

and Platania 1991). Survey results indicated that adults were common in shallow and braided runs over sand substrate, and almost never occurred in habitats with bottoms of gravel or cobble, while young-of-year fish (less than 1 year old) occupied shallow, low-velocity backwaters with sand-silt substrates (Dudley and Platania 1997; Platania and Dudley 1997; Platania 1991; Remshardt *et al.* 2001). Young-of-year silvery minnows were infrequently found at the same time in the same habitat as adults. River reaches dominated by straight, narrow, incised (deep) channels with rapid flows are not typically occupied by the silvery minnow (Bestgen and Platania 1991).

The habitats most often occupied by silvery minnow were characterized by low (<20 cm) to moderate depths (31 to 40 cm), little (<10 cm/s) to moderate (11 to 30 cm/s) water velocity, and silt and sand substrata (Dudley and Platania 1997; Remshardt *et al.* 2001). It is believed that silvery minnow select debris piles, pools, and backwaters as habitat, and generally avoid main channel runs (Dudley and Platania 1997).

The silvery minnow is believed to be a generalized forager, feeding upon items suspended in the water column and items lying on the substrate (e.g., plankton, algae, diatoms) (Sublette *et al.* 1990; Dudley and Platania 1997; Service 1999). The silvery minnow's elongated and coiled gastrointestinal tract suggests that detritus (partially decomposed plant or animal matter), including sand and silt, is scraped from the river bottom (Sublette *et al.* 1990). Other species of *Hybognathus* have similar food habits, consuming rich organic ooze and detritus found in silt or mud substrates (Pflieger 1997).

The silvery minnow is a pelagic spawner, with each female capable of producing an average of 3,000 semibuoyant, non-adhesive eggs during a spawning event (Platania 1995; Platania and Altenbach 1998). Collection of eggs in the middle of May, late May, early June, and late June suggest a contracted spawning period in response to a spring runoff or spike (increase in flow that occurs when winter snows melt) (Service 1999; BOR 2001a). However, the peak of egg production appears to occur in mid-May (Smith 1998, 1999). If the spring spike occurs at the wrong time or is reduced, then silvery minnow reproduction could be impacted. Similar to other species of *Hybognathus* in other drainages (Lehtinen and Layzer 1988; Taylor and Miller 1990), the silvery minnow appears capable of multiple spawns. For example, a late spawn was

documented in the Isleta and San Acacia reaches on July 24, 25, and 26, 2002, following a high flow event produced by a thunderstorm (see also Dudley and Platania 2002d). This spawn was smaller than the typical spawning event in May, but a significant number of eggs was collected (N = 496) in 2 hours of effort (J. Smith, NMESFO, pers. comm. 2002). In 2002, small spawning events (a few eggs in each spawn) have been documented in all reaches except the Cochiti Reach as late as August 7 (J. Smith, NMESFO, pers. comm. 2002).

Platania (1995, 2000) found that early development and hatching of eggs is correlated with water temperature. Silvery minnow eggs raised in 30°C water hatched in about 24 hours, while eggs reared in 20°C water hatched within 50 hours. Eggs were 1.6 mm (0.06 in) in size upon fertilization, but quickly swelled to 3 mm (0.12 in). Recently hatched larval fish are about 3.7 mm (0.15 in) in standard length and grow about 0.15 mm (0.005 in) per day during the larval stages. Eggs and larvae remain in the drift for 3 to 5 days, and may be transported from 134 to 223 mi (216 to 359 km) downstream depending on river flows and habitat conditions (e.g., debris piles, low velocity backwaters) (Platania and Altenbach 1998). About 3 days after hatching, the larvae begin moving to low-velocity habitats where food (mainly phytoplankton and zooplankton) is abundant and predators are scarce. Because eggs and larvae can be swept downstream, where recruitment (that portion of young-of-the-year fish added to the breeding population) of fish may be poor in the current degraded condition of the middle Rio Grande (e.g., channelization, banks stabilization, levee construction, disruption of natural processes throughout the floodplain, etc.), adequate stream length appears to be an important determinant of reproductive success.

Platania (1995) indicated that the downstream transport of eggs and larvae of the silvery minnow over long distances may have been, historically, beneficial to the survival of their populations. This behavior could have promoted recolonization of reaches impacted during periods of natural drought (Platania 1995). Alternatively, in a natural functioning river system (e.g., a natural, unregulated flow regime), a variety of low-velocity refugia (e.g., oxbows, backwaters, etc.) would have been available for silvery minnow, and lengthy downstream drift of eggs and larvae may not have been common (J. Brooks, U.S. Fish and Wildlife Service pers. comm., 2001). Currently,

the release of floating silvery minnow eggs may replenish downstream reaches, but the presence of the diversion dams (Angostura, Isleta, and San Acacia Diversion Dams) prevents recolonization of upstream habitats (Platania 1995). As upstream reaches are depleted upstream, and diversion structures prevent upstream movements, population decline of the species within river reaches may occur through loss of connectivity (*i.e.*, preventing upstream movement of fish). Silvery minnows, eggs, and larvae are also transported downstream to Elephant Butte Reservoir, where it is believed that survival of these fish is highly unlikely because of poor habitat, and, more importantly, because of predation from reservoir fishes (Service 2001b). The population center (*i.e.*, the river reach that contains the majority of adult silvery minnows) is believed to have moved farther downstream over the last several years (Dudley and Platania 2001; 2002a; 2002b). For example, in 1997, it was estimated that 70 percent of the silvery minnow population was found in the reach below San Acacia Diversion Dam (Dudley and Platania 1997). Moreover, during surveys in 1999, over 95 percent of the silvery minnows captured occurred downstream of San Acacia Diversion Dam (Dudley and Platania 1999a; Smith and Jackson 2000). Probable reasons for this distribution include: (1) The spawning of semibuoyant eggs during the spring and early summer high flows, resulting in downstream transport of eggs and larval fish; (2) diversion dams that restrict or preclude the movement of fish into upstream reaches; and (3) reduction in the amount of available habitat due to the current degraded condition of some areas within the middle Rio Grande (e.g., channelization, streambed degradation, reduction in off-channel habitat, and the general narrowing and incising of the stream channel) (Platania 1998; Lagassee 1981; BOR 2001).

Most Great Plains streams are highly variable environments. Fish in these systems (e.g., the Rio Grande) are subjected to extremes in water temperatures, flow regimes, and overall water quality conditions (especially the concentration of dissolved oxygen). Native fish in these streams often exhibit life history strategies and microhabitat preferences that enable them to cope with these natural conditions. For example, Matthews and Maness (1979) reported that the synergistic (combined) effects of high temperature, low oxygen, and other