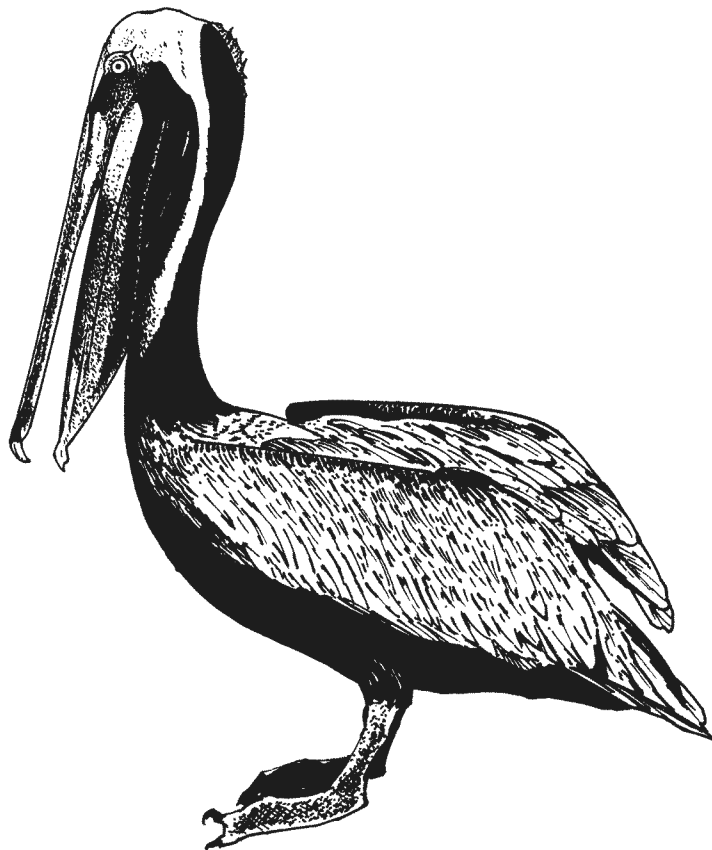


The Brown Pelican



Eggshell strength experiment

Materials:

1 dozen eggs	small, lightweight plastic bucket
1 qt cider vinegar	8 lbs dry beans
scale	aluminum foil
6 plastic drinking cups	small shallow pan to hold 1 egg

Method:

Weigh all 12 eggs individually.

Place eggs 1-6 aside. Put eggs 7-12 in individual cups. Cover each egg with cider vinegar and let soak 5-6 hours to thin shells. Drain and dry eggs.

Weigh the soaked eggs again. (Weight loss is due to loss of calcium carbonate in the shell.)

For each egg:

Weigh egg on scale. Record weight in Table 1.

Set egg on small "nest" of aluminum foil in shallow pan.

Have 1 student balance bucket on egg

Slowly add dry beans to bucket until egg cracks.

Weigh bucket + beans.

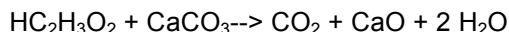
Record weight in Table 2.

Add all of the weights needed to crack eggs 1-6 and divide this number by 6. This is the average weight needed to crack a normal egg. The average weight is _____.

Add all of the weights needed to crack eggs 7-12 and divide this number by 6. This is the average weight needed to crack the weakened eggs. . The average weight is _____

Compare the average weights needed to crack normal and weakened eggs. What was the difference? How could a weakened shell affect the hatching success of Pelican eggs?

Note: When the egg was placed in the vinegar, the acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$) in the vinegar dissolved (ionized) the calcium carbonate (CaCO_3) in the egg shell by the reaction



This formed bubbles of carbon dioxide (CO_2) on the outside of the shell, as well as additional water (H_2O) and calcium oxide (CaO).

Be sure that students understand that this is NOT what happens when an eggshell is thinned inside the mother pelican because of DDT poisoning. The DDT derivative in the female bird causes less calcium carbonate to be deposited in the egg eggshell before she lays the egg.

Eggshell strength experiment

Table 1: weight of eggs

Egg no.	Original Weight (grams or ounces)	Post-soaking weight (grams or ounces)
1		_____
2		_____
3		_____
4		_____
5		_____
6		_____
7		
8		
9		
10		
11		
12		

Table 2: weight needed to crack egg

Egg no.	Weight (grams/ounces)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Case Study - the California Brown Pelican

The story of the California Brown Pelican (*Pelecanus occidentalis*) off the coast of Los Angeles exemplifies the need for strict monitoring of human impacts on Santa Monica Bay. Now commonly seen in coastal areas such as rocky shores, sloughs, and harbors, the California Brown Pelican was threatened with extinction in the 1970's due to nearly ten consecutive years of reproductive failure during its breeding season. The reason for this failure was determined to be DDT pollution.

DDT and its derivatives

Introduced as an insecticide in 1939, DDT has many ideal properties for insect control:

- it is extremely toxic to insects, yet much less toxic to other animals,
- it is very persistent in the environment, with a half-life in the soil of about ten years,
- it remains effective as an insecticide for a long time, and
- it is relatively cheap.

The two primary uses of DDT-based insecticides have been the protection of cotton crops and the control of malaria, a human disease carried by mosquitoes. Thus the use of DDT has been limited to rural, agricultural areas and to tropical malarial regions. Nevertheless, by the 1960's DDT had been found in the tissues of marine organisms in areas as remote as Antarctica! The reason for this global contamination of DDT is due to its persistence and its volatile nature, which causes the compound to enter the atmosphere quickly and remain there.

In the environment, DDT is broken down into DDD and DDE. While these derivatives are less toxic than DDT, all three compounds affect the calcium metabolism of birds that eat prey such as marine fish that store DDT, DDD or DDE in their body tissues. As a result, birds with high concentrations of DDT and its derivatives lay eggs with thin, brittle shells. These shells are very fragile and the eggs usually break before they can hatch.

The California Brown Pelican (Pelecanus occidentalis)

The California Brown Pelican ranges along the coast from British Columbia to Central America. Adult pelicans can weigh up to 10 lb. (4.5 kg) and have a wingspan of up to 7 ft. (214 cm). They have grayish-brown bodies, a brown neck, and a light head. Immature pelicans, however, are brown all over. Like all pelicans, the Brown Pelican has a long pouched bill that can store three times more food than the pelican's stomach. The pouched bill is used to catch fish, to feed young pelicans, and to regulate their body temperature during warm weather.



Pelicans are social birds that can be found foraging in large groups. Their primary food source is schooling fishes at the surface, such as anchovies, herring, menhaden, mullet, and sardines. Birds dive down into the water from as high as 20 - 60 feet above the surface and use their expandable pouched bill to scoop up the schooling fish. Air sacs beneath the pelican's skin cushion the impact of diving from such heights and also help the bird to surface after the dive.

The breeding season of the Brown Pelican is in the early spring, with egg laying occurring in March and April. Eggs are incubated by both parents for about one month. After hatching, both parents help take care of young, feeding them regurgitated fish. Fledging takes place 10 - 12 weeks after hatching. The long life span of the brown pelican, 25 - 30 years, was a key factor in preventing the extinction of the species despite many years of reproductive failure.

Threats to and Recovery of the Brown Pelican

Historically, breeding colonies of the Brown Pelican were found at Pt. Lobos in Monterey County up until 1959, and also throughout the Channel Islands and Baja California. In the 1960's, however, Brown Pelican populations off the coast of Los Angeles began experiencing reproductive failure and by the 1970s, the Brown Pelican was near extinction.

The cause of the population decline and the threat of extinction was DDT, which caused egg shell thinning of 35% in some populations. This finding perplexed many environmental scientists and ecologists, for an urbanized area such as Los Angeles does not use DDT nearly as much as agricultural areas. While agricultural runoff was a suspected source of pollution, the source of DDT and its residues came from a factory in the Los Angeles area which was discharging 200 - 500 kg of DDT everyday- equal to 100 tons of DDT pollution per year! Further studies on marine sediments showed that DDT pollution first began appearing in the Los Angeles area in 1952, demonstrating how there is often a time lag between the actual onset of pollution and its negative impacts on the environment.

In 1972, use of DDT was banned in the United States (although the production of DDT was not). In the same year, the Brown Pelican had its first successful reproductive season. Other threats, including fish population declines, human development, and oil spills, have slowed the recovery of the California Brown Pelican. Nevertheless, the National Park Service protects the breeding colonies and offshore fishing areas in the Channel Islands National Park, and the California Dept. of Fish and Game manages habitats in Monterey to protect roosting areas.

Sources:

- California Department of Fish and Game. California's Threatened and Endangered Species - California Brown Pelican.
- http://newt.dfg.ca.gov/t&e_species/index/classification/birdslist/pelican.html
- Clark, R. B. 1992. Marine Pollution, 3rd Ed. Clarendon Press, Oxford. 172 pp.
- Goldberg, E. D. 1976. The Health of the Oceans. The UNESCO Press, Paris. 172 pp.
- Marine Pollution. 1974. A series of articles in *Oceanus*. 18(1).
- Nybakken, J. W. 1993. Marine Biology: An Ecological Approach, 3rd Ed. Harper Collins College Publishers, New York. 462 pp.

MORE ABOUT THE BROWN PELICAN



THE BROWN PELICAN – A SUCCESS STORY

One of the most unusual seabirds you will see in Santa Monica Bay is the Brown Pelican (*Pelicanus occidentalis*). Although these large, fascinating birds now are common, they almost became extinct in the 1970s. The discovery of why these birds were disappearing and the solution that led to their recovery is an exciting environmental detective story.

On the west coast of North America, Brown Pelicans breed in the Channel Islands (West Anacapa Island and Santa Barbara Island) and on islands off the coast of Baja California. In the 1960s the numbers of pelicans on these islands decreased drastically. On Anacapa Island in 1969, 1,125 pairs of pelicans fledged only 4 chicks, and in 1970, 727 pairs produced only 5 chicks. When alarmed biologists visited West Anacapa Island, they found the colony was littered with broken eggs, with shells up to 50% thinner than normal eggs. Even the shells of intact eggs were about 31% thinner than normal eggs. Parent pelicans incubate their eggs by standing on them with their highly vascularized feet (“vascularized” means that the bare, unfeathered feet contain many blood vessels). Body heat radiating from the parent pelican’s bare feet keeps the eggs warm. With such thin shells the eggs couldn’t support the weight of a 9-10 pound adult pelican.

Eventually scientists determined that the thin eggshells were related to exposure of the parent pelicans to the pesticide DDT, which until the 1970s was used with little caution.

“First used heavily in World War II for preinvasion spraying, DDT was disseminated in great quantities thereafter throughout the world to combat yellow fever, typhus, elephantiasis, and other insect-vectored diseases. In India, DDT reduced malaria from 75 million cases to fewer than 5 million cases in a decade. Crops and livestock sprayed with DDT sometimes as much as doubled their yields” (*Microsoft® Encarta® Encyclopedia 99*).

Research projects carried out by University of California, Davis staff and students revealed the presence of high levels of DDT and DDE (a stable, widespread and common metabolite of DDT) in the marine environment off Southern California, both in the sediments and in the plants and animals living in these waters. They also found a positive relationship between the amount of DDE residue in the bodies of female pelicans when they were laying eggs and the thinness of their eggs’ shells. Controlled laboratory experiments eventually confirmed that DDE (which originated from DDT in the pelicans’ food) affected the shell gland of mother pelicans and caused them to lay eggs with dangerously thin shells. How did the pesticide get into the ocean and how did it get into the pelicans?

While DDT pollution results from its application as an insecticide on land, DDT was not used extensively along the Southern California coast, where there was little farming. Instead, the extensive DDT/DDE contamination in the ocean off Southern California was traced back to the Montrose Chemical Corporation that manufactured DDT in Torrance. The plant daily discharged contained hundreds of pounds of DDT into the Los Angeles sewer system, which eventually drained into the Pacific Ocean. DDT is a synthetic (man-made) pesticide and it does not occur naturally in the environment. Unfortunately, plants and animals have not evolved to digest or eliminate DDT and its metabolites such as DDE. Consequently, the pesticide accumulates in ever greater concentration at each level of the food chain. Once the DDT reached the ocean it was ingested by oceanic invertebrates and fishes, which were eaten by the pelicans.

In October, 1970, the Environmental Defense Fund filed suit against Montrose and by the end of the year the DDT discharge had been stopped. By 1974, DDT residues in anchovies, the primary food of the pelicans, had declined by 97% and contamination of pelican eggs by DDT, DDE and DDD declined 89%. Intact eggs had shells that were only 16% thinner than normal eggs and broken eggshells were 34% thinner than normal, indicating that the abnormal shell thinning caused by DDT and DDE had been reduced by nearly half. Improvement in reproductive success was spectacular. In 1974, 1,286 pairs of pelicans fledged 1,185 young birds, an improvement in reproductive success of more than 200-fold. The number of birds in the breeding population at West Anacapa Island has steadily increased to 4,000-6,000 nesting attempts every year. This is in sharp contrast to the early 70's in which there were only about 100 nest attempts. On Santa Barbara Island, the once ephemeral colony produces 400-700 nests every year.

Brown Pelicans became Federally protected under the Endangered Species Act in 1972. While breeding attempts appear to have leveled out there are still many reasons for concern regarding the Brown Pelicans. Human disturbance and pollution remain large threats to these birds.

Because of DDT's proven disastrous effects on bird populations, the chemical has been banned from agriculture use in the United States since 1972, and can no longer be used except in cases of public health emergency. Unfortunately, it is still used as an insecticide in other countries, where it endangers the survival of many egg-laying species.

Sources for this report:

- <http://www.nps.gov/chis/pelican.htm>
BROWN PELICANS IN CHANNEL ISLANDS NATIONAL PARK
- http://www.edf.org/pubs/EDF-Letter/1976/Mar/e_pelicans.html
Environmental Defense Fund Letter, Vol. VII, No. 2 -- March 1976; Postscript on pelicans.
- <http://www.igc.org/envreview/anderson.htm>
Environmental Review Newsletter Volume One Number Seven, July 1994; "Effects of DDT on Birds: Does Dixy Know Something the Experts Do Not?"
- <http://www.nsc.org/ehc/ew/chems/ddt.htm>
Environment Writer. DDT (C14H9Cl5) / DDE (C14H8Cl4) / DDD (C13H10Cl4): Chemical Backgrounder
- Microsoft Encarta Encyclopedia 99 CDROM

The Pelican Is Getting Well Again

Wildlife: Species was once thought to be on the verge of extinction because of DDT contamination. While the birds are still endangered, their numbers have increased dramatically.;

By: DARYL KELLEY, TIMES Staff Writer

VENTURA - This is a time of rebirth for a stately seabird once nearly wiped out by a virulent pesticide, but now flourishing on the rugged cliffs and wind-swept plateaus of two isolated islands off the Ventura coast.

Though still listed as a federal endangered species, California brown pelicans by the thousands are nesting on West Anacapa Island, a nature preserve closed to the public, and on tiny Santa Barbara Island 46 miles offshore.

Downy chicks are hatching as the peak spring birthing season arrives. If estimates are correct, more than 3,000 fledglings will spread their wings and fly away by late summer.

"It is like a giant maternity ward, a nursery, really," said Paige Martin, a biologist in charge of the seabird monitoring program at Channel Islands National Park in Ventura.

That is quite a change from 1970, when bets were that brown pelicans on both the East and West coasts would become extinct.

That year, just one chick on West Anacapa, the primary West Coast rookery, survived long enough to leave the nest. And only five chicks survived in Southern California and northern Baja California.

Things looked so bad for the brown pelican in the United States that its near-demise created a national furor that helped lead to the 1972 ban of the pesticide DDT and passage of the Endangered Species Act in 1973.

The brown pelican, bald eagle and peregrine falcon--once all common in Southern California--suffered horrendously as DDT caused their eggs' shells to become so thin that they were easily crushed during incubation.

The birds came upon the pesticide indirectly through the fish they ate. Anchovies, brown pelicans' favorite local food, were laden with the poison, which was washed into the ocean from Southland farms and piped miles off the Palos Verdes Peninsula by a large pesticide manufacturer.

New evidence shows that DDT is still killing the Channel Islands' eagles and harming peregrine falcon chicks. But the pesticide apparently has been less of a lasting problem for the brown pelican.

Although experts say pelican eggs still are thin, a decline in anchovies is now the primary reason that brown pelicans do not produce enough young to be officially declared a stable population and taken off the nation's list of endangered or threatened wildlife.

Yet the brown pelican, a poster bird of the budding environmental movement three decades ago, is generally considered a conservation success story.

On the East Coast, pelicans have come back to such an extent that they were declared recovered in 1985, and protective measures were removed. The West Coast recovery has been less dramatic, but it is still noteworthy, scientists say.

Los Angeles Times, May 14, 1997. Home Edition, PART A, p. A3, A18
Copyright (c) 1997 Los Angeles Times. Reprinted by permission.

"I think it is a success story. It is one of the few endangered species in the country that has shown encouraging signs of recovery," said Dan Anderson, a UC Davis biologist who has studied the brown pelican since 1971.

Former UC Davis biologist Franklin Gress, who has studied West Anacapa pelicans more than anyone else, said from Santa Barbara Island last week that he considers the local pelican population stable, despite lower birth rates here than on the East Coast and in Mexico.

"We're a little hesitant to say, 'Yes, it's a 100% success,' but there's been a lot of improvement," he said. "They're recovering nicely, but they're still vulnerable."

Gress and Anderson support the reclassification of the brown pelican from endangered to threatened because the bird's numbers rebounded so quickly once DDT was banned.

Over the five years ending in 1973, an average of 722 pairs nested in Southern California and northern Baja. But those numbers surged to about 6,500 pairs from 1985 to 1989, when food was especially plentiful. The number hovers between 5,000 and 6,000 pairs today, scientists estimated.

The U.S. Fish and Wildlife Service began updating data on the species in 1995, anticipating a reclassification of the California brown pelican to threatened, or perhaps its removal altogether as a protected species, said biologist David Pereksta, who did the study.

That work ground to a halt because of federal budget cuts, but might be renewed in the next year or two, he said.

"The [pelican] recovery plan projected that Anacapa might be able to support 3,000 pairs, and that number has been routinely surpassed," Pereksta said.

And even though the number of fledglings per nest is only two-thirds of that in Mexico, Gress said the rate of chick survival here has been consistent since the mid-1980s.

Still, the number of nesting pairs on the Channel Islands dropped precariously, to only a few hundred, in three El Niño years--1984, 1990 and 1992--as anchovies avoided the warmer waters, Pereksta said.

Anderson and other pelican experts also are studying the sudden deaths of about 1,500 brown pelicans killed by botulism at the Salton Sea last summer. And they are taking a long look at the gradual decline of anchovies near the Channel Islands.

"It's just like Roseanne Roseannadanna used to say on 'Saturday Night Live': 'It just goes to show you, it's always something,'" Anderson said. "With the pelican, it's always something. If it isn't DDT, it's the potential of oil [contamination] or changes in the food supply or the activities of man."

Today, the greatest threats to the species--which numbers about 100,000 when the crowded rookeries in mainland Mexico and the Gulf of California are counted--exist mostly in Mexico, Anderson said. Invasion of nesting areas by people has driven brown pelicans off some islands completely, and the Mexican government is inconsistent in its protection, he said.

That cannot be said about the Channel Islands National Park. Special permits are required before visitors can journey to the West Anacapa preserve. The three-hour boat trip to Santa Barbara Island, and the fact that a permit is required to leave hiking trails there, keep intruders at bay.

California Brown Pelican Resources

ONLINE

(There is much more online than listed here. Do a word search on "California brown pelican" to find more sources of information)

- ◆ California's Threatened and Endangered Species
http://newt.dfg.ca.gov/t&e_species/index/index.html
From this page, click on "Birds", and then find the link to the California Brown Pelican. This site has general information- description of the birds, their habitat range, reproduction, diet, and threats to their survival.
- ◆ Environmental Defense Fund Letters. "Postscript on Pelicans" Vol. VII, No. 2 (March 1976)
http://www.edf.org/pubs/EDF-Letter/1976/Mar/e_pelicans.html
Short article on DDT pollution and brown pelicans in Los Angeles.
- ◆ Environmental News Network - "El Niño hampers brown pelican breeding" Tuesday, June 2, 1998
<http://www.enn.com/enn-news-archive/1998/06/060298/pelican.asp>
News article plus links to related reports.
- ◆ U. S. Geologic Survey- Pauxtent Bird Identification InfoCenter
<http://www.mbr.nbs.gov/id/framlst/framlst.html>
This is a large list of descriptions of birds. Scroll down to the Brown Pelican link. This site has only brief and general descriptions for identification purposes, but also includes maps of their range.

IN PRINT

- ◆ Clark, R. B. 1992. *Marine Pollution*, 3rd Ed. Clarendon Press, Oxford. 172 pp.
- ◆ Goldberg, E.D. 1976. *The Health of the Oceans*. UNESCO Press, Paris. 172 pp.
- ◆ *Marine Pollution*. 1974. A series of articles in *Oceanus*. 18(1).
- ◆ Nybakken, J. W. 1993. *Marine Biology: An Ecological Approach*, 3rd Ed. Harper Collins College Publishers, New York. 462 pp.
- ◆ Thelander, C. G., ed. 1994. *Life on the edge: a guide to California's endangered natural resources: wildlife*. BioSystems Books, Santa Cruz, CA.