CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

Avian Influenza Surveillance Summary

July 2022 - June 2023 Season

Executive Summary

Avian influenza H5N1 (Eurasian lineage goose/Guangdong H5 clade 2.3.4.4b) was detected for the first time along the Atlantic Coast of North America in late 2021 and early 2022 in both wild and domestic birds. Following its introduction into the eastern United States, the virus continued to spread west and south to other states. In California, the first avian influenza H5N1 detections were in wild birds, including Canada geese and an American white pelican, collected from Glenn and Colusa counties in Northern California in early July 2022. These detections followed virus detections in bordering states in domestic and wild birds in Oregon in May, wild birds in Arizona in June, and a backyard flock in Nevada also in early July.

Between July 2022 and June 2023, avian influenza H5N1 was detected in 367 wild birds in California during state-wide mortality surveillance. Detections were made in birds collected from 44 counties. Initial detections of the virus were generally geographically made in a mostly southward direction, likely coinciding with the arrival and southward movement of migrating birds. It took roughly 4 months between the initial detection in Northern California in July to detections in Southern California in October.

In general, the number of avian influenza detections gradually increased through the fall of 2022, peaking in November. Detections then began to decline, beginning in December 2022 through June 2023. This pattern corresponds with the southward fall migration and over-wintering of numerous waterfowl in the state. By late winter and spring, birds begin spring migration northward to breeding areas.

Detections were made in about 50 different species of wild and feral birds. Detections were generally highest in species of waterfowl, followed by other waterbirds, and predators and scavengers. Species with the highest number of detections included Canada geese, turkey vultures, snow geese, red-tailed hawks, and American white pelicans.

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Canada geese at a park in Sacramento County, California. Photo credit: Krysta Rogers, CDFW.

1. Introduction

Avian influenza is an infectious disease of birds caused by avian-origin influenza A viruses. Viruses are classified based on two surface proteins, Hemagglutinin (H) and Neuraminidase (N), which combine to form different subtypes (e.g., H5N1, H5N2, H7N3, H12N5) (Stallknecht et al. 2007). Different subtypes, and strains within a subtype, vary in their ability to cause disease in birds. Avian influenza viruses may be further categorized as highly pathogenic (HP) or low pathogenic (LP) based on their ability to cause disease in domestic poultry.

Avian-origin influenza A viruses naturally circulate in wild waterbirds including species within the orders of Anseriformes (ducks, geese, and swans) and Charadriiformes (gulls, terns, and shorebirds) (Hill et al. 2022; Stallknecht et al 2007). Avian influenza viruses are shed in bodily fluids such as saliva, nasal secretions, and feces. Water is important for virus transmission between individual waterbirds. These birds may be inadvertently exposed to viruses when eating, drinking, preening, and/or bathing in water potentially contaminated with viruses. In wild waterbirds, virus circulation has historically increased during fall migration as individual birds co-mingle at various stopover locations (e.g., wetlands, ponds, lakes) through migration (van Dijk et al. 2014). These naturally circulating viruses are of low virulence and rarely cause illness or death of wild birds (Stallknecht et al. 2007).

Avian influenza H5N1 (Eurasian lineage goose/Guangdong H5 clade 2.3.4.4b) was detected for the first time along the Atlantic Coast of North America in Canada in December 2021 and in the United States in January 2022 (Alkie et al 2022; Youk et al. 2023). Detections of this virus had been on the rise across parts of Europe during the preceding years, and especially in 2022 with detections in both wild and domestic birds (EFSA et al., 2022). Prior to this current outbreak, avian influenza viruses considered highly pathogenic had been more of a disease of domestic poultry with occasional spill-over into wild birds which may or may not have caused mortality (Ramey et al. 2022). This current outbreak is unprecedented in terms of the geographic range and diversity of wild birds and mammals potentially impacted. The virus has near world-wide circulation with detections on all continents except Oceania (Xie et al. 2025). Notably, this was the first avian influenza virus to reach seabirds in Antarctica. A high diversity of wild birds and mammals are susceptible to fatal infection with avian influenza H5N1. Since 2022, outbreaks have impacted backyard and commercial domestic poultry in the United States and elsewhere, and dairy cattle in the United States since 2024 (Xie et al., 2025).

Avian influenza H5N1 in free-ranging wild birds may be maintained in waterfowl and shorebirds, the natural hosts of avian influenza viruses, and water is important for transmission among these species (Harvey et al. 2023; Hill et al. 2022). As such, the focus of virus activity tends to occur around some type of waterbody, typically a closed or semi-closed waterbody, where waterfowl may congregate and the virus has the potential to become more concentrated. Avian and mammalian predators and scavengers that feed on infected animals also may be at risk of becoming infected.

Bird species that spend little to no time in wetlands and other water-dominant habitats are generally less likely to be exposed to the virus (e.g., small songbirds).

Snow geese and northern pintail ducks on a wetland pond in Glenn County, California. Photo credit: Krysta Rogers, CDFW.

2. Surveillance & diagnostic testing

2.1. Mortality-based surveillance

The California Department of Fish and Wildlife's (CDFW) Wildlife Health Laboratory conducts mortality-based surveillance for avian influenza which involves testing wild birds found dead. Mortality-based surveillance occurs year-round and is opportunistic when dead birds are submitted. Birds may be submitted by agencies, wildlife rehabilitation centers, other organizations, and members of the public. Mortality surveillance can help identify what species are susceptible to clinical or fatal infection rather than those that may be reservoirs of the virus.

Mortality events involving multiple dead birds are prioritized for surveillance. Mortality events are generally more easily detected than an individual dead bird. Additionally, mortality surveillance generally increases the likelihood of a detection since many dead birds in a location may indicate an infectious disease outbreak. Surveillance testing of individual birds may be considered for certain species known to be at higher risk of infection (e.g., predators, scavengers) and for lower risk species found in locations with a known outbreak and/or presenting with suspicious clinical signs. Since reporting of dead birds relies on observations made by people, submissions of dead birds, and therefore testing of birds, tends to be biased towards areas with more people including the San Francisco Bay Area and the South Coast. Birds that die in more remote or less human-populated areas are less likely to be represented during testing. Submissions also tend to bias larger-bodied birds since they are more visible and persist longer on the landscape.

Mortality-based surveillance provides a broad account of virus activity over time across the entire state. Initial surveillance generally targets areas without virus detections. Once a detection is made in an area, subsequent testing may occur periodically thereafter to monitor virus activity over the longer term. It is important to note, only a portion of birds are tested, although many more may be reported. Therefore, the number of birds with detections does not accurately represent the total number of birds that may have ultimately died of infection.

Surveillance testing of wild birds is primarily coordinated though CDFW's Wildlife Health Lab. Although, other agencies and organizations may perform surveillance testing of wildlife independently from CDFW. For example, the United States Fish and Wildlife Service (USFWS) may conduct surveillance testing during mortality investigations on federal public lands. In some cases, CDFW may or may not be made aware of the details of testing performed by other partners.

2.2. Diagnostic testing

For wild birds, the diagnostic standard for avian influenza testing is the collection of an oropharyngeal swab and a cloacal swab from each bird. The swabs are inoculated into viral transport medium.

The CDFW's Wildlife Health Lab receives dead birds year-round for mortality investigation and surveillance testing. Bird species and age are routinely recorded. Swab samples are collected from each bird and submitted for testing to the California Animal Health and Food Safety (CAHFS) Laboratory system which is part of the National Animal Health Laboratory Network.

A real-time reverse-transcriptase polymerase-chain-reaction (rRT-PCR) is commonly used for surveillance testing for avian influenza viruses (USDA 2022). The PCR test detects the genetic material of the virus, if present. Generally, preliminary testing at CAFHS includes an initial PCR to detect influenza A viruses. If detected, a subsequent PCR is performed to determine if the virus is an H5 subtype. If an influenza A virus is detected, a sample is forwarded to the United States Department of Agriculture's (USDA) National Veterinary Services Laboratories (NVSL) for confirmatory testing. The NVSL performs PCR testing for influenza A and the H5 subtype. Virus isolation is also attempted to further genetically characterize the virus and to determine if the virus is of low or high pathogenicity. Because highly pathogenic avian influenza is a federally regulated disease for poultry, all detections of avian influenza must undergo confirmatory testing by NVSL.

3. Surveillance results

3.1. Mortality investigations

Between January and June 2022, prior to avian influenza H5N1 being detected in California, roughly 475 birds were received at the CDFW's Wildlife Health Lab. Following the first detection of avian influenza H5N1 in California in July 2022, roughly 1,091 birds were received between July 2022 and June 2023. Of these birds, 649 were selected for surveillance testing by the CDFW's Wildlife Health Lab. Approximately 299 birds were tested by other agencies and organizations. Note, the results of surveillance testing presented in this summary report should be considered preliminary and subject to change.

3.2. Avian influenza detections

In California, the first avian influenza H5N1 detections were in wild birds collected from Glenn and Colusa counties in Northern California in early July 2022. This included detections in one American white pelican and two Canada geese collected during a mortality event on federal land with testing coordinated by USFWS. Between January 2022 and June 2023, approximately 948 wild birds were tested for avian influenza by CDFW and partners. Between July 2022 and June 2023, avian influenza H5N1 was detected in about 367 wild birds collected from 44 counties (Fig. 1; Appendix Table 1).

Figure 1. California counties shaded in orange with avian influenza detections in wild birds during the July 2022 - June 2023 season. The black star indicates the location of the first detection of the season in July 2022. Map credit: Krysta Rogers, CDFW.

3.3. Detections over time

The initial detections of the virus were generally geographically made in a mostly southward direction, likely coinciding with the arrival and southward movement of migrating birds. Less than 4 months separate the initial detections in Northern California in July 2022 from detections in Southern California in October 2022 (Fig. 2). While detections in November and December were filling in some of the counties for which detections had not been made previously (Fig. 2).

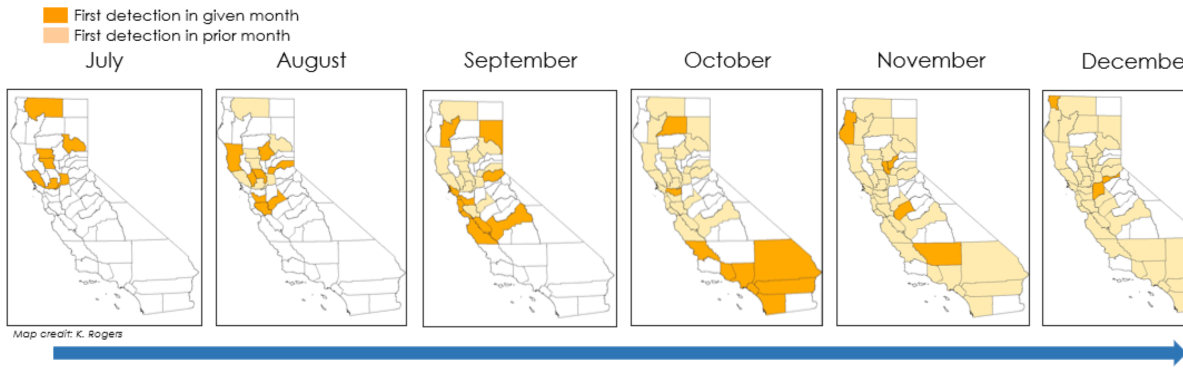


Figure 2. The first detections of avian influenza H5N1 in wild birds in California by month between July and December 2022. Counties with a detection during the given month are in orange, and the detections in prior months are in tan. Initial detections were generally geographically made in a mostly southward direction likely coinciding with the southward movement of migrating birds. Map & image credit: Krysta Rogers, CDFW.

In general, the number of avian influenza detections gradually increased through the fall, peaking in November 2022 (Fig. 3). Detections then began to decline between December 2022 and June 2023 (Fig. 3). The first detections of avian influenza H5N1 were in wild birds collected on July 5, 2022 during a mortality event in Glenn and Colusa counties. Detections continued in birds collected in August through November, steadily increasing during this time. Detections then dropped off, beginning in December, and continued to decline between January and March 2023. Only four detections were made in birds collected between April and June 2023. The last detection of the season was made in a bird collected on June 16, 2023. Detections in waterfowl generally lead detections through the fall, followed in a few weeks with detections in waterbirds, raptors, and scavengers. (Fig. 4; see Appendix Table 2 for generalized bird group taxonomic classifications).

Turkey vultures scavenging on spawned salmon along the American River in Sacramento County, California. Photo credit: Krysta Rogers, CDFW.

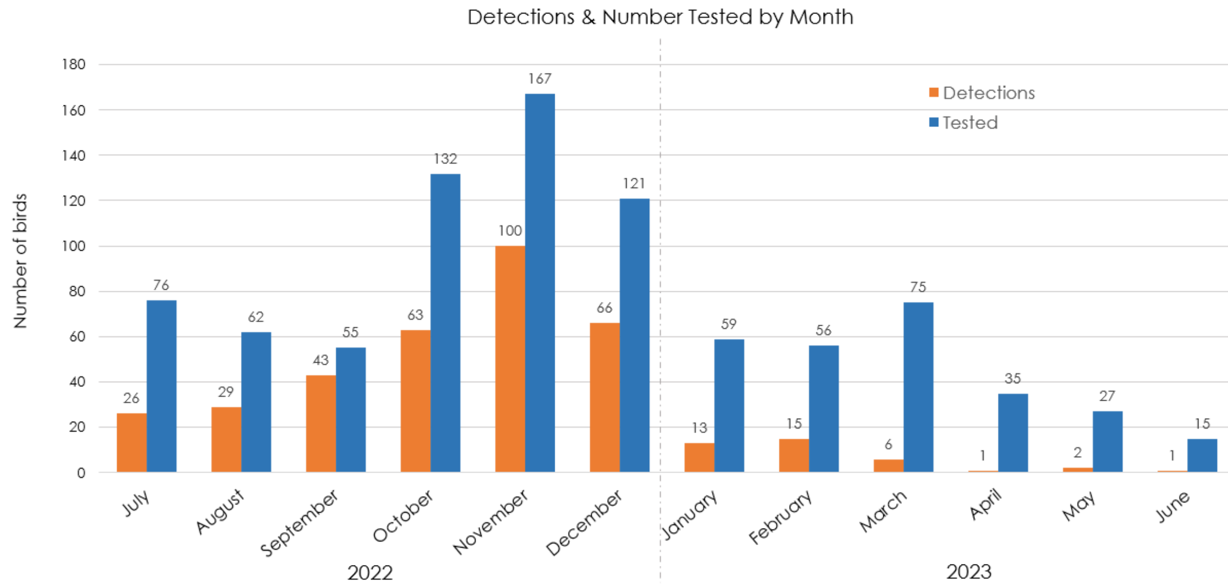


Figure 3. Detections of avian influenza H5N1 in wild birds by month in California during the July 2022 - June 2023 season. The orange bars indicate the number of detections in wild birds. The blue bars indicate the number of wild birds tested for avian influenza. Image credit: Krysta Rogers, CDFW.

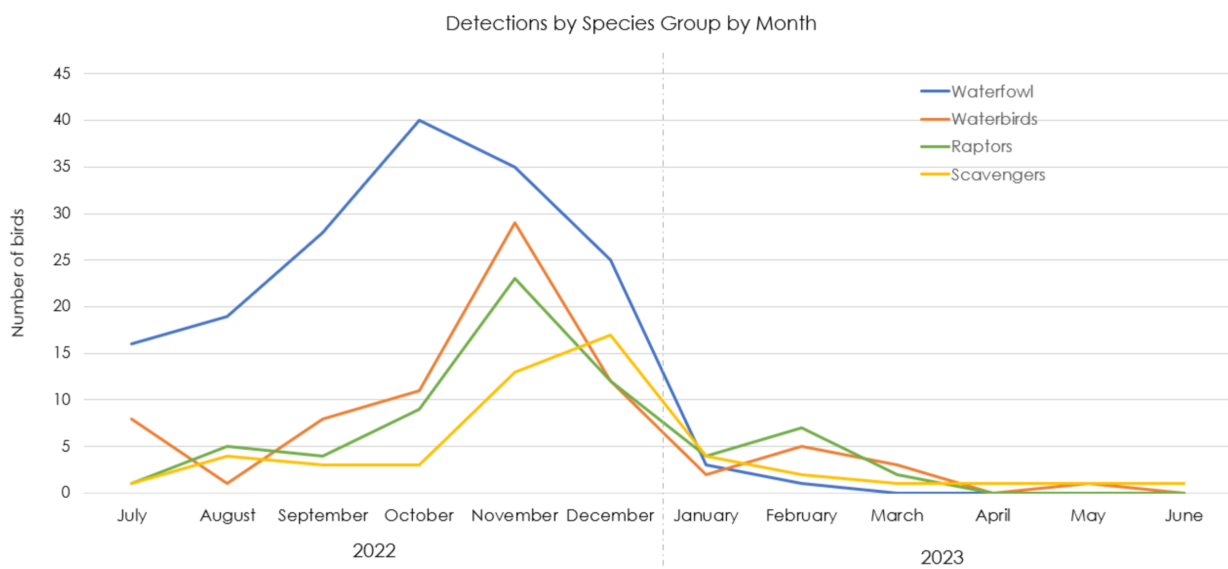


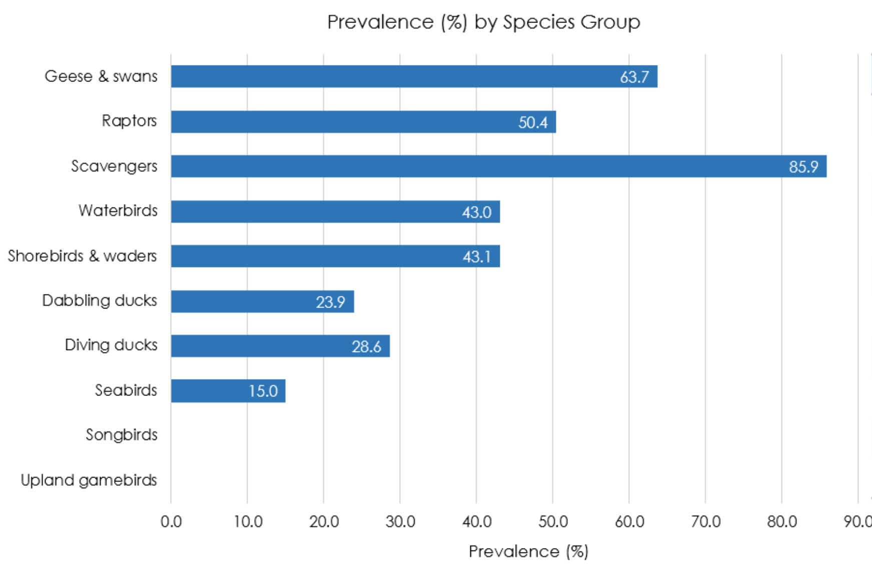
Figure 4. Detections of avian influenza H5N1 by wild bird group by month in California during the July 2022 - June 2023 season. Line colors correspond to waterfowl in blue, waterbirds in orange, raptors in green, and scavengers in yellow (see Appendix Table 2 for bird group taxonomic classifications). Image credit: Krysta Rogers, CDFW.

3.4. Detections by avian species

Detections were made in about 50 different species of wild and feral birds between July 2022 and June 2023 (Appendix Table 1). Detections were made in 16 waterfowl species, 11 waterbird species, 10 predator and scavenger species, 9 shorebird and wader species, and 4 seabird species (Appendix Table 2).

Evaluating detections by bird functional group, in which similar species are grouped together, the highest number of detections were in geese and swans as a group, followed by raptors as a group, then scavengers, waterbirds, shorebirds and waders, dabbling ducks, diving ducks, and seabirds (Fig. 5; see Appendix Table 3 for bird functional group taxonomic classifications). No detections were made in songbirds or upland game birds, out of about 124 and 17 birds tested, respectively (Fig. 5). Detection prevalence was highest for scavengers, followed by geese and swans, raptors, shorebirds and waders, waterbirds, diving ducks, dabbling ducks, and seabirds (Fig. 5).

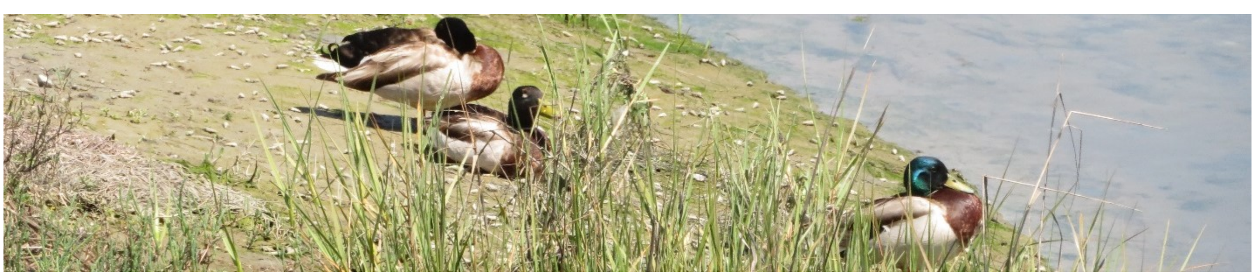
The wild bird species with the highest number of detections included Canada geese, turkey vultures, red-tailed hawks, snow geese, and American white pelicans (Fig. 6; Appendix Table 1). It is important to note, the number of detections gives a general idea of virus activity in these species but since not all birds reported dead are tested, detections do not relate directly to actual number of birds that died during the outbreak.



Species Group	AIV Detections	Number Tested
Geese & swans	149	234
Raptors	67	133
Scavengers	61	71
Waterbirds	52	121
Shorebirds & waders	22	51
Dabbling ducks	16	67
Seabirds	6	40
Diving ducks	4	14
Songbirds	0	124
Upland gamebirds	0	17

*Species not specified for 8 birds (data not shown).

Figure 5. Graph depicting the percent prevalence (%) of avian influenza H5N1 detections by wild bird functional group in California during the July 2022 - June 2023 season. Table depicting the number of avian influenza (AIV) H5N1 detections and the total number tested for each wild bird functional group for the same period (see Appendix Table 3 for bird functional group taxonomic classifications). Image credit: Krysta Rogers, CDFW.



Mallard ducks roosting along a slough in San Diego County, California. Photo credit: Krysta Rogers, CDFW.

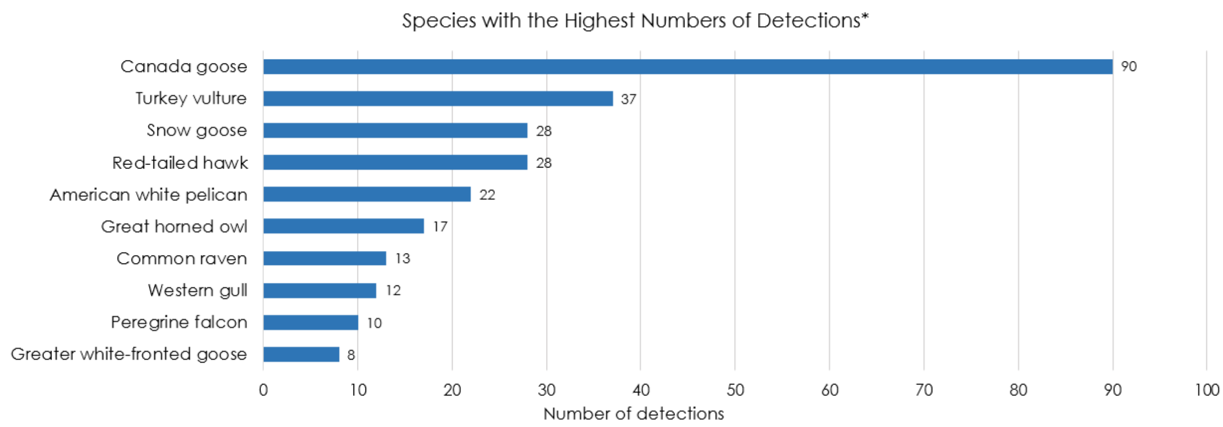


Figure 6. Wild bird species with the highest number of avian influenza H5N1 detections in California between July 2022 and June 2023. *Note, only a portion of reported birds are tested. Actual mortality due to infection may be higher. Image credit: Krysta Rogers, CDFW.

3.5. Detections by virus subtype and strain

The USDA's NVSL attempts to genetically characterize the subtype and strain of virus detections. Avian influenza viruses are constantly changing, and Eurasian (EA) subtypes and strains may reassort with North American (AM) subtypes and strains circulating in the same avian host. During the 2022-23 season, the subtype for detected viruses included EA/AM 2.3.4.4b H5N1 (n = 230), which is a recombination of Eurasian and North American viruses, and EA 2.3.4.4b H5N1 (n = 50), which is a predominately Eurasian virus. Subtype was not reported for 85 birds. Virus strain was not regularly reported by USDA's NVSL for detections during the 2022-23 season. The virus strain reported for 4 birds was EA/AM 2.3.4.4b H5N1 B3.2.

4. Conclusions

Overall, mortality-based surveillance was useful to assess the geographic distribution of avian influenza activity and the wild bird species impacted. The highest number of detections in California wild birds occurred in the fall, peaking in November, which coincided with the arrival and southward movements of migratory birds. A higher number of detections were made initially in waterfowl species followed within a few weeks by detections in other waterbirds, that share habitat with waterfowl, and predators and scavengers, that feed on infected animals. A high diversity of wild bird species appeared to be susceptible to infection with detections in about 50 different species in California.

It is difficult to assess the full impact of this disease on wild bird populations. Mortality may go unreported and uninvestigated in more remote or natural areas. Additionally, only a portion of reported birds are able to be tested. It also is challenging to get an accurate account of how many birds may have died over a prolonged period across the entire state. Mortality reporting can be helpful to fill in some of these information gaps but reporting consistency over time may be variable due to reporting fatigue and it may be absent in more remote areas or when fewer numbers of birds are observed.

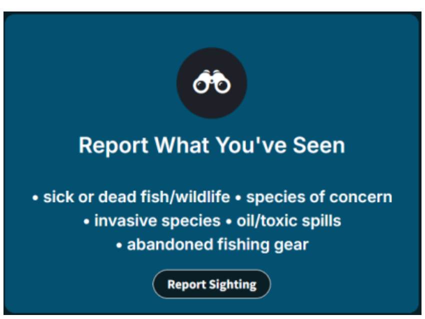
Since this virus appears to be adapting to certain migratory bird hosts (e.g., dabbling ducks), the H5 clade 2.3.3.4b virus is likely to remain in circulation at some level increasing in some seasons and decreasing in others. Additionally, if the virus persists in domestic poultry and dairy cattle year-round, there may be more opportunities for spill-over into wild birds outside of the fall migratory period. Given that testing resources are limited, it will be important to balance the need for avian influenza surveillance with the need for mortality investigations caused by other threats.

Ducks on a wetland pond at dusk in Glenn County, California. Photo credit: Krysta Rogers, CDFW.

Mortality Reporting

Wildlife mortality may be reported to CDFW using the Wildlife Mortality Reporting System, link for website: [Wildlife Mortality Reporting (ca.gov)]

Alternatively, the link may be accessed through the CDFW homepage (*https://wildlife.ca.gov/*), just *scroll partway down and click on "report what you've seen."*



5. Appendices

5.1. Appendix 1

Appendix Table 1. Number of avian influenza H5N1 detections by wild bird species in California between July 2022 and June 2023. *Note, only a portion of reported birds are tested. Actual mortality due to infection may be higher.

Bird Species	No. of Detections*
AMERICAN CROW	1
AMERICAN WHITE PELICAN	22
AMERICAN WIGEON	1
BALD EAGLE	5
BLACK SWAN (feral)	1
BLACK TURNSTONE	1
BLACK-CROWNED NIGHT HERON	5
BONAPARTE'S GULL	1
BRANDT'S CORMORANT	1
BRANT	1
BROWN PELICAN	3
BUFFLEHEAD	4
CACKLING GOOSE	4
CALIFORNIA GULL	2
CANADA GOOSE	90
CHINESE GOOSE (feral)	1
COMMON LOON	1
COMMON RAVEN	13
COOPER'S HAWK	3
CORMORANT (not specified)	1
DOMESTIC GOOSE	1
DOUBLE-CRESTED CORMORANT	1
EARED GREBE	2
GLAUCOUS-WINGED GULL	1
GOLDEN EAGLE	1
GOOSE (not specified)	2
GREAT EGRET	1
GREAT HORNED OWL	17
GREATER WHITE-FRONTED GOOSE	9
GREEN HERON	1
GULL (not specified)	2
HERRING GULL	3
HORNED GREBE	1
MALLARD	4
MUSCOVY (feral)	8

MUTE SWAN (feral)	2
NORTHERN FULMAR	1
NORTHERN PINTAIL	1
PELICAN (not specified)	1
PEREGRINE FALCON	10
PIED-BILLED GREBE	1
RED-SHOULDERED HAWK	3
RED-TAILED HAWK	28
RING-BILLED GULL	1
ROSS'S GOOSE	2
SANDERLING	3
SNOW GOOSE	36
SNOWY EGRET	4
SNOWY PLOVER	2
TURKEY VULTURE	37
WESTERN GREBE	1
WESTERN GULL	12
WHITE-FACED IBIS	4
WILLET	1
WOOD DUCK	2

5.2. Appendix 2

Appendix Table 2. Taxonomic classifications, and corresponding common names, included in each generalized bird group for raptors, scavengers, waterfowl, and waterbirds (Chesser et al. 2024).

Generalized Bird Group	Taxonomic Classification	Common Name
Raptors	Orders Accipitriformes, Falconiformes, & Strigiformes	eagles, falcons, hawks, owls
Scavengers	Genera Cathartes & Corvus	crows, ravens, vultures
Waterbirds	Orders Charadriiformes, Gaviiformes, Gruiformes, Pelecaniformes, Podicipediformes, Procellariiformes, & Suliformes	auks, cormorants, grebes, gulls, loons, pelicans, shorebirds, terns, waders, other seabirds
Waterfowl	Order Anseriformes	ducks, geese, swans

5.3. Appendix 3

Appendix Table 3. Taxonomic classifications included in each bird functional group for dabbling ducks, diving ducks, geese & swans, raptors, scavengers, seabirds, shorebirds & waders, songbirds, upland gamebirds, and waterbirds (Chesser et al. 2024).

Bird Functional Group	Taxonomic Classification
Dabbling ducks	Genera Aix, Anas, Cairina, Mareca, & Spatula
Diving ducks	Genera Aythya, Bucephala, Lophodytes, Melanitta, Mergus, & Oxyura
Geese & swans	Genera Anser, Branta, & Cygnus
Raptors	Orders Accipitriformes, Falconiformes, & Strigiformes
Scavengers	Genera Cathartes & Corvus
Seabirds	Families Alcidae, Gaviidae, Hydrobatidae, Oceanitidae, Phalacrocoracidae (except *Nannopterum auritum*), Procellariidae, & Stercorariiae; *Pelecanus occidentalis*
Shorebirds & waders	Families Ardeidae, Charadriidae, Gruidae, Haematopodidae, Raillidae, Recurvirostridae, Scolopacidae, & Threskiornithidae
Songbirds	Orders Apodiformes, Caprimulgiformes, Coraciiformes, Cuculiformes, Passeriformes (except Corvidae), & Piciformes
Upland gamebirds	Orders Columbiformes & Galliformes
Waterbirds	Families Laridae & Podicipedidae; *Pelecanus erythrorhynchos*; *Nannopterum auritum*

6. References

Alkie TN, Lopes S, Hisanaga T, Xu W, Sunderman M, Koziuk J, Fisher M, and others. 2022. A threat from both sides: multiple introductions of genetically distinct H5 HPAI viruses into Canada via both East Asia-Australasia/Pacific and Atlantic flyways. Virus Evolution 8: 1-8. https://doi.org/10.1093/ve/veac077

Chesser RT, Billerman SM, Burns KJ, Cicero C, Dunn JL, Hernández-Baños BE and others. 2024. Check-list of North American Birds (online). American Ornithological Society. https://checklist.americanornithology.org/taxa/

EFSA. European Food Safety Authority, European Centre for Disease Prevention and Control, European Union Reference Laboratory for Avian Influenza, Adlhoch C, Fusaro A, Gonzales JL, Kuiken T, Marangon S, Niqueux E, Staubach C, Terregino C, Aznar I, Munoz Guajardo I, and Baldinelli R. 2022. Avian influenza Overview December 2021-March 2022. EFSA Journal 2022; 20(4):7289, 64 pp. https://doi.org/10.2903/j.efsa.2022.7289

Harvey JA, Mullinax JM, Runge MC, and Prosser DJ. 2023. The changing dynamics of highly pathogenic avian influenza H5N1: next steps for management and science in North America. Biological Conservation 282: 110041. https://doi.org/10.1016/j.biocon.2023.110041

Hill NJ, Bishop MA, Trovão NS, Ineson KM, Schaefer AL, Puryear WB, and others. 2022. Ecological divergence of wild birds drives avian influenza spillover and global spread. PLoS Pathogens 18: e1010062. https://doi.org/10.1371/journal.ppat.1010062

Ramey AM, Hill NJ, DeLiberto TJ, Gibbs SEJ, Hopkins MC, Lang AS, and others. 2021. Highly pathogenic avian influenza is an emerging disease threat to wild birds in North America. The Journal of Wildlife Management 86: e22171. https://doi.org/10.1002/jwmg.22171

Stallknecht DE, Nagy E, Hunter DB, and Slemons RD. 2007. Avian influenza. In: Infectious Diseases of Wild Birds. Thomas NJ, Hunter DB, and Atkinson CT (editors). Blackwell Publishing, Ames, IA, USA. Pp. 108-130.

USDA. United States Department of Food and Agriculture. Animal and Plant Health Inspection Service. Case definition, Avian influenza (AI) (notifiable), March 2022, 4 pp. https://aphis.stg.platform.usda.gov/sites/default/files/avian-influenza-case-definition.pdf.

van Dijk JGB, Hoye BJ, Verhagen JH, Nolet BA, Fouchier RAM, and Klaassen M. 2014. Juveniles and migrants as drivers for seasonal epizootics of avian influenza virus. Journal of Animal Ecology 83: 266-275. https://doi.org/10.1111/1365-2656.12131

Xie Z, Yang J, Jiao W, Li X, Iqbal M, Liao M, and Dai M. 2025. Clade 2.3.4.4b highly pathogenic avian influenza H5N1 viruses: knowns, unknowns, and challenges. Journal of Virology 99: 1-17. https://doi.org/10.1128/jvi.00424-25

Youk S, Torchetti MK, Lantz K, Lenoch JB, Killian ML, Leyson C, Bevins SN, and others. 2023. H5N1 highly pathogenic avian influenza clade 2.3.4.4b in wild and domestic birds: introductions into the United States and reassortments, December 2021-April 2022. Virology 587: 109860. https://doi.org/10.1016/j.virol.2023.109860

Greater white-fronted geese on a flooded field in Northern California. Photo credit: Krysta Rogers, CDFW.