Comparisons of home range, site fidelity and mortality of red snapper (*Lutjanus campechanus*) on artificial & natural reefs in the northern Gulf of Mexico

Comparaciones de rango de hogar, fidelidad al sitio y mortalidad de pargo rojo (*Lutjanus campechanus*) en arrecifes artificiales y naturales en el norte del Golfo de México

Comparaisons du domaine vital, de la fidélité au site et de la mortalité du vivaneau rouge (*Lutjanus campechanus*) sur les récifs artificiels et naturels dans le nord du golfe du Mexique

STEPHEN T. SZEDLMAYER*, and PETER A. MUDRAK
*School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University, 8300 State Highway 104, Fairhope, Alabama 36532 USA. *szedlst@auburn.edu*

EXTENDED ABSTRACT

INTRODUCTION

Artificial reefs have been deployed around the world, especially in the northern Gulf of Mexico in areas with limited natural reef habitat (Bortone 2011). These artificial habitats are important for red snapper (*Lutjanus campechanus*) as this species is typically a dominant component of these fish communities (Szedlmayer et al. 2020). Considering the common association of red snapper with artificial reefs, it is important to determine if artificial reefs have similar ecological functions compared to natural reefs for this species.

Acoustic telemetry is a valuable method that can provide comparisons of red snapper movement, site fidelity and fishing mortality among different habitat types. However, most previous telemetry studies on red snapper examined habitat use around artificial reefs (Williams-Grove and Szedlmayer 2020).

Thus, there was little information available for comparing the habitat use patterns of red snapper between artificial and natural reefs. The purpose of the present study was to compare home range area, site fidelity and fishing mortality of red snapper between natural and artificial reefs. This study provides a comparison of the functional ecology of artificial and natural reefs for red snapper that will help in the management of this species and in the evaluation of future artificial reef deployments.

METHODS

Red snapper were tracked on small artificial reefs (metal cages), gas platforms and natural reefs (rock outcrops) from 2018 to 2020, in the northern Gulf of Mexico. Each site (n = 8) had an array of 5 or 6 telemetry receivers (VR2W or VRTx, Innovasea Systems, Boston, Massachusetts) with one deployed near (20 m) the reef, and four or five additional receivers placed around the reef at 300 m distances from the reef (Everett et al. 2020).

All receivers were moored 3 to 5 m above the seafloor, with temperature loggers (U22-001, Onset Incorporated, Bourne, Massachusetts) placed both adjacent to the receiver, and 0.3 m above the seafloor. A control transmitter was also placed approximately 2 m above the seafloor on a mooring buoy within each receiver array around a reef site. The telemetry receivers were retrieved by SCUBA divers and detection data were downloaded every 66 to 325 days.

Red snapper were captured with hook-and-line, and only fish > 330 mm TL were tagged and released with transmitters. After capture, red snapper were tagged with a unique transmitter (Innovasea V16-6x-R64k, transmission delay = 20–69 s) that was surgically implanted into the peritoneal cavity. All tagged red snapper were released on the seafloor with a predator protection cage (Williams-Grove and Szedlmayer 2020).

Fish positions were based on the time differential of a transmitter's signal arrival among receivers and were calculated by Innovasea post-processing or with Fathom software. Calculated fish positions and transmitter detection patterns were used to determine the fate of transmitter-tagged red snapper (Williams-Grove and Szedlmayer 2020).

Fish positions were analyzed with the R program (R Core Team 2022: https://www.R-project.org/) to calculate 95% kernel density estimate (KDE) areas by monthly time intervals for each fish. The Kaplan-Meier survival function was used to estimate site fidelity and fishing mortality. Site fidelity (SF) was defined as total fish survival after one year with mortalities right censored or removed. Home range area, site fidelity and fishing mortality were compared between natural and artificial reef types. All statistical analyses were computed in SAS vers.9.4 (SAS Institute Inc., Cary, North Carolina), with generalized linear mixed models (proc GLIMMIX) with fish as a random factor (i.e., a fish was repeatedly measured over time) and an assumed negative binomial distribution.

RESULTS AND DISCUSSION

The present study tracked 164 transmitter-tagged red snapper with time intervals for individual fish ranging from 8 to 900 days, from 1 January 2018 to 11 Dec 2020. The first recorded event (emigration or mortality) indicated that 73 were caught, 6 suffered natural mortalities and 82 emigrated. The fates of the remaining three red snapper were undetermined after 26, 294 and 394 days of tracking on their release sites.

Home ranges as defined by monthly 95% KDE areas were significantly ($P < 0.05$) different among reef types. The mean 95% KDE was 3,583 m^2 for cage reefs, 7,463 m^2 for platform reefs and 18,129 m^2 for natural reefs (Figure 1). Site fidelity was marginally different among reef types (log-rank test, $P < 0.07$), and was 0.51 for cage reefs, 0.38 for platform reefs and 0.22 for natural reefs (Figure 2). Over the tracking period fishing mortality (F) was significantly lower for platforms compared to cage and natural reef types, but not significantly different between cage and natural reefs. Fishing mortality was 0.51 for platforms, 1.83 for cage reefs, and 1.35 for natural reefs.

Differences in home range (KDE) among reef types was likely related to reef area size. By far the largest reef area was observed on natural-1. This reef area is a well-known natural rock reef (Southeast banks) that encompasses approximately 90,000 m^2. Other reef types had much smaller areas with platform-1 encompassing approximately 1,500 m^2, platform-2 300 m^2 and cage reefs 16 m^2. Fishing mortality was extremely high and likely unsustainable. This conclusion of an unsustainable fishing mortality rate is based on reports from management efforts that indicate an F of around 0.05 was needed for a sustainable fishery (SEDAR 2018). The reefs in the present study were very likely being fished at effort levels that far exceeded this recommended level for a sustainable fishery. Site fidelity was lower than previous estimates. This lower site fidelity was likely due to the substantial loss of fish from the extremely high fishing mortality rates. If these sites were subject to lower fishing pressure we would predict that site fidelity would have been greater. In conclusion it appears that artificial and natural reefs have similar ecological benefits for red snapper. Unexpected was the lower fishing mortality observed on the platforms as it might be predicted that platforms would be exposed to greater fishing effort because of the ease in locating these large visual structures compared to locating much smaller submerged reef habitats.

KEYWORDS: telemetry, movements, habitat use, residency

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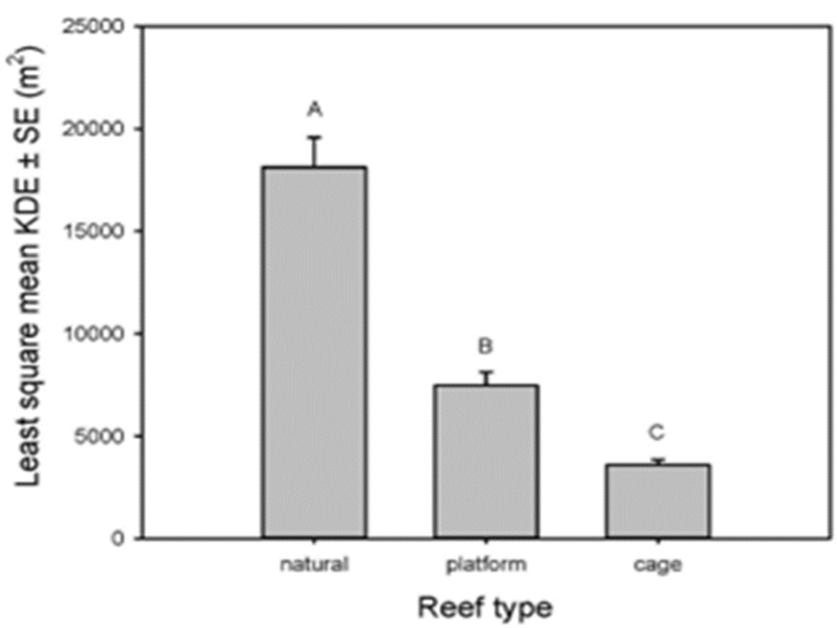

Figure 1: Home range as defined by monthly 95% KDE areas among different reef types for red snapper (*Lutjanus campechanus*) in the northern Gulf of Mexico. Different letters indicate significant differences at P < 0.05.

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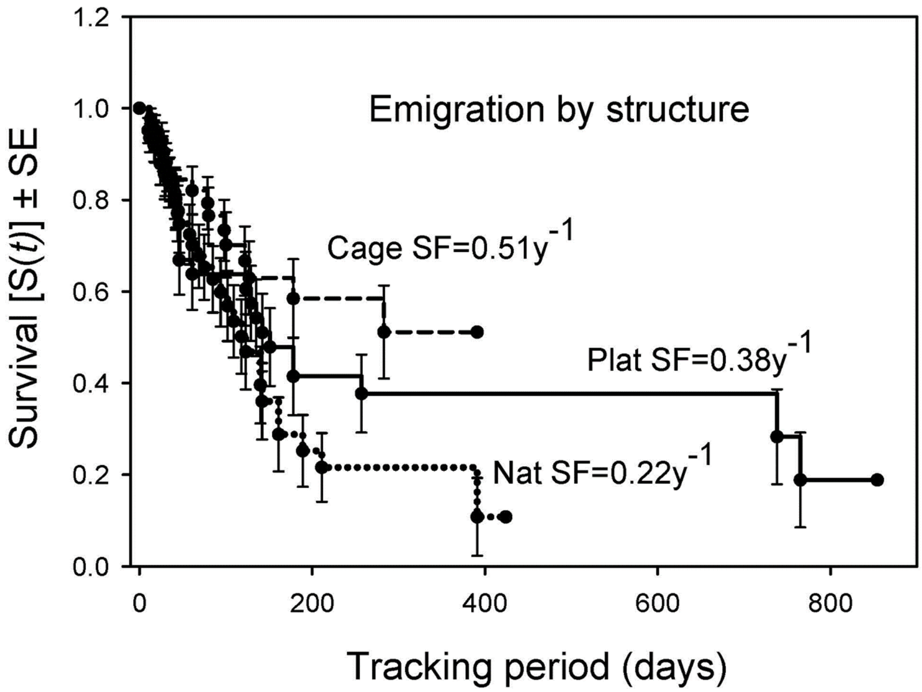

Figure 2. Site fidelity based on Kaplan-Meier survival function for red snapper (Lutjanus campechanus) in the northern Gulf of Mexico. SF = site fidelity after one year.