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Home range, habitat use, and site fidelity of barred sand bass within a southern California marine protected area

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ABSTRACT

Barred sand bass (*Paralabrax nebulifer*) is an important recreational species in southern California, which may benefit from marine protected areas. Understanding species movement patterns is a key component to identifying if a species will benefit from marine protected areas. Acoustic telemetry methods coupled with a GIS were used to quantify the home range, site fidelity, and habitat use of barred sand bass at the Catalina Marine Science Center Marine Life Refuge located at Santa Catalina Island, California. Barred sand bass utilized soft-sediment habitats within close proximity to rocky reefs and had home ranges that averaged 10,003 $m^2 \pm 4773\ m^2$ (±SD). During the day, individuals generally used multiple areas on or near reefs, and at night repeatedly used one area over soft-sediment habitat. Fifty percent of the acoustically tagged individuals exhibited year round fidelity to the study site indicating that even small marine protected areas may be an effective management strategy.

1. Introduction

In 1999, the California Marine Life Protection Act mandated the establishment of a network of marine protected areas (MPAs) initiating a move towards ecosystem-based management for California. While traditional fisheries management is typically conducted over large spatial scales at the single species level (i.e. catch quotas, size limits, season closures), ecosystem-based management by implementing MPAs has until recently only been conducted at local scales (Rice, 2005). To be effective, MPA size largely depends upon the species found within an area and their home range size and site fidelity, while placement depends on species habitat requirements (Dayton et al., 2000; Halpern and Warner, 2003; Parnell et al., 2005). Because fish home range and habitat use studies occur on local scales, they have not been important considerations in traditional fisheries management due to challenges of extrapolating results to larger spatial scales (Rice, 2005). Nevertheless, home range and habitat studies of fishes are valuable considerations for future ecosystem-based management because most MPAs are created at the local scale, but are expected to operate as part of larger networks at regional scales.

Studies of home range size and habitat use of a variety of marine fishes have increased due to advances in acoustic telemetry and multibeam sonar seafloor mapping technology (e.g., Zeller, 1997; Lowe et al., 2003; Jadot et al., 2006; Lowe and Bray, 2006). However, studies examining fish habitat use have lagged behind their terrestrial counter parts, due in part to the relatively recent availability of detailed benthic habitat maps. Most studies to date addressing fish habitat utilization have used diver observation to quantify the densities of fish in different habitats to infer habitat preference or have quantified habitats that were used more or less, than what was available. These studies have focused primarily on population level metrics, using fish surveys or catch data to estimate densities. Quite often, these studies represent brief snapshots of population distributions and typically miss diel shifts or processes that underlie the dynamic nature of habitat use. However, observations of individual behavior relative to habitat use can provide a higher resolution picture of fish habitat preference and behavior. The detailed spatial information that acoustic telemetry provides, in conjunction with high resolution habitat maps, allows the analysis of habitat edge use and movement within and between habitats, which has received little attention.

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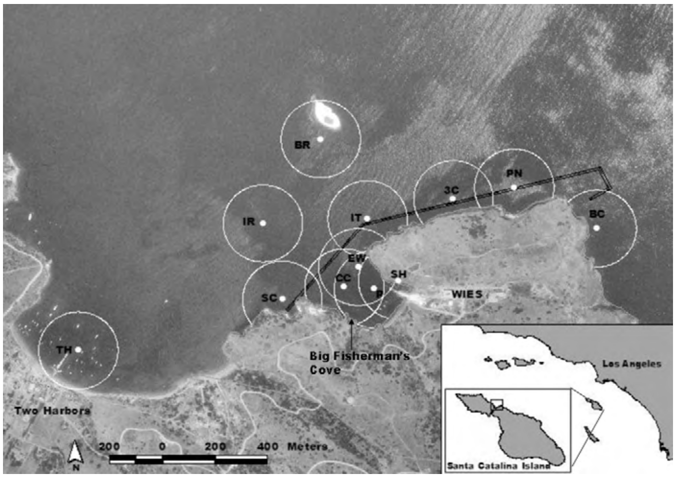

Fig. 1. Aerial photograph of the Catalina Marine Life Refuge (33°26_N, 118°29_W) and town of Two Harbors. The inset shows the location of the site at Santa Catalina Island in relation to the southern California coast. White dots represent the location of 12 VR1 acoustic receivers (TH—Two Harbors, SC—Seal Cove, IR—Isthmus Reef, BR—Bird Rock, CC—Chalk Cliffs, P—Pier, SH—Shark Cove, EW—East Wall, IT—Intake Pipes, 3C—3 Caves, PN—Pumpernickel, and BC—Blue Caverns) and white rings indicate the 150 m acoustic detection range of each receiver. The black and white hatched line represents the reserve boundary.

Barred sand bass (*Paralabrax nebulifer*) (family Serranidae), which is an aggregate spawner, has consistently ranked among the top 10 recreationally caught species in southern California. Barred sand bass habitat use has been reported from fishing and diver surveys, which indicate that they are found more frequently and at higher densities along the sand side of the sand/reef ecotone within 3 m of the sea floor (Quast, 1968; Feder et al., 1974; Anderson et al., 1989; Johnson et al., 1994). However, the extent to which individuals move within and between these habitats has not been quantified. While results from tag and recapture studies indicate movements of up to 92 km are possible (Jarvis et al., in press), barred sand bass home range size and site fidelity have not been described, making it difficult to determine how effective current or future MPAs may be in protecting a portion of the population. Therefore, the goal of this study was to quantify barred sand bass habitat use, home range, and site fidelity at Santa Catalina Island, which will aid fishery managers in the planning and monitoring of future MPAs.

2. Methods

2.1. Study site

This study was conducted at the Catalina Island Marine Science Center Marine Life Refuge (CMLR) and nearby surrounding areas located at Santa Catalina Island, California (Fig. 1). The CMLR was designated a no-take marine reserve in 1988 and encompasses an area of 0.13 km^2. A high resolution bathymetry and geological habitat map was created for the CMLR and nearby areas in 2001 using multibeam, side-scan sonar with 2 m resolution (supplied by California State University Monterey Bay Seafloor Mapping Lab). Habitats in the CMLR include low and high relief rocky reefs, soft bottom habitats, and anthropogenic habitats including mooring blocks and a small concrete pier. Additionally, the reserve is comprised of two distinct areas, a shallow (0–25 m) soft-sediment protected cove (Big Fisherman's Cove) bordered on each side by rocky reefs, and a narrow exposed rock wall with contiguous boulder and steep rocky reefs that meet soft-sediment habitats at depths of up to 50 m (Fig. 1).

2.2. Capture and transmitter attachment

Barred sand bass were captured within the CMLR using hook and line or traps during the summer months of 2005 and 2006. Once landed, fish were placed in a saltwater bath containing 20 ppm of clove oil, for 2–4 min (Cho and Heath, 2000; Topping et al., 2005). A small acoustic transmitter (9 mm diam. × 24 mm long) (VEMCO Ltd.; V8) was inserted through a 1.5 cm long incision made through the abdominal wall and closed with 2 or 3 interrupted dissolvable sutures (Ethicon, Inc. Chromic Gut sutures). Transmitters were coated with beeswax/paraffin (1:2.3) to reduce immuno-rejection (Lowe et al., 2003). During the recovery period (~5 min), each fish was measured (total length; TL) and fitted with an external dart tag to allow easy identification while diving or upon recapture (e.g., Lowe et al., 2003; Topping et al., 2005).

2.3. Tracking methods

Tracking commenced immediately upon release of an individual and was used to assess fine-scale movements, habitat use, and site fidelity of barred sand bass in the CMLR. Active tracking was used to collect data on the fine-scale, short-term movements of barred sand bass implanted with continuous pulse transmitters (VEMCO Ltd.;V8SC-2L or V8SC-6L). These transmitters pulsed at a single frequency every 1–1.5 s. Six barred sand bass were tracked for three non-successive 24-h periods from a small boat using a directional hydrophone (VEMCO Ltd.; VH10) and acoustic receiver (VEMCO Ltd.; VR60), with GPS coordinates recorded every 10 min. Four of these fish were also implanted with coded acoustic transmitters to monitor their longer-term movements through passive tracking. The two transmitters weighed a total of 7.2 g in air, which represented at most 0.8% of the body weight of these individuals.

Passive tracking was used to monitor the long-term (1-year) movements and site fidelity of 10 barred sand bass, four of which were also actively tracked. Barred sand bass were surgically implanted with uniquely coded acoustic transmitters (VEMCO Ltd.; V8SC-2H-R256). These transmitters pulse randomly every 50–150 s at a frequency of 69 kHz and nominal battery life just exceeding 1 year, which allowed site fidelity to be measured for a 1-year period. The presence of tagged individuals was recorded (time and date) by stationary automated underwater acoustic receivers (VEMCO Ltd.; VR1) strategically placed at 12 locations inside and outside the CMLR (Fig. 1). The effective range at which the VR1 acoustic receivers could detect a coded transmitter was measured by conducting range tests, and conservatively estimated to be 150 m radius.

2.4. Data analysis

A GIS (ArcView 3.3) with Animal Movements Analysis Extension (AMAE) (Hooge and Eichenlaub, 2000) was used to analyze barred sand bass movements. The home ranges of barred sand bass were estimated using two different methods available in AMAE: the minimum convex polygon (MCP) and a 95% Kernel Utilization Distribution (KUD). An MCP is a non-statistical measure of home range size, which encapsulates the total area used and traversed by an individual (Hooge et al., 2001). A 95% KUD is a probabilistic approach to estimating home ranges, where the area defined represents a 95% probability of relocating an individual (Seaman and Powell, 1996). Additionally, a 50% KUD was used to measure the core area use of barred sand bass. To account for day-to-day variation in area use, home range size was estimated from data pooled across all 24-h sampling periods for each individual.

A linearity index was used to measure home ranging behavior. This index is calculated by dividing the distance between an individual's first and last relocation by the total distance traveled during