Broad-scale acoustic telemetry reveals long-distance movements and larger home ranges for invasive lionfish on Atlantic coral reefs

La telemetría acústica a gran escala revela movimientos de larga distancia y mayores áreas de distribución del pez león invasor en los arrecifes de coral del Atlántico

La télémétrie acoustique à grande échelle révèle des déplacements sur de longues distances et des domaines vitaux plus étendus pour le poisson-lion envahissant les récifs coralliens de l' Atlantique

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ABSTRACT

Tracking studies for invasive lionfish (*Pterois volitans* and *P. miles*) in the Western Atlantic can provide key information on habitat use to inform population control, but to date have likely underestimated home range size and movement due to constrained spatial and temporal scales. We tracked 35 acoustically tagged lionfish for >1 year (March 2018-May 2019) within a 35 km2 acoustic array within Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands (10x larger than previous studies). Tracking lionfish at this scale reveals home range size is 3-20 times larger than previously estimated and varies more than 8-fold across individuals (48,000 m2 - 385,000 m2; average:101,000 m2), with estimates insensitive to assumptions about potential mortality for low-movement individuals. Lionfish move far greater distances than previously reported, with 37% of fish travelling >1 km from the initial tagging site toward deeper habitats, and one individual moving ~10 km during a 10-day period. Movement rates, home range size, and maximum distance traveled were not related to lionfish size (18 - 35 cm total length) or lunar phase. Lionfish movement was lowest at night and greatest during crepuscular periods, with fish acceleration (m s-2) increasing with water temperature during these times. Our results help reconcile observed patterns of rapid recolonization following lionfish removal, and suggest complex drivers likely result in highly variable patterns of movement for similarly sized fish occupying the same habitat. Culling areas; the average lionfish home range size identified here (i.e., ~10 hectares), or prioritizing habitat patches isolated by ~180m (radius of average home range) may minimize subsequent recolonization. If the shallow-deep long-distance movements observed here are unidirectional, mesophotic habitats

KEYWORDS: invasive species, lionfish, acoustic telemetry, movement ecology, coral reef fish

INTRODUCTION

The invasion of Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) into coastal marine habitats in the Tropical Western Atlantic Ocean and Caribbean Sea represents species for which information on movement patterns and home range size is urgently needed to inform ongoing management. Small home range sizes reported by previous studies suggest that culling programs could be highly effective at controlling lionfish locally, with little movement of adult fish (i.e. post-settlement) from adjacent reef sites. However, high rates of recolonization have been reported in studies of lionfish removal on reefs that are larger than the majority of home range estimates (i.e. 2,500 m^2) and spaced apart at distances greater than traveled by most lionfish (i.e. >500 m). These observations suggest that the restricted spatial and temporal scale of previous work on lionfish movement, presumably due to logistical constraints, may underestimate home range sizes and movements across the seascape. In particular, studies that take place over small spatial scales are more likely to underestimate home range as individuals that move 'out of bounds' are excluded from analysis. Likewise, studies that take place over short temporal scales have a reduced likelihood that observations are taking place across the range of environmental factors and conditions that influence movement across the seascape, especially if the focal species undergoes shifts in habitat occupancy as a result of environmental drivers (e.g. temperature, seasons, lunar phases) and biological processes (e.g. across ontogeny).

METHODOLOGY

To generate a more complete picture of lionfish movement and home range size, we tracked 35 acoustically tagged lionfish for >1 yr (March 2018−May 2019)

within a 35 km2 acoustic array in Buck Island Reef National Monument, St. Croix, US Virgin Islands (an area 10× larger than previous studies; Green et al. 2021). In March 2018, 40 (of 42 sighted) lionfish were captured and tagged underwater by SCUBA divers from patch (n = 30) and continuous fringing reef (n = 10) habitats south of Buck Island following methods adapted from Akins et al. (2014). Fish >18 cm (n = 35) were implanted with an internal acoustic transmitter (InnovaSea, V9-2h, 110–250 s delay, 492 d battery life, 9 mm × 43 mm, 3.3 g in water) and fitted with an external streamer tag (Floy, FTSL-73). Seven transmitters (InnovaSea, V9AP-2h, 170–270 s delay, 365 d battery life, 9 mm × 48 mm, 3.6 g in water) also included acceleration and pressure sensors to provide additional movement information. Since V9AP tags were larger and heavier, they were implanted in the larger lionfish (>24 cm). Fish <18 cm TL (n = 5) were tagged exclusively with an external streamer tag. Acoustic transmitters were placed within the body cavity through a 1–2 cm incision anterior of the vent. Fish collections and surgeries were conducted under University of the Virgin Islands Institutional Animal Care and Use Committee permit 949107 and National Park Service research permits BUIS-00072 and BUIS-2016-SCI-0004.

RESULTS

Tracking lionfish at this scale revealed that home range size is 3−20 times larger than previously estimated and varies more than 8-fold across individuals (~48,000−379,000 m^2; average: 101 000 m^2), with estimates insensitive to assumptions about potential mortality for low-movement individuals. Lionfish move far greater distances than previously reported, with 37% of fish traveling >1 km from the initial tagging site toward deeper habitats, and 1 individual moving ~10 km during a 10-day period. Movement rates, home range size, and maximum distance traveled were not related to lionfish size (18−35 cm total length) or lunar phase. Lionfish movement was lowest at night and greatest during crepuscular periods, with fish acceleration (m s−2) increasing with water temperature during these times.

CONCLUSIONS

Our results help reconcile observed patterns of rapid recolonization following lionfish removal, and suggest complex drivers likely result in highly variable patterns of movement for similarly sized fish occupying the same habitat. Culling areas ≥ the average lionfish home range size identified here (i.e. ~10 ha) or habitat patches isolated by ≥ ~180 m (radius of average home range) may minimize subsequent recolonization. If the shallow−deep long-distance movements observed here are unidirectional, mesophotic habitats may require culling at relatively greater frequencies to counteract ongoing migration.

LITERATURE CITED

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