INCUBATION BEHAVIOR AND ARTIFICIAL NEST STRUCTURE USAGE IN BLACK TERNS NESTING ALONG THE MISSISSIPPI RIVER

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ABSTRACT

Night incubation behavior of black terns was studied in 1991 by use of an 8 mm camcorder operated in time-lapse mode and linked to a night vision device. While some birds remained on the nest throughout the night, others left the nest unattended the entire night or left during the night. In each case that a nest was left unattended during the night, a bird returned to incubate near sunrise and incubation then proceeded without significant interruption throughout the day. During the day, the nest was frequently left for very short periods (usually two minutes or less) and incubation duties were exchanged between male and female frequently, usually within the hour. Two instances of owls approaching near the nest during the night were observed in 14 nights of taping. In one case the tern remained on the nest; in the other, it fled the nest and did not return until sunrise. In neither case did the owl make any attempt to take the eggs, suggesting that owls are not significant predators of black tern eggs.

Two sizes of artificial platforms were tested as nesting substrates in both 1990 and 1991. Platforms were distributed in four marshes in 1990 and in five marshes in 1991. Despite previous significant colonies in these marshes, little nesting occurred in any of them except Trempealeau National Wildlife Refuge in 1990 and 1991. Platforms were used only by birds in TNWR in 1990 and 1991. In each year, five platforms of each size were available for use in TNWR. In 1990, seven of the platforms were used and accounted for ten nest attempts. In 1991, five of the

platforms were used and accounted for six nest attempts. Overall, 12 of 20 platforms were used for 16 nest attempts. Large platforms were preferred over small ones with eight and four being used, respectively. A ring of hardware cloth was added to the platforms in 1991 to help retain nesting material. Hatching success was nearly identical on large and small platforms. Large platforms were used for four renest attempts over the two years while none of the small platforms were re-used. Hatching success was significantly greater on artificial platforms (89%) compared with that on natural platforms (52%) in 1990 ($\chi^2 = 4.36$, $\underline{p} = .036$). Hatching success was similar on artificial and natural platforms in 1991, but was greater on small artificial platforms in 1989 (50% versus 29%). Widespread usage of large artificial platforms may significantly increase hatching success and renesting of black terns and offers hope of reversing their population decline.

INTRODUCTION

The black tern, Chlidonias niger, is a common resident of Minnesota marshes. It is both piscivorous and insectivorous. Nests are placed on floating mats of decaying vegetation in shallow water, usually adjacent to emergent vegetation such as giant bur-reed (Sparganium eurycarpum), broad-leaved cattail (Typha latifolia), or narrow-leaved cattail (Typha angustifolia). The species has experienced significant decline across the United States. Breeding Bird Survey data have shown a national annual decline of 7.26% from 1966-1987. The decline in Minnesota during the same time period was 3.94%. This decline has not been fully explained.

Previous research by the author has shown low hatching success resulting from disappearance of eggs from the nest. Predation appears to account for most of the egg losses, although some eggs are lost due to waves washing over the nests or nest damage due to decay of the vegetation. Predators certainly include raccoons (Procyon lotor) and mink (Mustela vison), but may also include water snakes (Natrix sipedon), great horned owls (Bubo virginianus), red-winged blackbirds (Agelaius phoenicus), and snapping turtles (Chelydra serpentina).

Significant losses from predation are somewhat surprising because of the species' tendency to vigorously defend the nest from intruders. Human visitors are sometimes actually struck on the head when near the nest. Predators such as mink and snapping turtles present in the nest area elicit a vigorous mobbing response by virtually all the birds in the area until the predator leaves. These observations led to the hypothesis that night incubation behavior was abnormal, leaving the nest vulnerable to predators. The hypothesis was confirmed by night observations with a spotting scope on moonlit nights and the use of temperature sensitive radiotransmitters placed in the nest. These observations showed birds leaving the nest during the night and failing to return until first light of the morning. Some nests were left unincubated for as much as six hours. In 1990, 12 nests were monitored using radiotransmitters. Of these, eight left the nest unincubated for at least two hours.

In the work reported here, the incubation process was photographed throughout the night using a night vision instrument linked with a video camcorder. Responses of terns to two designs of artificial nest platforms were also studied.

METHODS AND MATERIALS

Incubation Behavior

Night incubation behavior was recorded during late June and early July, 1991, using a combination of a night vision device and video camcorder. The night vision device was a Dark Invader second-generation light intensifier with 50,000X gain. A 70-210 mm telephoto lens was affixed to the front for image magnification. Power was provided by a 12-volt battery. An infrared spotlight was attached to the instrument to provide additional illumination. Power for this device was provided by an integral Ni-Cd battery. The camcorder was a Canon A1 Hi-8 with integral 8-80 mm lens. Power was provided by replacement of the Ni-Cd battery with a 12-volt adapter connected to a 12-volt car battery. The camcorder was fixed in position with the lens approximately one-half inch from the eyepiece of the night vision device by means of a machined aluminum adapter plate custom-made for the purpose. This plate was then attached to a heavy-duty tripod for rigidity. The entire unit was bolted to a wood table four feet square and four feet high. This table was also made as rigid as possible, with 3/4 inch plywood top, 4 x 4 inch legs, and braced with 1 x 3 inch cross members.

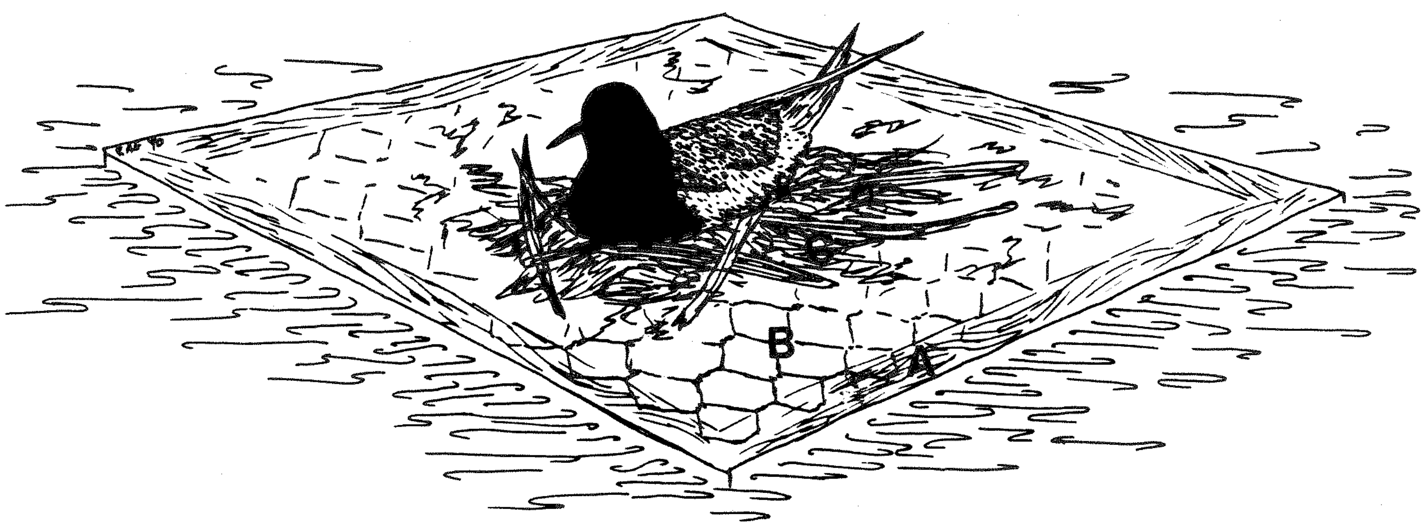
The unit was placed in the marsh approximately 40 to 75 feet from active nests. The night vision device cannot be turned on in daylight because of its sensitivity. Thus, the unit was put in place after nightfall (approximately 9:30 pm), turned on, and focused on the nest. The camcorder was then attached, turned on, and focused. The viewfinder is small on this unit and made focusing difficult at best. The camcorder was then placed in time-lapse mode and left to operate through the night. In this mode, the unit turns on for one-half second every ten seconds. An unfortunate feature of the unit is that this time-lapse mode can only be maintained for six hours. It then shuts off automatically. This required the researcher to revisit the device during the night to restart it. Anyone using such devices for research is advised to carefully investigate the equipment specifications before purchase.

This minor detail (shutoff after six hours) was not noted in the descriptive advertising literature and caused more than a little difficulty in the research. The unit was revisited at sunup (about 5 am) and returned to the lab to copy the night's tape onto a VHS tape for interpretation. In some cases, taping continued through the day using only the camcorder to enable comparison of night and day incubation patterns.

Artificial Nest Platforms

Artificial nest platforms were tested both in 1990 and in 1991. The platforms consisted of a 2 x 2 inch pine lumber frame measuring either 24 x 24 inches or 32 x 32 inches covered with 1 inch mesh poultry wire (Figure 1). The frame pieces were joined with 3-1/2 inch galvanized nails. The poultry wire was stapled in place with 9/16 inch steel staples. Platforms distributed in 1991 were modified to include a ring of hardware cloth to hold the nest material in place. This was made by cutting a strip of 1/2 inch mesh hardware cloth two feet long and one inch wide. The strip was formed into a ring and attached to the poultry wire by wrapping a few of the free ends of the hardware cloth around the poultry wire.

The platforms were distributed in early May in various marshes where black terns had been observed nesting in previous years. The platforms were laid in the water with the poultry wire facing up. They were anchored by means of a 6-10 foot long nylon cord tied to a wooden pole



A. 2" x 2" pine lumber frame for flotation, 24" x 24" or 32" x 32"

B. 1" mesh poultry wire stapled to frame

C. Decomposing vegetation added as nest material

Figure 1. Design of black tern artificial nest platforms.

driven into the sediment. Decaying vegetation was raked from the bottom and piled atop the platforms until enough material was added to make the poultry wire just touch the surface of the water. Each platform was revisited before nesting began to insure that the nest material was still in place. In some cases, it had been blown or washed off and was replaced with fresh material. The addition of the hardware cloth ring acted as a "corral" and significantly reduced this loss of nesting material in 1991. Locations of the marshes and numbers of platforms distributed in 1990 and 1991 are given in Table 1. Locations were determined by a GPS unit loaned by the U.S. Fish & Wildlife Service's Environmental Management Technical Center in Onalaska, Wisconsin.

After placement of the platforms and a revisit to replace lost nesting material, the terns were left alone until nesting had begun. Regular visits to the marshes to follow nesting began in the first week of June. Thereafter, nests were visited approximately once every 2-3 days until hatching. A sample of nests on natural platforms were studied along with those on artificial platforms to provide a control group for evaluation of the success of the artificial platforms. Approximate incubation stage was determined by egg flotation. Nests whose eggs disappeared before 17 days' incubation were considered to have failed. Those that hatched at least one young were considered successful. Any other outcome was considered as unknown because of the tendency of young to flee the nest when intruders come near beginning at 2 to 3 days after hatching. If the nest was found near hatching time without young or eggs, an area at least ten feet in diameter was searched thoroughly

Table 1. Distribution of artificial nest platforms, 1990 and 1991.

			No. Platforms Distributed			
			1990		1991	
Marsh Name	Pool	Lat-Long	Large	Small	Large	Small
Johnson Lake	5	44°12'18"N-91°55'29"W	5	5	3	2
Riley Lake	6	44°04'24"N-91°41'55"W	2	3	2	2
Boller Lake	6	44°03'25"N-91°42'06"W	3	2	3	3
Prairie Island	6	44°04'01"N-91°40'20"W	0	0	2	3
TNWR*	6	44°03'03"N-91°33'31"W	5	5	6	6
TOTALS			15	15	16	16

* Trempealeau National Wildlife Refuge

to find the young. The young are very well camouflaged in this environment and the search must be done very carefully. Outcome must be determined within a few days of hatching because of the tendency of the young not only to flee the nest when an intruder is near, but to permanently abandon the nest site. No attempt was made to follow the young until fledging because of this tendency to flee the nest. Platforms were left in place in the marshes until at least mid-July in order to evaluate usage of platforms by late-nesting birds.

RESULTS AND DISCUSSION

Incubation Behavior

This portion of the study was plagued with technical difficulties. A 300 mm lens which was to be attached to the night vision device was dropped and damaged before filming began. This forced usage of a 70-210 mm lens which limited the visibility of birds on the nest. The three components of the system (night vision device, infrared spotlight, and camcorder) each required battery power. The infrared spotlight used sealed Ni-Cd batteries which failed frequently. The device had to be returned to the lab for recharging. These batteries took many hours to fully recharge. Both the night vision device and the camcorder were powered from a 12 volt lead-acid battery. This battery also had to be returned to the lab for occasional recharging. It failed during two nights' filming.

The biggest problem occurred with the camcorder. The unit normally operates with a small Ni-Cd battery pack which provides power for only a bit more than an hour, completely inadequate for the application used here. A 12-volt adapter was purchased to provide more than eight hours' power from the lead-acid battery. This adapter failed completely during the first night's use. A heavy-duty replacement was available from Canon, but could not be located anywhere in Minnesota or Wisconsin. It had to be ordered from New York and took approximately a week to arrive. These problems delayed the start of night-long filming considerably and sometimes disrupted it later on.

Additional problems occurred due to condensation and difficulty in focusing. Marshes of course tend to have high humidity levels near the water surface. As the air temperature drops during the night, the moisture condenses on surfaces. The night vision recording apparatus has three lens surfaces (objective and ocular lenses of the night vision device and objective lens of the camcorder) and thus was vulnerable to condensation. Sometimes this caused image degradation to such an extent that nothing could be discerned on the tape. Also, focusing the apparatus was difficult because of the grainy image of the night vision device and especially because of the small black-and-white viewfinder on the camcorder. The first two night's recordings were not able to be interpreted because of focus problems.

The fact that the night vision device could not be turned on in sunlight and that the camcorder could only operate in time-lapse mode for six hours at a time required visits to the apparatus just after nightfall to turn the unit on, at 3-4 am to restart the camcorder, and again at approximately 5 am to turn the unit off. In daylight, birds often leave the nest when the researcher approaches this closely to the nest. This was not the case during these night visits. No bird was ever observed to leave the nest when the researcher visited the apparatus after nightfall.

One nest was approached by what appeared to be a great horned owl on two separate nights (Table 2). In each case the owl perched on the wooden stake used to mark the nest. On the first occasion, the tern surprisingly remained on the nest while the owl perched nearby. On the second night, the tern called as the owl approached and flew away from the nest just as the owl arrived. The owl remained on the perch for a couple of minutes, then flew away. The black tern did not return to the nest that night. There was no evidence of any attempt at predation of the eggs in either of these instances. These observations suggest that great horned owls are probably not common predators of black tern eggs.

There was a marked difference in behavior patterns between day and night. During the day, the birds were active at the nest, leaving occasionally and returning within one or two minutes. Exchanges of incubation duties between male and female occurred frequently, typically within an hour. When an incubation bout extended past one hour, the incubating bird usually showed more tendency to leave the nest for

Table 2. Summary of observations of black tern incubation behavior.

Marsh-Nest No.	Date	Observations
TNWR-01	6/14-15/91	9:15 pm - 12:00 am. very dark, infrared failed after 10 min., rain came at midnight, taping halted
TNWR-01	6/15-16/91	10:15 pm - 4:43 am. poorly focused, bird could not be seen on tape
TNWR-01	6/16-17/91	9:01 pm - 5:13 am. bird was not present at nest when taping began; infrared was very dim; image nearly black around midnight; bird was on nest at 5:01 am; lenses were heavily fogged by condensation
TNWR-01	6/17-18/91	9:40 pm - 5:00 am. bird was not present from 8:45 till 9:40 when taping began; infrared was dim and focus poor because of condensation; bird was on nest at 4:56 am.
TNWR-02	6/19-20/91	9:41 pm - 3:38 am. bird was on nest from 9:15 - 9:41 when taping began; bird remained on nest throughout night until 3:38 when unit shut off; researcher could not find unit in the dark to reset it; bird was on nest at 4:45 am when equipment was retrieved
TNWR-02	6/20-21/91	9:37 pm - 5:07 am. bird on nest from 9:10 throughout night; terns begin flying about marsh at 4:30

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Table 2. (continued)

Marsh-Nest No.	Date	Observations
TNWR-02	6/21-22/91	no taping due to rain
TNWR-02	6/22-23/91	9:52 pm - 4:47 am. bird stayed on nest throughout night; at 11:17 pm the tern called and a horned owl landed on pole and stayed until 11:22 pm; tern remained on nest despite presence of owl
TNWR-02	6/23-24/91	9:38 pm - 4:57 am. bird was not on nest when researcher arrived at 9:15; absent from nest throughout the night
TNWR-02	6/24-25/91	9:38 pm - 3:55 am. bird stayed on nest from 9:15 until 1:46 am; at 1:46 the bird called and flew from nest just as a horned owl landed on the pole; the owl stayed until 1:49 without approaching the nest; the tern did not return to the nest throughout the night
Shep-01*	6/25-26/91	9:54 pm - 5:02 am. bird was on nest at 9:15 but was off nest at 9:25 and remained off throughout night; it returned after taping was completed at about 5:15

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Table 2. (continued)

Marsh-Nest No.	Date	Observations
TNWR-02	6/27-28/91	8:22 pm - 11:27 am. bird was on nest at 8:22 and throughout night; at 5 am taping with camcorder only continued; below are noted times when bird left nest; exch indicates a time when two birds were at nest and probably exchanged incubation duties: 5:09 exch; 5:29; 5:38; 6:05; 6:10; 6:15 exch; 6:28; 6:43; 7:12; 7:38; 7:49; 8:31; 8:35; 8:46; 9:29; 9:39; 9:47 exch; 9:59 exch; 10:05 exch; 10:40; 10:48 researcher visits; 11:06
TNWR-03	6/28-29/91	9:32 pm - 9:38 pm (24 hr, 6 min). bird on nest at 9:32 and remained on all night; there was a weak tern call at 1:55 am; camcorder was off between 3:30 and 4:10 am; image was degraded by condensation on lens; taping with camcorder only continued throughout the day; time notations below indicate times when bird left nest briefly; exch indicates a time when both birds were seen and probably exchanged incubation duties:

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Table 2. (continued)

Marsh-Nest No.	Date	Observations
TNWR-03	6/28-29/91	5:33; 5:57; 6:34; 6:39; 7:02; 7:08; 7:28; 7:35 exch; 8:08 exch; 8:38; 9:11; 9:15 exch; 9:35; 10:12; 10:26 exch; 10:53; 11:19 exch; 11:26 (researcher present); 12:03 - 12:05; 12:19 - 12:21; 12:55 exch; 1:01; 2:16 - 2:23; 2:27 - 2:32; 2:36 - 2:40; 3:07; 3:21; 3:31; 3:49; 3:56 - 3:58; 4:16 - 4:18; 4:26; 5:30 - 5:37; 5:43; 5:52; 6:05; 6:17; 6:38 - 6:40; 7:03 - 7:06; 7:17 - 7:19; 7:32 - 7:34; 8:02; 8:24 - 8:26; 8:30 - 8:33; 8:49 - 8:51
TNWR-02	7/1-2/91	4:49 pm - 10:10 am. times noted as above: 5:15; 5:35 - 5:39; 6:02 - 6:07; 6:37 - 6:40; 6:58 - 7:02; 7:04 - 7:22; 7:38 - 7:40; 7:59 - 8:01; 8:26 - 8:28; 8:39; 8:56; 9:01; 9:07; image dark from 9:22 to 10:42; bird on nest 10:42 until 2:16 when image failed; bird on nest at 3:19; image foggy 4:30 - 5:13; 5:13 - 5:24 (researcher present); 6:06 exch; 6:38 exch; 7:24 exch; 7:24 exch; 7:42 - 7:54 pair present; 8:23 exch; 9:04 - 9:06; 9:26; 9:46; battery failed at 10:10

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Table 2. (continued)

Marsh-Nest No.	Date	Observations
TNWR-04	7/2-3/91	10:25 pm - 4:19 am. bird was not on nest at beginning of taping and throughout the night; battery failed at 4:19

* Shep = Shepardson Marsh in Pool 8

short periods. In one case (TNWR-03, 6/28-29/91), during approximately 16 hours of daylight, the nest was left unattended at least 45 times. More exchanges may have occurred than noted, since the tape ran for 1/2 second each 10 seconds. Quick exchanges might have occurred during the time when the tape was off. During the night, no such activity was observed. It appeared that the bird beginning the night's incubation continued until near sunrise. No short flights were observed either; the bird remained in place on the nest throughout the night.

Incubation at night did involve movement, however. The birds were observed moving on the nest: turning the head, preening, standing up, etc. This suggests that future work on incubation patterns might make use of infrared motion sensors placed close to the nest. The birds exhibit enough activity to use this technology to monitor their presence at the nest throughout the night.

In all, 14 nights of taping were accomplished. Of these, there were six nights with birds remaining on the nest throughout the time when taping continued, three nights with birds absent from the nest throughout the night, one night with the bird leaving the nest during the night and remaining off until morning, two nights with birds absent from the nest at nightfall but present in the morning, and two nights that yielded no data. Overall then, half of the nights yielded evidence of a bird leaving the nest unattended during part or all of the night. This occurred in four of the five nests which were studied.

Artificial Nest Platforms

Thirty and 32 platforms were distributed in 1990 and 1991, respectively, in various marshes (Table 1). In each year, half of the platforms were small (24" x 24") and half were large (32" x 32"). Those tested in 1991 were modified with a ring of hardware cloth to better hold nest material in place. In 1991, two of the platforms in Trempealeau National Wildlife Refuge failed. One became waterlogged and sank; the other lost nesting material because of failure of the poultry wire. Thus, 30 platforms were available to birds for nesting in both 1990 and 1991.

The marshes selected for distribution of the platforms were ones where black terns had nested successfully in the past. However, both 1990 and 1991 were unusual in the high water levels experienced during the nesting season. Whether for this or another reason, little nesting occurred in these marshes in 1990-1991 except for TNWR (Table 3). Johnson Lake was particularly surprising because it had previously held more than ten nests each year for several years. The presence of the platforms themselves was not a likely cause for the lack of nesting because a preliminary test in 1989 in Johnson Lake, Riley Lake, and Boller Lake did not interfere with nesting and platforms were utilized by black terns in each of them. Whatever the cause, none of the platforms in any of these marshes were used in 1990 or 1991.

Table 3. Numbers of nests in marshes used for testing artificial platforms, 1990 and 1991.

Marsh	1990	1991
Johnson Lake	0	3*
Riley Lake	4*	0
Boller Lake	2	0
Prairie Island	6	0

* in a portion of the marsh away from previous nesting area

Trempealeau National Wildlife Refuge held very active colonies of black terns in both 1990 and 1991. Utilization of artificial nest platforms was significant in both years in this marsh (Table 4). There were a total of 12 nest attempts on ten large platforms compared with four attempts on ten small platforms over the two years. Eight of the large platforms were used while only four of the small ones were used. The hatching rate was nearly identical on large and small platforms. Large platforms were used for four renest attempts while none occurred on small ones. These data strongly suggest that the large platforms are preferable for black tern nesting.

Hatching success of nests on artificial platforms was significantly greater in 1990 than that of nests on natural platforms (Table 5), but not in 1991. The chi-square goodness of fit test comparing hatching success of artificial platform nests with that of natural platform nests gave a chi-square value of 4.36 (p = .036) for the 1990 data. Combining the 1990 and 1991 data gave a chi-square value of 3.14 (p = .073). Although the 1991 data did not show a difference between artificial and natural platforms, other data suggest that the trend observed in 1990 is real. In 1989, ten small platforms were placed in TNWR. Hatching success was 50% (five of ten nests) on artificial platforms while that of nests on natural platforms was only 29% (eight of 35 nests). These data strongly suggest that hatching success can be improved by usage of artificial nest platforms.

Table 4. Usage of artificial platforms at TNWR, 1990 and 1991.

Parameter	1990	1991	Total
Large platforms			
Number available	5	5	10
Number with nests	4	4	8
Number with second nests	3	1	4
Number hatched	6*	2	8
Number failed	0	3	3
Small platforms			
Number available	5	5	10
Number with nests	3	1	4
Number with second nests	0	0	0
Number hatched	2	1	3
Number failed	1	0	1

* the outcome of the seventh nest was not determined

Table 5. Per cent hatching success (number of hatched nests/number of nests with known outcomes) of black tern nests on natural and artificial platforms.

Platform Type	1990	1991	Total
Natural	52 (36/69)	47 (38/81)	49 (74/150)
Artificial	89 (8/9)	50 (3/6)	73 (11/15)

CONCLUSIONS AND RECOMMENDATIONS

1. The linkage of a video camcorder with a night vision device was an effective technology for study of night incubation behavior, but technical problems (especially condensation and battery problems) limited its reliability. It may be possible to overcome these limitations for future study.

2. There was a marked difference in behavior between day and night. During the day the birds left the nest frequently for short periods. Incubation duties were exchanged between male and female frequently, each bout usually lasting less than an hour. During the night, incubation was conducted by one bird only and that individual stayed on the nest continuously. None was observed returning to the nest before daylight once it had left. Few vocalizations were made by the birds during the night.

3. No predation of eggs was observed during the taping. In two instances owls landed near the nest, but in neither case did they approach the eggs. In one case the incubating tern remained on the nest even though an owl was perched approximately ten feet away. In the other case the incubating tern vocalized and fled the nest as the owl approached. It remained off the nest for the rest of the night.

4. Several instances of birds staying off the nest throughout the entire night were observed. These same individuals incubated constantly during the day. During twelve nights for which the tapes were interpretable, there were six nights with birds remaining on the nest throughout the night. On six other nights birds were off the nest for at least part of the time.

5. Artificial nest platforms were heavily utilized by terns nesting in Trempealeau National Wildlife Refuge. None were used in other marshes, but these marshes had little or no nesting in 1990 and 1991 (a marked contrast from previous years). There was a clear advantage of the larger size platforms in terms of the numbers utilized and especially in the number supporting renests. Hatching success was similar on the two sizes of platforms. The addition of a ring of hardware cloth to the platform acted as a "corral" to keep nesting material in place and reduced the need to revisit the platforms to replace blown- or washed-off nesting material. Thus, the preferred design for this platform is a 32" x 32" frame covered with poultry wire to which a ring of hardware cloth is attached.

6. Hatching success of nests on these platforms was significantly greater than that of nests on natural platforms in 1990. Little difference was observed in 1991, but small platforms used in 1989 were nearly twice as successful as natural platforms. These platforms, properly used, have the potential to significantly increase

hatching success of black terns. Their usage should be promoted as widely as possible. If extensively used, they could potentially reverse the trend of population decline that has been observed.