NEW DISTRIBUTION RECORDS FOR THE SPOTFIN KILLIFISH, *FUNDULUS LUCIAE* (BAIRD), IN THE LOWER HUDSON RIVER ESTUARY AND ADJACENT WATERS

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ABSTRACT - The spotfin killifish, *Fundulus luciae*, occurs in salt and brackish marshes of the east coast of the United States from Georgia to Massachusetts. The purpose of this study was to provide additional information on the distribution and habitat preferences of spotfin killifish in the lower Hudson River Estuary, where prior to 2000, this species had not been reported. The primary study site was Piermont Marsh, Rockland County, NY. Additional collection sites included Ralph Creek, Brooklyn, NY; Saw Mill Creek, Staten Island, NY; and Lincoln Park, Jersey City, NJ. Twenty-five spotfin killifish were collected at Piermont Marsh and Ralph Creek during 2001. All specimens were collected from the upper intertidal zone, in accordance with the reported habitat preferences and life history of this species. Samples from previous studies in northeastern U.S. brackish/salt marshes were examined, and spotfin killifish were identified from samples collected at Branford, CT in 1999; Milford, CT in 2000; and Larchmont, NY in 1976. These findings indicate that spotfin killifish may not necessarily be rare; however, their cryptic lifestyle and preference for high intertidal brackish/salt marsh habitat has often precluded detailed assessments of their life history and geographic distribution.

INTRODUCTION

One of the most often cited functions of intertidal wetlands is their utilization by resident and estuarine-dependent fish and macrocrustacean species. Marsh-resident species are defined as those organisms that utilize intertidal marshes for most or all of their life history (Kneib 1997). Examples of marsh-resident species in northeastern U.S. tidal wetlands include various killifishes (*Fundulus* spp.) and caridean shrimps (*Palaemonetes* spp.). The mummichog, *Fundulus heteroclitus* (Linnaeus), is the resident fish species that is most abundant in tidal wetlands of the U.S. Atlantic coast and that has been most studied by researchers (Yozzo et al. 1994). *Fundulus heteroclitus* and other resident nekton move onto and off of the marsh surface with the rising and falling tide and represent an important energy link between

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the surface of tidal marshes and deeper estuarine waters (Nixon and Oviatt 1973, Rozas and Reed 1993).

The spotfin killifish, *Fundulus luciae* (Baird, 1855), has been reported infrequently in brackish coastal habitats from Long Island, New York (Butner and Brattstrom 1960) to Georgia (Jorgenson 1969). Spotfin killifish was considered rare (Hildebrand and Schroeder 1928, Nichols and Breder 1927, Richards and Bailey 1967) prior to focused studies which documented local abundance and distribution patterns of this species in New Jersey, Georgia, and Virginia (Able et al. 1983, Kneib 1984, Yozzo et al. 1994). Recent reports indicate that the northern limit for spotfin killifish is southern Massachusetts, where they have been collected in tidal tributaries of Narragansett Bay (Hartel et al. 2002). Recent collections in salt marshes of the lower Housatonic River, at Milford, CT, indicate that spotfin killifish may be common in habitats dominated by both common reed, *Phragmites australis* (Cav.) Trin. ex Steud., and saltmarsh cordgrass, *Spartina alterniflora* Loisel (Osgood et al. 2003).

Relatively little is known about the life history and habitat preferences of spotfin killifish. Unlike mummichogs, adult and juvenile spotfin killifish tend to remain on the intertidal marsh during all stages of the lunar tidal cycle, seeking refuge in shallow micro-depressions, which retain standing water at low tide (Able et al. 1983). Although not widely distributed among marsh habitats, spotfin killifish are environmentally tolerant and adaptable, and are found in waters of varying temperature, salinity, and dissolved oxygen content (Byrne 1978, Talbot and Able 1984). Byrne (1978) studied habitat preferences, food habits, and reproduction in a Virginia population of spotfin killifish; this is the most intensive study of the species to date. He found the species’s preferred habitat to be *S. alterniflora* marsh with shallow, water-filled depressions and small, seasonal pools in saltmeadow hay, *Spartina patens* (Ait.) Muhl., marsh. Byrne (1978) observed adults throughout the year, with greatest abundance in spring and summer months. In a North Carolina study, spotfin killifish was collected using pit traps and found to be common in irregularly flooded black needlerush, *Juncus roemerianus* Scheele, marsh (Shields and Mayes 1983).

The New York State Museum has archived 168 spotfin killifish from seven studies conducted between 1938 to 1985. All specimens were collected on the south shore of Long Island, NY, or Fishers Island (R. Schmidt, NYS Museum, pers. comm.). Previously this was thought to be the extent of their range in New York waters. However, in 2000, two adult females were collected in seine samples and nine juveniles were collected in intertidal lift nets at Piermont Marsh. These collections represent the first record of spotfin killifish in the Hudson River (NYSM
The few occurrences of spotfin killifish reported from New York may be a result of the collection methods and habitats previously sampled. This study documents the results of intensive sampling in irregularly flooded, brackish marsh habitat in the lower Hudson River Estuary along with selected locations throughout NY/NJ Harbor (e.g., Jamaica Bay, Hackensack River). This study provides additional information on the distribution of spotfin killifish near the northern limit of the range of the species.

METHODS

Study Sites
The primary study site was the Piermont Marsh component of the Hudson River National Estuarine Research Reserve (HRNERR). Previous research at Piermont Marsh documented the presence of a population of spotfin killifish, with 11 specimens (juveniles and females) collected in intertidal lift nets and seines in mid–late summer, 2000 (NYSM 52033). Piermont Marsh is located in the mesohaline portion of the Hudson-Raritan Estuary (Fig. 1). Vegetation cover is > 75% *P. australis*; the remaining 25% is *S. alterniflora, S. patens*, saltgrass (*Distichlis spicata* (L.)), cattails (*Typha spp.*), American threesquare (*Scirpus americanus* Pers.) and rose-mallow (*Hibiscus moscheutos* L.) (Blair and Nieder 1993).

At Piermont Marsh, four 250 m transects were established across the marsh surface encompassing the major intertidal vegetation zones. Habitats sampled included monospecific stands of *P. australis*, mixed...
stands of *P. australis* and non-invasive marsh vegetation, irregularly flooded high marsh (lacking *P. australis*), unvegetated substrates (i.e., mudflats/salt barrens), intertidal rivulets, and ponds.

Three additional study sites were selected in an attempt to locate additional populations of spotfin killifish in NY/NJ Harbor (Fig. 1). These sites were Saw Mill Creek, a tidal tributary of the Arthur Kill, Staten Island, NY; Ralph Creek, a tidal tributary of Spring Creek, located at the head of Jamaica Bay, Brooklyn, NY; and Lincoln Park, located along the lower Hackensack River, Jersey City, NJ. These three sites were located in either mesohaline or polyhaline portions of the estuary. The primary vegetative cover at the three secondary study sites was *S. alterniflora* in the lower intertidal zone and *S. patens/D. spicata* in the upper intertidal zone. Lincoln Park and Ralph Creek are undergoing invasion of high intertidal areas by *P. australis*, although not to the extent observed at Piermont Marsh. The Saw Mill Creek site has not experienced significant invasion of *P. australis*.

**Sampling**

Pit traps were the primary sampling technique at Piermont Marsh and the three secondary sites. The traps consisted of 3.8 L plastic containers placed in an excavated pit in the marsh surface. The spacing of transects at Piermont Marsh was approximately 50 meters to insure statistically independent samples (Yozzo and Smith 1998). Pit traps were checked during low tide by pouring the contents of each trap through a 1-mm sieve. All fish and macrocrustaceans collected in traps were placed in plastic bags on ice for transport to the laboratory. To insure recovery efficiency, the remaining ponded water in each depression was sieved with a fine-mesh aquarium net for fish that may have burrowed under the trap. Traps were sampled immedi-

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<th>Site</th>
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ately after a spring high tide. Piermont Marsh was sampled fourteen times from May–September of 2001. Shallow pools of standing water on the high marsh were sampled on each collection date with a finemesh dip net. Six wire mesh minnow traps (baited with bread) were permanently deployed in a small pond located in the mash interior, beyond the *P. australis*. Minnow traps were sampled on the same schedule as the pit traps.

All fish and macrocrustaceans collected in traps were preserved in 10% neutral formalin. In the laboratory, fish were identified to species, measured (total length, in mm), and weighed (wt wt., in g). Adult specimens were sexed. To verify identification of juvenile *Fundulus* spp., dorsal fin rays were counted (Able and Fahay 1998, Byrne 1978).

Sampling of the secondary study sites (Saw Mill Creek, Ralph Creek, and Lincoln Park) followed the same protocols as Piermont Marsh. At each of these sites, 48 pit traps were installed along perpendicular transects spanning the intertidal vegetation zones, from creekbank to upland, with particular attention to transition areas and microhabitats (depressions, intertidal rivulets). Six minnow traps were installed in adjacent shallow subtidal habitats (tidal creeks, marsh pools). Pit traps and minnow traps were installed prior to a night spring high tide event, and sampled the following morning. Shallow pools of standing water were also dip netted. Samples were collected and processed as described above for the Piermont Marsh collections.

**RESULTS**

Twenty-five spotfin killifish were collected from all sites between May 7, 2001 and September 27, 2001, either in pit traps or by dip netting (Table 1). Fourteen collections were made at Piermont Marsh from May 7 though September 27 with spotfin killifish collected on May 24 (n = 1), August 2 (n = 8) and September 27, (n = 7). Collections at the secondary sites yielded nine spotfin killifish at Ralph Creek (Jamaica Bay) on July 19. No spotfin killifish were collected at Saw Mill Creek (Staten Island) and Lincoln Park (Jersey City). Mummichog was the most abundant marsh-resident species at Piermont Marsh, Ralph Creek, and Lincoln Park, with 147, 317, and 353 individuals collected at each site, respectively. Three striped killifish, *Fundulus majalis* (Walbaum), and 37 dagger-blade grass shrimp, *Palaemonetes pugio* Holthuis, were collected in pit traps, natural depressions, and a discarded tire at Lincoln Park. Collection efforts at Saw Mill Creek (pit traps and minnow traps) yielded no specimens.

A topographic survey of the Piermont Marsh study area conducted in 1998 revealed only a 2–3 cm difference from the highest elevations (creek bank berm) to the lowest areas of the interior marsh, approxi-
mate1y 120–150 meters from the creekbank (Hanson et al. 2002). The interior marsh is characterized by numerous natural depressions and rivulets, many of which retain standing water throughout the year, providing suitable habitat for marsh–resident nekton. The 16 spotfin killifish collected at Piermont Marsh were all taken in pit traps or collected with dip nets from small ponds located in the interior marsh.

In order to supplement the field collections, we examined fish samples from previous studies. Lift net and seine samples collected at Piermont Marsh in 1999–2000 were re-examined, but did not yield any additional specimens (other than the original 11 reported in 2000). Lift net and seine samples collected from the oligohaline portion of the Hudson River Estuary (Manitou Marsh and Constitution Island Marsh) in 1997–1998 were examined, but did not contain any spotfin killifish. Intertidal lift net samples from Sybil Creek, Branford, CT were examined, yielding 12 female and/or juvenile spotfin killifish (10–25 mm TL; previously misidentified as juvenile mummichogs) (D. Osgood, unpub. data). Housatonic River (Milford, CT) lift net samples yielded 46 spotfin killifish (15–27 mm TL) (Osgood et al. 2003). Archived seine samples collected at Larchmont, NY (Long Island Sound) in 1976 were examined and yielded four spotfin killifish (18–36 mm). All of these identifications represent new localities for spotfin killifish in the northeastern U.S.

DISCUSSION

Previous studies on the abundance and distribution of spotfin killifish have resulted in a variety of assessments ranging from “rare” (Hildebrand and Schroeder 1928, Nichols and Breder 1927, Richards and Bailey 1967), to “common” in salt marshes (Able et al. 1983, Byrne 1978, Shields and Mayes 1983, Yozzo and Smith 1998). Recent studies indicate that the reason for the early perceptions of rarity may have been due to inadequacy of conventional fishery sampling techniques in intertidal habitats (Byrne 1978, Kneib 1978, Shields and Mayes 1983). The recent discovery of a population of spotfin killifish in Piermont Marsh (Yozzo & Osgood, unpub. data) prompted an interest in determining abundance and distribution patterns of this species in salt and brackish marshes in the lower Hudson River Estuary and NY/NJ Harbor, using sampling techniques which have proven effective in sampling intertidal marsh habitats (Kneib 1984, Layman and Smith 2001, Yozzo and Smith 1998).

In this study spotfin killifish were captured at two of the four sampling sites. At Piermont Marsh, fourteen collections yielded a total of 16 spotfin killifish. These results may be related to significant amounts of rainfall in May and June, which resulted in continuous inundation of the
high marsh until July of 2001. The accumulated water on the high marsh surface greatly increased the available habitat for spotfin killifish and other high marsh species, allowing for greater dispersion of individuals and resulting in reduced trapping efficiency. Byrne (1978) attempted to sample Fox Creek Marsh, Virginia, after storms that inundated the marsh surface. These efforts were ineffective because the fish were widely dispersed over the flooded marsh, and not concentrated in microhabitats such as ditches and intertidal rivulets. This observation is corroborated in studies by Kneib (1978) and Able et al. (1983). These investigators, working in North Carolina and New Jersey, respectively, noted that spotfin killifish occurred in a variety of high marsh habitats and readily moved over the flooded marsh surface. The upper intertidal zone at Piermont Marsh began to drain in July, with water remaining only in the shallow depressions and rivulets; collections on August 2 yielded eight spotfin killifish.

Unlike Piermont Marsh, the three NY/NJ Harbor sites did not retain large, permanent or semi-permanent areas of standing water. These marshes were regularly inundated (presumably every tidal cycle) and drained completely at low tide. However, only one of the secondary sites (Ralph Creek) appeared to support a population of spotfin killifish. In a recent study conducted in Massachusetts, intensive sampling of seemingly suitable spotfin killifish habitat also failed to yield fish (Stallsmith 1999). Byrne (1978) stated that spotfin killifish were a “hardy euryhaline species of the high marsh, capable of tolerating extreme fluctuations in temperature, salinity and oxygen levels.” This characterization suggests that they would be widely distributed across intertidal marsh habitats within their geographic range, however they are often elusive in both space and time.

Results from this study substantiate data from previous studies regarding habitat preference, size distribution, and environmental tolerances. The spotfin killifish that were collected during this study inhabited upper intertidal marsh habitat, vegetated by S. patens/D. spicata and the short growth form of S. alterniflora. This is consistent with previous observations (Able et al. 1983, Byrne 1978, Kneib 1978, Shields and Mayes 1983). Pit traps installed at creekbanks or on mud flats did not yield any spotfin killifish. This is consistent with the observation that spotfin killifish spend their entire life history on the high marsh surface (Byrne 1978). However, it should be noted that the initial discovery of spotfin killifish at Piermont was the capture of a single individual (adult female) in a seine haul in the first-order tidal creek adjacent to our primary study site. Adult spotfin killifish have occasionally been reported from seine collections made in tidal creeks in Virginia (Richards and Bailey 1967, Yozzo and Smith 1998). These observations suggest that some individuals occasionally stray off of the
marsh surface, or are inadvertently transported to the lower intertidal zone during ebb tides.

Juvenile mummichogs were captured in pit traps along with spotfin killifish in the high marsh at both Piermont Marsh and Ralph Creek. Able et al. (1983) and Kneib (1984) documented co-occurrence of these two species in high marsh habitats in New Jersey and Georgia, respectively. There is no evidence in the literature indicating any habitat or niche separation between spotfin killifish and mummichog, although this phenomenon has been demonstrated for other species of *Fundulus* (Weisberg 1986).

Previous records of spotfin killifish in New York waters include two locations on Staten Island (Kill Van Kull and Lemon Creek) sampled in 1974 by Kiley (1975). Briggs and Waldman (2002) list spotfin killifish as “locally common” and report that the species was abundant in collections at Flax Pond, Long Island during the 1970s. Greeley (1939) reported collecting spotfin killifish at three locations in the vicinity of Shelter Island, NY, during extensive shore zone fish surveys conducted in 1938. The collection/identification of spotfin killifish from Milford, CT, Branford, CT, and Larchmont, NY, along with Piermont Marsh and Ralph Creek, represent new distribution records for the species. Figure 2 depicts the locations of new collections/identifications of spotfin killifish in New York and Connecticut. Information on local geographic distribution and life history characteristics of spotfin killifish adds to the body of ecological information on intertidal wetlands of the Hudson-Raritan Estuary and contributes to the characterization of biodiversity resources in this region.

![Figure 2. New distribution records for spotfin killifish in the northeastern U.S.: Site A: Piermont Marsh, Piermont, NY; B: Larchmont Harbor, Larchmont, NY; C: Housatonic River, Milford, CT.; D: Sybil Creek, Branford, CT.; E: Ralph Creek, Brooklyn, NY.](image-url)
ACKNOWLEDGMENTS

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