AVIAN ANALYSIS

A New Approach to Christmas Bird Count Data at the Salton Sea

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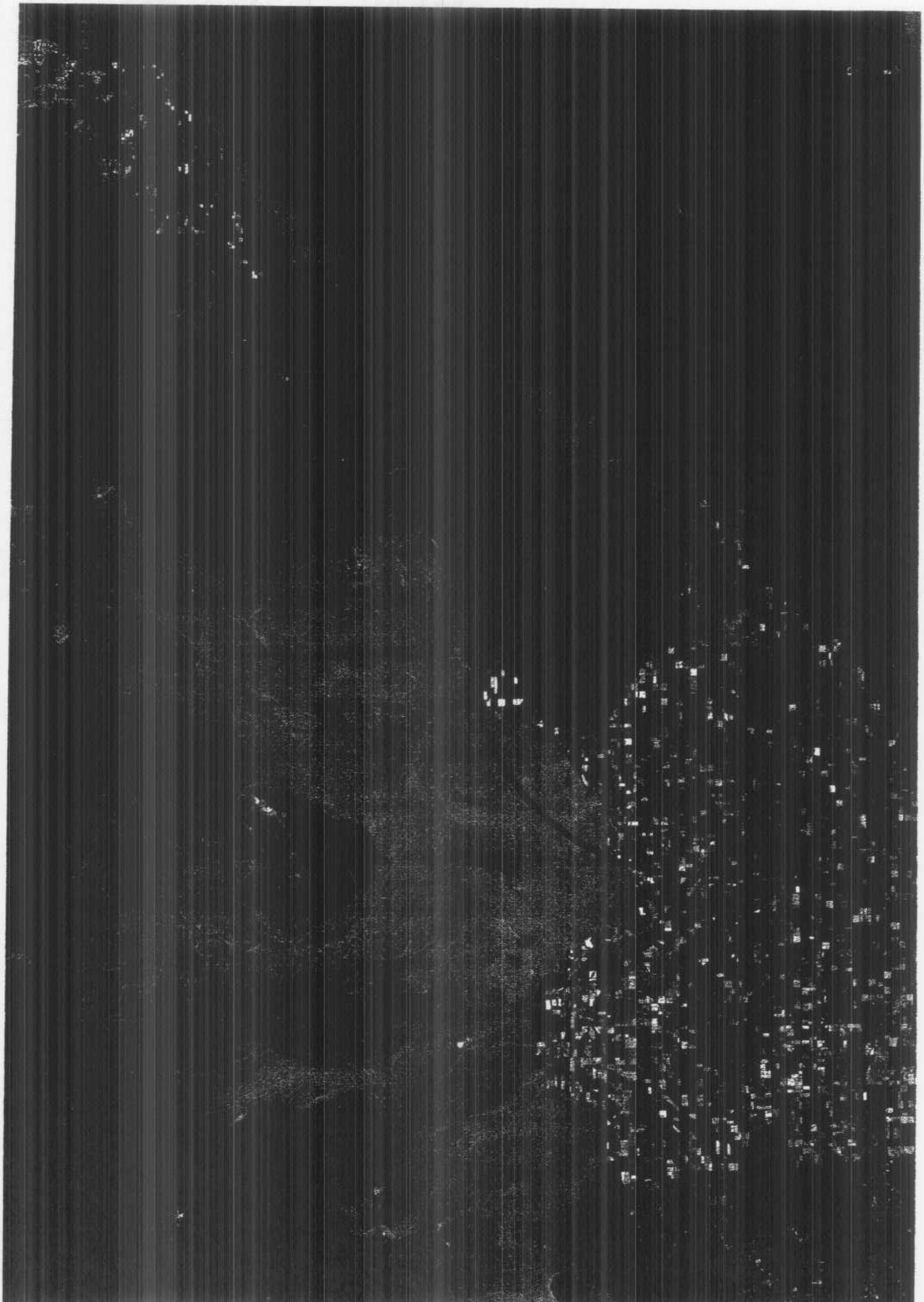
CBC SURVEY LOCATIONS



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Introduction

Christmas Bird Count data has been collected annually for the last century, making it the largest and longest running nationwide comprehensive avian survey. The data in raw form is composed of extensive year to year lists for over 1,700 locations. This data is stored in a publicly accessible database that offers internet-users a direct link to avian information. This database can be found at http://birdsource.cornell.edu/. The main objective of the CBC surveys is to yield valuable insights into shifting patterns, distributions, and population trends of bird species during a specific count time. This will effectively highlight periods of success or demise of a species. The data can then be correlated with other environmental and human factors to explain historic fluctuations. Conservation efforts can greatly benefit from the CBC data because it allows discovery of what harms a species or what fosters it, which will help to preserve a threatened species. This conservation information may be vital in many areas around the nation.

The CBC data is an excellent source for research and analysis. However, the existing difficulty with CBC data is the cumbersome nature of its list format. The information is not organized for use in analysis, and it is overwhelming and often indiscernible as a result. The list format makes it difficult to compare species and families because of lack of data organization. In this format, one must sift through countless entries of irrelevant information prior to finding what they are looking for. This makes the data far less functional than it could be. Point Reyes Bird Observatory utilized the CBC data in its drafting of <u>The Avifauna of the Salton Sea, A Synthesis</u>. In this document, reference is made to CBC counts and their contribution to avian analysis, which is currently underway at the Salton Sea. It states, "Christmas Bird Counts at two parts of the Salton Sea offer significant data on bird occurrences and numbers, although these data are often difficult to interpret" (PRBO, 1998).

The CBC data has great potential to be a continually growing resource for research and analysis, provided the data is presented in a manner that can be easily understood. The natural "next step" for the data is the progression into a working format. This enables the user to interject their own observations and theories, allowing the user to arrive at valuable conclusions. Consequently, the existing database has been modified into a structure that fills the analytical void of the previous format. Providing this structure is necessary for the data to be truly useful.

The new system recognizes natural biological divisions between groups of birds by categorizing them into families. Consequently, birds can be analyzed on both a family and species level, allowing examination of the role of a species or multiple species in determining family trends. This structure also enables one to focus on the tendencies of individual birds isolated from the family as a whole. In addition, the new system provides graphic representation of data covering a thirty-year time period, displaying trends and cumulative numbers of individual species and families.

History of the Salton Sea

The Salton Sea was accidentally created during the construction of the All-American Canal in 1905. The Colorado River broke through a levee and inundated the Salton trough, flooding a large portion of the Salton Basin. The basin extends north from Palm Springs and south to the Gulf of California. This "accident" resulted in the release of millions of gallons of water into the basin of the ancient Lake Cahuilla. The two-year period between the break and the eventual rebuilding of the broken levees created the present day Salton Sea. The sea is currently 35 miles long, 9–15 miles wide, with an average depth of approximately 29.9 feet deep. The deepest spot registers approximately 51 feet deep, which is only five feet higher than the lowest point in Death Valley. Three mountain ranges enclose the Salton Sea, which include the Chocolate Mountains to the east, the Little San Bernardino Mountains to the northeast and the Santa Rosa Mountains to the northwest. Thus, it is located inside a closed basin, which allows for no outflow of water. The only source of outflow is evaporation, which currently occurs at a rate of 1.3 million-acre feet/year (Horvitz, 1998). This is due to the arid desert climate which averages over 70 degrees year round, with June, July and August temperatures averaging 103°, 105° and 105° respectively (http://www.filmhere.com/agric.htm).

In the early history of the sea, it received little water from external sources, enabling evaporation to rapidly reduce surface elevation. In the 1930's, that changed with the introduction and development of the Coachella and Imperial Valley agricultural industry. Agricultural runoff from local fields subsequently became the main source of water and has provided in this manner ever since. The sea currently receives about 1.3 million acre/feet of inflow per year, roughly equaling the amount of water lost to evaporation (Horvitz, 1998). Stabilization of the sea encouraged gradual ecological and economic development of the area. In 1930, the Salton Sea National Wildlife Refuge was established by Presidential Proclamation, creating a protected area for the abundant fauna that use the sea as a water source and home. Originally the refuge encompassed 35,000 acres. However, it has been significantly reduced by rising sea levels in recent history, rendering only 2,200 manageable acres (Desert USA, 1996).

In the 1950's and 1960's, the sea was a prime location for recreational activities. The introduction of the Salton Sea State Recreation Area and the rapidly growing sport fishery lured anglers and recreationalists in flocks. At its peak, the Salton Sea attracted more annual visitors than Yosemite National Park (Horvitz, 1999). Unfortunately, the 1980's brought a drastic rise in surface elevation. This was a direct result of a boom in the neighboring agricultural industry, inundating the sea with excess runoff and consequently devastating local businesses and real estate.

Despite the demise of the tourist industry, the sea has remained arguably one of the most crucial wetland areas in the nation for migratory birds. The location of the Salton Sea along the Pacific Flyway makes this area an ideal location for migration along the Pacific coast. Over 400 species have been recorded at the Salton Sea, approximately half of the birds in North America. The sea is home to four endangered species including the Mountain Plover (*Charadrius montanus*), the Yuma Clapper Rail (*Rallus longirostris yumanensis*), the Brown Pelican (*Pelecanus occidentalis*), and the Peregrine Falcon (*Falco peregrinus*). The location of the sea with respect to the Gulf of California makes the sea a sensible resting or residing place for birds. Moving north from the Gulf, birds encounter the sea as the next location of open water, a haven in an otherwise harsh Sonoran desert climate.

Millions of birds each year depend on this water along their journey between their summer and winter residences. Federal and state governments have supplemented the area with managed wetland habitat to provide permanent and visiting birds a greater expanse for foraging and other such activities. Managed wetland habitat or natural wetland habitat at the sea include: the National Wildlife Refuge (which encompasses the mouths of the Alamo and New Rivers), the Wister Unit, the Finney/Ramer Unit, Thiery Creek, Salt Creek, San Felipe Creek, the Whitewater River delta, and many seasonal duck clubs.

Wetland areas around the Salton Sea are dominated by *Tamarix ramosissima*, an exotic species commonly known as salt cedar. This plant has rapidly taken over the desert environment. Extensive and deep root systems can penetrate down to approximately 100 feet deep. This enables the plant to utilize and consequently deplete the already sparse supply of water, which would otherwise be available to native plants. It also exudes salt, creating a very alkaline soil that is too harsh for other plants to grow in. *Tamarix* species were originally introduced to the sea to serve as wind breaks, but they have since become home to many birds. Native vegetation includes cattails (*Typha latifolia)*, bulrush (*Scirpus robustus)*, *Phragmites australis*, fan palms (*Washingtonia filifera*), willows (*Salix exigua*) and mesquite (*Prosopis glandulosa* and *P. pubescens)*. All of these species provide shelter and protection to many birds in the area. Fremont cottonwoods (*Populus fremontii*) used to be a dominant species around the mouths of the three rivers entering the sea, but a combination of rising salt water and competitive

Tamarix resulted in the species' demise. Although dead, cottonwood snags provide offshore nesting areas for Great Blue Herons (*Ardea herodias*) and Great Egrets (*Ardea alba*), and they are also used by Double-Crested Cormorants (*Phalacrocorax auritus*) and Osprey (*Pandion haliaetus*) as perches.

The current ecological state of the Salton Sea has recently become the focus of national attention. Large die-offs of birds and fish are raising questions and concerns about the continual decline of the ecosystem. Many factors have contributed to the ecological degradation of the sea, the foremost issue being one of geography. High desert temperatures speed evaporation, allowing for the accumulation of salts. Leftover salt combined with the initial salt content of Colorado River water and salt leeched from agricultural soils have made the sea an extremely saline environment. The salinity level of the Salton Sea is 44 parts per thousand (PPT), as compared to the Pacific Ocean, which is 34.9 PPT (Horvitz, 1998). Without intervention, the salinity level of the Salton Sea will continue to increase from the current level at a rate of .4 PPT per year. This would drastically affect food sources for birds that rely on fish and invertebrates. As salinity rises, tolerance levels will be exceeded, no longer allowing sustainability of life. At 80 PPT, nothing will be able to survive except specialized halotolerant invertebrates such as brine shrimp and brine flies (Thiery, 1998). Another negative circumstance is the frequency of eutrophication, which occurs when there are too many nutrients in the water. Agricultural runoff draining into the Salton Sea contains fertilizers, making the water very nutrient rich. The abundance of nutrients causes algal blooms. Algal blooms while alive produce oxygen yet conversely consume oxygen as they decompose. This leaves little available oxygen for fish, ultimately causing the fish to die from suffocation.

Moreover, occurrences of disease such as avian botulism, cholera and others have plagued both temporary and permanent avian residents of the sea. In response to this grave ecological forecast, there are numerous proposals being discussed to restore this valuable ecosystem.

The Revised Database

Transforming preexisting data into a more workable form required the installation of specific guidelines. These additions help to reduce much of the cumbersome nature of the CBC data, for they also group years of greater consistency and accuracy together. Numerous criteria have been applied to create the new database. These requirements were designed to exclude any existing data that would not contribute to analysis. The following is an outline of all requirements and specifications for entry into the new project database.

All entries prior to 1965 have been eliminated. This specification was included for the purpose of creating a data set containing greater accuracy and consistency. A 30-year time frame between 1965 and 1998 is preferred, because it provides ample time for trends to be visible. This time period also allows enough time for new species to be introduced to specific habitat. For example, the Double-Crested Cormorant (*Phalacrocorax auritus*) did not inhabit the northern end of the sea until 1978. Also, by restricting the data to the past 30 years, there is greater assurance that the data is credible. Over the years birding has become more advanced, where birders have a greater knowledge base and skill level. This gives greater assurance to data collected in the second half of the century. Not only the advancement of birders but development of better optical equipment within the last 30 years gives a higher degree of accuracy, warranting a greater confidence in the data. Moreover, the CBC data contains gaps for years when the surveys were not collected. By establishing a cut-off line at 1965, the number of data gaps is limited because of a greater consistency of participants in the latter half of the century.

Another requirement for inclusion in the revised database was minimum sightings of at least five years. This qualification was enacted because of the need for long-term analysis; trends are generally indiscernible without at least five or more years of data. This removes any vagrants or transient individuals that may have been blown off course and are using the sea as a temporary home. To further exclude possible vagrants, the species must also be sighted on at least five different occasions during a sequence of at least five years. For example, the Rufous-sided Towhee (*Pipilo erythrophthalmus*) was seen for 17 years throughout the survey, yet its numbers never exceeded five individual members for any of the given counts and thus were excluded from any further consideration. Conversely, the Turkey Vulture (*Carthartes aura*) was sighted on the north end of the sea in only five CBC counts. Four of the five years registered sightings of two or less, yet 29 individuals were sighted in 1995. This displays a questionable occurrence, consequently requiring further analysis.

Within the CBC data, individual phases and other variations were counted as their own separate sightings. With the intent of reducing the cumbersome specificity of the data, such divisions were totaled and added to the sum of the species. For example, multiple entries of Snow Geese in blue phase were recorded, these records were totaled and added to the observations from the corresponding year.

The first step in organizing the CBC count totals was to group every occurrence of an individual species. This was done to organize the data in a manner that made the individual species distinguishable from one another. This obvious division is required to separate the data into workable form. In order to view trends or changes, it is important to look at numerous years of the same species.

The next step was dictated by the data gathering process. As previously mentioned, Christmas Bird Counts are conducted within a 15 mile diameter of a central location. Two separate survey circles are conducted, one at the northern end and another at the southern end. This division allows the circles to be viewed as their own separate entities, to be used in working comparison to one another.

To further assist in analysis, the birds were organized into families. This natural division groups species with similar characteristics. This division allows analysis to occur at the family level, creating a new type of comparison. This division is advantageous because it allows for the examination of relationships between species within families, giving greater insight into family trends. If one family member's population declines, analysis of trends from other family members may offer an explanation.

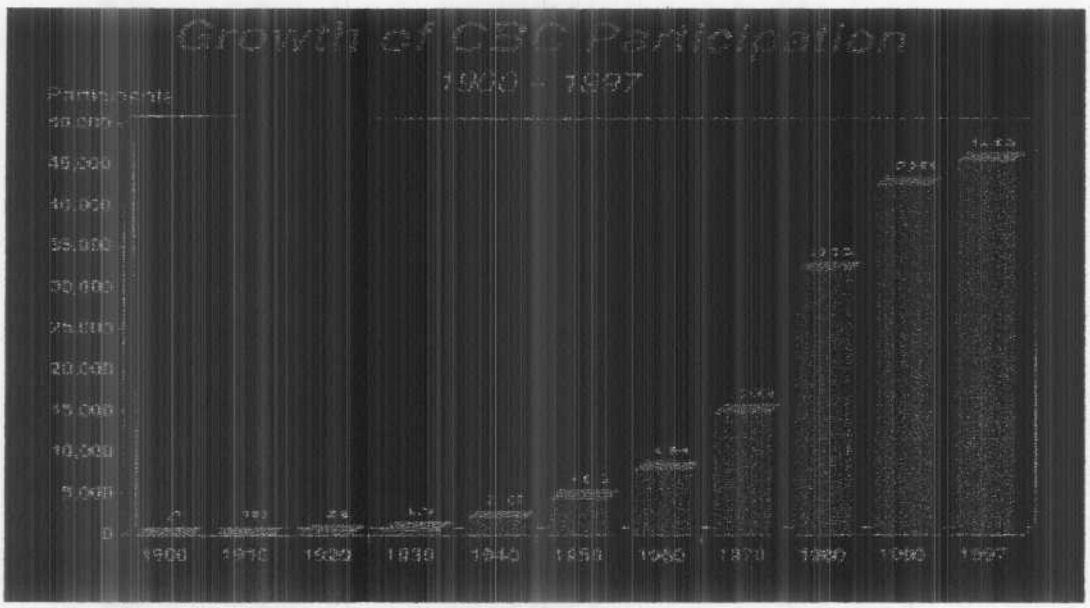
The CBC data is cumbersome by the nature of list formats. For convenience of analysis or CBC browsing, the most efficient means of displaying data is a graph format. This display method demonstrates distribution patterns over time for each species and family. Providing species graphs in addition to family graphs allows the user to identify the origin of family trends. It also enables the user to analyze on a species to species level. The graph section of this database is vital to analysis, because it makes the viewing of data easy and efficient.

Analysis requires some method of quantifying one's findings and being able to correlate them to related discoveries. Data manipulation also requires a reliable means of measuring variations in data. Statistical analysis is a reliable way of analyzing variations in data. For these reasons, the average and standard deviation have been calculated for each family and species. CBC data entries have an inclination to either increase or decrease in a short period of time. These statistical tools provide a means of measuring these jumps, allowing for cross comparisons among species.

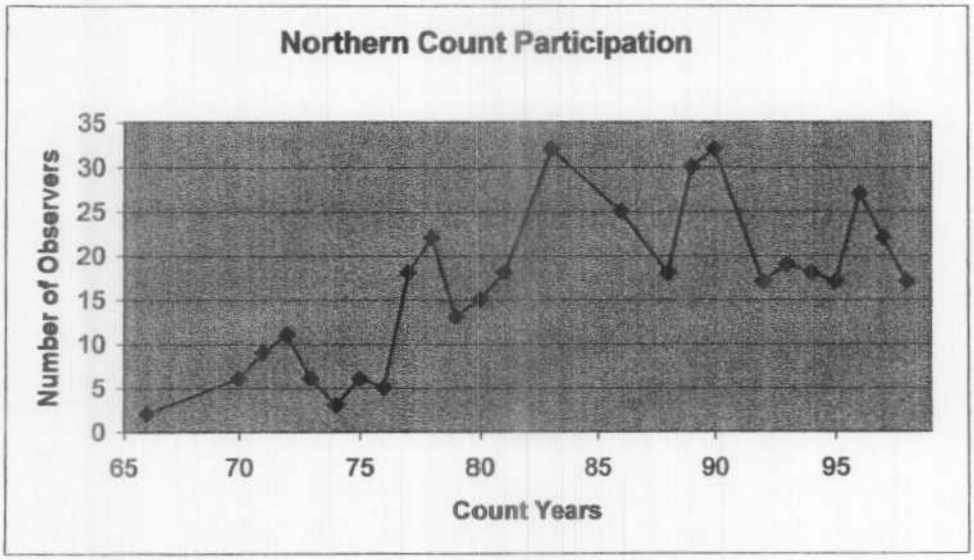
Data Reliability

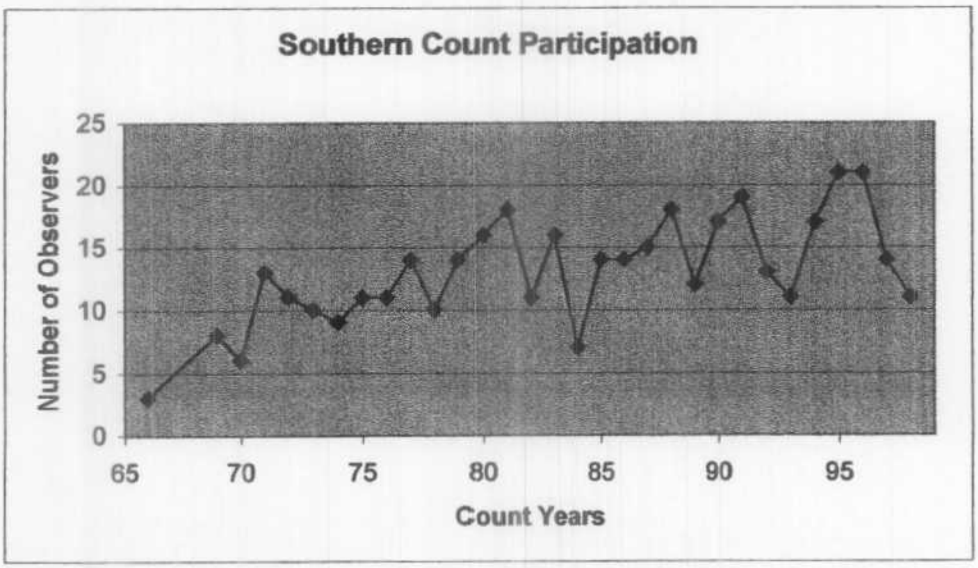
The main fault of the Christmas Bird Count data is the inconsistency of counts on a yearly basis. The southern survey circle provides greater accuracy than the north, with data collected for the years of 1966 and 1969 through 1998. This data set covers a thirty-year period including a two-year gap from 1966 to 1969. In contrast, the northern survey circle contains surveys for the following years: 66, 70-83, 86, 89-98. These gaps create an analytical void in the data.

Data is only as good as the observers who collect it. Christmas Bird Count data is completely volunteer-based, although counts are lead by a local ornithologist to give greater credibility. Many variables should be considered when determining the validity of the data. The number of observers has varied from year to year and from location to location. Nationwide, there has been a steady increase in participants in CBC counts, as shown in the following charts:



(http://birdsource.cornell.edu)


Northern Count Participation
Number of Observers
0
5
10
15
20
25
30
35
65
70
75
80
85
90
95
Count Years


Southern Count Participation
Number of Observers
0
5
10
15
20
25
65
70
75
80
85
90
95
Count Years

Current restoration efforts at the Salton Sea should make use of this revised database, for it provides gross numbers of avian inhabitants that have previously used and currently use the sea. However, despite the efforts of the new database to increase clarity, there still exist many inconsistencies in the CBC data. Numerous factors contribute to these flaws and inaccuracies in the figures represented.

The main fault of CBC is inconsistency of yearly counts. The southern survey circle has data for the years of 1966, and 1969 through 1998. This data set covers a thirty-year span with a two-year gap. In contrast, the northern survey circle contains surveys for the following years: 66, 70-83, 86, 89-98. These gaps create an analytical void, which must be considered when viewing this data.

Moreover, counts at the sea have experienced fluctuating attendance, yet popularity of bird watching has resulted in a general increase in the number of observers over time. Another variable that must be considered is technological advances in optical equipment. This contrast plays a significant role in the difference between bird watching in 1970 as compared to 1998. These advances provide greater coverage and accuracy, warranting greater confidence in the data.

Another drawback is an issue of coverage. The sea is divided into two 15-mile survey circles. However, these areas do not encompass all available habitat, most notably the central portion of the sea and it shores. The scope of the CBC counts allows overall numbers to be underestimated because of limited coverage around the sea. This type of yearly data collection would be more appropriate for an area like Big Morongo Preserve, another CBC survey location in the Mojave Desert. The preserve is an oasis, where water emerges from the ground surface and creates a small, heavily-vegetated habitat for many thirsty birds. In this case, a fifteen-mile survey circle is able to cover most of the available habitat within the preserve. In contrast, the Salton Sea and surrounding areas are too large to be contained within two fifteen-mile circles, and this inevitably excludes habitat that could contain significant bird populations.

Weather conditions may also play a role in determining the number of birds present on a given count day.

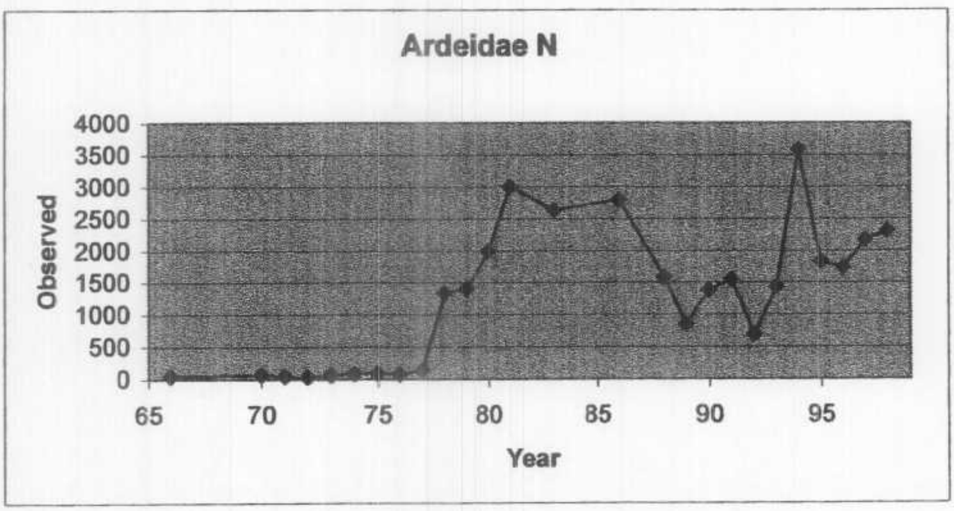
At this stage, the data exists in it most functional form. Manipulation or research of this data requires ornithological expertise and a working knowledge of the ecological processes in the Salton Sea community.

Analysis

This section displays the integrative process of applying ornithological and environmental knowledge to Christmas Bird Count data to arrive at explanations for trends and patterns.

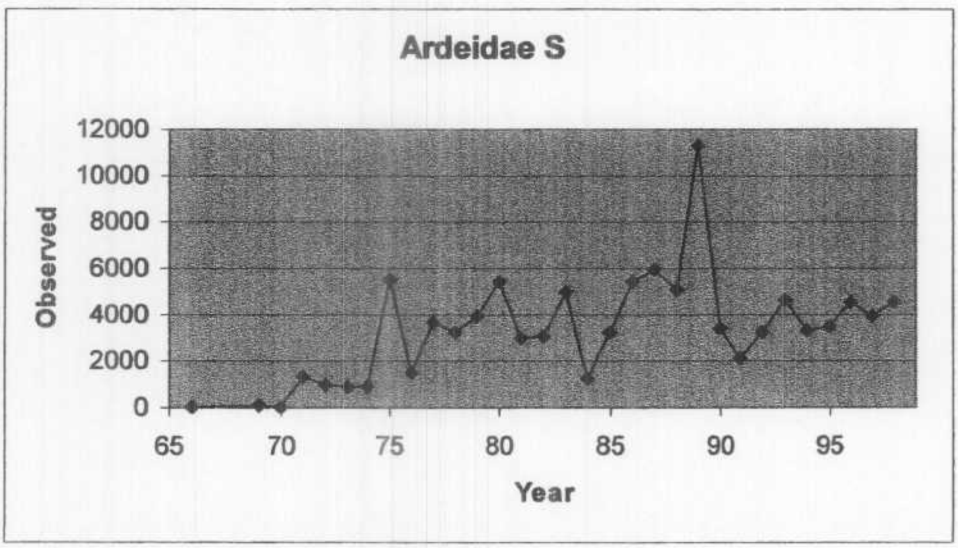
The creation of a year round agricultural industry has led to the introduction of numerous insects and insectivorous birds to the Salton Sea area. The Salton Sea was created during the construction of the All-American Canal, and the eventual completion of the canal has allowed for diversion of water from the Colorado River. Currently, the Imperial Irrigation District (IID), established in 1911, diverts approximately 3.2 million acre-feet of water to nine cities and 500,000 acres of agricultural land within the Imperial Valley. The water passes through the 82-mile long All-American canal and into over 1,457 miles of surface drains (IID, 1998). These figures give an idea of the sheer magnitude of the agricultural industry in the Imperial Valley.

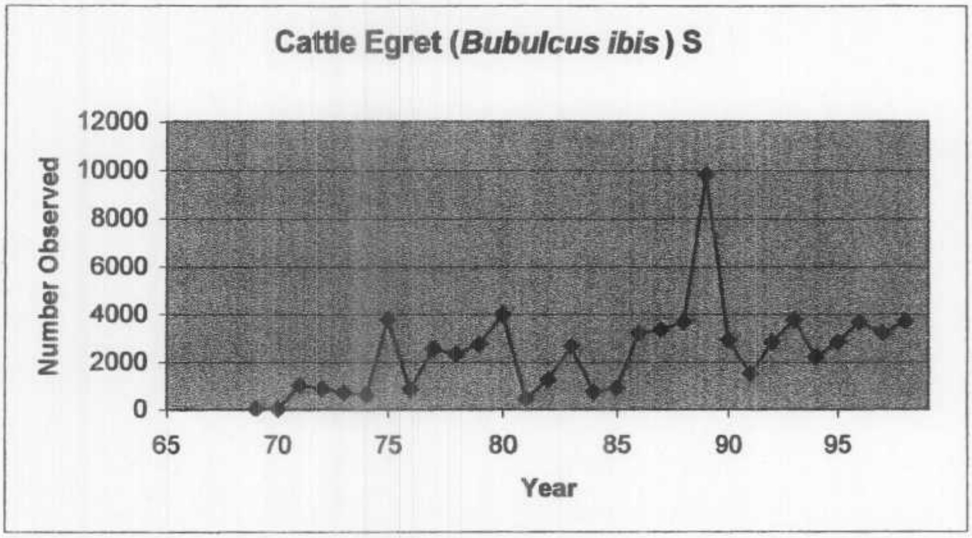
The Ardeidae family is currently found in large numbers in and around the Salton Sea. This was not always the case. Beginning in the mid- 1960's, the total Ardeidae population in the northern survey circle was less than 200 individual birds. In 1978, the population increased by greater than one standard deviation to 1,332 individual birds. By 1981 the numbers grew to over 3,000. There are multiple factors that may explain these figures. At this time in the Imperial Valley, a period of rising sea levels and rapid economic decline was occurring. The intolerable surface level was a result of the booming agricultural industry, where increased flow inundated the sea. Rising agriculture subsequently resulted in a significant increase in the area's insect population, due to more vegetation and larger areas of stagnant water resulting from runoff. The presence of insects attracts predators, including members of the Ardeidae family, who became permanent residents at the Salton Sea during this time. The family population has since fluctuated, at one time dropping over 1½ standard deviations in a short two year span. Conversely, the population reached its peak population of 3,582 only five years after this brief period. This sudden jump was dictated by increases in species populations of Great Egrets, Black-crowned Night Herons (*Nictocorax nictocorax*), and Snowy Egrets (*Egretta thula*). One notable species increase was the Great Blue Heron, which climaxed in 1998 at over 850 individual birds, up from the previous year total of 229. This increase may or may not be explained by a historical event. However, it is only a jump, not a long-term trend, the latter of which is far more dependable and credible for the purpose of analysis. The average annual sightings of Ardeidae members over the thirty-year span were 1, 257 with a standard deviation of 1,059.



Like the north, the southern distribution of Ardeidae members is strongly influenced by local agricultural practices. Areas around the sea are lined with an extensive system of canals and channels. Great Blue Herons, Great Egrets, and Snowy

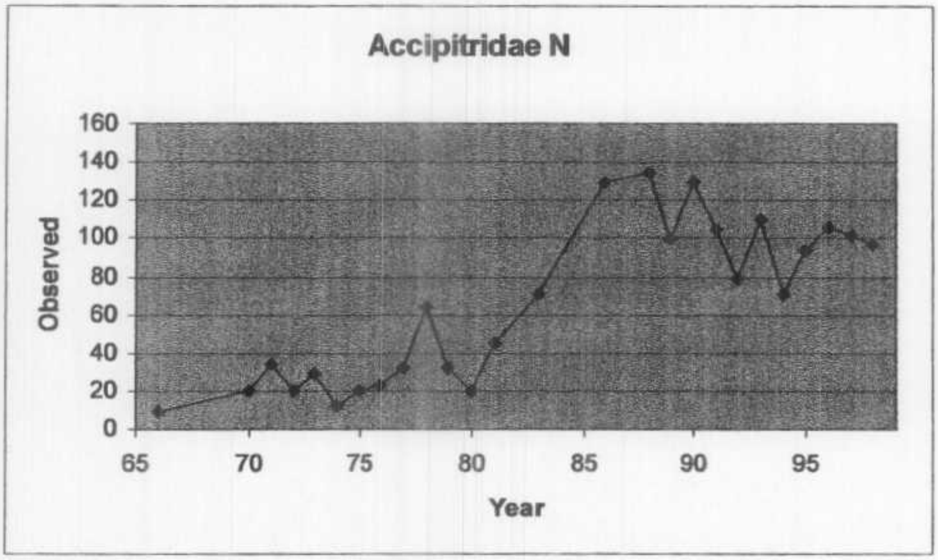
Egrets use these areas heavily for water and feeding. Inundated cottonwood snags, willows, and salt cedar provide protected breeding areas for Great Blue Herons, Great Egrets, Snowy Egrets and Cattle Egrets. The Southern graph below is a perfect example of how one species can dominate a family graph. In 1989, Cattle Egrets reached a population high of 9,792 individual birds. Even though this was an exceptional year for cattle egret populations, no other members of the family registered peak populations higher than the average number of Cattle Egret of 2,392. A Southern graph excluding Cattle Egret populations is still largely impressive, however. Peak populations were tallied at 753 Great Blue Herons, 694 Great Egrets, and 827 Black Crowned Night Herons, and over 1,400 Snowy Egret were counted in two separate count years. The average sighting for Ardeidae members at the south end of the sea was 3,332 individuals and the standard deviation was 2,265.



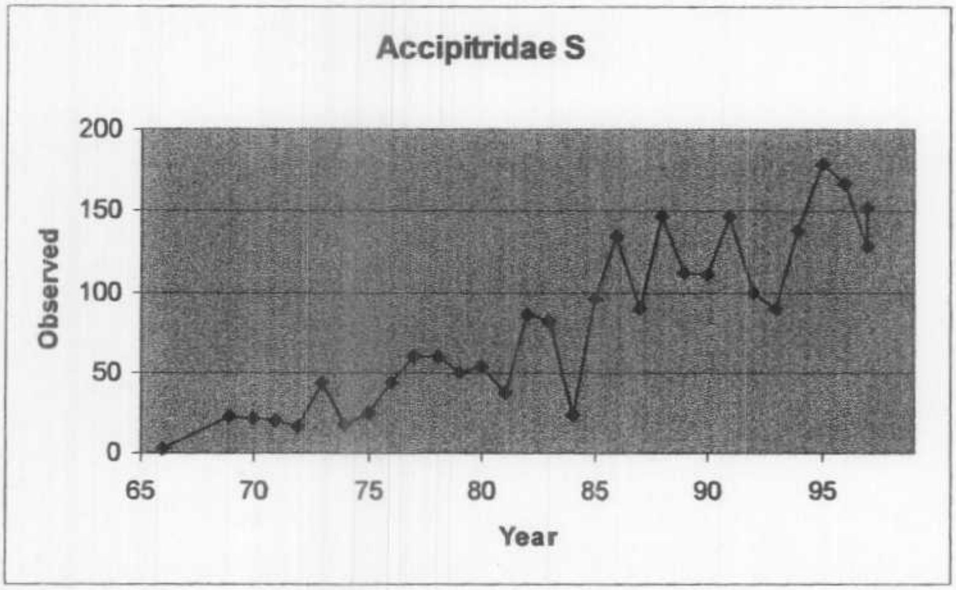


Other beneficiaries of the increase in agricultural lands were members of the Accipitridae family. The presence of insects attracts insectivorous birds, which in turn attract raptors that feed on smaller avifauna. Other food sources include small mammals and reptiles, which live in abundance around the Salton Sea. This family includes the Red-tailed Hawk (*Buteo jamaicensis*), Northern Harrier (*Circus cyaneus*), Cooper's Hawk (*Accipiter cooperii*), Sharp-Shinned Hawk (*Accipiter striatus*), Red-Shouldered Hawk (*Buteo lineatus*), Ferruginous Hawk (*Buteo regalis*), and Osprey. From 1980 to 1987, all species excluding the Osprey and Ferruginous Hawk experienced an increase in population of over two standard deviations within a three-year period. The family graph indicates this jump with an increase from 20 to an impressive 130 individual sightings. The family graph demonstrates a shift from below the mean during the first 15 years to completely above the average during the next 15 years. The average sightings were 64 individuals and the standard deviation was 40. The Red-Tailed Hawk was the dominant accipiter in the north, showing an increase of greater than 70 individuals from 1980 to

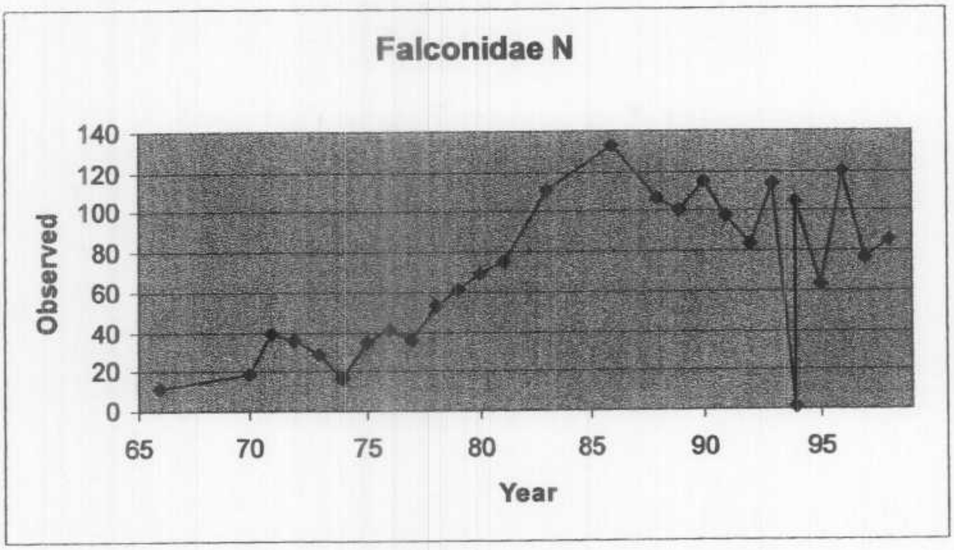
1987. The next closest peak population was the Northern Harrier at 35, only half the population of the peak Red-Tailed sightings.

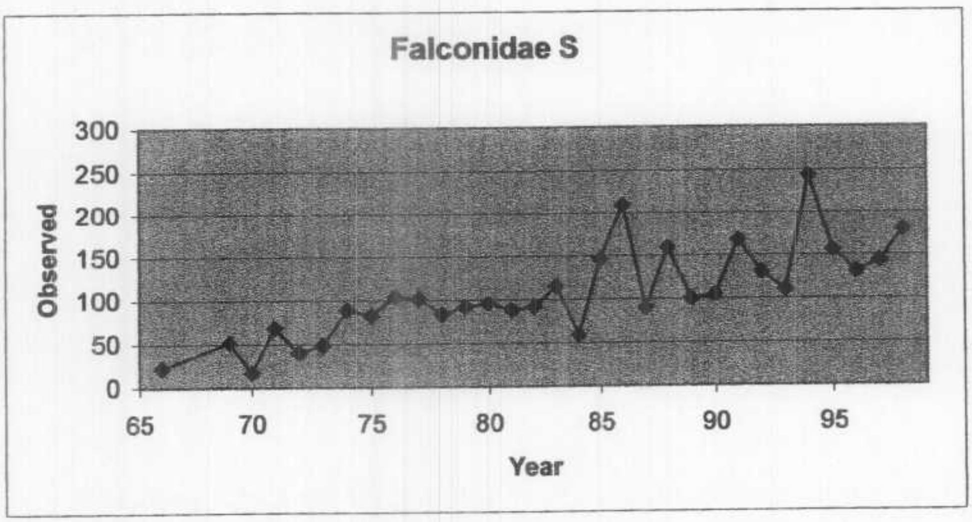


In contrast to the northern dominance of Red-Tails, the Northern Harriers reached populations of over eighty individuals in both 1991 and 1994. Red-tails were the next closest, peaking at 65. The southern population of Accipiters experienced similar success to that of their northern counterparts. The graphs are strikingly similar except for a singular standard deviation drop in southern populations from 1983 to 1984. This decline put the species well below the average of 79, down to only 23 individual birds. In contrast, the population over the following two years increased by over two standard deviations. The standard deviation for the southern area was 50.



The Falconidae and Accipitridae families can be compared by examining feeding guilds. Feeding guilds group individual species according to feeding habits. Shorebirds are an example of a feeding guild for all shorebirds probe for food. For example, Long-Billed Dowitchers and Curlews are members of the same guild. The designation of a raptor is a title for a feeding guild. Raptors include hawks, falcons, kites, eagles and owls. At the northern end of the sea, the Falconidae family shows close resemblance to the distribution of Accipiters. These patterns closely resemble each other because of the availability of food. The northern population of falcons within the first 15-year period remained below the 30-year average of 67 birds. The following 15 years showed the population remaining above the mean. The comparison of southern populations of Accipiters and falcons yields a similar increase, although not as closely as the northern comparison. Members of the Falconidae at the sea include the American Kestrel (*Falco sparverius*), the Peregrine Falcon, and the Prairie Falcon (*Falco mexicanus*).


Falconidae N
Observed
Year
140
120
100
80
60
40
20
0
65
70
75
80
85
90
95


Falconidae S
Observed
Year
300
250
200
150
100
50
0
65
70
75
80
85
90
95

Conclusion

This project has enabled me to learn a great deal. At the beginning of this project I had a limited knowledge of birds and their behaviors. Over time, I gained a greater appreciation for birds, and this has peaked my interest in learning more. After obtaining the data from the Cornell Lab of Ornithology, I was amazed at the sheer magnitude of information. At this point, I knew I had grossly underestimated the time it would take to mold this into an efficient, working database. In order to manipulate the CBC information, I needed to learn EXCEL. The learning process took a considerable amount of time, although I was able to teach myself after much frustration. Within EXCEL, I learned to make graphs for over 350 species and their corresponding family designations. This process proved quite tedious. The computer aspect of the project occupied most of my time, for I encountered frequent problems. My graphs were often missing or inaccurate, which resulted in the reconstruction of every graph.

Learning the family divisions was another difficult element of the project, although it was one of the more rewarding. Initially, my goal was to learn the Latin names for each species, but in response to time constraints, I limited myself to only learning family identifications. This repetition proved to be an effective way of absorbing the data. The Field Guide to the Birds of North America was initially used for determining family classifications. After reviewing The Avifauna of the Salton Sea, A Synthesis, produced by Point Reyes Bird Observatory, the family classifications were reclassified to concur with the most updated family divisions.

In retrospect, I would learn an alternate program. EXCEL proved to be an inefficient means of manipulating data. Admittedly, my knowledge of EXCEL was limited, but I found extreme difficulty in learning this program. I would also avoid learning the program while simultaneously doing the project, for many frustrations may have been avoided. Upon initial completion, I would not print out all the species and family graphs. More efficient time management would have greatly benefited this project. Another frustration was my own lack of ornithological experience; analysis beyond a beginning level was beyond my avian knowledge. The lack of consistency within the CBC counts was the only difficulty I had with the data itself.

In conclusion, the objective of this project was to create a tool for research and analysis. Implementation of guidelines and observation requirements has converted the existing Christmas Bird Count lists into an analytical database. Usage of the revised database offers greater efficiency and easy comprehension, while simultaneously offering valuable insights into shifting patterns, distributions, and population trends of avian communities at the Salton Sea. All CBC results should be converted into graphs, linking the data and making it even more valuable than its current worth. For use by the general public, conversion to a graph format would display a clearer representation of count results. In any method of use, the new database structure will allow for greater efficiency. Usage of the data can also contribute to conservation decisions at the Salton Sea.

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