AVIAN DISEASE AT THE SALTON SEA

Milton Friend
Executive Director
Salton Sea Science Subcommittee

Introduction

During recent years, the Salton Sea has experienced an unprecedented array and frequency of disease outbreaks in migratory birds. A wide variety of bird species have been affected and some of these outbreaks have been of catastrophic proportions (Fig. 1). The frequency of occurrence, magnitude of losses and variety of diseases occurring at the Sea is indicative of an ecosystem under severe stress (Rapport and Whitford 1999). This presentation highlights the avian diseases occurring at the Sea, considers their importance as a factor in the conservation of migratory birds and comments on what is being done at the Sea to minimize bird losses from disease.

Disease as a Concept

The occurrence of disease is an outcome involving three primary factors (Fig. 2). Those factors are susceptible hosts, agents capable of causing disease and suitable environmental factors that facilitate host-agent interactions in a manner that results in disease (Friend 1995). Therefore, the outcome of disease generally has an ecological basis and is not a random event. That outcome only occurs within the area of overlap between the host and agent depicted in Figure 2. Numerous factors moderate these relations in various ways. For example, factors that stress the hosts can increase their susceptibility to disease agents present in the environment; the environmental persistence

of disease agents at levels required to cause disease is greatly affected by the environment those agents are present in; and there must be adequate pathways for the agents to reach the host and result in disease. Several different types of disease agents are causing bird deaths at the Salton Sea, some of which are infectious and others that are not (Table 1).

Landscape Change as a Disease Factor

The quantity and quality of wildlife habitat are important factors relative to the well-being of the wildlife dependent upon that habitat (Friend 1992). Both of these parameters have been significantly degraded for wetland dependent wildlife. California leads the nation with losses of more than 90 percent of the inland wetland acreage present at the time of settlement of the United States (Dahl 1990) (Fig. 3). These losses have resulted in the Salton Sea, since its formation during 1905-1907, becoming an increasingly important component of the remaining wetland habitat within the Pacific Flyway (Fig. 4). However, the environmental quality of the Sea has degraded significantly since that time and is a factor in disease occurrence.

Limitations in the quantity of wetland habitat within the Flyway results in heavy bird use of the Sea. Additional reductions in habitat due to landscape change associated with human population growth and associated uses of lands and water to meet human needs will result in even greater use of the Sea as waterbird habitat. A consequence of reduced quantity of habitat is increased proportions of bird populations being concentrated on some of the remaining habitat and prolonged continued use of that habitat. These conditions facilitate increased vulnerability to any disease outbreaks that

occur and can also contribute to increasing the probability for outbreaks of disease due to the impacts by the birds on the quality of that habitat (Friend 1992).

Historic Perspective

Avian disease is not new to the Salton Sea. Disease outbreaks have occurred since at least the 1920s (Holmes 1933) and likely before then. Outbreaks occurred annually during the period of 1925-1935, with the exception of 1932, and each of these events killed a substantial number of birds (Holmes 1933; Kalmbach 1938). The frequency of outbreaks was far less during the period of 1936-1945 (Salton Sea National Wildlife Refuge narrative reports). Although the frequency of outbreaks has been high since 1946, with few exceptions, the magnitude of losses during disease events that occurred during the period of 1936-1987 was generally low (Salton Sea National Wildlife Refuge Narrative Reports, National Wildlife Health Center Database). Since 1987, the magnitude of losses from disease has increased substantially (Fig. 5) and resulted in considerable focus on disease as an important cause of bird mortality at the Salton Sea (National Wildlife Health Center Database).

Avian Disease Then and Now

During recent years, several new diseases have appeared at the Salton Sea (Fig. 6) along with an increased magnitude of bird losses from disease. Avian botulism was the first disease diagnosed as a cause of bird mortality (Kalmbach 1938) and has

persisted as a disease problem. However, during the mid 1990s, this disease has killed large numbers of fish-eating birds, primarily pelicans, in addition to the classical outbreaks of type C botulism in waterfowl, shorebirds, and accompanying losses of small numbers of other species (National Wildlife Health Center Database). Large-scale losses of fish-eating birds from type C avian botulism is a unique event that has not been reported elsewhere. Lead poisoning due to the ingestion of spent lead shot is another historic but seldom reported cause of bird mortality at the Salton Sea. Lead poisoning has been reported on just four occasions as a cause of mortality involving a few waterfowl. Those events occurred during the period of 1933-1991. Pesticides were reported to be the suspected cause of bird mortality at the Sea during 1962 and 1963, but diagnostic work was not done to confirm this cause or identify the type of pesticides involved. No other cases of pesticide poisoning in birds have been reported at the Sea although several events have been reported for agricultural fields and irrigation drains leading to the Sea (Fig. 6).

Avian cholera first appeared at the Salton Sea in 1979 as a cause of a major mortality event. This bacterial disease first appeared in wild birds within the United States in 1944, has been a continual problem in California since then and has greatly expanded its geographic distribution within North America since the 1970s (Friend 1999). Avian cholera has been a frequent visitor to the Salton Sea since 1987 (Fig. 6). Salmonellosis, a cosmopolitan bacterial disease has appeared at least five times since 1989 when it was first diagnosed at the Sea. Newcastle disease, an internationally important viral disease of poultry, made its first appearance at the Sea during 1997 and reappeared during 1998. Algal toxins had been suspected as the cause of bird mortality at

the Sea in 1955 and again in 1975 but was not confirmed by diagnostic evaluations to be the mortality factor. Repeated bird mortality events occurring since 1992 are also thought to be due to algal toxins (Fig. 6) but this cause has not been confirmed despite extensive diagnostic evaluations. It is clearly evident from the information available that disease outbreaks at the Salton Sea since the late 1980s have increased in frequency, that the magnitude of bird deaths is far greater than during previous times and that there has been an increase in the types of diseases causing those deaths.

Disease Impacts

Several of the disease outbreaks of recent years are of catastrophic proportions (Table 2). The 1992 mortality event killed an estimated 155,000 birds including approximately 150,000 eared grebes (Podiceps nigricollis) (Natural Wildlife Health Center Database). This loss was about 7 percent of the eared grebe population (Jehl 1996). A greater population impact occurred in 1996 when approximately 15-20 percent (Anderson 1999) of the western population of white pelicans (Pelicanus erythrorhynchos) died from avian botulism. More than 1,000 endangered California brown pelicans (Pelicanus occidentalis) were also affected by this disease (National Wildlife Health Center Database). The 1997 and 1998 occurrences of Newcastle disease essentially resulted in the loss of all of the several thousand double-crested cormorant (Phalacrocorax auritus) nestlings produced in those years by the Mullet Island cormorant colony. The disease events just cited are significant levels of loss for the populations being affected and require actions to minimize the potential for repeated losses of similar magnitude.

What is Being Done?

The increase in losses of birds from disease at the Salton Sea has resulted in increased efforts to combat this problem. Actions being taken include the following:

- Response to major disease outbreaks has been intensified to keep losses at lower levels than would otherwise occur.
- A disease surveillance program has been initiated to provide early detection of disease events, thereby increasing the opportunity to minimize losses by combating disease events before they reach crisis levels.
- Investigations have been initiated to gain a sound ecological understanding of the factors underlying the occurrence of major disease outbreaks at the Sea. This understanding is fundamental for the development of disease prevention strategies.
- The Salton Sea Restoration Project is focused on improving the environmental quality of the Sea. Achievement of this goal will greatly contribute to reducing the potential for major disease outbreaks.

Conclusion

The Salton Sea and surrounding area provides habitat for a richness of avian biodiversity seldom encountered. This biodiversity is a statement of the importance of the Sea as a component of the remaining interior wetlands of the Pacific Flyway. The Salton Sea Restoration Project specifically recognizes the importance of the Sea as wildlife habitat by the goal to:

"Provide a safe, productive environment at the Sea for resident and migratory birds and endangered species."

Findings from the scientific investigations being undertaken on disease ecology will help Restoration Project actions achieve environment conditions at the Sea that will provide for the well-being of the Sea's avian resources. Suppression of disease as a major cause of bird mortality at Sea is inherent in providing for this well-being.

Table 1. Examples of Causes of Avian Disease at the Salton Sea.

Disease	Type of Agent	Causative Agent
Avian botulism	Bacterial toxin	Clostridium botulinum
Avian cholera	Bacteria	Pasteurella multocida
Salmonellosis	Bacteria	Salmonella typhymerium
Newcastle disease	Virus	Newcastle disease virus
Algal toxicosis*	Natural toxin	Unknown

* Suspect cause, not proven but species of algae known to produce toxin are present.

Table 2. Examples of Major Bird Mortality Events at the Salton Sea.

Year	Causative Agent	Estimated Loss	Primary Species Affected
1992	Unknown*	155,000	Eared grebes, ruddy ducks
1996	Type C botulism	15,000	Approximately 15-20 percent of western population of white pelicans died along with more than 1,000 endangered California brown pelicans
1997	Newcastle disease	Most of Mullet Island breeding production	Double-crested cormorants.
1997	Avian cholera	8,000	Waterfowl.
1998	Newcastle disease**	Entire Mullet Island breeding production	Double-crested cormorants.

* Primary mortality thought to be due to algal poisoning but not proven to be so.

** Suspected cause, virus not isolated.

Figure Information

Figure 1. Photograph – Caption – Bagged white and brown pelican carcasses awaiting incineration at the Sonny Bono National Wildlife Refuge. Thousands of these birds have died at the Sea from avian botulism.

Figure 2 Photograph – Caption – Susceptible hosts, agents capable of causing disease and environmental conditions that facilitate host-agent interactions in a manner that result in disease are common factors for all disease events.

An alternative graphic is provided. This graphic requires a different caption. Perhaps the best approach is combining the drawings of the slide with this second graphic.

Figure 3. Data from publication of Dahl 1990 or other info to prepare a graphic (map or other form that illustrates:

- Wetland losses in California
- Could include larger scale of United States

Figure 4. Map showing importance of Salton Sea as a stop along the Pacific Flyway in a manner consistent with the text.

Figure 5. Graphic using data provided in table 1 left with you that supports the text by:

- Showing change in frequency of disease outbreaks over time.
- Showing change in relative magnitude of losses from disease in association with the disease outbreaks that have occurred over time.

This may lend itself to a bar graph.

Figure 6. Graphic using data provided in table 2 left with you that supports the text by:

- Showing the types of diseases occurring.
- Changes in frequency of occurrence over time.
- Highlights the first year of occurrence for each disease.
- Shows type C botulism in fish-eating birds as a distinct botulism event.

This may lend itself to a bar graph.