# Long-term Site Fidelity of Tagged Red Hinds (*Epinephelus guttatus*) at Two Spawning Aggregation Sites in Bermuda

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## ABSTRACT

The results of a multi-year tagging program of red hind (*Epinephelus guttatus*) at two spawning aggregation sites (NE1 and SW1) in Bermuda are presented. From 1995-2004, a total of 968 red hinds were caught, tagged and released, primarily at spawning aggregation sites, and were recaptured by hook and line fishing. Fishing and tagging effort were concentrated during the summer spawning period at the two aggregation sites. During the spawning period in 1997, a total of 105 red hinds were tagged and displaced between SW1 and NE1. Subsequent recapture of displaced fish yielded rates of 4.2% (SW1) and 10% (NE1) demonstrating a return straight-line migration distance of 50.7 km. The mean tag-recapture rate for the entire tagging program varied between aggregation sites (NE1 = 30.8%, SW1 = 14.0%) and the mean overall tag-recapture rate was 16.8%. The majority of recaptures occurred either in the same spawning month in which tagging took place or at approximate intervals of one, two or three years, often in the same month each year, suggesting some consistency in presence on site during the spawning period. The longest period at liberty of a tagged fish was in excess of five years. Although many of the tagged fish were recaptured more than once, the maximum number of recaptures of a given tagged fish was four.

KEY WORDS: Spawning aggregation, red hind, *Epinephelus guttatus*, tagging, Bermuda, return migration

## La Fidelidad a Largo Plazo del Sitio de Etiquetó Mero Cabrilla (*Epinephelus guttatus*) en Dos Sitios de Agregación de Desove en Bermuda

PALABRAS CLAVE: Agregación de desove, mero cabrilla, *Epinephelus guttatus,* Bermuda, la migración de retorno

## La Fidélité à Long Terme de Site D'étiqueté de Merou (*Epinephelus guttatus*) à Deux Sites D'agrégation Frayant dans les Bermudes

## INTRODUCTION

Management of red hind (*Epinephelus guttatus*) spawning aggregations has been ongoing in Bermuda for over 30 years (Luckhurst and Trott 2009). Research programs, primarily tagging, have contributed greatly to our understanding of the dynamics of these aggregations and have helped inform management. The first tagging program of red hinds took place in the vicinity of the SW1 aggregation site but yielded few tag recaptures (2.5 % recapture rate out of 400 tagged fish) with all recaptures reported by commercial fishermen (Burnett-Herkes 1975). As a consequence, the ability to verify the recapture information (location, size of fish) was limited. Approximately 20 years later, a tagging program commenced at the NE1 aggregation site and the first two years of the study (1993 - 1994) demonstrated return migration to NE1 of displaced red hinds and site fidelity (Luckhurst 1998). Tagging at the SW1 aggregation site commenced in 1996 after the abundance of red hinds at the NE1 site appeared to decline based on comparative catch-per-unit-effort (CPUE) data (Luckhurst Unpubl. data). After the accumulation of more tag-recapture data, the abundance of red hinds at the two spawning aggregation sites was estimated using the Peterson index (Luckhurst et al. 2006). From 1997 to 2004, almost all tagging was conducted at the SW1 site. In 1997, a double-displacement study of tagged red hinds was conducted between the two aggregation sites to examine return migration and site fidelity.

## MATERIALS AND METHODS

All red hind specimens were caught during daylight hours with hook-and-line fishing gear, using baited hooks. Most fishing effort occurred between 1030 – 1500 hrs. Specimens were brought to the surface slowly to minimize barotrauma. However, some specimens came on board with expanded gas bladders and it was necessary to deflate the gas bladders before placing them in a live-well. Deflation was accomplished by passing a hypodermic needle through the body wall into the gas bladder and expelling the air using hand pressure on the abdomen. All specimens were kept in the live-well until tagging, at which time specimens were removed from the live-well with a fine-mesh dipnet to avoid injury. Specimens were handled with a wet towel to minimize the removal of the mucous layer on the skin. Fish were measured (fork length [FL] to the nearest mm) and the abdomen was

gently stroked in the direction of the genital papilla to determine if any eggs or sperm were exuded. This technique allowed the determination of the sex of a number of individuals before tagging. A Floy anchor T-bar tag was then inserted into the dorsal musculature under the soft dorsal fin. Tagged fish were immediately released overboard and were observed continuously to determine if they swam down through the water column seeking benthic shelter.

On each sampling day, the position of the vessel was recorded with an onboard GPS to ensure that the vessel could return to the same site and to accurately estimate the displacement distances of specimens recaptured distant from the site.

## RESULTS

The two spawning aggregations sites were located at opposite ends of the Bermuda reef platform (Figure 1), a linear distance of approximately 50.7 km. Both sites had similar substrate – mixed coral and gorgonians with sand holes – and occurred in the same depth range 22 - 24 m. Both sites were inshore of the shelf break of the reef platform which is at a depth of 54 - 55 m.

In June 1997, during the peak spawning period, a double- displacement experiment was conducted. Over a three day period, finishing on the day of the full moon, a total of 95 red hinds were tagged and displaced to NE1 while only nine red hinds were displaced to SW1 (Table 1). This large differential in numbers reflects the apparent difference in abundance between the sites. A single fish from NE1 was tagged and displaced to SW1 opportunistically the following month.

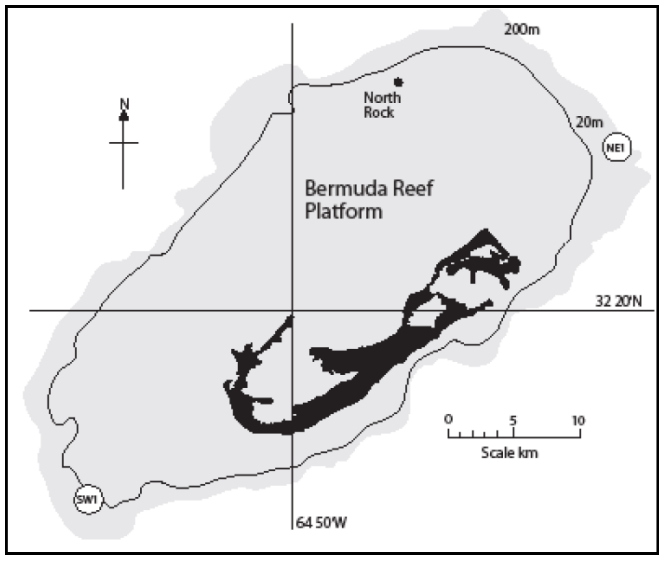


**Figure 1.** Bermuda reef platform showing location of the two red hind spawning aggregation sites (NE1 and SW1).

**Table 1**. Summary of tagged red hinds displaced to two spawning aggregation sites during a three day period around full moon in June 1997. dbfm = days before full moon

| Date | Moon Phase | Capture Site | # Tagged | Displacement Site |
|---|---|---|---|---|
| June 18, 1997 | 2 dbfm | SW1 | 41 | NE1 |
| June 19, 1997 | 1 dbfm | NE1 | 9 | SW1 |
| June 20, 1997 | Full | SW1 | 54 | NE1 |
| July 14, 1997 | 6 dbfm | NE1 | 1 | SW1 |

On July 17th (2 days before the July full moon) and 27 days after displacement, the first recapture took place at SW1 of a displaced fish (Table 2). Four additional recaptures of displaced fish occurred but at longer intervals ranging from 80 days to the longest period at liberty of over two years (Table 2). The recapture rate for displaced fish from SW1 to NE1 was 4.2% while that from NE1 to SW1, with a considerably smaller sample size, was 10% (Figure 2). Given the sampling method (handlining), these recapture rates should be considered as minimum estimates, as there may have been more displaced fish present at the two sites that were simply not captured. An interesting recapture was recorded by a commercial fisherman which may provide some insight into return migration behavior – a fish (42.6 cm FL, female) was caught at NE1, tagged and displaced to SW1 on June 20, 1997. On July 7, 1997 (17 days later), this fish was caught off the northeast corner of the Bermuda platform, approximately 12 km from NE1 and in the same depth as the aggregation site. A possible explanation is that the fish was migrating back to NE1 from SW1 around the edge of the Bermuda platform following the same depth contour where the aggregation site is located. In relation to navigational ability, an unusual recapture occurred during tagging at NE1. On July 14, 1997 a fish (40.9 cm FL) was caught at NE1 but was not displaced to SW1 because it appeared to be in some physiological stress from its capture. Instead, it was tagged and released on the day of capture at an inshore location (at the shoreline) at the eastern end of the island. This fish was recaptured at NE1 on October 2, 1997 (80 days later) in apparently good health having affected a straight line migration of approximately 18 km, the first part of which was entirely in inshore waters.

The size range of tagged, displaced fish (N = 105) was large, ranging from 33 – 58 cm TL (Figure 3). The modal size was 38-40 cm TL and four of the five recaptured fish were above the modal size, the largest being a female 53.6 cm TL. The other fish of known sex was a male, 48.1 cm TL. The sex of the other three recaptured fish was unknown.

**Table 2**. Summary of recapture data from displaced red hinds during June 1997. Return migration from release site to capture site is a straight line distance of 50.7 km. Size is fork length (FL).

| Release Date | Release Size (cm) | Release Site | Recapture Date | Recapture Site | Days at Liberty |
|---|---|---|---|---|---|
| June 20, 1997 | 35.9 | NE1 | March 19,1998 | SW1 | 272 |
| June 20, 1997 | 47.3 | NE1 | July 17, 1997 | SW1 | 27 |
| June 20, 1997 | 48.1 | NE1 | July 15, 1998 | SW1 | 390 |
| June 20, 1997 | 53.6 | NE1 | July 14, 1999 | SW1 | 754 |
| June 20, 1997 | 40.9 | SW1 | Oct. 2, 1997 | NE1 | 80 |

Recapture rate Displacement from SW1 to NE1 – 4/95 = 4.2%
Displacement from NE1 to SW1 – 1/10 = 10%

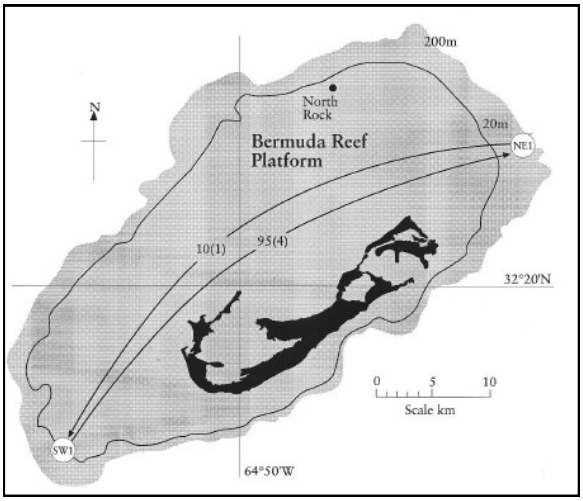


**Figure 2.** Diagrammatic representation of double-displacement of tagged red hinds between the two spawning aggregation sites, see text for details. The numbers on the curved arrows indicate the number of tagged fish displaced from one site to the other and the number in brackets represents the number of tagged fish recaptured at the original site. See Table 2 for times at liberty of recaptured fish.

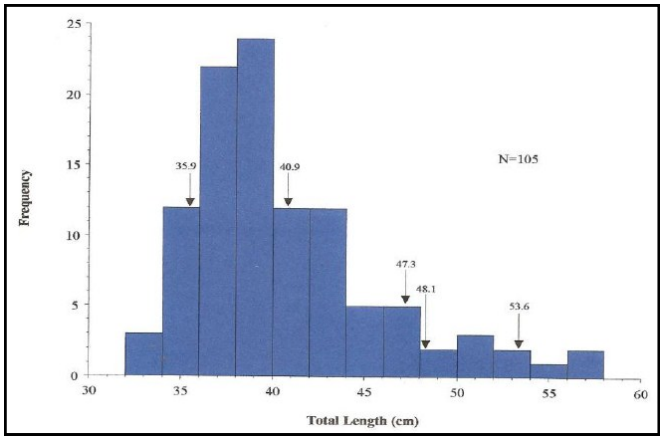


**Figure 3.** Size-frequency of tagged, displaced red hinds (N = 105). Arrows indicate sizes of recaptured fish. See text for details.

A summary of the number of red hinds tagged by year with associated recaptures in the same tagging year (Table 3) indicates that tagging effort was variable from year to year and that from 1997 onward tagging effort was concentrated at SW1. From 1996 - 2004, there were a total of 838 red hinds tagged with 58 (6.9%) being recaptured only a single time. Nine fish (1.1%) were recaptured two or more times in the same year in which they were tagged.

When examining the recapture patterns of fishes in the years following their tagging and release, it was observed that the majority of long-term recaptures were recorded one year later in the same spawning month in which the fish were originally tagged (Table 4). The total number of one-year recaptures was 45 with the number of two and three year recaptures declining to 20 and 13, respectively (Table 4). The one year recapture rate differed between the two aggregation sites i.e, NE1 = 13.2 %, SW1 = 4.9 %. whereas the two year recapture rate was almost identical (NE1 = 2.6 %, SW1 = 2.5 %). All but one of the three year recaptures occurred at SW1. The longest period at liberty for any tagged fish was in excess of five years (Table 4).

Pooling of the size-frequency tagging data into three time periods reveals a notable increase in the modal sizes with time: 1996-97 = 40 cm FL, 1999-2000 = 48 cm FL, 2001-2003 = 52 cm FL (Figure 4). There was a marked reduction in the smaller modal sizes (36 and 40 cm FL) as the tagging program proceeded.

## DISCUSSION

In the double-displacement experiment, the return migration of a tagged fish to SW1 in 27 days confirms the navigational ability of red hinds in relation to a spawning aggregation site demonstrated in earlier work (Luckhurst 1998). Given the shortcoming of having to capture the fish to confirm its presence on site, it is not possible to determine how quickly the return migration may have occurred, thus 27 days should be considered a maximum period. In earlier work on displaced red hinds from NE1, Luckhurst (1998) demonstrated return migration of six out of 24 fish from a release point 20.1 km away from NE1 in as little as seven days. The present result expands the distance component to over 50 km. In both instances, the distance estimate is a straight-line as the actual migration route is unknown. It seems improbable that return

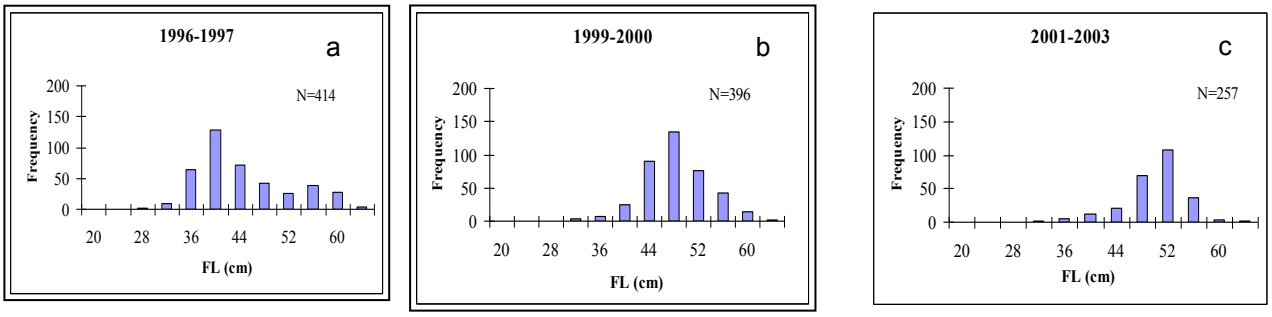


**Figure 4.** Size-frequency distributions of pooled data from tagged red hinds showing an increase in modal size. a)1996 - 1997, b) 1999 - 2000, and c) 2001 - 2003.

**Table 3.** Number of red hinds tagged by year and site with the number of single and multiple recaptures (2+) recorded for the same year in which tagging took place.

| Year | Aggregation Site | # Tagged | Single Recaptures | Multiple Recaptures (2+) |
|---|---|---|---|---|
| 1996 | NE | 46 | 11 | 3 |
| | SW | 9 | 0 | 0 |
| 1997 | NE | 38 | 2 | 0 |
| | SW | 135 | 10 | 2 |
| 1998 | NE | 3 | 0 | 0 |
| | SW | 44 | 3 | 0 |
| 1999 | NE | 3 | 0 | 0 |
| | SW | 163 | 11 | 0 |
| 2000 | NE | 27 | 6 | 2 |
| | SW | 123 | 2 | 1 |
| 2001 | NE | 4 | 0 | 0 |
| | SW | 133 | 10 | 1 |
| 2002 | SW | 65 | 1 | 0 |
| 2003 | SW | 12 | 0 | 0 |
| 2004 | SW | 33 | 2 | 0 |
| | Total | 838 | 58 | 9 |

**Table 4.** Summary of long-term recaptures of red hinds during the tagging program. The longest time at liberty was five years.

| Tagging Year | Site - # Tagged | 1 Year | 2 Years | 3 Years | 4 Years | 5 Years |
|---|---|---|---|---|---|---|
| 1996 | NE – 46 | 3 | 1 | 1 | 1 | 0 |
| | SW – 9 | 1 | 0 | 0 | 0 | 0 |
| 1997 | SW – 135 | 7 | 4 | 1 | 1 | 0 |
| 1998 | SW – 44 | 3 | 3 | 1 | 0 | 0 |
| 1999 | NE – 3 | 2 | 0 | 0 | 0 | 0 |
| | SW – 163 | 7 | 8 | 4 | 0 | 1 |
| 2000 | NE – 27 | 5 | 1 | 0 | 0 | 0 |
| | SW – 123 | 6 | 0 | 0 | 0 | 0 |
| 2001 | SW – 133 | 6 | 1 | 6 | 0 | 0 |
| 2002 | SW – 65 | 1 | 0 | 0 | 0 | 0 |
| 2003 | SW – 12 | 0 | 0 | 0 | 0 | 0 |
| 2004 | SW – 23 | 0 | 2 | 0 | 0 | 0 |
| | **Total** | 45 | 20 | 13 | 2 | 1 |

migration would be a straight line assuming that the fish are using a complex set of sensory and environmental cues for determining the migration route, thus the actual distance traveled could be considerably greater than 50 km. Although the navigational abilities of coral reef fishes are not well understood, it is possible that red hinds are following a depth contour, coupled with other sensory cues to affect the observed migrations. Burnett-Herkes (1975) found the maximum dispersion distance by tagged red hinds away from a spawning aggregation site was 15 km with a time at liberty of four weeks. In Puerto Rico, Sadovy et al. (1994) documented a movement of 18 km from a release site back to a spawning aggregation site with a time at liberty of two years. An additional three recaptures of displaced fish occurred at SW1 with periods at liberty ranging from 272 – 754 days. The single recapture of a displaced fish at NE1 took place after 80 days at liberty (Table 2). Given the difference in the

sample sizes, it is difficult to interpret the recapture rates for displaced fish between SW1 (4.2%) and NE1 (10%).

The sizes of the five displaced fish which were recaptured ranged from 35.9 – 53.6 cm TL (Fig. 3), the largest fish being a female. The other fish of known sex was a male 48.1 cm TL. Thus, both sexes exhibited return migration but the data are inadequate to draw any conclusions.

The number of red hinds tagged by year and aggregation site varied considerably dependent upon fishing effort, sea conditions and the timing of aggregation formation. There were a total of 838 red hinds tagged (NE1 = 121, SW1 = 717) from 1996-2004 but with tagging effort concentrated at SW1 from 1997 onward. Recaptures of fish in the same year as tagging indicate that 58 fish (6.9%) were recaptured a single time at the aggregation site, primarily during the spawning season, while nine fish (1.1%) were recaptured two or more times in the same year (Table 3). Recapture rates can be influenced by many factors when using hook-and-line fishing so it is difficult to draw many conclusions about the recapture rate. However, Rosario and Figuerola (2001) tagged 374 red hinds off the west coast of Puerto Rico and had a recapture rate of 7.5 % which is similar to the current study.

An examination of longer-term recaptures (one year or greater) reveals that the majority of recaptures were recorded one year later in the same spawning month in which the fish were originally tagged. The total number of one-year recaptures was 45 while the number of two-year and three-year recaptures were 20 and 13 respectively (Table 4) It is not known if red hinds leave the aggregation site during the non-spawning months but these results indicate strong site fidelity during the spawning period when sampling effort was greatest. Two fish were at liberty for four years before being recaptured and there was a single fish at liberty for five years (Table 4).

The size-frequency distributions of tagged fish, pooled into three time periods to ensure adequate sample sizes, indicate dramatic changes in the distributions over time with the modal size increasing from 40 cm FL in 1996-97 to 52 cm FL in 2001-2003 (Fig. 4). As the modes increased over time there was a concomitant decrease in the smaller modal sizes (36 and 40 cm FL). It is unclear what may have caused this pattern and the distributions may not accurately reflect the sizes of fish present due to a sampling bias. As sampling was done by hook-and-line fishing, bait competition may have been a factor with larger fish out-competing smaller fish at the aggregation site and thus being disproportionately represented in the samples.

This study has confirmed earlier work in Bermuda that there is strong site fidelity in red hinds with respect to spawning aggregations and provides further justification for their active management to ensure that aggregated fish are not over-exploited and to help ensure that an adequate spawning stock biomass is maintained in the long term.

## ACKNOWLEDGEMENTS

I express my thanks to fisherman Kevin Gregory for his long-standing support of red hind research in Bermuda and his assistance with field work. Fisheries staff, in particular Tammy Trott, John Whiting and Anson Nash, helped with field work and other aspects of the red hind tagging program.

## LITERATURE CITED

Burnett-Herkes, J. 1975. *Contribution to the Biology of the Red Hind,* Epinephelus guttatus*, a Commercially Important Serranid Fish from the Tropical Western Atlantic*. Ph.D. dissertation, University of Miami, Miami, Florida USA. 154 pp.

Luckhurst, B.E. 1998. Site fidelity and return migration of tagged red hinds (*Epinephelus gutttatus*) to a spawning aggregation site in Bermuda. *Proceedings of the Gulf and Caribbean Fisheries Institute* **50**:750-763.

Luckhurst, B.E., J. Hateley, and T. Trott. 2006. Estimation of the size of spawning aggregations of red hind (*Epinephelus guttatus*) using a tag-recapture methodology at Bermuda. *Proceedings of the Gulf and Caribbean Fisheries Institute* **57**:535-542.

Luckhurst, B.E. and T.M. Trott. 2009. Seasonally-Closed Spawning Aggregation Sites for Red Hind (*Epinephelus guttatus*) : Bermuda's Experience over 30 years (1974 –2003). *Proceedings of the Gulf and Caribbean Fisheries Institute* **61**:331-336.

Rosario, A. and M. Figuerola. 2001. Tag and recapture study of red hind and coney at three spawning aggregation sites off the west coast of Puerto Rico. *Proceedings of the Gulf and Caribbean Fisheries Institute* **52**:15-25.

Sadovy, Y., A. Rosario and A. Roman. 1994. Reproduction in an aggregating grouper, the red hind, *Epinephelus guttatus*. *Environmental Biology of Fishes* **41**:269-286.