

State of California
THE RESOURCES AGENCY
Department of Fish and Game

AMERICAN RIVER GREEN HERON STUDY, 1974^{1/}

Ronald M. Jurek
Wildlife Management Branch

ABSTRACT

A study of green heron (Butorides virescens) depredations at American River Trout Hatchery, near Sacramento, California, was conducted from February 15 to August 22, 1974. Objectives were to identify green heron depredation problems, to determine heron movement patterns, seasonal occurrence and seasonal abundance, to develop trapping and marking methods, and to recommend control measures to reduce depredation problems. Counts indicated that 6 nesting pairs frequented the ponds in April and May. The population increased in June. Late that month, 22 green herons were counted together at the ponds. The population was effectively reduced during July by mist net trapping of 19 depredating herons and releasing them in areas distant from the hatchery. Many new birds, however, replaced them in August. Twenty-seven green herons were banded, including 8 nestlings. Numbered wing tags were placed on most herons removed from the hatchery. Only one transported individual returned to the hatchery. Heron depredations occurred mainly during early mornings and in evenings after working hours. Most fish consumed by birds were 1.5 to 4 inches in length. Heron feeding rates varied with the size of fish fed upon. Fish losses to green herons during the study period ranged from 2 to 11 pounds of fish per day, depending on the size of the heron population. Recommendations were made for the removal of depredating green herons by the mist net capture methods, and for eventual protection of fish by improved hatchery screening that will exclude all fish-eating birds.

^{1/} Supported by Federal Aid in Wildlife Restoration, Project W-54-R-6, "Special Wildlife Investigations," Job Final Report, Job III-5.2 (October 1974).

RECOMMENDATIONS

Based on results of trapping operations and feeding behavior observations, the following recommendations are made as guidelines for future green heron depredation control measures at American River Trout Hatchery.

1. Green herons be live captured by mist netting, banded, and released at least 25 miles from the hatchery whenever control measures are needed for reducing the population of depredating birds.
2. Depredating herons be trapped and removed in March to prevent these birds from nesting near the hatchery.
3. The Department continue experiments to develop effective harassment methods that will discourage green herons and other fish-eating birds from frequenting the hatchery.
4. Present bird barrier netting be replaced with 2-inch mesh material, and efforts be made to replace or improve design of overhead gull wires to prevent access by all fish-eating birds.
5. Mosquito fish (Gambusia affinis) be planted in permanent ponds among dredge tailings near the hatchery beginning in early spring 1975 in an effort to establish a buffer population of abundant prey for fish-eating birds.
6. The Department determine the cost benefits of protecting hatchery ponds with permanent bird barrier fencing that will exclude all fish-eating birds.

INTRODUCTION

Loss of fish to fish-eating birds has long been an important problem in fish hatchery management. Large concentrations of available prey in rearing ponds are attractive to many species of avian predators, such as herons, kingfishers, mergansers and gulls. Uncontrolled, depredations may become a serious economic problem in fish culture operations.

Depredation by several species of birds has occurred at American River Trout Hatchery since it was built in 1968. Trout rearing ponds were originally constructed without provisions for preventing access by fish-eating birds. Early depredations by mergansers (Mergus sp.) and gulls (Larus sp.) were controlled after parallel wires were suspended above the rearing pond area. Seven-gauge wires were spaced 0.6 m (24 inches) apart, 4 m (13 feet) above the ground. Wires were supported by four crossbeams. Great blue herons (Ardea herodias), green herons and belted kingfishers (Megaceryle alcyon) were not deterred by these wires, and depredations continued. Hatchery personnel attempted to chase these birds away with noise making devices, flashing lights, and a mechanical dummy that moved along raceways on a pulley assembly. These scare devices were not effective.

Early in 1973 an effort was made to totally exclude herons from the rearing ponds. Additional strands of wire were connected to the beam supports, reducing the distance between overhead strands to 20 cm. (8 inches). In addition, 7.6 cm. (3-inch) mesh plastic bird barrier netting (J. A. Cissel Co.) was placed around the sides of the raceway area. Some great blue herons found openings in the netting and entered the enclosure, but they were unable to find their way back out. These birds were caught by hand and removed by hatchery personnel. Eventually, great blue herons avoided the hatchery pond area, and after May 1974, none of these birds were found in the enclosure.

The enclosure did not reduce depredations by kingfishers and green herons. Both species entered and exited the pond area freely, passing between wires, through the netting, or under the net panels. Kingfishers are not considered a serious economic threat at the hatchery and they are tolerated. However, the population of green herons using the hatchery has been increasing each year since 1971, and in late 1973, hatchery personnel expressed need for additional control measures.

The Department conducted an intensive study of green heron depredations at the hatchery from February 15 to August 22, 1974. Robert Leachman, seasonal aid, conducted field work from mid-February to mid-May, and the author resumed studies beginning June 11.

OBJECTIVES

Objectives of the program were to identify green heron depredation problems, to determine green heron seasonal occurrence, seasonal abundance, and movement patterns, to develop trapping and marking methods, and to recommend control measures to reduce or eliminate green heron depredations at the hatchery.

STUDY AREA

American River Trout Hatchery and the adjacent Nimbus Salmon Hatchery are located on the south bank of American River near the base of Nimbus Dam at Lake Natoma (Figure 1). Hatcheries are 13 miles northeast of Sacramento, California. The flood plain south of the river in this area is rolling terrain formed by gold dredge tailings. Scattered among the tailings are small groves of trees, and permanent and seasonal ponds occur in depressions. Steep bluffs overlook the river on the north bank. Between the bluffs and the river is Sailor Bar, an area of dredge tailings. The bar extends from 0.8 to 2.4 km ($\frac{1}{2}$ to $1\frac{1}{2}$ miles) downstream from the hatcheries and is vegetated by large groves of trees. Willows and other riparian vegetation border both banks of the river in the hatchery area.

The study centered about the trout rearing ponds at American River Trout Hatchery (Figure 2). There are 60 concrete rearing ponds in ten parallel rows or raceways. Ponds are 30.5 m. (100 feet) long and 3.1 m (10 feet) wide between walls. Raceway walls are 20 cm (8 inches) wide. Water levels usually are between .4 and .6 m (16 and 24 inches) below tops of walls. The pond area is completely enclosed by high walls of commercial bird barrier netting, and parallel strands of wire are suspended overhead.

Surveys of green heron populations along the American River were conducted from the hatchery to Sacramento River, a river distance of 35.4 km (22 miles). Dense riparian vegetation borders most of the river.

METHODS

Rearing Pond Observations

Green heron feeding behavior was observed with the aid of binoculars or 20x spotting scope. Observations were conducted from outside the net enclosure at the east end of rearing ponds. From this vantage point, the observer could easily observe the activities of the birds without disturbing them. Individual birds were watched for varying periods of time, and their activities recorded. Information was collected on time and duration of feeding or other behavior, feeding perch location, fishing method, code number of pond where feeding occurred, and success of feeding attempts. Periodically, all herons in the enclosure were counted, and their activity and location at the time of the count were recorded.

Determination of Fish Size

Determination of size of trout in each pond was based mainly on size records contained in the weekly Hatchery Feeding Schedule maintained by hatchery personnel. Fish sizes on these schedules were expressed in quantity of fish per pound. For purposes of this report, these figures were converted to average fork length (Leitritz, 1960:110) and rounded to the nearest half inch. It should be understood that the variation in fish size in a pond may be great, and the term "fish class size" in this report refers only to the average length of fish in a pond.

Visual estimates of size of fish taken by herons supplemented the hatchery records. Length of the fish was compared with the bird's bill length, which

Figure 1. American River and American River Trout Hatchery Study Area.

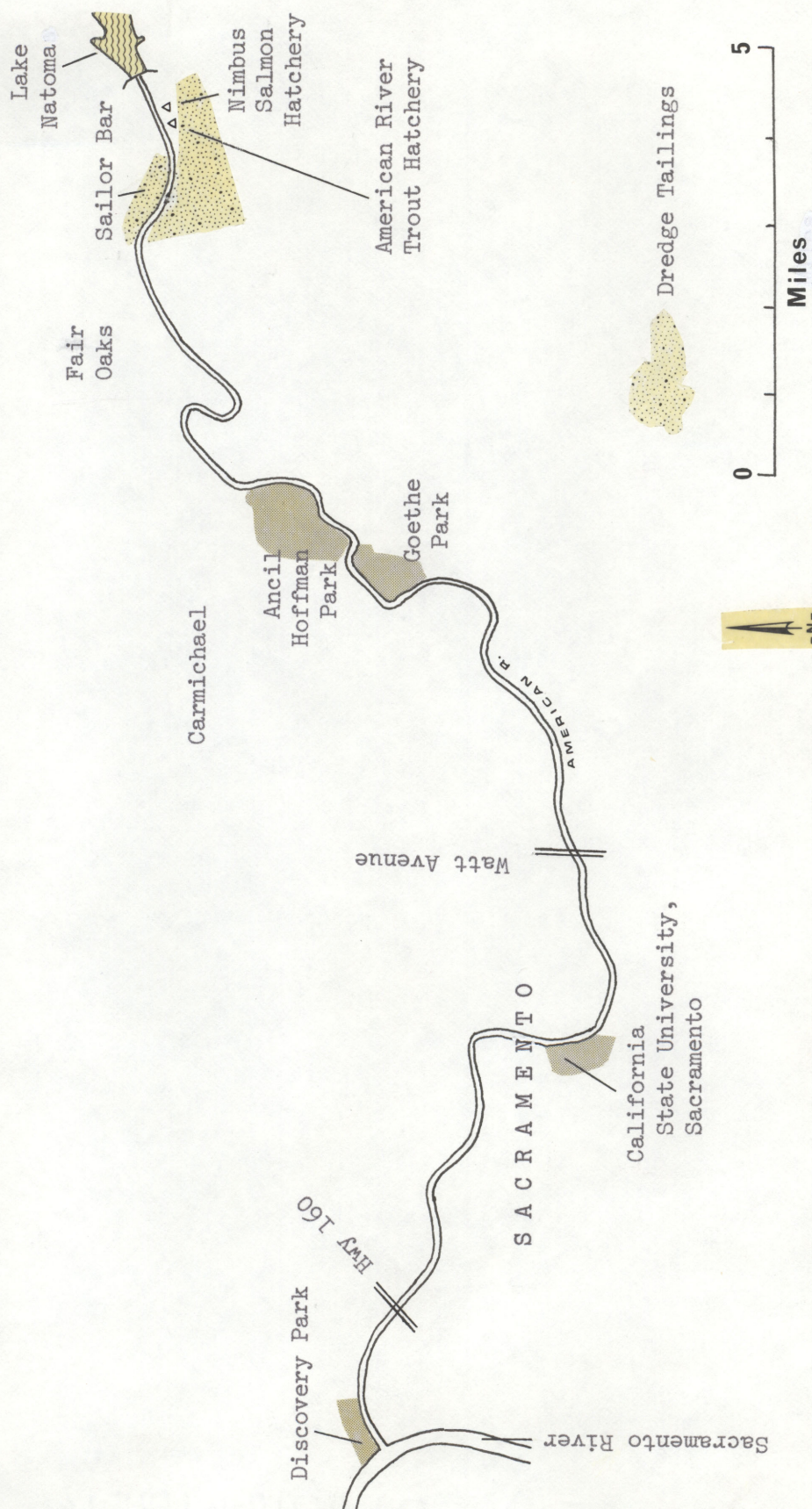
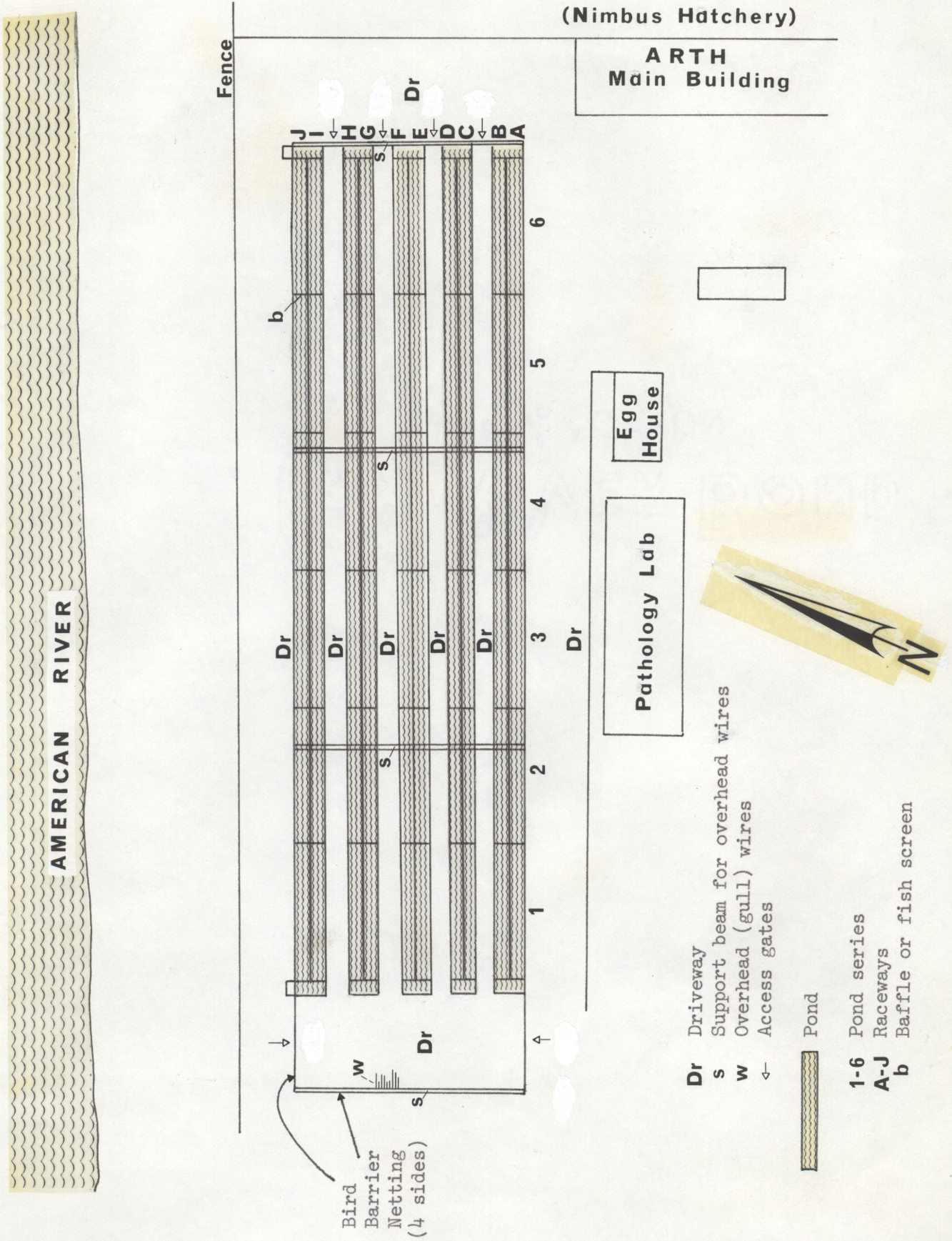


Figure 2. Rearing Ponds at American River Trout Hatchery



is approximately 7.6 cm.(3 inches), allowing the observer to make a reasonably accurate estimate of fish length.

Nest Survey and Banding of Nestlings

Beginning in late February, a search was made of all green heron nest sites in the hatchery vicinity. In nest trees that could be climbed, nests were checked periodically and information was collected on egg dates, clutch size, and hatching success. At selected nests, nestlings old enough for banding were removed from the nest, banded and measured on the ground, and immediately returned to the nest. Measurements included weight, bill length, wing chord length, and length of the tarsus. Two people were needed for banding, one in the nest tree and one, the bander, on the ground. Nestlings were lowered to the bander and returned to the nest in a small box on a rope.

Trapping, Marking and Transporting

Two early trapping methods were tried with no success. One method entailed the use of toe snares that were placed on feeding perches and pond walls. Snare construction was modified from Kirsher (1958). Soft monofilament line (5.6 kg or 15 pound test) was used in making slip nooses 4 cm (1.5 inches) in diameter. Nooses were attached to a flat hardware cloth matrix and spaced 2.5 to 5 cm (1 to 2 inches) apart. Hardware cloth sheets of 0.6 cm.(1/4 inch) mesh were cut into varying sizes from 5 to 15 cm (2 to 6 inches) wide and 30.5 to 61 cm (1 to 2 feet) long. Each snare was connected to a pond wall or other structure using a short length of nylon rope. The second trapping device tested was a drop net similar to that described by Johns (1963). A modified 121 mm mist net was positioned over a pathway where green herons frequently exited or entered the hatchery enclosure under netting walls. An observer was stationed nearby to release the net when a bird was under it.

Green herons were successfully captured beginning in May, when standard 12 meter mist nets were used. Nets were black nylon with a 61 mm mesh (NEBBA Mist Nets, Manomet Bird Observatory, Manomet, Mass.). Usually five mist nets were positioned during each trapping session. A net was strung across each of the two entrance gates at the west end of the enclosure. Usually three additional nets on 3-meter (10-foot) metal poles were positioned among ponds at the west end of the hatchery. Because the herons learned quickly to avoid net setups, these three movable nets were positioned differently from one trapping session to another.

When several herons were feeding in ponds, two banders, sometimes with the aid of a dog, walked toward the birds from the east end of the hatchery. At the first sign of restlessness by the birds, the banders began running, yelling and waiving arms. The loud commotion and fast approach by the banders seemed to confuse the birds, making them fly recklessly among the mist nets.

Each bird was banded with a U. S. Fish and Wildlife Service numbered aluminum band. Age was recorded, and the following measurements were taken: weight, wing length, bill length (culmen length from edge of feathers to tip), and the length of the tarsus. Most green herons received one yellow wing tag (Figure 3) with an identifying letter-number combination (Cogswell, 1973; Diem and Congdon, 1967). The flexible tags measured 6.3 cm.(2.5 inches) long and 2.5 cm.(1 inch) wide, and were made of vinyl plastic (Saflags). Tags were fastened to the patagium of the wing with a short nylon bolt (ITT Harper, Inc., Berkeley, Calif.).

Green herons trapped and marked in early May were released at the hatchery. Beginning in late June all herons were transported to selected release sites distant from the hatchery.

River Surveys

Surveys of the green heron population along the American River were conducted by two observers in a canoe. Observers used binoculars to aid in sightings. Six float trips were made. On one trip, observers were assisted by two additional observers in a kayak.

From 30 to 70 percent of the river was surveyed on each downstream trip. All portions of the 35.4 km (22 mile) stretch of the river were travelled, but efforts were concentrated along the 13.7 km (8.5 mile) portion between the hatchery and Goethe Park.

RESULTS AND DISCUSSION

Population Size

It was not possible to determine the population of green herons that fed at the hatchery each day. During observations, there was a constant turnover in the population as herons moved in and out of the hatchery. After the nesting season, some marked birds were observed making more than one feeding visit to the ponds in a period of several hours. Too few birds were marked in the study area to aid observers in calculating population size.

One index of heron population size is the maximum number of birds present at one time in the hatchery area during morning, the main heron feeding period of the day. Herons were most abundant in the hatchery at, or shortly after, sunrise. The peak morning count probably includes most of the herons that feed at the hatchery during the morning feeding period, but this number is an undetermined proportion of the total population of green herons that uses the hatchery each day, or over a period of several days.

As many as six green herons were counted at one time in the hatchery enclosure during April and early May. During this time, when herons were nesting, six active heron nests were located in the immediate vicinity of the hatchery. Since the parent birds take turns foraging and incubating or brooding (Palmer, 1962), data suggest that most, or all, green herons feeding at the hatchery during the nesting season are the foraging members of local nesting pairs.

During June, when young were flying and adults were freed of rearing chores, increasing numbers of herons appeared at the ponds. A maximum of nine adults was observed in the enclosure the afternoon of June 11. The first juvenile was sighted among the rearing ponds on June 14. During the morning of June 21, a maximum of 22 herons, including 5 juvenals, was recorded. This was the largest number of green herons recorded at one time during the study period.

From June 24 to July 31, frequent harassment and removal of herons during trapping operations effectively reduced the population frequenting the ponds. In morning counts, numbers declined from 12 on June 27 to 2 or 4 by late July. During this period 12 adults and 7 juveniles were trapped and relocated.

After trapping ended, new herons appeared at the hatchery. On August 22 a maximum of 14 green herons was counted at one time around the ponds, and at least 15 birds were in the area (6 adults and 9 juveniles). Only one of these was a tagged bird that had returned after being transported earlier in the season.

Nest Survey

Within 0.8 km. ($\frac{1}{2}$ mile) of the hatchery six active nests were located. A loose colony of four pairs nested at the east end of Sailor Bar, directly across the river from the hatchery. Nests of the other two pairs were widely separated in the area immediately south of the hatchery. Nests were built 4.6 to 6.1 meters (15 to 20 feet) above the ground in interior live oaks (Quercus wislizenii).

Burnstad and Hanson (personnel communication), hatchery employees, surveyed Lake Natomas by boat on May 5, 1974, to census green and great blue herons. No green herons were sighted, but a great blue heron colony of 20 nests was located.

Leachman collected nesting data at five green heron nests. Three nests contained completed clutches of 5 eggs, and two of 4 eggs. A completed clutch of 5 eggs was found on March 30, which is two weeks earlier than the earliest clutch dates reported by Bent (1926) and Palmer (1962). Eggs or young were present in one or all of the five study nests from about March 26 to June 4. Earliest hatching date was April 14. Eggs in the latest clutch were expected to hatch about May 10, but this was not confirmed. Of four nests followed to hatching, 16 of the 18 eggs hatched; the two unhatched eggs were in separate nests.

Since young may accompany adults to feeding grounds at 25 days of age (Palmer, 1962), earliest young were expected to make initial flights away from the nest about May 9. In fact, on that date Leachman sighted the first juvenile green heron flying near the hatchery.

Nest surveys were discontinued after May 8, so it is not known whether herons attempted to raise second clutches.

Trapping, Banding, and Transporting

Green Herons

Twenty-seven green herons were banded between April 25 and July 31. Included were 8 nestlings, 6 juveniles, and 13 adults. Patagial markers were placed on 16 of the birds in the latter two age groups (Figure 3).

On April 25 and April 30 measurements were recorded on nine nestlings estimated to be 7 to 17 days old. Week old young were more easily handled and less likely to climb out of their nest and onto tree limbs to avoid capture than were older nestlings. Eight nestlings were banded, but one of these is known to have died before attaining flight. One of the banded nestlings was recaptured 57 days later on June 26 in mist netting operations at the hatchery.

Except for the nestlings, all green herons were captured during mist netting operations. Twenty-five captures were made. Two of these were unusual in

that both birds were immediately caught on the ground after escaping momentary entanglement in mist nets. Before regaining flight, each was subdued; one was caught by a bander, and the other by a dog that was being used to help drive herons toward mist nets.

Adults present in the study area during the nesting season are resident well into summer. Of five adults banded, tagged and released at the hatchery from May 5-13, four were eventually recaptured there from 44 to 81 days after original banding. One that was banded May 11 was observed at the hatchery on August 22 after twice having been transported to distant areas.

After June 24, all captured herons were transported and released in areas far from the hatchery (Table 1). The 20 removals involved 19 individuals (12 adults and 7 juveniles). Only one of these herons returned to the hatchery during the study period. This bird, an adult, was transported twice and returned both times. It returned within 9 days after being released at Nicolaus, and within 6 days from Drytown, and was still at the hatchery August 22.

No reports were received of tagged birds away from the immediate vicinity of the hatchery. Observers at Colusa National Wildlife Refuge and Little Butte Creek release sites found no evidence that the birds remained in these areas.

The patagial wing tags were adequate for purposes of identifying individual birds in the hatchery vicinity. After three months, tags and painted numbers showed no signs of aging or fading. Letters and numbers were readable at a distance of 215 meters (700 feet) using a 20X spotting scope, or 90 meters (300 feet) using 7X binoculars.

Of the four herons tagged in May and later recaptured, two had lost their patagial tags within 11 weeks; one tag possibly was lost after only a few days. These early tags may not have been properly applied, and techniques were improved in later tag applications. Frequently herons enter or exit the hatchery by squeezing through the nylon mesh of the enclosure, and tags or bolts catching on the netting strands during this process may have contributed to the loss of these two tags. The other two tags are known to have remained firmly attached at least 12 weeks on one bird and 15 weeks on the other.

In efforts to capture green herons for removal from the hatchery, eight mist net trapping sessions were conducted from June 24 to July 31. Up to 5 mist nets were used at a time. Mist net hours totaled 116. Four morning sessions averaged 2.8 hours, and 8 herons were caught. Four afternoon sessions, averaging 3.3 hours, resulted in the capture of 12 herons. In all, 20 herons were captured in 25 trapping hours (57 man hours). Time spent by banders to catch each heron averaged 1.3 trapping hours (2.9 man hours).

Great Blue Herons

Seven individual great blue herons were captured between April 22 and May 18. All were hand caught by Leachman or by hatchery employees inside the hatchery enclosure. Although these birds had managed to get inside the enclosure through openings in the net fence, they could not find their way out.

Each great blue heron was banded, but no wing tags were applied. One bird was transported 51 km (32 miles) and released near Camino, Eldorado County.

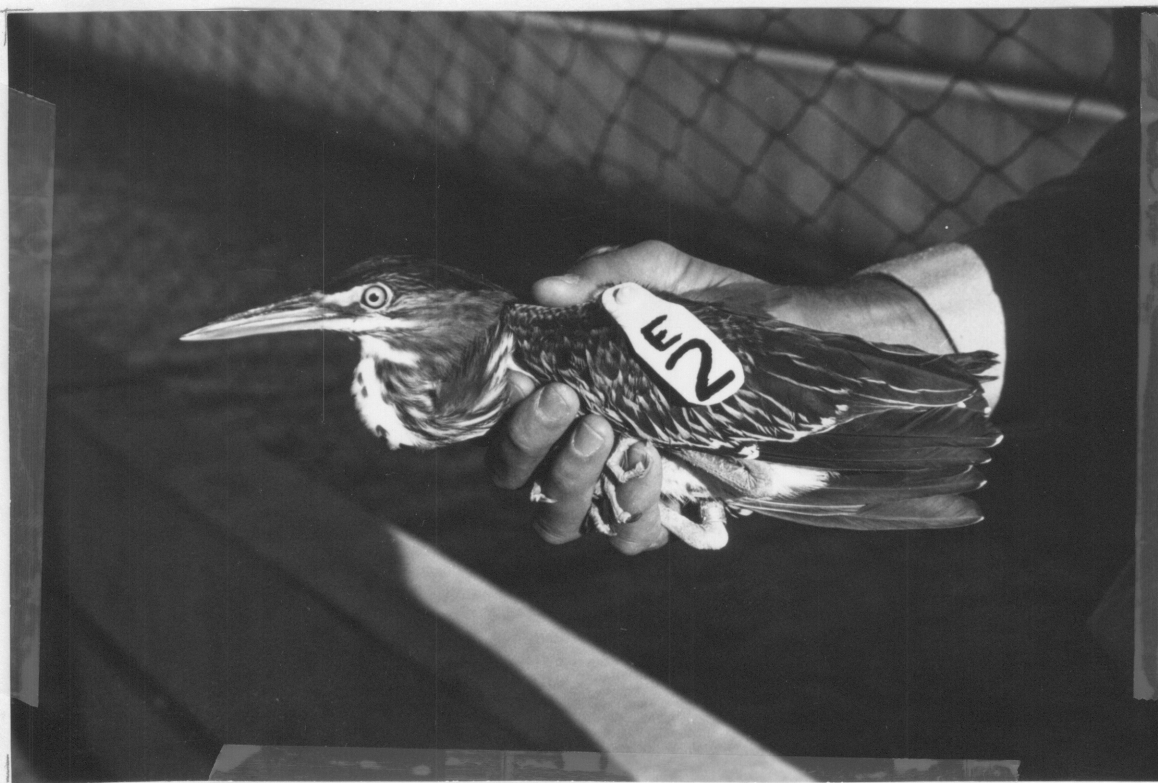
TABLE 1

Green Herons Removed from American River Trout Hatchery

| Release Date | Number of Herons Transported | Release Area | Distance from AR Hatchery Km. (Miles) |
|----------------|------------------------------|---|---------------------------------------|
| June 24, 1974 | 2 | 1.6 km (1 mi.) E. of Nicolaus, Sutter Co. | 42 (26) |
| June 27, 1974 | 8 | Colusa Nat. Wildl. Ref., Colusa Co. | 90 (56) |
| July 3, 1974 | 2 | 1.6 km (1 mi.) S. of Drytown, Amador Co. | 42 (26) |
| July 19, 1974 | 5 | 4.8 km (3 mi.) S. of Meyers, Eldorado Co. | 109 (68) |
| August 2, 1974 | 3 | Near mouth of Little Butte Cr., Butte Co. | 132 (82) |

FIGURE 3

Juvenile Green Heron Captured at American River Trout Hatchery,
Banded, and Marked with Yellow Wing Tag



Two others were taken to California State University, Sacramento, and measured before being released at the University, 19 km (12 miles) from the hatchery. The other four were released in the immediate vicinity of the hatchery; one of these was recaptured in the enclosure the day after it was first released. It was released again near the hatchery.

Although great blue herons were observed in the vicinity of the hatchery during the remainder of the study period, none was known to have entered the enclosure after May 18.

Belted Kingfisher

Six kingfishers were caught in mist nets during green heron trapping attempts. All were immediately released, and four were banded and measured. These included one adult captured on July 3, and three juveniles on July 31.

Green Heron Feeding Behavior

Feeding Methods

Green herons usually fished from perches near the water. With its feet tightly gripping the perch, the bird quickly seizes with its bill those fish near the surface of the water. Its long neck allows the bird to strike out at prey far from its foot. Perches include baffle boards, fish screens and walkways over ponds. Walkways and some fish screens were as high as 0.6 meter (2 feet) above the surface of the water, while some baffles extended only 5 cm (2 inches) above the water level. Baffles were the most frequently used feeding perches. Fish usually were in denser concentrations next to baffles than elsewhere in ponds.

Occasionally green herons dove into ponds to catch fish. They leaped from walkways over ponds, raceway walls and the higher fish screens, all from 0.4 to 0.6 meters (1.3 to 2 feet) above the water. In all observation periods from June 11 to August 22, this feeding behavior was observed in only 12 instances. No bird was observed to make more than four dives before quitting.

In June, experimental placement of single or paired wires 5 cm (2 inches) above baffle boards and fish screens prevented green herons from using some fishing platforms, but birds soon learned to adjust to the inconvenience and found other footholds to fish from.

Feeding Times

Green herons feed during daylight hours (Bent, 1926). At the hatchery they concentrated their feeding activity in the morning, from shortly before sunrise to 0800 or 0830, and in the evening, from 1630 or 1700 to sunset. This interim period during the day coincided with the time when hatchery personnel were at work in the area or when public visitors were present.

Sporadically one to several herons fed at the hatchery between 0800 and 1700, usually when there was little or no work activity or visitor activity in the pond area. The bolder herons, however, fed surprisingly close to hatchery workers. Compared with the amount of feeding in morning and afternoon feeding periods during this study, the amount of daytime feeding was not significant.

Largest concentrations of green herons were counted in the hatchery during mornings before 0800. Peak numbers were recorded at or shortly after sunrise, and the population declined thereafter. The herons apparently are hungriest early in the morning after not having fed for at least nine hours during the night.

During the study period, amount of available morning and evening feeding time varied with the changing lengths of day. Day length was longest in mid-June. In late March, morning and evening feeding periods totaled 3-3/4 hours per day; in mid-June, 6½ hours; and in late August, 5 hours.

Although available afternoon feeding periods exceeded morning periods by 1 to 1½ hours, heron use of the hatchery was greater in the mornings. On June 13, the available evening feeding period was 3-3/4 hours long. A maximum of 5 herons was counted, and 9.5 bird use hours were recorded. The following morning feeding period was 2½ hours long; a maximum of 12 birds was observed, and bird use hours totaled 19.6.

Although the herons enter the hatchery to feed, much of their time is spent in other activities, such as preening or roosting. The birds frequently must defend their particular feeding stations from encroachments by other herons, so some of their time also is spent chasing intruders or being chased. On many censuses, more birds were engaged in nonfeeding behavior than were feeding. During censuses conducted from June 11 to August 22, the proportion of green herons that were feeding, or appeared to be feeding, at any time averaged 58 percent in mornings (242 birds) and 69 percent in evenings (36 birds).

Sizes of Fish Eaten

During the study period green herons fed on fish primarily from 1.5 to 4 inches in length. Larger fish up to nearly 6 inches long and fry less than 1 inch long also were consumed. No stomach samples were taken, so accurate measurements of fish length were not possible.

Hatchery personnel sort trout by size in rearing ponds, but in any pond the range in size of fish may be great. Hatchery records give only the average size of fish in each pond. In many of the calculations dealing with heron feeding behavior in this report, fish sizes are based on these hatchery records. These calculations do not take into account fish size selectivity of feeding herons. In ponds containing fish longer than about 3 inches, the herons appeared to select fish shorter than average size indicated in hatchery records. Frequently, birds were observed catching 3-to-5 inch fish in ponds that hatchery records showed as containing fish averaging up to 3 inches longer. The calculations presented in this report probably over-emphasize the importance of the larger fish in the diet of green herons at the hatchery.

Availability of various fish sizes changed constantly at the hatchery (Table 2), and this influenced the feeding habits of the herons (Table 3). From late March to early May, herons feed mainly in ponds with fish size classes 2 to 4.5 inches. After mid-May, the herons shifted their feeding effort to smaller size classes that were then occupying increasing numbers of ponds. Based on censuses conducted between June 11 and July 12, 85.1 percent of all green herons that were feeding, or appeared to be feeding,

TABLE 2

Seasonal Availability of Fish Sizes in the 60 Rearing Ponds
at American River Trout Hatchery, 1974

| Fish Size Classes | | Number of Ponds | | | | | | |
|-------------------|-------------|-----------------|-------|-------|--------|--------|---------|--------|
| (in) | (cm) | Mar.8 | Apr.1 | May 1 | May 30 | Jun 27 | July 31 | Aug 19 |
| Less than 1 | < 2.5 | 1 | 0 | 5 | 1 | 1 | 0 | 0 |
| 1 - 2.5 | 2.5 - 6.4 | 0 | 1 | 1 | 13 | 23 | 10 | 7 |
| 3 - 4.5 | 7.6 - 11.4 | 7 | 4 | 2 | 0 | 0 | 20 | 28 |
| 5 - 6.5 | 12.1 - 16.5 | 9 | 6 | 10 | 10 | 4 | 0 | 0 |
| More than 6.5 | > 16.5 | 43 | 49 | 41 | 34 | 26 | 22 | 12 |
| Unstocked | | 0 | 0 | 1 | 2 | 6 | 8 | 13 |

TABLE 3

Sizes of Fish in Ponds at Which Green Herons Were Feeding
or Appeared to be Feeding at Times of Censuses

| | June 11-14 | June 20-27 | July 3 and 12 | Aug 22 |
|---|------------|------------|---------------|----------|
| No. of feeding observations | 34 | 120 | 14 | 43 |
| Size of fish in ponds frequented by birds: | | | | |
| Range in size classes (in.) | < 1 to 8.5 | < 1 to 8.5 | 2 to 6.5 | 2.5 to 4 |
| Mean size class (in.) | 2.3 | 2.7 | 2.4 | 3.5 |
| Standard Deviation (in.) | 1.66 | 1.58 | 0.67 | 0.39 |

were concentrated at ponds containing fish in the 1.5, 2 or 2.5 inch size classes. The herons continued to feed on these fish as they grew, and by late August, the birds were feeding wholly on fish in the 2.5 to 4 inch size classes.

Herons fed infrequently in ponds containing fish smaller than one inch long. Only 2.6 percent of feeding birds recorded on June censuses were located at these ponds. This low frequency might be explained by the fact that only 1 or 2 ponds contained fry during June; however, in 50 heron feeding observations made from April 15 to May 15, when from 5 to 9 ponds contained fry, only one heron attempted to feed on this size of fish, and it was unsuccessful in its attempts.

In this study, the largest fish taken by a green heron was estimated to be 5.5 or 6 inches long. Leachman recorded herons taking fish up to 5 inches long in observations from March 19 to May 19, but such observations were rare. During banding operations in June, one heron regurgitated two fish, one of which was 5 inches long.

Green herons often frequented ponds containing fish of size classes greater than 5 inches, but efforts by the birds to catch these larger fish were uncommon. Of all herons that were feeding, or appeared to be feeding, in the hatchery during censuses from June 11 to June 27, 12.3 percent were located at ponds containing fish size classes 5.5 inches to 8.5 inches; two-thirds of these birds were around ponds with fish averaging 5.5, 6 or 6.5 inches long. However, in 10.5 hours of hatchery observations during that month, only four fish estimated to be 5 inches long or greater were actually taken by feeding birds.

Feeding Rates

Feeding rates of green herons varied with the size of fish selected (Table 4). The birds fed most rapidly on the 1.5 inch size class, and capture rates decreased as fish size increased. Rate of capture also decreased when herons fed on fish smaller than the 1.5 inch class. This may indicate that the smaller fish are more difficult to catch, or there may be a sampling error because of the low sample size and short observation period. Exceptionally fast capture rates were sustained for short periods of time, usually only a minute or two. Fastest capture rates recorded were 5.8 fish per minute (1.5 inch class), 6.2 fish per minute (2 inch class), and 2.5 fish per minute (2.5 inch class), but such observations were unusual.

Herons successfully caught fish on 75 to 85 percent of strike attempts, depending on size of fish selected. Efficiency decreased as the birds selected larger fish. In the relatively few instances when herons dove into the water after fish, the success rate was similar to that of nondiving attempts. From June 11 to July 12, herons were observed diving for fish on 12 occasions. Trout ranging in size from 2 to 5 inches were caught on 79.2 percent of the 24 dives recorded. Undoubtedly some fish are injured or killed by unsuccessful capture attempts, but the extent of crippling loss was not determined. Herons feeding on 1.5 inch fish might cripple up to 18 percent more fish than they actually consume; for 2.5 inch fish, the figure would be no greater than 25 percent.

Individual birds fished at feeding stations for periods of time ranging from less than a minute to more than 22 minutes before moving to other feeding

TABLE 4

Feeding Rates of Green Herons at American River Trout Hatchery, June 11 - July 12, 1974

| Fish Size Class (in.) | No. of Herons Observed | Observation Time | Number of Fish Caught | Number of Strikes and Misses | Percent Successful Strikes | Feeding Rate | | |
|--------------------------|------------------------------|---------------------|-----------------------------|------------------------------------|----------------------------------|-------------------------|------------------------|--|
| | | | | | | Avg. No. Fish Caught | Feeding Hour / Bird | Est. Weight Consumed ^{1/} (pounds) / feeding Hour / Bird |
| 1 inch and less | 3 | 9 m. 10s. | 9 | -----Undetermined----- | | 58.9 | | Less than 0.04 |
| 1.5 | 7 | 43 m. 42s. | 55 | 10 | 84.6 | 75.5 | | 0.10 |
| 2 | 33 | 234 m. 49s. | 204 | 38 | 84.3 | 52.1 | | 0.17 |
| 2.5 | 6 | 50 m. 45s. | 24 | 6 | 80.0 | 28.4 | | 0.22 |
| 5 inches and greater | 8 | 43 m. 15 s. | 3 | 1 | 75.0 | 4.7 | | 0.33 ^{2/} |

^{1/} Weight-length conversion based on Leitritz (1960).^{2/} Assumes consumption of a maximum fish length of 5.5 inches.

areas, stopping to preen or roost, or leaving the hatchery. Feeding rates were quite variable from one observation to another. Rarely were herons observed to catch more than 15 fish of any size at one feeding spot. The largest number of fish a heron ate at one feeding was 21. These were 2 inch fish, and they were taken during a feeding period of 8 minutes and 15 seconds. After this, the bird left the hatchery. On the basis of hatchery fish weight records, this bird had consumed 43.2 gm (0.1 pound) of fish. This represents 17 percent of the mean weight (254 gm) of herons measured at the hatchery.

In Rhodesia, Junor (1972) determined the daily food requirements of seven species of fish-eating birds that were hand-reared. Included in experiments were four species of herons, including the green-backed heron (Butorides striatus), a species closely related to our green heron. All species when fully grown consumed an average daily quantity of fish equivalent to approximately 16 percent of their own body weight. Applying this figure to green herons in the study area, each bird would require an average of 40.6 gm (0.09 pounds) of fish per day.

Fish Loss

As mentioned earlier, the herons feed most heavily in the mornings at the hatchery. During morning feeding periods, apparently at least half the daily fish loss occurs; observations indicate that feeding activity in mornings may be as much as twice that of the evenings.

In an effort to quantify the fish loss, the total loss from green heron depredations was estimated for selected feeding periods (Table 5). These samples were representative of the range in populations observed at the hatchery during this study. Based on these calculations, estimated weight of fish consumed by herons ranged from less than 2 to 9 pounds of fish per day, during the study period. Assuming a maximum additional crippling loss of 20 percent, the total fish loss attributed to green herons ranged from about 2 to 11 pounds per day.

River Surveys

Counts made on canoe float trips along the river did not represent true population censuses of green herons (Table 6). The birds sighted undoubtedly were only a small proportion of the actual population in the survey area. Many backwater areas were inaccessible by canoe, and because most downstream trips were run with one boat, only one side of many portions of the river could be checked by observers. Also, observers probably overlooked many green herons in the dense riparian vegetation.

Densities recorded on four float trips from March 3 to March 17 ranged from 0.35 to 0.59 green herons per mile of river and averaged 0.46 birds per mile. The survey made on May 7 yielded a comparable figure of 0.57 birds per mile.

Highest density of green herons was recorded on the August 7 survey; nearly two birds per mile were sighted. Results of this final survey were not comparable with the earlier counts. Only on the August survey were two boats used. This allowed better coverage of the river than was possible on earlier surveys. Certainly, part of the increase in the number of herons counted in August can be attributed to the recruitment of young birds into the population after early May. Early fall migrants also may have been included in the August count.

TABLE 5

Estimated Amount of Fish Consumed by Green Herons
During Selected Feeding Periods

| Date | June 13 | June 21 | July 12 | August 22 |
|--|--------------|--------------|--------------|--------------|
| Time of Observations | 1633 to 2000 | 0541 to 0800 | 0545 to 0741 | 0530 to 0805 |
| No. of Censuses | 13 | 10 | 10 | 11 |
| A. Feeding period (hours) | 3.8 | 2.6 | 2.4 | 1.8 |
| B. Max. population counted ^{1/} | 5 | 22 | 5 | 14 |
| C. Mean population ^{1/} | 2.5 | 14.1 | 3.4 | 8.2 |
| D. Bird use hours (AxC) | 9.5 | 36.7 | 8.2 | 14.8 |
| E. Percent of time all birds spent feeding ^{1/} | 68% | 64% | 50% | 53% |
| F. Feeding hours (DxE) | 6.5 | 23.5 | 4.1 | 7.8 |
| G. Est. feeding rate ^{2/} | 0.2 | 0.2 | 0.2 | 0.3 |
| H. Est. fish loss (pounds) (FxG) | 1.3 | 4.7 | 0.8 | 2.3 |

^{1/} Based on periodic censuses.

^{2/} Pounds of fish per feeding hour per bird (Tables 3 and 4).

TABLE 6

Green Heron Sightings on Float Trip Surveys of American River

| Date | No. of Green Herons Sighted | Length of River (Km.) | Traveled (Mi.) | Starting Point | Ending Point |
|----------|-----------------------------|-----------------------|----------------|--------------------|--------------------|
| March 3 | 6 | 24.9 | 15.5 | Hatchery | CSUS ^{1/} |
| March 8 | 5 | 13.7 | 8.5 | Hatchery | Goethe Park |
| March 10 | 4 | 10.5 | 6.5 | CSUS ^{1/} | Discovery Park |
| March 17 | 3 | 13.7 | 8.5 | Hatchery | Goethe Park |
| May 7 | 4 | 11.3 | 7.0 | Watt Ave. Bridge | Highway 160 Bridge |
| August 7 | 30 | 24.9 | 15.5 | Hatchery | CSUS ^{1/} |

^{1/} California State University, Sacramento.

MANAGEMENT CONSIDERATIONS

Methods used by fish culturists to control depredations by fish-eating birds have been discussed by Cottam and Uhler (1937), Lagler (1939), McAtee and Piper (1937) and Pough (1941, 1949). Measures include shooting, trapping, use of scare devices, and placement of barriers, such as screens, wires and fences, around ponds.

Surveys of hatcheries in the United States in the late 1930's showed that the most common bird depredation control method used by hatchery personnel was killing by shooting or trapping. Because of increased public demand for the protection of all wildlife resources, including populations of fish-eating birds that frequent hatcheries, wildlife management agencies are obligated to develop control methods that protect hatchery fish without sacrificing birds or adversely affecting local bird populations. The mechanical dummy scare device and associated harassment procedures used at San Joaquin Hatchery, the capture-removal operations used at American River Trout Hatchery, and the complete fencing of Mad River Hatchery, Humboldt County, California, have all been successful in reducing or eliminating bird depredation problems.

Mist net capture and removal of birds was an effective control measure for reducing the population of green herons at American River Trout Hatchery. Trapping procedures took advantage of the construction design of the hatchery exclosure. Had it not been for the overhead wires and surrounding barrier netting, the herons would have easily avoided the mist nets. The exclosure helped to confine the birds to the trapping area, restricting their movements,

and increasing the likelihood that they would fly into mist nets. The harassment associated with trapping operations seemed to contribute to the population reduction by discouraging some herons, especially juveniles, from coming to the ponds.

As a short term control method, capture-removal is a relatively inexpensive operation. However, over a long period of time this method could become quite costly and time consuming. Heavy trapping succeeded in reducing the population of green herons at the hatchery in July, but after trapping operations were terminated, the population quickly built up again. To maintain the population of green herons at a low level after the nesting season, capture and harassment operations would be needed from early June through October. Latest fall migrants depart by early October (Bent, 1926), and by November a small, stable wintering population may remain in the hatchery area. Although capture removal operations should not be undertaken during the nesting season, early April through early June, heavy trapping at the hatchery in March would help to prevent the buildup of a local nesting population dependent on the hatchery food source.

It is recommended that the trap-removal method be used only as a temporary control measure until an effective bird barrier structure is built around rearing ponds that will exclude green herons.

ACKNOWLEDGMENTS

Grateful appreciation is extended to the many people who assisted in this study. Robert Leachman initiated the field work, developed observation methods and trapping techniques, and collected nesting data. Later trapping operations were conducted by the author with the assistance of two hatchery employees, Larry Hanson and David Rose, and Gordon Gould, seasonal aid. I also wish to thank Phil Flint and Jack Bell, fish hatchery managers, for their assistance and cooperation during the study.

LITERATURE CITED

- Bent, A. C. 1926. Life histories of North American marsh birds. U. S. National Mus. Bull. 135. 392 pp.
- Cogswell, H. L. 1973. Tabular summary and annotation of color-marking methods exhibited by W.B.B.A. at the Sep. 1971 meeting of the A.O.U. in Seattle. Western Bird Bander (Western Bird Banding Association) 48(1):5-9.
- Cottam, C. and F. M. Uhler. 1937. Birds in relation to fishes. U.S.D.A. Bureau of Biological Survey, Wildl. Res. and Manag. Leaflet No. 83. 16 pp.
- Diem, K. L., and D. D. Congdon. 1967. Banding studies of waterbirds on Molly Island, Yellowstone Lake, Yellowstone, Wyoming. Yellowstone Libr. and Mus. Assoc., Yellowstone Wyoming. 41 pp.
- Johns, J. E. 1963. A new method of capture utilizing the mist net. Bird Banding 34:209-213.
- Junor, F. J. R. 1972. Estimation of the daily food intake of piscivorous birds. The Ostrich 43(4):193-205.
- Kirsher, W. K. 1958. A bal-chatri trap for sparrow hawks. Western Bird Bander 33(4):41-42.
- Leitritz, E. 1960. Trout and salmon culture (hatchery methods). Calif. Dept. Fish and Game. Fish Bull. 107. 169 pp.
- McAtee, W. L. and S. E. Piper. 1937. Excluding birds from reservoirs and fishponds. U. S. Dept. of Agriculture, Leaflet No. 120. 6 pp.
- Palmer, R. S. (ed.) 1962. Handbook of North American birds, Vol. I, Yale Univ. Press. 567 pp.
- Pough, R. H. 1941. The fish-eating bird problem at the fish hatcheries of the Northeast. Trans. N. A. Wildl. Conf. 5:203-206.
- _____. 1949. Whose fish is it? Audubon 51(2):90-96.