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MOLT MIGRATION OF POSTBREEDING FEMALE MALLARDS FROM SUISUN MARSH, CALIFORNIA[1]

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Abstract. We monitored postbreeding movements of 34 Mallard (*Anas platyrhynchos*) hens that nested in Suisun Marsh, California, in 1987 using radio telemetry. Hens began leaving Suisun Marsh in late May, and 50% had departed by mid-June. We located 27 of 34 hens from late June through September during aerial searches; 25 hens had migrated north out of the study area, and two remained near the nesting area. We determined the molting areas of 20 hens: nine in Oregon and 11 in California. These molting areas were 12–536 km from nesting sites. Wetlands used by molting Mallards were dominated by bulrush (*Scirpus* spp.) and cattail (*Typha* spp.), were traditionally flooded during summer, and often associated with lakes or rivers. Molting areas of seven hens located at least once after leaving the study area were not determined, and seven other hens were never relocated indicating probable migration north of the search area. Two hens were recaptured in 1988 and radio-tracked to molting areas used the previous year, 121 and 484 km north of the breeding area. Mallards appear to exhibit site fidelity to molting areas. Migrating to an area with preferred molting habitat may enhance survival during the flightless period and early part of the hunting season.

Key words: Anas platyrhynchos; *California; Mallard; migration; molt; Oregon; postbreeding; telemetry.*

INTRODUCTION

Each year, adult waterfowl molt their remiges and become flightless following the breeding season. Habitat use and behavior during the flightless period vary among waterfowl species. Diving ducks (Aythyini) tend to congregate in large open bodies of water during the wing-molt period, whereas dabbling ducks (Anatini) generally seek seclusion in dense emergent vegetation at large, permanent wetlands (Hochbaum 1944, Oring 1964, Salomonsen 1968).

Most studies of molting ducks have been conducted in areas where large numbers of ducks (mostly adult drakes) were known to congregate (Oring 1964, Young and Boag 1982, Bailey and Titman 1984, Gordon 1985, Bowman and Longcore 1989). A few studies have addressed postbreeding ecology of hens or drakes at nesting areas (Gilmer et al. 1977, Thompson and Baldassarre 1989, Mauser 1991). However, breeding origin of flightless birds at molting areas, or the destination of ducks that disperse following nesting, is rarely determined. This is because postbreeding movements to molting areas have been considered unpredictable and possibly far-reaching (Salomonsen 1968).

Mallards (*Anas platyrhynchos*) are the most studied waterfowl species in North America (see review by Reinecke and Delnicki 1992). Several recent studies address postbreeding ecology or wing-molt dynamics of Mallards (Klint 1982; Young and Boag 1981, 1982; Gordon 1985; Pehrsson 1987; Leafloor and Batt 1990; Leafloor and Ankney 1991; Mauser 1991), yet few data concerning their postbreeding movements are available. Most hypotheses regarding postbreeding movements of Mallards have been speculative, based on indirect evidence from band returns (Anderson and Henny 1972, Gilmer et al. 1977, Rienecker 1990) or observations of birds at molting marshes (Oring 1964, Salomonsen 1968).

Salomonsen (1968) discussed postbreeding activities of waterfowl in detail and suggested that a true molt migration involved a movement of adult birds from the breeding area to a special area for molting. He concluded that "... no breeding females of any species of dabbling duck perform a real moult migration." This paper describes a molt migration of postbreeding female Mallards that nested in Suisun Marsh, California, and examines its significance to Mallard ecology and management.

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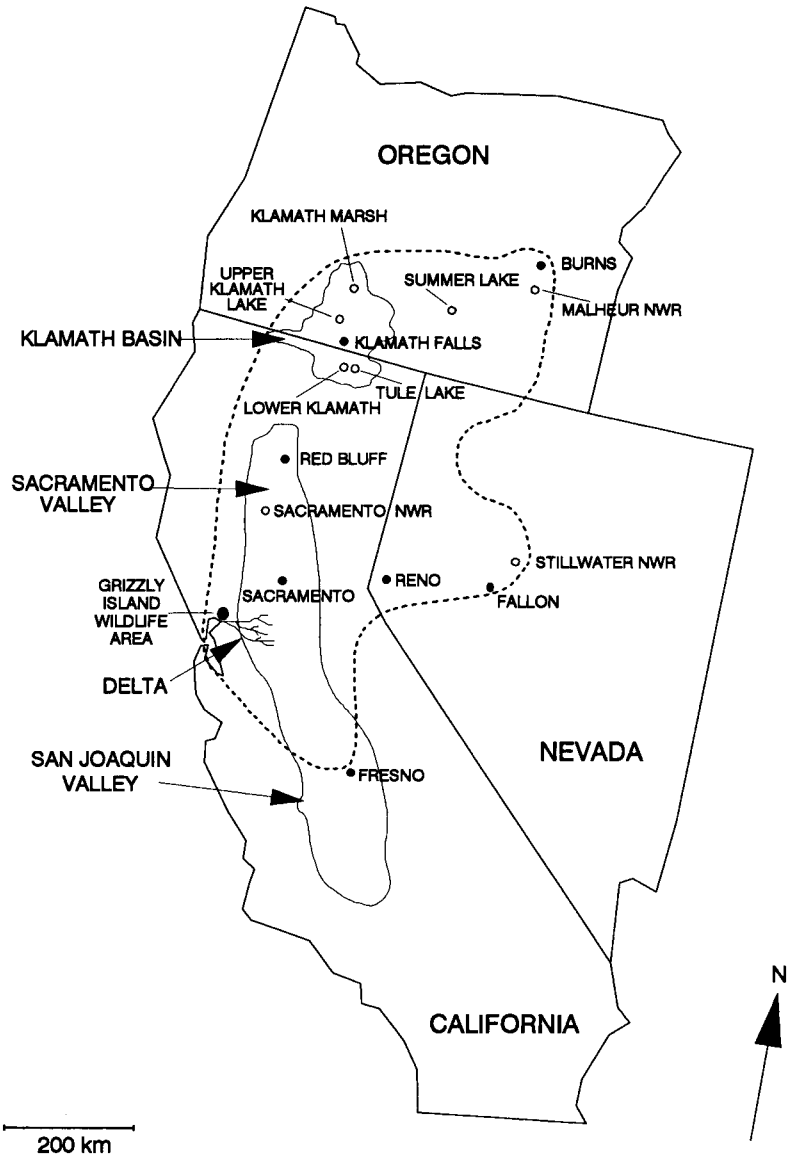

FIGURE 1. Location of Grizzly Island WA and areas searched for postbreeding Mallard hens (broken line indicates aerial search area).

STUDY AREA

The project was initiated at Grizzly Island Wildlife Area (WA), Solano County, California (Fig. 1). The 3,600-ha Grizzly Island WA (38°09′N, 121°58′W) is located in Suisun Marsh, a large (22,000 ha) estuarine wetland complex at the eastern edge of the San Francisco Bay system. Suisun Marsh is dominated by low-growing halophytic vegetation including alkali bulrush (*Scirpus robustus*), pickleweed (*Salicornia virginica*), and saltgrass (*Distichlis spicata*) (Mall 1969). Grizzly Island WA consists of approximately 2,000 ha of seasonally flooded wetlands and 1,600 ha of uplands. Wetland habitat is managed primarily for wintering waterfowl, but Grizzly Island WA is also a significant Mallard nesting area (McLandress et al., unpubl. data). Wetland impoundments are flooded and drained artificially

via water control structures and are isolated from the adjacent bay by a network of exterior levees (Mall 1969, Josselyn 1983, Heitmeyer et al. 1989).

Aerial searches for radio-marked postbreeding Mallards were conducted throughout the Central Valley and San Francisco Bay area of California, and the western Great Basin of California, Oregon, and Nevada (Fig. 1). These areas are described in detail by Heitmeyer et al. (1989) and Kadlec and Smith (1989).

METHODS

We radio-marked Mallard hens captured on their nests at Grizzly Island during 1987. We dragged a 50-m rope stretched between two all-terrain vehicles to flush hens and locate their nests (Klett et al. 1986). Cans containing a few stones to produce noise were attached every 2 m along the rope. Stage of embryo development was determined by candling (Weller 1956), and nest sites were marked with bamboo stakes. Hens were trapped on their nests during the last week of incubation using long-handled nets. In 1988, we tried to recapture hens radio-marked the previous year using swim-in bait traps or by nest trapping. Upon capture, hens were equipped with 24–26-g radio transmitters attached with an adjustable body harness (Dwyer 1972). Radio transmitters had predicted life spans of at least 120 days. Each bird was banded, weighed, and measured. Age was determined from wing feather characteristics (Palmer 1976, Krapu et al. 1979, Gatti 1983).

We estimated locations of marked hens by triangulating with hand-held antennas. We monitored hens with broods at least twice daily to determine local movements. Brood sightings were attempted twice during the first week and once a week thereafter to determine status of hens and their ducklings. We concluded that a hen lost her brood if she was observed repeatedly without ducklings, in a flock, or exhibited behavior that indicated she no longer had a brood (i.e., flushed without feigning when approached). We located hens without broods (non-nesters, unsuccessful nesters, and hens that lost broods) at least once a week to monitor movements and document additional nesting attempts. A large hill on the north edge of Suisun Marsh maximized our signal-receiving range and helped us determine major movements of birds within the area. We concluded that a hen left the study area if her transmitter signal was not received from the hill during weekly visits. We estimated the date that a hen departed as the mid-point between the last day she was located in Suisun Marsh and the first day she was known to be missing.

When hens left Suisun Marsh, we located them with aircraft (Cessna 182 or 185) equipped with receiving antennae and scanning receivers (Gilmer et al. 1981). Flights were scheduled every 2–4 weeks from the last week in June to the first week in October. Search areas outside Suisun Marsh were determined from recovery distribution patterns of Mallards banded during summer and fall in California (Rienecker 1990; McLandress, unpubl. data). We searched the wetland complexes of the Sacramento-San Joaquin River Delta (Delta), Sacramento Valley (portion of Central Valley north of Delta), northeastern California, and Klamath Basin at least twice each year. We searched wetlands in San Joaquin Valley (portion of Central Valley south of Delta), western Nevada, and south-central Oregon (excluding Klamath Basin) once each year (Fig. 1). Between aerial surveys, observers on the ground attempted to locate hens at wetlands to determine presence or absence. Hens that remained on the same wetland for at least one month following nesting were considered to have molted there based on the length of the typical flightless period for Mallards (Boyd 1961).

RESULTS

Thirty-six hen Mallards (six second-year and 30 after-second-year) were captured on their nests and radio-marked at Grizzly Island WA between mid-March and the first week in June 1987. One radio-marked hen was found dead on the study area, and the transmitter was removed from another when it was captured in a trap during banding operations. Three hens marked in 1987 were radio-marked again in 1988; two were caught on nests and one was caught in a bait trap. The radio transmitter on the bait-trapped hen failed soon after the hen was marked.

REPRODUCTIVE STATUS OF MARKED HENS

Our sample included 24 hens that nested successfully, two that had their nests destroyed by predators, and eight that abandoned their nests following transmitter attachment. We did not detect any subsequent nesting attempts by marked hens either before or after they left the study area. Most successful nesting hens lost their ducklings

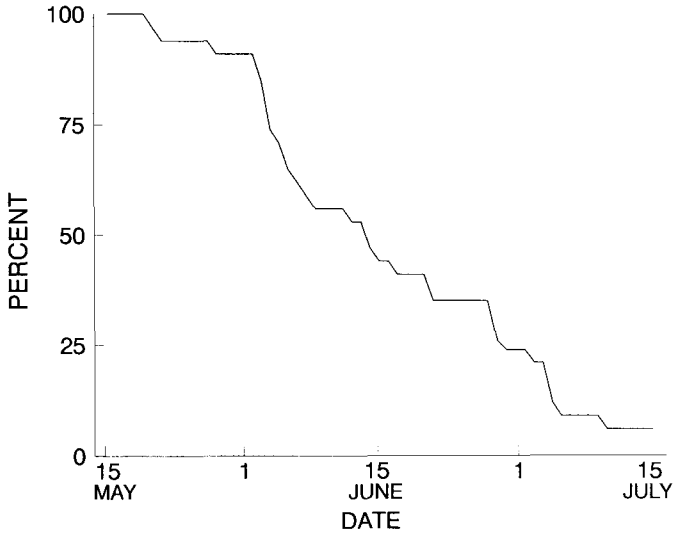

FIGURE 2. Postbreeding departure of female Mallards from Grizzly Island WA, California, 1987.

within two weeks following hatching, and only two hens raised ducklings to fledging (Yarris and McLandress, unpubl. data).

TIMING OF DEPARTURE AND POSTBREEDING MOVEMENTS

Thirty-two of the 34 radio-marked hens left Suisun Marsh before molting, including both hens that successfully raised broods. The earliest departure was on 22 May, and the latest was on 10 July. Two hens remained in Suisun Marsh for the duration of the study. By mid-June, 50% of all hens had left the Marsh (Fig. 2). Of 32 radio-marked hens that left Suisun Marsh, 25 (78%) were located at least once during aerial surveys. Radio-marked hens were located from the Delta east of Grizzly Island WA to as far north as south-central Oregon. Most birds were located numerous times after they departed, and 13 hens were found on more than one wetland during their northward movement. We found no relationship between time of departure and distance to known molting sites ($r = 0.061$, $P > 0.05$).

In general, hens initially moved in a northerly direction after leaving Suisun Marsh, and subsequent movements to molting areas were also northward. Thirty-five of 48 (73%) observed movements were within 45° of due north (Fig. 3). None of the pre-molt movements was in a predominantly southerly direction (i.e., within 45° of due south), although one hen moved south after the molting period. Two birds initially moved east of Suisun Marsh to the Delta but did not remain there; one was later located in Oregon and the other was never located again. Two hens moved 12 and 14 km west of their Grizzly Island WA nest sites but remained in Suisun Marsh to molt. Detailed analyses of the rates of movement were not possible because elapsed time between relocations was highly variable.

Using our criteria, we identified the molting areas of 20 hens (Fig. 4). All hens molted on permanent, emergent wetlands associated with shallow lakes or rivers, or on managed wetlands traditionally flooded in summer. The farthest a radio-marked hen was known to move was 536 km to Summer Lake, Oregon. Twelve radio-marked hens were found molting 450 km north of Suisun Marsh at the Klamath Basin: one hen at Klamath Marsh, six hens at Upper Klamath Lake, three hens at Tule Lake, one hen at Lower Klamath Lake, and one hen on a private hunting club adjacent to the Klamath River.

Five hens molted in Sacramento Valley. One hen was located at Sacramento National Wildlife Refuge (NWR), and three others molted on private hunting clubs. In addition, one hen molted on a pond adjacent to the Sacramento River near Red Bluff. Two hens remained in the Suisun Marsh to molt, both on private hunting clubs.

Molt areas of 14 hens that left Suisun Marsh were not determined. Seven hens were never located, and seven others were located at least once before disappearing from the search area.

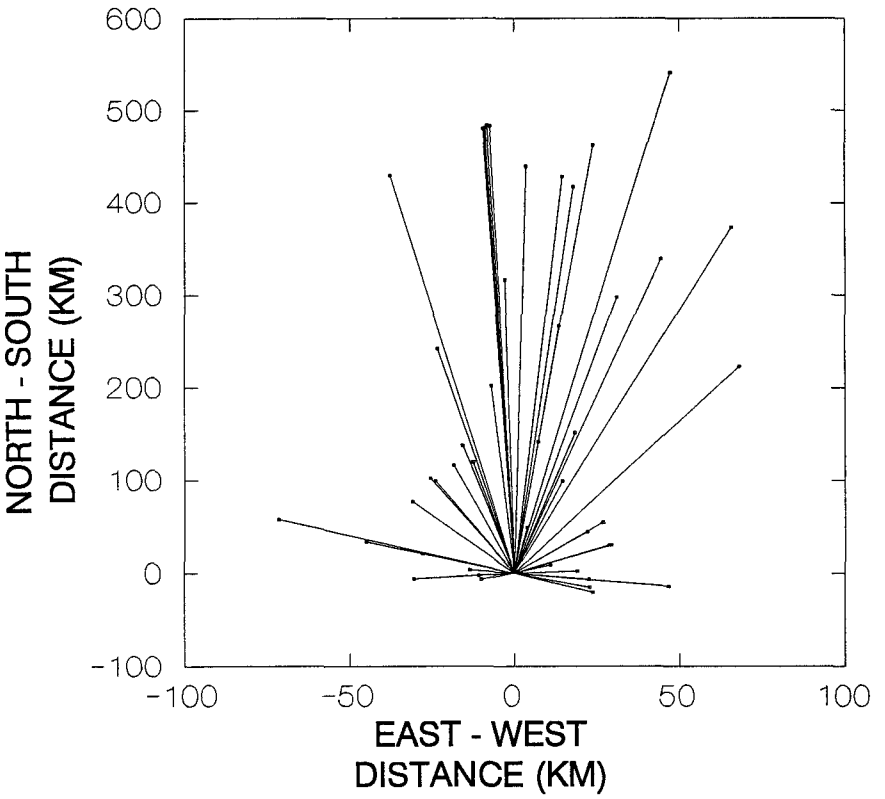

FIGURE 3. Direction of 48 individual movements made by postbreeding Mallards after leaving Grizzly Island WA, 1987.

The latter hens were last located in Sacramento Valley (three birds), northeastern California (three birds), and Oregon northeast of Klamath Falls (one bird). None of the hens was located south of the Delta. Some missing hens probably migrated to locations outside the search area. Mallard hens banded during summer in the Central Valley have been recaptured during summer banding operations in northern and eastern Oregon, Idaho, and Washington (McLandress, unpubl. data). Thus, hens that left the search area likely went farther north than we searched.

Both hens recaptured in 1988 molted at the same wetlands as in 1987. One molted at a Sacramento Valley wetland 120 km north of Grizzly Island WA. The other molted at Upper Klamath Lake in Oregon, 480 km north.

Most hens remained on or near molting areas until their radios expired. Of nine hens known to carry operational transmitters during the first week of October, only one had made a significant movement southward. This hen, which was last located on her molting site at Klamath Basin on 28 August, was absent there on 18 September and relocated in the Sacramento Valley on 23 September.

DISCUSSION

DISPERSAL TIMING AND PATTERNS

Chronology of Mallard nesting in California differs from northern breeding areas. Because of differences in climate, Mallards begin nesting as early as late February in California, and peak nest initiation is at least a month earlier than in the northern prairies (McLandress et al., unpubl. data). Although the nesting season is 20% longer in California, nest initiations after early June are rare (McLandress et al., unpubl. data).

The timing of the wing molt is largely dependent on breeding-season chronology, reproductive status, and social factors (Klint 1982, Wishart 1985, Leafloor and Ankney 1991), and flightless Mallard hens may molt as late as Oc-

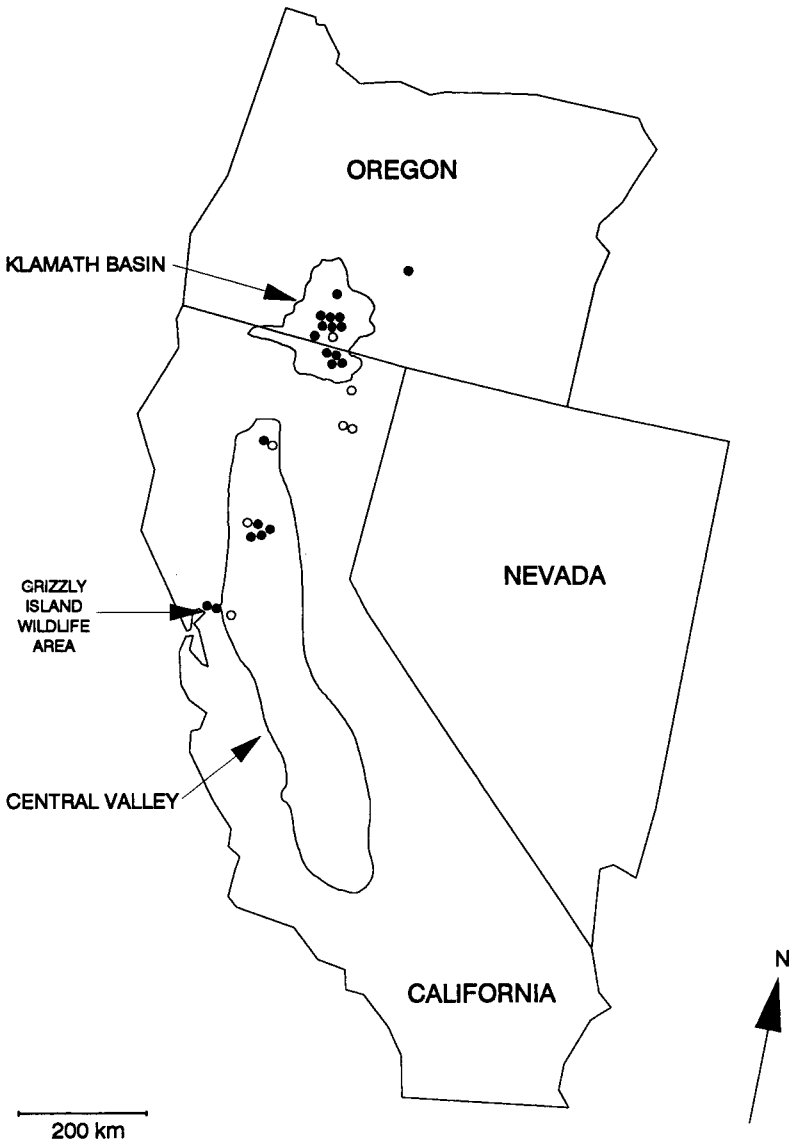

FIGURE 4. Known molting site (filled circle) or last known location (open circle) of postbreeding Mallard hens that nested at Grizzly Island WA, 1987.

tober (see Gilmer et al. 1977). Thus, virtually all Mallards nesting in central California have sufficient time to nest, raise a brood, and move elsewhere to molt before the fall. At more northerly breeding areas, the proportion of hens that disperse appears to be lower than in central California. For example, only half the successful Mallard hens dispersed from a study area in Minnesota before the flightless period, and the first brood hen did not depart until early July (Gilmer et al. 1977). During our study, all hens that left Suisun Marsh to molt did so before 10 July.

The proximity of potential molting habitat to breeding grounds probably determines the direction and distance of postbreeding movements. Mallards nesting in Suisun Marsh exhibited a strong northward tendency in their migration. Mallards probably dispersed to the north from central California because large predictable sources of water exist there. Radio-

marked hen Mallards followed during a Minnesota study did not exhibit the obvious northerly flight tendencies that we observed, although only four birds that left the study area were followed; two successful hens were observed going north and northwest, and two others (with unknown breeding histories) were followed east (Gilmer et al. 1977). Based on band returns, however, Gilmer et al. (1977) believed that most Mallard hens from their study area molted in northwestern Minnesota. During a Mallard production study in Klamath Basin, a principal molting area, most radio-marked hens remained near the nesting area to molt (Mauser 1991). Hens that did disperse (20 of 71 hens) moved a mean distance of only 73 km from their nesting sites, generally to the north (Mauser 1991). Large numbers of waterfowl that concentrate at traditional molting areas such as Delta Marsh in Manitoba and Camas NWR in Idaho probably originate from breeding areas throughout the region, since the number of molters often exceeds the local breeding population (Hochbaum 1944, Oring 1964). Other species of ducks appear to molt south of their nesting grounds en route to, or on, wintering areas (Chabreck 1966, Rogers 1967, Salomonsen 1968, Miller et al. 1992).

Salomonsen (1968) believed that molt migrations developed because of food shortages on breeding grounds. He added that the departure of post- or nonbreeding adults would benefit brood hens and ducklings by decreasing intraspecific competition for food. Based on the observed movements and habitat use of radio-marked Mallards in this study, however, we agree with Gilmer et al. (1977), who suggested that wetland habitat used for nesting and brood rearing may not be suitable for molting, resulting in postbreeding dispersal.

Molting Mallards typically use large permanent wetlands that provide sufficient food resources and protection from predators and other disturbances (Hochbaum 1944, Oring 1964, Salomonsen 1968, Gilmer et al. 1977, Gordon 1985). In addition to nutritional needs for body maintenance, feather growth requires amino acids and other nutrients from the diet (Hohman et al. 1992). Flightlessness also restricts mobility, reducing effective foraging area and requiring a change in predator avoidance behavior. Summer drought is normal in California, and large, permanent marshes are rare in the Central Valley relative to their availability at northern breeding areas. Therefore, northward postbreeding movement to predictable summer wetlands may be an adaptive trait for Mallards breeding in California.

It is unknown whether current postbreeding movement patterns of California Mallards occurred historically. Large emergent wetlands previously occurred throughout California's Central Valley, including an estimated 200,000 ha of permanent wetland habitat (California Department of Fish and Game [CDFG] 1983). California wetlands have been altered dramatically since the state's settlement, largely due to reclamation for agriculture, development, and flood control. About 95% of Central Valley wetlands has been drained or modified (Gilmer et al. 1982). Wetland loss in Klamath Basin has been less severe (about 75%; Akins 1970) and affected a relatively smaller proportion of permanent wetlands than in central California. Prehistoric Klamath Basin wetlands were subject to annual fluctuations in water levels (Akins 1970), but less so than in the Central Valley. In addition, water levels peaked later in Klamath Basin due to differences in climate and thus more closely coincided with the Mallard molting period. Although we suspect that more Mallards molted in the Central Valley than at present, an unknown proportion likely moved farther north to molt, especially during extreme drought years.

MOLTING SITE FIDELITY

Dabbling ducks, especially Mallards, are traditional in their use of habitats. Many researchers (Sowls 1955, Bishop et al. 1978, Lokemoen et al. 1990, Majewski and Beszterda 1990) have shown that female Mallards are philopatric to nesting areas, especially if they nested successfully the previous year (Lokemoen et al. 1990, Majewski and Beszterda 1990). Certain duck species also use traditional wintering areas (Sugden et al. 1974, Fedynich et al. 1989), although these tendencies are not as well documented as for nesting waterfowl. Conclusions concerning traditional use of molting areas are based on recaptures of banded birds at the same molting marsh (Hochbaum 1944, Anderson and Sterling 1974, Bowman and Brown 1992, Szymczak and Rexstad 1991), but breeding ground origin is seldom known. During this study, two Mallard hens radio-marked in consecutive seasons returned to molt on the same wetland used previously. Although the sample size is small, it strongly suggests that Mallards exhibit site fidelity to molting areas.

HUNTING MORTALITY

The importance of the Mallard as a game bird has resulted in comprehensive study of harvest and annual survival (e.g., Anderson and Burnham 1976, Burnham et al. 1984, Smith and Reynolds 1992). Females are of particular concern because high natural mortality is associated with breeding (Sargeant and Raveling 1992), and Mallard management efforts often focus on reducing female mortality. Evidence suggests that hen Mallards incur high hunting mortality at northern breeding grounds (Hochbaum 1944, 1947; Jessen 1970; Gilmer et al. 1977). Explanations for this apparent increased vulnerability include late nesting and molting (Clark et al. 1988, Hochbaum and Caswell 1991), poor physical condition (Caswell et al. 1985), and early hunting seasons and lack of dispersal (Caswell et al. 1985, Hochbaum and Caswell 1991). However, studies of the relationship of localized hunting mortality and annual survival have produced conflicting results (e.g., Cowardin and Johnson 1979, Kirby et al. 1983, Caswell et al. 1985).

The postbreeding migration by females in California differs from that of hens in northern areas and may affect hunting mortality rates. In our study, nine hens had operational transmitters near the start of the hunting season, but none had returned to Suisun Marsh. In addition, only two of 34 radio-marked females from California were harvested during the 1987–1988 hunting season. Hens banded on nests at Grizzly Island were also recovered at a low rate. There were only 11 direct recoveries of 528 Mallards captured from 1985 to 1991 (McLandress, unpubl. data). By contrast, the severity of hunting mortality on local nesting hens was documented with radio-marked Mallards in Minnesota (Gilmer et al. 1977). A total of 28 of 74 radio-marked hens was harvested, of which 13 were shot near the breeding area (Gilmer et al. 1977). Thus, hunting mortality of females breeding in Suisun Marsh, California, may not be as high as that recorded in northern breeding Mallards. We suggest that low vulnerability of Suisun Marsh hens to hunting results from the postbreeding migration.

IMPLICATIONS FOR HABITAT MANAGEMENT

Wetland habitat management in the Central Valley and Suisun Marsh emphasizes production of food plants for wintering waterfowl (Heitmeyer et al. 1989), a strategy that requires a drawdown period in spring or summer (Fredrickson and Taylor 1982). As a result, flooded emergent wetlands during summer are rare. Flooded rice fields are common in the Sacramento Valley and may provide loafing and feeding areas for postbreeding ducks until October. Radio-marked hens during this study were rarely located on flooded rice fields, however.

Goals of marsh management rarely emphasize habitat for postbreeding or molting ducks. Tall emergent vegetation preferred by molting Mallards typically occurs in managed wetlands left flooded during the summer for breeding ducks and their broods or in marshes that are contiguous with lakes or rivers where water level cannot be controlled. We suggest that important molting marshes in the West and elsewhere be identified and maintained as desirable habitat for postbreeding ducks (see also Ringelman 1990, Hohman et al. 1992). This would involve managing water levels by protecting habitat and securing necessary water rights.

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