tidal cycle, we suspect that fish were remaining at the bottom, and these small and consistent depth changes were associated with tide rather than behavioural changes associated with other routine environmental conditions like day/night intervals or mortality because BSB are known to remain resident at the ocean floor within a small home range (Mohan et al., 2020; Secor et al., 2021).

4 | DISCUSSION

To our knowledge, this is the first study to deploy PSATs on BSB. Because substantial variation in the success rate of these types of

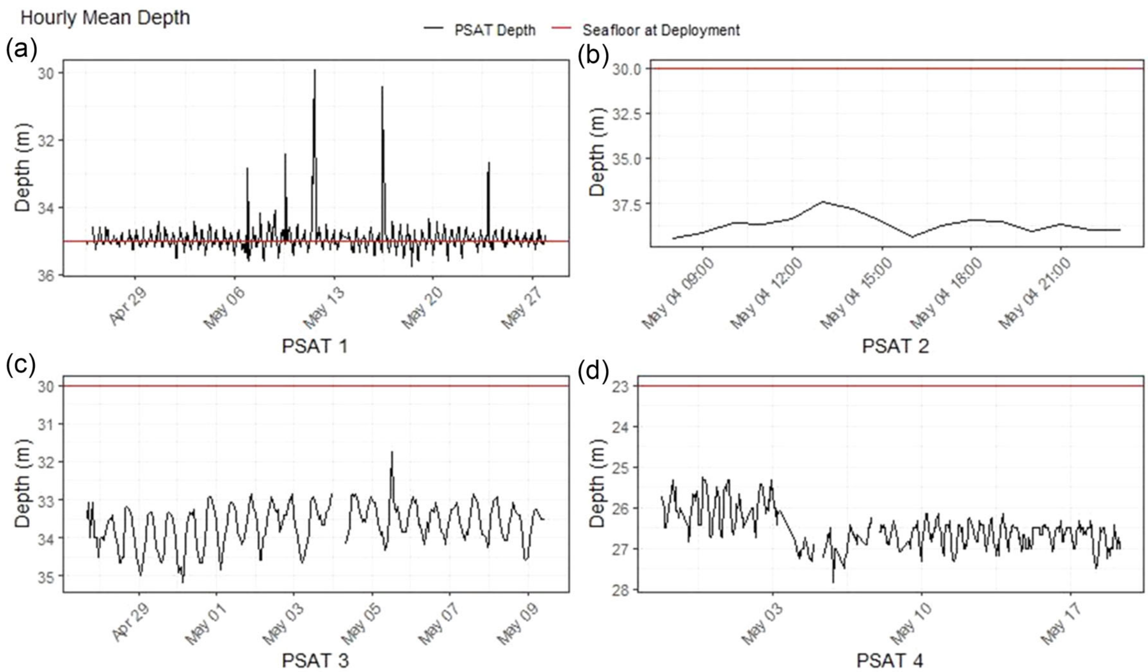

FIGURE 3 Hourly mean depth transmitted by all pop-up satellite archival tags (PSATs) (black lines) and the seafloor depth at deployment (red lines). PSAT1 (a) was deployed in 2019 and PSATs 2 (b), 3 (c) and 4 (d) were deployed in 2021.

tags exists, and due to the untested methodology on BSB, we were expecting the tags to release earlier than programmed (Lutcavage et al., 2015; Musyl et al., 2011). Although tank testing should have occurred to determine the best technique for equipping PSATs to BSB (e.g. Naisbett-Jones et al., 2023; Økland et al., 2013), this was not feasible for this study based on funding and available resources (Rodgveller et al., 2017). As a result, we attached the PSATs using a titanium anchor provided by the manufacturer that is typically used, with success, on larger fish species (Carlisle et al., 2019). This attachment technique, combined with the relatively large size of the tag, still returned between 8 and 32 days of data. The PSATs performed better than the Star-Oddi tags because we received data from all tagged fish, and tagging durations matched or exceeded the simplified loop technique. From our PSAT deployments, we documented three fish moving to deeper water after release, perhaps as part of their seasonal migratory movement (Moser & Shephard, 2009) or due to the drag caused by carrying a buoyant tag. However, considering fish were able to maintain a consistent depth throughout their deployments and exhibit occasional vertical movement both up and back down the water column, we do not think BSB were energetically compromised or dragged by the tags to new locations or the surface. As a result, we suggest that BSB can likely maintain near-natural behaviour with a PSAT, and tag durations could be extended if the attachment method is optimized for this species.

Deploying PSATs on BSB can provide behavioural and environmental data from offshore areas where the likelihood of recapture and the number of acoustic receivers are low. These data will likely be influenced by the size of the fish, as currently only the largest BSB can be equipped with these tags. However, this is true for most electronic tagging, and research is required to find the best techniques for equipping smaller marine species or age classes with data transmitters (Mansfield et al., 2021). For BSB, because they remain near bottom and seasonally occupy small home ranges, PSAT data need to be collected and analysed with considerations for tag-programming specifications (e.g. constant depth and mortality settings) and regional tide cycles to ensure accurate interpretation of transmitted information (Secor et al., 2021). If prices decrease and attachment techniques are optimized, PSATs could be an option for better understanding BSB ecology offshore, providing important movement information on a species with an increasing population and expanding range (McMahon et al., 2020). This type of information is needed as the mechanisms controlling BSB inshore/offshore migrations are unclear (Bell et al., 2015; McMahan et al., 2020; Moser & Shephard, 2009), and managers need this information to make the best decisions regarding access to the fishery (e.g. size limits, bag limits, seasonality and area closures).

We did not have a return from a fish equipped with a Star-Oddi using the saddle technique, and we also experienced short tag durations for the Star-Oddi data loggers using the simplified loop technique. As a result, we can only compare attachment techniques between these loggers and the PSATs and not the acquired data. We did not recover any fish that were equipped with a tag using the saddle technique; however, in tank testing, Naisbett-Jones et al. (2023) found that the required backing plates caused severe damage to sheepshead fish (*Archosargus probatocephalus*), and retention times of mrPAT (mark-report Popup Archival Tag, Wildlife Computers) were lowest compared to loop techniques. The mrPAT is 30% smaller than the PSATs deployed in this study. As a result, we do not recommend this technique for BSB.

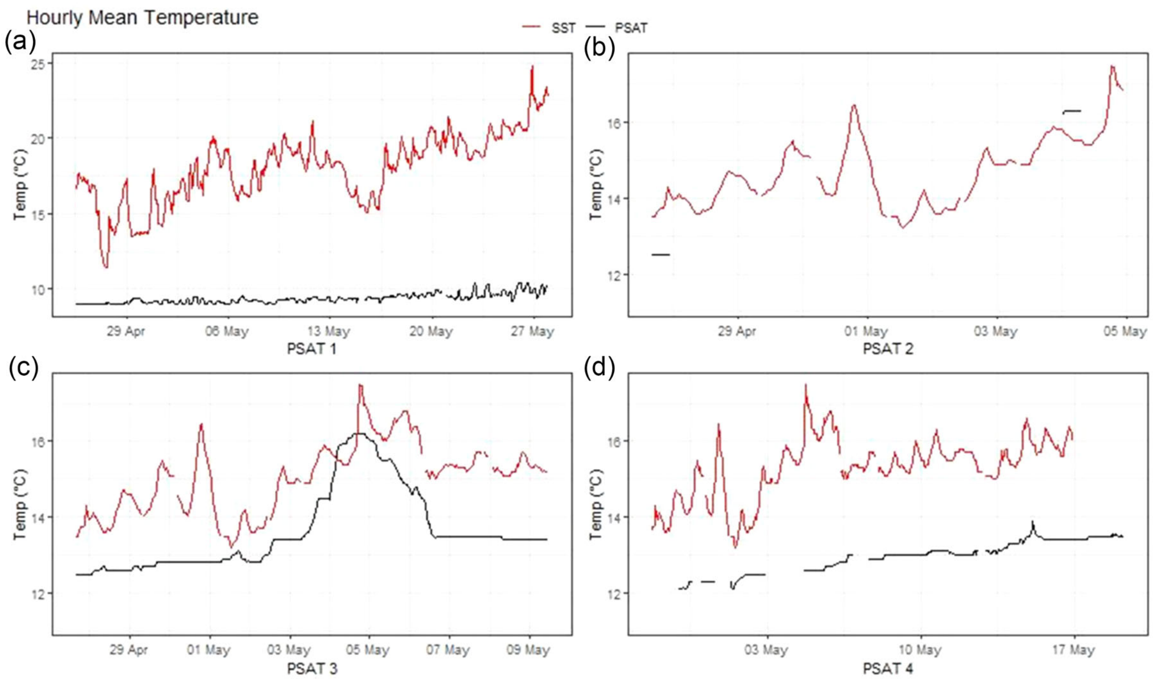

FIGURE 4 The black lines represent the hourly mean temperature transmitted by all pop-up satellite archival tags (PSATs), and the red lines represent sea surface temperature (SST) throughout the deployments from the nearby buoy stations. PSAT1 (a) was deployed in 2019, and PSAT2 (b), 3 (c) and 4 (d) were deployed in 2021, resulting in the large difference in SST scales.

Loop techniques were tank-tested recently by both Runde et al. (2022) and Naisbett-Jones et al. (2023) and used in situ by Rodgveller et al. (2017). Runde et al. (2022), outfitted BSB with acoustic tags similar in size to the Star-Oddi using two loop-style techniques. For both styles, tags were attached to the muscle through a single insertion, 2 cm below the anterior insertion of the dorsal fin, and were typically retained in a tank setting for the full 60-day treatment (Runde et al., 2022). Similarly, Naisbett-Jones et al. (2023) had success using a loop technique modified to have two insertion points to avoid overlapping the dorsal fin to deploy mrPAT on sheepshead fish, with retention times reaching 172 days. However, Rodgveller et al. (2017) did not have success using a single-insertion loop technique to attach PSATs on blackspotted rockfish (*Sebastes melanostictus*) with fork lengths ranging between 37 and 54 cm, except on one of the seven tagged fish.

The key difference was likely the use of monofilament versus a spaghetti tag threaded through the fish to create the loop (Naisbett-Jones et al., 2023). We, along with Rodgveller et al. (2017), used monofilament, whereas Runde et al. (2022) and Naisbett-Jones et al. (2023) had success using a spaghetti tag. Naisbett-Jones et al. (2023) also tested the difference in tank settings and found mrPATs were not retained as long when using monofilament. Fish are commonly able to expel foreign objects from their bodies, and perhaps the thin monofilament was easier to expel than the thicker spaghetti tag (Cooke et al., 2013). Naisbett-Jones et al. (2023) also suggested that the monofilament could become entangled more easily in the dorsal spines of the fish or even components of the reef or habitat. Furthermore, in supplementary underwater footage collected during this study to simply film the local habitat, we observed BSB with rounded superficial abrasions on their cheeks, likely from rubbing against a hard surface. Cullen and Stevens (2017) similarly observed, through video footage, BSB turning to rub their dorsal surfaces or heads on the sand. With our loop technique causing the Star-Oddi tag to dangle above the operculum of the BSB, we suspect that these rubbing behaviours, in combination with the tag location and use of monofilament, reduced tag retention.

For future PSAT deployments and other external tags, we suggest testing several attachment options but prioritizing both the single insertion loop technique with a spaghetti tag, as recommended by Runde et al. (2022), with consideration of the impacts to the dorsal fin (Naisbett-Jones et al., 2023), and a single-insertion saddle-style technique using softer and more flexible materials. The single-insertion saddle-style method was employed on BSB by Zemeckis et al. (2020) with acoustic tags that were larger than the Star-Oddi tags used in this study and tested by Runde et al. (2022) with smaller acoustic tags. Both methods are similar with monofilament, wire or a rod passing through the muscle through a single point ~2 cm below the insertion of the dorsal fin with caps placed on either end to secure the mount. Runde et al. (2022) and Bohaboy et al. (2020) found that a sharpened threaded stainless-steel rod passed through the fish yielded the longest retention in BSB and red snapper (*Lutjanus campechanus*), with potentially 200+ day duration. However, Runde et al. (2022) also found that the threaded rod and stainless-steel wire caused severe trauma in BSB compared to plastic materials. As a result, perhaps a modified version using softer, thinner and more flexible material passed through the fish, as used by Zemeckis et al. (2020), could yield both high retention of larger tags and low impact to the fish. From our study, we found the insertion point from thin monofilament healed within 26 days of deployment.

The Northwest Atlantic is expected to see a dramatic increase in offshore infrastructure with the construction of wind farms. BSB are excellent candidates for studying the effects of construction on marine species, and developing techniques that balance tagging logistics, data quality and impacts to study species is essential for immediate research. Given the small seasonal home range of BSB, their response to short-term construction can be easily identified based on simple movement metrics (Secor et al., 2021). In addition, climate change projections suggest that ocean warming along the Northeastern United States will occur two to three times faster than the global average (Kleisner et al., 2017; Saba et al., 2016). BSB biomass is expected to shift poleward as the ocean continues to warm (Slesinger et al., 2019), which can have a major impact on the northeast ecosystem due to competition with local species (Steimle et al., 1999). Consequently, PSATs, as has similarly been a solution for studying large pelagic fish species (Costa et al., 2010), could provide critical information on smaller species (e.g. Naisbett-Jones et al., 2023) that are rapidly adjusting to the large-scale ecosystem changes associated with ocean development and warming conditions.

AUTHOR CONTRIBUTIONS

Samir Patel: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; supervision; validation; visualization; writing — original draft; writing — review and editing. **Ricky Alexander**: Conceptualization; data curation; methodology; writing — review and editing. **Farrell Davis**: Methodology; validation; writing — review and editing. **Luisa Garcia**: Methodology; writing — review and editing. **Natalie Jennings**: Methodology; writing — review and editing. **William Pappas**: Conceptualization; methodology; project administration; resources; writing — review and editing. **Nathan Shivers**: Visualization; writing — review and editing. **Nicole Trenholm**: Conceptualization; methodology; project administration; validation; writing — review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data are available on request from the authors.

ETHICS STATEMENT

To conduct this research on a commercially managed species, we received an Exempted Fishing Permit (#20071) from the United States National Marine Fisheries Service and a Scientific Collection Permit (#19-038) from the State of VA. Handling methods were based on the guidelines on the use of fish in research published by the American Fisheries Society, the American Institute of Fishery Research Biologists and the American Society of Ichthyologists and Herpetologists (UFR Committee, 2013).

ORCID

Samir H. Patel https://orcid.org/0000-0003-0846-1795
Ricky Alexander https://orcid.org/0000-0002-4615-8036
Farrell Davis https://orcid.org/0009-0007-6276-5454
Luisa Garcia https://orcid.org/0009-0005-2672-0668
Natalie Jennings https://orcid.org/0009-0005-5726-1847
William Pappas https://orcid.org/0009-0008-4464-2693
Nathan Shivers https://orcid.org/0009-0009-6236-7063
Nicole Trenholm https://orcid.org/0000-0002-6650-6907

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