



Nesting ecology of the interior least tern on the Yellowstone River, Montana
by Lynn Marie Bacon

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Biological Sciences
Montana State University
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Abstract:

I estimated the number of interior least terns (*Sterna antillarum athalassos*) on the Yellowstone River, Montana, quantified available nesting habitat at 3 river-flow rates, and characterized nesting habitat during the 1994 and 1995 breeding seasons. In 1994, run-off from mountain snow-pack occurred 1 month earlier than historically and in 1995. Mean monthly flow rates in 1995 exceeded historical rates by 150 cubic meters/second (cms) and by 600 cms rates in 1994. More adult least terns were observed during 1994 ($n = 40$) than in 1995 ($n=24$). In 1994 and 1995, peak nest initiation occurred between 8-21 June ($x = 457.4$ cms, $SE = 73.1$), and 22 June - 5 July ($x = 1,064.4$ cms, $SE = 99.1$), respectively. Vegetated channel bars were used exclusively for nesting during both years; 10 different channel bars were colonized, 9 were used in 1994, 5 of which were recolonized in 1995. Average colony size was 1.93 nests/colony. Mean reproductive estimates for 1994 and 1995 were: apparent nest success, 76.3%; fledglings/nesting pair, 0.73; and clutch size, 2.38. In 1994, 23 young were fledged, whereas only 1 was fledged in 1995. A longer breeding season, due to earlier peak flows and lower river levels earlier in the season, likely contributed to more successful reproduction in 1994. In addition, weather-related mortality of eggs and chicks may have further compromised reproductive efforts in 1995. Nests were not inundated by floods during either season. Human disturbance of nesting colonies was not observed and only 1 predation event was witnessed.

Channel bars chosen for nesting sites were exposed above river level longer throughout the breeding season than non-nesting available habitats. In addition, there was no difference detected among heights of nesting cobble areas along 100 m transects that traversed the highest area of the cobble dome. Tern nests were placed in micro sites of the cobble area with heights equal to or greater than those along the crest of the cobble area. Most nest colonies and nests occurred in a section of the river where channel sinuosity began to increase and there was a higher incidence of channel bars and overlapping islands (land masses with mature vegetation) surrounded by irregular channel activity (i.e., sloughs). Because of the increase in channel sinuosity, deposition of sediment and bedload materials may be greater on channel bars in this section of the river channel.

The rapid stage fluctuation and sediment carrying capacity of the free-flowing Yellowstone River likely contribute to the maintenance of the early successional stage of channel bar nesting habitat. Though inundation from dam releases on the Yellowstone River is nonexistent, there is a danger of flooding nesting terns from controlled tributaries (Big Horn and Tongue Rivers). Simultaneous releases from dams, especially periods of increased discharge rates on the Yellowstone, will place least tern reproductive efforts on the Yellowstone River in serious danger of inundation. Communication among individuals responsible for water regulation on the Big Horn and Tongue Rivers will help reduce threats to the Yellowstone River least tern population.

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May 1996

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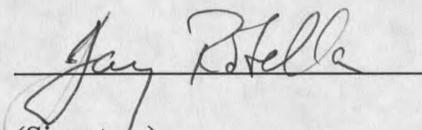
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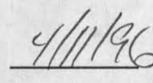
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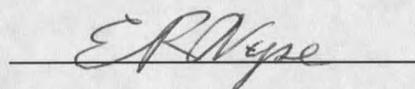
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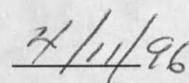
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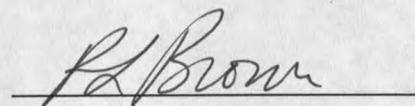
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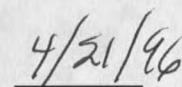
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ACKNOWLEDGMENTS

I wish gratitude could be as evenly spread as my Dad's homemade plum jam. Unfortunately, some corners of the bread will be missed, as the list of those to thank is as long as the Yellowstone. My parents, I thank for their faith and unending encouragement in the face of my constant adventures. I especially thank my friend and trusted advisor, Dr. Jay Rotella, for believing I could face the challenge this project offered. I am indebted to my committee members, Al Zale and Andrew Marcus, for their interest and sense of direction. Casey Kruse, of the Army Corps of Engineers, the principal funders, I thank for making this project possible and providing much advice. Lou Hanebury, U.S. Fish and Wildlife Service, I am grateful to for technical support and for listening to my river stories from the outpost of Glendive. Arnie Dood, Montana State Department of Fish, Wildlife and Parks, I thank for technical support, the ranting and raving, and being one of the first to suggest the need for this project. Others I extend thanks to include Dale Tribby of the Bureau of Land Management, Neil Martin and Phil Stewart, of the Montana State Department of Fish, Wildlife and Parks. Dan Gustafson, I heartily appreciate for his map making skills, dry humor and statistical advice. Nick Schnabel and Liz Burroughs, could not be thanked enough for their patience and talent as field technicians. Rob Ament, trusted love and plant ecologist, I thank for his assistance in vegetation community typing and for bringing the espresso machine to the outpost. Gratitude is extended to my family members: Carol, Al, Julie, Todd, Yo, John, Dave, Brook, Alissa, Jillian, Gabe, Jandee, Vicki, Heidi, Hanna, Nickie, and of course Mica, friends near and far. Makoshika State Park, for a hill to climb. None of this would have been possible without the mighty Yellowstone River, may it always remain wild. The Great Buffalo Spirit, I thank for watching over me.

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ABSTRACT

I estimated the number of interior least terns (*Sterna antillarum athalassos*) on the Yellowstone River, Montana, quantified available nesting habitat at 3 river-flow rates, and characterized nesting habitat during the 1994 and 1995 breeding seasons. In 1994, run-off from mountain snow-pack occurred 1 month earlier than historically and in 1995. Mean monthly flow rates in 1995 exceeded historical rates by 150 cubic meters/second (cms) and by 600 cms rates in 1994. More adult least terns were observed during 1994 ($n = 40$) than in 1995 ($n = 24$). In 1994 and 1995, peak nest initiation occurred between 8 - 21 June ($\bar{x} = 457.4$ cms, SE = 73.1), and 22 June - 5 July ($\bar{x} = 1,064.4$ cms, SE = 99.1), respectively. Vegetated channel bars were used exclusively for nesting during both years; 10 different channel bars were colonized, 9 were used in 1994, 5 of which were recolonized in 1995. Average colony size was 1.93 nests/colony. Mean reproductive estimates for 1994 and 1995 were: apparent nest success, 76.3 %; fledglings/nesting pair, 0.73; and clutch size, 2.38. In 1994, 23 young were fledged, whereas only 1 was fledged in 1995. A longer breeding season, due to earlier peak flows and lower river levels earlier in the season, likely contributed to more successful reproduction in 1994. In addition, weather-related mortality of eggs and chicks may have further compromised reproductive efforts in 1995. Nests were not inundated by floods during either season. Human disturbance of nesting colonies was not observed and only 1 predation event was witnessed.

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The rapid stage fluctuation and sediment carrying capacity of the free-flowing Yellowstone River likely contribute to the maintenance of the early successional stage of channel bar nesting habitat. Though inundation from dam releases on the Yellowstone River is nonexistent, there is a danger of flooding nesting terns from controlled tributaries (Big Horn and Tongue Rivers). Simultaneous releases from dams, especially periods of increased discharge rates on the Yellowstone, will place least tern reproductive efforts on the Yellowstone River in serious danger of inundation. Communication among individuals responsible for water regulation on the Big Horn and Tongue Rivers will help reduce threats to the Yellowstone River least tern population.

CHAPTER 1 GENERAL INTRODUCTION

The endangered interior least tern nests in the United States, from the Gulf of Mexico to Eastern Montana, within the Mississippi and Missouri River systems. Nesting habitats include salt flats, reservoir and lake beaches, and riverine channel bars. Many of the interior least terns that nest along the Missouri River and its tributaries colonize channel bars that have been partially scoured of vegetation and use slow moving river channels for foraging.

In Montana, least terns nest on the regulated Missouri River and the free-flowing Yellowstone River. A number of factors characterize free-flowing river systems, including erodible banks, rapid stage fluctuation, and high sediment carrying capacity. These factors are altered when a system is controlled by damming, dredging, or channelization. Though channel bars persist in controlled river systems, many are encroached by vegetation due to the lack of scouring river flows. Least terns that establish nests within controlled systems are often susceptible to inundation when water from dams is released during incubation or pre-fledging periods.

It is difficult to ascertain the ecological requirements and habitat use of the interior least tern in Montana without adequate historical records of population density and distribution. Information regarding the characteristics of breeding habitats prior to river damming is also lacking in Montana. Use of the free-flowing Yellowstone River by nesting least terns offers a unique opportunity to characterize nesting habitat and breeding success as a function of river hydrograph.

In Chapter 1, I present an overview of least tern ecology. In Chapter 2, I present results of the 1994 and 1995 breeding seasons of the interior least tern on the Yellowstone River: (1) population size and breeding success of the two seasons are compared between years, and breeding activities are related to river flows; (2) amount and type of available nesting habitat estimated within the 200 river kilometer (rkm) study area are summarized; (3) differences between nesting and non-nesting habitat are examined; and (4) nesting habitat is characterized and compared to habitat at random sites.

CHAPTER 2 ECOLOGY OF THE LEAST TERN

IntroductionTaxonomy

The least tern (*Sterna antillarum*), of the subfamily Sterninae and family Laridae in the order Charadriiformes, was originally described by Lesson in 1847 (Ridgeway 1895). An interior North American race (*Sterna albifrons athalassos*) of the Old World little tern (*Sterna albifrons*) was described by Burleigh and Lowery (1942). New World races on the east coast (*Sterna albifrons antillarum*) and coastal California (*Sterna albifrons browni*) were later delineated (U.S. Fish and Wildlife Service 1990). The American Ornithologist's Union (1983) now classifies the least tern of North America as a distinct New World species (*Sterna antillarum*) with three subspecies: interior (*Sterna antillarum athalassos*), Atlantic (*Sterna antillarum antillarum*), and California (*Sterna antillarum browni*).

Debate continues whether the least tern should be divided into distinct subspecies (Sidle et al. 1988). Providing reason for debate are sympatric populations of the interior and Atlantic least terns along the coast of Texas, and the observation of a least tern banded as a juvenile on the Texas coast (Atlantic subspecies) nesting in Quivira National Wildlife Refuge in Kansas (Boyd and Thompson 1985). In addition, morphometric and genetic differences have not conclusively supported subspeciation (Thompson et al. 1992). Therefore, the U.S. Fish and Wildlife Service (1985) considers each subspecies to constitute a population. Populations of interior and California least terns were designated

as endangered in 1985 and 1970, respectively (U. S. Fish and Wildlife Service 1985).

Description

The least tern is the smallest member (21-24 cm long) of the Laridae family and is characterized by a black cap, white forehead and black eye-stripe (U. S. Fish and Wildlife Service 1990). Boyd and Thompson (1985) determined slight differences between the sexes: (1) males tend to have bright orange feet while those of females tend to be more yellow; (2) male bills are larger, of greater depth, and a darker yellow than those of females; and (3) the wingcords of males are longer than those of females.

Ages of breeding least terns range from 2 to 8 years (Massey and Atwood 1978).

Ages of recovered least terns were between 1 and 21 years.

California least tern eggs range from 6.8 to 10.0 g in weight and average 30.5 mm in length and 23.0 mm in diameter. The color varies from light to dark buff. The shell has irregular brownish spots on the outside and duller, "lavender-gray" blotches under the outer-most shell layer (Bent 1921). Least tern eggs taper less sharply than the eggs of members of the Charadriidae family and thus give a more rounded appearance. These characteristics distinguish tern eggs from similar-sized eggs of sympatric killdeer (*Charadrius vociferus*) and piping plovers (*Actitis macularia*).

Newly hatched chicks are light-buff and speckled with black. Jackson (1976) has described age and development stage of chicks until after fledging. Two to 5 day-old chicks are downy with no primary feather development. Chicks 6 to 9 days old are in their postnatal molt with early development of primary quills. Wing feathers are one-third to one-half developed at 10-13 days. Some down feathers are retained until as late

as 14-17 days. Unsustained flight is attained at 18-21 days.

The back feathers of juvenile least terns are brownish to buff and the topside of wings and crown are speckled with black that becomes less prominent with age (Massey and Atwood 1978). The eye-stripe of a juvenile is a dull black and extends towards the nape. The underside of juveniles is white except for buff on the chin and upper chest. Generally, juveniles have blunt retrices and less deeply forked tails than adults.

Life History

Breeding Ecology California least terns often nest on sand-shell beaches with little vegetation (Massey 1974) and along barrier islands (U.S. Department of the Interior 1988). Least terns nest on islands and along mainland beaches in the Mississippi Gulf (Jackson 1976). Atlantic least terns nest on dredge spoils, barrier island beaches, sand shoals, and mainland sand beaches (Buckley 1978). Roof tops (Jackson 1994) and other sub-optimal areas have been used for nesting by least terns (U.S. Department of the Interior 1988).

Interior least terns nest on barren or sparsely vegetated islands along rivers of the interior river system (Schwalbach 1988, Smith and Renken 1991, Sidle et. al. 1993). This subspecies has also been reported to nest on islands within a Montana reservoir (Montana Piping Plover Recovery Committee 1994), on dredged sand islands (Wolk 1974, Kirsch 1992), spoil piles, areas mined for sand adjacent to rivers (Dinan et. al. 1993), salt flats (Utych 1993), and lake beaches (Wingfield 1993).

Least terns are typically colonial nesters but do breed successfully in small groups (Massey 1974). Burger (1988), using decoys to simulate colonies, found that least terns

were more attracted to larger colonies, especially those in which the artificial terns were placed 1.5 m apart rather than 0.5 m. The species also exhibits high rates of site tenacity for the preceding year's nesting area and especially for natal sites (Atwood and Massey 1988).

Nest initiation dates vary with latitude and availability of habitat. Initiation dates in riverine systems are strongly influenced by the appearance of sandbars as water levels decline and are directly associated with the timing of spring floods and the final late-spring or early-summer rise (Hardy 1957). Along the Missouri River and major tributaries in North and South Dakota, initiation dates occur between the first weeks of May and August (Dirks 1990, Schwalbach 1988). Late nests may be initiated by 2-year-old birds, which arrive with 1-year-old individuals up to 6 weeks after the first migrants arrived (Massey and Atwood 1981).

Nests are typically lined with materials surrounding the scrape but may only be bare depressions (Wolk 1974). Eggs are laid singly at 1-day intervals (Massey 1974), with predominantly 2-egg clutches (Massey 1974, Jackson 1976). Incubation is attended by both parents but a greater proportion of time by the female (Massey 1974). Hatching occurs 20 to 25 days after the first egg is laid. Renesting may occur if the first nest attempt fails or if no chicks survive (Massey 1974). Chicks are semi-precocial, leaving the nest 3 to 4 days post-hatching. Young are fed by both parents until fledging and remain with the adults until migration (Tompkins 1959). Fledging occurs 2-3 weeks after hatching.

Foraging Ecology Least terns catch fish by skimming over the water surface or

hovering and plunging (Bent 1921). Fish are normally speared or they may be taken from the surface (Tompkins 1959). Least terns are considered to be opportunistic feeders (Atwood and Minsky 1983) and have been observed taking surface-swimming crustaceans (Bent 1921), beach insects (Bent 1921, Wilson et al. 1993), and hawking for mayflies on the Yellowstone River, in North Dakota (R. Bramblett, pers. comm.). In California, a high percentage of fish consumed was <5.0 cm in length (Atwood and Kelly 1984). In Nebraska, most prey fish were <3.6 cm, but the size of prey captured varied annually (Wilson et al. 1993).

Least terns forage within a wide range of distances from the nesting colony. Terns forage in close proximity to their nesting colony (Atwood and Minsky 1983, U.S. Fish and Wildlife Service 1990), at sites away from the colony (Wilson et al. 1993), or several kilometers from nesting sites (U.S. Fish and Wildlife Service 1990).

Distribution

Atlantic least terns breed from Maine to Port Isabel, Texas, on islands east of Central America and near Venezuela, and on the islands of Bahama, Bermuda and the Antilles. California least terns breed from the San Francisco Bay to southern Baja (U.S. Dept. of the Interior 1988).

Interior least terns breed from Texas to Montana in the Rio Grande, Red, Missouri, Mississippi, Arkansas, and Ohio river systems (U.S. Fish and Wildlife Service 1990). The population abundance of the interior least tern ranged from approximately 3,000 in 1985 to 4,000-5,000 in 1986-1988 (U.S. Fish and Wildlife Service 1990). According to these surveys, 50.1% of the population nested on the Lower Mississippi

River and 34.2% nested on the Missouri River system in 1988. In 1990 and 1991, the population had increased to an estimated 7,789 and 6,833, respectively (E. Kirsch, pers. commun.). Population trends were estimated as positive (annual population growth rate = 8.2 %) and estimated fledglings/adult pair or nesting pair for 17 areas within the interior U.S. were 0.558 (E. Kirsch, pers. commun.).

The northern-most range of interior least terns in the U.S. is in Montana. Only 0.7% of the interior population occurs in Montana, comprising 2.0% of the population on the Missouri River systems (U.S. Fish and Wildlife Service 1990). The first documentation of least terns on the northern reaches of the Missouri River in Montana was on Fort Peck Reservoir in 1987 (Rabenburg et al. 1993). In 1988 active nests were also found below the Fort Peck Dam. Skaar (1970) documented a possible sighting on the lower Yellowstone River in 1970.

Although the Yellowstone River was considered to offer little appropriate habitat (Sidle et al. 1988), least terns were found nesting on the North Dakota stretch in 1986 (Kreil and Dryer 1987) and on the Montana portion in 1988. In general, islands in the Yellowstone River are larger, more permanent, and consist of cobble rather than sand substrate seen on the Missouri River (Rabenburg et al. 1993).

The Yellowstone River of North Dakota has been surveyed for least terns since 1986 (The Montana Piping Plover Recovery Committee 1995). The survey has been conducted cooperatively on an annual basis on the Montana portion of the Yellowstone River by personnel of Montana Department of Fish, Wildlife and Parks and North Dakota Game and Fish since 1990.

An adult survey has been conducted during a 10-day period in the last week of June and the first week of July since 1990 (U.S. Army Corps of Engineers 1993). Hatching-period and late-summer inventories have also been conducted on stretches of the river between Terry and Marsh, Montana, by personnel of the Bureau of Land Management. Twenty-eight percent of the terns in Montana during 1988 to 1991 were observed on the Yellowstone River (Rabenburg et al. 1993). No studies have been conducted on the Yellowstone River during the entire breeding season.

Conservation

Density of least terns declined on the east coast in the late 1880's as a result of plume hunting (Bent 1921, Tompkins 1959). After a resurgence, the Atlantic subspecies apparently decreased again in the coastal South after 1925 and again in the late 1950's (Tompkins 1959). California least tern populations declined after World War II, apparently as a result of loss of nesting and foraging habitat (Atwood and Minsky 1983). Declines in the interior population of least terns have been concurrent with the alteration of river systems (U. S. Fish and Wildlife Service 1985, 1990).

The recovery objective of U. S. Fish and Wildlife Service is to delist the interior least tern as endangered when the adult density reaches 7,000, with 2,100 nesting adults in the Missouri River system, and those levels are maintained for 10 years (U.S. Fish and Wildlife Service 1990). The U.S. Fish and Wildlife Service has established an objective of 50 adult least terns for the state of Montana, which has been surpassed each year since 1989 (Rabenburg et al. 1993, The Montana Piping Plover Recovery Committee 1995).

The Endangered Species Act dictates that threats to the survival of the species or

its habitat be removed in order to enhance population densities and production (U. S. Fish and Wildlife Service 1990). River channelization and the subsequent shortening of the river course, siltation, reservoir construction, and irrigation projects (U.S. Fish and Wildlife Service 1990) have drastically changed riverine behavior and topography. The first large-scale dam on the Missouri River system was constructed at Fort Peck, Montana, in 1937 (Keenlyne 1993).

Habitat destruction caused by flow manipulation, inundation by dam releases, and the lack of scouring runoffs (Sidle et al. 1992) is detrimental to the survival of the interior least tern. Over the last 50 years, these alterations have caused a 90% reduction in the number of sandbars and a loss of 75% of the backwater areas (Keenlyne 1993).

Prior to river damming, least terns in South Dakota nested primarily on unvegetated sandbars in the Missouri River (Dirks et al. 1993). Quantity of available least tern nesting habitat is a function of sandbar area and thus water level regulation on sections of the Missouri River (Mayer 1993).

A river in its natural state is constantly readjusting its topography as the system changes throughout the seasons and over time (Keenlyne 1993). As a result of these alterations, sandbars will become islands and in time connect to land as terraces if undisturbed (Keenlyne 1993). Stages of succession from sandbar to established island are extremely important to nesting least terns.

Demands placed on controlled river systems by hydropower, navigation, wildlife conservation, recreation and flood control alter the timing of runoff from snowmelt or rain, resulting in less predictable peak river flows (U.S. Fish and Wildlife Service 1990).

Active nests may become inundated by flood waters as a result of system operations (McPhillips 1993), which may be less likely to occur after snow-melt run-offs in rivers that are free-flowing. Secondly, but no less important, is the decrease in least tern production due to increased predation and human disturbance (U.S. Fish and Wildlife Service 1990).

In Montana, least tern nests on the Missouri River may be inundated because of adverse weather conditions and subsequent high inflows from the Milk and Poplar rivers without a corresponding decrease in dam releases (The Montana Piping Plover Recovery Committee 1994). Unexpected flooding because of system releases during the nesting season and island succession are believed to be the main causes of poor nesting success on the Missouri River, Montana. Releases from dammed tributaries, such as the Big Horn and Tongue Rivers, into the free-flowing Yellowstone River, may also cause excessive flooding on the Yellowstone if releases occur during periods of increased flow rates.

The yearly flood pulses of a free-flowing river during late winter and early summer trigger critical events in the life cycle of many animals (Junk et al. 1989). Major flood events functioned to reestablish habitat to early successional stages and are believed to have occurred on the Missouri River every 20-30 years (Sveum 1988). Such an event may have occurred during the 1993 least tern breeding season in Montana when the coldest and wettest July on record was documented. As a possible result, recruitment of least terns on the Yellowstone River (Montana) was believed to be non-existent, and was very low on the Missouri River (Montana) due to flooding during incubation and

hatching periods (The Montana Piping Plover recovery Committee 1994).

Water regulation in managed riverine systems should enhance the development of sandbars and the resetting of successional stages on established islands. The quantity, size, vegetative characteristics, and juxtaposition of sandbars and islands in a river system are vitally important to the viability of least terns. Unfortunately, with no historical data on the relationship of unregulated-river topography and flow rates to tern population density and reproductive success, it is difficult to devise appropriate action.

The Yellowstone River in Montana is an unregulated river, and it is a major tributary of the Missouri River. The geographical relationship of these two rivers, differences in management strategies, and presence of nesting least terns offer a unique opportunity to examine population dynamics on the Yellowstone River as a result of free-flowing river behavior (Kreil and Dryer 1987, Montana Piping Plover Recovery Committee 1994).

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CHAPTER 3 NESTING ECOLOGY OF THE INTERIOR LEAST TERN ON THE LOWER YELLOWSTONE RIVER, MONTANA

Introduction

The interior least tern was classified as endangered in 1985 (U.S. Fish and Wildlife Service 1985). The recovery objective of the U. S. Fish and Wildlife Service is to delist the interior least tern as endangered when an adult-population level of 7,000 is maintained for 10 years (U.S. Fish and Wildlife Service 1990). The recovery objective also includes 2,100 nesting adults in the Missouri River system, with 50 adult least terns in the state of Montana (U.S. Fish and Wildlife Service 1990). In 1988, 34.2% of the interior population occurred within the Missouri River System, with 0.7% of the total population in Montana (U.S. Fish and Wildlife Service 1990).

The decline in population of interior least terns has been concurrent with the alteration of river systems (U. S. Fish and Wildlife Service 1985, 1990). Prior to river damming, least terns nested primarily on unvegetated sandbars (Dirks et al. 1993). Quantity of available nesting habitat is a function of sandbar area and thus water level regulation on sections of the Missouri River (Mayer 1993). In the interior river system there has been a 90% reduction in the number of sandbars and a loss of 75% of the backwater areas due to changes in natural flow regimes (Keenlyne 1993).

Scouring floods are needed to reduce the amount of vegetation encroachment and to create nesting habitat (Sidle et al. 1992). Currents methods of water regulation in managed riverine systems do not enhance the development of sandbars and the resetting of successional stages. The early successional features of sandbar habitats are extremely

important to nesting least terns (Keenlyne 1993).

High river flows from dam releases that occur after initiation of the breeding season decrease the amount of available nesting habitat and inundate nests and young terns (Sidle et al. 1988). High tributary inflows due to weather events are also responsible for least tern chick and egg mortality and loss of available nesting habitat (Sidle et al. 1992, The Montana Piping Plover Recovery Committee 1994).

The Yellowstone River in Montana, which is an unregulated river and a major tributary of the regulated Missouri River, supports a small but undetermined number of least terns. The first documentation of interior least terns on the Missouri River, Montana, was in 1987 at Fort Peck Reservoir. Skaar (1970) documented a possible sighting on the lower Yellowstone River, east of Glendive, Montana, in 1970, and nests were found in that general area in 1988 (Rabenburg et al. 1993). The use of the unregulated Yellowstone River by nesting least terns offers a unique opportunity to examine habitat availability and reproductive success on a river with a natural hydrograph (Kreil and Dryer 1987, Montana Piping Plover Recovery Committee 1994). Therefore, I established and conducted this study with the following objectives: (1) to examine the nesting ecology and population status of the least tern on the Yellowstone River; (2) to quantify and characterize available nesting habitat as a function of river hydrograph; and (3) to characterize nesting habitat.

Study Area

The study area was approximately 200 river kilometers (rkm) of the Yellowstone River from Miles City to Crane, Montana (Figure 1). An average river-bed slope of

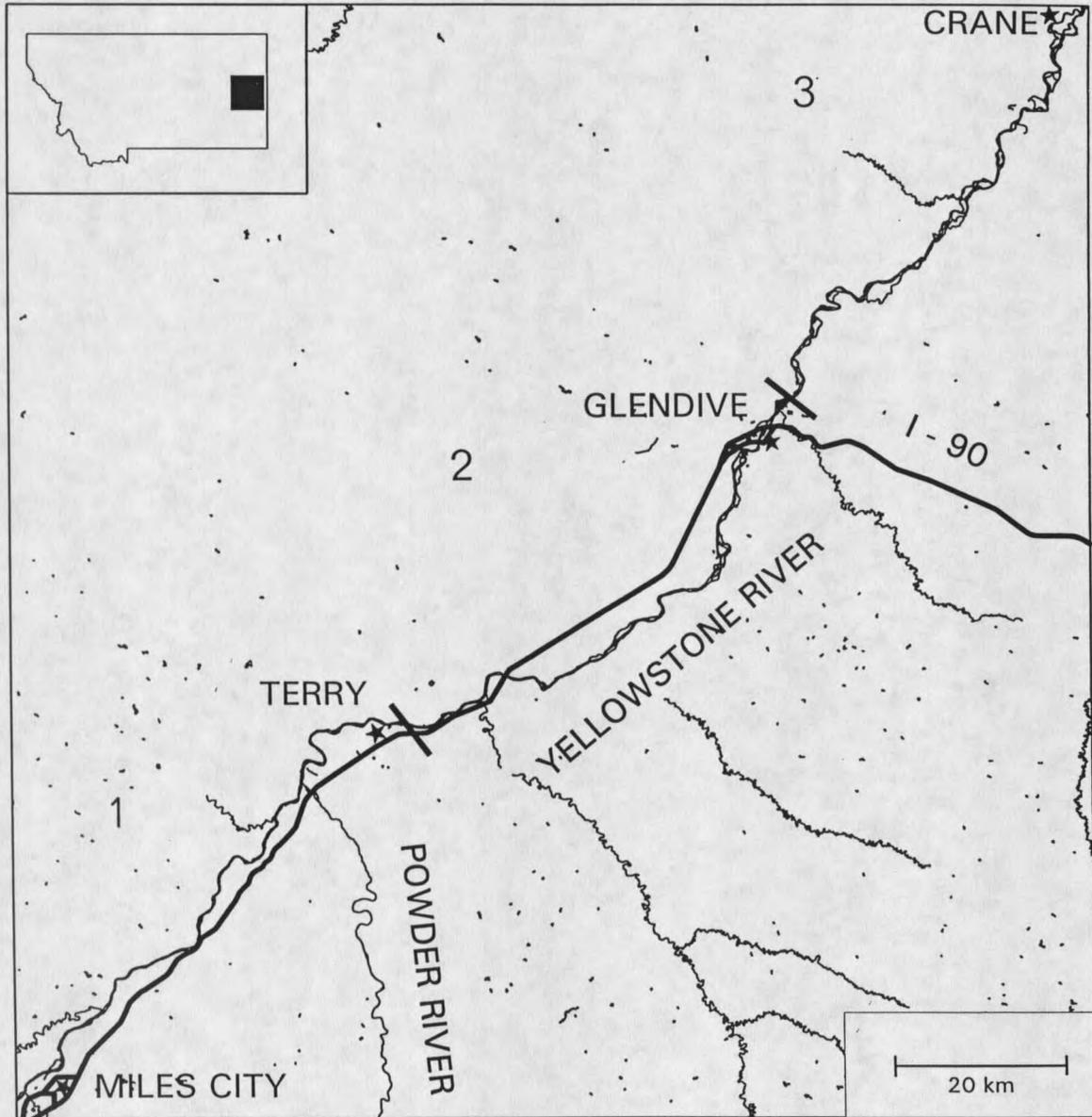


Figure 1. The Yellowstone River from Miles City to Crane, Montana (200 river kilometers), used to study the nesting ecology of the interior least tern in 1994-1995. Lines across the Yellowstone River indicate divisions of strata 1, 2, and 3 (see Appendix A for locations of river accesses, towns, and diversion dam).

0.14% in the middle reach of the river (250 rkm upstream of study area) decreases to 0.05% at the North Dakota border (50 rkm downstream), whereas the ratio of channel length to downvalley difference (sinuosity value) increases from 1.14 to 1.36 (Koch et al. 1977). River-bed material grades from gravel in the upper section of the study area to sand in the lower stretches (Koch et al. 1977). As the river approaches the North Dakota border it is characterized as a warm-water prairie river (White and Bramblett 1993).

The average historical mean-daily-discharge rate at Miles City (September 1928-September 1995) and Sidney (October 1924-December 1931, October 1933-September 1995), Montana, 32 km below the end of the study area was 335 cubic meters/second (cms) (U.S. Geological Service, unpublished data 1995). The highest mean-monthly-discharge rates (average of Miles City and Sidney flow rates) occurred in June at 1,012.3 cms. The average 30-year (1961-1990) mean annual rainfall for Miles City and Glendive was 35.2 cm, with a monthly mean of 4.8 cm from May to August (National Oceanic and Atmospheric Administration 1994, unpubl. data 1995). Mean monthly high/low temperatures during the months of May to August were 27.3 / 12.6 °C.

I delineated 3 strata within the study area (Figure 1). Each stratum had different characteristics and was approximately 66.5 rkm long. The river channel in stratum 1 was characterized as sinuous to meandering with occasional channel bars (Koch et al. 1977). In stratum 3, the channel was sinuous to irregular with many overlapping islands, frequently occurring mid-channel bars, and an increase in irregular lateral channel activity (i.e., slough formation). Stratum 2 had a gradation of characteristics, with an increasing prevalence of overlapping islands, frequency of mid-channel bars, and

irregular lateral channel activity, particularly in the downstream portion of the stratum.

Methods

Data Collection

Available Nesting Habitat In 1995, I estimated the amount of available nesting habitat and characterized used nesting habitat. I used a 4.9 m, flat-bottomed boat with a 40-horsepower outboard motor and the most current U.S. Geological Survey maps to navigate the river and locate available and active nesting areas. River flow rates were monitored daily through the U. S. Geological Service, Helena, Montana. Flow rates within the study area were estimated by averaging rates recorded at the Miles City and Sidney hydrograph stations. Climatological data of the study area were estimated by averaging rainfall and high/low temperature values at the Miles City and Glendive weather stations (National Oceanic and Atmospheric Administration 1994, unpubl. data 1995).

To estimate available nesting habitat, I divided each stratum into 19 3.5-rkm units. I selected 10 units within each stratum ($n = 30$) by simple random sampling (Schaeffer et al. 1990). The amount of habitat was estimated in the selected units during 3 different river discharge rates: (1) 1,000 to 1,100 cms, (2) 800 to 850 cms, and (3) 400 to 500 cms. Flow rates varied by 50 to 100 cms (rounded to nearest 50 cms) during each of the 3 different river discharge rates due to the time required to float the entire 200 rkm study site.

Areas $>30 \text{ m}^2$ and with $<10\%$ vegetative cover were defined as available nesting habitat. Each area of available nesting habitat was classified as : (1) unvegetated mid-

channel bar, (2) slough point, (3) vegetated mid-channel bar, or (4) point bar based on its location within the channel bar (Figure 2, Kellerhals et al. 1976). Dimensions of available habitat were paced (m) and the area (ha) estimated using the formula for an ellipse, rectangle, or triangle depending on the shape of the area. When a vegetated channel bar was sampled, I estimated the total size of the island and calculated the ratio of exposed cobble to total channel bar area.

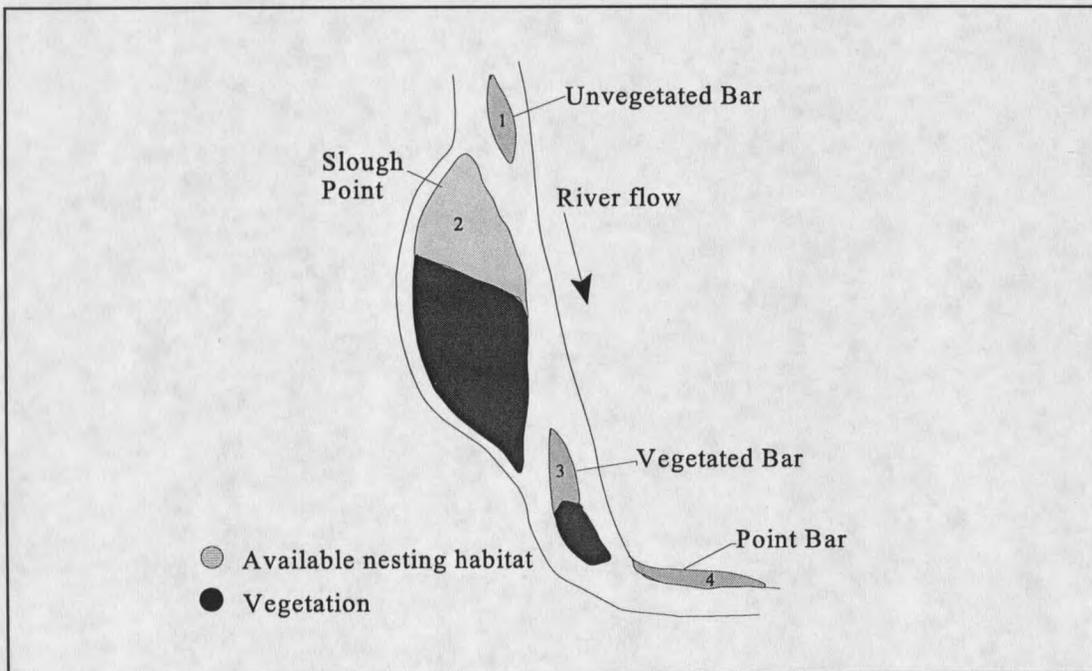


Figure 2. Types of available least tern nesting habitat estimated on the Yellowstone River between Miles City and Crane, Montana: (1) unvegetated bar, (2) slough point (3) vegetated bar, and (4) point bar (modified Kellerhals et al. 1976).

I calculated the heights of exposed cobble areas above water level at the 3 river flow rates. The highest points were generally located in the center of a vegetated channel bar, where exposed cobble of the upstream portion of the bar abutted the vegetated

downstream portion. On other habitat types, locations of high areas varied depending on characteristics of the cobble area. I sighted a 3-m rod with a 10-power rifle scope mounted on a tripod at the highest cobble point and at river level. The height above river level was calculated by subtracting the high point value from the value at river level. To determine the profile of the cobble area on vegetated channel bars (e. g., flat versus a downward slope from the high point to the upstream point), I placed additional height assessment points at 25 m, 50 m, and 100 m from the highest cobble point along a longitudinal line extending toward the upstream point.

Population Size and Breeding Success Surveys of least terns began 9 June in 1994 and 25 May in 1995. An attempt was made to census the study area by conducting thorough surveys throughout the 200 rkm study area. Prior to the onset of the breeding season, I scanned the edges of available nesting habitat from the boat. As the season progressed, I walked through potential nesting habitat to find nesting colonies.

I located nests in areas used by terns by observing tern behavior. From a distance of >30 m, I was able to observe adults returning to their nests. I approached an indicated nest after waiting 5 to 10 minutes, which allowed the adult to bring the eggs to incubation temperature. Tongue depressors and a forked stick <0.5 m long were placed 1-2 m from each nest bowl to aid relocation. The direction and distance to the nest from landmarks were written on the tongue depressor to further ensure nest relocation.

Nests were visited every 5 to 7 days to monitor survival. The incubation stage of each nest was assessed by egg flotation (Figure 3, Hays and LeCroy 1971, Schwalbach 1988) and all data were recorded on nest sheets provided by the Army Corps of Engineers

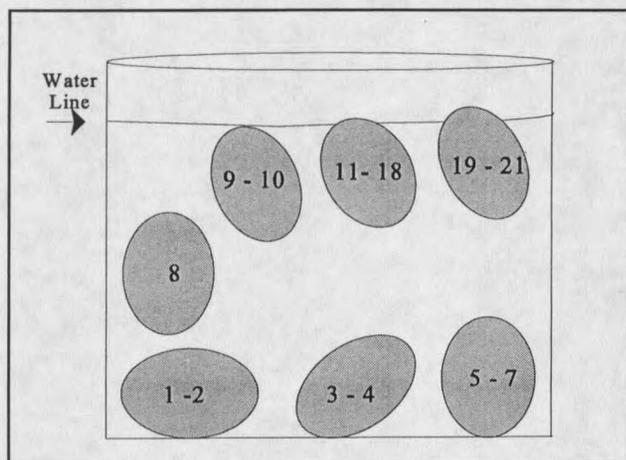


Figure 3. Egg flotation as an indicator of incubation stage in the interior least tern. Eggs are floated in a container of river water. Numbers indicate days of incubation (adapted from Hays and LeCroy 1977, Schwalbach 1988).

(Appendix B). A nest that contained ≥ 1 pipped or starred egg, egg fragments, or chick droppings within, or in close proximity to, the nest bowl was classified as successful and recorded as terminated. Hatching typically occurred after 20 days of incubation. Young fledged 15 to 20 days after hatching. Nest locales were monitored until the first week of August to estimate the number of young fledged.

Nest-site Characteristics I examined characteristics of: (1) nesting habitat (i.e., bare cobble) on channel bars used for nesting during 1995, and (2) available nesting habitat (area $>30 \text{ m}^2$ and $<10\%$ vegetative cover) on channel bars within randomly selected units. Data relating to size characteristics were collected at the 3 different flow rates (1,000 to 1,100 cms; 800 to 850 cms; 400 to 500 cms). Vegetation cover was assessed during the 400 to 500 cms flow rates.

The dimensions of used and available nesting habitat were paced and used to

calculate the area (ha) using the formula for an ellipse, rectangle or triangle. I estimated the total size of used and available channel bars and calculated the ratio of used and available nesting habitat to total channel bar area. I assessed vegetation within the cobble area for the following vegetation-height categories: <0.5 m, 0.5-2 m, and >2 m, using these percent cover categories: 0%, 1-5%, 6-15%, 16-25%, 26-50%, 51-75%, 76-95%, >95%. For used nesting locations, the percent of the channel bar that was covered by vegetation <2 m and >2 m in height was recorded. In addition, I identified the plant community type of each channel bar used for nesting (Hansen et al. 1995).

For each nest site, I established an associated random nest site along a random compass bearing and 20 m from each used nest site. During the 1994 nesting season, I paced the distance (m) from each used nest site to the closest used and random nest sites. In 1995, I paced the distance between all used nest sites and between all used and all random nest sites within a breeding colony.

I measured heights above river level of used and random nest sites during 1995. In each vegetation-height category, I recorded the 3 plants >10 cm height that were closest to used and random nests and I paced the distance (m) between each plant and nest site. For the 3 pieces of drift wood >5 mm diameter closest to used and random nest sites, I recorded: (1) length (< or >0.5 m), (2) diameter (5 mm-2 cm, 2-4 cm, 4-8 cm, 8-12 cm, 12-24 cm, >24 cm), and (3) distance (m) to the nest site.

Data Analysis

Available Nesting Habitat Using data from 1995, I compared the amounts of each available habitat type among strata during each of the river hydrographs (1,000 to 1,100

cms, 800 to 850 cms, and 400 to 500 cms). I used median tests to delineate the primary location of each type of habitat among strata during each of the river flow rates (Conover 1980, Statistica, Inc. 1994).

In 1994, only vegetated channel bars were used for nesting by least terns. Therefore, I examined differences between characteristics of available vegetated channel bars (non-nesting) and each of the other habitat types. I used paired-median tests to determine if there were differences between the amount of available nesting habitat on vegetated channel bars and the amount of each of the other habitat types. Tests were done on data collected prior to peak nest initiation (1,000 to 1,100 cms) and at the 800 to 850 cms flow rates. I also used median tests to determine whether heights above river at the highest cobble point differed among all habitat types (non-nesting vegetated channel bars, unvegetated channel bars, point bars, slough points) during the 1,000 to 1,100 cms and 800 to 850 cms flow rates. For descriptive purposes, data were presented graphically using means to estimate the amount and type of habitat per 10 rkm and 200 rkm.

Population Size and Breeding Success All terns present on the study site before eggs hatched each year were assumed to be adults birds and were counted to estimate annual population size. The number of nesting pairs was based on the number of nests initiated minus the number of reneest attempts.

Nest-initiation date was calculated for each nest by subtracting 20 days from the date the first egg hatched. Nest success was calculated using the Mayfield method (Mayfield 1975, Erwin and Custer 1982), which assumes that mortality rate was constant through the laying and incubation periods. Nest success was also calculated using the

binomial estimator (total number of nests/number of successful nests) because detectability of least tern nests is high and mortality may occur catastrophically (e. g., flooding) rather than at a constant rate (Johnson and Shaffer 1990). I divided the number of fledglings by the number of nesting pairs to calculate a fledging ratio. I did not know which young within a breeding colony fledged once chicks left the nest. Therefore, I could not calculate confidence limits on fledging ratios.

Nest-Site Characteristics I used Mann-Whitney U tests to compare characteristics of nesting and non-nesting vegetated channel bars prior to peak nest initiation (1,000 to 1,100 cms) and at the 800 to 850 cms flow rates. Characteristics tested were: (1) size of exposed cobble area, and (2) ratio of cobble area to total channel-bar area.

I examined characteristics of the cobble-area profile (e. g., flat versus sloped) of vegetated channel bars used for nesting and non-nesting vegetated channel bars. To examine the profile, I tested for differences among heights within nesting bars and within non-nesting bars. Median tests were used to test for differences between height measurements of paired points on nesting and non-nesting bars (e. g., the height at 25 m from the high point on nesting bars was compared to the height at 25 m on non-nesting bars). I used median tests to determine whether the height of the highest points of available nesting habitat were different among nesting vegetated channel bars, unvegetated channel bars, point bars, and slough points.

I used Mann-Whitney U tests to compare the following characteristics between actual and random nest-site characteristics: (1) height above river, (2) distances between

nest sites, (3) diameter of woody debris closest to the nest site, (4) distance from the nest site to the closest woody debris, (5) height of vegetation closest to the nest site, and (6) distance to vegetation closest to the nest site.

I used a significance level of 0.1 for all tests to balance Type I and II errors.

Nonparametric tests were used because of small sample sizes and non-normal distributions of data (Conover 1980).

Results

Available Nesting Habitat

Daily discharge rates peaked from mountain snow-melt on 16 May 1994 at 883 cms and 19 June 1995 at 1,537 cms (APPENDIX C). Historically and in 1995, peak flows occurred in June, whereas in 1994 the peak occurred in May (Figure 4), an event that has happened only twice in 70 years of record keeping. Mean monthly discharge rates in 1995 were about 150 cms greater than historical rates and exceeded peak flow rates in 1994 by 600 cms. The magnitude of the 1994 (547 cms) and 1995 (1,153) mean monthly peak flow rates have occurred 1 in 10 years and 1 in 2.5 years, respectively.

[Slight increases in March were due to early spring snow-melt and were to a large degree the result of gauges located in an area of pooling caused by downstream ice dams (M. White, pers. commun.).]

The 1995 breeding season was slightly wetter and cooler than during 1994 or the 30-year mean (1961-1990) (National Oceanic and Atmospheric Administration 1994, unpubl. data 1995). May to August rainfall was 3.6 cm in 1994 and 5.6 cm in 1995. The 30-year mean rainfall was 4.8 cm. Mean high/low temperatures were 28.1/12.1 °C in

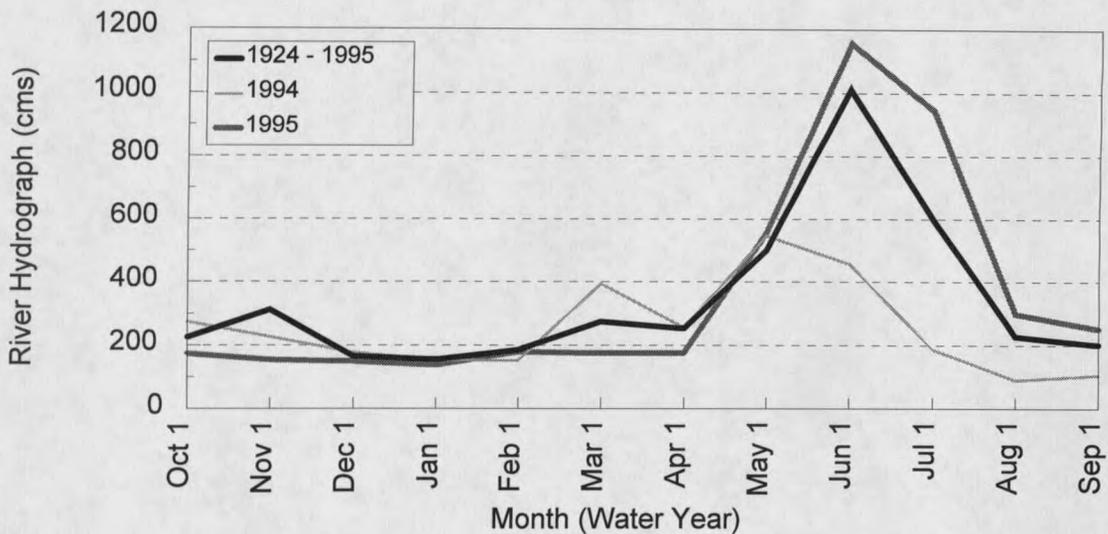


Figure 4. The mean monthly discharge rates at Miles City and Sidney, Montana, water years 1924-1995 (Miles City: September 1928-September 1995; Sidney: October 1924-December 1931, October 1933-September), and water years 1994 (October 1993-September 1994), and 1995 (October 1994-September 1995) (U.S. Geological Service 1994, U.S. Geological Service, unpublished data 1995).

1994, 26.9/11.5°C in 1995, and the 30-year means were 27.3/12.6°C.

Comparing habitat among strata at the 3 river flow rates in 1995, I found significant differences in the amount and location of available habitat during the time of peak nest initiation (1,000 to 1,100 cms) (Figure 5). Only vegetated channel bar habitat was available for nesting throughout the study area during these high flows. Most vegetated bar habitat was in stratum 1, significantly less was found in stratum 2, and none was available in stratum 3 (Table 1).

At river flows of 800 to 850 cms, all types of potential nesting habitat were available within the study area, although available habitat within stratum 1 continued to be comprised of bare cobble areas on vegetated channel bars (Table 1). With the exception of slough point habitat, availability of other habitat types did not differ

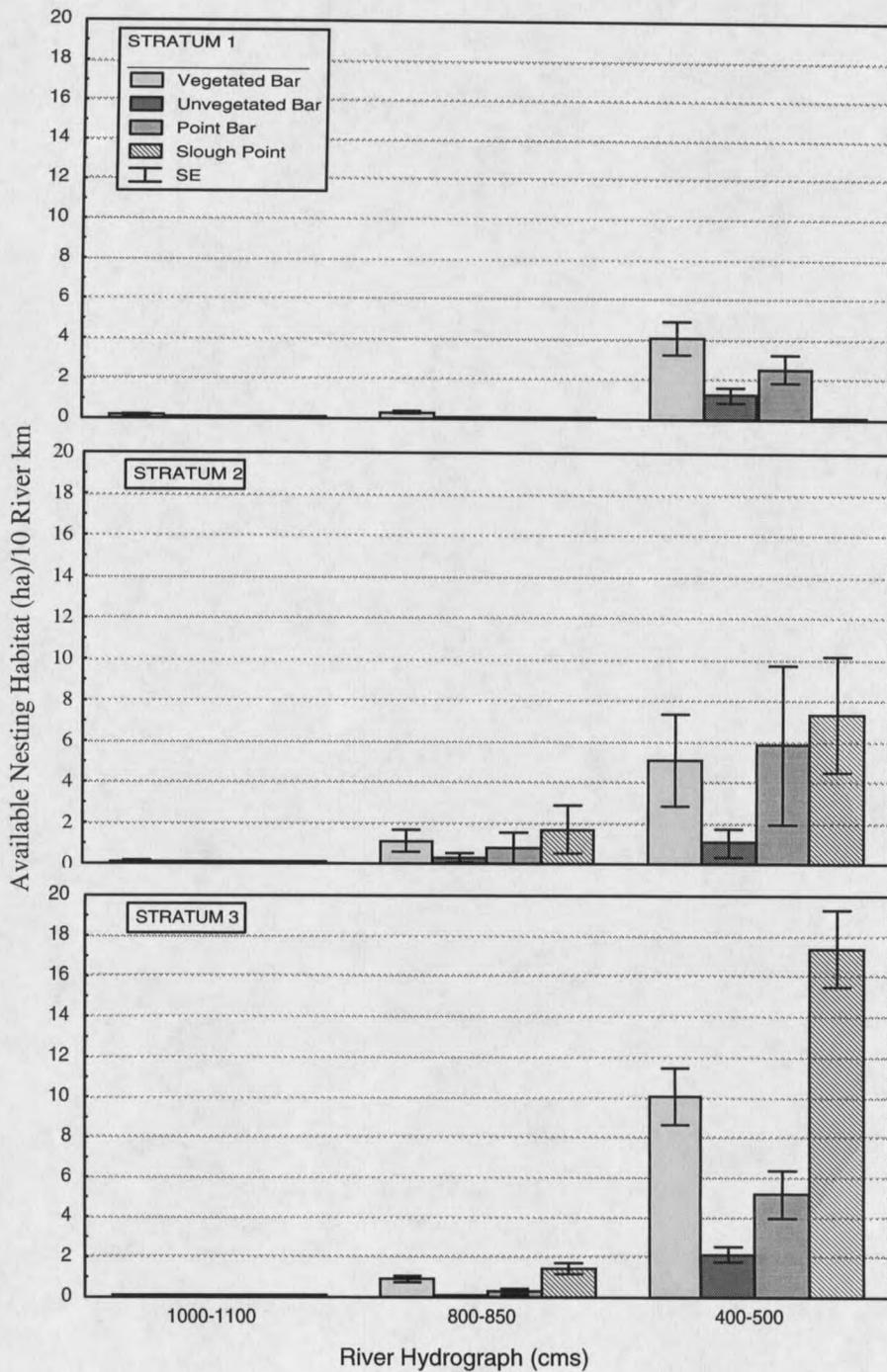


Figure 5. Availability of 4 types of least tern nesting habitat (ha/10 rkm) with in stratum 1, 2, and 3, on the Yellowstone River between Miles City and Crane, Montana. Data were collected 9 - 13 July (1000-1100 cms), 21 - 24 July (800-850 cms), and 2 - 6 August (400-450 cms), 1995. Estimates of habitat quantities presented in the graph are based on means of sampled units.

Table 1. Quantities of available nesting habitat types within 3 strata during 3 flow rates on the Yellowstone River between Miles City and Crane, Montana, in 1995. (ha/10 rkm)

River flow rate	Stratum 1				Stratum 2				Stratum 3				P value 1
	Quartiles				Quartiles				Quartiles				
	\bar{x}	25%	median	75%	\bar{x}	25%	median	75%	\bar{x}	25%	median	75%	
1,000-1,100 cms													
Vegetated bar	0.07	0	0A ²	0.13	0.04	0	0A	0.03	0	0	0B	0	0.09 *
Unvegetated bar	0	0	0	0	0	0	0	0	0	0	0	0	1.0
Point bar	0	0	0	0	0	0	0	0	0	0	0	0	1.0
Slough point	0	0	0	0	0	0	0	0	0	0	0	0	1.0
800-850 cms													
Vegetated bar	0.12	0	0.04	0.19	0.39	0	0.13	0.54	0.31	0	0	0.4	0.87
Unvegetated bar	0	0	0	0	0.1	0	0	0	0	0	0	0	0.12
Point bar	0	0	0	0	0.27	0	0	0	0.1	0	0	0	0.57
Slough point	0	0	0A	0	0.59	0	0A	0	0.5	0	0.16B	0.91	0.01 *
400-500 cms													
Vegetated bar	1.43	0	0.64	1.3	1.78	0	0.68	2.4	3.52	0	2.78	5.4	0.2
Unvegetated bar	0.43	0	0	0.35	0.36	0	0	0	0.75	0	0.28	1.6	0.35
Point bar	0.89	0	0	0.99	2.03	0	0	1.75	1.8	0	0.52	1.5	0.87
Slough point	0	0	0A	0	2.56	0	1.45B	4.13	6.1C	0	6.42C	8.6	0.001*

¹Median test; strata showing the same capital letter do not have significantly different quantities of available nesting habitat ($P < 0.1$).

among strata. At flow rates of 400 to 500 cms, slough point habitat was more prevalent in stratum 3.

Effects of river hydrograph on temporal habitat type availability were illuminated by examining differences among quantities of habitat types within the entire study area during each flow rate (Figure 6). Differences among quantities of all habitat types were detected during each of the flow rates (1,050 cms, 850 cms, 450 cms) (Table 2).

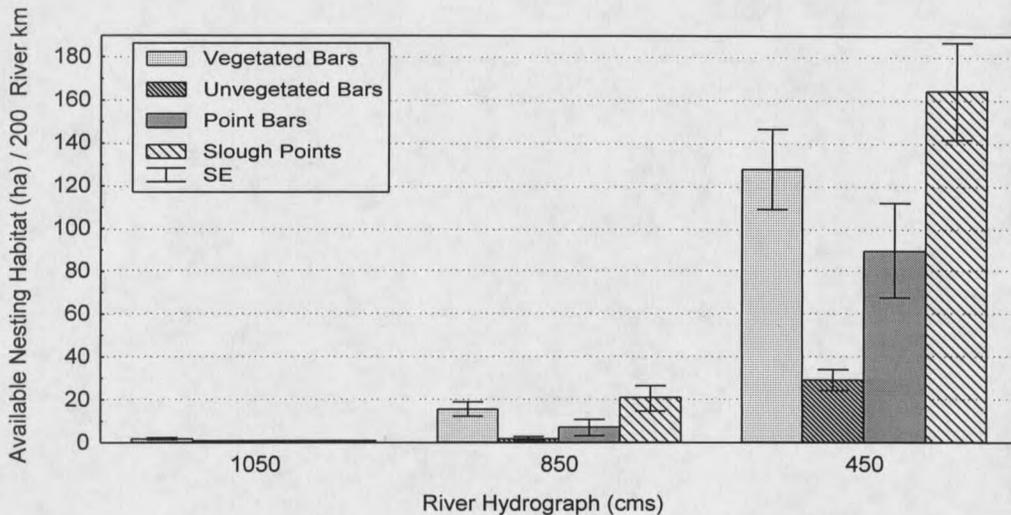


Figure 6. Availability of 4 types of nesting habitat (ha/200 rkm) within the study area on the Yellowstone River between Miles City and Crane, Montana. Data were collected 9 - 12 July (1050 mean cms), 21 - 24 July (850 mean cms), and 2 - 6 August (450 mean cms), 1995. Estimates of habitat quantities presented in the graph are based on means of sampled units.

During peak nest initiation (1,050 cms), only vegetated channel bar habitat was available throughout the study area (Table 2). During the 850 cms flow rates, the amount of vegetated bar habitat was greater than quantities of unvegetated and point bar habitat but did not differ from the quantity of slough point habitat. Differences in quantities of vegetated bar, point bar and slough point habitat were not detected during the 450 cms

Table 2. Quantities of available nesting habitat types within 3 strata during 3 Yellowstone River flow rates between Miles City and Crane, Montana, in 1995. (ha/10km)

Habitat type ¹	River Flow Rates (cms)											
	1,000-1,100				800-850				400-450			
	\bar{x}	Quartiles			\bar{x}	Quartiles			\bar{x}	Quartiles		
	25%	median	75%		25%	median	75%		25%	median	75%	
Vegetated bar	0.03	0	0	0	0.27	0	0	0.4	2.24	0	1.04	4.0
Unvegetated bar	0	0	0*	0	0.03	0	0*	0	0.51	0	0*	0.8
Point bar	0	0	0*	0	0.12	0	0*	0	1.57	0	0	1.7
Slough point	0	0	0*	0	0.36	0	0	0.1	2.88	0	0	5.0

¹ Overall median tests indicated that habitat availability differed among habitat types at each river flow rate ($P < 0.07$).

² Pairwise median tests were used to determine which habitat types had different amounts of available habitat than the amount of habitat on vegetated channel bars during that river flow. Within a column, the quantity of a habitat type with an asterisk (*) is significantly different than the quantity of vegetated channel bar habitat.

flow rates. Heights among all habitat types (non-nesting vegetated channel bars, unvegetated bars, point bars, slough points) at the highest point of bare substrate (<10% vegetation cover) during peak nest initiation were not different ($P = 0.31$).

Population Size and Breeding Success

The Yellowstone River supported 40 adult terns in 1994 and ~~24~~²¹ in 1995 (Table 3, see APPENDIX D). When terns arrived on the breeding area in 1995, channel bars used for nesting in 1994 were partially or totally submerged. Small amounts of bare cobble, vegetation on the downstream end of the channel bars, and log debris were the only visible evidence of the presence of 7 of the 9 channel bars used for nesting in 1994; the other 2 were completely inundated. During high flows and prior to nest initiation in 1995, terns were observed loafing on logs or small amounts of exposed cobble on the 7 channel bars that were visible. On 2 of those channel bars that were visible, terns were observed exhibiting breeding behavior on log debris. In 1 of these areas, a pair eventually initiated a nest on a strip of cobble <2 m wide and 50 to 100 m long, that was nearly inundated during an increase in river flows. On another channel bar, a pair initiated a nest on a cottonwood log lodged onto the cobble area during high river flows.

A total of 10 vegetated channel bars were used for nesting during the 1994 and 1995 breeding seasons (Figure 7, see APPENDIX E for UTM coordinates). Five of the 9 channel bars colonized in 1994 were recolonized in 1995. There were only 1.93 nests per nesting channel bar. Thus, least terns on the Yellowstone River did not nest in large colonies.

Least terns on the Yellowstone River used 6 of the estimated 15 vegetated channel

Table 3. Breeding activity of interior least terns on the Yellowstone River between Miles City and Crane, Montana, 1994-1995.

	1994	1995	Annual Mean (SE) ¹	
Adults	40	21 24	30.5 32.0	13.9 (8.0)
Colonies	9	6	8.0	(2.0)
Nests	18 (1 renest)	11	14.5	(3.5)
Mean nests/colony (SE)	2.0 (0.37)	1.83 (0.54)	1.91	(0.32)
Eggs	48	23	35.5	(12.5)
Mean clutch size (SE)	2.67 (0.12)	2.09 (0.16)	2.38	(0.1)
Successful nests ²	16	7	11.5	(4.5)
Fledglings	23	1	12.0	(11.0)

¹ SE - standard errors.

² A nest was considered successful when 1 egg was pipped or hatched.

bars available for nesting within the study area during peak nest initiation in 1995 (1,000 to 1,100 cms). In 1995, at flow rates corresponding to the 1994 peak nest initiation (400 to 500 cms), I estimated that 74 vegetated channel bars were available for nesting in 1994. Terns nested on 9 channel bars in 1994.

During both seasons, nearly 70% of the total number of nesting colonies and nests occurred in stratum 2 (Figure 7). One channel bar was colonized within stratum 3 during 1994 but none were colonized in that stratum during 1995. All nesting channel bars remained surrounded by river channels throughout the breeding season except for the bar in stratum 3, which accreted to the river bank as river levels decreased. In 1994, 13 of 18 nests (72.2 %) were initiated between 8 and 21 June (\bar{x} = 474 cms, Figure 8), 4 to 6 weeks after the river flow rate reached the highest daily discharge rate from mountain

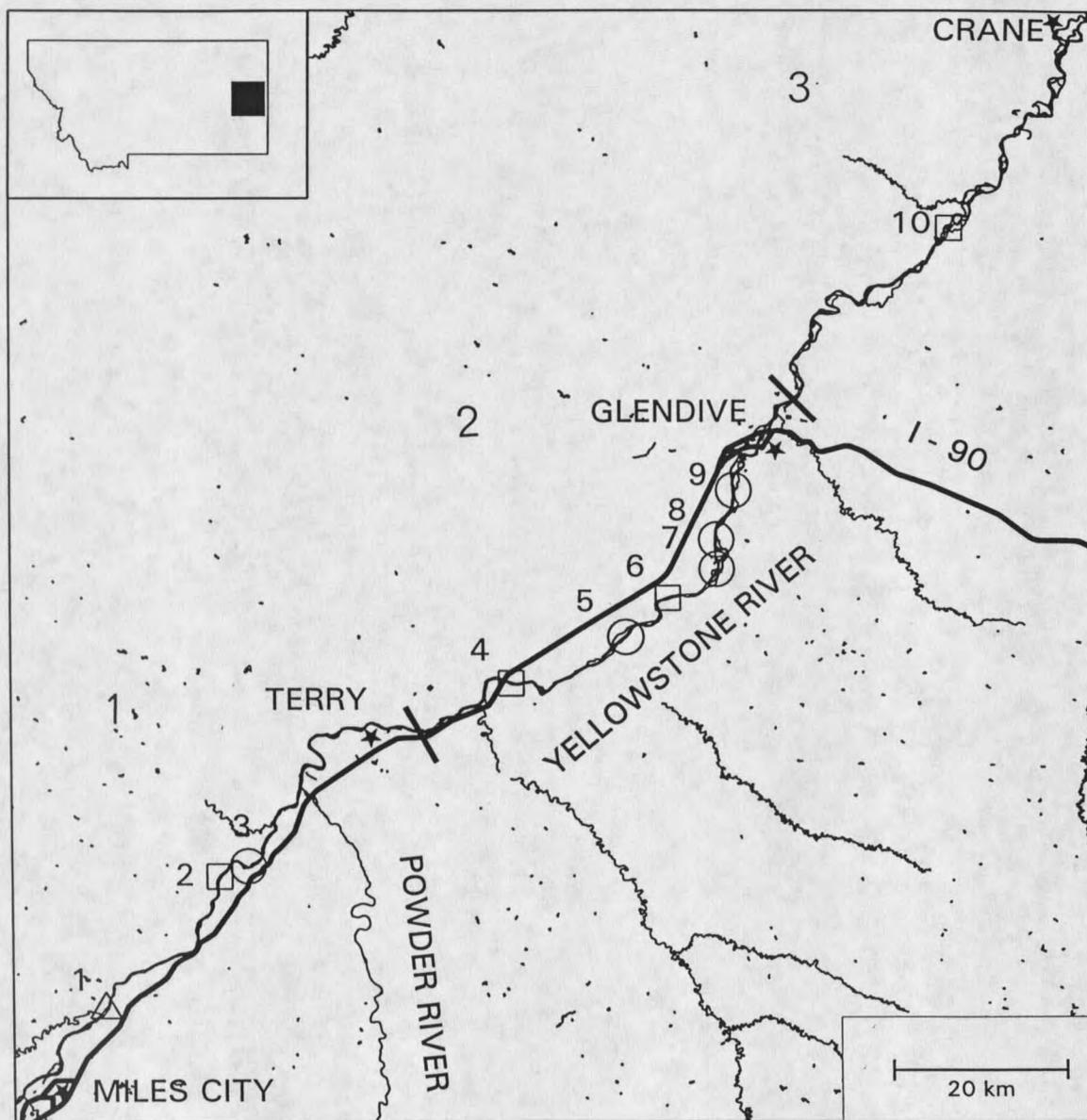


Figure 7. Nest site locations of interior least tern breeding seasons on the Yellowstone River between Miles City and Crane, Montana, 1994-1995 (APPENDIX E). Circles and numbers (1-10) indicate colony locations (APPENDIX D); channel bars colonized in 1994: \square , in 1995: \triangle , and both years \circ . Lines across the Yellowstone River indicate location of the strata divisions and the large numbers (1, 2, 3) indicate strata.

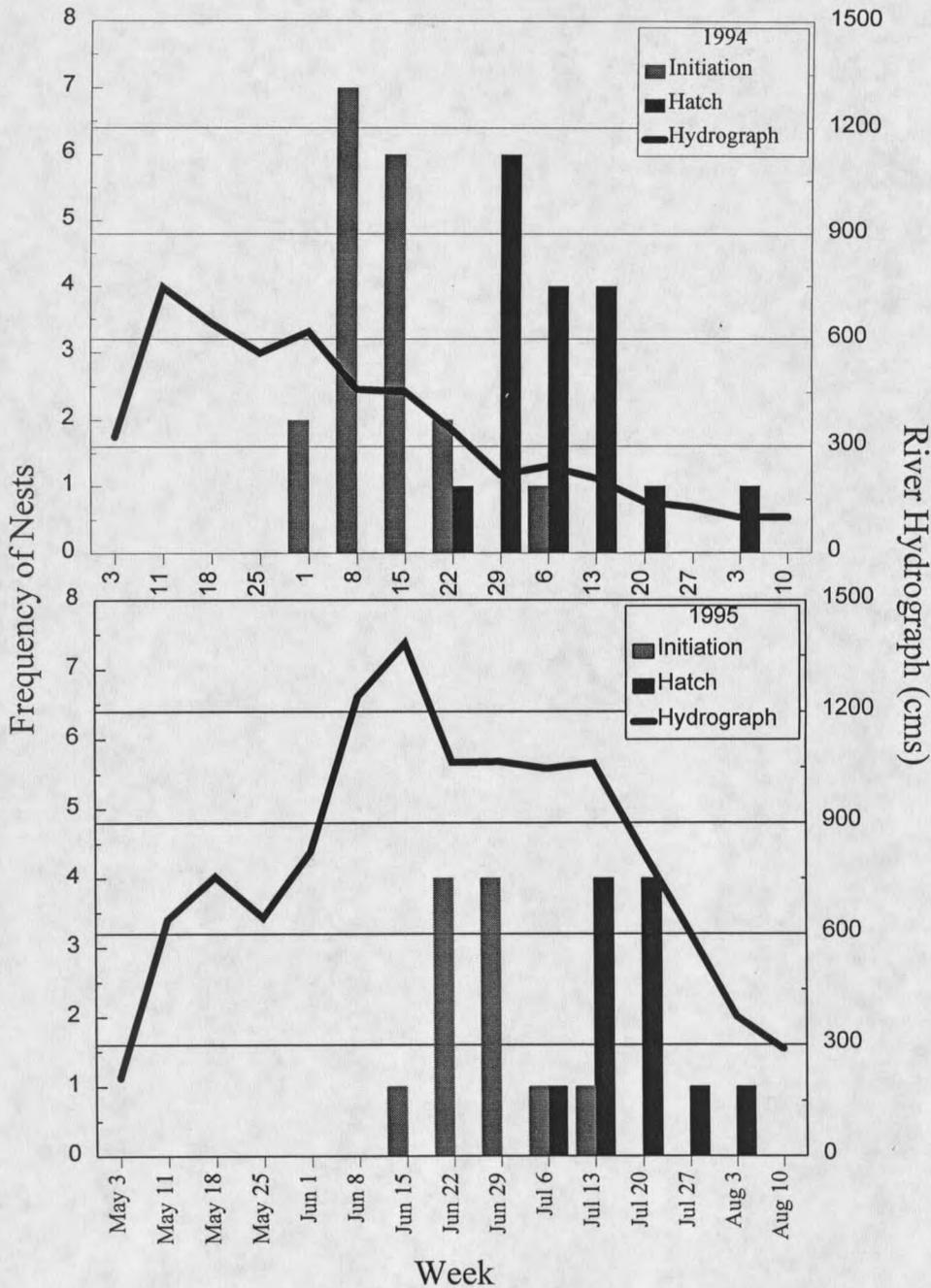


Figure 8. Frequency of least tern nest-initiation and hatch dates and the Yellowstone River mean weekly discharge rates between Miles City and Sidney, Montana, 1994-1995 (U.S. Geological Service 1994, unpubl. data 1995).

snow-melt. In 1995, 8 of 11 nests (72.7%) were initiated between 22 June and 5 July (\bar{x} = 1,064 cms), which was 3 days to 3 weeks after peak flows due to snow-melt occurred. In 1994, the peak of hatching was 2 weeks earlier than the peak of 1995.

Breeding success was more favorable in 1994 than 1995 (Table 4). Annual variation in population size and breeding success resulted in large discrepancies in fledgling production; 23 chicks were fledged in 1994 whereas only 1 fledged in 1995 (Tables 3 and 4).

Table 4. Reproductive success of interior least terns on the Yellowstone River between Miles City and Crane, Montana, 1994-1995.

Productivity Variables	1994	1995	Annual Mean (SE) ¹
Mayfield Survival ²	83.5%	55.8%	69.7% (13.9%)
90 % CI	78.4-88.6%	46.6-65.0%	
Binomial Survival ³	88.9%	63.64%	76.3% (12.6%)
90 % CI	83.5-94.3%	43.2-84.1%	
Fledglings/nesting pair ⁴	1.35	0.1	0.72 (0.63)
Fledglings/successful nest attempt ⁵	1.44	0.14	0.79 (0.65)

¹ Equal weighting of annual means, SE of annual means.

² Mayfield 1975, Johnson and Shaffer 1990.

³ Number of failed nests divided by the number of successful nests.

⁴ Number of fledglings divided by the number of known nesting pairs.

⁵ A nest is successful when 1 egg is pipped or hatched.

I found no direct evidence of predation of eggs during either season. However, predation was suspected in 1 nesting colony in 1995 when albumen was observed in 1 of 3 nests that failed within a 5-day period. Failure of the 3 nests may have been due to hail

storms that passed through the area during that time period. Two chicks 5 to 7 days old died in their nest bowl in another colony, apparently due to a rain or hail storm. No depredation of terns by mammals was observed, but predators were common throughout the study area. Raccoon (*Procyon lotor*) tracks were ubiquitous on the area and on nesting bars. I saw a badger (*Taxidea taxus*) swimming across the river channel in the vicinity of a nesting colony. The only predation event that I witnessed was a toad (*Bufo woodhouseii*) ingesting a 1 to 2 day old tern chick. Toad tracks were numerous within the nesting colony and in many locations throughout the study area.

Disturbance of nesting colonies by humans was not detected. Domestic cattle may have disturbed the nest in stratum 3 during 1994 when the bar accreted to shore enabling cattle access. No evidence of nest or chick inundation by high river flows was found during either season. Though difficult to determine, a high percentage of nest and chick mortality was likely the result of heat stress or hypothermia during rain, wind or hail events.

Nest-Site Characteristics

In 1995, nests were initiated on 4 vegetated bars during the 1,050 cms river flows, and on 2 additional bars during the 850 cms flows. During peak nest initiation ($\bar{x} = 1,050$ cms), the amount of exposed cobble was greater ($P = 0.09$) on nesting bars (median = 0.24 ha, 25th-75th percentile = 0.17-0.6, $n = 4$) than on non-nesting bars (median = 0.12 ha, 25th-75th percentile = 0.09-0.18, $n = 8$). No differences in the amount of exposed cobble were detected during the 850 cms flow rates ($P = 0.15$).

The ratio of exposed cobble area to total island area was not different ($P = 0.31$)

between nesting and non-nesting channel bars during the 1,050 cms flows. As the breeding season advanced, and river levels decreased to 850 cms, the ratio of exposed cobble to total island area was greater ($P = 0.07$) for nesting bars (median = 28.5%, 25th-75th percentile = 12-34%, $n = 6$) than for non-nesting bars (median = 11.0%, 25th-75th percentile = 3-24%, $n = 20$).

Tests among heights on nesting bars and among heights on non-nesting bars indicated that profiles of cobble areas differed on the 2 types of bars (Figure 9). There were no differences during the 1,050 cms ($P = 0.57$) and 850 cms ($P = 0.72$) flow rates among all height measurements on nesting bars. Differences were found among heights of non-nesting islands during both flows (1,050 cms: $P = 0.002$, 850 cms: $P < 0.001$). Heights of the highest cobble point among all habitat types (nesting vegetated channel bars, unvegetated bars, point bars, slough points) were not different ($P = 0.62$).

Pair-wise tests between each height measurement of nesting and non-nesting channel bars revealed which heights were different within the cobble area profiles (Figure 9). Differences between nesting and non-nesting bars were detected at 50 m ($P = 0.05$) and 100 m ($P = 0.02$) from the high point during the 1,050 flows rates, and also during the 850 cms flows (50 m: $P = 0.05$, 100 m: $P = 0.01$). Nesting channel bars were higher at 50 m and 100 m from the high point than non-nesting bars.

Heights of nests in 1995 were equal to or slightly larger than all other heights that were measured on the channel bar on which the nest was placed. Four of the 11 nests were placed in microsites that exceeded the height of the cobble area at the high point.

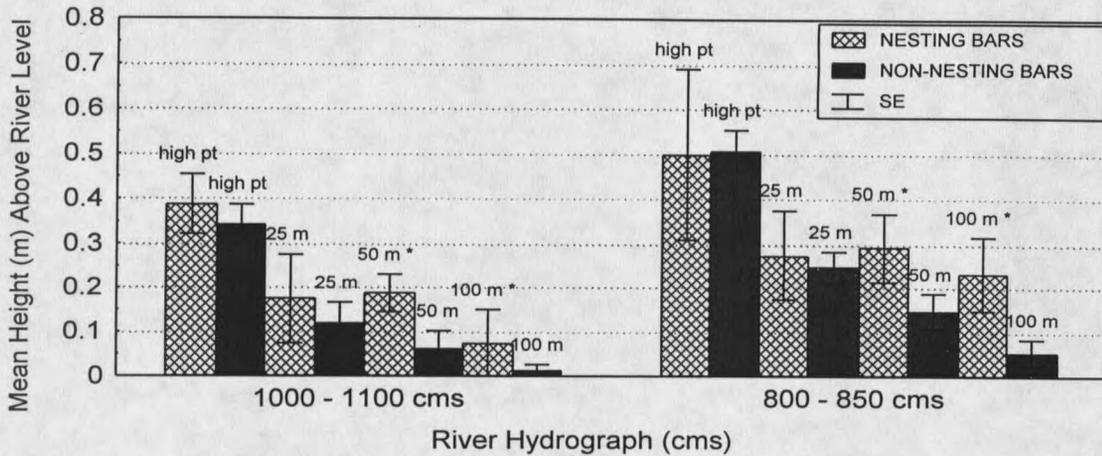


Figure 9. Comparisons of heights-above-river-level of exposed cobble areas at various points on nesting and non-nesting vegetated bars measured during 1,000-1,100 cms and 800-850 cms flow rates on the Yellowstone River between Miles City and Crane, Montana, 1994-1995. Measurements were taken at the highest point of exposed cobble and at additional points placed at 25 m, 50 m, and 100 m along a transect extending toward the upstream point. (Asterisk (*) indicates a significant difference between the height of nesting and non-nesting channel bars at 50 m and 100 m.)

Vegetation cover on channel bars used for nesting during both breeding years was

largely plants <2 m in height (Table 5). Community type of vegetation on all nesting bars was plains cottonwood (*Populus deltoides*)/ ~~recent alluvial bar~~, representing early ~~alluvial bar~~, *sandbar willow (S. exigua)*, recent ~~alluvial bar~~, *stage* (Hansen et al., 1995).

In 1995, no differences in nest-site characteristics were found between associated random and used nest sites. Nests were placed on sites with sparse vegetative and sparse woody debris cover (Table 6). Length of driftwood was >0.5 m in 69.7% of the drift material measured ($n = 33$). Nest heights of used nest sites ($n = 11$) above river during the week of 2 to 7 August (1995) were greater ($P = 0.09$, median = 1.2 m, 25th-75th percentile = 1.0-1.5) than the height of random nest sites (median = 1.05 m, 25th-75th

Table 5. Percent vegetation cover of 15 channel bars used for nesting by interior least terns on the Yellowstone River between Miles City and Crane, Montana, 1994-1995.

Vegetation characteristics	Quartiles		
	25%	Median	75%
Total channel bar			
% <2 m in height	50.0	62.6	90.0
% >2 m in height	5.0	37.5	50.0
Cobble habitat area			
Total % plant cover	2.5	2.5	10.0
% <0.5 m in height	15.0	37.5	75.0
% 0.5-2.0 m in height	5.0	50.0	85.0
% >2.0 m in height	0	0	0

Table 6. Characteristics of 11 nest sites used by interior least terns on the Yellowstone River between Miles City and Crane, Montana, 1995.

Characteristic	Quartiles		
	25%	Median	75%
Woody debris diameter (cm) ¹	0.1	0.3	9.5
Distance to woody debris (m) ¹	5.0	7.0	14.0
Vegetation height (cm) ²	17.5	37.5	75.0
Distance to vegetation (m) ²	2.0	3.0	6.0

¹ Three drift wood >5 mm diameter that were closest to the nest sites.

² Three plants >10 cm in height that were closest to the nest sites.

percentile = 0.6-1.2). Random nest sites ($n = 18$) were located a median distance of 46.0 m (25th-75th percentile = 25.0-64.5 m) from used nest sites, whereas the median distance between used nest sites ($n = 18$) was 39.4 m (25th-75th percentile = 20.0-58.0 m).

Discussion

Least terns were more numerous on the Yellowstone River in 1994 ($n = 40$) than in 1995 ($n = 21$). Several interacting factors may influence the number of terns that arrive annually on the breeding area. I hypothesize that the magnitude and timing of peak river flows primarily determine the annual density of least terns on the Yellowstone River during the breeding season.

In 1994, peak flows from the melting of mountain snow-pack occurred earlier than is typical. A mean monthly peak flow as early as the month of May has only occurred twice in the past 70 years. The magnitude of the mean monthly peak flow rates in 1994 were also atypical (1 in 10 year event). In 1995, the timing and magnitude of mean monthly peak flows were typical (1 in 2 to 3 year events). More breeding habitat was available earlier in the season in 1994 due to lower river levels and warmer, drier climatic conditions than in 1995. These more favorable conditions may explain why more terns were observed in 1994.

I observed twice as many adult least terns on the Yellowstone River during 1994 and 1995 ($\bar{x} = 30.5$ /year) than were observed during 1988-1993 (Rabenburg et al. 1993: $\bar{x} = 15.2$ /year, S.E. = 1.5). Previous surveys were generally conducted during a 1 week period at the end of June, whereas I surveyed weekly throughout the breeding seasons. Thus, increased sampling effort was probably responsible for the higher numbers in 1994 and 1995 and likely represent more accurate estimates.

In Montana, least terns also nest on the Missouri River and the Fort Peck Reservoir. Terns have been observed on the lower Yellowstone River downstream of the

study area near the North Dakota border, but no nests have been found. A mean of 114 adult least terns were estimated in the state of Montana during 1994 and 1995 (The Montana Piping Plover Recovery Committee 1995, Chalfoun and Goodchild 1995).

Thus, the mean population estimate of ^{30.5}32 adults on the Yellowstone River represented ²⁷28% of the total Montana population during 1994 and 1995. The Montana least tern recovery objective of 50 adults (U.S. Fish and Wildlife Service 1990) has been exceeded since 1989 (Rabenburg et al. 1993, The Montana Piping Plover Recovery Committee 1995). This study suggests that the Yellowstone River supports an important number of least terns, which in some years approaches the recovery goal of 50. Montana may support ≥ 2 separate breeding populations; future research should include investigations into the degree to which these populations interact.

Disturbances from humans and their machines have resulted in mortality of least tern eggs and chicks (Smith and Renken 1993). However, human disturbance was not known to affect least tern reproductive activities on the Yellowstone River. Recreation is usually limited to fishing and agate hunting within the study area. Very few people were observed close to nesting channel bars. The relative seclusion of the channel bars used for nesting, the limited number of access sites to the river, and difficult navigation during mid-summer low flows, likely decrease the probability of disturbance from humans. Only 1 incidence of probable domestic animal disturbance (cattle) was known to occur (1994).

Average apparent nest success ($\bar{x} = 76\%$) of least terns on the Yellowstone River during this study was 8% greater than success on the Missouri River, Montana,

1993-1995 (The Montana Piping Plover Recovery Committee 1995, Chalfoun and Goodchild 1995: \bar{x} = 68%), and 56% greater than estimates on the Yellowstone River, 1989-1991 (Rabenburg et al. 1993: \bar{x} = 20.0%). Kirsch (1996) estimated 54% nest success on the Platte River, Nebraska (1987-1990), and Smith and Renken (1993) estimated 62% on the lower Mississippi River (1987-1989). Though nest success on the Yellowstone River was highly variable, the mean was similar to or greater than the nest success of these other studies within the interior river system.

The Yellowstone River produced 1.35 fledglings/nesting pair in 1994. During the same year, the highest fledging ratio (1.1) since record keeping began in 1990 was observed on the Missouri River, Montana. High nest success rates on both rivers suggest that factors affecting tern reproduction may operate on a broad scale in Montana. Low fledgling ratio in 1995 on the Yellowstone River (0.1) was not due to inundation from high flows but likely due to severe, localized weather events.

On the Yellowstone River during 1994 and 1994, the mean annual fledging ratios were variable between years (\bar{x} = 0.72, S. E. = 0.63) but were comparable to or better than fledging ratios in other areas within the interior river system. Fledging ratios for the Missouri River (1990-1995) and for 17 areas in the interior U.S. (1986 - 1991, E. Kirsch, pers. commun.) were 0.61 and 0.56, respectively. Estimates for the Platte River, Nebraska, 1987-1990 (Kirsch 1996) and the lower Mississippi River (Smith and Renken 1993) were 0.47 and 0.70, respectively. The estimate calculated for the Yellowstone River, 1989-1991, of 0.2 (Rabenburg et al. 1993) may have been an underestimate due to incomplete surveys of a small number of the colonies. The fledging of chicks within 2-3

weeks after hatching can result in underestimating fledgling production (Hardy 1957).

During both seasons, nest initiation occurred after the peak flow, which is typical of riverine-nesting species (Hardy 1957). No nests were inundated by high river flows on the Yellowstone River during 1994 and 1995, but inundation from dam releases (Sidle et al. 1993, The Montana Piping Plover Recovery Committee 1995) and high tributary inflows (Sidle et al. 1992, Smith and Renken 1993, The Montana Piping Plover Recovery Committee 1994) remain as threats to nesting least terns within the interior river system. Initiated nests may be in danger of inundation if water from impoundments on the Big Horn and Tongue Rivers are released during increased flows on the Yellowstone River.

All habitat types were likely available for nesting throughout the entire study area during peak flow rates (883 cms) in 1994. Thus, based on availability of nesting habitat, terns could have nested earlier than they did in 1994. However, most terns waited 4 to 6 weeks after peak flows occurred before nesting. Because peak flows have occurred in June in 68 out of the past 70 years, I suspect that terns on the Yellowstone River use proximate cues that are correlated with the average peak as an indication that peak flows have passed. These cues could be day length, air or water temperature, clarity of water, or food availability (Perrins 1969), and not only the amount of habitat available.

In 1995, least terns were observed loafing and exhibiting breeding behavior on channel bars used for nesting in 1994, which suggests high nest-site fidelity (Atwood and Massey 1988). Terns that initiated nests on partially flooded channel bars in 1995 that were used for nesting in 1994 further suggests nest-site fidelity. This behavior does not support the suggestion of Buckley and Buckley (1980) that least terns readily change nest

sites. Observations of color-banded adults in multiple years are needed to determine the degree to which site tenacity determines nest-site choice on the Yellowstone River (Burger 1984).

Most nesting colonies and nests occurred within stratum 2. Within this stratum, the channel became more sinuous than in stratum 1, and overlapping islands (land masses with mature vegetation growth) surrounded by irregular channel activity (i. e., sloughs) and channel bars became more numerous. Terns were frequently observed foraging in the lateral channels, and around the periphery of unvegetated bars and slough points that were more numerous as river levels dropped. Unvegetated bars were also used by adults and fledglings as safe areas when intruders disturbed natal areas. Due to greater channel sinuosity, the high sediment carrying capacity of the river during elevated flows may decrease as the river loses velocity in stratum 2. Consequently, sediment and bedload deposition onto channel bars may also increase within stratum 2, thus explaining why more channel bars in stratum 2 were used as nesting locations. Stratum 3 was more meandering than stratum 2, with multiple river channels and overlapping islands. Much of the cobble habitat in stratum 3 was not available for nesting until river levels dropped below 850 cms and was subject to shore accretion.

The community type of nesting channel bars (plains cottonwood/ recent alluvial bar) indicated that the habitat was maintained in an early seral stage of primary succession (Hansen et al. 1995). The scouring floods needed to prevent vegetation encroachment (Sidle et al. 1992) and to reset successional stages (Sveum 1988) occur in most years on the Yellowstone River. Such scouring appears to be important to nesting

terns on this free-flowing river as nests were consistently located in areas almost completely denuded of vegetation (<2.5% cover), which is commonly the case in least tern breeding areas (Schwalbach 1988, Smith and Renken 1991, Sidle et al. 1993).

During peak nest initiation in 1995, available nesting habitat was limited to exposed cobble on vegetated channel bars. The length of time that nesting habitat is exposed above water may partially explain why terns exclusively used vegetated channel bars for nesting in the Yellowstone River. Smith and Renken (1991) found that sand bars and sand islands used for nesting were more likely to remain exposed above water for at least 100 days.

Though more habitat was available on nesting than non-nesting vegetated bars during peak nesting flows in 1995, neither the height above river level (at the high point or 25 m from the high point), or ratio of cobble area to total channel bar area of nesting bars were different from these characteristics of non-nesting bars. Thus, there were other important characteristics of those channel bars specifically chosen for nesting that were not apparent until river levels dropped. As the flow rate decreased to 800 - 850 cms, the ratio of cobble area to total area of nesting bars exceeded this ratio of non-nesting bars. This suggests that vegetated channel bars used for nesting may be scoured of vegetation more often than non-nesting bars.

The profile of the cobble dome on nesting channel bars was different than non-nesting bars; nesting bar cobble areas were higher toward the upstream channel bar point than non-nesting bars. This may indicate that there is more sediment or bed load deposition onto the cobble areas of nesting bars than onto non-nesting bars. No

differences among heights of the cobble dome on nesting bars suggests the profile was somewhat flat, whereas differences among heights on non-nesting bars indicate a steady decline in the slope of the dome toward the upstream point. Thus, cobble habitat on non-nesting bars may become inundated at lower river levels than the cobble habitat on nesting bars.

Higher cobble domes on nesting bars resulted in more available nesting habitat at high river flows than on non-nesting bars. Within other areas of the interior river system, least terns typically nest in the largest areas of available habitat (Schwalbach 1988, Kirsch 1996). Although there were large expanses of available habitat on the Yellowstone River, these habitats were not available until later in the breeding season in 1995 (<1,050 cms). Later availability of a habitat indicates that the area was more susceptible to inundation during river flows that typically occur during mid-June.

Terns placed their nests within the highest areas of the cobble dome in 1995. Also, nests were higher above water than were random nest-sites, which provided further evidence that terns nested on the highest portion of the cobble dome. Thompson and Slack (1982) also observed this phenomenon on the coast of Texas, as did Schwalbach (1988) in South Dakota on the Missouri River. In 1995, 4 of 11 nests initiated in 1995 were actually placed in areas that were greater in height than any point measured along the crest of the dome, which suggests that terns may use small mounds as a nest site. Such microsites may offer additional protection from floods or drain more efficiently after torrential rain events.

In addition to protection against flooding, high and expansive areas of exposed

cobble provided refugia for hatchlings fleeing from disturbance. As young terns matured, they sought refuge at the edge of the cobble area, where newly exposed, silt-covered cobbles provided excellent camouflage for the tawny-colored young. After fledging, young birds also spent their time along the large area of river-cobble interface.

The exclusive use of channel bars for nesting during 1994 and 1995 on the Yellowstone River indicates the importance of channel bars as nesting habitat. Channel bars on the Yellowstone River had characteristics other than length of time the habitat remained above river level that attracted nesting terns and consequently imparted reproductive advantages. Active river channels remained around channel bars and likely provided a barrier to many predators. Nests in colonies on islands that accrete to shore or on sand pits along a river bank experience higher rates of predation and disturbance than nesting habitat isolated by river channels (Smith and Renken 1993, Kirsch 1996).

The Yellowstone River population of least terns is small. Although the population may be insignificant within the context of the total number of adult terns within the interior river system, it does represent about one-third of the Montana population. Though it is not advisable to compare 2 years of variable reproductive data of least terns on the Yellowstone River to other longer term data bases, the mean reproductive values were equal to or slightly higher than rates for many areas within the interior river system. Given that the Yellowstone River is one of the only free-flowing rivers used by breeding least terns and that reproductive success was very high in 1994, further study of terns breeding in this natural environment is warranted.

Management and Research Implications

Reproductive success on the Yellowstone River, Montana, was variable in the 1994 and 1995 breeding seasons, but a potential for high fledgling production was evident. Nest predation and human disturbance have negatively affected least tern reproduction in other areas within the Missouri and Mississippi River systems (Sidle et al. 1992, Smith and Renken 1993, Kirsch 1996), but these factors did not appear to be threats in the areas of greatest nesting density on the Yellowstone River. Weather-induced mortality from hail, rain, and wind storms was likely the largest threat to reproductive success during the 1994 and 1995 breeding seasons on the Yellowstone River.

The high degree of apparent nest-site tenacity for partially vegetated channel bars on the Yellowstone River indicates that particular nesting habitat is preferred by least terns. These observations suggest that protection of nesting habitat that is located in riverine systems that receive a high degree of human and predator disturbance is advisable. Placement of fences and signs on nesting habitat may provide the needed protection from disturbance, although in some cases such warnings may draw unneeded attention to the nesting colonies.

Chicks that hatched on the Yellowstone River were most vulnerable to perishing during the first week post-hatching. Smith and Renken (1991) recommended installing logs and debris near the nest site to serve as protective cover for the chicks. Fencing large circumference areas around nests for the first week after hatching may increase chick survival. These recommendations are intended for areas where several disturbance

factors are present (human, predation, inundation from dam releases, severe weather).

Due to the apparent lack of impacts on the Yellowstone River, I do not recommend these measures at this time.

Surveys and estimates of reproductive activities should continue for least terns on the Yellowstone River. Population viability of least terns on the Yellowstone River is undetermined because we lack estimates of several population parameters that are required to determine population growth rate. Using fledging ratios of 0.5, Kirsch (1996) estimated that population trends for least terns are negative unless 90% of fledglings survive. Given higher fledging ratios (0.72) on the Yellowstone River, a positive population trend would not demand as high of a fledging survival rate. Because of the sensitivity of long-lived birds to post-fledging survival rates and our lack of accurate rates for interior least terns (Kirsch 1996), accurate projections of population growth are not possible and more research is needed to delineate these estimates. Banding studies on the Yellowstone River would provide us with survivorship and philopatry data for least terns breeding on a natural river.

Though no dams exist on the Yellowstone River, there is a danger of flooding tern nests with tributary-dam releases. The Big Horn River (Yellowtail Dam) has the greatest capacity to flood nesting habitat on the Yellowstone River, especially if water is released during increasing discharge rates on the Yellowstone. Tongue River Reservoir is currently being enlarged, and though it has a smaller holding capacity than the Yellowtail Reservoir, simultaneous large releases from both dams would place least tern nests and chicks on the Yellowstone River in serious danger of inundation. Based on my findings

that: (1) >85% of the least tern nests were initiated after the first week of June, (2) >80% of nests hatched before the last week of July during 1994 and 1995, and (3) nesting habitat on channel bars used for nesting during both seasons was above river level at 850 cms, I recommend that releases from dammed tributaries be tempered when flow rates on the Yellowstone River exceed 800 cms between 7 June and 25 July.

The natural rate of disturbance on the Yellowstone River due to its unrestricted flow regime maintains channel bar nesting habitat in an early successional stage. Ice floes and sustained floods of large magnitudes scour vegetation from the cobble area of nesting channel bars. During the declining stage of peak flow rates, sediment is deposited onto channel bars used for nesting at heights sufficient to protect nests and chicks from inundation during high flow rates. The variable hydrograph and sediment carrying capacity of the Yellowstone River and its unrestricted access to erodible banks during the course of meandering results in the geomorphology characteristic of free-flowing rivers. Maintaining the Yellowstone River in its natural state will continue to provide an excellent source of valuable information regarding the ecology of free-flowing river systems and their inhabitants.

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APPENDICES

A.--THE YELLOWSTONE RIVER STUDY AREA INDICATING
RIVER ACCESSES AND DIVERSION DAM

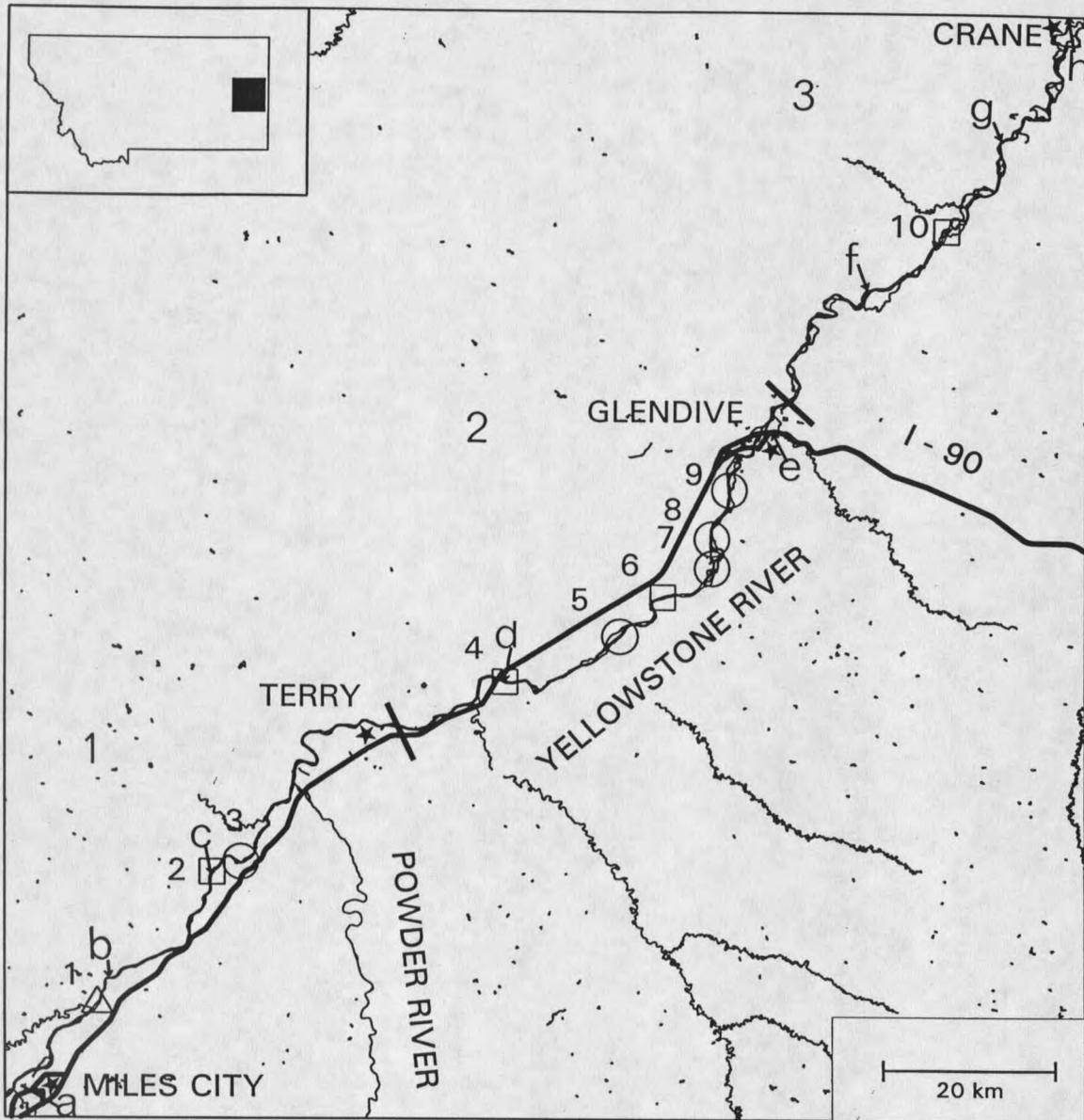


Figure 10. Nest site locations of interior least tern breeding seasons on the Yellowstone River between Miles City and Crane, Montana, 1994-1995 (APPENDIX E). Letters indicate river accesses: (A) Miles City (south [S] access), (B) Kinsey Bridge (north [N] access), (C) Kinsey [N], (D) Fallon Bridge [N], (E) Glendive [S], (F) Intake Diversion Dam and access [N], (G) Savage, Elk Island [N], (H) Crane, Seven Sisters [N]. Numbers (1-10) indicate colony locations (APPENDIX D); channel bars colonized in 1994: \square ; in 1995: \triangle ; and both years \circ . Lines across the Yellowstone River indicate location of the strata divisions and the numbers 1, 2, and 3 above the river indicate strata.

B.--NEST RECORD SHEETS

NEST RECORD

1 2 3			SITE SUMMARY (DATA CONTROL 1)												4 5	
SPECIES															SITE	
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
NEST			YEAR				HABITAT		REACH	RIVER MILE						
(For Reservoir Use Only)																
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
STATE		TOWNSHIP				RANGE		SECTION		1/4-1/4 SECTION						

NEST DATA (DATA CONTROL 2)

VISIT	DATE			OBSERVER	WEATHER		WHOLE EGGS		NEST STATUS					
	MO	DAY	42		TEMP	WIND	NO.	INCUB.						
35	40	41	42	43	44	45	46	47	48	49	50	51	52	53

54	55	56	57	58	NEST SUMMARY		62	63	64	65	66	67	
EGGS HATCH	EGGS ADDL	NEST INITIATION	EXACT TERM DATE	ESTIMATED HATCH DATE	EXPOSURE DAYS	CHICKS FLEDGG							
68	69	70	71	72	PREDATOR MANAGEMENT			76	77	78	79	80	81
FATE	CAUSE	PRED	REASON	CAGE DATE	STROBE DATE	OTHER							

COMMENTS:

NEST SITE MAP

NEST RECORD PROCEDURES

SPECIES

Box 1-3
A.G.U. Species No.
277 Piping Plover
074 Least Tern

SITE

Box 4
River Reach (See Box 16)
Box 5-6
Site Number

SITE SUMMARY (Data Control 1)

Box 7-9
Total Nests w/in Reach
Box 10-13
Year Nest Located
Box 14-15
Nest Site Habitat
River Systems
01 Sandbar
02 Beach or Shore
03 Island
04 Island Beach
Reservoir Systems
05 Beach
06 Peninsula/Point
07 Island
08 Island Beach
09 Isl. Peninsula/Point
10 Other

Box 16
Reach Nest Located In
1 Fort Peck Reservoir
2 Fort Peck River
3 Lake Sakakawea
4 Garrison River
5 Lake Oahe, ND
6 Lake Oahe, SD
7 Fort Randall River
8 Lewis and Clark
9 Gavins Point River

Box 17-21
River Mile of Colony Site to Nearest 10th of Mile
Box 22-38
Legal Description of Colony Site (Reservoirs)

NEST DATA (Data Control 2)

Box 39
Number of Nest Visit
1 Final Nest Visit
Box 40-42
Date of Nest Visit
Box 43-45
Observers Initials
Box 46-47
Temp to Nearest 5°F
Box 48-49
Wind to Nearest 5mph
Box 50
No. Eggs in Nest

Box 51-52
Incubation Stage (See Diagram Below)
00 Laying Stage
nn Number Days Inc.
44 Pipped
53 Hatched
Box 53
Status of Nest
0 Unknown
1 Undist/Normal
2 Abandoned
3 Eggs Missing from Previous Visit
4 Hatched
5 Destroyed
6 Other

NEST SUMMARY

Box 54
Number of Eggs Hatched
Box 55
Nonviable Eggs in Nest
Box 56-58
Nest Initiation Date
Plovers
(2)(50)-1)+51&52-41&42
Terns
(1)(50)+51&52-41&42
Box 59-61
Exact Term Date (Only if Known)
00 Unknown
Box 62-64
Computer Generated
Box 65-66
Computer Generated
Box 67
From Productivity Rec.

NEST FATE

Box 68
Fate
1 Hatched
2 Destroyed
3 Abandoned
4 Nonviable Eggs
5 Unknown
Box 69-70
Cause
Hatched
10 Other (explain)
11 Chicks in Bowl
12 Chicks on Site
13 Hatched Egg Shells
14 Pipping Fragments
15 Chick Droppings
Destroyed
Flooded
20 Other (explain)
21 Eggs Washed Out
22 Nest Filled, No Eggs
23 Flood Debris
Destroyed
Weather
30 Other (explain)
31 Eggs Suspended
32 Eggs Smashed
33 Eggs Blown Out
Destroyed
Predator
40 Other (explain)

41 Tracks w/in 2m of Nest
42 Des. Egg Shells
43 Egg Yolk in Bowl
44 Predator Observed
Destroyed
50 Sandbar Erosion
60 Harren Disturbance
70 Other (explain)
Abandoned
80 Other (explain)
81 Observer Disturb.
Box 71
Known Predator
1 Mink
2 Raccoon
3 Coyote
4 Red Fox
5 Domestic Dog
6 Striped Skunk
7 Ring-billed Gull
8 American Crow
9 Other
Box 72
Factor For Predator Identification
1 Predator Observed
2 Tracks Near Nest
3 Destroyed Egg Characteristics

PREDATOR MANAGEMENT

Box 73-81
Date of Management Applications



Threatened & Endangered Species Program 1994

Figure 11. Nest record sheets provided by the Army Corps of Engineers.

C.--MEAN DAILY FLOW RATES OF THE YELLOWSTONE RIVER BETWEEN
MILES CITY AND CRANE, MONTANA, 1994 - 1995:

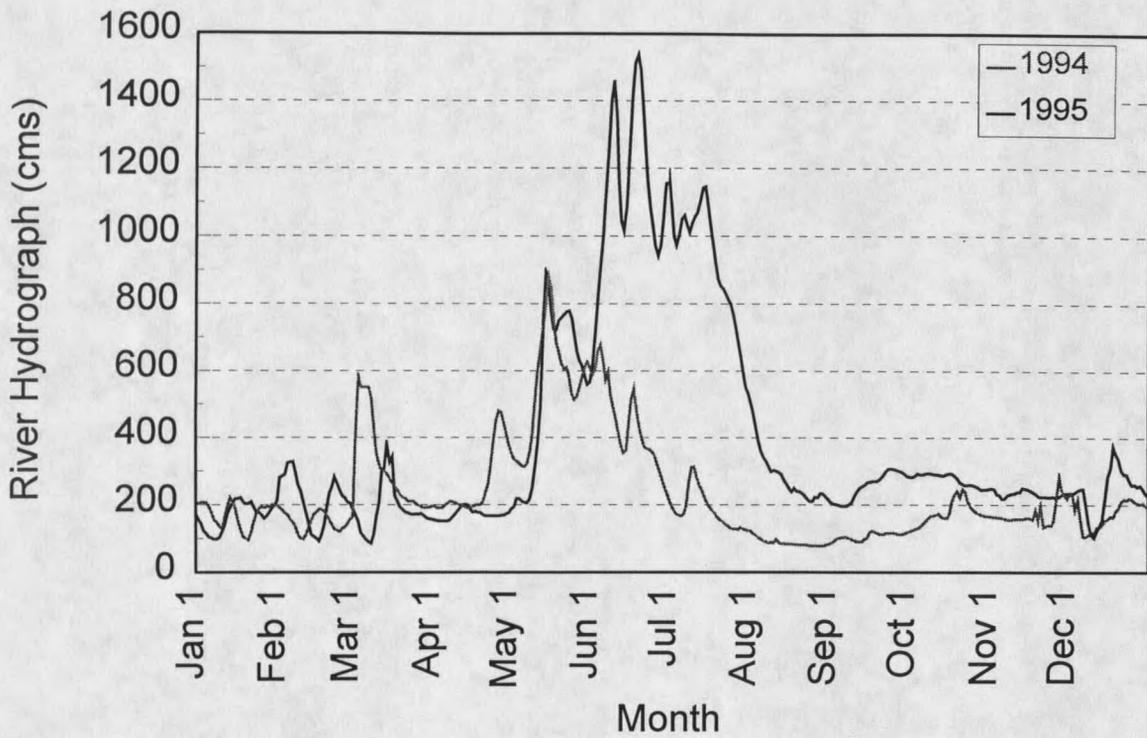


Figure 12. Mean daily discharge rates of the Yellowstone River between Miles City and Sidney, Montana, 1994-1995 (U.S. Geological Service 1994, U.S. Geological Service unpublished data 1995).

D.--BREEDING ACTIVITY, 1994 - 1995

Table 7. Breeding activity of the interior least tern on the Yellowstone River between Miles City and Crane, Montana, 1994.

STRATUM ¹	COLONY ²	# ADULTS	# NESTS	# EGGS	# SUCCESSFUL NESTS ³	# FLEDGLINGS
1	2	4	3	7	2	3
	3	2	1	3	1	2
2	4	4	2	5	2	2 ⁴
	5	11	4	11	4	5 ⁵
	6	2	1	3	1	0
	7	4	2	5	2	5
	8	6	3	8	3	4
	9	2	1	3	1	2
3	10	5	1	3	0	0
Total	10 ⁶	40	18	48	16	23

¹ Stratum are approximately 66.5 km in length; stratum 1 begins at Miles City and stratum 3 ends at Crane.

² Colonies use different channel bars; breeding season locations combined: (1) most upstream to (10) most downstream.

³ A nest is successful when 1 egg is pipped or hatched.

⁴ Fledglings from 1 nest, unknown if 2nd nest produced fledglings.

⁵ Fledglings difficult to count; 5 represents minimum number counted during an observation period.

⁶ Three "colonies" were comprised of only 1 nesting pair.

Table 8. Breeding activity of the interior least tern on the Yellowstone River between Miles City and Crane, Montana, 1994.

STRATUM ¹	COLONY ²	# ADULTS	# NESTS	# EGGS	# SUCCESSFUL NESTS ³	# FLEDGLINGS
1	1	2	1	3	0	0
	3	6	3	5	0	0
2	5	8	4	9	4	0
	7	23	1	2	1	1
	8	2	1	2	1	unknown
	9	2	1	2	1	0
3		none	none			
Total	6 ⁴	24	21	11	23	7

prob. missed here

¹ Stratum are approximately 66.5 rkm in length; stratum 1 begins at Miles City and stratum 3 ends at Crane.
² Each colony uses a different channel bar; breeding season locations combined: (1) most upstream to (10) most downstream.
³ A nest is successful when 1 egg is pipped or hatched.
⁴ Four "colonies" were comprised of only 1 nesting pair.

E.--UTM COORDINATES OF LEAST TERN
NESTING CHANNEL BARS

Table 9. UTM coordinates of the nest locations on the Yellowstone River during the 1994 and 1995 nesting seasons between Miles City and Crane, MT.

Strata	Colony # ¹	UTM Coordinates	
		East	North
1	1	443,350	5,150,000
1	2	457,000	5,165,800
1	3	460,400	5,167,000
2	4	492,000	5,188,600
2	5	505,600	5,194,100
2	6	510,600	5,198,800
2	7	516,500	5,202,300
2	8	516,450	5,205,800
2	9	518,500	5,211,700
3	10	543,300	5,243,200

¹ Breeding season locations combined: (1) most upstream to (10) most downstream (see APPENDIX D).

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