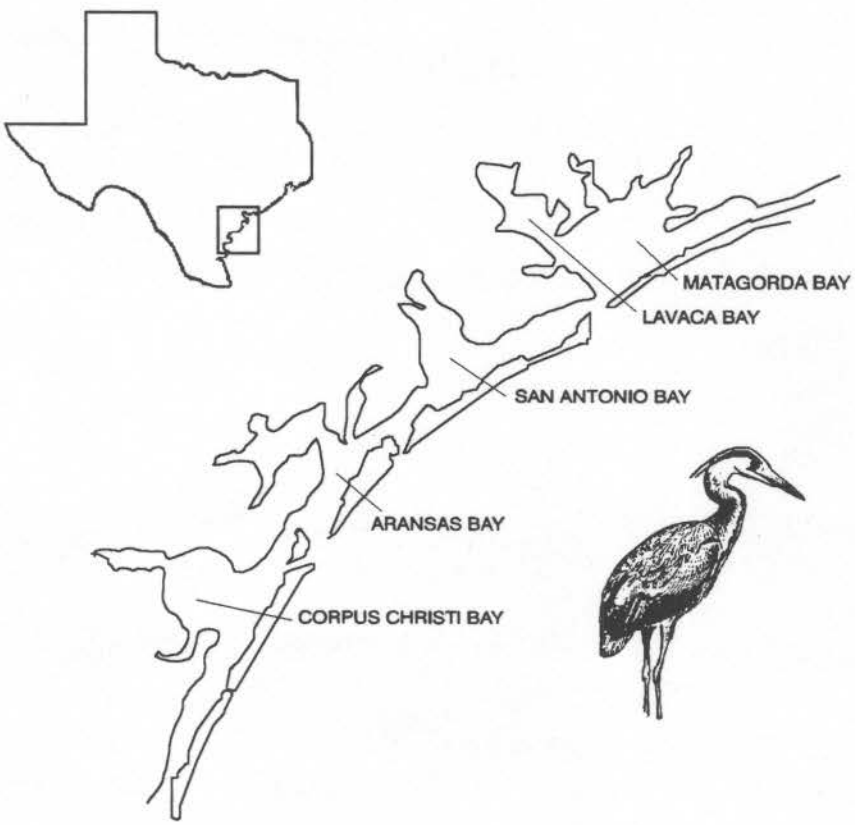
# PRELIMINARY EVALUATION OF MERCURY CONTAMINATION OF FISH-EATING WATERBIRDS IN LAVACA BAY, TEXAS

## PHASE I REPORT




REGION 2
U.S. FISH AND WILDLIFE SERVICE
CORPUS CHRISTI, TEXAS, FIELD OFFICE

APRIL 1994

# PRELIMINARY EVALUATION OF MERCURY CONTAMINATION IN FISH-EATING WATERBIRDS OF LAVACA BAY, TEXAS

## PHASE I REPORT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## EXECUTIVE SUMMARY

In 1966, the Aluminum Company of America (ALCOA) began operating a chlor-alkali plant at its Point Comfort facility in Calhoun County, Texas. This plant produced caustic (sodium hydroxide) and chlorine gas by electrolysis of brine solution using liquid mercury as a cathode. Between 1966 and 1970, mercury-ladened process water from this plant was piped to an offshore lagoon on the spoil island west of the ALCOA plant. After settling in the lagoon, the effluent was discharged directly into Lavaca Bay through one of two outfalls (Holman 1977). After September 1970, the effluent stream was diverted to bauxite residue lakes until the chlor-alkali plant was shut down in the early 1980's. Significant mercury contamination of ground water beneath the ALCOA facility has subsequently occurred and may represent a continuing discharge of mercury into Lavaca and Matagorda bays (Heidi Tomich, personal communication).

Research and monitoring efforts by ALCOA, academic interests, and state and federal agencies have demonstrated that mercury levels remain high in the sediments (Reigel 1990, ALCOA 1992, USGS 1992) and biota (Gamble et al. 1989, Palmer 1992, Texas Department of Health 1991) surrounding Point Comfort. In particular, methylmercury concentrations in the edible portions of certain fish and crab species continue to exceed FDA guidelines, which is the basis of a fishery closure currently in effect in Lavaca Bay (Texas Department of Health 1988).

In December 1990, state and federal agencies designated as trustees of natural resources convinced ALCOA to fund a series of preliminary investigations to determine if avian resources in Lavaca Bay were being exposed to, or potentially injured by, mercury contamination. Studies were initiated by the U.S. Fish and Wildlife Service in the spring of 1991 to determine: (1) accumulation and effects of mercury in fish-eating birds of Lavaca Bay based on historical data, (2) accumulation and effects of mercury on nesting fish-eating birds in Lavaca Bay, and (3) accumulation of mercury in migratory fish-eating birds that winter in Lavaca Bay. Results of those studies indicate:

1) Historical population trend data indicates a decline in numbers of several resident nesting birds, including Great Blue Herons, Great Egrets, and Black Skimmers; however, available historical data from the central and upper Texas coast indicate such population fluctuations are not uncommon, preventing correlation of the decline with the release of mercury in Lavaca Bay. The effort to correlate the above population declines with increasing mercury concentrations was further precluded due to the

unavailability of museum specimens for chemical analysis.

2) Eggs and nestlings of some species of resident colonial waterbirds in Lavaca Bay demonstrated elevated levels of mercury when compared to reference sites.

3) Mean levels of mercury in eggs of Lavaca Bay Great Blue Herons and Tricolored Herons are within the range that has been associated with reproductive impairments demonstrated in other bird species.

4) No conclusion was made on potential effects of mercury on the reproduction of breeding birds in Lavaca Bay due to the possible impact on nest success from confounding factors such as extended, inclement weather, predation, and fire ant depredation.

5) Granular cell necrosis in the cerebral cortex of Tricolored Heron nestlings appeared to correspond with elevated mercury content in their tissues at both the Lavaca Bay and the reference sites.

6) There was no significant difference between mercury levels in samples of early and late winter samples of Lesser Scaup or Double-crested Cormorants; however, mercury concentrations found in livers of some Double-crested Cormorants wintering in Lavaca Bay indicate exposure to excessive levels of mercury. Certain individual birds exhibited mercury concentrations far in exceedance of levels previously reported for cormorants, and in concentrations that have been demonstrated to cause toxic effects in other species of birds. These levels suggest that other piscivorous birds that also winter in Lavaca Bay, such as loons and mergansers, may also be potentially at risk from mercury exposure.

## ACKNOWLEDGEMENTS

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# 1. INTRODUCTION

Lavaca and Cox Bays are, respectively, secondary and tertiary bays of the Matagorda Bay Estuarine System (Figure 1-1). Located on the central Texas coast in Calhoun County, the bays cover about 176 square kilometers in surface area, and typically range in depth from 0.3 to 2.2 meters (m). Lavaca Bay also has a number of dredged ship channels, some of which are as deep as 13 m (Holman 1977). Both bays support diverse and abundant fish and wildlife communities throughout the year. During the winter, these bays also host large numbers of migratory waterfowl and shorebirds.

Lavaca Bay was contaminated with mercury beginning in the late 1960s by the operation of a chlor-alkali process plant at Point Comfort. Discharges were curtailed in the early 1970s, but several studies have shown that the mercury has been incorporated into the food web of Lavaca Bay (Holmes 1977, 1986, Texas Department of Health 1988, Reigel 1990, ALCOA 1992, Palmer 1992). In 1988, the Texas Department of Health (TDH) closed a portion of the mercury-impacted area to sport and commercial finfish and crab harvesting due to the elevated levels of mercury and the potential for harm to humans. Although residual groundwater and sediment levels of concern remain (Trebatoski and Gooris 1990), comprehensive information is lacking on the current distribution of mercury in the Matagorda Bay ecosystem, or the effects it may be exhibiting on the systems biota, particularly waterbirds.

Mercury has received a great deal of attention because of its' dramatic toxic effects on both humans and wildlife (Chang 1979, 1980, National Academy of Sciences 1978, Eisler 1987, 1989, and Walsh 1990). In the central nervous system, mercury quickly penetrates the blood-brain barrier and can eventually lead to a breakdown of that system (Chang 1977). This effect can be seen at very small amounts (<1.0 ppm) of mercury in the blood stream. Subsequently, characteristic lesions may occur in vulnerable areas, including the sensory neurons in the dorsal root ganglia (part of the spinal column) and the granule cells of the cerebellum.

Elemental mercury has no known metabolic functions, and through biological processes can be converted into even more toxic organic forms (Eisler 1987). In the environment, mercury bioaccumulates through the food chain and is generally highest in species at higher trophic levels (Fimreite et al. 1971). Among birds, predatory and fish-eating birds typically accumulate mercury in higher concentrations than other types of birds (Fimreite 1974, Hesse et al. 1975). In addition to

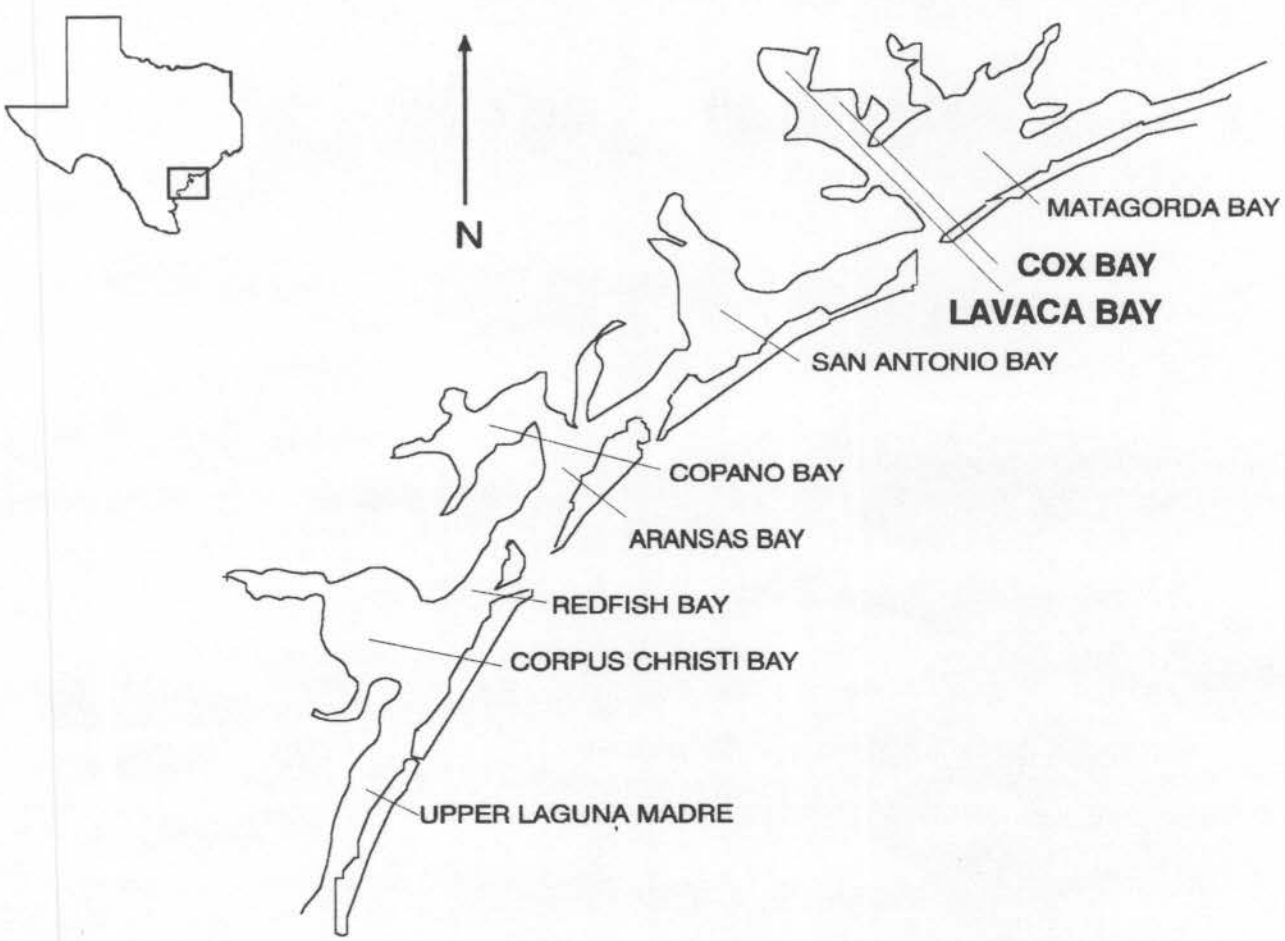


Figure 1-1. Map of Lavaca and Cox Bays in relation to the middle Texas coast.

fish, foods of colonial waterbirds include insects, polychaetes, crustaceans, and molluscs, which all absorb mercury from their diet and/or their surroundings, subsequently biomagnifying it from trophic level to trophic level (Palmer 1992).

The effects of mercury on egg development, hatching, growth, and survival in young birds are of special concern because the effects occur at much lower tissue concentrations than those levels known to produce lethal results in adult birds. Several controlled studies have found that mercury may cause reproductive dysfunction through reductions in the rate of egg laying, clutch size, egg hatchability, and nestling survival (Brown and Yoshida 1965, Fimreite 1971, Spann et al. 1972, Heinz 1976, 1979, Heinz and Locke 1975, Hill and Shaffner 1975, Hill and Soares 1977, Finley and Stendell 1978, Scheuhammer 1989). Elevated levels of mercury, sufficient to cause reproductive dysfunction, have been found in several avian species in field studies in many locations (Borg et al. 1969, Fimreite et al. 1971, Faber et al. 1972, Vermeer and Armstrong 1972, Vermeer 1973, Vermeer et al. 1973, Hoffman 1974, Norheim and Froslie 1978, van der Molen et al. 1982, King et al. 1983, Santoro and Koepp 1986, Braune 1987, Ohlendorf et al. 1988, Becker and Sperveslage 1989, Newton et al. 1989, and Custer and Myers 1990). Although death in birds may occur at $\geq$ 20 ppm in liver (wet wt) (Fimreite and Karstad 1971) sublethal doses may have far-reaching consequences (Scheuhammer 1987). According to Fimreite (1971) 2 ppm (wet wt) in the liver of pheasants causes a reduction in hatchability and an increase in shell-less eggs. Other studies have also indicated that mercury reduces reproductive success by increasing the number of unfertilized eggs, lowering hatchability of eggs, lowering of egg production, and reducing the survival of young birds (Fimreite 1974, Hesse et al. 1975, Heinz 1976, 1979).

In addition to the above effects, mercury may alter the behavior of birds. Ducklings exhibit a hyper-responsiveness in their avoidance behavior (Heinz 1979), loons show an increase in abandonment of territories (Barr 1986), and mallards lay an increased number of eggs outside of nest boxes (Heinz 1979). Though the degree of impairment is dependent on the species (Scheuhammer 1987), sex, age, and physiological condition of the organism (Fimreite 1974), mercury has the potential to adversely affect avian resources by reducing the number of fledglings produced, thereby reducing the number of nesting birds.

## 2. Historical Data on the Accumulation and Effects of Mercury on Fish-eating Birds of Lavaca Bay

### OBJECTIVES

The extended period that mercury was discharged into Lavaca Bay by a chlor-alkali facility, and the fact that mercury still persists in the environment today (Reigel 1990, Palmer 1992), raised the concern of the U.S. Fish and Wildlife Service (Service) about the past and present effects mercury may be having on avian species that utilize the bay. The purpose of this investigation was two-fold; 1) to document historical changes in populations, and 2) to attempt to determine historical trends of avian mercury levels from chemical analysis of archived collections of eggs and feathers of fish-eating birds from Lavaca Bay.

### MATERIALS AND METHODS

Historical Records

To account for avian population trends in Lavaca Bay, information was reviewed on the life history of the area's waterbirds, especially that pertaining to nesting, colony site selection, and feeding. Local colonial waterbird experts were questioned about the possible existence of unpublished papers, reports, theses, or censuses of Lavaca Bay waterbirds. To account for long-term changes in availability of nesting habitat, efforts were made to obtain historical aerial photographs of the spoil islands of the bay. Photographs were sought to help document changes in the island sizes and vegetation as a result of time, erosion, and spoil deposition. Another source of historical information was the Audubon Society Warden reports for Lavaca Bay.

To assist in documenting historical population trends, the following censuses were considered:

1. The North American Breeding Bird Survey, which was started in 1965 and coordinated by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service. However, the data was confined primarily to inland areas and did not include spoil islands.

2. The Christmas Bird Count, which began in 1900 and was developed by the National Audubon Society. Results are published each year in American Birds. Count areas consist of 24 km diameter circles divided into sections by local coordinators. Thorough count coverage within any given circle is dependent on the number of

participants and site accessibility. The count circle nearest Lavaca Bay was located a considerable distance away at the Aransas National Wildlife Refuge, and consequently the survey was not considered.

3. The Mid-Winter Waterfowl Survey is normally conducted in early January by State Fish and Wildlife agencies in conjunction with the Service. Two transects, number 14 and 15, were near but not inclusive of Lavaca Bay, and therefore were considered as an unsuitable reference.

4. The Texas Colonial Waterbird Census (TCWBC), begun in 1967 by Blacklock and Hildebrand (Blacklock et al. 1978), originally included only the central coast. In 1968 it was expanded to include the entire Texas coast. Only anhingas, cormorants, herons, egrets, ibises, and pelicans were counted during the first few years of the census. Observers counted individuals on or near the colonies including those resting, feeding, and loafing (Blacklock et al. 1978). By 1973, pairs were counted, field techniques were standardized, other fish-eating birds were added, and colonies were numbered systematically and recorded individually. This census became our primary source of information for bird populations.

Data for the following colony sites were used to determine population trends in Lavaca Bay (Figure 2-1):

| TCWBC# | TCWBC Name | USFWS Site Name |
|---|---|---|
| #609-120 | Point Comfort Alcoa | Lavaca 1 |
| #609-121 | Lavaca Bay Spoil (63-77) | Lavaca 2 |
| #609-220 | Lavaca Bay Spoil (51-63) | Lavaca 2.5 and 3 |
| #609-122 | Mouth Lavaca River | |

Since Lavaca Bay was included in the upper coast but was adjacent to the TCWBC boundary line dividing the central coast and the upper coast, data from both of these coastal sections were graphed along with Lavaca Bay in order to detect population shifts from one area to another and to compare overall trends. Also, since there was a vast difference in total numbers between the coastal sections and Lavaca Bay, the data was standardized using the peak year of each series. Because numbers of colonial waterbird species can fluctuate from year to year by as much as 50% (King 1978) only broad general trends over a long period of time were discernable.

Censuses are often used to detect changes in bird populations over large areas and over long expanses of time (Nisbet 1973,

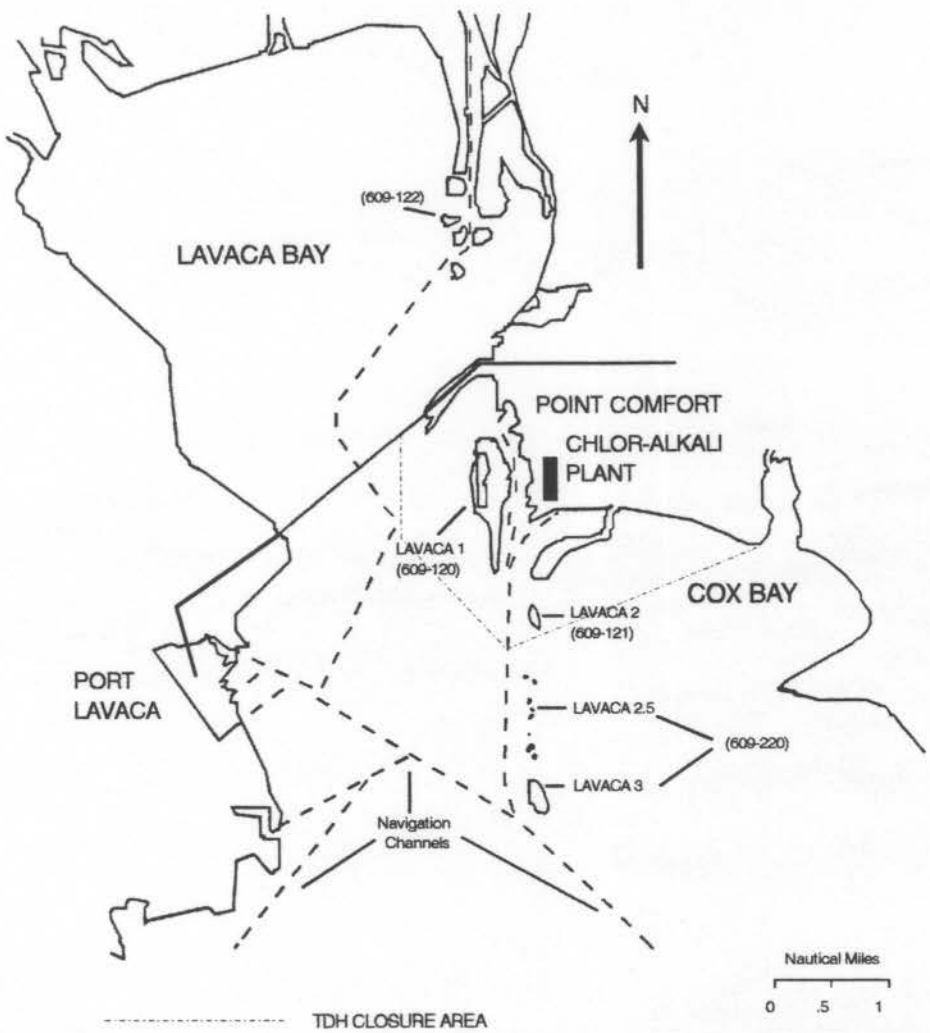


Figure 2-1. Map of Lavaca Bay showing location of colonial waterbird colonies.

Morrison et al. 1983). One of the problems in using censuses is difference in observer effort (Johnston 1990); however, in this instance the sites chosen were censused almost entirely by a single Service biologist (Appendix A-1).

Museum Search

Library catalogs (Tyler and Tyler 1983, Texas Historical Commission 1988) were consulted to determine which museums or collections might be capable of supplying the required specimens. Names and addresses of targeted collections are listed in Appendix A-2. In October 1991, these universities and museums were contacted with a request to identify eggs and specimens of fish-eating birds that were collected in Lavaca or Matagorda Bays between the early 1960's and late 1980's. A cover letter was written explaining that mercury had been discharged from an aluminum processing plant into Lavaca Bay during the late 1960's and early 1970's. The letter further explained that substantial levels of mercury in the biota of the bay resulted in the closure of certain portions of the bay to fishing, instigating a major effort by several state and federal agencies to determine the distribution of mercury in Lavaca Bay. Information was requested as to the ability of the museum to furnish eggshell membranes, and carcasses or skins from the specific study area for mercury analysis. This letter was accompanied by a species list arranged in order of importance to the study (Appendix A-3), a data sheet identifying the required survey information (Appendix A-4), and a return envelope.

A reply to our inquiry was requested by 31 January 1992. At that time, all data would be reviewed, and the 50 most appropriate egg and bird specimens (according to collection date, location, and species) would be identified. Selected curators would then be given the choice of sending us the specimens for processing, or of having sample kits sent to them with the necessary supplies and instructions on how to collect the tissues.

## RESULTS AND DISCUSSION

### Historical Population Trends

Trends were examined for thirteen species of resident colonial waterbirds and two wintering species in Lavaca Bay. Four species of the colonial waterbirds showed population increases, three species showed decreases, five species showed no obvious trends, and one species did not nest in Lavaca Bay. No long-term data was available for the two wintering species.

The Roseate Spoonbill population in Lavaca Bay appeared stable, with peaks every 4-5 years (Figure 2-2). Likewise,

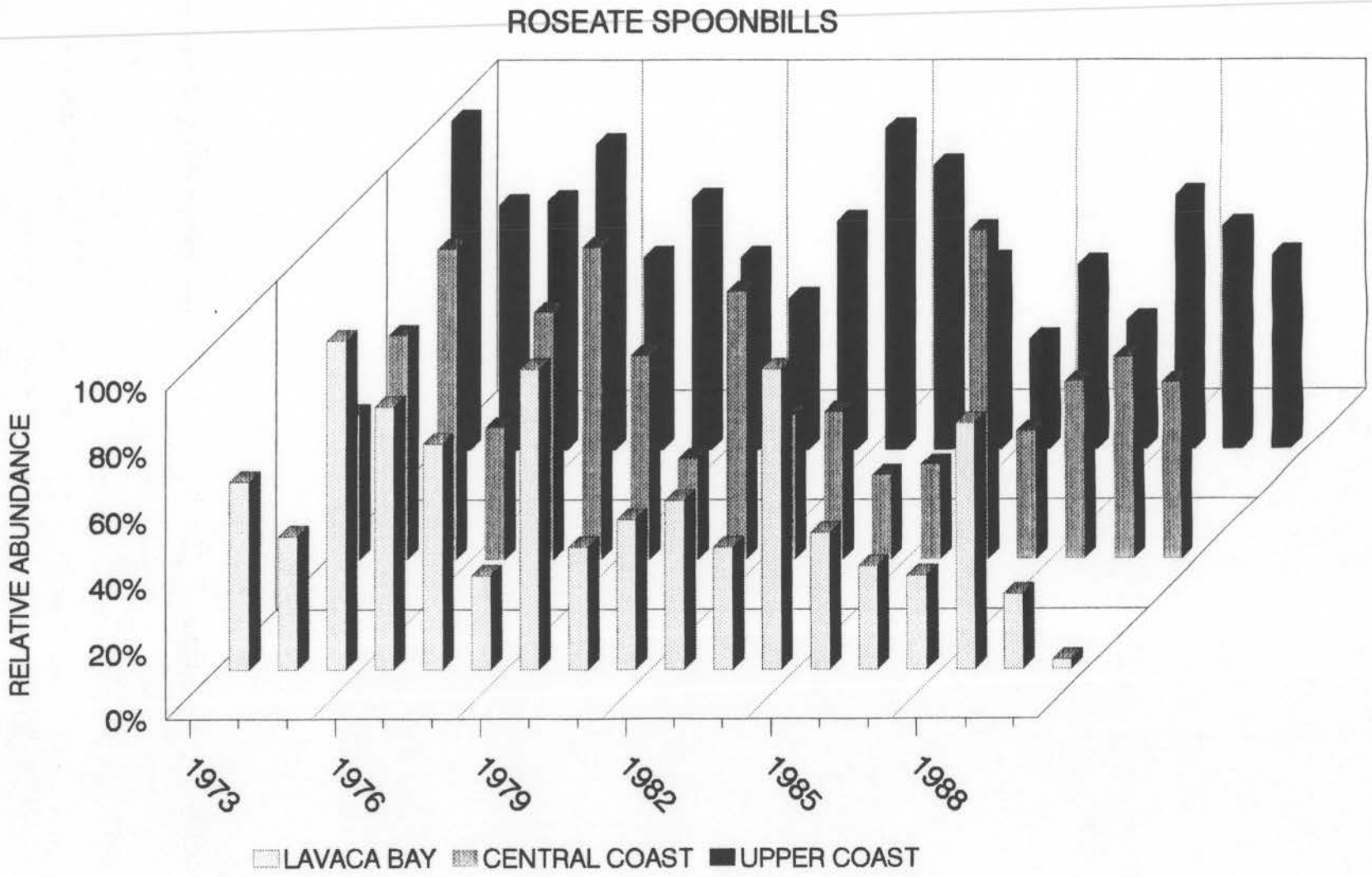


Figure 2-2. Relative abundance of Roseate Spoonbills in Lavaca Bay and the central and upper coasts from 1973-1990.

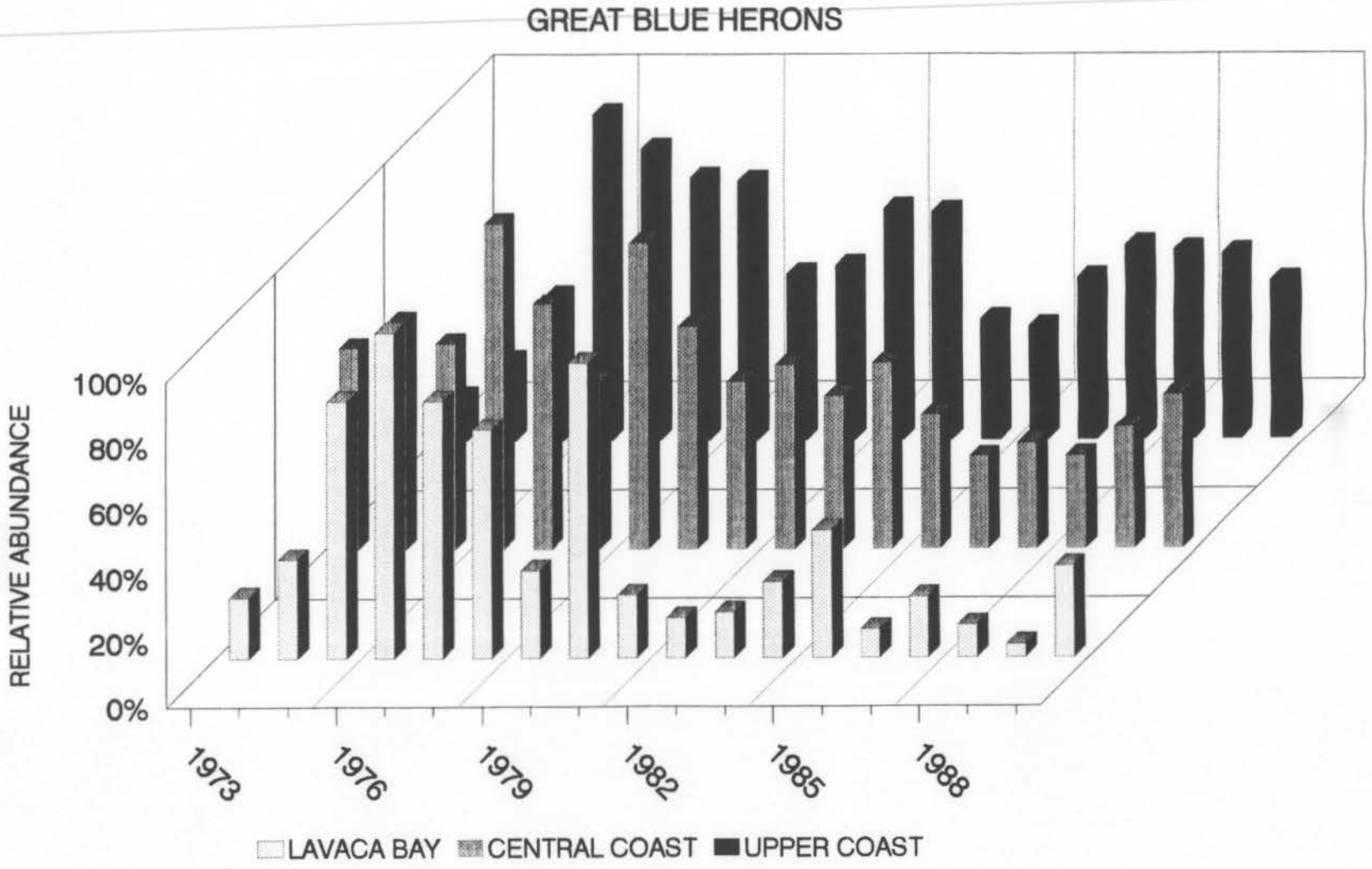


Figure 2-3. Relative abundance of Great Blue Herons in Lavaca Bay and the central and upper coasts from 1973-1990.

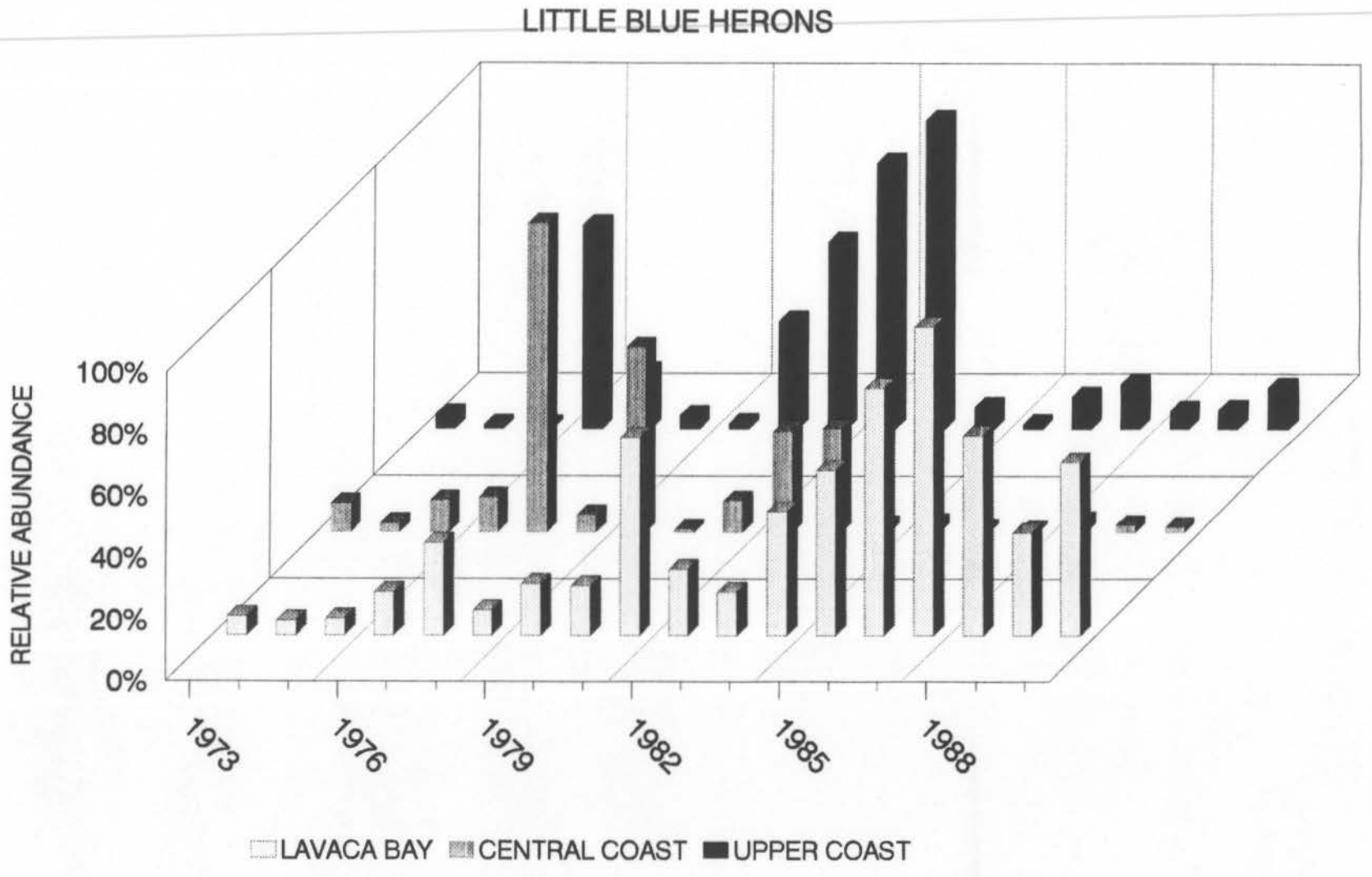


Figure 2-4. Relative abundance of Little Blue Herons in Lavaca Bay and the central and upper coasts from 1973-1990.

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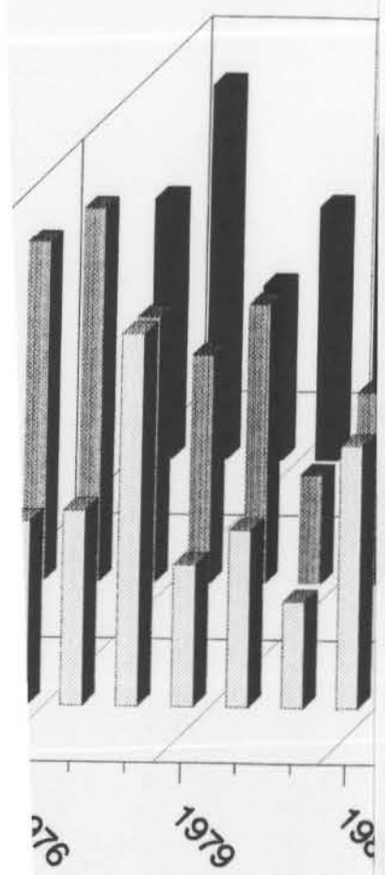


ndance of Snowy Egrets in La

GREAT EGRETS

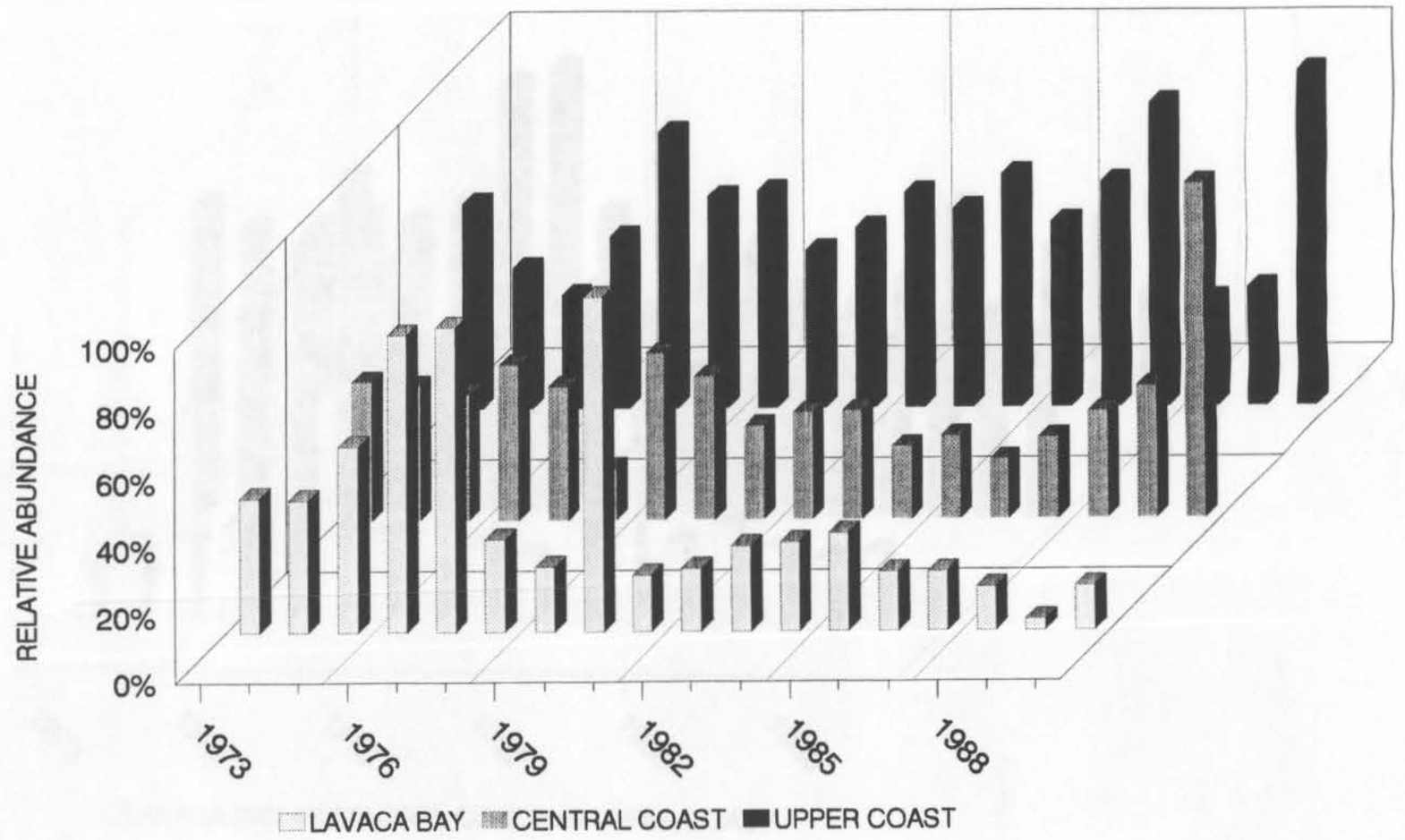


Figure 2-5. Relative abundance of Great Egrets in Lavaca Bay and the central and upper coasts from 1973-1990.

Numbers of Least Terns have been low on the upper coast since 1974. The central coast population peaked in 1979 (251) and has declined since then. Changes in vegetation and the presence of other birds may be the reason for the cyclic trend in Lavaca Bay (Figure 2-8). Least Terns prefer to nest on barren sand, shell beaches (Blus and Prouty 1979) or in areas with a large amount of shell in the substrate (Soots and Parnell 1975). They are site-faithful, returning year after year as long as the colony site is kept free of vegetation by wind or waves (Jackson and Jackson 1985).

There is no discernable trend for Forster's Terns in Lavaca Bay or the central coast (Figure 2-9). There appears to be a slight increase on the upper coast.

Royal Terns nested in Lavaca Bay only three times; in 1980, in 1986 when 5,000 pairs nested on colony #609-220 (Lavaca Bay Spoil), and in 1990. Populations have remained stable on the central coast and have increased slightly on the upper coast (Figure 2-10).

The number of Laughing Gulls nesting in Lavaca Bay has increased dramatically since 1978 (Figure 2-11), although the reason for this sudden increase is unclear. The population has remained high on both the upper and central coast.

Numbers of Black-crowned Night-herons have decreased along the central coast. The population on the upper coast appeared stable but cyclic, with a slight increase in Lavaca Bay (Figure 2-12) possibly due to an increase in vegetation favorable for nesting.

The Black Skimmer population has declined on the central coast but numbers on the upper coast remain fairly stable. Black Skimmer numbers peaked in Lavaca Bay in 1980 (480) (Figure 2-13) and have declined to 92 pairs in 1990. During this same time, the numbers of Laughing Gulls rose from 23 pairs in 1979 to 500-2700 in the following 10 years. The colony may have moved due to a vegetative transition to less suitable nesting habitat, and/or the increase in Laughing Gulls, which are known to prey on skimmer eggs (DePue 1974).

No Brown Pelicans nested on any of the colony sites in Lavaca Bay or Sundown Island from 1973-1990. Currently, Brown Pelicans nest on few islands along the Texas coast. Pelican Island in Corpus Christi Bay and Sundown Island in Matagorda Bay are the two most consistent and productive nesting sites.

There was no data available for the two Lavaca Bay wintering species, the Lesser Scaup or the Double-crested Cormorant, in Lavaca Bay. However, Morrison et al. (1983) used nine Christmas Bird Count areas to determine population trends in

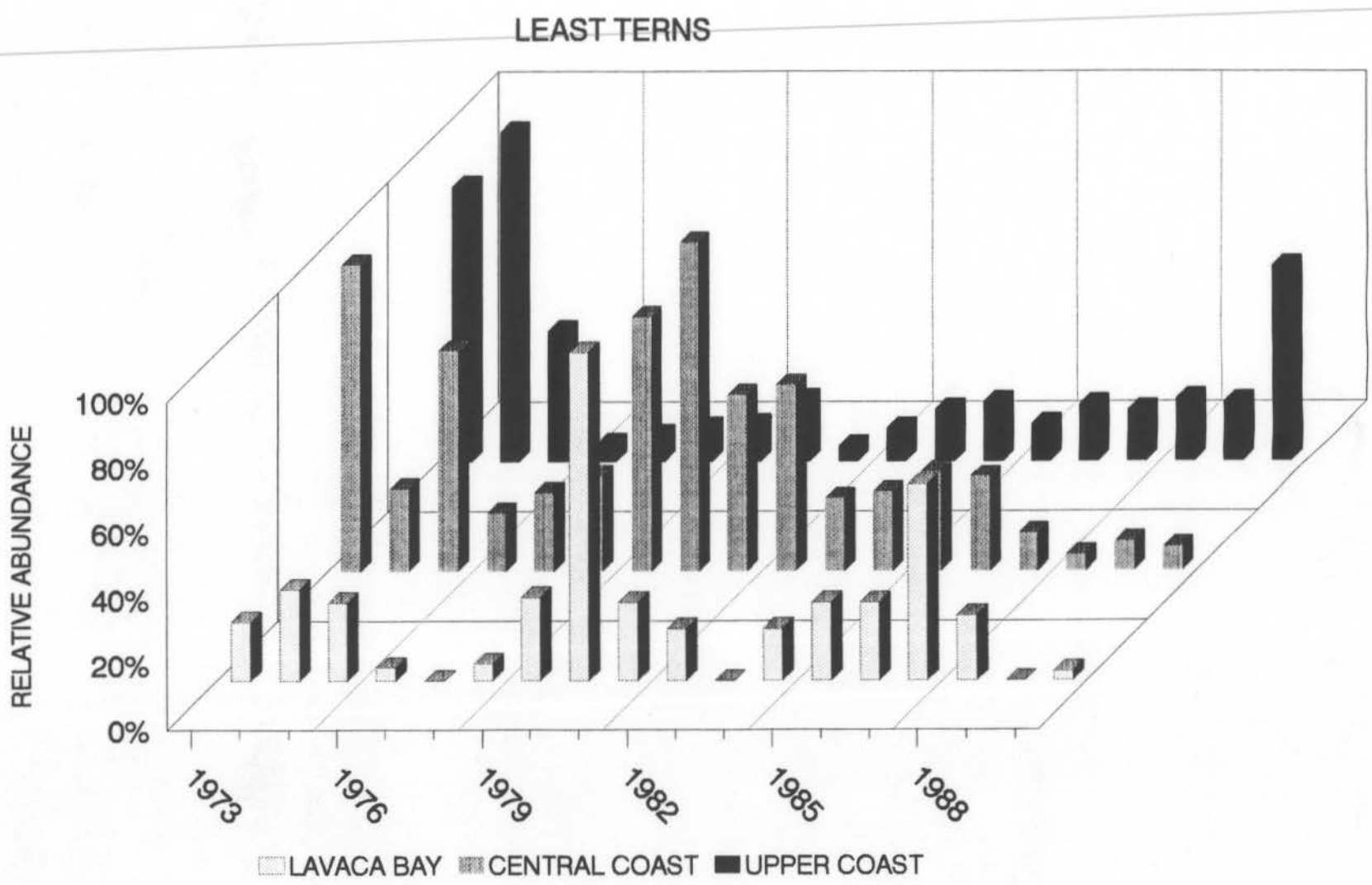


Figure 2-8. Relative abundance of Least Terns in Lavaca Bay and the central and upper coasts from 1973-1990.

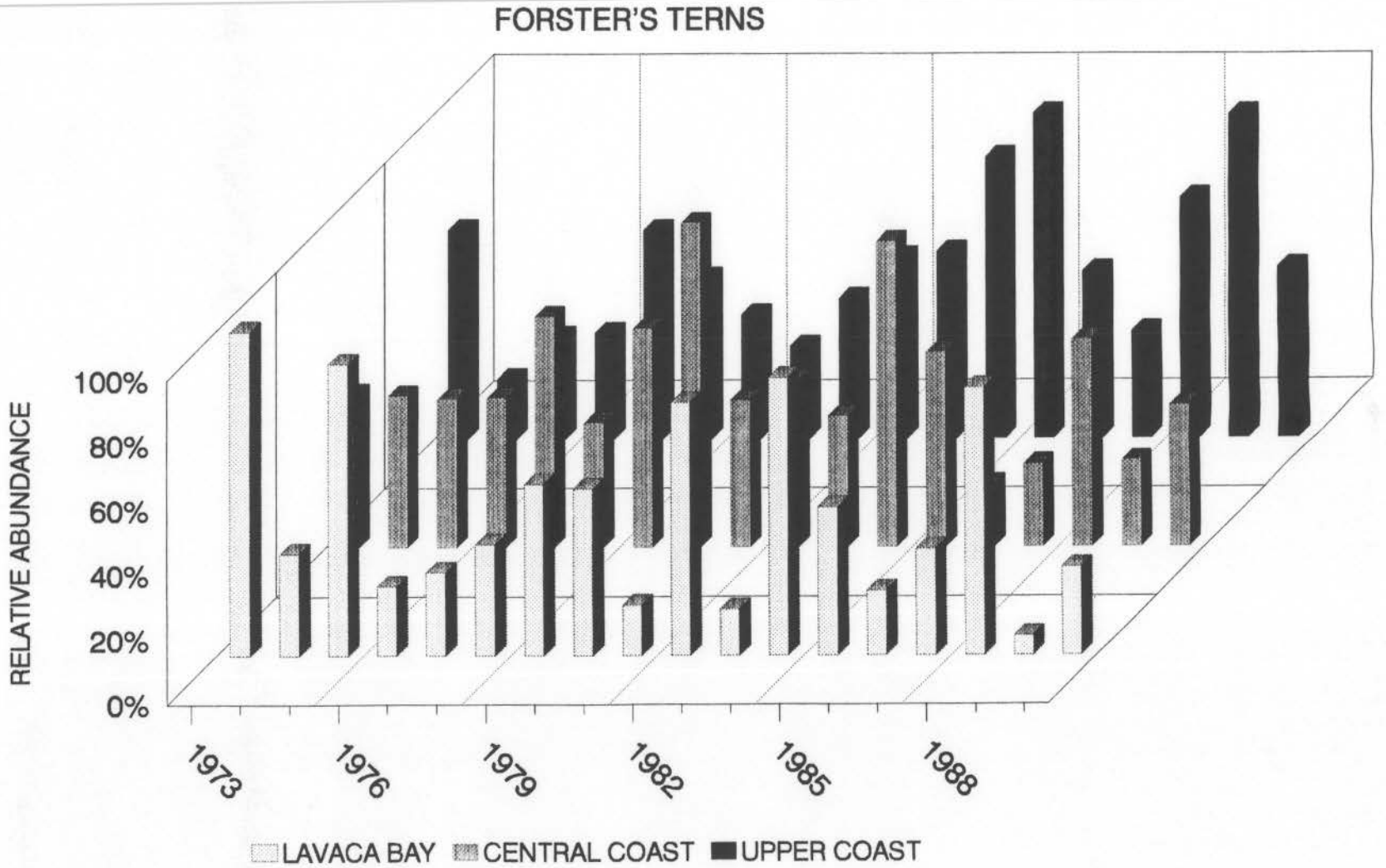


Figure 2-9. Relative abundance of Forster's Terns in Lavaca Bay and the central and upper coasts from 1973-1990.

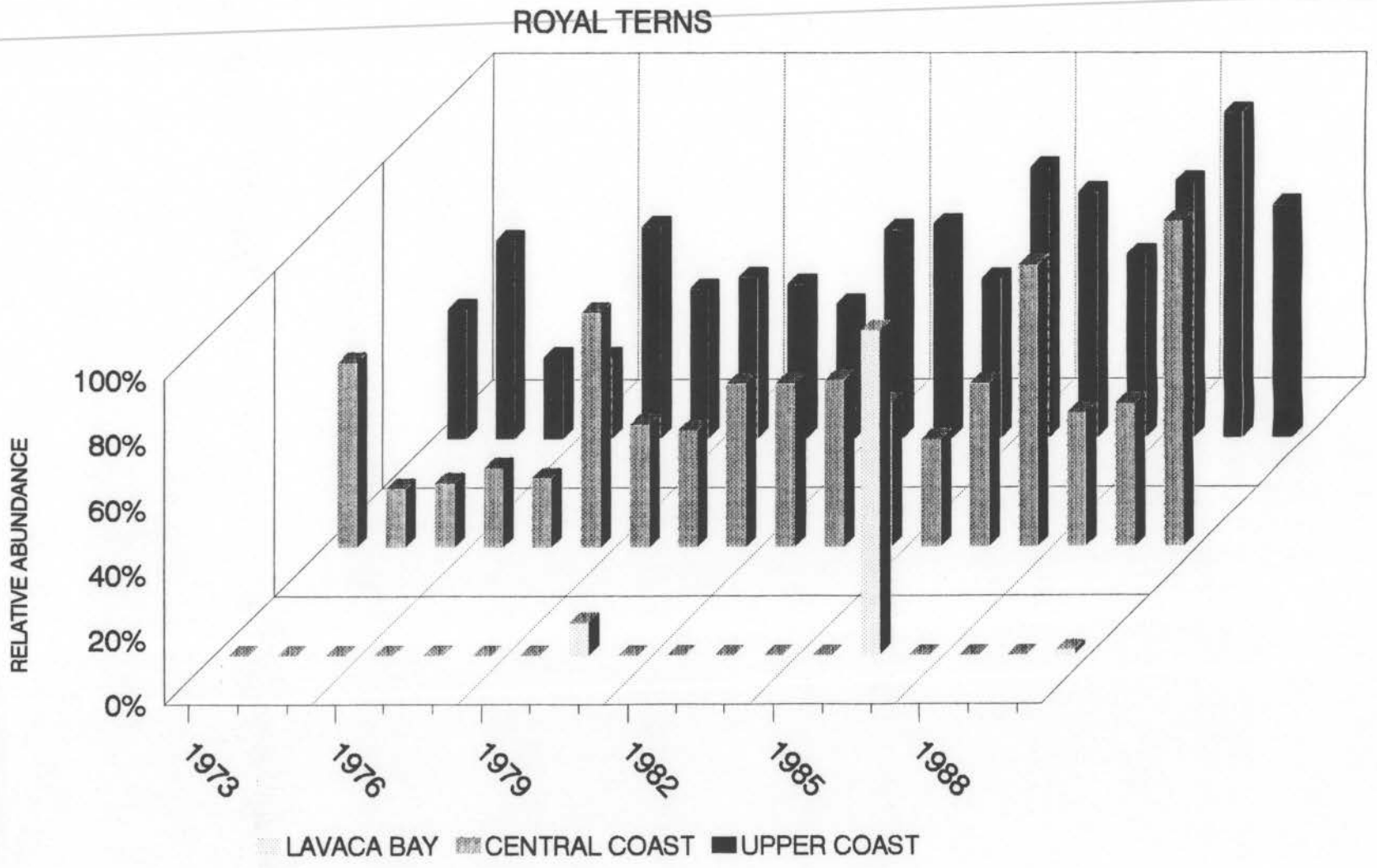


Figure 2-10. Relative abundance of Royal Terns in Lavaca Bay and the central and upper coasts from 1973-1990.

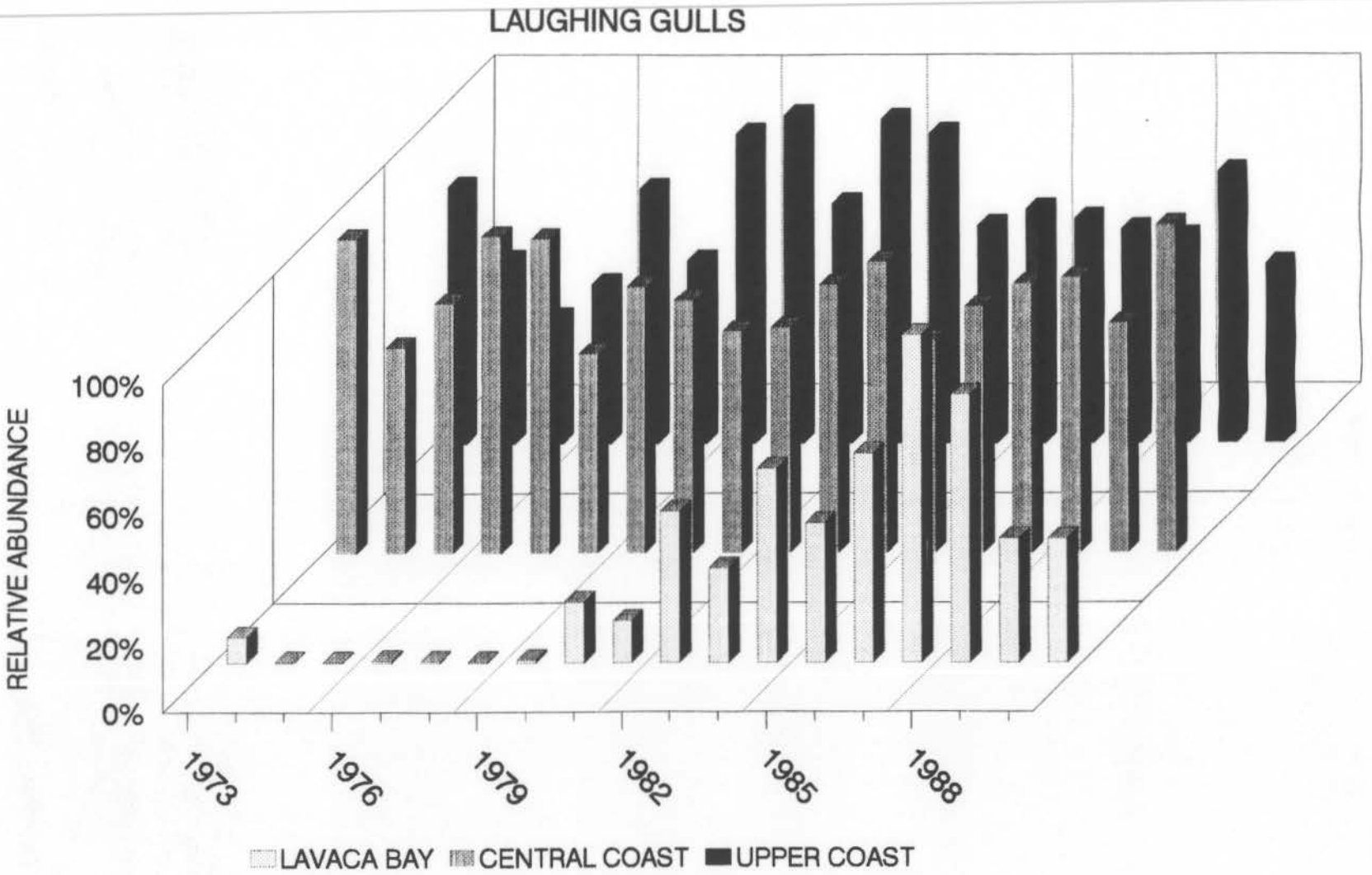


Figure 2-11. Relative abundance of Laughing Gulls in Lavaca Bay and the central and upper coasts from 1973-1990.

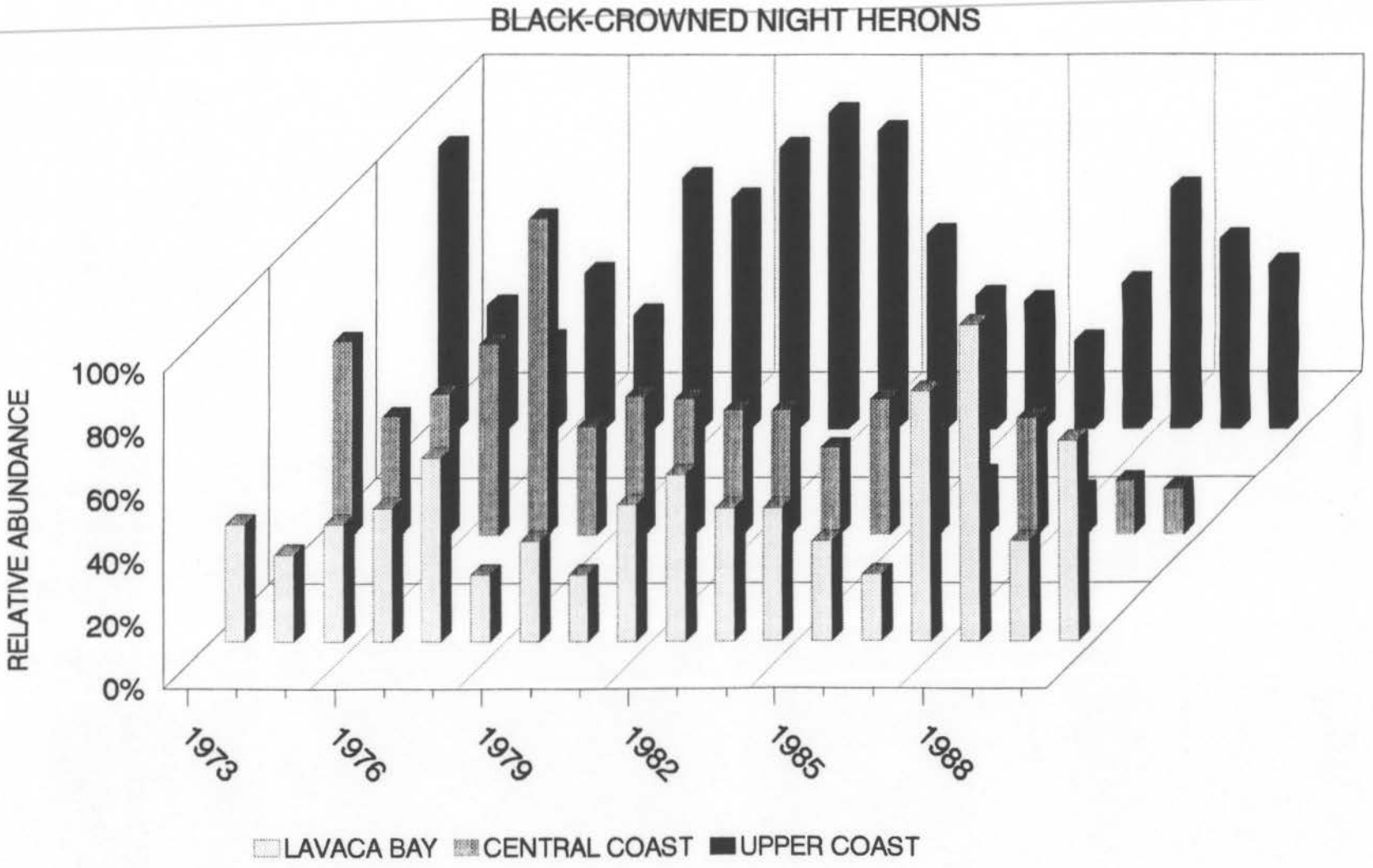


Figure 2-12. Relative abundance of Black-crowned Night Herons in Lavaca Bay and the central and upper coasts from 1973-1990.

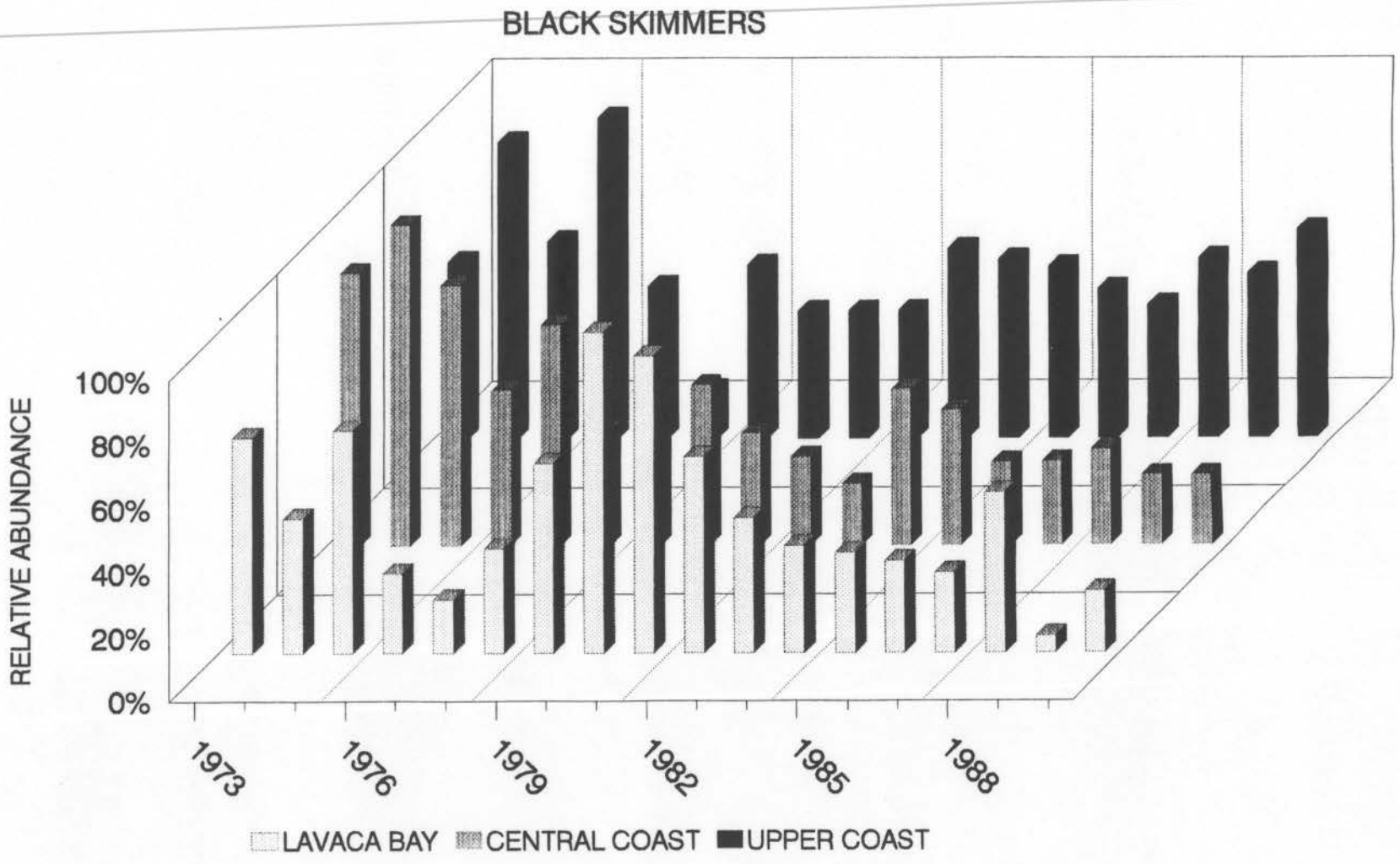


Figure 2-13. Relative abundance of Black Skimmers in Lavaca Bay and the central and upper coasts from 1973-1990.

Texas from the period 1949-1981. Double-crested Cormorants peaked in the mid 1970's and declined through 1981. Although these graphs may indicate an upward or downward trend, it is impossible to attribute the trends to any one cause.

The above fluctuations in historical populations of waterbirds in Lavaca Bay may be reflective of the many natural factors that influence where birds will nest and how successful they will be. Ground-nesting birds, such as Black Skimmers and Laughing Gulls, are subject to flooding from high tides associated with severe storms which inundate nests and cause desertion by adult birds (White et al. 1984, King and Krynitsky 1986). Great Blue Herons (Burkholder and Smith 1991) and other tree nesting species may also suffer nestling mortality from severe weather. Predators that can cause some loss of eggs or nestlings include: raccoons and opossums (Kelsall and Simpson 1979), Crows (Jenni 1969, Burger and Hahn 1977), Great-tailed Grackles, snakes (Jenni 1969) and Laughing Gulls (Simersky 1971, DePue 1974, Blus and Stafford 1980). Fire ants may also kill newly hatched young (Simersky 1971) or irritate the adults to the point that they desert the nest, leaving the young subject to overexposure and predators (Mrazek 1974). Human disturbance has been cited repeatedly as a problem for nesting birds (Simersky 1971, Robert and Ralph 1975, Werschkul et al. 1976, Safina and Burger 1983). Depending on the frequency and time of occurrence, this type of disturbance can inhibit egg-laying, increase predation, cause nest abandonment, and contribute to nestling mortality (Tremblay and Ellison 1979). Other impacts include egg breakage, overheating or cooling of eggs or young, and nestlings being accidently kicked from the nest (Vos et al. 1985).

Mercury In Archived Collections

Because of its stability, mercury in feathers is considered to be a reliable indicator of environmental contamination (Appelquist et al. 1984, Furness et al. 1986, Fimreite 1979). The plumage of fish-eating birds has been shown to contain high concentrations of methyl mercury (Westermark et al. 1975, Appelquist et al. 1985) thus reflecting the extent of habitat contamination (Furness et al.1990). The advantage of using feathers has been demonstrated by a positive correlation between feather and internal tissue mercury concentration in a ratio of 7:3:1 (feathers: liver: muscle) (Appelquist et al. 1985). Although this ratio is subject to variation caused by differences in sampling time and form of mercury it can be used as a rough means to estimate mercury contamination in liver and muscle tissue (Thompson et al. 1990). Several previous studies have utilized museum specimens to accurately measure and establish consistent mercury levels in feathers of fish-eating birds across a broad expanse of time (Berg et al.

1966, Johnels and Westermark 1969, Doi et al. 1984, Appelquist et al. 1984, 1985, Braune 1987, Thompson and Furness 1989, Thompson et al. 1992). Eggs are also useful as indicators of mercury contamination because they may reflect levels in the female at the time the egg was laid (Ohlendorf et al. 1988). Newton et al. (1989) postulated that residues in eggs may result from various prey eaten during the egg formation period and from residues already present in the body of the female. Due to seasonal changes in animal physiology and behavior, concentrations of mercury tend to be higher in tissues prior to egg-laying and are typically depurated in the first-laid egg (Becker 1992). Eggshell membranes, if properly preserved, can help determine mercury contamination of the embryo if sufficient membrane tissue remains to analyze for mercury contamination.

Of the forty-eight letters sent to universities and museums, only sixteen replies were received, and only two of those indicated an ability to supply specimens from the Lavaca or Matagorda Bay area. Texas A&M University has three specimens of three species out of the fifteen targeted species of fish-eating birds: a Least Tern collected on 15 July, 1980, 13.6 km ESE of highway junction 35 and 87 in Port Lavaca; a Roseate Spoonbill collected on 20 September, 1977, 5-6 km W. of Port Lavaca; and a Tricolored Heron collected on 5 August, 1973 near Olivia, all locations within Calhoun County. The Welder Wildlife Foundation holds five royal tern eggs from a small island in San Antonio Bay, 8 km off the town of Seadrift, Texas, all collected on 17 May, 1924. Given the above circumstances, the museum collection portion of this study was abandoned because of the lack of suitable samples for comparison.

## CONCLUSIONS

Although population trend data showed a decline in three species of colonial waterbirds in Lavaca Bay, four species showed population increases, while populations of five other species remained relatively stable. However, due to the lack museum specimens for chemical analysis, it was not possible to link the declines of Great Blue Heron, Great Egret, and Black Skimmer with mercury contamination. Because their numbers have decreased in Lavaca Bay, these populations should continue to be monitored, and the causes of any continuing trends be determined.

## 3. Accumulation and Effects of Mercury on Nesting Biology of Colonial Waterbirds in Lavaca Bay

### OBJECTIVES

Very little is known regarding the extent that reproduction of avian species using Lavaca Bay has been or continues to be affected by mercury contamination. King et al. (1991) examined mercury levels and associated effects on two species of fish-eating colonial waterbirds nesting in Lavaca Bay. Mercury levels in the eggs of Forster's Terns (Sterna forsteri) and Black Skimmers (Rynchops niger) were significantly higher in Lavaca Bay compared to reference sites. Although they concluded that concentrations of mercury were not related to hatching success of either species in Lavaca Bay, the highest mercury levels detected were similar to levels associated with reproductive failure of some species of birds in controlled studies (Fimreite 1971, Vermeer et al. 1973, Connors et al. 1975, Heinz and Locke 1975).

Field investigations were conducted in Lavaca Bay in Spring 1991 to determine the potential effects of mercury on the reproductive biology and neurological condition of the area's colonial waterbirds. Objectives of the investigations were the following:

1) to determine the impact of mercury on reproductive success of four species of colonial waterbirds from Lavaca Bay, nesting studies were conducted on Great Blue Herons (Ardea herodias), Great Egrets (Casmerodius albus), Tricolored Herons (Egretta tricolor), and Brown Pelicans (Pelecanus occidentalis);

2) to investigate the occurrence of mercury-related brain lesions in nestlings of three of the above species of colonial waterbirds (excluding Brown Pelicans) common to Lavaca Bay using histopathological investigation of brain tissue;

3) to determine mercury levels in the eggs of nine other species of colonial waterbirds which nest in Lavaca Bay.

## MATERIALS AND METHODS

### Sample Design

#### Species Selection

Three species of fish-eating colonial waterbirds investigated, Great Blue Heron, Great Egret, and Tricolored Heron, were selected because they are highly piscivorous, they feed on relatively large fish (Bent 1926), and a minimum of 50 nesting pairs of each species were expected at both the Lavaca Bay and reference sites (Texas Colonial Waterbird Society 1982). Mercury levels in eggs and nesting success were also investigated for the Brown Pelican, because they: 1) are a Federally-listed endangered species; 2) nest in nearby Matagorda Bay and also winter in the area; 3) have been observed feeding in the closed portions of Lavaca Bay; 4) feed on relatively large fish (25 cm or longer); 5) are a long-lived species (up to 20 years) (Clapp et al. 1982); 6) tend to return to the same nesting island from year to year, and; 7) have been shown to be particularly sensitive to some contaminants (King et al. 1978).

The eggs of nine species of colonial waterbirds were also evaluated for mercury contamination, including Little Blue Heron (Egretta caerulea), Snowy Egret (Egretta thula), Least Tern (Sterna antillarum), Roseate Spoonbill (Ajaia ajaja), Royal Tern (Sterna maxima), Laughing Gull (Larus atricilla), Black Skimmer (Rynchops niger), Black-crowned Night-heron (Nycticorax nycticorax), and Forster's Tern (Sterna forsteri). These survey species were selected because they are also piscivorous (Bent 1926, Allen 1942, Clapp et al. 1983) and are common breeding birds in both the Lavaca Bay and reference sites (Texas Colonial Waterbird Society 1982).

#### Colony Selection and Description

Selection of Lavaca Bay colony sites concentrated primarily on identifying colonies which were within the Texas Department of Health (TDH) closure area, or alternatively, as close as possible to the mercury-contaminated areas identified by Holmes (1977). In 1991, there were colonies on three dredge material islands located along the Matagorda Ship Channel in Lavaca Bay (Figure 3-1). The northernmost site was a 40-ha island created during the dredging, construction, and maintenance of the harbor at Point Comfort, and subsequent disposal of bauxite tailings from the ALCOA processing plant (colony 609-120, Texas Colonial Waterbird Society, 1982). Nesting occurred primarily in dense mesquite (Prosopis glandulosa), huisache (Acacia farnesiana), and prickly pear cactus (Opuntia lindheimeri) brush along the east edge of the island.

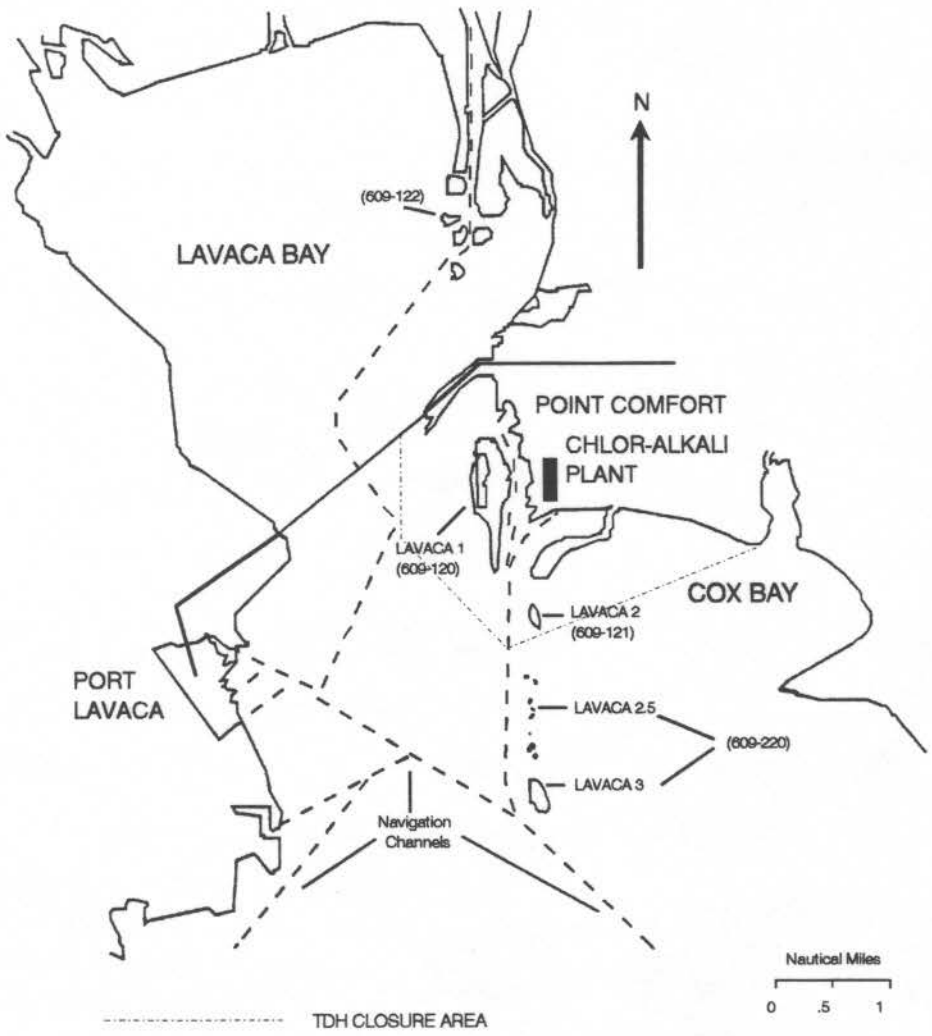


Figure 3-1. Map of Lavaca Bay showing locations of colonial waterbird study sites, Spring 1991.

The next nesting island to the south was created during the construction and subsequent maintenance of the Matagorda Ship Channel. It covered 8 ha and nesting occurred primarily in mesquite and sea myrtle (Baccharis halmifolia) brush.

The southernmost island in the study area was a 9-ha dredged material island at the intersection of the Matagorda Ship Channel and the Port Lavaca Channel. Great Blue Herons and Great Egrets nested in vegetation similar to that described above, plus retama (Parkinsonia aculeata) and huisache. Tricolored Herons nested in low halophytes and subshrubs. These latter two islands comprise the majority of colony 609-121 (Texas Colonial Waterbird Society 1982).

Selection of a reference site was dependent on locating colonies of the appropriate species and of sufficient size and in habitat similar to that of the study site, but that were isolated from significant known sources of mercury contamination. Two reference sites were selected for comparison against the Lavaca Bay site (Figure 3-2). One reference site was the Second Chain of Islands, a series of six natural islands totaling approximately 2 ha (colony 609-422, Texas Colonial Waterbird Society 1982), and was located approximately 53 km SW of Lavaca Bay on the coast. Vegetation consisted of low halophytes, sunflower (Helianthus annuum) and sea myrtle. The second reference site, located approximately 128 km southwest on the coast (Figure 3-2), was a series of dredged material islands in the upper Laguna Madre (colony 614-240, Texas Colonial Waterbird Society, 1982), and one island nearby (colony 614-221, Texas Colonial Waterbird Society, 1982). Vegetation included a variety of halophytes, prickly pear cactus, mesquite, and sea myrtle, with nesting occurring in the latter two species for
Great Blue Herons and Great Egrets, and in low halophytes for Tricolored Herons.

Only two active Brown Pelican colonies (Sundown Island and Pelican Island) were found on the Texas coast, and they served as the study site and reference site, respectively. Sundown Island, a dredged material island of approximately 20 ha, was located in adjacent Matagorda Bay at the intersection of the Matagorda Ship Channel and the Gulf Intracoastal Waterway, 29.6 km from the boundary of the TDH closure area (Figure 3-2), (colony 609-300, Texas Colonial Waterbird Society, 1982). Brown Pelicans have been observed feeding in the contaminated areas of Lavaca Bay and Matagorda Bay as identified by Holmes (1977). Vegetation on the island consisted of typical halophytes and low shrubs, including mesquite, and sea myrtle. Nesting took place in brush dominated by sea ox-eye daisy (Borrichia frutescens) and camphor daisy Machaeranthera

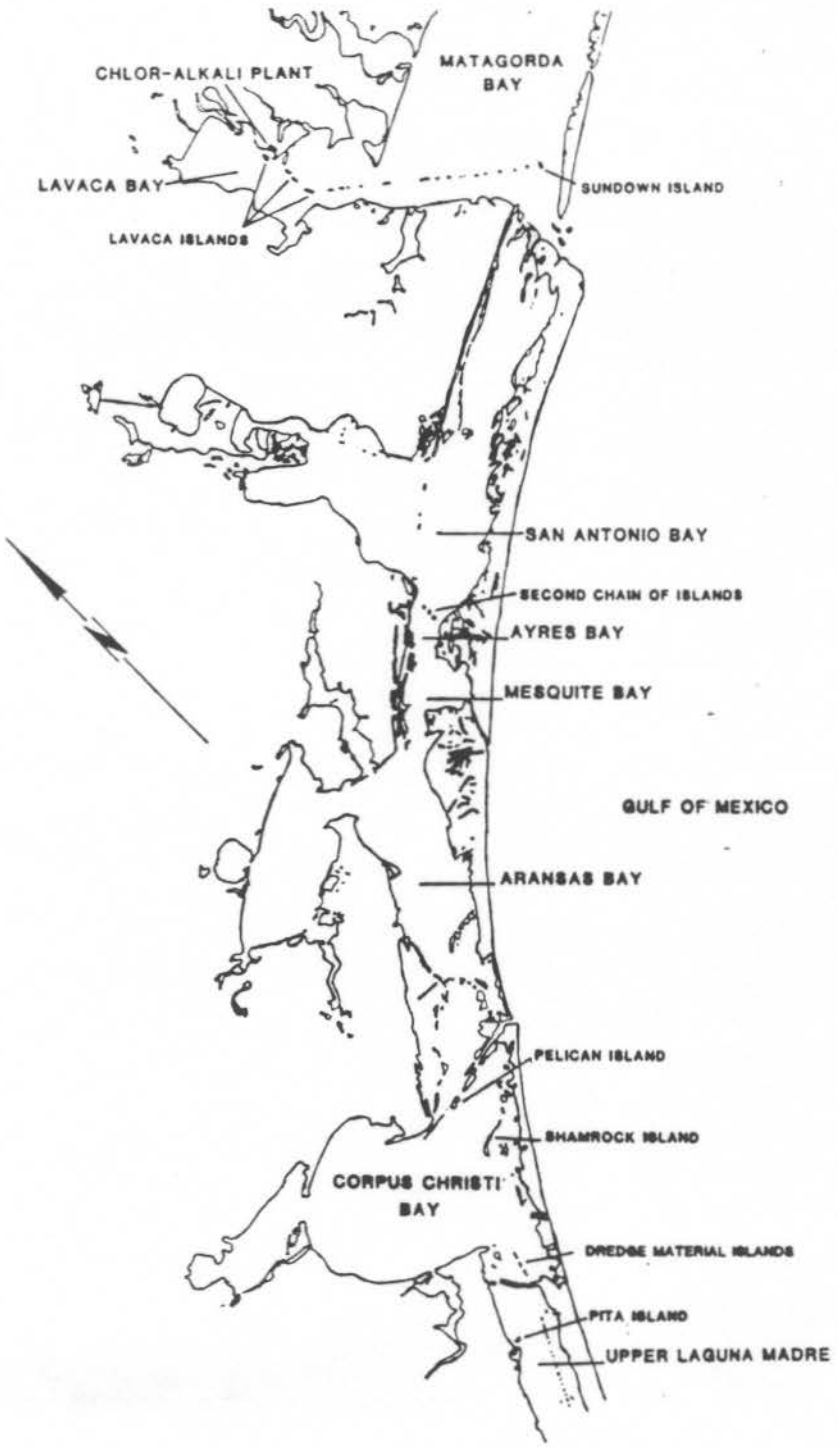


Figure 3-2. Location of colonial waterbird study sites on middle Texas coast, Spring 1991.

phyllocephala. The reference site, Pelican Island, was a dredged material island of approximately 162 ha located in Corpus Christi Bay (Figure 3-2), (colony 614-184, Texas Colonial Waterbird Society 1982). This site was expected to serve as a suitable reference site since no anthropogenic sources of mercury were known to occur nearby, and historical data on mercury levels in Brown Pelican eggs was available from this colony (King et al. 1985). Nesting occurred in areas dominated by sea ox-eye daisy, camphor daisy, and stands of sunflower.

The nine other species of fish-eating colonial waterbirds evaluated have been found nesting on four dredged material islands in Lavaca Bay (Texas Colonial Waterbird Society 1982). In addition to the three islands used for the three primary study species, a fourth site comprised of a series of small dredged material islands 0.4-1.9 km outside the closure area (Figure 3-1) was used (part of colony 609-121, Texas Colonial Waterbird Society 1982). Because this portion of the investigation was intended as a general survey, eggs were collected from only one reference site for each species. Three sites in or near the upper Laguna Madre sufficed for the nine species. The upper Laguna Madre site described above supported the same survey species as Lavaca Bay, except for Royal Terns, Roseate Spoonbills, and Forster's Terns. Roseate Spoonbill eggs were collected at Shamrock Island, a natural island in Corpus Christi Bay, (colony 614-186, Texas Colonial Waterbird Society 1982), Royal Tern eggs were collected at the dredged material islands near Humble Channel (Figure 3-2), and Forster's Tern eggs were collected at Pita Island, another natural island in the upper Laguna Madre (Figure 3-2), (colony 614-300, Texas Colonial Waterbird Society 1982).

## Field Methods

### Nesting Biology Field Methods

Nesting biology data for Great Blue Herons, Great Egrets, and Tricolored Herons were collected by visiting nests in the study site and reference sites on a weekly basis. Visits began on 27 March, 1991, when nesting by Great Blue Herons had begun, and the last visit for observation or collection was 27 June, 1991. In order to minimize human disturbance, site visits were initiated during late egglaying or incubation stage (Frederick and Collopy 1989). For purposes of this study, a nest was considered active if it contained one or more eggs (Custer et al. 1983). Active nests were marked with plastic flagging, upon which a unique alpha-numeric code was inscribed. Nests were identified to species by observing adults on the nest before they flew and/or by observing nest shape, location, position and size, and egg size and coloration.

Each site visit was conducted by two field personnel, one to conduct nest examinations while the other recorded the results. The nest contents were examined to determine the number of eggs, number of nestlings, nestling condition, and pipping eggs, if any. The records of the nests from previous visits were compared to determine if losses had occurred. If so, the nest (if it could be located) and surroundings below were examined to determine if losses could be attributed to predation (e.g., fire ants), storm events (including high tides), human disturbance, or other causes. Observations of nests located in high shrubs or trees were made using an adjustable mirror attached to a telescoping pole. Repeat visits were made to each nest until one of the following conditions were met: 1) the nest could no longer be found, 2) it was abandoned, 3) it was destroyed, or 4) the young had fledged from the nest.

Because of the status of the Brown Pelican as an endangered species and its sensitivity to frequent nest visits (King 1978), weekly nest visits were not conducted. Instead, only two visits were made to each of the two Brown Pelican colonies for the collection of data. During the first visit a subcolony was selected at each site, all active nests in that subcolony were counted, and the number of eggs and chicks in each nest were recorded. Subcolonies used were at similar stages of nesting. Only eggs which were abandoned or addled (by inspection or having been lost from the nest) were collected for mercury analysis from study and reference sites. Due to the sensitivity of Brown Pelicans to nest visits, the interval between visits to Sundown and Pelican Island was 30 days and 21 days, respectively. This delayed the second trip until the young were three to four weeks old, thereby reducing the possibility of nest abandonment by the adults. Care was taken not to startle young birds in the colony. The number of active nests, the contents of these nests, the number of ambulatory young, and the number of abandoned nests in the same subcolony were recorded.

Field Collection of Eggs

A sample egg was collected from each Great Blue Heron, Great Egret, and Tricolored Heron nest for which a record was maintained. To the extent practicable, sample eggs were collected only from nests with completed clutches of three or more eggs (Bent 1926), or after clutch size was stable for two visits. This egg was used to correlate mercury levels with nesting biology. Additional eggs were collected from nests as opportunities occurred, i.e., those observed to be nonviable were collected to determine if high mercury levels may have been a factor in their failure to hatch, and eggs which were ejected from a marked nest were collected to better determine mercury levels in that nest. The collection of each egg was

noted on the data sheet, and the nest number, date, and location were written on each egg with a wax pencil.

The sample egg technique employed, originally used by Ratcliffe (1967), involved collection of one egg from each of the study nests of the species of interest. The fate of the study nests was then determined, and the sample eggs were analyzed for mercury to allow comparison with the fate of the corresponding nests. All sample eggs were placed in egg cartons, which were then placed in a cushioned plastic container in an ice chest with ice for transportation back to the laboratory. Eggs were stored in refrigeration in the lab until they were processed. Details of these procedures are available in Appendix B-1.

During the first visit to each of the two brown pelican colonies, all identifiable abandoned eggs were collected to be analyzed for mercury content. This included only eggs which were on the ground or in obviously abandoned nests, and no eggs were collected from active nests. All eggs were labeled with the location and date, and stored in egg cartons in an ice chest for transportation. No additional eggs were collected on the second visit.

Only five eggs were collected from each of the nine survey species at both the study site and reference site. During each site visit, observations were made to locate colonies of the survey species, and nests were examined to determine the stage of nesting. If a count of eggs in a nest indicated that the clutch was complete, based on clutch size reported by Bent (1926), an egg was collected, and this procedure was repeated until five eggs of each species for a site were collected. Each egg was collected without regard to size, color, or location in the nest. Locations of nests with incomplete clutches were noted for future visits, if needed. Eggs were collected, labeled and handled as above.

Field Collection of Nestlings

Approximately 10 nestlings of each of the three main study species were collected from each site for histopathological examination of brain tissues and to determine mercury levels in the livers. When possible, moribund or very recently dead nestlings were selected for collection; however, visits at weekly intervals and the rate of autolysis in the summer heat greatly reduced opportunities to collect these nestlings. When sufficient numbers of moribund or very recently dead nestlings were not discovered, live nestlings were sacrificed. Live nestlings were euthanized by suffocation, and all specimens were placed in polyethylene bags labeled with sample number, date, location of collection, species, condition at time of collection (alive or dead) and nest number (if

applicable). All samples were immediately placed on ice. Field dissections for brain and liver tissues were done as soon as possible, generally within two hours. No nestlings were collected from the Brown Pelican colonies or from the nests of the survey species. Details of the dissection procedures are provided in Appendix B-1.

### Egg Sample Preparation

Eggs were refrigerated until immediately prior to processing. Each egg and its contents were assigned a unique sample number, and the means of three length and three width measurements and weight of each egg was recorded. Procedures were used to prevent cross-contamination between samples. Eggs were cut open at the equator with a scalpel and contents were placed into tared, chemically clean jars and labeled with the sample number. Jars were then placed in a secure freezer at -20°C. Details of these procedures are available in Appendix B-1.

### Nestling Organ Samples

Brains and livers were removed from nestling carcasses and preserved or frozen, respectively, as soon as possible to minimize any deterioration or changes associated with death. For collections made at Lavaca Bay or Second Chain of Islands, dissections occurred immediately upon return to the boat launch facility. Birds collected from upper Laguna Madre were dissected upon return to the lab. Livers from nestlings were placed in chemically clean jars, labeled with the appropriate collection information and sample number, and placed on ice until storage at -20°C. The brains of nestling birds were placed in chemically clean jars and preserved with a buffered formalin solution. For shipping, frozen liver samples were placed in ice chests with dry ice and preserved brain samples were decanted, wrapped in cheesecloth dampened with formalin, and resealed in the original containers for non-frozen shipment.

## Laboratory Methods

### Chemical Analysis

Eggs and livers were analyzed for total mercury content by Cold Vapor Atomic Absorption Spectrophotometry (CVAAS) at Geochemical and Environmental Research Group (GERG) of Texas A&M University. The procedures for digestion of the samples and the technique for CVAAS are found in Appendix B-2.

The contents of 20 selected sample eggs were subdivided by the contract laboratory for analysis of organochlorine compounds to determine if organochlorine residues in Lavaca Bay could be

responsible for any reduction in nesting success. Sample eggs selected included 5 Great Blue Heron eggs and 5 Great Egret eggs each from Lavaca Bay and upper Laguna Madre. The laboratory procedure for organochlorine analysis is found in Appendix B-2.

### Histopathological Examination

The brains of 77 nestling birds were sent to the National Wildlife Health Research Center, Madison, Wisconsin (NWHRC), for examination. Representative sections of tissue of each brain were mounted, stained, and examined by light microscopy for presence of histological changes, emphasizing changes that have been associated with elevated mercury levels in tissues. The existence and severity of changes were recorded for each specimen examined, and observations on the possible causes of the changes were included.

## Data Analysis

### Nest Success

Nest success of Great Blue Herons, Great Egrets, and Tricolored Herons were estimated using the Mayfield Method (1961, 1975). The aspects of nesting biology that were included as factors in the calculation of nest success were: nest survival probability, egg survival probability, and nestling survival probability. The product of these three factors was the total Nest Success (NS). Breeding, nest-building and egg-laying periods were not considered. Calculation of exposure began with the completion of the clutch. Because most nests were found and labeled after the clutch was initiated, it was impractical to use the incubation period as used by Custer et al. (1983) and King et al. (1991). Instead, incubation periods used in calculations were 28 days, 26 days, and 21 days for Great Blue Herons, Great Egrets and Tricolored Herons, respectively (Bent 1926). The date before the first egg hatched was used as the last day of the incubation period, and the first day of the incubation period was determined by subtraction using the number of days appropriate for each species. Hatching period was combined with the nestling period, and began on the day the first egg hatched and continued to the 15th day following. Most known effects of mercury toxicity were thought to be manifest by the 10th day, and by the 15th day nestling birds were well developed and would leave the nest upon human approach.

Nest success, using the nest success estimators suggested by Mayfield (1961, 1975), considers the survival of a nest and its contents as a function of time, which Mayfield refers to as exposure. The procedure takes into account several aspects of nesting biology and is more accurate than the apparent nest

success found by comparing nests seen to nests that fledged birds (Johnson 1979).

Several assumptions were made in applying this technique: 1) the halfway point of the interval between observation dates was assumed as the cutoff between visits for calculation purposes, rather than a point 40% through the period, based on the guidelines of Johnson (1979), and Miller and Johnson (1978); the interval between visits was short (6-8 days) and calculated values of survival were moderate. 2) All changes in the nest or its contents not witnessed were assumed to have happened at the midpoint between visits. For example, an abandoned nest was assumed to have been abandoned for 3.5 days prior to a visit made seven days after the previous visit. 3) Erwin and Custer (1982) recommend that the individual stages of nesting, including egglaying, incubation, hatching, and nestling periods be calculated separately because the rate of loss of nests is not constant from one period to the next. However, in this investigation the egglaying period was assumed to be part of, and combined with, the incubation period, as the frequency of nest visits did not permit finer discrimination of events and incubation begins with the laying of the first egg. 4) The hatching period (beginning the day the first egg hatched) was assumed to be part of and therefore combined with the nestling period. Mayfield (1961) used a period of two days as the hatching period and calculated a separate survival rate, a valid technique for most passerine species, which complete the clutch before incubation begins. However, the species in this investigation lay eggs at daily intervals and begin incubation after the first egg is laid. As a result, eggs hatch generally in the same sequence as laid but over a period of days approximately equal to the number of eggs. Therefore, from hatch day forward, the contents of each nest were assumed to be nestlings for the purposes of calculation of nest success. 5) Because the known toxic effects of mercury in nestlings of other species are manifest by the tenth day of age (Heinz and Locke 1975), calculations of nest success were carried only to the fifteenth day of nestling age. Also, by this age the species investigated readily left the nest upon approach, which made continued accurate observation in the colonies impractical. All nestlings which survived beyond 15 days were assumed to have fledged.

Cumulative values for the aspects of nesting success and total nest success were calculated for each species and colony. Appropriate variance estimates and comparisons of daily survival rates are available (see Hensler and Nichols 1981). Regression analysis using the linear model $Y = a + bX$, where $Y$ = the concentration of mercury in sample eggs and $X$ = each selected aspect of nest success, was performed for each species. The regression analysis was performed for each

species and site, and for pooled values for each species from all sites.

Nests were placed into one of three classes based on hatch success (HSC) (King et al. 1991). Classes were: 1) No eggs hatched, 2) Some eggs hatched, and 3) All eggs hatched. Only eggs that were present in the nest at the time of hatching or when hatching should have occurred were used to determine HSC. One-way ANOVA was performed on the associated mercury data for each HSC and site, to determine if mercury data from Lavaca Bay were significantly different from reference sites. Where there was significant difference ($P < 0.05$), Tukey's multiple range test was performed to determine significance between HSC groups. Unless specified, a statistical significance level of $P = 0.05$ was used. For the Brown Pelican, the apparent nesting success and mean clutch size were calculated for each site, to be compared with the geometric mean of the mercury values of the eggs collected from each site.

Mean clutch size was determined for all nests, for each species and site. Clutch size and distribution comparisons were made using Chi-square ($P = 0.05$).

Mercury Analysis of Eggs

For Great Blue Herons, Great Egrets, and Tricolored Herons, dry weight total mercury levels in eggs were log transformed and means were calculated only when at least 50% of the values were above the detection limit, and values which were below the detection limit were assigned the value of half of the detection limit. One-way ANOVA and Tukey's multiple range test (Statistical Graphics Corporation 1989) were used to determine significant differences between data sets. For the Brown Pelican, statistical comparisons were not attempted due to the weathered condition of many of the eggs. Geometric means of mercury values for eggs of each of the survey species at each site were calculated and presented for comparison. However, due to a small sample size, no comparative statistics were employed.

Organochlorine Analysis of Eggs

Wet weight levels of organochlorine compounds in the 20 selected sample eggs were log transformed and geometric means were calculated. Means were calculated only when at least 50% of the values were above the detection limit of 0.05 ppm. Values which were below the detection limit were assigned a value of half of the detection limit. One-way ANOVA and Tukey's multiple range test were used to determine if there were any significant differences in the organochlorine concentrations of eggs collected from Lavaca Bay and reference

sites.

Mercury Analysis of Nestling Livers

Geometric means of the mercury values (ppm wet weight) from the analysis of nestling livers were calculated for each species and site. All values were log transformed. For calculations, values which were below the detection limit were assigned the value of half the detection limit. One-way ANOVA was used to determine if means from nestlings in Lavaca Bay were significantly different from the reference sites, and Tukey's multiple range test was used to identify data sets that were significantly different.

Histopathological Examination of Nestling Brains

The data were analyzed to determine if mercury levels in livers of nestlings could be responsible for histopathological changes observed in the nestling brains. Three of the histopathological changes were selected on the basis of their significance in the brain specimens. These were: occurrence of clear crescent shapes in the cytoplasm of scattered neurons, potential shrinkage of neurons in the stratum griseum proventriculare, and necrosis of granule cells of the granular cell layer of the cerebellum. For each of these observed effects, mercury levels in the corresponding livers were compared to the levels in all other specimens of the same species. Mercury levels were also compared within the same species for each site. One-way ANOVA and Tukey's multiple range test were used to determine significant differences between data sets. The rate of occurrence of each histopathological change showing statistically significant difference was calculated for each species for both study and reference sites.

## RESULTS AND DISCUSSION

Nesting Biology

A total of 43 Great Blue Heron nests, 52 Great Egret nests, and 75 Tricolored Heron nests were marked at the study site for collection of sample eggs and for monitoring. At the Second Chain of Islands reference site, a total of 50 Great Blue Heron nests and 27 Great Egret nests were marked; no Tricolored Herons nested on Second Chain of Islands during the course of the study. A fire ant (Solenopsis sp.) infestation developed during nesting, causing the failure of all Great Egret nests and numerous Great Blue Heron nests present. Therefore, no nesting data were gathered for Great Egrets and Tricolored Herons from Second Chain of Islands. Totals of 47, 33, and 48 nests of Great Blue Herons, Great Egrets, and Tricolored Herons, respectively, were marked at the upper

Laguna Madre reference site for collection of nesting data and sample eggs.

Nest Success

Cumulative values from the Mayfield nest success calculations for the three main study species are presented in Table 3-1. Further analysis using variance estimates and comparisons of daily survival rates (Hensler and Nichols 1981) were considered unnecessary, because the cumulative values were sufficient to make comparisons between sites.

For Great Blue Herons, total nest success in Lavaca Bay (0.326) was greater than Second Chain of Islands (0.089) but was lower than upper Laguna Madre (0.415). For Great Egrets, total nest success in Lavaca Bay (0.200) was lower than upper Laguna Madre (0.406). For Tricolored Herons, total nest success in Lavaca Bay (0.200) was lower than upper Laguna Madre (0.406), as was the number of young/nest to 15 days. For Great Blue Herons, number of young/nest was 1.13, greater compared to 0.29 for Second Chain of Islands, but very near the 1.09 for upper Laguna Madre. For Great Egrets, number of young/nest to 15 days from Lavaca Bay was 0.66, which was less than the 1.19 for upper Laguna Madre. For Tricolored Herons, the number of young/nest to 15 days was 0.06 for Lavaca Bay, which was less than the 0.45 from upper Laguna Madre.

The cumulative data suggest the presence of factors that may mask or distort the effects of mercury on avian reproductive success in Lavaca Bay. For example, a thunderstorm between the initial trip to mark Tricolored Heron nests and the next visit caused severe losses of Tricolored Heron nests from one large subcolony that was most exposed to the weather. That single event effectively lowered the nest success for Tricolored Herons at the study site. Several factors may account for the ambiguous results found in the nest success study. The presence of observed but unquantified variables such as inclement weather and fire ant depredation caused losses in both study and reference populations, and therefore may have masked the effects of mercury on nesting. A series of storm-related high tides resulted in the loss of all nests of one subcolony of Tricolored Herons at the Lavaca Bay study site, with less severe losses occurring to all species at all sites in association with weather events. Also, while fire ants were not abundant early in the season and therefore had a lesser affect on the early nesting Great Blue Herons, they became a severe problem as the breeding season progressed. The ants were severe at both the Lavaca Bay and Second Chain study sites, and caused the complete failure of nesting by Great Egrets on one island at the Second Chain of Islands reference site. Losses were evidenced by the entry of fire ants into pipped eggs, causing the subsequent death of the

embryos, and by the attack of fire ants on nestlings, which resulted in the deaths of the nestlings.

Although the results show differences in nest success between sites for each species, similar differences occur in studies of other species of colonial waterbirds in which reproductive success was determined contemporaneously. Faber et al. (1972) found declines in reproductive success for Great Egrets but not Great Blue Herons between the years 1967 and 1970, and those variations in reproductive success are within the range found here. Also, differences in reproductive success were not consistent with differences in mercury levels in the same groups. There are at least two factors that explain the wide range of nest success values found with a given level of mercury in birds: 1) the inherent range of nest success values in normal populations (especially true for colonial waterbirds), and 2), the wide range of response to mercury shown by avian species.

The distribution of mercury in the eggs of a clutch may also affect the sample egg technique. The distribution of organochlorine compounds is random within the clutch (Custer et al. 1990), thus the level of an organochlorine residue in a random egg (the sample egg) will reflect that of the other eggs. The result will be that the reproductive success of the remaining eggs of the clutch will accurately reflect the impact of the contaminant. This is the basis of the sample egg technique (Ratcliffe 1967). Mercury, however, is more concentrated in the first egg and declines with subsequent eggs in a clutch, and the first hatched chick should be the most vulnerable (Becker 1992). Therefore, in environments where the level of mercury contamination may be marginal with respect to its reproductive effects, the position of the sample egg in the chronology of the clutch is critical. If the first, most vulnerable egg is selected as the sample egg, relatively elevated levels of mercury may be found without reproductive impacts in the rest of the clutch, leading to the erroneous conclusion that mercury, while elevated, had no effect. If a later egg is selected, lower levels of mercury will be found, while there may be a reproductive loss of the first egg. This would lead to the conclusion that factors other than mercury lead to the loss of the first egg. At best, this situation may obscure the effect of mercury on reproduction, and at worst, it could lead to the false conclusion that there is an inverse correlation between mercury and nest success. These factors acting together may confound attempts to determine if there is reproductive injury to birds.

The Mayfield nest success calculations could have been further analyzed to provide a statistical basis for comparison.

Table 3-1. Mercury levels (ppm dry weight) in sample eggs and nesting success totals for colonial waterbirds in Lavaca Bay, Texas study site and two reference sites, Spring 1991.

| Species | Colony | mean min-max (n) | Nest success | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Nest survival (A) | Egg survival (B) | Nest-ling survival (C) | Total nest success (AxBxC) | Mean clutch size (D) | Young /nest to 15 days (AxBx CxD) |
| Great Blue Heron | LAV[a] | 0.912 A[b] 0.312-3.45 (42) | 0.565 | 0.755 | 0.766 | 0.326 | 3.47 A[c] 149/43[d] | 1.13 |
| | SCI | 0.295 B 0.144-0.941 (45) | 0.341 | 0.468 | 0.557 | 0.089 | 3.26 A 163/50 | 0.29 |
| | ULM | 0.408 C 0.212-2.06 (43) | 0.563 | 0.813 | 0.907 | 0.415 | 2.86 B 140/49 | 1.19 |
| Great Egret | LAV | 0.787 A 0.293-2.69 (46) | 0.445 | 0.642 | 0.701 | 0.200 | 3.32 A 176/53 | 0.66 |
| | ULM | 0.555 A 0.194-1.92 (30) | 0.725 | 0.755 | 0.742 | 0.406 | 2.91 B 99/34 | 1.19 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LAV | 0.614 A<br>0.131-<br>3.46<br>(74) | 0.120 | 0.329 | 0.481 | 0.019 | 3.01 A<br>262/87 | 0.06 |
| Tricolo<br>-red<br>Heron | | | | | | | | |
| | | 0.430 B<br>0.092-<br>2.12<br>(39) | 0.448 | 0.539 | 0.657 | 0.159 | 2.80 B<br>126/45 | 0.45 |

[a] LAV = Lavaca Bay; SCI = Second Chain of Islands; ULM = upper Laguna Madre.
[b] values for a species and parameter that share a common letter were not significantly different (One-way ANOVA and Tukey's multiple range test, P = 0.05) from those in the same group.
[c] distribution of clutch size values for the same species that share a common letter were not significantly different (Chi-square, P = 0.05) from each other.
[d] (eggs/nests)

However, the lack of clear results from the nest success calculations, the factors discussed above, and the lack of sufficiently elevated mercury levels in eggs of the species evaluated indicated that further analysis was not warranted.

Clutch Size

Mean clutch size for the Great Blue Heron, Great Egret, and Tricolored Heron appear in Table 3-2. Mean clutch size for Great Blue Heron nests from Lavaca Bay ($n = 43$) was not significantly different from mean clutch size for the Second Chain of Islands ($n = 50$), (Chi-square = 6.53, d.f. = 4) but was significantly greater than mean clutch size for upper Laguna Madre ($n = 49$), (Chi-square = 34.0, d.f. = 3, $P < 0.0001$). Mean clutch size was significantly greater for Great Egret nests from Lavaca Bay ($n = 53$) compared to upper Laguna Madre ($n = 34$), (Chi-square = 107, d.f. = 3, $P < 0.00001$). Mean clutch size was also significantly greater for Tricolored Heron nests from Lavaca Bay ($n = 87$) compared to upper Laguna Madre ($n = 45$), (Chi-square = 41.3, d.f. = 2, $P < 0.0001$).

Declines in clutch size in birds due to mercury residues have been reported (Finley and Stendell 1978, Heinz 1979). This contrasts with Hill and Shaffner (1976), who found that for Japanese Quail fed mercuric chloride from hatching, the average rate of egg production was significantly greater for hens fed diets containing 8 ppm mercury than controls. However, this increase in egg production was counterbalanced by decreases in egg fertility, and ultimately, healthy hatchlings. The clutch size data reported here follow the findings of Hill and Shaffner (1976), i.e., that clutch size may have been increased by the presence of mercury in the diet of the adults.

Hatch Success Classes

Differences in the percent of nests belonging to each hatch success class showed no strong trends between study and reference sites (Table 3-3); however, for all three species, the percentage of nests in which all eggs hatched was greater at the upper Laguna Madre site. These increases were 15.1%, 14.5%, and 43.5%, for Great Blue Herons, Great Egrets, and Tricolored Herons, respectively. However, although there was an apparent difference in the mean mercury levels in eggs from those same

Table 3-2. Distribution of clutch size for colonial waterbirds in Lavaca Bay, Texas and reference sites, Spring 1991.

| Species | Site | Number of eggs | | | | | n | Mean Clutch Size |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| Great Blue Heron | LAV[a] | 0 | 1 | 21 | 21 | 0 | 43 | 3.47A[b] |
| | SCI | 1 | 4 | 27 | 17 | 1 | 50 | 3.26A |
| | ULM | 2 | 11 | 28 | 8 | 0 | 49 | 2.86B |
| Great Egret | LAV | 7 | 0 | 18 | 26 | 2 | 53 | 3.32A |
| | ULM | 1 | 8 | 18 | 7 | 0 | 34 | 2.91B |
| Tricolo -red Heron | LAV | 3 | 11 | 56 | 16 | 1 | 87 | 3.01A |
| | ULM | 1 | 7 | 37 | 0 | 0 | 45 | 2.80B |

[a] LAV = Lavaca Bay study site; SCI = Second Chain of Islands reference site; ULM = upper Laguna Madre reference site.

[b] distribution of clutch size values for the same species that share a common letter were not significantly different (Chi-square, P = 0.05).

Table 3-3 (Cont.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Upper Laguna Madre | All | 28 (65.1) | 0.337 (0.212-2.06) | 20 (64.5) | 0.432 (0.194-1.92) | 24 (63.2) | 0.329 (0.092-1.00) |
| | Some | 6 (14.0) | 0.394 (0.299-0.727) | 4 (12.9) | 0.384 (0.289-1.23) | 5 (13.2) | 0.426 (0.304-2.12) |
| | None | 9 (20.9) | 0.302 (0.231-0.900) | 7 (22.6) | 0.455 (0.369-1.89) | 9 (23.7) | 0.398 (0.209-1.39) |

[a] number of nests (and eggs) in each hatch success class.
[b] values for a species and location were not significantly different (One-way ANOVA, P = 0.05).

groups, the difference was not statistically significant. Although reduced hatchability from mercury exposure has been found in mallards (Heinz 1979), Japanese quail (Hill and Shaffner (1976), black ducks (Finley and Stendell 1978), and pheasants (Borg et al. 1969, Fimreite 1971), King et al. (1991) found no correlation between hatch success and mercury for Forster's Terns and Black Skimmers in Lavaca Bay.

Brown Pelican Nesting Success

Forty-seven Brown Pelican eggs were collected from the Sundown Island study site and 21 eggs were collected from the Pelican Island reference site from subcolonies in which the nests were in the last stages of incubation. Calculations of apparent nest success for the Brown Pelican appear in Table 3-4. At the Sundown Island site on the first visit there were 104 active nests with a mean clutch size of 2.68 eggs per nest (279/104). On the second visit to the Sundown Island site on 7 June, there were 49 nests which were still intact and presumed to be active, judging from the freshness of materials at the nest and the absence of mortalities (e.g., broken eggs, dead young, addled eggs), for an apparent nest success of 47.1%. On the first visit to the Pelican Island site there were 152 nests containing 406 eggs, a mean clutch size of 2.67 eggs per nest. On the second visit to the Pelican Island reference site (24 May), 98 active nests remained, an apparent nest success of 64.4%. Clutch size means for the two sites were nearly identical, 2.68 and 2.67 eggs/nest for Sundown Island and Pelican Island, respectively. These means were near the middle of the range reported by King et al. (1985) for coastal Texas populations from 1975 to 1981.

The nesting success values calculated for the Brown Pelican colonies from Sundown Island and Pelican Island were inconclusive, possibly due to several factors. First, the specific source nests of the ambulatory birds counted on the second visit to each site could not be determined, i.e., the counts could have included recruits from other subcolonies, which would have artificially increased the apparent nesting success. Second, since nesting success is a function of time (Mayfield 1961, 1975), daily losses during the course of the nesting season could have caused the number of surviving nests to decrease during the season. Assuming a constant rate of loss, the longer the period between visits the greater the reductions in surviving nests. Because of logistical problems, the interval between the first and second visits was not equal for both the study site and the reference site. This may have resulted in a misleading difference in the apparent nesting success. As a result of these two

Table 3-4. Mercury levels in eggs (ppm dry weight) and nesting success totals for Brown Pelicans (Pelecanus occidentalis) from Sundown Island, Matagorda Bay, Texas study site, and Pelican Island, Corpus Christi Bay, Texas reference site, Spring 1991.

| Parameter | Sundown Island | Pelican Island |
|---|---|---|
| Geometric mean<br>(minimum-maximum)<br>n | 1.130<br>(0.432-2.39)<br>47 | 1.329<br>(0.603-2.67)<br>21 |
| Apparent nest success (active nests remaining second visit/nests marked first visit) x 100 | 47.1 %<br>(49/104) | 64.4 %<br>(98/152) |
| Mean clutch size (eggs/nests) | 2.68<br>(279/104) | 2.67<br>(406/152) |

factors, no clear conclusions can be reached regarding differences in nesting success between the study and reference sites.

Mercury Analysis Of Eggs

The mean dry weight value of mercury (Table 3-1) for Great Blue Herons eggs from Lavaca Bay (0.912 ppm) was significantly greater than the means from Second Chain of Islands (0.295 ppm, P =0.001), and upper Laguna Madre (0.408 ppm, P = 0.01). The mean dry weight value for Great Egret eggs from Lavaca Bay (0.787 ppm) was not significantly greater than the mean from upper Laguna Madre (0.555 ppm). The mean dry weight value for Tricolored Heron eggs from Lavaca Bay (0.614 ppm) was significantly greater than the mean from upper Laguna Madre (0.430 ppm). Results of the mercury analysis of Brown Pelican eggs are in Table 3-4. Forty-seven and 21 eggs were analyzed from the study and reference sites, respectively. Eggs from the Sundown Island study site contained 1.130 ppm (dry weight), and eggs from the Pelican Island reference site contained 1.329 ppm. Although mean mercury levels in the eggs from the reference site were higher than the mean for the study site, the differences were not statistically significant.

The significant differences in the mercury values in the eggs of Great Blue Heron and Tricolored Heron and the trend for the Great Egret data (Table 3-1) suggest that avian species were being exposed to the mercury contamination in Lavaca Bay, approximately 20 years after the direct discharges reportedly ceased. Mean values for mercury in the samples of eggs analyzed for Great Blue Herons, Great Egrets, and Tricolored Herons, while showing elevated levels in Lavaca Bay over reference sites, were below mean levels known to cause reductions in reproductive success in species in some studies (Finley and Stendell 1978, Scheuhammer 1989) and although means did not reach concern levels, some maximum values were within the range found to cause reductions in species in other studies (Fimreite 1971, Spann et al. 1972, Heinz 1976).
Mean levels for Brown Pelicans, while also elevated, were not significantly different between sites, and were below means known to cause reductions in reproductive success in the same studies. Means were similar to levels reported by King et al. (1985) (0.04-0.60 ppm wet weight) from 1975 to 1978 in South Texas Brown Pelicans. Even though the field collection of Brown Pelican eggs was not random (as discussed above), and may not accurately depict exposure levels, mercury concentrations detected in the eggs are still cause for concern.

Many studies indicate a wide range of response to mercury exposure both between avian species and within species. Ducks, pheasants, and chickens each exhibited different tolerances for mercury (methyl mercury dicyandiamide, Gardiner 1972), with a mortality of 90, 85 and 7.5% in pheasants, ducks, and chickens, respectively, from a diet containing 33 ppm mercury. In the same study, rate of depuration after removal of mercury from the diet was also different, from highest to lowest in the chicken, pheasant and duck, respectively, which suggests an interspecific variation in the efficiency of response mechanisms. Within a species, using eggs of Ring-necked Pheasant (Phasianus colchicus), levels in the range of 0.5-1.5 ppm (Fimreite 1971) were associated with reproductive failure, compared to 0.9-3.1 ppm for Spann et al. (1972). It would be expected then, first, that the species investigated here might exhibit different responses to mercury, and second, that there would be a broad range of response within each species. Fimreite (1979) has summarized lethal effects in avian species (in which the bird dies immediately or shortly after exposure) and sublethal symptoms (which may affect long-term survival and/or reproduction). These effects vary between species, but occur mainly in the central nervous system. Lethal levels in birds vary with the form of mercury, route of administration, dosage, species, sex, age, and physiological condition. Sublethal effects in adult birds vary with the same factors but mainly occur in reproduction, causing decreases in egglaying, clutch size, and hatch success. There is a wide range of mercury levels at which these effects are seen, between species and within species, with no clear correlation between mercury levels and appearance of symptoms, and there are subtle alterations in the normal behavior of birds (adult and fledgling) at levels of mercury below which clear symptoms occur.

The effects of mercury on reproductive success are of special concern because they occur at much lower tissue concentrations relative to those known to produce lethal effects in adult birds. Several laboratory studies have found that mercury may cause reproductive dysfunction through reductions in the rate of egg laying, clutch size, egg hatchability, and nestling survival (Brown and Yoshida 1965, Fimreite 1971, Spann et al. 1972, Heinz 1976, 1979, Heinz and Locke 1975, Hill and Shaffner 1976, Hill and Soares 1977, Finley and Stendell 1978, Scheuhammer 1989). Elevated levels of mercury, sufficient to cause reproductive dysfunction, have been found in several avian species in field studies in many locations (Borg et al. 1969, Fimreite et al. 1971, Faber et al. 1972, Vermeer and Armstrong 1972, Vermeer 1973, Vermeer et al. 1973, Hoffman 1974, Norheim and Froslie 1978, Van der Molen et al. 1982, King et al. 1983, Santoro and Koepp 1986, Braune 1987,

Ohlendorf et al. 1988, Becker and Sperveslage 1989, Newton et al. 1989, and Custer and Myers 1990). With two exceptions (Fimreite 1974, and Barr 1986), field studies of reproductive biology have not confirmed reproductive dysfunction found in the laboratory. These field studies nevertheless have shown mercury levels in many species to be of concern (Vermeer et al. 1973, Hoffman 1974, Connors et al. 1975, Helander et al. 1982, Blus et al. 1985, King et al. 1991, and Thompson et al. 1991).

Regression Analysis of Nesting Success Factors and Mercury Levels

Results of the regression analysis showed no significant correlation between nest success factors and mercury levels in sample eggs. There was no correlation between mercury levels and nest success probability, egg success probability, egg-nestling success probability or for total nest success for Great Blue Herons or Great Egrets, and only a very weak negative correlation coefficient (-0.312) for total nest success in Tricolored Herons from the upper Laguna Madre reference site. Combining data points for each species and nest success factor also produced no correlation for the same comparisons. Pooled values for both sites for Tricolored Herons yielded a correlation coefficient of -0.212 for total nest success.

Organochlorine Analysis of Eggs

The results of the organochlorine analysis of selected Great Blue Heron and Great Egret sample eggs appear in Table 3-5. The full report of the laboratory analysis appears in Appendix B-4. Only two compounds, total PCBs and P,P` DDE, appeared in at least 50% of the samples at levels sufficient to perform calculations of geometric means. Maximum values for PCBs were 0.84 ppm (wet weight) for Great Blue Herons from Lavaca Bay and 2.07 ppm from upper Laguna Madre. Maximum PCB values for Great Egrets were 0.79 and 3.58 ppm (wet weight) from Lavaca Bay and upper Laguna Madre, respectively. Maximum values for P,P` DDE were 0.48 ppm (wet weight) for Great Blue Herons from Lavaca Bay and 1.56 ppm from upper Laguna Madre. Maximum P,P` DDE values for Great Egrets were 2.16 and 4.38 ppm (wet weight) from Lavaca Bay and upper Laguna Madre, respectively. All other compounds were below the detection limit of 0.05 ppm for 50% of the samples. All results were below concern levels for all compounds analyzed. Values for total PCBs were below most levels reviewed by Ohlendorf and Fleming (1988) for other species of colonial waterbirds. Values for P,P' DDE in Great Blue Heron eggs were also below reported values, and values for Great Egret eggs were within the range of other species

Table 3-5. Organochlorine levels (ppm wet weight) in selected sample eggs of colonial waterbirds from Lavaca Bay and a reference site, Spring 1991. n = 5.

| | Great Blue Heron | | Great Egret | |
|---|---|---|---|---|
| Compound | LAV[a] | ULM | LAV | ULM |
| Total PCBs | 0.369[b] (0.23-0.84) | 0.536 (0.47-2.07) | 0.358 (0.28-0.79) | 0.541 (0.22-3.58) |
| PCB-1254 (%) | 96.1 | 91.0 | 93.5 | 95.1 |
| PCB-1260 (%) | 3.9 | 9.0 | 6.5 | 4.9 |
| P,P' DDE | 0.183 (0.07-0.48) | 0.277 (0.12-1.56) | 0.351 (0.24-2.16) | 0.312 (0.05-4.38) |

[a] LAV = Lavaca Bay; ULM = upper Laguna Madre reference site
[b] geometric mean (minimum - maximum)

(Ohlendorf and Fleming 1988).

Mercury Analysis of Nestling Livers

Results of the analysis of 77 livers from the nestlings of Great Blue Herons, Great Egrets, and Tricolored Herons are shown in Table 3-6. All wet weight values of mercury were above the detection limit. The mean mercury concentrations for Great Blue Heron nestling livers from Lavaca Bay (2.715 ppm, n = 9) were significantly greater than those from Second Chain of Islands (1.332 ppm, n = 10), and upper Laguna Madre (0.546 ppm, n = 11), (One-way ANOVA and Tukey's multiple range test, $P < 0.0001$). The mean mercury concentrations for Great Egret nestling livers from Lavaca Bay (1.389 ppm, n = 10) were not significantly greater than those collected from Second Chain of Islands (0.967 ppm, n = 8) but were significantly greater than those from upper Laguna Madre (0.621 ppm, n = 8), (One-way ANOVA and Tukey's multiple range test, $P < 0.01$). The mean mercury concentrations for nestling Tricolored Heron livers from Lavaca Bay (1.083 ppm, n = 9) were not significantly greater than those collected from upper Laguna Madre (0.593 ppm, n = 12) at the 95% confidence level, however, $P = 0.1021$ (One-way ANOVA). There was no significant difference between mean mercury levels of dead nestlings and those collected alive in any of the species investigated, nor was there a significant difference in mean mercury levels in dead nestlings from the study site and reference sites.

The results of the mercury analysis of nestling livers support the results on the exposure to mercury in eggs. There are significant differences between study and reference sites for mercury in eggs, and some of the same significant differences are also demonstrated by the mercury analysis of nestling livers. This supports the conclusion that avian species in Lavaca Bay were exposed to mercury contamination. There are, however, differences in significance for livers compared to that among egg means. Some of these differences may be attributable in part to the small sample size for the mercury analysis in livers.

Histopathological Analysis of Nestling Brains and Mercury in Livers

The laboratory report on the histopathological examination of nestling brains is presented in Appendix B-5. The nestling brains of Great Blue Herons, Great Egrets, and Tricolored Herons were examined for the existence of a total of 11 conditions associated with mercury toxicosis. Three conditions were noted in the attached report as being the most

Table 3-6. Mercury concentrations (ppm wet weight) in livers of nestling colonial waterbirds from Lavaca Bay, Texas and reference sites, Spring 1991.

| Species | Location | Mercury Concentrations |
|---|---|---|
| Great Blue Heron | Lavaca Bay | |
| | Geometric Mean | 2.715 A[a] |
| | Minimum-Maximum | (1.340-4.110) |
| | n | 9 |
| | Second Chain of Islands | |
| | Geometric Mean | 1.332 B |
| | Minimum-Maximum | (0.804-2.420) |
| | n | 10 |
| | Upper Laguna Madre | |
| | Geometric Mean | 0.546 C |
| | Minimum-Maximum | (0.269-1.600) |
| | n | 11 |
| Great Egret | Lavaca Bay | |
| | Geometric Mean | 1.389 A |
| | Minimum-Maximum | (0.769-2.340) |
| | n | 10 |
| | Second Chain of Islands | |
| | Geometric Mean | 0.967 AB |
| | Minimum-Maximum | (0.282-2.150) |
| | n | 8 |

| | | | |
|---|---|---|---|
| | Upper Laguna Madre | | |
| | | Geometric Mean | 0.621 B |
| | | Minimum-Maximum | (0.246-1.010) |
| | | n | 8 |
| Tricolored Heron | Lavaca Bay | | |
| | | Geometric Mean | 1.083 A |
| | | Minimum-Maximum | (0.626-2.550) |
| | | n | 9 |
| | Upper Laguna Madre | | |
| | | Geometric Mean | 0.593 A |
| | | Minimum-Maximum | (0.130-2.150) |
| | | n | 12 |

[a] means for a species that share a common letter were not significantly different from other means for the same species (One-way ANOVA and Tukey's multiple range test, P = 0.05).

significant changes observed. A summary of the distribution of those conditions, and mercury levels (ppm wet weight) in associated livers, is in Table 3-7. These conditions were: 1) spaces around and potential shrinkage of neurons in the stratum griseum proventriculare ("N" in attached histopathology report), 2) granule cell necrosis of the granular cell layer of the cerebellum ("G" in attached histopathology report), and 3) clear crescent shapes in the cytoplasm
of scattered neurons ("A" in attached histopathology report). For the Great Blue Heron, there was no significant difference between specimens in the distribution of two conditions (spaces around and shrinkage of neurons in the stratum griseum proventriculare, and granule cell necrosis) with regard to mercury levels in livers. The third condition (clear crescent shapes in the cytoplasm of scattered neurons) was absent. All three conditions appeared in the Great Egret nestlings but there was no significant difference in mercury levels. In the Tricolored Heron, there was no significant difference in specimens in the distribution of two conditions (spaces around and shrinkage of neurons in the stratum griseum proventriculare, and clear crescent shapes in the cytoplasm of scattered neurons). However, the occurrence of granule cell necrosis in the brains of Tricolored Herons was greater among those nestlings which had higher mercury concentrations in liver tissue.

There was a significant difference in mercury levels (Table 3-8) from all (study and reference site combined) livers associated with brains affected by granule cell necrosis ($n = 5$) and unaffected ($n = 13$) brains (One-way ANOVA, $P < 0.05$). Also, in Tricolored Heron nestlings from Lavaca Bay, there was a significant difference between affected ($n = 3$) and unaffected ($n = 5$) nestlings (One-way ANOVA, $P < 0.05$); however, there was no significant difference between affected ($n = 2$) and unaffected ($n = 8$) nestlings from the upper Laguna Madre reference site. Considering all useful Tricolored Heron specimens collected (autolyzed specimens excluded), granule cell necrosis was found in 37.5% (3/8) of the Tricolored Heron nestlings from Lavaca Bay, and 20.0% (2/10) of Tricolored Heron nestlings from the reference site, a difference in rate of occurrence of 17.5%.

Mercury may also affect reproductive success by reducing survival of nestlings and fledglings. Embryonic and newborn birds may be more susceptible to damage because the blood-brain barrier is not fully functional in early life stages (Brown and Yoshida 1965), thus damage can occur to young at levels which are not toxic to adults. Brain lesions have been found and associated with neurological impairment and death in

Table 3-7. Listing of total mercury levels (ppm. dry weight) in livers and selected brain abnormalities in nestling colonial waterbirds, Spring 1991.

| Great Blue Heron | | | | |
|---|---|---|---|---|
| Site[a] | Condition when collected | Mercury in liver (ppm dry wt.) | Selected brain abnormality[b] "N" | Selected brain abnormality[b] "G" |
| LAV | LIVE | 4.11 | -[c] | - |
| LAV | LIVE | 3.88 | - | - |
| LAV | DEAD | 3.74 | + | - |
| LAV | LIVE | 2.98 | - | - |
| LAV | LIVE | 2.79 | - | - |
| LAV | LIVE | 2.67 | - | - |
| SCI | LIVE | 2.42 | - | - |
| LAV | LIVE | 2.18 | - | - |
| LAV | DEAD | 2.07 | - | - |
| SCI | DEAD | 1.67 | NA | NA |
| ULM | DEAD | 1.60 | NA | NA |
| SCI | DEAD | 1.57 | - | - |
| SCI | DEAD | 1.50 | NA | NA |
| LAV | LIVE | 1.34 | - | - |
| SCI | LIVE | 1.28 | - | - |
| SCI | LIVE | 1.25 | - | - |
| SCI | LIVE | 1.23 | - | + |
| SCI | DEAD | 1.10 | + | - |
| SCI | DEAD | 1.06 | - | - |
| ULM | DEAD | 0.822 | - | - |
| SCI | DEAD | 0.804 | + | - |
| ULM | DEAD | 0.656 | + | - |
| ULM | DEAD | 0.626 | - | - |
| ULM | DEAD | 0.524 | + | - |
| ULM | DEAD | 0.502 | - | - |
| ULM | DEAD | 0.471 | - | - |
| ULM | DEAD | 0.469 | - | + |
| ULM | DEAD | 0.426 | + | - |
| ULM | DEAD | 0.359 | - | - |
| ULM | DEAD | 0.269 | NA | NA |

Table 3-7. (Cont.)

| Great Egret | | | | | |
|---|---|---|---|---|---|
| Site | Condition when collected | Mercury in liver (ppm dry wt.) | Selected brain abnormality | | |
| | | | "N" | "G" | "A" |
| LAV | LIVE | 2.34 | - | - | - |
| LAV | LIVE | 2.30 | - | + | - |
| LAV | LIVE | 2.30 | - | - | - |
| SCI | LIVE | 2.15 | + | - | - |
| SCI | LIVE | 1.95 | + | - | - |
| LAV | LIVE | 1.81 | - | + | - |
| SCI | LIVE | 1.67 | + | + | - |
| SCI | DEAD | 1.34 | NA | NA | NA |
| LAV | LIVE | 1.31 | - | - | - |
| LAV | LIVE | 1.27 | + | - | - |
| LAV | LIVE | 1.18 | + | - | - |
| ULM | DEAD | 1.01 | - | - | - |
| SCI | DEAD | 0.981 | + | - | - |
| LAV | DEAD | 0.969 | NA | NA | NA |
| ULM | DEAD | 0.839 | - | + | - |
| LAV | LIVE | 0.813 | - | + | - |
| LAV | LIVE | 0.769 | - | + | - |
| ULM | DEAD | 0.769 | + | + | - |
| SCI | DEAD | 0.766 | + | - | - |
| ULM | DEAD | 0.661 | - | - | - |
| ULM | DEAD | 0.648 | - | + | - |
| ULM | DEAD | 0.623 | - | + | + |
| ULM | DEAD | 0.517 | + | + | - |
| SCI | LIVE | 0.386 | - | - | + |
| SCI | LIVE | 0.282 | + | - | + |
| ULM | DEAD | 0.246 | NA | NA | NA |

(Cont.)

Table 3-7. (Cont.)

Tricolored Heron

| Site | Condition when collected | Mercury in liver (ppm dry wt.) | Selected brain abnormality | | |
|---|---|---|---|---|---|
| | | | "N" | "G" | "A" |
| LAV | LIVE | 2.55 | - | + | - |
| ULM | DEAD | 2.15 | NA | NA | NA |
| LAV | LIVE | 1.40 | - | + | + |
| ULM | LIVE | 1.37 | - | + | + |
| ULM | LIVE | 1.30 | - | - | + |
| LAV | DEAD | 1.21 | NA | NA | NA |
| LAV | LIVE | 1.20 | - | + | - |
| ULM | LIVE | 1.07 | + | - | - |
| LAV | LIVE | 1.03 | + | - | - |
| LAV | LIVE | 1.01 | + | - | - |
| ULM | DEAD | 0.879 | NA | NA | NA |
| LAV | LIVE | 0.83 | - | - | - |
| ULM | LIVE | 0.759 | + | - | + |
| LAV | LIVE | 0.732 | - | - | - |
| LAV | LIVE | 0.626 | + | - | + |
| ULM | LIVE | 0.616 | - | - | + |
| ULM | LIVE | 0.503 | - | + | - |
| ULM | LIVE | 0.326 | + | - | + |
| ULM | LIVE | 0.265 | + | - | + |
| ULM | LIVE | 0.199 | - | - | + |
| ULM | LIVE | 0.130 | + | - | + |

[a]LAV = Lavaca Bay study site; SCI = Second Chain of Islands reference site; ULM = upper Laguna Madre site.

[b]"N" = spaces around, and potential shrinkage of neurons in the stratum griseum proventriculare. "G" = necrosis of the granule cells in the granular cell layer of the cerebellum. "A" = clear crescent shapes in the cytoplasm of scattered neurons.

[c] + = abnormality present in brain specimen. - = abnormality absent. NA = brain too autolyzed for examination.

Table 3-8. Mercury concentrations (ppm wet weight) in livers and associated granule cell necrosis in brains of Tricolored Heron (Egretta tricolor) nestlings from Lavaca Bay, Texas, and a reference site, Spring 1991.

| | Granule Cell Necrosis | |
|---|---|---|
| Location | Present | Not Found |
| Lavaca Bay | | |
| Geometric mean | 0.386 A[a] | 0.187 B |
| Minimum-Maximum | 0.304-0.593 | 0.143-0.240 |
| n | 3 | 5 |
| Upper Laguna Madre | | |
| Geometric mean | 0.191 A | 0.097 AB |
| Minimum-Maximum | 0.136-0.269 | 0.029-0.340 |
| n | 2 | 8 |
| Both sites | | |
| Geometric mean | 0.291 A | 0.125 B |
| Minimum-Maximum | 0.136-0.593 | 0.029-0.340 |
| n | 5 | 13 |

[a] means that share a common letter were not significantly different from other means in the same row or column (One-way ANOVA and Tukey's multiple range test, P = 0.05).

mallard ducklings from parents fed methyl mercury (Heinz and Locke 1975, Heinz 1979), in Black Ducks (Finley and Stendell 1978), and in chicks of domestic chickens (fed methyl mercury in diet, Brown and Yoshida 1965). Neurological signs in the affected Mallard chicks prior to death include loss of balance and tremors, as well as changes in behavioral responses to maternal calls and fright stimuli. The data indicate that brain lesions and death were probably the result of mercury passed to the egg from the hen (Heinz and Locke 1975). Mercury is passed into the egg at the time of its production, based primarily on the amount of mercury in the recent diet of the adult (Scheuhammer 1987, Walsh 1990). Mercury is also ingested by the nestling (Finley and Stendell 1973, Vermeer et al. 1973, Heinz 1979, King et al. 1991).

The appearance of granule cell necrosis in the granular cell layer of the cerebellum has been found to be characteristically present with mercury (Chang 1977, 1980, Reuhl and Chang 1979, Koestner and Norton 1991), however, little effort has been made to correlate mercury levels and lesions. It has been identified as one of the earliest changes observed in birds at low dosages of mercury, and its' occurrence is identifiable by electron microscopy (Chang 1977, Brown and Yoshida 1965). Three facts regarding granule cell necrosis were apparent in this investigation: 1) it was the only histopathological condition for which there was a statistically significant difference in mercury levels between affected and unaffected specimens, 2) the mercury levels in the corresponding livers were at or below levels reported to cause injury in other species, and 3) the condition was identified by light microscopy. The first two facts suggest that the mercury is responsible for the changes seen (in Tricolored Heron) and that the effects occur at lower mercury levels than previously seen, and the third suggests that EM would have confirmed the findings reached by light microscopy in the affected specimens and perhaps have revealed the condition in more of the specimens and species.

The histopathological analysis was complicated by several factors, including the mixed age of the nestlings, technique of field preparation, and condition of some nestlings at the time of collection. The ages of the nestlings collected ranged from newly-hatched to approximately 15 days. The technique of field preparation of the brains, including perforation of the brains to enhance formalin penetration, and artifacts of laboratory preparation may have lessened the brains' usefulness for examination. To reduce the impact to the species being investigated, and to determine if mercury was a causative factor in their death, fresh dead birds were preferentially collected; the results, however, indicated that

there were generally more low levels in the dead nestlings than in the nestlings collected alive (Table 3-7). Such an effect could be due to distortion of liver mercury concentrations by autolysis (normal decomposition) in dead birds (Thompson et al. 1991), or an increase in liver mass (and consequent decrease in mercury concentration) after death due to the presence of clotted blood (Franson 1984).

At low methyl mercury levels in the diet, there may be a delay, or latent period, between administration of mercury and development of symptoms (Brown and Yoshida 1965, Heinz 1979). Several laboratory studies have shown that there is a period between initiation of mercury administration and onset of symptoms in nestlings, including ataxia and death after 11 days for domestic chickens (Brown and Yoshida 1965), and neurological lesions after 10 days for Mallards (Pass et al. 1975). At the levels of mercury in the food apparently fed to the nestlings in this investigation, it may be that a longer latent period should be expected. No information is currently available on the effective dose rate present in the specific prey items of colonial waterbirds in Lavaca Bay, and although levels are elevated above background (Texas Department of Health 1992), they are below levels which are likely to cause immediate effects. Therefore it may have been expected to observe a latent period in the species being investigated. Some specimens showed brain abnormalities while other specimens with equal or higher mercury levels showed no abnormal conditions. Even the occurrence of granule cell necrosis, which is characteristic of mercury toxicity, while statistically significant in its occurrence in Tricolored Herons, occurred in a pattern that suggests a wide effective range.

Specimens of nestlings of the three species used were collected without regard to age. Because of this, it is possible that granule cell necrosis was found in the Tricolored Heron nestlings largely as a product of the inadvertent clumping of samples of a particular age and that age happened to be one at which granule cell necrosis was most detectable, and not necessarily because Tricolored Herons are more sensitive to the neurological effects of mercury than Great Blue Herons or Great Egrets.

Mercury Analysis of Survey Species

Results of the mercury analysis of eggs of the survey species are presented in Table 3-9. Sample size for all species and sites was 5, except for Roseate Spoonbills from Shamrock Island, which was 4. Mean mercury levels between sites for

Table 3-9. Mercury levels (ppm dry weight, geometric means) in eggs of colonial waterbirds collected in Lavaca Bay, Texas and a reference site, Spring 1991. n = 5 for all samples except for Roseate Spoonbills from Shamrock Island, for which n = 4.

| Species | Location[a] | Mean | Minimum | Maximum |
|---|---|---|---|---|
| Little Blue Heron | LAV | 0.666 | 0.213 | 2.840 |
| | Shamrock Is. | 0.477 | 0.305 | 1.480 |
| Snowy Egret | LAV | 0.570 | 0.460 | 0.698 |
| | ULM | 0.411 | 0.181 | 0.737 |
| Black-crowned night-Heron | LAV | 0.642* | 0.478 | 0.876 |
| | ULM | 0.245 | 0.103 | 0.729 |
| Roseate Spoonbill | LAV | 1.182 | 0.645 | 2.530 |
| | Shamrock Is. | 1.305 | 0.763 | 1.880 |
| Royal Tern | LAV | 3.042 | 1.840 | 3.610 |
| | ULM | 3.280 | 1.550 | 4.800 |
| Least Tern | LAV | 1.478** | 0.995 | 2.400 |
| | ULM | 0.609 | 0.442 | 0.794 |
| Forster's Tern | LAV | 3.490* | 2.420 | 5.070 |
| | ULM | 1.972 | 1.200 | 2.580 |
| Black Skimmer | LAV | 2.276* | 0.641 | 4.680 |
| | ULM | 0.759 | 0.526 | 1.870 |
| Laughing Gull | LAV | 0.920* | 0.614 | 1.730 |
| | ULM | 0.297 | 0.075 | 0.542 |

[a] LAV = Lavaca Bay study site; SCI = Second Chain of Islands reference site; ULM = upper Laguna Madre reference site.

* Means for a species were significantly different (One-way ANOVA, $P < 0.05$).

** Means for a species were significantly different (One-way ANOVA, $P < 0.01$).

Little Blue Herons were not significantly different ($P = 0.4996$, d.f. = 9), or for Snowy Egrets ($P = 0.3100$, d.f. = 9). Mean mercury levels in eggs were significantly higher at Lavaca Bay for Black-crowned Night-herons ($P = 0.0272$, d.f. = 9). Mean mercury levels between sites for Roseate Spoonbills or Royal Terns were not significantly different ($P = 0.8102$, d.f. = 8, and $P = 0.7118$, d.f. = 9, respectively). There were significant differences in mean mercury values between sites for Least Terns ($P = 0.0035$, d.f. = 9), Forster's Tern ($P = 0.0152$, d.f. = 9), Black Skimmers ($P = 0.0266$, d.f. = 9) and for Laughing Gulls ($P = 0.0114$, d.f. = 9). All survey species had greater levels of mercury in samples from Lavaca Bay than the reference sites, except for Roseate Spoonbills and Royal Terns; five of the nine survey species (55.6%) had statistically significant higher mean mercury levels for samples taken from Lavaca Bay compared to reference sites. These findings concur with those of King et al. (1991) using eggs of Forster's Terns and Black Skimmers from the Lavaca Bay site; both of which exhibited a significant difference in mercury values between study sites and references. Field studies in other locations demonstrate the increase in mercury levels in areas of contamination as compared to references (Borg et al. 1969, Vermeer and Armstrong 1972, Vermeer 1973, Connors et al. 1975, Helander et al. 1982, Van der Molen et al. 1982, Blus et al. 1985, Becker and Sperveslage 1989, Thompson et al. 1991). Maximum values for Forster's Terns and Black Skimmers from the study site were above the effect threshold level of 0.9 ppm (wet wt.) proposed by Eisler (1987). The collection of eggs for these survey species was not random, but opportunistic; therefore, first eggs had an equal probability of being collected compared to the other eggs in each clutch. Since the first egg may contain higher levels of mercury residues (Becker 1992), it is possible that the collection of first eggs from all clutches of a sample population would produce higher values for all of the parameters presented here. Further investigations should be conducted to provide data on first eggs from species of concern.

## CONCLUSIONS

1. Five of nine survey species of colonial waterbirds eggs from Lavaca Bay had significantly higher levels of mercury as compared to reference sites.

2. Maximum levels of mercury measured in the eggs of all species examined are within the range associated with reproductive impairments shown in other species.

3. Measures of nesting success for Great Blue Herons,

Great Egrets, and Tricolored Herons in Lavaca Bay were not significantly different from reference sites, likely due to the effects of repeated inclement weather events and fire ant depredation on measurements of nesting success.

4. The appearance of granule cell necrosis, along with significantly elevated levels of mercury among specimens of Tricolored Herons, indicates the need for further investigation of potential injury.

## RECOMMENDATIONS

1. Exposure of avian species to mercury in Lavaca Bay, as demonstrated in the eggs and nestling livers of representative species of birds, indicates the need for continued concern and monitoring of Lavaca Bay.

2. The significance of the existence of granule cell necrosis in the Tricolored Heron specimens warrants evaluation with a larger, more statistically valid sample size, and the elimination of the influence of mixed ages of nestlings.

3. A re-examination of the samples of nestlings of Great Blue Herons and Great Egrets should be conducted. The age structure of the Great Blue Heron and Great Egret nestlings should be examined to determine if granule cell necrosis is found at specific ages.

## 4. Accumulation of Mercury in Migratory, Fish-eating Birds That Winter in Lavaca Bay

### OBJECTIVES

To determine the amount of mercury bioaccumulated in tissues of two species of waterbirds that winter in Lavaca Bay, Double-crested Cormorants (Phalacrocorax auritus) and Lesser Scaup (Aythya affinis) were collected from Lavaca and Cox Bays shortly after their arrival in the late fall of 1991. Both species were again collected in late winter before return migrations had started. The Double-crested Cormorant and the Lesser Scaup were selected because they are migratory birds, neither of which is listed as threatened or endangered. Both species are abundant on the Texas coast during winter months and field collections were not expected to have a significant effect on their populations. Specific objectives of the collections were: 1) to compare levels of total mercury in tissues of early and late collections of each species; and 2) to compare levels of methylmercury in edible tissues of early and late collections of Lesser Scaup.

### MATERIALS AND METHODS

The Double-crested Cormorant was selected because it feeds on relatively large midwater and benthic species of fish (Clapp et al. 1982a), and it represents an ecological guild of birds (i.e. diving fish-eaters) that would potentially accumulate mercury from Lavaca Bay. Double-crested Cormorants begin migrating south in September and usually winter in Texas from early October to late March and early April (Campo et al. 1988, Dolbeer 1991). Because it is one of the first winter migrants to arrive, and one of the last to leave, the extended exposure period increases their potential for bioaccumulation of mercury.

The Lesser Scaup was selected as a target species because it feeds primarily on snails, and small clams and crabs (Bellrose 1976, Clapp et al. 1982b) that potentially bioconcentrate and bioaccumulate mercury from water, plankton, sediment, and detritus. The Lesser Scaup was also selected because it is a game bird and potentially may expose humans to mercury through their consumption of contaminated muscle and liver tissue.

#### Field Collection of Wintering Birds

To determine if cormorants or scaup were accumulating mercury while wintering in Lavaca Bay, efforts were taken to maximize the amount of time between fall and winter collections. These

efforts included assistance from bird watchers in the Lavaca Bay area to verify the arrival of the birds at the bay, and to help determine when the population densities began to stabilize at the completion of the fall migration. The timing of the late winter collections was based on information available in the literature and observations by local bird watchers, to insure that late winter collections were made prior to the onset of northern migration by each species.

Southward migrations of Lesser Scaup typically begin as early as late October, and peak between mid-November and mid-December (Bellrose 1976). Lesser Scaup began arriving in Lavaca Bay around 18 November 1991, and their numbers appeared to peak around 2 December 1991. Early winter collections of scaup were made from oil and gas platforms in northwest Cox Bay on 5 December 1991. Duck decoys positioned around the platforms were used to attract the birds, which were then collected with a shotgun. Since northward return migrations of lesser scaup normally occur between late February and early April (Bellrose 1976), the late winter collections of scaup were conducted on February 12-14, 20-21, and 27-28, 1992.

The arrival of Double-crested Cormorants in Lavaca Bay was first noted on October 10, 1991, and the population numbers appeared to peak around 15 November 1991. Early winter collections of cormorants were made with a shotgun from a boat on November 13-14, 1991. Collection locations included the power lines northwest of the Highway 35 causeway, middle Lavaca Bay south to the intersection of the Lavaca and Matagorda Ship Channels, and in Cox Bay east to Cox Point (Figure 4-1).

Although return migrations for the Double-crested Cormorant usually occur from early April to May (Dolbeer 1991), cormorant densities appeared to be somewhat reduced in Lavaca and Cox bays by February, so late winter collections of cormorants were initiated on February 13-14, 1992. Cormorants remained abundant in Lavaca Bay for several more weeks, however, and a second collection was made on March 18, 1992. Both collections were made from stationary positions on the shoreline, or from platforms and channel markers in the ALCOA and Calhoun County Navigation District turning basins.

Sample Processing

Individual birds were recovered by the support boat, immediately toe tagged with a sample identification number, placed in a polyethylene bag labeled with the same information, and stored on ice until the tissue samples could be removed and processed. Corresponding entries were then

made on a field data sheet identifying the time, date, location, and sample identification number for each bird.

Procedures used to process the tissue samples follow those established by the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility (PACF 1990) in Laurel, Maryland. Liver was selected to indicate total mercury exposure because it accumulates high amounts compared to other soft tissues, and has a high degree of average correlation with mercury concentrations in other tissues (Gochfeld 1980, Walsh 1990). Cormorant livers were removed in the field on the same day of collection, and placed in certified chemically clean jars. The samples were then frozen with dry ice until they could be stored in secure freezers at minus 20°C. The gender of each bird was noted to allow comparison of mercury accumulations between the sexes. All carcasses were rebagged, chilled on ice, and stored in secure freezers upon arrival back at the lab. Livers of cormorants collected 18 March were removed the following day in the lab, and immediately frozen to -20°C in secured freezers.

These same procedures were used to remove entire livers and portions of breast muscle from the Lesser Scaup. Livers, however, were split into two separate jars for shipment to the laboratories performing the total and methylmercury analysis. To reduce the potential for significant amounts of methylmercury to be demethylated in the tissues of dead birds, it was necessary to remove these tissues within approximately two hours and freeze them on dry ice.

Chain-of-custody procedures were followed throughout the handling, processing, shipping, and analysis of the tissues. Each laboratory was contacted to confirm shipment and receipt of samples, all of which were shipped on dry ice by certified overnight carrier.

Laboratory Analysis of Tissues

Analysis of the tissue samples for mercury and methylmercury were conducted by laboratories under contract with PACF. Specific contract requirements of PACF, as well as the standard operating procedures and quality assurance plans for both laboratories are presented in Appendix C-2.

Precision and accuracy of both total mercury and methylmercury analyses were confirmed with procedural blanks, duplicates, and reference material analyses. Accuracy of total mercury analyses was also confirmed through the recovery of spiked materials. The analytical results were reviewed by the PACF

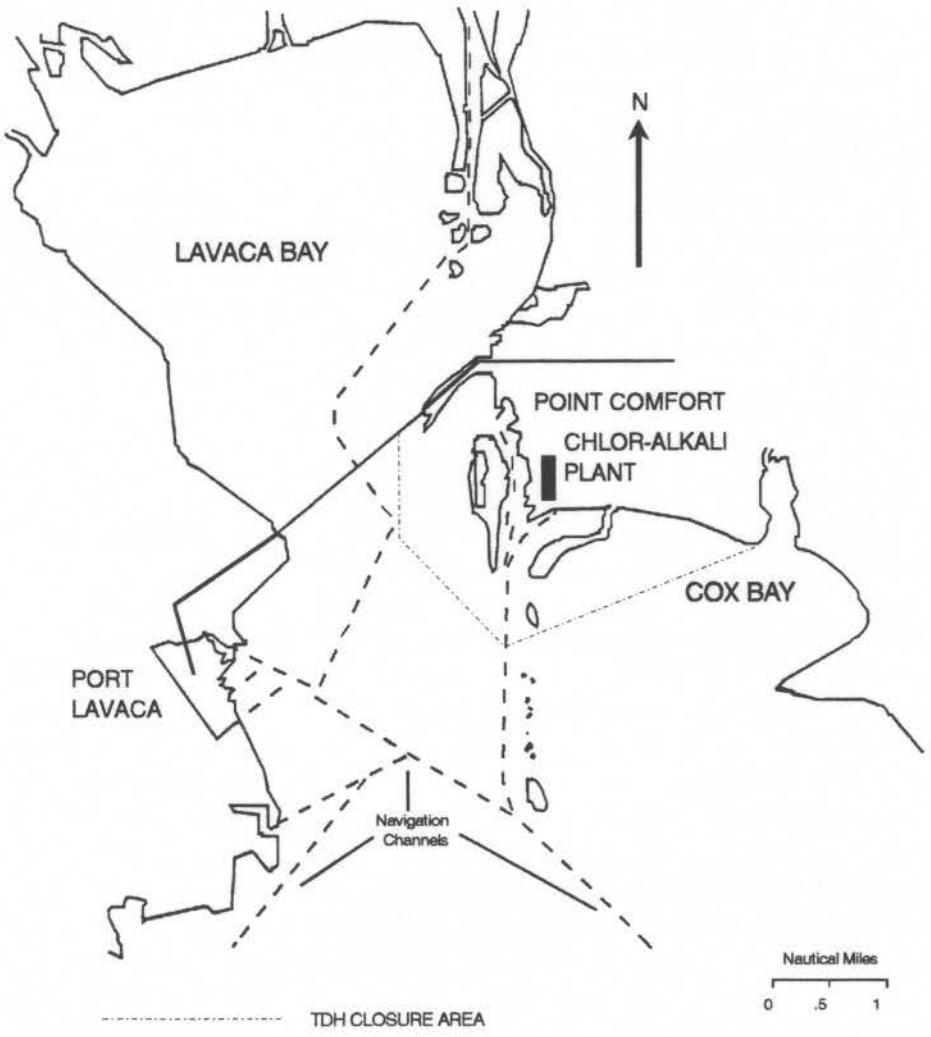


Figure 4-1. Map of Lavaca Bay study area for collection of wintering Double-crested Cormorants and Lesser Scaup, Winter, 1991-1992.

Quality Control Officer, and met PACF's established standards for quality control and quality assurance.

Data Analysis

The Double-crested Cormorant data for both early and late collections was positively skewed, all values were above detection limits, and were spread over a very broad range. Therefore, geometric means were used as a measure of central tendency, and minimum and maximum values were used to show the range over which the data sets were distributed. Because the data were not normally distributed, the nonparametric Wilcoxon-Mann-Whitney Two-sample Test (Steel and Torrie 1980) was used to compare the early and late cormorant collections.

The Lesser Scaup data for the early collection was also positively skewed, but distributed over a much narrower range compared to the cormorant data. All reported values were also above laboratory detection limits.

## RESULTS AND DISCUSSION

Summary results of total mercury levels found in the tissues of Lesser Scaup and Double-crested Cormorants are presented in Table 4-1. Individual analytical results for all tissues submitted are presented in Appendices C-1 through C-3.

Lesser Scaup

The levels of total mercury found in the livers of Lesser Scaup taken during the early winter collection were considered below those considered to be normally harmful to birds. Unfortunately, by the time the late winter collections were initiated, the scaup had redistributed out of Lavaca and Cox Bays. As a result, the nine scaup taken during the three late winter collections were not considered to be truly representative of birds that had wintered in Lavaca Bay, and comparisons between the early and late collections were not considered valid.

The reason for the redistribution of the Lesser Scaup population is uncertain. However, by the time the late winter collections of these scaup were initiated, abnormally heavy and extended rainfalls had substantially reduced the salinity of Lavaca and Cox bays, and it is possible that the scaup preferred the higher salinity water found closer to the Gulf. A survey conducted by Texas Parks and Wildlife Department

Table 4-1. Summary data on total mercury concentrations in livers of Lesser Scaup and Double-crested Cormorants collected from Lavaca Bay during the winter of 1991-1992.

| | Lesser Scaup | | Double-crested Cormorant | |
|---|---|---|---|---|
| Collection | Dry wt. (ppm) | Wet wt. (ppm) | Dry wt. (ppm) | Wet wt. (ppm) |
| Early | | | | |
| Sample size | 20 | 20 | 19 | 19 |
| Geometric mean | 1.895 | 0.563 | 36.29 | 10.39 |
| Minimum | 0.388 | 0.107 | 6.04 | 1.82 |
| Maximum | 6.56 | 1.93 | 497.0 | 146.0 |
| Late | | | | |
| Sample size | * | * | 20 | 20 |
| Geometric mean | - | - | 28.35 | 7.87 |
| Minimum | - | - | 5.83 | 1.62 |
| Maximum | - | - | 712 | 221 |

*Population had moved out of bay.

biologists showed that Lesser Scaup were in Barroom Bay by the hundreds, and that the northward migration of this species had not yet begun. Barroom Bay is a small bay located at the southern most end of Matagorda Bay approximately 26 kilometers southeast of ALCOA, and four kilometers northwest of Pass Cavallo leading to the Gulf of Mexico.

A likely explanation for the redistribution of the scaup may be a shift in the availability of their preferred food items caused by unusually large fresh water inflows. Lesser Scaup are omnivorous, feeding on both plant and animal material. Along the Gulf Coast, the majority of their winter diet consists of crustaceans, small fish, and mollusks (Bellrose 1976). While most estuarine organisms are tolerant of very low salinities for short periods of time, the extended period of large freshwater inflows during the winter of 1991-1992 may have had a substantial negative effect on the abundance of forage items eaten by scaup. Very few Lesser Scaup were sighted in Lavaca and Cox bays during the attempted late winter collections. Those that were sighted occurred in abnormally small flocks of less than a dozen. Scaup forage daily over large areas (Mulholland 1985), so it is likely that the individuals sighted or collected were transients on the periphery of their normal flight pattern centered near the coast.

None of the twenty breast muscles submitted from the early winter collections exceeded the Food and Drug Administration's Human Health Standard of 1 ppm wet weight of methyl mercury in edible tissue. However, two livers did exceed that standard with values of 2.17 and 1.11 ppm wet weight, indicating a potential risk to people who consume scaup livers.

Double-crested Cormorants

Double-crested Cormorants are highly piscivorous birds that typically feed on relatively large benthic and midwater fish. In freshwater lakes, forage fish up to 415 mm in length are preferred (Campo et al. 1988). In estuarine habitats, common food items include gizzard shad (Dorosoma cepedianum), toadfish (Opsanus tau), sea catfish (Arius felis), and eels (Clapp et al. 1982a).

The Double-crested Cormorant was selected as a surrogate species to represent an ecological guild of birds (i.e. diving fish-eaters), all of which receive similar exposures to the mercury contamination. Other members of that guild, such as the Common Loon (Gavia immer) and Red-breasted Merganser (Mergus serrator), are less suitable for study due to their relatively small winter populations along the Texas coast.

The use of Double-crested Cormorants to measure concentrations and effects of toxic contaminants has been recommended by other researchers as well (Fox et al. 1991).

Summary data for both the early and late collections of Double-crested Cormorants (Table 4-1) indicate that liver mercury concentrations were well above levels known to cause injury to other avian species (Fimreite 1979, Eisler 1987, Scheuhammer 1987, Walsh 1990). In general, studies show that clinical symptoms and death in adults of various species occur at mercury concentrations in livers of 20-130 ppm wet weight. Most field and laboratory studies also show that the effects of mercury toxicosis occur over a wide range for an individual species. This is generally due to a variety of factors that may affect individuals, and sometimes whole populations of a species.

The wide range over which mercury effects different species makes it difficult to identify precise levels of concern for any given species. Currently, there is a lack of evidence that identifies a threshold level for mercury that is known to affect Double-crested Cormorants. However, a number of researchers have reported mercury concentrations in other populations of this species (Fimreite et al. 1971, Hesse et al. 1975, Braune 1987, Elliott et al. 1992). The highest value noted in these studies (92.4 ppm wet weight, Hesse et al. 1975), which was considered to be a level of concern, was less than half of the maximum concentration (221 ppm wet weight) found in Lavaca Bay cormorants during 1991-1992.

Mercury concentrations in both the early and late winter collections of Double-crested Cormorants exhibited substantial variation, and were highly skewed with relatively few individuals having extremely high concentrations. According to Walsh (1990), such a distribution of mercury concentrations implies a lack of regulation of this metal by cormorants. Results of the Wilcoxon-Mann-Whitney Two-sample Test ($Z = 0.32$) indicate no significant difference between the early and late collections ($P < 0.05$), and implies that the timing of the collections had little influence on the levels of mercury found in cormorant livers during 1991-1992.

If Double-crested Cormorants did not accumulate mercury while wintering in Lavaca Bay, then their nesting grounds would be the next most likely source of the mercury. The data and available literature on cormorants, however, indicates that this scenario is unlikely. As stated above, injury to birds exposed to mercury contaminated areas may occur at liver tissue concentrations as low as 20 ppm wet weight, a value exceeded by thirty-two percent (6 of 19) of the cormorants

mercury is limited, such a response would lead to accumulation of inorganic mercury in the liver of birds (Thompson and Furness 1989, Walsh 1990). If Double-crested Cormorants in Lavaca Bay are undergoing accumulation of inorganic mercury with age, this may account for a great deal of the variability and skewness of the data based upon variability in the age (unknown) of the birds sampled.

A number of researchers have suggested that the feeding pattern of individual birds is one of the most significant modifiers affecting mercury tissue burdens (Appelquist et al. 1985, Eisler 1987, Furness et al. 1990, Thompson et al. 1991). Because the feeding patterns of individual birds typically do not change from year to year, liver mercury levels are expected to vary the least from year to year for individual birds. Differences between individuals of the same species will be comparatively greater, and the variability between different species will be the greatest. However, mercury is typically accumulated through the food chain as methyl mercury, a substantial portion of which is depurated from soft tissues through the growth of new feathers (Braune and Gaskin 1987, Thompson et al. 1991). In effect, annual accumulations of methyl mercury tend to vary little from year to year for an individual bird, but an individual birds' mercury tissue levels may vary considerably at different times within a year according to the molt patterns of individual species.

Double-crested Cormorants acquire their breeding plumage through a prealternate molt which occurs during February and March (Palmer 1962). Ninety percent (9/10) of the cormorants collected in March 1992 had liver mercury levels below 10 ppm wet weight, whereas only 50% of the cormorants in each of the other collections (November and February) were below 10 ppm. Because so much of the methyl mercury in the soft tissues is transferred during the growth of new feathers, the apparent reduction in liver mercury levels of the 10 cormorants collected in March 1992 may be explained by the molting patterns of this species. Because the March collection occurred just prior to onset of return migrations, it is also possible that the reduced levels observed in these cormorants were associated with other changes such as behavior, distribution, or diet. However, no such changes were identifiable at the time collections were made.

The unusually heavy rainfalls along the Texas coast which began in December of 1991 generated large freshwater inflows into most of the estuaries, and reduced salinities for an extended period of time in many of the secondary and tertiary bays. As with the Lesser Scaup, such extended freshwater inflows could have altered feeding locations and/or the type

of prey Double-crested Cormorants consumed, perhaps accounting for the apparent lack of increase in cormorant liver mercury levels between early and late collections. This may be supported by observations made by field biologists during the late winter collections that the number of Double-crested Cormorants in Lavaca Bay appeared reduced as compared to the population seen three months earlier, indicating that the cormorants also dispersed out of Lavaca Bay, though to a much lesser degree than Lesser Scaup.

The gender of each bird collected during this investigation was also identified to allow for comparisons between the levels of mercury accumulated by males and females. For Lesser Scaup, mercury levels in the early collection appear to be below that which would cause biological injury to this species, so no attempt was made to correlate gender of each scaup with their respective mercury levels. For cormorants, mercury levels in male cormorant livers ranged from 2.75 to 135.0 ppm wet weight, as opposed to a range of 1.82 to 221.0 ppm wet weight for females. The distribution of mercury between individual birds was similar for the two sexes, and gender did not appear to be a significant factor in wintering cormorants. However, only 13% (5/39) of the Double-crested Cormorants were male, so the comparison may not be representative of breeding populations. This disparity in the ratio of males to females was also noted by King et al. (1987), who suggested that cormorants may be segregated by sex while wintering along the Texas Coast. A number of researchers have also examined the effects of gender on body and tissue burdens of mercury (Braune and Gaskin 1987, Furness et al. 1990, Thompson et al. 1991), and the data appear to be mixed. As with other biotic factors, it is likely that the degree to which gender affects mercury accumulation and depuration will vary between species.

The results of this investigation indicate that Lavaca Bay is a potential source of mercury contamination in piscivorous birds such as Double-crested Cormorants; however, the variability in the data appears to be great enough to mask any seasonal trends in mercury accumulation that might have occurred over the 13 to 17-week interval separating the early and late collections.

## CONCLUSION

Mercury concentrations in Lesser Scaup and Double-crested Cormorants showed no significant difference between samples of early and late winter migrants. However, mercury concentrations found in livers of Double-crested Cormorants wintering in Lavaca Bay indicate that these birds have been

exposed to high levels of mercury, with some individual birds exhibiting mercury accumulations exceeding levels that have been documented to cause toxic effects in other species of birds. These levels also suggest that other members of the guild of wintering fish-eating birds (e.g. loons and mergansers) are potentially at risk.

## RECOMMENDATION

Determining the source of the mercury contamination in Double-crested Cormorants wintering in Lavaca Bay will require future investigations to account for some of the factors affecting mercury accumulation in migratory, fish-eating birds. Future studies should include the identification of flight, feeding, and seasonal migration patterns, and wintering site fidelity, through the use of radio and satellite telemetry.

## LITERATURE CITED


ALCOA. 1992. Draft report - Lavaca Bay sediment sampling data report Point Comfort, Texas. Project No. 92T158C, Task 402. Prepared by Woodward-Clyde Consultants, Inc. Houston, Texas.

Allen, R.P. 1942. The Roseate Spoonbill. Res. Rep. 2. Natl. Audubon Soc., New York. 142 pp.

Appelquist, H., S. Asbirk, and I. Drabaek. 1984. Mercury monitoring: mercury stability in bird feathers. Marine Poll. Bull. 15:22-24.

Appelquist, H., I. Drabaek, and S. Asbirk.. 1985. Variation in mercury content of Guillemot feathers over 150 years. Mar. Poll. Bull. 16:244-248.

Barr, J.F. 1986. Population dynamics of the Common Loon (Gavia immer) associated with mercury-contaminated waters in northwestern Ontario. Canadian Wild. Serv. Occas. Pap. No. 56.

Becker, P.H. 1992. Egg mercury levels decline with the laying sequence in Charadriiformes. Bull. Environ. Contam. Toxicol. 48:762-767.

Becker, P.H. and H. Sperveslage. 1989. Organochlorines and heavy metals in Herring Gull (Larus argentatus) eggs and chicks from the same clutch. Bull. Environ. Contam. Toxicol. 42:721-727.

Bellrose, F.C. 1976. Ducks, geese and swans of North America. Excerpts on migration & feeding of Common Goldeneye & Lesser Scaup. Wildl. Manage. Instit.

Bent, A.C. 1926. Life histories of North American marsh birds. U.S. Natl. Mus. Bull. 135.

Berg, W., A. Johnels, B. Sjostrand, and T. Westermark. 1966. Mercury content in feathers of Swedish birds from the past 100 years. Oikos 17:71-83.

Blacklock, G.W., D.R. Blankinship, S. Kennedy, K.A. King, R.T. Paul, R.D. Slack, J.C. Smith, and R.C. Telfair II. 1978. Texas colonial waterbird census, 1973-1976. Tex. Parks Wildl. Dep. FA Rep. Ser. No. 15, Austin. 108 pp.

Blus, L.J. and C.J. Stafford. 1980. Breeding biology and

relation of pollutants to Black Skimmers and Gull-billed Terns in South Carolina. USFWS Spec. Sci. Rep. - Wildl. No. 230.

Blus, L.J., C.J. Henny, A. Anderson, and R.E. Fitzner. 1985. Reproduction, mortality, and heavy metal concentrations in Great Blue Herons from three colonies in Washington and Idaho. Col. Waterbirds 8:110-116.

Borg, K., H. Wanntorp, K. Erne, and E. Hanko. 1969. Alkyl mercury poisoning in terrestrial Swedish wildlife. Viltrevy 6:301-376.

Braune, B.M. 1987. Comparison of total mercury levels in relation to diet and molt for nine species of marine birds. Arch. Environ. Contam. Toxicol. 16:217-224.

Braune, B.M. and D.E. Gaskin. 1987. Mercury levels in Bonaparte's Gulls Larus philadelphia during autumn molt in the Quoddy Region, New Brunswick, Canada. Arch. Environ. Contam. Toxicol. 16:539-549

Brown, W.J. and N. Yoshida. 1965. Organic mercurial encephalopathy: An experimental electron microscope study. Adv. Neurol. Sci. (Tokyo) 9:34-42.

Burger, J. and D.C. Hahn. 1977. Crow predation on Black-crowned Night Heron eggs. Wilson Bull. 89:350-51.

Burkholder, G. and D.G. Smith. 1991. Nest trees and productivity of Great Blue Herons (Ardea herodias) at Knox Lake, north-central Ohio. Col. Waterbirds 14:61-62.

Campo, J.J., B. Thompson., J.C. Barron, P.D. Durocher, and S.J. Gutreuter. 1988. Feeding habits of Double-crested Cormorants wintering in Texas. Texas Parks and Wildlife Dept. Federal Aid Project W-103-R

Chang, L.W. 1977. Neurotoxic effects of mercury - A review. Environ. Res. 14:329-373.

Chang, L.W. 1979. Pathological effects of mercury poisoning. pp. 519-580 in The Biogeochemistry of Mercury in the Environment (J.O. Nriagu, Ed.) Elsevier/North-Holland Biomedical Press, Amsterdam.

Chang, L.W. 1980. Mercury. pp. 508-526 in Experimental and Clinical Neurotoxicology (Spencer and Shaumburg, Eds.)

Williams & Wilkins, Baltimore.

Clapp, R.B., R.C. Banks, D. Morgan-Jacobs, and W.A. Hoffman. 1982. Marine birds of the Southeastern United States and Gulf of Mexico. Part I. Gaviiformes through Pelecaniformes. U.S. Fish and Wildl. Serv., Office of Biological Services, Washington, D.C. FWS/OBS-81/01.

Clapp, R.B., D. Morgan-Jacobs, and R.C. Banks. 1982b. Marine birds of the southeastern United States and Gulf of Mexico. Part II: Anseriformes. U.S. Fish and Wildl. Serv., Office of Biological Services, Washington, D.C. FWS/OBS-82/20.

Clapp, R.B., D. Morgan-Jacobs, and W.A. Hoffman. 1983. Marine birds of the Southeastern United States and Gulf of Mexico. Part III: Charadriiformes. U.S. Fish and Wildl. Serv., Office of Biological Services, Washington, D.C. FWS/OBS-83/30.

Connors, P.G., V.C. Anderlini, R.W. Risebrough, M. Gilbertson, and H. Hays. 1975. Investigations of metals in Common Tern populations. Can. Fld.-Nat. 89:157-162.

Custer, T.W. and P.C. Frederick. 1990. Egg size and laying order of Snowy Egrets, Great Egrets, and Black-crowned Night Herons. Condor 92:772-775.

Custer, T.W. and C.A. Mitchell. 1989. Organochlorine contaminants in White-faced Ibis eggs in southern Texas. Col. Waterbirds 12:126-129.

Custer, T.W. and J.P. Myers. 1990. Organochlorines, mercury, and selenium in wintering shorebirds from Washington and California. Calif. Fish and Game 76:118-125.

Custer, T.W., G. Pendleton, and H.M. Ohlendorf. 1990. Within- and among-clutch variation of organochlorine residues in eggs of Black-crowned Night Herons. Environ. Monit. Assess. 15:83-89.

Custer, T.W., G.L. Hensler, and T.E. Kaiser. 1983. Clutch size, reproductive success, and organochlorine contaminants in Atlantic coast Black-crowned Night Herons. Auk 100:699-710.

DePue, J. 1974. Nesting and reproduction of the Black Skimmer (Rhynchops niger niger Linnaeus) on four spoil islands in the Laguna Madre, Texas. M.S. Thesis, Texas A&I Univ., Kingsville, Texas. 155 pp.

birds. pp. 601-627 in: The Biogeochemistry of Mercury in the Environment (J.O. Nriagu, ed.). North/Holland Biomedical Press, Amsterdam.

Fimreite, N.W.M., J.A. Holsworth, P.A. Pearce, and I.M. Grunchy. 1971. Mercury in fish and fish-eating birds near sites of industrial contamination in Canada. Can. Fld. Nat. 85:211-220.

Finley, M.T. and R.C. Stendell. 1978. Survival and reproductive success of Black Ducks fed methyl mercury. Environ. Poll. 16:51-64.

Franson, J.C. 1984. Postmortem changes in liver weight of Japanese Quail. Bull. Environ. Contam. Toxicol. 33:313-316.

Frederick, P.C. and M.W. Collopy. 1989. Researcher disturbance in colonies of wading birds: effects of frequency of visit and egg-marking on reproductive parameters. Col. Waterbirds 12:152-157.

Furness, R.W., S.A. Lewis, and J.A. Mills. 1990. Mercury levels in the plumage of Red-billed Gulls Larus novaehollandiae scopulinus of known sex and age. Environ. Poll. 63:33-39.

Furness, R.W., S.J. Muirhead, and M. Woodburn. 1986. Using bird feathers to measure mercury in the environment: Relationships between mercury content and moult. Mar. Poll. Bull. 17:27-30.

Gamble, L.R., G.J. Jackson, and T.C. Maurer. 1989. Contaminants investigation of the Aransas Bay complex, Texas, 1985-1986. U.S. Fish & Wildl. Serv., 38 pp.

Gardiner, E.E. 1972. Differences between ducks, pheasants, and chickens in tissue mercury retention, depletion, and tolerance to increasing levels of dietary mercury. Can. J. Anim. Sci. 52:419-423.

Gochfeld, M. 1980. Tissue distribution of mercury in normal and abnormal young Common Terns. Mar. Poll. Bull. 11:362-377.

Heinz, G.H. 1976. Methylmercury: second-year feeding effects on Mallard Duck reproduction and duckling behavior. J. Wildl. Manage. 40(1):82-90.

Heinz, G.H. 1979. Methylmercury: reproductive and behavioral

effects on three generations of Mallard Ducks. J. Wildl. Manage. 43(2):394-401.

Heinz, G.H. and L.N. Locke. 1975. Brain lesions in Mallard ducklings from parents fed methylmercury. Avian Diseases 20:9-17.

Helander, B., M. Olsson, and L. Reutergardh. 1982. Residue levels of organochlorine and mercury compounds in unhatched eggs and the relationships to breeding success in White-tailed Sea Eagles (Haliaeetus albus). Holarctic Ecology 5:349-366.

Hensler, G.L. and J.D. Nichols. 1981. The Mayfield method of estimating nesting success: A model, estimators and simulation results. Wilson Bull. 93:42-53.

Hesse, L.W., R.L. Brown, and J.F. Heisinger. 1975. Mercury contamination of birds from a polluted watershed. J. Wildl. Manage. 39(2):299-304.

Hill, E.F. and C.S. Shaffner. 1975. Sexual maturation and productivity of Japanese Quail fed graded concentrations of mercuric chloride. Poul. Sci. 55:1449-1459.

Hill, E.F. and J.H. Soares, Jr. 1977. Reproductivity of Japanese Quail fed mercuric chloride in the absence of Vitamin D1. Poul. Sci. 56:710-712.

Hoffman, R.D. 1974. Mercury in herons, egrets and their nesting environment. M.S. Thesis, Ohio State Univ. 85 pp.

Holman, S. 1977. Water quality segment report for segment nos. 2453 and 2454 Lavaca and Cox Bays. Texas Water Quality Board, Austin.

Holmes, C.W. 1977. Effects of dredged channels on trace-metal migration in an estuary. Res. U.S. Geol. Sur. 5:243-251.

Holmes, C.W. 1986. Trace metal seasonal variations in Texas marine sediments. Mar. Chem. 20:13-27

Jenni, D.A. 1969. A study of the ecology of four species of herons during the breeding season at Lake Alice, Alachua County, Florida. Ecol. Mono. 39(3):245-270.

Johnels, A.G. and T. Westermark. 1969. Mercury contamination

of the environment in Sweden. Pages 221-239 in: Chemical Fallout. Research of Persistent Pesticides (M.W. Miller & G.G. Berg, eds.). Thomas, Springfield.

Johnson, D.H. 1979. Estimating nest success: The Mayfield method and an alternative. Auk 96:651-66.

Johnston, D.W. 1990. Description of surveys: Breeding bird censuses. Pages 33-36 in: Survey designs and statistical methods for the estimation of avian population trends (J.R. Sauer & S. Droege eds.) U.S. Fish Wildl. Serv., Biol. Rep. 90(1).

Kelsall, J.P., and K. Simpson. 1979. A three year study of the Great Blue Heron in southwestern British Columbia. Proc. Col. Waterbird Group 3:69-74.

King, K.A., E.L. Flickinger, and H.H. Hildebrand. 1978. The decline of Brown Pelicans on the Louisiana and Texas Gulf coast. Southwest. Nat. 21:417-431.

King, K.A. 1978. Colonial wading bird survey and census techniques. pp 155-159 in: Wading Birds. Research Rep. No. 7. Nat. Audubon Soc.

King, K.A., C.A. Lefever, and B.M. Mulhern. 1983. Organochlorine and metal residues in Royal Terns nesting on the central Texas Coast. J. Field Ornithol. 54:295-303.

King, K.A., D.R. Blankinship, E. Payne, A.J. Krynitsky, and G.L. Hensler. 1985. Brown Pelican populations and pollutants in Texas 1975-1981. Wilson Bull. 97:201-214.

King, K.A. and A.J. Krynitsky. 1986. Population trends, reproductive success, and organochlorine chemical contaminants in waterbirds nesting in Galveston Bay, Texas. Arch. Environ. Contam. Toxicol. 15:367-376.

King, K.A., C.J. Stafford, B.W. Cain, A.J. Mueller, and H.D. Hall. 1987. Industrial, agricultural, and petroleum contaminats in cormorants wintering near the Houston Ship Channel, Texas, USA. Col. Waterbirds 10:93-99

King, K.A. 1989. Food habits and organochlorine contaminants in the diet of Black Skimmers, Galveston Bay, Texas, USA. Col. Waterbirds 12:109-112.

King, K.A., T.W. Custer, and J.S. Quinn. 1991. Effects of

mercury, selenium, and organochlorine contaminants on reproduction of Forster's Terns and Black Skimmers nesting in a contaminated Texas bay. Arch. Environ. Contam. Toxicol. 20:32-40.

Koestner, A. and S. Norton. 1991. Nervous system. pp 641-642 in Handbook of Toxicologic Pathology (W.M. Haschek and C.G. Rousseaux, Eds.), Academic Press, New York.

Mayfield, H.F. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

Mayfield, H.F. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Miller, H.W. and D.H. Johnson. 1978. Interpreting the results of nesting studies. J. Wildl. Manage. 42:471-476.

Morrison, M.L., B.S. Hale, and R.D. Slack. 1983. Recent population trends of cormorants (Aves: Pelicaniformes) in Texas. Tex. J. Sci. 35:239-242.

National Academy of Sciences. 1978. An assessment of mercury in the environment. Natl. Acad. of Sci., Washington, D.C.

Newton, I., J.A. Bogan and M.B. Haas. 1989. Organochlorines and mercury in the eggs of British Peregrines Falco peregrinus. Ibis 131:355-376.

Nisbet, I.C.T. 1973. Terns in Massachusetts: Present numbers and historical changes. Bird Banding 44(1):27-55.

Norheim, G. and A. Froslie. 1978. The degree of methylation and organ distribution of mercury in some birds of prey in Norway. Acta Pharmacol. et Toxicol. 43:196-204.

Ohlendorf, H.M., T.W. Custer, R.W. Lowe, M. Rigney, and E. Cromartie. 1988. Organochlorines and mercury in eggs of coastal terns and herons in California, USA. Col. Waterbirds 11(1):85-94.

Ohlendorf, H.M. and W.J. Fleming. 1988. Birds and environmental contaminants in San Francisco and Chesapeake Bays. Mar. Poll. Bull. 19:487-495.

PACF. 1990. Patuxent analytical control facility reference manual. U.S. Fish and Wildlife Service, Patuxent Analytical Control Facility, Laurel, MD. 121 pp.

Palmer, S.J. 1992. Mercury bioaccumulation in Lavaca Bay, Texas. M.S. Thesis, Texas A&M Univ., 139 pp.

Palmer, R.S. (ed.) 1962. Handbook of North American birds, Vol. I: Loons through flamingos. Yale University Press, New Haven, Conneticutt. 567 pp.

Pass, D.A., P.B. Little, and L.H. Karstad. 1975. The pathology of subacute and chronic methyl mercury poisoning of the Mallard Duck (Anas platyrhynchos). J. Comp. Path. 85:7-21.

Ratcliffe, D.A. 1967. The Peregrine situation in Great Britain 1965-66. Bird Study 14:238-246.

Reigel, D.V. 1990. The distribution and behavior of mercury in sediments and marine organisms of Lavaca Bay, Texas. M.S. Thesis, Texas A&M Univ., 113 pp.

Reuhl, K.R. and L.W. Chang. 1979. Effects of methylmercury on the development of the nervous system: A review. Neurotoxicology 1:21-55.

Robert, H.C. and C.J. Ralph. 1975. Effects of human disturbance on the breeding success of gulls. Condor 77:495-499.

Safina, C. and J. Burger. 1983. Effects of human disturbance on reproductive success in Black Skimmers. Condor 85:164-171.

Santoro, E.D. and S.J. Koepp. 1986. Mercury levels in organisms in proximity to an old chemical site (Berrys Creek, Hackensack Meadowlands, New Jersey, USA). Mar. Poll. Bull. 17:219-224.

Scheuhammer, A.M. 1987. The chronic toxicity of aluminium, cadmium, mercury, and lead in birds: A review. Environ. Poll. 46:263-295.

Scheuhammer, A.M. 1989. Reproductive effects of chronic, low-level dietary metal exposure in birds. Trans. N. Am. Wildl. Nat. Resour. Conf. 52:658-664.

Simersky, B.L. 1971. Competition and nesting success of four species of herons on four spoil islands in Laguna Madre. M.S. Thesis Texas A&I Univ., Kingsville, Texas. 92 pp.

Soots, R.F., Jr., and J.F. Parnell. 1975. Ecological

succession of breeding birds in relation to plant succession on dredge islands in North Carolina. Sea Grant Publication UNC-SG-75-27, Raleigh, N. Carolina, USA: Univ. of N. Carol.

Spann, J.W., R.G. Heath, J.F. Kreitzer, and L.N. Locke. 1972. Ethyl mercury p-toluene sulfonanilide: Lethal and reproductive effects on pheasants. Science 175:328-331.

Statistical Graphics Corporation. 1989. Statgraphics: Statistical Graphics System. STSC, Inc.

Steel, R.G.D and J.H. Torrie 1980. Principles and procedures of statistics: A biometrical approach. Second Edition. McGraw-Hill Book Company, New York, New York. 633 pp.

Texas Colonial Waterbird Society. 1982. An atlas and census of Texas waterbird colonies. Caesar Kleberg Wildl. Res. Instit., Kingsville, Texas.

Texas Department of Health. 1991. Mercury samples collected from Lavaca Bay. Texas Department of Health, Division of Shellfish Sanitation and Control, Austin, Texas.

Texas Department of Health 1988. Classification of Lavaca Bay for the taking of finfish and crabs. Order Number: AL-1 (21 April 1988). Texas Department of Health, Division of Shellfish Sanitation Control, Austin, Texas.

Texas Historical Commission. 1988. Texas Musuem Directory. County Historical Commission and Museum Services Dept. of the Texas Historical Commission, Austin, Texas. 67 pp.

Thompson, D.R., K.C. Hamer, and R.W. Furness. 1991. Mercury accumulation in Great Skuas (Catharacta skua) of known age and sex and its effects upon breeding and survival. Journ. of Appl. Eco. 28:672-684.

Thompson, D.R., F.M. Stewart, and R.W. Furness. 1990. Using seabirds to monitor mercury in marine environments: The validity of conversion ratios for tissue comparisons. Mar. Pollut. Bull. 21(7):339-342.

Thompson, D.R. and R.W. Furness. 1989. The chemical form of mercury stored in South Atlantic seabirds. Ennviron. Poll. 60:305-317.

Thompson, D.R., R.W. Furness and P.M. Walsh. 1992. Historical changes in mercury concentrations in the marine ecosystem of the north and north-east Atlantic ocean as indicated by seabird feathers. J. Appl. Ecol. 29:79-84.

Tomich, Heidi. 1993. Damage Assessment and Restoration Team, Texas Water Commission, Austin, Texas.

Trebatoski, B. and J. Gooris. 1990. Texas Water Commission Natural Resource Damage Assessment screening document of Lavaca Bay-2453. Texas Water Commission, Austin, Texas.

Tremblay, J. and L.N. Ellison. 1979. Effects of human disturbance on breeding of Black-crowned Night Herons. Auk 96:364-369.

Tyler. P. A., and R. Tyler. 1983. Texas Museums: a guidebook. Univ. of Texas Press, Austin, Texas. 313 pp.

USGS. 1992. Progress report, preliminary investigation of variability of mercury in sediments, Lavaca - Matagorda Bay estuarine system, Calhoun County, TX. U.S. Geological Survey, San Antonio, TX. December 1992.

Van Der Molen, E.J., A.A. Blok and G.J. De Graaf. 1982. Winter starvation and mercury intoxication in Grey Herons (Ardea cinerea) in the Netherlands. Ardea 70:173-184.

Vermeer, K., F.A.J. Armstrong, and D.R.M. Hatch. 1973. Mercury in aquatic birds at Clay Lake, western Ontario. J. Wildl. Manage. 37:58-61.

Vermeer, K. 1973. Comparison of food habits and mercury residues of Caspian and Common Terns. Can. Fld.-Nat. 87:305.

Vermeer, K. and F.A.J. Armstrong. 1972. Mercury in Canadian prairie ducks. J. Wildl. Manage. 36:179-182.

Vos, D.K., R.A. Ryder, and W.D. Graul. 1985. Response of breeding Great Blue Herons to human disturbance in north central Colorado. Col. Waterbirds 8(1):13-22.

Walsh, P.M. 1990. The use of seabirds as monitors of heavy metals in the marine environment. Pages 183-204 in Heavy Metals in the Marine Environment (R.W. Furness,

and P.S. Rainbow, Eds.) CRC Press, Boca Raton, Florida.

Werschkul, D.F., E. McMahon, and M. Leitschuh. 1976. Some effects of human activities on the Great Blue Heron in Oregon. Wilson Bull. 88:660-662.

Westermark, T., T. Odsjo, and A.G. Johnels. 1975. Mercury content of bird feathers before and after Swedish ban on alkyl mercury in agriculture. Ambio 4:87-92.

White, D.H., C.A. Mitchell, and D.M. Swineford. 1984. Reproductive success of Black Skimmers in Texas relative to environmental pollution. J. Field Ornithol. 55(1):18-30.

# TECHNICAL APPENDICES

# APPENDIX A-1

## YEARLY TOTALS FOR NESTING PAIRS OF COLONIAL WATERBIRDS, 1973-1990

TABLE 1
YEARLY TOTALS FOR NESTING PAIRS OF ROSEATE SPOONBILLS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 100 | 1876* | 596 |
| 1974 | 71 | 1398 | 919 |
| 1975 | 175* | 1420 | 1271 |
| 1976 | 140 | 1742 | 542 |
| 1977 | 120 | 1102 | 1013 |
| 1978 | 50 | 1430 | 1277 |
| 1979 | 160 | 1102 | 838 |
| 1980 | 65 | 867 | 413 |
| 1981 | 80 | 1306 | 1100 |
| 1982 | 90 | 1830 | 590 |
| 1983 | 65 | 1621 | 606 |
| 1984 | 160 | 1076 | 346 |
| 1985 | 73 | 632 | 388 |
| 1986 | 55 | 1056 | 1346* |
| 1987 | 50 | 740 | 524 |
| 1988 | 131 | 1452 | 728 |
| 1989 | 40 | 1274 | 826 |
| 1990 | 5 | 1111 | 725 |

*PEAK YEAR

TABLE 2
YEARLY TOTALS FOR NESTING PAIRS OF GREAT BLUE HERONS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 32 | 198 | 1167 |
| 1974 | 52 | 360 | 1320 |
| 1975 | 135 | 646 | 1192 |
| 1976 | 171* | 1454* | 1884* |
| 1977 | 135 | 1301 | 1419 |
| 1978 | 120 | 1172 | 975 |
| 1979 | 46 | 1158 | 1773 |
| 1980 | 155 | 745 | 1290 |
| 1981 | 33 | 783 | 968 |
| 1982 | 21 | 1035 | 1066 |
| 1983 | 24 | 1019 | 884 |
| 1984 | 40 | 542 | 1076 |
| 1985 | 67 | 510 | 774 |
| 1986 | 15 | 727 | 533 |
| 1987 | 32 | 871 | 610 |
| 1988 | 17 | 849 | 537 |
| 1989 | 7 | 834 | 700 |
| 1990 | 48 | 711 | 886 |

*PEAK YEAR

TABLE 3
YEARLY TOTALS FOR NESTING PAIRS OF LITTLE BLUE HERONS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 9 | 289 | 380 |
| 1974 | 7 | 85 | 115 |
| 1975 | 8 | 69 | 420 |
| 1976 | 21 | 3929 | 462 |
| 1977 | 45 | 1119 | 4106* |
| 1978 | 12 | 267 | 229 |
| 1979 | 25 | 115 | 2465 |
| 1980 | 24 | 2094 | 42 |
| 1981 | 96 | 3606 | 416 |
| 1982 | 32 | 5121 | 1335 |
| 1983 | 21 | 5942* | 1367 |
| 1984 | 60 | 437 | 89 |
| 1985 | 80 | 104 | 118 |
| 1986 | 120 | 637 | 49 |
| 1987 | 150* | 879 | 30 |
| 1988 | 97 | 366 | 149 |
| 1989 | 50 | 385 | 93 |
| 1990 | 84 | 816 | 70 |

*PEAK YEAR

TABLE 4
YEARLY TOTALS FOR NESTING PAIRS OF GREAT EGRETS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 181 | 3584 | 1283 |
| 1974 | 178 | 2458 | 1242 |
| 1975 | 250 | 1984 | 1164 |
| 1976 | 400 | 2999 | 1436 |
| 1977 | 410 | 4812 | 1233 |
| 1978 | 125 | 3695 | 478 |
| 1979 | 88 | 3791 | 1539 |
| 1980 | 450* | 2758 | 1320 |
| 1981 | 76 | 3149 | 864 |
| 1982 | 85 | 3754 | 985 |
| 1983 | 115 | 3477 | 999 |
| 1984 | 120 | 4075 | 670 |
| 1985 | 132 | 3247 | 765 |
| 1986 | 80 | 3934 | 551 |
| 1987 | 80 | 5289 | 750 |
| 1988 | 59 | 1872 | 992 |
| 1989 | 15 | 2081 | 1219 |
| 1990 | 60 | 5841* | 3090* |

*PEAK YEAR

TABLE 5
YEARLY TOTALS FOR NESTING PAIRS OF TRICOLORED HERONS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 388 | 6459 | 3271 |
| 1974 | 542 | 6940 | 3020 |
| 1975 | 1486 | 6716 | 2859 |
| 1976 | 675 | 7300 | 3596* |
| 1977 | 2400* | 11883 | 2753 |
| 1978 | 860 | 12521* | 1885 |
| 1979 | 640 | 7111 | 1915 |
| 1980 | 400 | 3595 | 2318 |
| 1981 | 570 | 5099 | 2436 |
| 1982 | 500 | 6039 | 2189 |
| 1983 | 920 | 3431 | 1459 |
| 1984 | 1200 | 3829 | 2256 |
| 1985 | 600 | 4850 | 2429 |
| 1986 | 720 | 7514 | 2086 |
| 1987 | 570 | 3055 | 1847 |
| 1988 | 499 | 6062 | 2142 |
| 1989 | 555 | 7104 | 2214 |
| 1990 | 368 | 4370 | 1933 |

*PEAK YEAR

TABLE 6
YEARLY TOTALS FOR NESTING PAIRS OF SNOWY EGRETS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 174 | 3470 | 2707 |
| 1974 | 253 | 4988* | 2983* |
| 1975 | 259 | 2334 | 2120 |
| 1976 | 275 | 3385 | 1827 |
| 1977 | 525* | 4344 | 2231 |
| 1978 | 200 | 3508 | 867 |
| 1979 | 250 | 2881 | 1538 |
| 1980 | 150 | 1370 | 1269 |
| 1981 | 370 | 2293 | 1383 |
| 1982 | 285 | 3682 | 1639 |
| 1983 | 136 | 2905 | 896 |
| 1984 | 60 | 907 | 1355 |
| 1985 | 480 | 2841 | 1191 |
| 1986 | 470 | 2378 | 768 |
| 1987 | 440 | 1705 | 886 |
| 1988 | 512 | 3624 | 801 |
| 1989 | 315 | 2757 | 734 |
| 1990 | 271 | 2834 | 611 |

*PEAK YEAR

TABLE 7
YEARLY TOTALS FOR NESTING PAIRS OF LEAST TERNS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 45 | 1904 | 955 |
| 1974 | 70 | 2279* | 258 |
| 1975 | 60 | 908 | 687 |
| 1976 | 10 | 122 | 181 |
| 1977 | 0 | 184 | 244 |
| 1978 | 13 | 237 | 296 |
| 1979 | 64 | 259 | 793 |
| 1980 | 251* | 431 | 1023* |
| 1981 | 60 | 107 | 550 |
| 1982 | 40 | 233 | 580 |
| 1983 | 0 | 363 | 226 |
| 1984 | 40 | 414 | 248 |
| 1985 | 60 | 262 | 309 |
| 1986 | 60 | 395 | 294 |
| 1987 | 150 | 355 | 119 |
| 1988 | 50 | 437 | 51 |
| 1989 | 0 | 414 | 92 |
| 1990 | 7 | 1357 | 75 |

*PEAK YEAR

TABLE 8
YEARLY TOTALS FOR NESTING PAIRS OF FORSTER'S TERNS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 350* | 2368 | 423 |
| 1974 | 110 | 687 | 418 |
| 1975 | 315 | 1162 | 408 |
| 1976 | 75 | 1206 | 411 |
| 1977 | 90 | 2364 | 636 |
| 1978 | 120 | 1823 | 342 |
| 1979 | 185 | 1408 | 602 |
| 1980 | 180 | 1052 | 891* |
| 1981 | 55 | 1592 | 404 |
| 1982 | 273 | 2059 | 458 |
| 1983 | 50 | 2117 | 360 |
| 1984 | 300 | 3175 | 840 |
| 1985 | 160 | 3668* | 535 |
| 1986 | 70 | 1896 | 173 |
| 1987 | 115 | 1216 | 228 |
| 1988 | 289 | 2723 | 570 |
| 1989 | 21 | 3659 | 237 |
| 1990 | ^H^EH^I"^O988 | 95* | 844 143 |
| 1989 | 30 | 669 | 174 |
| 1990 | 60 | 580 | 149 |

*PEAK YEAR

TABLE 9
YEARLY TOTALS FOR NESTING PAIRS OF ROYAL TERNS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 0 | 6350 | 6898 |
| 1974 | 0 | 9702 | 2185 |
| 1975 | 0 | 4000 | 2387 |
| 1976 | 0 | 4000 | 2950 |
| 1977 | 0 | 10364 | 2570 |
| 1978 | 0 | 7337 | 8743 |
| 1979 | 0 | 7895 | 4570 |
| 1980 | 500 | 7550 | 4350 |
| 1981 | 0 | 6597 | 6084 |
| 1982 | 0 | 10210 | 6091 |
| 1983 | 0 | 10476 | 6221 |
| 1984 | 0 | 7835 | 5361 |
| 1985 | 0 | 13200 | 4008 |
| 1986 | 5000* | 12000 | 6089 |
| 1987 | 0 | 9001 | 10503 |
| 1988 | 0 | 12520 | 4972 |
| 1989 | 0 | 15865* | 5334 |
| 1990 | 70 | 11385 | 12109* |

*PEAK YEAR

TABLE 10
YEARLY TOTALS FOR NESTING PAIRS OF LAUGHING GULLS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 211 | 40101 | 25914 |
| 1974 | 10 | 28740 | 17031 |
| 1975 | 10 | 19724 | 20606 |
| 1976 | 20 | 25093 | 26159 |
| 1977 | 15 | 39908 | 25954 |
| 1978 | 10 | 28716 | 16456 |
| 1979 | 23 | 48443 | 22018 |
| 1980 | 500 | 51328* | 20893 |
| 1981 | 350 | 37614 | 18363 |
| 1982 | 1250 | 50654 | 18662 |
| 1983 | 779 | 48456 | 22171 |
| 1984 | 1600 | 34160 | 24073 |
| 1985 | 1150 | 36687 | 17644 |
| 1986 | 1725 | 35191 | 20391 |
| 1987 | 2700* | 33565 | 22256 |
| 1988 | 2210 | 32385 | 22752 |
| 1989 | 1025 | 42525 | 18991 |
| 1990 | 1020 | 28093 | 27084* |

*PEAK YEAR

TABLE 11
YEARLY TOTALS FOR NESTING PAIRS OF BLACK-CROWNED NIGHT HERONS

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 35 | 989 | 628 |
| 1974 | 26 | 438 | 384 |
| 1975 | 35 | 317 | 457 |
| 1976 | 40 | 552 | 619 |
| 1977 | 55 | 406 | 1024* |
| 1978 | 20 | 882 | 351 |
| 1979 | 30 | 810 | 450 |
| 1980 | 20 | 985 | 441 |
| 1981 | 41 | 1107* | 405 |
| 1982 | 50 | 1044 | 404 |
| 1983 | 40 | 686 | 282 |
| 1984 | 40 | 469 | 439 |
| 1985 | 30 | 451 | 338 |
| 1986 | 20 | 311 | 196 |
| 1987 | 75 | 514 | 379 |
| 1988 | 95* | 844 | 143 |
| 1989 | 30 | 669 | 174 |
| 1990 | 60 | 580 | 149 |

*PEAK YEAR

TABLE 12
YEARLY TOTALS FOR NESTING PAIRS OF BLACK SKIMMERS.

| | LAVACA BAY | UPPER COAST | CENTRAL COAST |
|---|---|---|---|
| 1973 | 322 | 3515 | 4038 |
| 1974 | 201 | 5875 | 4751* |
| 1975 | 333 | 3923 | 3865 |
| 1976 | 119 | 6353* | 2306 |
| 1977 | 80 | 3027 | 3269 |
| 1978 | 156 | 989 | 1696 |
| 1979 | 284 | 3445 | 2417 |
| 1980 | 480* | 2534 | 2381 |
| 1981 | 445 | 2539 | 1665 |
| 1982 | 293 | 2547 | 1311 |
| 1983 | 202 | 3764 | 913 |
| 1984 | 160 | 3553 | 2318 |
| 1985 | 150 | 3411 | 2006 |
| 1986 | 138 | 2965 | 1235 |
| 1987 | 120 | 2645 | 1243 |
| 1988 | 240 | 3574 | 1424 |
| 1989 | 25 | 3279 | 1031 |
| 1990 | 92 | 4130 | 1033 |

*PEAK YEAR

# APPENDIX A-2

## ALPHABETICAL LISTING OF MUSEUMS CONTACTED

Curator
Angelo State University
Natural History Collection
Dept. of Biology
San Angelo, Texas 76909

Curator
Austin College
Biology Teaching Collection
Dept. of Biology
Sherman, Texas 75090

Curator
Baylor University
G.W. Carroll Collection
Strecker Museum
Waco, Texas 76798

Curator
Dallas Museum of Natural History
DMNH Mammal Collection
Fair Park, P.O. Box 26193
Dallas, Texas 75226

Curator
Davis Mountains State Park
Interpretative Center
Box 786
Fort Davis, Texas 79734

Curator
James Diersing Collection
Star Route
Graford, Texas 76045

Curator
Fort Worth Museum of Science and History
Science and History Collection
1501 Montgomery St.
Fort Worth, Texas 76107

Curator
Hardin-Simmons University
Dept. of Biology
Specimen Collections
Abilene, Texas 79601

Curator
Midwestern State University
Mammal Collections
MSU Collection of Recent Mammals
Wichita Falls, Texas 76308

Curator
North Texas State University
Dept. of Biological Sciences
Specimen Collections
Denton, Texas 76201

Curator
Pan American University
PAU Mammal Collection
Dept. of Biology
Edinburg, Texas 78539

Curator
Panhandle-Plains Historical Museum
Natural History Collections
Box 967 W T Station
Canyon, Texas 79016

Curator
Sam Houston State University
Vertebrate Natural History Collection
Div. of Life Sciences, Geoscience and Geography
Huntsville, Texas 77341

Curator
Southern Methodist University
Specimen Collections
Dept. of Biology
Dallas, Texas

Curator
Stephen F. Austin University
Specimen Collections
Dept. of Biology
Nocogdoches, Texas

Curator
Sul Ross State University
Vertebrate Collection
Dept. of Biology
Alpine, Texas 79832

Curator
Tarleton State University
Tarleton State Collection
Dept. of Biological Science
Stephensville, Texas 76402

Curator
Texas A & I University
Texas A & I Collections
Box 158
Kingsville, Texas 78363

Curator
Texas Memorial Museum-Univ. of Texas
Texas Natural History Collection
2400 Trinity
Austin, Texas 78705

Curator
Texas Memorial Museum-Univ. of Texas
Balcones Research Center
Vertebrate Paleontology Collection
10100 Burnet Road
Austin, Texas 87858

Curator
Texas Tech University
The Museum
P.O. Box 4499
Lubbock, Texas 79409

Curator
Texas Wesleyan College
Museum of Zoology
Fort Worth, Texas 76105

Curator
University of Mary Hardin-Baylor
Collection of Mammals
Dept. of Biology
Belton, Texas 76513

Curator
University of Texas at Arlington
UTA Collection of Vertebrates
Dept. of Biology
Arlington, Texas 76019

Curator
University of Texas at El Paso
Mammal Division
Resource Collections
Laboratory for Environmental Biology
El Paso, Texas 79968

Curator
Wayland University
Llano Estacado Museum
Plainview, Texas 79072

Curator
Welder Wildlife Foundation
P.O. Drawer 1400
Sinton, Texas 78387

Curator
West Texas State University
Dept. of Biology
Canyon, Texas 79016

Curator
Witte Memorial Museum
San Antonio Museum Association
P.O. Box 2601
San Antonio, Texas 78299

Curator
Bird Egg Collection of R.L. More,Sr.
1907 Wilbarger St.
Vernon, Texas 76384

Curator
Brazosport Museum of Natural Science
400 College Drive
Brazosport, Texas 77566

Curator
Caeser Kleberg Wildlife Research Inst.
Texas A & I University
Kingsville, Texas 78363

Curator
Dallas Zoo
Specimen Collection
621 E. Clarendon
Dallas, Texas 75203

Curator
Edith L. Moore Nature Sanctuary
440 Wilchester
Houston Texas 77079

Curator
El Campo Museum
Art History and Natural Science
201 E. Jackson St.
El Campo, Texas 77437

Curator
Houston Museum of Natural Science
1 Hermann Circle Dr.
Houston, Texas 77030

Curator
Houston Zoological Gardens
Specimen Collections
1 Zoo Circle Dr.
Houston, Texas 77030

Curator
R.A. Vines Environmental Science Center
Spring Branch ISD
8856 Westview Dr.
Houston, Texas 77055

Curator
Red Horse Museum
Expressway 83 & Virginia Ave.
Mercedes, Texas 78570

Curator
Sea Rim State Park
S. H. 87
Sabine Pass, Texas 77655

# APPENDIX A-3

## SPECIES LIST OF FISH-EATING BIRD SPECIMENS REQUESTED FROM MUSEUMS

## SPECIES LIST

| COMMON NAME | SCIENTIFIC NAME |
|---|---|
| Great Blue Heron | Ardea herodias |
| Brown Pelican | Pelecanus occidentalis |
| Great Egret | Casmerodius albus |
| Tricolored Heron | Egretta tricolor |
| Double-crested Cormorant | Phalacrocorax auritus |
| Lesser Scaup | Aythya affinis |
| Roseate Spoonbill | Ajaia ajaia |
| Little Blue Heron | Egretta caerulea |
| Black-crowned Night-heron | Nycticorax nycticorax |
| Snowy Egret | Egretta thula |
| Laughing Gull | Larus atricilla |
| Black Skimmer | Rynchops niger |
| Royal Tern | Sterna maxima |
| Least Tern | Sterna artillarum |
| Forster's Tern | Sterns forsteri |

# APPENDIX B-1

# QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance/Quality Control for chemical analyses was provided by the Service's Patuxent Analytical Control Facility (PACF), Patuxent, Maryland. A description of the technique and procedures used are included in the following sections. These procedures followed the guidelines established by the Service's Patuxent Analytical Control Facility, Laurel, Maryland (PACF, 1990). Analysis of the egg and tissue samples for mercury were arranged by PACF and was performed at Geochemical and Environmental Research Group (GERG) of Texas A&M University, College Station, Texas.

Standard chain of custody procedures were followed throughout the handling, preparation, shipping, and analysis of the tissues.

Eggs were refrigerated until immediately prior to processing. The egg and its contents were assigned its own unique catalog number. For the three main study species, this number was made of the prefix CC91 plus the number of the nest from which the egg came, which included the species identifier. Brown pelican eggs and the nine survey species' eggs were numbered with the prefix CC91, an abbreviation of the species, location and a sequential number in order of preparation. All data on each egg were transferred to egg data charts including nest number of each egg (for numbered nests) or species of egg, date of collection, location, date of preparation, and the initials of the preparer. The means of three length and three width measurements (using vernier calipers measuring to 0.01 mm) and weight of each egg (using a Mettler PE-600 electronic balance measuring to 0.01 g) were also recorded.

For harvesting the contents of each egg, preparers wore new, non-sterile latex gloves, and used a new, stainless steel surgical scalpel blade to avoid cross-contamination of eggs. The scalpel was used to score around the equator of the egg until it cracked. The halves of the shell were pried open and the contents were dropped into a tared, certified chemically clean sample jar. The jar and the contents of the egg were then weighed, and the net weight of the contents of the egg was calculated and recorded. Each jar was sealed with a lid, and labeled with the catalog number. The condition of the egg and stage of development of the embryo were noted. Each jar was then frozen and kept locked in a -20°C freezer. Records for all eggs were maintained in a secure area for transferral to chain of custody forms. The numbered egg shells were retained for future investigation.

Brains and livers were dissected from nestling carcasses and preserved or frozen, respectively, as soon as possible to minimize any deterioration or changes associated with death. For collections made in Lavaca Bay or distant reference sites, dissections occurred immediately upon return to the boat launch facility. Birds collected from reference sites near the lab were dissected upon return to the lab. As with the

egg samples, cross-contamination was avoided through the use of new gloves and scalpels for each specimen. All non-disposable instruments used during this procedure were cleaned with a series of washes prior to each dissection: 1) a wash with mild, soapy water, 2) a rinse with tap water, 3) a rinse with hexane, and 4) a final rinse in deionized water.

Livers from nestlings were removed from each carcass and placed in certified chemically clean jars. The jars were labeled with the appropriate collection information and catalog number, and placed on ice for later storage (in 3-4 hours) at -20°C in a secure, locked freezer.

The brains of nestling birds were dissected, placed in clean, appropriately labeled jars, and preserved with a buffered formalin solution. Brains were then maintained in a secure area at the Corpus Christi Field Office until being shipped for examination.

Frozen samples were shipped in ice chests with dry ice. Brains were decanted, wrapped in cheesecloth dampened with formalin and then resealed in the original containers. Shipping was by overnight express by common carrier.

# APPENDIX B-2

## STANDARD LABORATORY PROTOCOL FOR CHEMICAL ANALYSIS

# DIGESTION OF BIOLOGICAL MATERIALS FOR TRACE METAL ANALYSIS

## 1.0 INTRODUCTION

Organisms have a natural background content of all trace metals that can vary widely from place to place. Organisms obtain their trace metals from the sediments and water in which they live and from the food they eat. Water, sediment and food will all vary in trace metal content due to both natural and anthropogenic causes. Furthermore, different species of organisms vary in their ability to take up different metals from the environment. Thus, for example, mussels and oysters living side by side in a given bay will vary greatly in their concentration of Zn, Cu and other metals. Even such factors as age, size, sexual stage and general health can affect the trace metal content of organisms. Of course, organisms can also vary in trace metal content due to variable inputs by man. Abnormal levels of trace metals in organisms may be investigated by examining temporal and geographic distribution patterns in relation to known or suspected sources of pollutant metals, while at the same time considering those factors (age, specie of organism, etc.) which can affect natural variability.

A method is described herein for the preparation of biological tissue samples for trace metal analysis by atomic absorption spectrophotometry. This technique requires that wet, solid samples are converted to a liquid state that can be either aspirated or injected into flame or flameless atomizers. The first step in this procedure involves drying and sample homogenization to reduce inherent variability. Tissue is freeze dried in order to minimize loss of analytes and to facilitate subsequent sample preparation steps, and then homogenized to a fine powder. Approximately 0.20 to 0.25 g of powdered tissue is weighed into a Teflon reaction vessel and 3 ml of $HNO_3$ are added. The closed reaction vessel is heated in a 130°C oven until digestion is complete. Samples are then diluted to a final volume of 20 ml with quartz distilled water and stored in 1 oz. polyethylene bottles for later analysis by atomic absorption techniques.

## 2.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

### 2.1 Sample Collection

Tissue samples are collected in precleaned glass jars or plastic bags, rinsed of excess sediment and frozen in the field.

### 2.2 Sample Preservation and Storage

Tissue samples are stored at -20°C. Samples are shipped frozen to the laboratory and stored at -20°C until subsampled. After subsampling, excess sample is stored at -20°C. Freeze dried subsamples and tissue digests are stored at room temperature.

## 3.0 INTERFERENCES

Method interferences may be caused by trace metal contaminants associated with reagents, reaction vessels, or sample collection hardware that lead to increased metal concentrations in the digest solution. All materials used in this method are routinely demonstrated to be free from added trace metals by processing procedural blanks identical to samples (2 blanks per 30 samples or each batch, whichever is more frequent).

Care is taken in dissecting tissue from benthic organisms. If possible, sediment is rinsed from the shells or exoskeleton prior to thawing and removal of tissue for analysis. Tissue is again rinsed immediately after removal from the shell to dislodge sediment from gills and surface tissues.

Matrix interferences may also be caused by compounds other than the analytes of interest in the tissue matrix. Biogenic materials that cause interferences may result in a deviation from reported values in reference materials of a similar tissue type. Each digestion set (not to exceed 30 samples) contains 2 reference materials of similar tissue type and trace metal concentration. Deviation from reported values indicates matrix problems and analytical conditions are adjusted as necessary to remove interferences.

## 4.0 APPARATUS AND MATERIALS

### 4.1 Labware and Apparatus

Reaction vessels are cleaned first by soaking in detergent (Micro cleaning solution) for 24 hrs and then rinsed with distilled water. They are then soaked in an acid bath (50% $HNO_3$) for 24 hrs, rinsed with distilled deionized water, and air dried in a laminar flow hood in a dust free environment. After drying, the reaction vessels are sealed and stored in a dust free environment. Other plasticware used in sample preparation is either used only a single time (e.g. 1 oz. bottles) or is reused after washing with Micro solution, appropriate acids

(either HCl or $HNO_3$, depending upon resistance to attack), and distilled, deionized water.

The following labware is needed to perform the tissue digestion and dilution procedure:

**Stainless Steel Knife or Shears:** For dissecting animals and removing soft tissue from shells.

**Spex Mill:** To homogenize sample.

**Teflon Beads:** Acid washed.

**Reaction Vessels:** Savillex 50 ml Teflon reaction vessels or equivalent.

**Oven:** Heated to 130°-135°C.

**Disposable Plastic Transfer Pipets:** 1 ml.

**Balance:** Top loading with accuracy of 0.01 g.

**Analytical Balance:** With an accuracy of 0.0001 g.

**Screw Top Bottles:** 1 oz. Nalgene or equivalent.

**Repipet:** To add water for dilution, 10 ml capacity.

**Microliter Pipets:** 1000-, 500-, 300-, 200-, 100-, 50-, 25- and 10 µl capacity.

Note: Microliter pipets must be calibrated.

**4.2 Reagents**

The procedure requires the following:

**Reagent Water:** Reagent water contains no analytes above the method detection limit. Reagent water is produced by subboiling redistillation of water in a quartz still.

**Nitric Acid:** Baker Ultrex Grade or equivalent, stored in Teflon bottle.

## 5.0 PROCEDURES

All tissue samples are freeze dried and mechanically powdered with Teflon beads in a Spex mill prior to digestion.

### 5.1 Preparation of Samples

**5.1.1 Fish:** While still partially frozen, fish are rinsed with distilled water to remove extraneous material. The edible portions of the fish or other target organs are dissected in a clean room under contaminant-free conditions. Sufficient tissue is pooled in a clean mason jar or polystyrene vial and freeze dried.

**5.1.2 Crabs, Sea Urchins, Brittle Stars:** The animals are rinsed with distilled water to remove extraneous material. The tissues of interest are dissected in a clean room under contaminant-free conditions. Sufficient tissue is pooled in a clean mason jar or polystyrene vial and freeze dried.

**5.1.3 Clams, Mussels, and Oysters:** The animals are rinsed with distilled water to remove extraneous material. Bivalves are shucked with a stainless steel knife (using care not to touch the tissue). Tissue is removed with plastic forceps and rinsed to remove sediment particles from gills and exterior tissue surfaces. Sufficient tissue is pooled in a clean mason jar or polystyrene vial and freeze dried.

### 5.2 Digestion and Extraction

**5.2.1** Approximately 0.20 g of dry powdered tissue is weighed and placed in a preweighed Teflon reaction vessel. Three ml of Ultrex $HNO_3$ is added and the lid is replaced loosely. The sample is allowed to react at room temperature for 24 hrs before proceeding.

**5.2.2** Reaction vessel lids are tightened to 18 ft lbs torque and the vessels are placed into a 130°C oven for 3 hrs. The vessels are then removed from the oven, allowed to cool, and opened to vent excess pressure. This step is repeated 3 additional times, or until vessels do not display excessive internal pressure.

**5.2.3** Vessels are retightened and allowed a final heating for 12 hrs. They are then removed from the oven, allowed to cool, and 17 ml of quartz-distilled water are added with a repipet. Vessel lids are retightened and samples are heated for 3 hrs to aid dissolution.

**5.2.4** After cooling, the solution is transfered from the reaction vessels to 1 oz Nalgene sample bottles. Samples are ready to be analyzed by atomic absorption spectrophotometry according to GERG SOP-ST09, ST10, and ST11.

## 6.0 QUALITY CONTROL

Quality control samples are processed in a manner identical to actual samples.

**6.1** Two method blanks are run with every 30 samples or with every sample set, whichever is more frequent. Blank levels should be no more than 2x method detection limit (MDL). If blank levels for any analyte are above the 2x MDL, samples analyzed in that sample set are redigested. If insufficient sample is available, the data are reported with a blank correction and flagged as such.

**6.2** Reference Materials: Tissue reference materials, as closely matching the sample set as available, are run with each sample set. Two different materials are run to maximize the possible interferences seen. Control charts for these analyses are then established. Criteria for reference material performance can be found in GERG SOP-ST09, ST10, and ST11.

## 7.0 REPORTING AND PERFORMANCE

**7.1** Reporting units for trace metals are µg/g (dry weight).

**7.2** Results from sample processing and digestion are used in subsequent analyses, and are expressed as a "digestion dilution factor", having units of ml/g.

**7.3** Trace metal performance standards are determined for each individual analyte and are discussed in GERG SOP-ST09,.ST10, and ST11.

## 8.0 EXAMPLE FORMS

### 8.1 TAMU Inorganic Chemistry Sample Log

# ANALYSIS OF MERCURY BY COLD-VAPOR ATOMIC ABSORPTION

## 1.0 INTRODUCTION

Mercury is analyzed by an atomic absorption procedure that differs from flame and graphite furnace AAS in the technique used to produce a cloud of free analyte atoms. Whereas flame and graphite furnace AAS rely on heat to break chemical bonds and to atomize the elements of interest, the cold vapor mercury method, as developed by Hatch and Ott (1968) takes advantage of elemental mercury's high vapor pressure.

In this procedure, divalent mercury ($Hg^{++}$) in aqueous samples (either water samples or tissue or sediment digests) is reduced to the elemental state ($Hg^{o}$) by a strong reducing agent (stannous chloride). The fraction of $Hg^{o}$ that enters the gas phase is introduced into an atomic absorption cell, where light produced by a separate mercury vapor lamp is absorbed by the free Hg atoms. The amount of mercury in the sample is determined by comparing light absorption of the sample with that of calibration standards.

The quantitative methods described in this document are for the analyses of tissue or sediments prepared according to SOP-ST07 or ST08, respectively. Sample collection, preservation, storage and digestion are described in these documents.

## 2.0 APPARATUS AND LABWARE

### 2.1 Apparatus

#### 2.1.1 Cold Vapor Mercury Analyzer

The cold vapor mercury analyzer used in this laboratory is an LCD Model 1235 uvMonitor equipped with a 30 cm path length absorption cell and operating at the 254 nm wavelength. The instrument is attatched to a Houston Instrument Omniscribe chart recorder operating at 10 mV full scale.

### 2.2 Labware

The following labware is needed to perform the analytical procedure:

**Balance:** Top loading with accuracy of 0.01 g.

**Microliter Pipets:** 1000-, 500-, 300-, 200-, 100-, 50-, 25- and 10 µl capacity.

Note: Microliter pipets must be calibrated.

**Reaction Flasks:** 25 ml glass Erlenmeyer flasks, one required for each analysis.

**Rubber Septum Stoppers:** To seal mouth of 25 ml glass Erlenmeyer flasks.

**Syringe:** Disposible 2 cc plastic syringe, fitted with small-bore needle.

## 3.0 REAGENTS

The procedure requires the following:

**Reagent Water:** Reagent water contains no analytes above the method detection limit. Reagent water is produced by redistilling water in a quartz still.

**Nitric Acid:** Baker Ultrex Grade or equivalent, stored in Teflon bottle.

**Hydrochloric Acid:** Baker Ultrex Grade or equivalent, stored in Teflon bottle or original glass bottle.

**Calibration Standard:** The calibration solution is comprised of a commercially available reference standard diluted in nitric acid. Our experience has shown that almost all tissue and sediment samples can be analyzed with optimum accuracy and precision at the uvMonitor's "0.02" range setting. This produces a near full scale pen deflection for a solution containing 2 ppb Hg. Therefore, serial dilutions of a 1000 ppm Hg stock solution are made with 0.2 M $HNO_3$, using polystyrene snap cap vials as containers. The final working standards (≤ 2ppb) must have a small amount of Ultrex grade HCl added (final concentration ~0.01 M HCl) or the solution will deteriorate within a few hours of preparation.

**Matrix Recovery Spiking Solution:** The matrix spiking solution customarily is the Calibration Standard solution. In cases where addition of a 25% volume will not raise the sample concentration more than 20% another more concentrated solution is needed. The concentration of this solution is determined such that addition of up

to a 25% volume will cause at least a 20% increase in observed concentration with care taken not to exceed the linear range of analysis.

**Stannous Chloride**: A 10% $Sn^{++}$ solution is used to reduce $Hg^{++}$ to $Hg^{o}$. It is made by adding 10 g $SnCl_2$ to 100 ml of 0.5 N $H_2SO_4$. Any Hg contamination can be removed by stirring this solution overnight, allowing $Hg^{o}$ to escape to the atmosphere.

## 4.0 PROCEDURES

All tissue or sediment samples are collected, preserved, stored and digested as described by GERG SOP-ST07 or ST08, respectively.

### 4.1 Operation

Unlike some cold-vapor procedures that involve the use of a gas stream to strip Hg from the reaction vessel, the technique utilized in this laboratory is essentially a "head-space" technique. A small volume of sample or standard solution is introduced to the 25 cc Erlenmeyer flask, and the mouth is sealed with a rubber septum stopper. The $Sn^{++}$ reductant is injected into the flask with the 2 cc plastic syringe, resulting in the reduction of $Hg^{++}$ to $Hg^{o}$, and the flask is swirled to produce an equilibrium distribution of between the solution volume and the head space in the flask. Finally, the flask is connected to the uvMonitor by means of a syringe needle, and a large-bore needle that is connected to a water supply is inserted through the septum and forced to the bottom of the flask. A pinch clamp on the water line is opened, and the water entering the flask forces the head space gas, with its $Hg^{o}$, into the absorption cell.

Operating Steps:

1. Using an Eppendorf pipet, add 1 ml of sample or standard to a clean 25 cc flask.

2. Insert rubber stopper into mouth of flask. Prior to insertion, stopper should have small gauge needle inserted into it to allow air to escape from flask as stopper is inserted. Remove this needle after stopper is in place.

3. Using 2 cc plastic syringe and small gauge needle, inject 10% $SnCl_2$ (three drops) into flask.

4. Swirl flask for 45 seconds to mix solutions and allow exchange of $Hg^{o}$ across the air-water interface.

5. Activate chart recorder.

6. Pierce rubber septum with syringe needle connected to Hg monitor with tygon tubing. Pierce stopper with large gauge needle connected to water supply, and force tip of needle to bottom of flask to minimize turbulence when adding water. Open pinch clamp on water line, and allow water to displace air from the flask until water level is within 0.5 cm of the stopper. Close pinch clamp.

7. Remove needles from stopper. Remove $Hg^0$ from absorption cell with vacuum. When recorder pen returns to baseline, turn recorder off.

8. Quantitate by measuring peak height in millimeters, and compare with calibration standards analyzed with same starting volume.

## 5.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Quality control samples are processed in a manner identical to actual samples.

### 5.1 Method Blanks

Two method blanks are run with every 30 samples or with every sample set, whichever is more frequent.

### 5.2 Reference Materials

Tissue reference materials, as closely matching the sample set as available, are run with each sample set. Two different materials are run to maximize the possible interferences seen. Control charts for these analyses are then established.

### 5.3 Reagent Blanks

New batches of digestion acids ($HNO_3$, HF, $HClO_4$, $H_3BO_3$) and laboratory water supplies (both distilled/deionized and distilled/sub-boiling quartz-distilled) are routinely analyzed to identify sources of contamination before samples are processed.

### 5.4 Matrix Spikes

Possible matrix interferences are investigated by performing matrix spike determinations on the samples. A small volume of a Hg

standard is added to a portion of the sample, which is then analyzed as above. Matrix spike recovery is considered acceptible when it is within 10% of 100%. If the recovery is outside these limits, it is repeated and the reanalysis data is reported if it meets the criterion.

### 5.5 Duplicate Analyses

Duplicate samples are run with every 20 samples or with every sample set. Inhomogeneous samples may result in greater variability between duplicates. Experience has indicated that reference materials are more homogeneous than are samples, and thus comparison of a) reference material duplicate analyses, b) sample duplicate analyses and c) duplicate analyses from single digestion solutions gives an indication of a) total analytical variability (i.e. processing + instrumental variability), b) the sum of analytical variability and natural sample inhomogeneity, and c) instrumental variability.

### 5.5 Recalibration

Calibration standards are rerun after each 20 samples. If these differ from those run earlier by > 5%, they are rerun. If there is still a difference, the system is checked for leaks, partially blocked syringe needles, etc. Our experience has shown the mercury analyzer to be extremely stable, and that sources of sensitivity changes are generally either flow-related (leaks, clogging) or due to either a standard problem (e.g. introduction of only a minute amount of $SnCl_2$ will lead to a significant loss of Hg from the standard) or to a deteriorated $SnCl_2$ solution.

## 6.0 CALCULATIONS

Because elemental mercury is distributed between the aqueous and gas phases, it is important that similar volumes of samples and standards are added to the reaction flasks at the beginning of the procedure. Since there is a limited volume available in the flask, the amount of Hg in the gas phase is dependent upon the total amount of Hg available and on the relative volumes of liquid and air in the flask.

Calculations are based upon measurements of peak height of samples, standards, and blanks, and are based on the following formula:

$$Hg\ (ppm) = [PH_{spl} \times DF_{Hg} - PB] \times slope \times DF_{dig'n} \div 1000$$

where

Hg (ppm) is the final mercury concentration in units of µg Hg per gram dry weight of tissue or sediment,

$PH_{spl}$ is the peak height of the sample, in mm,

$DF_{Hg}$ is the dilution facor needed to dilute samples to a concentration where they can be analyzed on the "0.02" range scale (i.e. to a level ~2 ppb)

Slope is the slope of the calibration curve, with units ppb Hg/mm,

PB is the peak height of the procedural blanks analyzed with the current batch of samples, in mm,

$DF_{dig'n}$ is the dilution factor resulting from digestion of the samples, with units of ml/g.

## 7.0 REPORTING AND PERFORMANCE

### 7.1 Reporting Units

Reporting units are µg/g (dry weight).

### 7.2 Minimum Method Performance Criteria

The minimum method performance standard for the method is dependent upon the dilution factor resulting from digestion of the tissue or sediment sample. Assuming a typical dilution factor of 100 and normal blank levels and instrumental sensitivity, the minimum method performance standard is 0.01 ppm Hg in a sample.

### 7.3 Significant Figures

Results are reported to two (2) significant figures for samples with Hg peaks < 100 mm, and to three (3) significant figures for samples with Hg peaks ≥ 100 mm.

### 7.4 Duplicate Analyses

All duplicate analyses are reported. Duplicate analyses are run at least every 20 samples.

### 7.5 Reference Materials

Reference materials analyzed with the samples are matched as closely as possible to sample composition and expected Hg concentration. Reference materials currently in use include:

Tissue samples:

DORM-1 (NRC, Canada),
DOLT-1 (NRC, Canada), and
MUSSEL No. 6 (NIES, Japan).

Sediment samples:

BCSS-1 (NRC, Canada),
MESS-1 (NRC, Canada),
Estuarine sediment, #1646 (NBS, U.S.), and
HS-2 (TAMU house reference standard).

# QUANTITATIVE DETERMINATION OF CHLORINATED HYDROCARBONS

## 1.0 INTRODUCTION

The quantitative method described in this document determines chlorinated hydrocarbons (e.g. chlorinated pesticides and PCBs) in extracts of biological tissues and sediments. The method is based on high resolution, capillary gas chromatography using electron capture detection (GC/ECD).

Extracts should be prepared as described in GERG SOP's-ST01 and ST02 for biological tissues and sediments, respectively.

Sample collection, preservation, storage and holding times are discussed under the analytical procedures for sample extraction and purification.

## 2.0 APPARATUS AND MATERIALS

A gas chromatograph with a split/splitless injection system, capillary column capability and a electron capture detector (ECD) is utilized.

### 2.1 GC Column

A 30-m long x 0.25-mm I.D. fused silica capillary column with DB-5 bonded phase (J&W Scientific or equivalent) should be used. The column should provide good resolution of chlorinated hydrocarbons, surrogates and internal standards.

### 2.2 Autosampler

The autosampler is capable of making 1-4 µL injections.

## 3.0 REAGENTS

### 3.1 Calibration Solution

The calibration solution is comprised of, at a minimum, the chlorinated hydrocarbons listed in Table 1.

Table 1. Chlorinated Hydrocarbons of Interest.

**Chlorinated Pesticides**

| | | |
|---|---|---|
| Aldrin | Heptachlor Epoxide | o-p' DDT |
| alpha-Chlordane | Hexachlorobenzene | p-p' DDT |
| Dieldrin | Lindane | o-p' DDD |
| Endrin | Mirex | p-p' DDD |
| Heptachlor | Trans-Nonachlor | o-p' DDE |
| | | p-p' DDE |

**Polychlorinated Biphenyls**

| Dichlorobiphenyls | Pentachlorobiphenyls | Heptachlorobiphenyls |
|---|---|---|
| 7* | 100 | 178 |
| 8 | 88 | 187/182 |
| 15 | 92 | 183 |
| | 84 | 185 |
| Trichlorobiphenyls | 101 | 174 |
| 18 | 99 | 177 |
| 24 | 83 | 171 |
| 16/32 | 97 | 172 |
| 26 | 87 | 180 |
| 25 | 85 | 191 |
| 31 | 110 | 170 |
| 28 | 82 | 189 |
| 33 | 107/108 | |
| 22 | 118 | Octachorobiphenyls |
| 37 | 114 | 202 |
| | 105 | 200 |
| Tetrachlorobiphenyls | 126 | 201 |
| 45 | | 196 |
| 46 | Hexachorobiphenyls | 195 |
| 52 | 136 | 194 |
| 49 | 151 | 205 |
| 47/48 | 144 | |
| 44 | 149 | Nonachlorobiphenyls |
| 42 | 146 | 208 |
| 41/64 | 153 | 206 |
| 40 | 141 | |
| 74 | 137 | Decachlorobiphenyls |
| 70 | 138 | 209 |
| 66 | 158 | |
| 60/56 | 129 | |
| 77 | 159 | |
| | 128 | |
| | 167 | |

*PCB number from: Ballschmiter, K. and M. Zell, 1980. Analysis of Polychlorinated Biphenyls (PCB) by Glas Capillary Gas Chromatography. *Freesenius Z. Anal. Chem.*, 302: 20-31.

Calibration standards should be prepared in the concentration range of 5 to 200 ng/ml (at four concentrations) at a minimum. Internal standard and surrogate compounds should be added at 100 ng/ml to all calibration standards.

### 3.2 Surrogate Spiking Solution

The surrogate compounds for all sample types are DBOFB, εHCH, PCB-103, and PCB-198. A surrogate solution is made by weighing an appropriate aliquot of pure material into a volumetric flask and diluting to volume with hexane. Surrogate standards are added to each sample at a concentration of ~10 times the MDL. For higher concentrations of chlorinated hydrocarbons the surrogate standard concentrations are appropriately increased.

### 3.3 Internal Standard Solution

The internal standard for this analysis is TCMX. An internal standard solution is made by weighing an appropriate aliquot of pure material into a volumetric flask and diluting to volume with hexane. Internal standard should be added to each sample extract to obtain a final concentration of approximately 100 ng/ml. For higher concentrations the internal standard concentration is appropriately increased.

### 3.4 Matrix Recovery Spiking Solution

The matrix spiking solution consists of chlorinated pesticides and PCBs listed on Table 1.

The matrix spike is added to samples at a concentration ~10x the MDL. For higher concentrations of oil the matrix spike is appropriately increased.

### 3.5 Retention Index Solution

The calibration mixture is also used as a retention index solution.

## 4.0 PROCEDURE

### 4.1 Sample Extraction and Purification

Tissue samples are extracted and purified following GERG SOP-ST01. Sediment samples are extracted and purified following GERG SOP-ST02.

### 4.2 High Resolution GC-ECD Analysis

#### 4.2.1 GC Conditions

For the analysis of chlorinated hydrocarbons, the analytical system, or its equivalent, should include at a minimum:

| | |
|---|---|
| **Instrument:** | Hewlett-Packard 5880A or Varian 3500 Series |
| **Features:** | Split/splitless capillary inlet system, HP-1000 LAS 3357 data acquisition system |
| **Inlet:** | Splitless |
| **Detector:** | Electron Capture |
| **Column:** | 0.25-mm I.D. x 30-m DB-5 fused silica capillary column (J&W Scientific) |
| **Gases:** | |
| Carrier: | Helium 1 ml/min |
| Make-Up: | Argon/methane (95/5) or Nitrogen, 20 ml/min. |

**Temperatures:**

| | |
|---|---|
| Injection port: | 275°C |
| Detector: | 325°C |
| Oven Program: | 100°C for 1 min., then<br>5°C/min. to140°C, hold 1 min.;<br>1.5°C/min to 250°C, hold 1 min.;<br>10°C/min to 300°C, hold 5 min. |

The GC oven temperature program may be modified to improve resolution.

| | |
|---|---|
| **Calibration:** | Five-point calibration (5 or 20, 40, 80, and 200 ng/ml) |
| **Quantification:** | Internal standard/calibration |

### 4.2.2 Calibration

The GC calibration is performed at a minimum of four concentrations. One of the concentration levels is near, but above the MDL. The remaining concentrations correspond to the expected range of the sample analytes. A concentration range of 5 to 200 ng/ml is recommended. An average calibration factor from the authentic standard of each individual compound is used to calculate sample analyte concentrations. The initial calibration is verified by the measurement of calibration standards after every 6 samples.

A mid-level standard is analyzed immediately prior to conducting any analyses, and after each group of 6 samples. The response factor criteria for an in control calibration check is ±15% on average from the initial calibration and no single analyte should exceed ±25%.

### 4.2.3 Sample Analysis

Chlorinated hydrocarbon analyses are initiated with a calibration check, followed by 6-8 samples, and ending with a calibration check. If the response factor for any analyte in the calibration check fails to meet the criteria established in Section 4.2.2, the instrument is recalibrated. All samples that were injected after the standard exceeded the criteria must be reinjected or recalculated based on the analysts review of the data.

Sample injections of 1 to 4 µL are made with an autosampling device.

If the response for any peak exceeds the highest calibration solution, the extract is diluted and reanalyzed.

#### 4.2.4 Calculations

Concentrations in samples are based on surrogate standards added. All analyte concentrations are calculated from specific surrogates. The internal standard is used to calculate surrogate recoveries.

## 5.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) REQUIREMENTS

### 5.1 Initial Calibration and Continuing Calibration Checks

Prior to the analyses, a five-point calibration curve establishes the response of the detector. The calibration curve is prepared using a non-linear calibration equation of the form:

$$Y = (C_S/C_{IS}) = A * (A_S/A_{IS})^B$$

where:

A = Constant
B = Constant
Cs = Concentration of the analyte to be measured (ng/ml).
Cis = Concentration of the internal standard (ng/ml) (PCB 103).
$A_S$ = Area for the analyte to be measured.
$A_{IS}$ = Area for the internal standard (PCB 103).

For every 6 sample analyses or at least once daily, the calibration for each compound of interest is determined relative to the internal standard and compared to the initial calibration curve. If the average concentration for all analytes is within ±15 percent of the corresponding value, the analysis may proceed. If, for any individual analyte, the daily response factor calculated concentration exceeds ±25 percent of the corresponding value, a five-point calibration curve must be repeated for all compounds prior to the analysis of the samples. All samples are calculated from the initial calibration.

### 5.2 Method Blank Analysis

An acceptable method blank analysis does not contain any target compound at concentration 3 times greater than the MDL. If the method blank does not meet these criteria, the analytical system is out of control and the source of the contamination must be investigated, corrective measures taken, and documented before further sample analysis proceeds.

### 5.3 Surrogate Standards Analysis

All samples and quality control samples are spiked with DBOFB, PCB 103 and PCB 198. The surrogate standard solution will be spiked into the sample prior to extraction to measure individual sample matrix effects associated with sample preparation and analysis.

The laboratory will take corrective action whenever the recovery of DBOFB, PCB 103 and PCB 198 is outside of 40 to 120 percent for sediment and tissue matrices.

The following corrective action will be taken when an out of control event occurs:

a. Calculations are checked to assure that no errors have been made.

b. The surrogate standard solutions are checked for degradation, contamination, etc., and instrument performance is checked.

c. If the surrogate could not be measured because the sample required dilution or only a portion of the sample was analyzed, no corrective action is required. The surrogate recovery is properly annotated.

d. If the steps above fail to reveal a problem, the sample or extract is reanalyzed. If reanalysis of the extract yields surrogate recoveries within the stated limits, then the reanalysis data is reported. If upon reinjection QA criteria are still violated, the sample will be submitted for re-extraction if sufficient sample is available. If the sample was completely consumed, the data will be reported but designated as outside the QA criteria.

## 6.0 CALCULATONS

### 6.1 Chlorinated Hydrocarbon Calculations

All calculations are based on the surrogates added before extraction and purification. The actual sample concentration (C, see section 7.1 for reporting units) for each compound is calculated by the following formula:

$$C = A * (A_S/A_{IS})^{B} * (I_S/S_W)$$

where:

A = Constant
B = Constant
$A_S$ = Area for the analyte to be measured.
$A_{IS}$ = Area for the internal standard (PCB 103).
$I_S$ = Amount of internal standard added to the sample.
$S_W$ = Sample weight.

### 6.2 Calculation Notes

**6.2.1** To each sample, a specific amount of surrogate standard is added. The recovery of this compound is monitored in each sample using the response of the internal standard (GC-IS) (TCMX) that is added to the final extract.

$$\text{Percent recovery} = (R_1 * R_2 / R_3) * (I_{gc} / I_s) * 100$$

where:

$R_1$ = (Analyte peak area / surrogate peak area) in sample.
$R_2$ = (Analyte concentration / I surrogate concentration) in reference.
$R_3$ = (Analyte peak area / I surrogate peak area) in reference.
$I_{gc}$= Amount of internal standard added to sample.
$I_s$ = Amount of internal standard added to sample.

## 7.0 REPORTING

### 7.1 Reporting Units

Data is reported in ng/g dry weight for biological tissues and sediments.

### 7.2 Minimum Method Performance Criteria

The minimum method performance standard for tissues and sediments is 2 ng/g for individual compounds.

### 7.3 Significant Figures

Results are reported to three (3) significant figures.

### 7.4 Surrogate Recovery

Surrogate recoveries are reported for each sample analyzed.

### 7.5 Matrix Spike

Matrix spike recoveries are reported for each batch of samples analyzed.

### 7.6 Reference Materials

When available the results of the analysis of reference materials is reported for each batch of samples analyzed.

Note: The effective minimum performance standard can be adjusted by decreasing final sample volume, increasing sample amount and/or increasing volume injected on the GC-ECD.

# APPENDIX B-3

## LABORATORY REPORT OF MERCURY ANALYSIS OF NESTLING LIVERS AND SAMPLE EGGS OF COLONIAL WATERBIRDS FOR LAVACA BAY AND REFERENCE SITES, SPRING 1991

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B114 | Avian Egg | | 81.5 | | - | F6037 |
| CC91B115 | Avian Egg | | 82.6 | | - | F6038 |
| CC91B116 | Avian Egg | | 83.9 | | - | F6039 |
| CC91B117 | Avian Egg | | 82.2 | | - | F6040 |
| CC91B118 | Avian Egg | | 83. | | - | F6041 |
| CC91B119 | Avian Egg | | 82. | | - | F6042 |
| CC91B12 | Avian Egg | | 81.1 | | - | F6043 |
| CC91B120 | Avian Egg | | 80.4 | | - | F6044 |
| CC91B121 | Avian Egg | | 79.7 | | - | F6045 |
| CC91B122 | Avian Egg | | 81.4 | | - | F6046 |
| CC91B123 | Avian Egg | | 81.8 | | - | F6047 |
| CC91B124 | Avian Egg | | 79.4 | | - | F6048 |
| CC91B125 | Avian Egg | | 77.6 | | - | F6049 |
| CC91B126 | Avian Egg | | 82.8 | | - | F6050 |
| CC91B127 | Avian Egg | | 81.9 | | - | F6051 |
| CC91B128 | Avian Egg | | 75.5 | | - | F6052 |
| CC91B129 | Avian Egg | | 79.5 | | - | F6053 |
| CC91B13 | Avian Egg | | 83.1 | | - | F6054 |
| CC91B130 | Avian Egg | | 80.4 | | - | F6055 |
| CC91B131 | Avian Egg | | 81.7 | | - | F6056 |
| CC91B132 | Avian Egg | | 81.7 | | - | F6057 |
| CC91B134 | Avian Egg | | 81.5 | | - | F6058 |
| CC91B135 | Avian Egg | | 79.4 | | - | F6059 |
| CC91B136 | Avian Egg | | 80.4 | | - | F6060 |
| CC91B137 | Avian Egg | | 82.4 | | - | F6061 |
| CC91B138 | Avian Egg | | 80.8 | | - | F6062 |
| CC91B14 | Avian Egg | | 83.4 | | - | F6063 |
| CC91B141 | Avian Egg | | 80.9 | | - | F6064 |
| CC91B143 | Avian Egg | | 84. | | - | F6065 |
| CC91B148 | Avian Egg | | 66.2 | | - | F6066 |
| CC91B149 | Avian Egg | | 84. | | - | F6067 |
| CC91B15 | Avian Egg | | 82.5 | | - | F6068 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91LT4 | Avian Egg | | 1.13 | 0.273 | 0.052 | F6393 |
| CC91LT5 | Avian Egg | | 1.78 | 0.397 | 0.057 | F6394 |
| CC91LT6 | Avian Egg | | 2.4 | 0.561 | 0.052 | F6395 |
| CC91LT7 | Avian Egg | | 0.794 | 0.186 | 0.054 | F6396 |
| CC91LT8 | Avian Egg | | 0.735 | 0.167 | 0.052 | F6397 |
| CC91LT9 | Avian Egg | | 0.442 | 0.091 | 0.06 | F6398 |
| CC91PP1 | Avian Egg | | 1.37 | 0.21 | 0.076 | F6399 |
| CC91PP10 | Avian Egg | | 2.19 | 0.381 | 0.068 | F6400 |
| CC91PP11 | Avian Egg | | 0.698 | 0.127 | 0.067 | F6401 |
| CC91PP12 | Avian Egg | | 1.62 | 0.356 | 0.053 | F6402 |
| CC91PP13 | Avian Egg | | 1.37 | 0.236 | 0.069 | F6403 |
| CC91PP14 | Avian Egg | | 1.5 | 0.268 | 0.067 | F6404 |
| CC91PP15 | Avian Egg | | 0.833 | 0.157 | 0.062 | F6405 |
| CC91PP16 | Avian Egg | | 2.11 | 0.352 | 0.072 | F6406 |
| CC91PP17 | Avian Egg | | 0.603 | 0.098 | 0.069 | F6407 |
| CC91PP18 | Avian Egg | | 0.823 | 0.133 | 0.071 | F6408 |
| CC91PP19 | Avian Egg | | 1.56 | 0.289 | 0.066 | F6409 |
| CC91PP2 | Avian Egg | | 2.4 | 0.48 | 0.059 | F6410 |
| CC91PP20 | Avian Egg | | 0.95 | 0.148 | 0.08 | F6411 |
| CC91PP21 | Avian Egg | | 0.914 | 0.145 | 0.075 | F6412 |
| CC91PP3 | Avian Egg | | 2.67 | 0.431 | 0.075 | F6413 |
| CC91PP4 | Avian Egg | | 0.975 | 0.19 | 0.06 | F6414 |
| CC91PP5 | Avian Egg | | 2.24 | 0.371 | 0.071 | F6415 |
| CC91PP6 | Avian Egg | | 2.39 | 0.411 | 0.07 | F6416 |
| CC91PP7 | Avian Egg | | 1.31 | 0.771 | 0.02 | F6417 |
| CC91PP8 | Avian Egg | | 1.02 | 0.162 | 0.075 | F6418 |
| CC91PP9 | Avian Egg | | 1.07 | 0.176 | 0.075 | F6419 |
| CC91PS1 | Avian Egg | | 1.4 | 0.212 | 0.077 | F6420 |
| CC91PS10 | Avian Egg | | 1.76 | 0.273 | 0.08 | F6421 |
| CC91PS11 | Avian Egg | | 1.19 | 0.188 | 0.076 | F6422 |
| CC91PS12 | Avian Egg | | 2.36 | 0.379 | 0.076 | F6423 |
| CC91PS13 | Avian Egg | | 1.43 | 0.237 | 0.073 | F6424 |
| CC91PS14 | Avian Egg | | 0.757 | 0.117 | 0.078 | F6425 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B16 | Avian Egg | | 82.3 | | - | F6069 |
| CC91B17 | Avian Egg | | 82.6 | | - | F6070 |
| CC91B18 | Avian Egg | | 79. | | - | F6071 |
| CC91B19 | Avian Egg | | 82.2 | | - | F6072 |
| CC91B2 | Avian Egg | | 81.7 | | - | F6073 |
| CC91B20 | Avian Egg | | 82.2 | | - | F6074 |
| CC91B21 | Avian Egg | | 82.5 | | - | F6075 |
| CC91B22 | Avian Egg | | 82.9 | | - | F6076 |
| CC91B23 | Avian Egg | | 83.2 | | - | F6077 |
| CC91B24 | Avian Egg | | 82.7 | | - | F6078 |
| CC91B25 | Avian Egg | | 84.7 | | - | F6079 |
| CC91B26 | Avian Egg | | 83. | | - | F6080 |
| CC91B27 | Avian Egg | | 84.1 | | - | F6081 |
| CC91B29 | Avian Egg | | 83.1 | | - | F6082 |
| CC91B3 | Avian Egg | | 83.7 | | - | F6083 |
| CC91B30 | Avian Egg | | 84.4 | | - | F6084 |
| CC91B31 | Avian Egg | | 84.5 | | - | F6085 |
| CC91B32 | Avian Egg | | 82.4 | | - | F6086 |
| CC91B32A | Avian Egg | | 88. | | - | F6087 |
| CC91B33 | Avian Egg | | 82. | | - | F6088 |
| CC91B34A | Avian Egg | | 84. | | - | F6089 |
| CC91B35 | Avian Egg | | 80.9 | | - | F6090 |
| CC91B36 | Avian Egg | | 82.6 | | - | F6091 |
| CC91B37 | Avian Egg | | 83.2 | | - | F6092 |
| CC91B38 | Avian Egg | | 82.1 | | - | F6093 |
| CC91B39 | Avian Egg | | 84.3 | | - | F6094 |
| CC91B3A | Avian Egg | | 84.7 | | - | F6095 |
| CC91B4 | Avian Egg | | 84.3 | | - | F6096 |
| CC91B40 | Avian Egg | | 84.6 | | - | F6097 |
| CC91B41 | Avian Egg | | 83.7 | | - | F6098 |
| CC91B42 | Avian Egg | | 81.7 | | - | F6099 |
| CC91B43 | Avian Egg | | 79.3 | | - | F6100 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B44 | Avian Egg | | | 80.2 | - | F6101 |
| CC91B5 | Avian Egg | | | 82.6 | - | F6102 |
| CC91B52 | Avian Egg | | | 81.5 | - | F6103 |
| CC91B54 | Avian Egg | | | 83.9 | - | F6104 |
| CC91B55 | Avian Egg | | | 82.1 | - | F6105 |
| CC91B57 | Avian Egg | | | 82. | - | F6106 |
| CC91B57A | Avian Egg | | | 82.5 | - | F6107 |
| CC91B58 | Avian Egg | | | 81.7 | - | F6108 |
| CC91B59 | Avian Egg | | | 82.1 | - | F6109 |
| CC91B6 | Avian Egg | | | 83.6 | - | F6110 |
| CC91B60 | Avian Egg | | | 82. | - | F6111 |
| CC91B61 | Avian Egg | | | 81.9 | - | F6112 |
| CC91B62 | Avian Egg | | | 81.9 | - | F6113 |
| CC91B63 | Avian Egg | | | 82.3 | - | F6114 |
| CC91B64 | Avian Egg | | | 80.6 | - | F6115 |
| CC91B65 | Avian Egg | | | 83.1 | - | F6116 |
| CC91B66 | Avian Egg | | | 82.2 | - | F6117 |
| CC91B67 | Avian Egg | | | 81.1 | - | F6118 |
| CC91B68 | Avian Egg | | | 15.3 | - | F6119 |
| CC91B69 | Avian Egg | | | 82. | - | F6120 |
| CC91B7 | Avian Egg | | | 80.1 | - | F6121 |
| CC91B70 | Avian Egg | | | 81.9 | - | F6122 |
| CC91B71 | Avian Egg | | | 82.2 | - | F6123 |
| CC91B72 | Avian Egg | | | 83.6 | - | F6124 |
| CC91B73 | Avian Egg | | | 82.2 | - | F6125 |
| CC91B74 | Avian Egg | | | 81. | - | F6126 |
| CC91B75 | Avian Egg | | | 80.8 | - | F6127 |
| CC91B76 | Avian Egg | | | 81.7 | - | F6128 |
| CC91B77 | Avian Egg | | | 81.6 | - | F6129 |
| CC91B78 | Avian Egg | | | 78.3 | - | F6130 |
| CC91B79 | Avian Egg | | | 81.5 | - | F6131 |
| CC91B8 | Avian Egg | | | 82.2 | - | F6132 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B80 | Avian Egg | | | 79.1 | - | F6133 |
| CC91B81 | Avian Egg | | | 81.1 | - | F6134 |
| CC91B82 | Avian Egg | | | 81.9 | - | F6135 |
| CC91B83 | Avian Egg | | | 82.3 | - | F6136 |
| CC91B86 | Avian Egg | | | 80. | - | F6137 |
| CC91B87 | Avian Egg | | | 81.3 | - | F6138 |
| CC91B88 | Avian Egg | | | 81.4 | - | F6139 |
| CC91B89 | Avian Egg | | | 81. | - | F6140 |
| CC91B9 | Avian Egg | | | 81.5 | - | F6141 |
| CC91B90 | Avian Egg | | | 83.1 | - | F6142 |
| CC91B91 | Avian Egg | | | 81.4 | - | F6143 |
| CC91B92 | Avian Egg | | | 82.6 | - | F6144 |
| CC91B93 | Avian Egg | | | 83. | - | F6145 |
| CC91B94 | Avian Egg | | | 82.5 | - | F6146 |
| CC91B95 | Avian Egg | | | 81.5 | - | F6147 |
| CC91B96 | Avian Egg | | | 81.8 | - | F6148 |
| CC91B97 | Avian Egg | | | 82.8 | - | F6149 |
| CC91B98 | Avian Egg | | | 83.4 | - | F6150 |
| CC91B99 | Avian Egg | | | 83.2 | - | F6151 |
| CC91B9A | Avian Egg | | | 81.3 | - | F6152 |
| CC91B9B | Avian Egg | | | 82.1 | - | F6153 |
| CC91BAA | Avian Egg | | | 81.4 | - | F6154 |
| CC91BC1 | Avian Egg | | | 82.2 | - | F6155 |
| CC91BC10 | Avian Egg | | | 78.2 | - | F6156 |
| CC91BC2 | Avian Egg | | | 82.5 | - | F6157 |
| CC91BC3 | Avian Egg | | | 80.7 | - | F6158 |
| CC91BC4 | Avian Egg | | | 81.8 | - | F6159 |
| CC91BC5 | Avian Egg | | | 78.1 | - | F6160 |
| CC91BC6 | Avian Egg | | | 80.6 | - | F6161 |
| CC91BC7 | Avian Egg | | | 75.8 | - | F6162 |
| CC91BC8 | Avian Egg | | | 79.9 | - | F6163 |
| CC91BC9 | Avian Egg | | | 79.6 | - | F6164 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91BS1 | Avian Egg | | 75.5 | | - | F6195 |
| CC91BS10 | Avian Egg | | 76.7 | | - | F6196 |
| CC91BS2 | Avian Egg | | 79.4 | | - | F6197 |
| CC91BS3 | Avian Egg | | 80.2 | | - | F6198 |
| CC91BS4 | Avian Egg | | 79. | | - | F6199 |
| CC91BS5 | Avian Egg | | 77.6 | | - | F6200 |
| CC91BS6 | Avian Egg | | 77.1 | | - | F6201 |
| CC91BS7 | Avian Egg | | 76.9 | | - | F6202 |
| CC91BS8 | Avian Egg | | 77.9 | | - | F6203 |
| CC91BS9 | Avian Egg | | 75.5 | | - | F6204 |
| CC91E1 | Avian Egg | | 79.3 | | - | F6205 |
| CC91E10 | Avian Egg | | 80.8 | | - | F6206 |
| CC91E100 | Avian Egg | | 83.7 | | - | F6207 |
| CC91E101 | Avian Egg | | 82.8 | | - | F6208 |
| CC91E103 | Avian Egg | | 82.2 | | - | F6209 |
| CC91E104 | Avian Egg | | 81.1 | | - | F6210 |
| CC91E106 | Avian Egg | | 80.1 | | - | F6211 |
| CC91E107 | Avian Egg | | 80.7 | | - | F6212 |
| CC91E108 | Avian Egg | | 82.1 | | - | F6213 |
| CC91E109 | Avian Egg | | 80.5 | | - | F6214 |
| CC91E10A | Avian Egg | | 81.2 | | - | F6215 |
| CC91E11 | Avian Egg | | 81.6 | | - | F6216 |
| CC91E110 | Avian Egg | | 83.2 | | - | F6217 |
| CC91E111 | Avian Egg | | 82. | | - | F6218 |
| CC91E112 | Avian Egg | | 82.8 | | - | F6219 |
| CC91E113 | Avian Egg | | 85.8 | | - | F6220 |
| CC91E114 | Avian Egg | | 83.7 | | - | F6221 |
| CC91E115 | Avian Egg | | 82.8 | | - | F6222 |
| CC91E116 | Avian Egg | | 81.4 | | - | F6223 |
| CC91E117 | Avian Egg | | 82.7 | | - | F6224 |
| CC91E118 | Avian Egg | | 82.7 | | - | F6225 |
| CC91E119 | Avian Egg | | 84.2 | | - | F6226 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91E12 | Avian Egg | | | 79.4 | - | F6227 |
| CC91E120 | Avian Egg | | | 83.2 | - | F6228 |
| CC91E121 | Avian Egg | | | 84.3 | - | F6229 |
| CC91E122 | Avian Egg | | | 81.1 | - | F6230 |
| CC91E123 | Avian Egg | | | 80. | - | F6231 |
| CC91E124 | Avian Egg | | | 81.6 | - | F6232 |
| CC91E125 | Avian Egg | | | 78.8 | - | F6233 |
| CC91E126 | Avian Egg | | | 82.9 | - | F6234 |
| CC91E128 | Avian Egg | | | 81.1 | - | F6235 |
| CC91E13 | Avian Egg | | | 80.2 | - | F6236 |
| CC91E130 | Avian Egg | | | 81.6 | - | F6237 |
| CC91E14 | Avian Egg | | | 81.1 | - | F6238 |
| CC91E142 | Avian Egg | | | 81. | - | F6239 |
| CC91E144 | Avian Egg | | | 80.1 | - | F6240 |
| CC91E14A | Avian Egg | | | 80.7 | - | F6241 |
| CC91E14B | Avian Egg | | | 80.9 | - | F6242 |
| CC91E15 | Avian Egg | | | 79.9 | - | F6243 |
| CC91E15A | Avian Egg | | | 80.3 | - | F6244 |
| CC91E16 | Avian Egg | | | 80. | - | F6245 |
| CC91E17 | Avian Egg | | | 80. | - | F6246 |
| CC91E18 | Avian Egg | | | 81.4 | - | F6247 |
| CC91E19 | Avian Egg | | | 80.6 | - | F6248 |
| CC91E2 | Avian Egg | | | 81.7 | - | F6249 |
| CC91E20 | Avian Egg | | | 82.1 | - | F6250 |
| CC91E21 | Avian Egg | | | 81.4 | - | F6251 |
| CC91E22 | Avian Egg | | | 81.3 | - | F6252 |
| CC91E23 | Avian Egg | | | 80.8 | - | F6253 |
| CC91E23A | Avian Egg | | | 82.2 | - | F6254 |
| CC91E24A | Avian Egg | | | 81.7 | - | F6255 |
| CC91E25A | Avian Egg | | | 81.8 | - | F6256 |
| CC91E26A | Avian Egg | | | 81.1 | - | F6257 |
| CC91E27A | Avian Egg | | | 82.9 | - | F6258 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91E28A | Avian Egg | | | 80.5 | - | F6259 |
| CC91E29A | Avian Egg | | | 81.6 | - | F6260 |
| CC91E2A | Avian Egg | | | 80.1 | - | F6261 |
| CC91E3 | Avian Egg | | | 79.5 | - | F6262 |
| CC91E30A | Avian Egg | | | 81.4 | - | F6263 |
| CC91E31 | Avian Egg | | | 81.1 | - | F6264 |
| CC91E31A | Avian Egg | | | 81.2 | - | F6265 |
| CC91E32 | Avian Egg | | | 80.2 | - | F6266 |
| CC91E32A | Avian Egg | | | 78.7 | - | F6267 |
| CC91E33 | Avian Egg | | | 81.6 | - | F6268 |
| CC91E33A | Avian Egg | | | 81.2 | - | F6269 |
| CC91E33B | Avian Egg | | | 82.4 | - | F6270 |
| CC91E34 | Avian Egg | | | 81.9 | - | F6271 |
| CC91E35 | Avian Egg | | | 81.2 | - | F6272 |
| CC91E36 | Avian Egg | | | 81.4 | - | F6273 |
| CC91E37 | Avian Egg | | | 81.2 | - | F6274 |
| CC91E38 | Avian Egg | | | 81.7 | - | F6275 |
| CC91E39 | Avian Egg | | | 81.4 | - | F6276 |
| CC91E4 | Avian Egg | | | 79.5 | - | F6277 |
| CC91E40 | Avian Egg | | | 81.8 | - | F6278 |
| CC91E41 | Avian Egg | | | 81.8 | - | F6279 |
| CC91E42 | Avian Egg | | | 82.5 | - | F6280 |
| CC91E43 | Avian Egg | | | 81.6 | - | F6281 |
| CC91E44 | Avian Egg | | | 81.5 | - | F6282 |
| CC91E45 | Avian Egg | | | 80.8 | - | F6283 |
| CC91E5 | Avian Egg | | | 81.9 | - | F6284 |
| CC91E51 | Avian Egg | | | 83.2 | - | F6285 |
| CC91E52 | Avian Egg | | | 82.3 | - | F6286 |
| CC91E53 | Avian Egg | | | 83.3 | - | F6287 |
| CC91E54 | Avian Egg | | | 82.6 | - | F6288 |
| CC91E55 | Avian Egg | | | 82.6 | - | F6289 |
| CC91E56 | Avian Egg | | | 83.2 | - | F6290 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91E57 | Avian Egg | | | 82.6 | - | F6291 |
| CC91E58 | Avian Egg | | | 82.3 | - | F6292 |
| CC91E59 | Avian Egg | | | 83.2 | - | F6293 |
| CC91E6 | Avian Egg | | | 83.3 | - | F6294 |
| CC91E60 | Avian Egg | | | 81.8 | - | F6295 |
| CC91E61 | Avian Egg | | | 83. | - | F6296 |
| CC91E62 | Avian Egg | | | 81.8 | - | F6297 |
| CC91E63 | Avian Egg | | | 82.2 | - | F6298 |
| CC91E64 | Avian Egg | | | 82.8 | - | F6299 |
| CC91E65 | Avian Egg | | | 83.5 | - | F6300 |
| CC91E66 | Avian Egg | | | 84.5 | - | F6301 |
| CC91E66A | Avian Egg | | | 82.2 | - | F6302 |
| CC91E67 | Avian Egg | | | 82.3 | - | F6303 |
| CC91E68 | Avian Egg | | | 81.1 | - | F6304 |
| CC91E69 | Avian Egg | | | 82.1 | - | F6305 |
| CC91E6A | Avian Egg | | | 78. | - | F6306 |
| CC91E7 | Avian Egg | | | 81.2 | - | F6307 |
| CC91E70 | Avian Egg | | | 82.5 | - | F6308 |
| CC91E71 | Avian Egg | | | 80.9 | - | F6309 |
| CC91E72 | Avian Egg | | | 81.1 | - | F6310 |
| CC91E72A | Avian Egg | | | 81.5 | - | F6311 |
| CC91E73 | Avian Egg | | | 81.2 | - | F6312 |
| CC91E74 | Avian Egg | | | 82. | - | F6313 |
| CC91E75 | Avian Egg | | | 81.1 | - | F6314 |
| CC91E76 | Avian Egg | | | 80.3 | - | F6315 |
| CC91E77 | Avian Egg | | | 81.5 | - | F6316 |
| CC91E78 | Avian Egg | | | 82.1 | - | F6317 |
| CC91E79 | Avian Egg | | | 82.3 | - | F6318 |
| CC91E8 | Avian Egg | | | 82. | - | F6319 |
| CC91E80 | Avian Egg | | | 81.7 | - | F6320 |
| CC91E81 | Avian Egg | | | 81.7 | - | F6321 |
| CC91E82 | Avian Egg | | | 81.7 | - | F6322 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91E83 | Avian Egg | | | 82. | - | F6323 |
| CC91E84 | Avian Egg | | | 81.2 | - | F6324 |
| CC91E85 | Avian Egg | | | 82.1 | - | F6325 |
| CC91E86 | Avian Egg | | | 82.3 | - | F6326 |
| CC91E87 | Avian Egg | | | 80.2 | - | F6327 |
| CC91E88 | Avian Egg | | | 81.5 | - | F6328 |
| CC91E89 | Avian Egg | | | 81.5 | - | F6329 |
| CC91E9 | Avian Egg | | | 78.4 | - | F6330 |
| CC91E90 | Avian Egg | | | 82.9 | - | F6331 |
| CC91E91 | Avian Egg | | | 81.5 | - | F6332 |
| CC91F1 | Avian Egg | | | 77.3 | - | F6359 |
| CC91F10 | Avian Egg | | | 78. | - | F6360 |
| CC91F2 | Avian Egg | | | 71.1 | - | F6361 |
| CC91F3 | Avian Egg | | | 78.2 | - | F6362 |
| CC91F4 | Avian Egg | | | 78.3 | - | F6363 |
| CC91F5 | Avian Egg | | | 77.8 | - | F6364 |
| CC91F6 | Avian Egg | | | 79.8 | - | F6365 |
| CC91F7 | Avian Egg | | | 77.9 | - | F6366 |
| CC91F8 | Avian Egg | | | 79.7 | - | F6367 |
| CC91F9 | Avian Egg | | | 78.7 | - | F6368 |
| CC91LB1 | Avian Egg | | | 82.9 | - | F6369 |
| CC91LB10 | Avian Egg | | | 83.5 | - | F6370 |
| CC91LB2 | Avian Egg | | | 84.6 | - | F6371 |
| CC91LB3 | Avian Egg | | | 81.6 | - | F6372 |
| CC91LB4 | Avian Egg | | | 80.9 | - | F6373 |
| CC91LB5 | Avian Egg | | | 81.8 | - | F6374 |
| CC91LB6 | Avian Egg | | | 80.7 | - | F6375 |
| CC91LB7 | Avian Egg | | | 81.3 | - | F6376 |
| CC91LB8 | Avian Egg | | | 81.3 | - | F6377 |
| CC91LB9 | Avian Egg | | | 83. | - | F6378 |
| CC91LG1 | Avian Egg | | | 73.9 | - | F6379 |
| CC91LG11 | Avian Egg | | | 74.1 | - | F6380 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91LG12 | Avian Egg | | | 77. | - | F6381 |
| CC91LG13 | Avian Egg | | | 77.7 | - | F6382 |
| CC91LG14 | Avian Egg | | | 75.8 | - | F6383 |
| CC91LG15 | Avian Egg | | | 74. | - | F6384 |
| CC91LG2 | Avian Egg | | | 74.7 | - | F6385 |
| CC91LG3 | Avian Egg | | | 76. | - | F6386 |
| CC91LG4 | Avian Egg | | | 76.3 | - | F6387 |
| CC91LG5 | Avian Egg | | | 76.3 | - | F6388 |
| CC91LT10 | Avian Egg | | | 78.5 | - | F6389 |
| CC91LT11 | Avian Egg | | | 77.9 | - | F6390 |
| CC91LT2 | Avian Egg | | | 75.2 | - | F6391 |
| CC91LT3 | Avian Egg | | | 75.9 | - | F6392 |
| CC91LT4 | Avian Egg | | | 75.9 | - | F6393 |
| CC91LT5 | Avian Egg | | | 77.6 | - | F6394 |
| CC91LT6 | Avian Egg | | | 76.6 | - | F6395 |
| CC91LT7 | Avian Egg | | | 76.5 | - | F6396 |
| CC91LT8 | Avian Egg | | | 77.2 | - | F6397 |
| CC91LT9 | Avian Egg | | | 79.4 | - | F6398 |
| CC91PP1 | Avian Egg | | | 84.6 | - | F6399 |
| CC91PP10 | Avian Egg | | | 82.6 | - | F6400 |
| CC91PP11 | Avian Egg | | | 81.7 | - | F6401 |
| CC91PP12 | Avian Egg | | | 78. | - | F6402 |
| CC91PP13 | Avian Egg | | | 82.8 | - | F6403 |
| CC91PP14 | Avian Egg | | | 82.1 | - | F6404 |
| CC91PP15 | Avian Egg | | | 81.1 | - | F6405 |
| CC91PP16 | Avian Egg | | | 83.3 | - | F6406 |
| CC91PP17 | Avian Egg | | | 83.7 | - | F6407 |
| CC91PP18 | Avian Egg | | | 83.8 | - | F6408 |
| CC91PP19 | Avian Egg | | | 81.4 | - | F6409 |
| CC91PP2 | Avian Egg | | | 80. | - | F6410 |
| CC91PP20 | Avian Egg | | | 84.4 | - | F6411 |
| CC91PP21 | Avian Egg | | | 84. | - | F6412 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91PP3 | Avian Egg | | | 83.8 | - | F6413 |
| CC91PP4 | Avian Egg | | | 80.5 | - | F6414 |
| CC91PP5 | Avian Egg | | | 83.4 | - | F6415 |
| CC91PP6 | Avian Egg | | | 82.8 | - | F6416 |
| CC91PP7 | Avian Egg | | | 40.9 | - | F6417 |
| CC91PP8 | Avian Egg | | | 84. | - | F6418 |
| CC91PP9 | Avian Egg | | | 83.5 | - | F6419 |
| CC91PS1 | Avian Egg | | | 84.9 | - | F6420 |
| CC91PS10 | Avian Egg | | | 84.5 | - | F6421 |
| CC91PS11 | Avian Egg | | | 84.2 | - | F6422 |
| CC91PS12 | Avian Egg | | | 83.9 | - | F6423 |
| CC91PS13 | Avian Egg | | | 83.4 | - | F6424 |
| CC91PS14 | Avian Egg | | | 84.4 | - | F6425 |
| CC91PS15 | Avian Egg | | | 84.3 | - | F6426 |
| CC91PS16 | Avian Egg | | | 81.6 | - | F6427 |
| CC91PS17 | Avian Egg | | | 81.6 | - | F6428 |
| CC91PS18 | Avian Egg | | | 82.8 | - | F6429 |
| CC91PS19 | Avian Egg | | | 82. | - | F6430 |
| CC91PS2 | Avian Egg | | | 83.4 | - | F6431 |
| CC91PS20 | Avian Egg | | | 83.6 | - | F6432 |
| CC91PS21 | Avian Egg | | | 82.7 | - | F6433 |
| CC91PS22 | Avian Egg | | | 83.2 | - | F6434 |
| CC91PS23 | Avian Egg | | | 82.7 | - | F6435 |
| CC91PS24 | Avian Egg | | | 82.3 | - | F6436 |
| CC91PS25 | Avian Egg | | | 82.9 | - | F6437 |
| CC91PS26 | Avian Egg | | | 80.7 | - | F6438 |
| CC91PS27 | Avian Egg | | | 82.8 | - | F6439 |
| CC91PS28 | Avian Egg | | | 80.6 | - | F6440 |
| CC91PS29 | Avian Egg | | | 81.8 | - | F6441 |
| CC91PS3 | Avian Egg | | | 84. | - | F6442 |
| CC91PS30 | Avian Egg | | | 80.8 | - | F6443 |
| CC91PS31 | Avian Egg | | | 83.2 | - | F6444 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91PS32 | Avian Egg | | | 83.3 | - | F6445 |
| CC91PS33 | Avian Egg | | | 83.1 | - | F6446 |
| CC91PS34 | Avian Egg | | | 84.7 | - | F6447 |
| CC91PS35 | Avian Egg | | | 82.2 | - | F6448 |
| CC91PS36 | Avian Egg | | | 82.2 | - | F6449 |
| CC91PS37 | Avian Egg | | | 82.6 | - | F6450 |
| CC91PS38 | Avian Egg | | | 83.8 | - | F6451 |
| CC91PS39 | Avian Egg | | | 82.4 | - | F6452 |
| CC91PS4 | Avian Egg | | | 84. | - | F6453 |
| CC91PS40 | Avian Egg | | | 82.7 | - | F6454 |
| CC91PS41 | Avian Egg | | | 82.3 | - | F6455 |
| CC91PS42 | Avian Egg | | | 83. | - | F6456 |
| CC91PS43 | Avian Egg | | | 83. | - | F6457 |
| CC91PS44 | Avian Egg | | | 79.5 | - | F6458 |
| CC91PS45 | Avian Egg | | | 82.4 | - | F6459 |
| CC91PS46 | Avian Egg | | | 83. | - | F6460 |
| CC91PS47 | Avian Egg | | | 81.9 | - | F6461 |
| CC91PS5 | Avian Egg | | | 83.9 | - | F6462 |
| CC91PS6 | Avian Egg | | | 83.2 | - | F6463 |
| CC91PS7 | Avian Egg | | | 83.2 | - | F6464 |
| CC91PS8 | Avian Egg | | | 81.5 | - | F6465 |
| CC91PS9 | Avian Egg | | | 81.5 | - | F6466 |
| CC91RS1 | Avian Egg | | | 80.2 | - | F6467 |
| CC91RS2 | Avian Egg | | | 82.5 | - | F6468 |
| CC91RS3 | Avian Egg | | | 81.2 | - | F6469 |
| CC91RS4 | Avian Egg | | | 82.3 | - | F6470 |
| CC91RS5 | Avian Egg | | | 83.6 | - | F6471 |
| CC91RS6 | Avian Egg | | | 79.4 | - | F6472 |
| CC91RS7 | Avian Egg | | | 83.2 | - | F6473 |
| CC91RS8 | Avian Egg | | | 81.2 | - | F6474 |
| CC91RS9 | Avian Egg | | | 79.2 | - | F6475 |
| CC91RT1 | Avian Egg | | | 75.4 | - | F6476 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91RT11 | Avian Egg | | | 75.7 | - | F6477 |
| CC91RT12 | Avian Egg | | | 75.1 | - | F6478 |
| CC91RT13 | Avian Egg | | | 75.4 | - | F6479 |
| CC91RT14 | Avian Egg | | | 74. | - | F6480 |
| CC91RT15 | Avian Egg | | | 74. | - | F6481 |
| CC91RT2 | Avian Egg | | | 77. | - | F6482 |
| CC91RT3 | Avian Egg | | | 75.8 | - | F6483 |
| CC91RT4 | Avian Egg | | | 75.4 | - | F6484 |
| CC91RT5 | Avian Egg | | | 74.2 | - | F6485 |
| CC91SE1 | Avian Egg | | | 81.7 | - | F6486 |
| CC91SE10 | Avian Egg | | | 84.2 | - | F6487 |
| CC91SE2 | Avian Egg | | | 81.8 | - | F6488 |
| CC91SE3 | Avian Egg | | | 83. | - | F6489 |
| CC91SE4 | Avian Egg | | | 83.7 | - | F6490 |
| CC91SE5 | Avian Egg | | | 78.1 | - | F6491 |
| CC91SE6 | Avian Egg | | | 84. | - | F6492 |
| CC91SE7 | Avian Egg | | | 84.9 | - | F6493 |
| CC91SE8 | Avian Egg | | | 81.2 | - | F6494 |
| CC91SE9 | Avian Egg | | | 83.6 | - | F6495 |
| CC91T1 | Avian Egg | | | 82.4 | - | F6496 |
| CC91T10 | Avian Egg | | | 82. | - | F6497 |
| CC91T11 | Avian Egg | | | 78.8 | - | F6498 |
| CC91T11A | Avian Egg | | | 82.1 | - | F6499 |
| CC91T11B | Avian Egg | | | 81.9 | - | F6500 |
| CC91T12 | Avian Egg | | | 79.7 | - | F6501 |
| CC91T13 | Avian Egg | | | 79.2 | - | F6502 |
| CC91T13A | Avian Egg | | | 81.6 | - | F6503 |
| CC91T13B | Avian Egg | | | 80.6 | - | F6504 |
| CC91T14 | Avian Egg | | | 82.8 | - | F6505 |
| CC91T15A | Avian Egg | | | 84.1 | - | F6506 |
| CC91T16 | Avian Egg | | | 83.7 | - | F6507 |
| CC91T16A | Avian Egg | | | 82.5 | - | F6508 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91T17 | Avian Egg | | | 81.4 | - | F6509 |
| CC91T17A | Avian Egg | | | 81.8 | - | F6510 |
| CC91T18 | Avian Egg | | | 84.3 | - | F6511 |
| CC91T18A | Avian Egg | | | 83.3 | - | F6512 |
| CC91T19 | Avian Egg | | | 82.9 | - | F6513 |
| CC91T20 | Avian Egg | | | 84.3 | - | F6514 |
| CC91T21 | Avian Egg | | | 77.9 | - | F6515 |
| CC91T21A | Avian Egg | | | 81.9 | - | F6516 |
| CC91T22 | Avian Egg | | | 83.8 | - | F6517 |
| CC91T23 | Avian Egg | | | 81. | - | F6518 |
| CC91T23A | Avian Egg | | | 81.4 | - | F6519 |
| CC91T24 | Avian Egg | | | 81.7 | - | F6520 |
| CC91T25 | Avian Egg | | | 84.8 | - | F6521 |
| CC91T26 | Avian Egg | | | 81.8 | - | F6522 |
| CC91T27 | Avian Egg | | | 82.8 | - | F6523 |
| CC91T27A | Avian Egg | | | 78.5 | - | F6524 |
| CC91T28 | Avian Egg | | | 80.8 | - | F6525 |
| CC91T29 | Avian Egg | | | 81.6 | - | F6526 |
| CC91T29A | Avian Egg | | | 82. | - | F6527 |
| CC91T2A | Avian Egg | | | 81.4 | - | F6528 |
| CC91T3 | Avian Egg | | | 79.5 | - | F6529 |
| CC91T30 | Avian Egg | | | 81.2 | - | F6530 |
| CC91T31 | Avian Egg | | | 81.3 | - | F6531 |
| CC91T32 | Avian Egg | | | 80.7 | - | F6532 |
| CC91T33 | Avian Egg | | | 82.7 | - | F6533 |
| CC91T33A | Avian Egg | | | 81. | - | F6534 |
| CC91T34 | Avian Egg | | | 81.8 | - | F6535 |
| CC91T34A | Avian Egg | | | 83.3 | - | F6536 |
| CC91T35 | Avian Egg | | | 82.6 | - | F6537 |
| CC91T36 | Avian Egg | | | 82.8 | - | F6538 |
| CC91T36A | Avian Egg | | | 82.6 | - | F6539 |
| CC91T37 | Avian Egg | | | 81.3 | - | F6540 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91T38 | Avian Egg | | 81.4 | | - | F6541 |
| CC91T39 | Avian Egg | | 82.9 | | - | F6542 |
| CC91T3A | Avian Egg | | 83.7 | | - | F6543 |
| CC91T3B | Avian Egg | | 82.3 | | - | F6544 |
| CC91T4 | Avian Egg | | 82. | | - | F6545 |
| CC91T42 | Avian Egg | | 82.2 | | - | F6546 |
| CC91T43 | Avian Egg | | 81.1 | | - | F6547 |
| CC91T44 | Avian Egg | | 82.5 | | - | F6548 |
| CC91T45 | Avian Egg | | 79.2 | | - | F6549 |
| CC91T45X | Avian Egg | | 82.8 | | - | F6550 |
| CC91T46 | Avian Egg | | 83.5 | | - | F6551 |
| CC91T47 | Avian Egg | | 84.4 | | - | F6552 |
| CC91T47A | Avian Egg | | 82.5 | | - | F6553 |
| CC91T48 | Avian Egg | | 83.7 | | - | F6554 |
| CC91T48A | Avian Egg | | 83.5 | | - | F6555 |
| CC91T49 | Avian Egg | | 84.1 | | - | F6556 |
| CC91T51 | Avian Egg | | 82.9 | | - | F6557 |
| CC91T54 | Avian Egg | | 83. | | - | F6558 |
| CC91T55 | Avian Egg | | 81.9 | | - | F6559 |
| CC91T56 | Avian Egg | | 78.7 | | - | F6560 |
| CC91T57 | Avian Egg | | 82.2 | | - | F6561 |
| CC91T58 | Avian Egg | | 80.8 | | - | F6562 |
| CC91T59 | Avian Egg | | 81.5 | | - | F6563 |
| CC91T5A | Avian Egg | | 82.9 | | - | F6564 |
| CC91T6 | Avian Egg | | 81.2 | | - | F6565 |
| CC91T60 | Avian Egg | | 80.6 | | - | F6566 |
| CC91T61 | Avian Egg | | 81.3 | | - | F6567 |
| CC91T62 | Avian Egg | | 80.5 | | - | F6568 |
| CC91T63A | Avian Egg | | 82.1 | | - | F6569 |
| CC91T64 | Avian Egg | | 81.1 | | - | F6570 |
| CC91T65 | Avian Egg | | 83.1 | | - | F6571 |
| CC91T66 | Avian Egg | | 82.4 | | - | F6572 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91T67 | Avian Egg | | | 83.7 | - | F6573 |
| CC91T67A | Avian Egg | | | 82.1 | - | F6574 |
| CC91T68 | Avian Egg | | | 80.1 | - | F6575 |
| CC91T69 | Avian Egg | | | 78.9 | - | F6576 |
| CC91T7 | Avian Egg | | | 81.6 | - | F6577 |
| CC91T70 | Avian Egg | | | 64.4 | - | F6578 |
| CC91T71 | Avian Egg | | | 80.6 | - | F6579 |
| CC91T72 | Avian Egg | | | 82.7 | - | F6580 |
| CC91T73 | Avian Egg | | | 79.6 | - | F6581 |
| CC91T74 | Avian Egg | | | 82.4 | - | F6582 |
| CC91T75 | Avian Egg | | | 82.2 | - | F6583 |
| CC91T76 | Avian Egg | | | 79.6 | - | F6584 |
| CC91T77 | Avian Egg | | | 80.7 | - | F6585 |
| CC91T79 | Avian Egg | | | 80.9 | - | F6586 |
| CC91T8 | Avian Egg | | | 82.3 | - | F6587 |
| CC91T81 | Avian Egg | | | 81.5 | - | F6588 |
| CC91T83 | Avian Egg | | | 79.3 | - | F6589 |
| CC91T84 | Avian Egg | | | 80.3 | - | F6590 |
| CC91T85 | Avian Egg | | | 81.6 | - | F6591 |
| CC91T86 | Avian Egg | | | 80.4 | - | F6592 |
| CC91T88 | Avian Egg | | | 81. | - | F6593 |
| CC91T89 | Avian Egg | | | 81.2 | - | F6594 |
| CC91T91 | Avian Egg | | | 80.6 | - | F6595 |
| CC91T91A | Avian Egg | | | 82.6 | - | F6596 |
| CC91T93 | Avian Egg | | | 83.7 | - | F6597 |
| CC91T94 | Avian Egg | | | 82.7 | - | F6598 |
| CC91T95 | Avian Egg | | | 83.8 | - | F6599 |
| CC91T97 | Avian Egg | | | 84.4 | - | F6600 |
| CC91T9B | Avian Egg | | | 82.3 | - | F6601 |
| CC91TAA | Avian Egg | | | 81.5 | - | F6602 |
| CC91TBB | Avian Egg | | | 83.1 | - | F6603 |
| CC91TCCA | Avian Egg | | | 81.8 | - | F6604 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91TDD | Avian Egg | | 81.2 | | - | F6605 |
| CC91TEE | Avian Egg | | 81.4 | | - | F6606 |
| CC91TFF | Avian Egg | | 81.8 | | - | F6607 |
| CC91TGG | Avian Egg | | 78.5 | | - | F6608 |
| CC91THH | Avian Egg | | 80.9 | | - | F6609 |
| CC91TLL | Avian Egg | | 81.4 | | - | F6631 |
| CC91BL04 | Kidney | | 84.5 | | - | F6168 |
| CC91BL07 | Kidney | | 85.3 | | - | F6171 |
| CC91BL01 | Liver | | 78.7 | | - | F6165 |
| CC91BL02 | Liver | | 81.3 | | - | F6166 |
| CC91BL03 | Liver | | 79.4 | | - | F6167 |
| CC91BL05 | Liver | | 77.9 | | - | F6169 |
| CC91BL06 | Liver | | 80.7 | | - | F6170 |
| CC91BL09 | Liver | | 83.8 | | - | F6172 |
| CC91BL10 | Liver | | 81.3 | | - | F6173 |
| CC91BL11 | Liver | | 80.7 | | - | F6174 |
| CC91BL12 | Liver | | 76.9 | | - | F6175 |
| CC91BL13 | Liver | | 78.4 | | - | F6176 |
| CC91BL14 | Liver | | 78.6 | | - | F6177 |
| CC91BL15 | Liver | | 79.2 | | - | F6178 |
| CC91BL16 | Liver | | 76.8 | | - | F6179 |
| CC91BL17 | Liver | | 74.8 | | - | F6180 |
| CC91BL18 | Liver | | 80.3 | | - | F6181 |
| CC91BL19 | Liver | | 84.3 | | - | F6182 |
| CC91BL20 | Liver | | 79.3 | | - | F6183 |
| CC91BL21 | Liver | | 81.1 | | - | F6184 |
| CC91BL22 | Liver | | 77.7 | | - | F6185 |
| CC91BL23 | Liver | | 74.4 | | - | F6186 |
| CC91BL24 | Liver | | 78.9 | | - | F6187 |
| CC91BL25 | Liver | | 81. | | - | F6188 |
| CC91BL26 | Liver | | 80.5 | | - | F6189 |
| CC91BL27 | Liver | | 79.5 | | - | F6190 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91BL28 | Liver | | 78.9 | | - | F6191 |
| CC91BL29 | Liver | | 80.7 | | - | F6192 |
| CC91BL30 | Liver | | 81.5 | | - | F6193 |
| CC91BL31 | Liver | | 81.5 | | - | F6194 |
| CC91EL01 | Liver | | 80.2 | | - | F6333 |
| CC91EL02 | Liver | | 80.2 | | - | F6334 |
| CC91EL03 | Liver | | 83. | | - | F6335 |
| CC91EL04 | Liver | | 75.1 | | - | F6336 |
| CC91EL05 | Liver | | 82.9 | | - | F6337 |
| CC91EL06 | Liver | | 77.2 | | - | F6338 |
| CC91EL07 | Liver | | 81.5 | | - | F6339 |
| CC91EL08 | Liver | | 81.3 | | - | F6340 |
| CC91EL09 | Liver | | 79.7 | | - | F6341 |
| CC91EL10 | Liver | | 78.3 | | - | F6342 |
| CC91EL11 | Liver | | 77.6 | | - | F6343 |
| CC91EL12 | Liver | | 74.5 | | - | F6344 |
| CC91EL13 | Liver | | 78.4 | | - | F6345 |
| CC91EL14 | Liver | | 79.8 | | - | F6346 |
| CC91EL15 | Liver | | 78.9 | | - | F6347 |
| CC91EL16 | Liver | | 81.5 | | - | F6348 |
| CC91EL17 | Liver | | 77.3 | | - | F6349 |
| CC91EL18 | Liver | | 74.9 | | - | F6350 |
| CC91EL21 | Liver | | 74. | | - | F6351 |
| CC91EL22 | Liver | | 77.8 | | - | F6352 |
| CC91EL23 | Liver | | 73.5 | | - | F6353 |
| CC91EL24 | Liver | | 74.6 | | - | F6354 |
| CC91EL25 | Liver | | 75.2 | | - | F6355 |
| CC91EL26 | Liver | | 81.8 | | - | F6356 |
| CC91EL27 | Liver | | 72.1 | | - | F6357 |
| CC91EL28 | Liver | | 75.1 | | - | F6358 |
| CC91TL01 | Liver | | 76.3 | | - | F6610 |
| CC91TL02 | Liver | | 77.1 | | - | F6611 |

ANALYTICAL REPORT (6-1)
Weight, % Moisture, % Lipid - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Sample Weight (g) | (A) Percent Moisture | (B) Percent Lipid | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91TL03 | Liver | | | 77. | - | F6612 |
| CC91TL04 | Liver | | | 74.7 | - | F6613 |
| CC91TL05 | Liver | | | 76.8 | - | F6614 |
| CC91TL06 | Liver | | | 76.7 | - | F6615 |
| CC91TL07 | Liver | | | 77.1 | - | F6616 |
| CC91TL08 | Liver | | | 80. | - | F6617 |
| CC91TL09 | Liver | | | 78.2 | - | F6618 |
| CC91TL11 | Liver | | | 78.5 | - | F6619 |
| CC91TL12 | Liver | | | 78.6 | - | F6620 |
| CC91TL13 | Liver | | | 77.5 | - | F6621 |
| CC91TL14 | Liver | | | 80. | - | F6622 |
| CC91TL15 | Liver | | | 80.3 | - | F6623 |
| CC91TL16 | Liver | | | 74. | - | F6624 |
| CC91TL17 | Liver | | | 78. | - | F6625 |
| CC91TL18 | Liver | | | 78.4 | - | F6626 |
| CC91TL19 | Liver | | | 79. | - | F6627 |
| CC91TL20 | Liver | | | 78.1 | - | F6628 |
| CC91TL21 | Liver | | | 78. | - | F6629 |
| CC91TL22 | Liver | | | 72.8 | - | F6630 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

Lab Name: GERG  02/06/92  P.O.#: 85800-1-2763

Analyte: Hg  Analytical Method Code: 002

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| C91B104A | Avian Egg | | 0.282 | 0.043 | 0.082 | F6010 |
| C91B104B | Avian Egg | | 0.272 | 0.047 | 0.07 | F6011 |
| C91B147A | Avian Egg | | 0.727 | 0.147 | 0.06 | F6012 |
| C91B148A | Avian Egg | | 0.311 | 0.055 | 0.065 | F6013 |
| C91B149A | Avian Egg | | 0.212 | 0.037 | 0.069 | F6014 |
| C91E103R | Avian Egg | | 0.558 | 0.107 | 0.062 | F6015 |
| C91E106A | Avian Egg | | 0.549 | 0.099 | 0.068 | F6016 |
| C91E121A | Avian Egg | | 0.6 | 0.116 | 0.064 | F6017 |
| C91E125A | Avian Egg | | 0.746 | 0.138 | 0.066 | F6018 |
| C91E130A | Avian Egg | | 1.08 | 0.224 | 0.057 | F6019 |
| C91E131A | Avian Egg | | 0.289 | 0.052 | 0.066 | F6020 |
| C91E132A | Avian Egg | | 0.206 | 0.038 | 0.065 | F6021 |
| CC91B1 | Avian Egg | | 2.93 | 0.473 | 0.074 | F6022 |
| CC91B100 | Avian Egg | | 0.9 | 0.163 | 0.07 | F6023 |
| CC91B101 | Avian Egg | | 0.335 | 0.066 | 0.064 | F6024 |
| CC91B102 | Avian Egg | | 1.63 | 0.295 | 0.071 | F6025 |
| CC91B103 | Avian Egg | | 0.382 | 0.069 | 0.071 | F6026 |
| CC91B104 | Avian Egg | | 0.26 | 0.045 | 0.062 | F6027 |
| CC91B106 | Avian Egg | | 0.631 | 0.116 | 0.065 | F6028 |
| CC91B107 | Avian Egg | | 0.213 | 0.042 | 0.06 | F6029 |
| CC91B108 | Avian Egg | | 0.256 | 0.055 | 0.054 | F6030 |
| CC91B109 | Avian Egg | | 0.503 | 0.095 | 0.061 | F6031 |
| CC91B11 | Avian Egg | | 0.66 | 0.126 | 0.059 | F6032 |
| CC91B110 | Avian Egg | | 0.507 | 0.084 | 0.063 | F6033 |
| CC91B111 | Avian Egg | | 0.244 | 0.046 | 0.06 | F6034 |
| CC91B112 | Avian Egg | | 0.247 | 0.047 | 0.067 | F6035 |
| CC91B113 | Avian Egg | | 0.322 | 0.052 | 0.085 | F6036 |
| CC91B114 | Avian Egg | | 0.495 | 0.091 | 0.064 | F6037 |
| CC91B115 | Avian Egg | | 0.297 | 0.052 | 0.067 | F6038 |
| CC91B116 | Avian Egg | | 0.329 | 0.053 | 0.074 | F6039 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B117 | Avian Egg | | 0.456 | 0.081 | 0.069 | F6040 |
| CC91B118 | Avian Egg | | 0.231 | 0.039 | 0.072 | F6041 |
| CC91B119 | Avian Egg | | 0.292 | 0.053 | 0.068 | F6042 |
| CC91B12 | Avian Egg | | 0.91 | 0.171 | 0.066 | F6043 |
| CC91B120 | Avian Egg | | 0.416 | 0.082 | 0.062 | F6044 |
| CC91B121 | Avian Egg | | 0.456 | 0.092 | 0.057 | F6045 |
| CC91B122 | Avian Egg | | 0.541 | 0.1 | 0.065 | F6046 |
| CC91B123 | Avian Egg | | 0.831 | 0.151 | 0.063 | F6047 |
| CC91B124 | Avian Egg | | 0.537 | 0.11 | 0.057 | F6048 |
| CC91B125 | Avian Egg | | 0.223 | 0.05 | 0.056 | F6049 |
| CC91B126 | Avian Egg | | 0.429 | 0.073 | 0.072 | F6050 |
| CC91B127 | Avian Egg | | 0.401 | 0.073 | 0.067 | F6051 |
| CC91B128 | Avian Egg | | 0.229 | 0.056 | 0.05 | F6052 |
| CC91B129 | Avian Egg | | 0.394 | 0.081 | 0.058 | F6053 |
| CC91B13 | Avian Egg | | 1.81 | 0.306 | 0.074 | F6054 |
| CC91B130 | Avian Egg | | 0.472 | 0.092 | 0.063 | F6055 |
| CC91B131 | Avian Egg | | 0.245 | 0.045 | 0.066 | F6056 |
| CC91B132 | Avian Egg | | 0.405 | 0.074 | 0.066 | F6057 |
| CC91B134 | Avian Egg | | 0.299 | 0.055 | 0.065 | F6058 |
| CC91B135 | Avian Egg | | 0.288 | 0.059 | 0.059 | F6059 |
| CC91B136 | Avian Egg | | 0.717 | 0.14 | 0.059 | F6060 |
| CC91B137 | Avian Egg | | 2.06 | 0.364 | 0.068 | F6061 |
| CC91B138 | Avian Egg | | 0.285 | 0.055 | 0.062 | F6062 |
| CC91B14 | Avian Egg | | 3.45 | 0.57 | 0.078 | F6063 |
| CC91B141 | Avian Egg | | 0.615 | 0.117 | 0.063 | F6064 |
| CC91B143 | Avian Egg | | 0.343 | 0.055 | 0.077 | F6065 |
| CC91B148 | Avian Egg | | 0.323 | 0.107 | 0.035 | F6066 |
| CC91B149 | Avian Egg | | 0.519 | 0.083 | 0.075 | F6067 |
| CC91B15 | Avian Egg | | 0.312 | 0.055 | 0.066 | F6068 |
| CC91B16 | Avian Egg | | 1.18 | 0.208 | 0.07 | F6069 |
| CC91B17 | Avian Egg | | 1.76 | 0.305 | 0.071 | F6070 |
| CC91B18 | Avian Egg | | 1.02 | 0.214 | 0.058 | F6071 |
| CC91B19 | Avian Egg | | 1.13 | 0.2 | 0.065 | F6072 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B2 | Avian Egg | | . 0.459 | . 0.084 | 0.063 | F6073 |
| CC91B20 | Avian Egg | | . 1.16 | . 0.206 | 0.069 | F6074 |
| CC91B21 | Avian Egg | | . 0.429 | . 0.075 | 0.068 | F6075 |
| CC91B22 | Avian Egg | | . 0.796 | . 0.135 | 0.07 | F6076 |
| CC91B23 | Avian Egg | | . 0.74 | . 0.123 | 0.074 | F6077 |
| CC91B24 | Avian Egg | | . 1.68 | . 0.29 | 0.073 | F6078 |
| CC91B25 | Avian Egg | | . 0.698 | . 0.106 | 0.078 | F6079 |
| CC91B26 | Avian Egg | | . 0.868 | . 0.147 | 0.072 | F6080 |
| CC91B27 | Avian Egg | | . 0.392 | . 0.062 | 0.073 | F6081 |
| CC91B29 | Avian Egg | | . 0.83 | . 0.14 | 0.073 | F6082 |
| CC91B3 | Avian Egg | | . 0.583 | . 0.095 | 0.072 | F6083 |
| CC91B30 | Avian Egg | | . 0.62 | . 0.097 | 0.082 | F6084 |
| CC91B31 | Avian Egg | | . 0.986 | . 0.152 | 0.069 | F6085 |
| CC91B32 | Avian Egg | | . 1.27 | . 0.223 | 0.068 | F6086 |
| CC91B32A | Avian Egg | | . 1.6 | . 0.191 | 0.1 | F6087 |
| CC91B33 | Avian Egg | | . 2.2 | . 0.395 | 0.064 | F6088 |
| CC91B34A | Avian Egg | | . 1.01 | . 0.162 | 0.069 | F6089 |
| CC91B35 | Avian Egg | | . 1.45 | . 0.277 | 0.063 | F6090 |
| CC91B36 | Avian Egg | | . 0.523 | . 0.091 | 0.075 | F6091 |
| CC91B37 | Avian Egg | | . 0.878 | . 0.146 | 0.074 | F6092 |
| CC91B38 | Avian Egg | | . 0.506 | . 0.091 | 0.067 | F6093 |
| CC91B39 | Avian Egg | | . 0.551 | . 0.086 | 0.08 | F6094 |
| CC91B3A | Avian Egg | | . 0.775 | . 0.118 | 0.075 | F6095 |
| CC91B4 | Avian Egg | | . 0.869 | . 0.136 | 0.077 | F6096 |
| CC91B40 | Avian Egg | | . 0.988 | . 0.151 | 0.08 | F6097 |
| CC91B41 | Avian Egg | | . 1.05 | . 0.171 | 0.077 | F6098 |
| CC91B42 | Avian Egg | | . 0.805 | . 0.147 | 0.07 | F6099 |
| CC91B43 | Avian Egg | | . 0.527 | . 0.109 | 0.061 | F6100 |
| CC91B44 | Avian Egg | | . 1.93 | . 0.382 | 0.063 | F6101 |
| CC91B5 | Avian Egg | | . 0.619 | . 0.107 | 0.067 | F6102 |
| CC91B52 | Avian Egg | | . 0.766 | . 0.141 | 0.066 | F6103 |
| CC91B54 | Avian Egg | | . 0.452 | . 0.073 | 0.079 | F6104 |
| CC91B55 | Avian Egg | | . 0.669 | . 0.119 | 0.069 | F6105 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B57 | Avian Egg | | 0.153 | 0.028 | 0.072 | F6106 |
| CC91B57A | Avian Egg | | 0.866 | 0.151 | 0.072 | F6107 |
| CC91B58 | Avian Egg | | 0.221 | 0.041 | 0.072 | F6108 |
| CC91B59 | Avian Egg | | 0.941 | 0.168 | 0.073 | F6109 |
| CC91B6 | Avian Egg | | 1.03 | 0.168 | 0.07 | F6110 |
| CC91B60 | Avian Egg | | 0.853 | 0.153 | 0.068 | F6111 |
| CC91B61 | Avian Egg | | 0.251 | 0.045 | 0.066 | F6112 |
| CC91B62 | Avian Egg | | 0.245 | 0.044 | 0.07 | F6113 |
| CC91B63 | Avian Egg | | 0.438 | 0.077 | 0.07 | F6114 |
| CC91B64 | Avian Egg | | 0.264 | 0.051 | 0.065 | F6115 |
| CC91B65 | Avian Egg | | 0.374 | 0.063 | 0.075 | F6116 |
| CC91B66 | Avian Egg | | 0.23 | 0.041 | 0.062 | F6117 |
| CC91B67 | Avian Egg | | 0.247 | 0.047 | 0.066 | F6118 |
| CC91B68 | Avian Egg | | 0.127 | 0.108 | 0.044 | F6119 |
| CC91B69 | Avian Egg | | 0.387 | 0.07 | 0.07 | F6120 |
| CC91B7 | Avian Egg | | 0.598 | 0.118 | 0.061 | F6121 |
| CC91B70 | Avian Egg | | 0.459 | 0.083 | 0.068 | F6122 |
| CC91B71 | Avian Egg | | 0.307 | 0.055 | 0.066 | F6123 |
| CC91B72 | Avian Egg | | 0.235 | 0.039 | 0.072 | F6124 |
| CC91B73 | Avian Egg | | 0.211 | 0.038 | 0.069 | F6125 |
| CC91B74 | Avian Egg | | 0.178 | 0.034 | 0.064 | F6126 |
| CC91B75 | Avian Egg | | 0.163 | 0.031 | 0.059 | F6127 |
| CC91B76 | Avian Egg | | 0.281 | 0.051 | 0.069 | F6128 |
| CC91B77 | Avian Egg | | 0.181 | 0.033 | 0.065 | F6129 |
| CC91B78 | Avian Egg | | 0.392 | 0.085 | 0.058 | F6130 |
| CC91B79 | Avian Egg | | 0.246 | 0.046 | 0.067 | F6131 |
| CC91B8 | Avian Egg | | 2.31 | 0.412 | 0.069 | F6132 |
| CC91B80 | Avian Egg | | 0.392 | 0.082 | 0.055 | F6133 |
| CC91B81 | Avian Egg | | 0.262 | 0.05 | 0.066 | F6134 |
| CC91B82 | Avian Egg | | 0.284 | 0.052 | 0.071 | F6135 |
| CC91B83 | Avian Egg | | 0.62 | 0.109 | 0.069 | F6136 |
| CC91B86 | Avian Egg | | 0.144 | 0.029 | 0.063 | F6137 |
| CC91B87 | Avian Egg | | 0.169 | 0.032 | 0.065 | F6138 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91B88 | Avian Egg | | 0.358 | 0.067 | 0.067 | F6139 |
| CC91B89 | Avian Egg | | 0.241 | 0.046 | 0.066 | F6140 |
| CC91B9 | Avian Egg | | 0.501 | 0.092 | 0.062 | F6141 |
| CC91B90 | Avian Egg | | 0.33 | 0.056 | 0.075 | F6142 |
| CC91B91 | Avian Egg | | 0.147 | 0.027 | 0.067 | F6143 |
| CC91B92 | Avian Egg | | 0.187 | 0.033 | 0.074 | F6144 |
| CC91B93 | Avian Egg | | 0.247 | 0.042 | 0.074 | F6145 |
| CC91B94 | Avian Egg | | 0.259 | 0.045 | 0.071 | F6146 |
| CC91B95 | Avian Egg | | 0.191 | 0.035 | 0.068 | F6147 |
| CC91B96 | Avian Egg | | 0.297 | 0.054 | 0.069 | F6148 |
| CC91B97 | Avian Egg | | 0.451 | 0.077 | 0.071 | F6149 |
| CC91B98 | Avian Egg | | 0.316 | 0.053 | 0.072 | F6150 |
| CC91B99 | Avian Egg | | 0.406 | 0.068 | 0.078 | F6151 |
| CC91B9A | Avian Egg | | 3.5 | 0.654 | 0.068 | F6152 |
| CC91B9B | Avian Egg | | 0.471 | 0.084 | 0.07 | F6153 |
| CC91BAA | Avian Egg | | 0.173 | 0.032 | 0.066 | F6154 |
| CC91BC1 | Avian Egg | | 0.478 | 0.085 | 0.06 | F6155 |
| CC91BC10 | Avian Egg | | 0.309 | 0.067 | 0.054 | F6156 |
| CC91BC2 | Avian Egg | | 0.79 | 0.138 | 0.072 | F6157 |
| CC91BC3 | Avian Egg | | 0.876 | 0.168 | 0.065 | F6158 |
| CC91BC4 | Avian Egg | | 0.637 | 0.115 | 0.066 | F6159 |
| CC91BC5 | Avian Egg | | 0.518 | 0.113 | 0.059 | F6160 |
| CC91BC6 | Avian Egg | | 0.729 | 0.141 | 0.064 | F6161 |
| CC91BC7 | Avian Egg | | 0.254 | 0.061 | 0.052 | F6162 |
| CC91BC8 | Avian Egg | | 0.15 | 0.03 | 0.058 | F6163 |
| CC91BC9 | Avian Egg | | 0.103 | 0.021 | 0.062 | F6164 |
| CC91BS1 | Avian Egg | | 3.21 | 0.786 | 0.05 | F6195 |
| CC91BS10 | Avian Egg | | 0.822 | 0.191 | 0.054 | F6196 |
| CC91BS2 | Avian Egg | | 2.63 | 0.541 | 0.064 | F6197 |
| CC91BS3 | Avian Egg | | 4.68 | 0.927 | 0.065 | F6198 |
| CC91BS4 | Avian Egg | | 2.41 | 0.506 | 0.06 | F6199 |
| CC91BS5 | Avian Egg | | 0.641 | 0.143 | 0.056 | F6200 |
| CC91BS6 | Avian Egg | | 0.567 | 0.129 | 0.054 | F6201 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91BS7 | Avian Egg | | 1.87 | 0.431 | 0.052 | F6202 |
| CC91BS8 | Avian Egg | | 0.526 | 0.116 | 0.058 | F6203 |
| CC91BS9 | Avian Egg | | 0.548 | 0.134 | 0.049 | F6204 |
| CC91E1 | Avian Egg | | 0.293 | 0.061 | 0.056 | F6205 |
| CC91E10 | Avian Egg | | 0.548 | 0.104 | 0.063 | F6206 |
| CC91E100 | Avian Egg | | 0.816 | 0.132 | 0.076 | F6207 |
| CC91E101 | Avian Egg | | 1.34 | 0.231 | 0.07 | F6208 |
| CC91E103 | Avian Egg | | 0.479 | 0.085 | 0.067 | F6209 |
| CC91E104 | Avian Egg | | 0.413 | 0.078 | 0.064 | F6210 |
| CC91E106 | Avian Egg | | 0.369 | 0.073 | 0.061 | F6211 |
| CC91E107 | Avian Egg | | 0.804 | 0.155 | 0.061 | F6212 |
| CC91E108 | Avian Egg | | 0.515 | 0.092 | 0.068 | F6213 |
| CC91E109 | Avian Egg | | 1.92 | 0.375 | 0.062 | F6214 |
| CC91E10A | Avian Egg | | 0.592 | 0.11 | 0.06 | F6215 |
| CC91E11 | Avian Egg | | 1.2 | 0.22 | 0.065 | F6216 |
| CC91E110 | Avian Egg | | 0.414 | 0.069 | 0.07 | F6217 |
| CC91E111 | Avian Egg | | 1.67 | 0.301 | 0.066 | F6218 |
| CC91E112 | Avian Egg | | 1.89 | 0.325 | 0.073 | F6219 |
| CC91E113 | Avian Egg | | 0.594 | 0.09 | 0.077 | F6220 |
| CC91E114 | Avian Egg | | 0.663 | 0.107 | 0.075 | F6221 |
| CC91E115 | Avian Egg | | 0.313 | 0.054 | 0.067 | F6222 |
| CC91E116 | Avian Egg | | 0.671 | 0.124 | 0.062 | F6223 |
| CC91E117 | Avian Egg | | 0.194 | 0.033 | 0.071 | F6224 |
| CC91E118 | Avian Egg | | 0.375 | 0.065 | 0.067 | F6225 |
| CC91E119 | Avian Egg | | 0.402 | 0.063 | 0.078 | F6226 |
| CC91E12 | Avian Egg | | 0.906 | 0.186 | 0.06 | F6227 |
| CC91E120 | Avian Egg | | 1.23 | 0.208 | 0.072 | F6228 |
| CC91E121 | Avian Egg | | 0.819 | 0.128 | 0.076 | F6229 |
| CC91E122 | Avian Egg | | 0.729 | 0.137 | 0.065 | F6230 |
| CC91E123 | Avian Egg | | 0.372 | 0.075 | 0.06 | F6231 |
| CC91E124 | Avian Egg | | 0.438 | 0.081 | 0.067 | F6232 |
| CC91E125 | Avian Egg | | 0.556 | 0.117 | 0.056 | F6233 |
| CC91E126 | Avian Egg | | 0.522 | 0.089 | 0.07 | F6234 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91E128 | Avian Egg | | 0.23 | 0.043 | 0.066 | F6235 |
| CC91E13 | Avian Egg | | 0.518 | 0.102 | 0.063 | F6236 |
| CC91E130 | Avian Egg | | 0.673 | 0.123 | 0.064 | F6237 |
| CC91E14 | Avian Egg | | 1.06 | 0.2 | 0.065 | F6238 |
| CC91E142 | Avian Egg | | 0.5 | 0.095 | 0.066 | F6239 |
| CC91E144 | Avian Egg | | 0.249 | 0.05 | 0.061 | F6240 |
| CC91E14A | Avian Egg | | 0.933 | 0.179 | 0.063 | F6241 |
| CC91E14B | Avian Egg | | 0.99 | 0.188 | 0.063 | F6242 |
| CC91E15 | Avian Egg | | 0.652 | 0.131 | 0.06 | F6243 |
| CC91E15A | Avian Egg | | 0.625 | 0.123 | 0.063 | F6244 |
| CC91E16 | Avian Egg | | 0.538 | 0.107 | 0.057 | F6245 |
| CC91E17 | Avian Egg | | 0.646 | 0.129 | 0.058 | F6246 |
| CC91E18 | Avian Egg | | 1. | 0.186 | 0.064 | F6247 |
| CC91E19 | Avian Egg | | 0.651 | 0.126 | 0.061 | F6248 |
| CC91E2 | Avian Egg | | 0.908 | 0.166 | 0.065 | F6249 |
| CC91E20 | Avian Egg | | 1.11 | 0.198 | 0.067 | F6250 |
| CC91E21 | Avian Egg | | 2.69 | 0.501 | 0.064 | F6251 |
| CC91E22 | Avian Egg | | 0.411 | 0.077 | 0.066 | F6252 |
| CC91E23 | Avian Egg | | 1.95 | 0.374 | 0.063 | F6253 |
| CC91E23A | Avian Egg | | 2.05 | 0.363 | 0.067 | F6254 |
| CC91E24A | Avian Egg | | 1.26 | 0.231 | 0.065 | F6255 |
| CC91E25A | Avian Egg | | 0.667 | 0.121 | 0.068 | F6256 |
| CC91E26A | Avian Egg | | 0.837 | 0.158 | 0.066 | F6257 |
| CC91E27A | Avian Egg | | 1.07 | 0.183 | 0.071 | F6258 |
| CC91E28A | Avian Egg | | 0.602 | 0.117 | 0.065 | F6259 |
| CC91E29A | Avian Egg | | 0.802 | 0.147 | 0.067 | F6260 |
| CC91E2A | Avian Egg | | 0.815 | 0.162 | 0.063 | F6261 |
| CC91E3 | Avian Egg | | 1.06 | 0.217 | 0.059 | F6262 |
| CC91E30A | Avian Egg | | 0.809 | 0.15 | 0.063 | F6263 |
| CC91E31 | Avian Egg | | 0.775 | 0.146 | 0.063 | F6264 |
| CC91E31A | Avian Egg | | 1.59 | 0.299 | 0.066 | F6265 |
| CC91E32 | Avian Egg | | 0.878 | 0.173 | 0.062 | F6266 |
| CC91E32A | Avian Egg | | 0.916 | 0.195 | 0.056 | F6267 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91E33 | Avian Egg | | 0.937 | 0.172 | 0.065 | F6268 |
| CC91E33A | Avian Egg | | 0.838 | 0.157 | 0.063 | F6269 |
| CC91E33B | Avian Egg | | 0.96 | 0.168 | 0.068 | F6270 |
| CC91E34 | Avian Egg | | 1.16 | 0.21 | 0.067 | F6271 |
| CC91E35 | Avian Egg | | 0.482 | 0.09 | 0.064 | F6272 |
| CC91E36 | Avian Egg | | 0.559 | 0.103 | 0.067 | F6273 |
| CC91E37 | Avian Egg | | 0.724 | 0.135 | 0.064 | F6274 |
| CC91E38 | Avian Egg | | 0.887 | 0.161 | 0.066 | F6275 |
| CC91E39 | Avian Egg | | 0.674 | 0.125 | 0.064 | F6276 |
| CC91E4 | Avian Egg | | 0.715 | 0.146 | 0.061 | F6277 |
| CC91E40 | Avian Egg | | 0.899 | 0.163 | 0.067 | F6278 |
| CC91E41 | Avian Egg | | 0.506 | 0.092 | 0.066 | F6279 |
| CC91E42 | Avian Egg | | 0.813 | 0.141 | 0.068 | F6280 |
| CC91E43 | Avian Egg | | 0.733 | 0.134 | 0.063 | F6281 |
| CC91E44 | Avian Egg | | 0.597 | 0.11 | 0.067 | F6282 |
| CC91E45 | Avian Egg | | 0.618 | 0.118 | 0.061 | F6283 |
| CC91E5 | Avian Egg | | 0.753 | 0.135 | 0.068 | F6284 |
| CC91E51 | Avian Egg | | 0.341 | 0.057 | 0.074 | F6285 |
| CC91E52 | Avian Egg | | 0.471 | 0.083 | 0.065 | F6286 |
| CC91E53 | Avian Egg | | 0.311 | 0.052 | 0.072 | F6287 |
| CC91E54 | Avian Egg | | 0.514 | 0.089 | 0.071 | F6288 |
| CC91E55 | Avian Egg | | 1.2 | 0.209 | 0.069 | F6289 |
| CC91E56 | Avian Egg | | 0.465 | 0.078 | 0.071 | F6290 |
| CC91E57 | Avian Egg | | 0.279 | 0.049 | 0.069 | F6291 |
| CC91E58 | Avian Egg | | 1.34 | 0.236 | 0.067 | F6292 |
| CC91E59 | Avian Egg | | 0.392 | 0.066 | 0.069 | F6293 |
| CC91E6 | Avian Egg | | 0.76 | 0.126 | 0.074 | F6294 |
| CC91E60 | Avian Egg | | 0.494 | 0.09 | 0.067 | F6295 |
| CC91E61 | Avian Egg | | 0.78 | 0.132 | 0.072 | F6296 |
| CC91E62 | Avian Egg | | 0.519 | 0.094 | 0.065 | F6297 |
| CC91E63 | Avian Egg | | 0.301 | 0.053 | 0.07 | F6298 |
| CC91E64 | Avian Egg | | 0.436 | 0.075 | 0.065 | F6299 |
| CC91E65 | Avian Egg | | 0.47 | 0.078 | 0.072 | F6300 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91E66 | Avian Egg | | 0.539 | 0.084 | 0.081 | F6301 |
| CC91E66A | Avian Egg | | 0.369 | 0.066 | 0.07 | F6302 |
| CC91E67 | Avian Egg | | 1.55 | 0.273 | 0.069 | F6303 |
| CC91E68 | Avian Egg | | 0.389 | 0.074 | 0.062 | F6304 |
| CC91E69 | Avian Egg | | 0.494 | 0.088 | 0.069 | F6305 |
| CC91E6A | Avian Egg | | 0.585 | 0.128 | 0.057 | F6306 |
| CC91E7 | Avian Egg | | 0.439 | 0.082 | 0.063 | F6307 |
| CC91E70 | Avian Egg | | 0.404 | 0.071 | 0.069 | F6308 |
| CC91E71 | Avian Egg | | 0.303 | 0.058 | 0.061 | F6309 |
| CC91E72 | Avian Egg | | 0.755 | 0.142 | 0.064 | F6310 |
| CC91E72A | Avian Egg | | 0.501 | 0.092 | 0.066 | F6311 |
| CC91E73 | Avian Egg | | 0.343 | 0.064 | 0.065 | F6312 |
| CC91E74 | Avian Egg | | 0.674 | 0.12 | 0.065 | F6313 |
| CC91E75 | Avian Egg | | 0.55 | 0.103 | 0.066 | F6314 |
| CC91E76 | Avian Egg | | 0.317 | 0.062 | 0.06 | F6315 |
| CC91E77 | Avian Egg | | 0.77 | 0.142 | 0.063 | F6316 |
| CC91E78 | Avian Egg | | 1.49 | 0.266 | 0.067 | F6317 |
| CC91E79 | Avian Egg | | 1. | 0.176 | 0.07 | F6318 |
| CC91E8 | Avian Egg | | 0.894 | 0.16 | 0.065 | F6319 |
| CC91E80 | Avian Egg | | 1.03 | 0.189 | 0.068 | F6320 |
| CC91E81 | Avian Egg | | 0.16 | 0.029 | 0.064 | F6321 |
| CC91E82 | Avian Egg | | 1.58 | 0.288 | 0.067 | F6322 |
| CC91E83 | Avian Egg | | 0.547 | 0.098 | 0.068 | F6323 |
| CC91E84 | Avian Egg | | 0.278 | 0.052 | 0.065 | F6324 |
| CC91E85 | Avian Egg | | 3.4 | 0.607 | 0.07 | F6325 |
| CC91E86 | Avian Egg | | 1.21 | 0.215 | 0.07 | F6326 |
| CC91E87 | Avian Egg | | 0.309 | 0.061 | 0.06 | F6327 |
| CC91E88 | Avian Egg | | 0.432 | 0.08 | 0.064 | F6328 |
| CC91E89 | Avian Egg | | 0.421 | 0.078 | 0.067 | F6329 |
| CC91E9 | Avian Egg | | 1.08 | 0.233 | 0.054 | F6330 |
| CC91E90 | Avian Egg | | 0.367 | 0.063 | 0.068 | F6331 |
| CC91E91 | Avian Egg | | 0.735 | 0.135 | 0.065 | F6332 |
| CC91F1 | Avian Egg | | 5.07 | 1.14 | 0.055 | F6359 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91F10 | Avian Egg | | 2.5 | 0.55 | 0.051 | F6360 |
| CC91F2 | Avian Egg | | 3.12 | 0.902 | 0.041 | F6361 |
| CC91F3 | Avian Egg | | 3.23 | 0.704 | 0.056 | F6362 |
| CC91F4 | Avian Egg | | 2.42 | 0.524 | 0.058 | F6363 |
| CC91F5 | Avian Egg | | 4.19 | 0.931 | 0.055 | F6364 |
| CC91F6 | Avian Egg | | 2.58 | 0.52 | 0.053 | F6365 |
| CC91F7 | Avian Egg | | 1.81 | 0.4 | 0.057 | F6366 |
| CC91F8 | Avian Egg | | 2.13 | 0.432 | 0.063 | F6367 |
| CC91F9 | Avian Egg | | 1.2 | 0.255 | 0.054 | F6368 |
| CC91LB1 | Avian Egg | | 0.395 | 0.068 | 0.072 | F6369 |
| CC91LB10 | Avian Egg | | 0.405 | 0.067 | 0.071 | F6370 |
| CC91LB2 | Avian Egg | | 0.806 | 0.123 | 0.078 | F6371 |
| CC91LB3 | Avian Egg | | 2.84 | 0.521 | 0.066 | F6372 |
| CC91LB4 | Avian Egg | | 0.213 | 0.04 | 0.066 | F6373 |
| CC91LB5 | Avian Egg | | 0.678 | 0.123 | 0.069 | F6374 |
| CC91LB6 | Avian Egg | | 0.373 | 0.072 | 0.067 | F6375 |
| CC91LB7 | Avian Egg | | 1.48 | 0.277 | 0.067 | F6376 |
| CC91LB8 | Avian Egg | | 0.361 | 0.067 | 0.061 | F6377 |
| CC91LB9 | Avian Egg | | 0.305 | 0.052 | 0.072 | F6378 |
| CC91LG1 | Avian Egg | | 0.7 | 0.182 | 0.047 | F6379 |
| CC91LG11 | Avian Egg | | 0.342 | 0.089 | 0.048 | F6380 |
| CC91LG12 | Avian Egg | | 0.542 | 0.124 | 0.054 | F6381 |
| CC91LG13 | Avian Egg | | 0.494 | 0.11 | 0.056 | F6382 |
| CC91LG14 | Avian Egg | | 0.334 | 0.081 | 0.05 | F6383 |
| CC91LG15 | Avian Egg | | 0.075 | 0.02 | 0.048 | F6384 |
| CC91LG2 | Avian Egg | | 0.813 | 0.205 | 0.048 | F6385 |
| CC91LG3 | Avian Egg | | 1.09 | 0.262 | 0.051 | F6386 |
| CC91LG4 | Avian Egg | | 0.614 | 0.145 | 0.048 | F6387 |
| CC91LG5 | Avian Egg | | 1.73 | 0.409 | 0.051 | F6388 |
| CC91LT10 | Avian Egg | | 0.729 | 0.156 | 0.054 | F6389 |
| CC91LT11 | Avian Egg | | 0.446 | 0.098 | 0.054 | F6390 |
| CC91LT2 | Avian Egg | | 1.47 | 0.364 | 0.048 | F6391 |
| CC91LT3 | Avian Egg | | 0.995 | 0.239 | 0.05 | F6392 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91PS15 | Avian Egg | | 1.54 | 0.242 | 0.08 | F6426 |
| CC91PS16 | Avian Egg | | 0.821 | 0.15 | 0.069 | F6427 |
| CC91PS17 | Avian Egg | | 1.01 | 0.185 | 0.068 | F6428 |
| CC91PS18 | Avian Egg | | 0.752 | 0.129 | 0.07 | F6429 |
| CC91PS19 | Avian Egg | | 2.39 | 0.43 | 0.066 | F6430 |
| CC91PS2 | Avian Egg | | 1.55 | 0.256 | 0.069 | F6431 |
| CC91PS20 | Avian Egg | | 1.62 | 0.265 | 0.074 | F6432 |
| CC91PS21 | Avian Egg | | 1.88 | 0.324 | 0.067 | F6433 |
| CC91PS22 | Avian Egg | | 1.37 | 0.23 | 0.075 | F6434 |
| CC91PS23 | Avian Egg | | 0.837 | 0.144 | 0.069 | F6435 |
| CC91PS24 | Avian Egg | | 0.749 | 0.132 | 0.069 | F6436 |
| CC91PS25 | Avian Egg | | 0.756 | 0.129 | 0.068 | F6437 |
| CC91PS26 | Avian Egg | | 1.96 | 0.377 | 0.063 | F6438 |
| CC91PS27 | Avian Egg | | 0.705 | 0.121 | 0.067 | F6439 |
| CC91PS28 | Avian Egg | | 0.959 | 0.185 | 0.061 | F6440 |
| CC91PS29 | Avian Egg | | 1.41 | 0.256 | 0.067 | F6441 |
| CC91PS3 | Avian Egg | | 1.82 | 0.29 | 0.079 | F6442 |
| CC91PS30 | Avian Egg | | 0.682 | 0.13 | 0.059 | F6443 |
| CC91PS31 | Avian Egg | | 0.616 | 0.103 | 0.071 | F6444 |
| CC91PS32 | Avian Egg | | 0.678 | 0.113 | 0.075 | F6445 |
| CC91PS33 | Avian Egg | | 0.98 | 0.165 | 0.07 | F6446 |
| CC91PS34 | Avian Egg | | 1.94 | 0.297 | 0.076 | F6447 |
| CC91PS35 | Avian Egg | | 0.811 | 0.144 | 0.067 | F6448 |
| CC91PS36 | Avian Egg | | 0.763 | 0.135 | 0.068 | F6449 |
| CC91PS37 | Avian Egg | | 0.432 | 0.075 | 0.071 | F6450 |
| CC91PS38 | Avian Egg | | 1.1 | 0.178 | 0.076 | F6451 |
| CC91PS39 | Avian Egg | | 0.982 | 0.171 | 0.069 | F6452 |
| CC91PS4 | Avian Egg | | 0.886 | 0.141 | 0.072 | F6453 |
| CC91PS40 | Avian Egg | | 1.35 | 0.233 | 0.071 | F6454 |
| CC91PS41 | Avian Egg | | 1.11 | 0.197 | 0.071 | F6455 |
| CC91PS42 | Avian Egg | | 1.36 | 0.23 | 0.072 | F6456 |
| CC91PS43 | Avian Egg | | 1.49 | 0.253 | 0.074 | F6457 |
| CC91PS44 | Avian Egg | | 0.761 | 0.155 | 0.059 | F6458 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91PS45 | Avian Egg | | 1.06 | 0.187 | 0.071 | F6459 |
| CC91PS46 | Avian Egg | | 2.17 | 0.369 | 0.071 | F6460 |
| CC91PS47 | Avian Egg | | 1.08 | 0.195 | 0.067 | F6461 |
| CC91PS5 | Avian Egg | | 1.4 | 0.225 | 0.075 | F6462 |
| CC91PS6 | Avian Egg | | 1.07 | 0.181 | 0.07 | F6463 |
| CC91PS7 | Avian Egg | | 1.03 | 0.174 | 0.071 | F6464 |
| CC91PS8 | Avian Egg | | 2.07 | 0.382 | 0.064 | F6465 |
| CC91PS9 | Avian Egg | | 0.675 | 0.124 | 0.067 | F6466 |
| CC91RS1 | Avian Egg | | 0.645 | 0.127 | 0.061 | F6467 |
| CC91RS2 | Avian Egg | | 1.33 | 0.233 | 0.072 | F6468 |
| CC91RS3 | Avian Egg | | 1.2 | 0.225 | 0.064 | F6469 |
| CC91RS4 | Avian Egg | | 0.884 | 0.156 | 0.068 | F6470 |
| CC91RS5 | Avian Egg | | 2.53 | 0.413 | 0.074 | F6471 |
| CC91RS6 | Avian Egg | | 0.763 | 0.157 | 0.06 | F6472 |
| CC91RS7 | Avian Egg | | 1.28 | 0.215 | 0.072 | F6473 |
| CC91RS8 | Avian Egg | | 1.88 | 0.352 | 0.064 | F6474 |
| CC91RS9 | Avian Egg | | 1.58 | 0.327 | 0.059 | F6475 |
| CC91RT1 | Avian Egg | | 3.41 | 0.838 | 0.047 | F6476 |
| CC91RT11 | Avian Egg | | 1.55 | 0.377 | 0.05 | F6477 |
| CC91RT12 | Avian Egg | | 3.58 | 0.888 | 0.048 | F6478 |
| CC91RT13 | Avian Egg | | 4.8 | 1.18 | 0.048 | F6479 |
| CC91RT14 | Avian Egg | | 4.28 | 1.1 | 0.047 | F6480 |
| CC91RT15 | Avian Egg | | 3.33 | 0.866 | 0.045 | F6481 |
| CC91RT2 | Avian Egg | | 3.61 | 0.827 | 0.052 | F6482 |
| CC91RT3 | Avian Egg | | 1.84 | 0.464 | 0.049 | F6483 |
| CC91RT4 | Avian Egg | | 3.4 | 0.835 | 0.049 | F6484 |
| CC91RT5 | Avian Egg | | 3.39 | 0.872 | 0.048 | F6485 |
| CC91SE1 | Avian Egg | | 0.582 | 0.106 | 0.064 | F6486 |
| CC91SE10 | Avian Egg | | 0.279 | 0.044 | 0.072 | F6487 |
| CC91SE2 | Avian Egg | | 0.698 | 0.127 | 0.062 | F6488 |
| CC91SE3 | Avian Egg | | 0.46 | 0.078 | 0.071 | F6489 |
| CC91SE4 | Avian Egg | | 0.579 | 0.094 | 0.074 | F6490 |
| CC91SE5 | Avian Egg | | 0.554 | 0.121 | 0.054 | F6491 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91SE6 | Avian Egg | | 0.181 | 0.029 | 0.071 | F6492 |
| CC91SE7 | Avian Egg | | 0.737 | 0.111 | 0.079 | F6493 |
| CC91SE8 | Avian Egg | | 0.532 | 0.1 | 0.065 | F6494 |
| CC91SE9 | Avian Egg | | 0.591 | 0.097 | 0.075 | F6495 |
| CC91T1 | Avian Egg | | 0.473 | 0.083 | 0.065 | F6496 |
| CC91T10 | Avian Egg | | 1.09 | 0.196 | 0.069 | F6497 |
| CC91T11 | Avian Egg | | 0.568 | 0.12 | 0.053 | F6498 |
| CC91T11A | Avian Egg | | 1.01 | 0.18 | 0.069 | F6499 |
| CC91T11B | Avian Egg | | 1.05 | 0.189 | 0.062 | F6500 |
| CC91T12 | Avian Egg | | 0.624 | 0.126 | 0.06 | F6501 |
| CC91T13 | Avian Egg | | 0.397 | 0.082 | 0.059 | F6502 |
| CC91T13A | Avian Egg | | 0.131 | 0.024 | 0.062 | F6503 |
| CC91T13B | Avian Egg | | 0.706 | 0.136 | 0.06 | F6504 |
| CC91T14 | Avian Egg | | 0.924 | 0.158 | 0.072 | F6505 |
| CC91T15A | Avian Egg | | 0.397 | 0.063 | 0.073 | F6506 |
| CC91T16 | Avian Egg | | 0.848 | 0.137 | 0.075 | F6507 |
| CC91T16A | Avian Egg | | 3.46 | 0.604 | 0.07 | F6508 |
| CC91T17 | Avian Egg | | 0.686 | 0.127 | 0.062 | F6509 |
| CC91T17A | Avian Egg | | 0.475 | 0.086 | 0.065 | F6510 |
| CC91T18 | Avian Egg | | 0.367 | 0.057 | 0.078 | F6511 |
| CC91T18A | Avian Egg | | 0.838 | 0.14 | 0.071 | F6512 |
| CC91T19 | Avian Egg | | 0.657 | 0.112 | 0.069 | F6513 |
| CC91T20 | Avian Egg | | 0.607 | 0.095 | 0.073 | F6514 |
| CC91T21 | Avian Egg | | 0.519 | 0.114 | 0.054 | F6515 |
| CC91T21A | Avian Egg | | 0.703 | 0.127 | 0.066 | F6516 |
| CC91T22 | Avian Egg | | 0.35 | 0.057 | 0.074 | F6517 |
| CC91T23 | Avian Egg | | 0.479 | 0.091 | 0.061 | F6518 |
| CC91T23A | Avian Egg | | 0.668 | 0.124 | 0.065 | F6519 |
| CC91T24 | Avian Egg | | 0.897 | 0.163 | 0.068 | F6520 |
| CC91T25 | Avian Egg | | 0.469 | 0.071 | 0.078 | F6521 |
| CC91T26 | Avian Egg | | 0.56 | 0.101 | 0.063 | F6522 |
| CC91T27 | Avian Egg | | 0.268 | 0.046 | 0.071 | F6523 |
| CC91T27A | Avian Egg | | 0.369 | 0.079 | 0.056 | F6524 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91T28 | Avian Egg | | 0.339 | 0.065 | 0.065 | F6525 |
| CC91T29 | Avian Egg | | 0.778 | 0.142 | 0.066 | F6526 |
| CC91T29A | Avian Egg | | 1.01 | 0.183 | 0.068 | F6527 |
| CC91T2A | Avian Egg | | 0.975 | 0.181 | 0.066 | F6528 |
| CC91T3 | Avian Egg | | 0.317 | 0.065 | 0.059 | F6529 |
| CC91T30 | Avian Egg | | 0.29 | 0.055 | 0.065 | F6530 |
| CC91T31 | Avian Egg | | 0.588 | 0.109 | 0.067 | F6531 |
| CC91T32 | Avian Egg | | 0.753 | 0.145 | 0.062 | F6532 |
| CC91T33 | Avian Egg | | 1.08 | 0.188 | 0.068 | F6533 |
| CC91T33A | Avian Egg | | 0.659 | 0.125 | 0.065 | F6534 |
| CC91T34 | Avian Egg | | 0.746 | 0.135 | 0.064 | F6535 |
| CC91T34A | Avian Egg | | 0.686 | 0.111 | 0.073 | F6536 |
| CC91T35 | Avian Egg | | 0.501 | 0.081 | 0.072 | F6537 |
| CC91T36 | Avian Egg | | 0.42 | 0.076 | 0.064 | F6538 |
| CC91T36A | Avian Egg | | 0.638 | 0.11 | 0.067 | F6539 |
| CC91T37 | Avian Egg | | 0.496 | 0.092 | 0.066 | F6540 |
| CC91T38 | Avian Egg | | 0.392 | 0.073 | 0.064 | F6541 |
| CC91T39 | Avian Egg | | 0.657 | 0.115 | 0.071 | F6542 |
| CC91T3A | Avian Egg | | 0.288 | 0.048 | 0.075 | F6543 |
| CC91T3B | Avian Egg | | 0.528 | 0.093 | 0.067 | F6544 |
| CC91T4 | Avian Egg | | 0.863 | 0.158 | 0.067 | F6545 |
| CC91T42 | Avian Egg | | 0.635 | 0.117 | 0.064 | F6546 |
| CC91T43 | Avian Egg | | 0.789 | 0.149 | 0.063 | F6547 |
| CC91T44 | Avian Egg | | 0.343 | 0.062 | 0.064 | F6548 |
| CC91T45 | Avian Egg | | 0.292 | 0.063 | 0.056 | F6549 |
| CC91T45X | Avian Egg | | 0.835 | 0.138 | 0.072 | F6550 |
| CC91T46 | Avian Egg | | 1. | 0.17 | 0.07 | F6551 |
| CC91T47 | Avian Egg | | 0.606 | 0.096 | 0.075 | F6552 |
| CC91T47A | Avian Egg | | 0.355 | 0.062 | 0.07 | F6553 |
| CC91T48 | Avian Egg | | 1. | 0.167 | 0.071 | F6554 |
| CC91T48A | Avian Egg | | 1.21 | 0.199 | 0.075 | F6555 |
| CC91T49 | Avian Egg | | 0.699 | 0.11 | 0.077 | F6556 |
| CC91T51 | Avian Egg | | 0.428 | 0.073 | 0.072 | F6557 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91T54 | Avian Egg | | 0.251 | 0.043 | 0.073 | F6558 |
| CC91T55 | Avian Egg | | 0.404 | 0.075 | 0.065 | F6559 |
| CC91T56 | Avian Egg | | 1. | 0.212 | 0.057 | F6560 |
| CC91T57 | Avian Egg | | 0.574 | 0.102 | 0.066 | F6561 |
| CC91T58 | Avian Egg | | 0.334 | 0.064 | 0.063 | F6562 |
| CC91T59 | Avian Egg | | 0.472 | 0.087 | 0.064 | F6563 |
| CC91T5A | Avian Egg | | 1. | 0.171 | 0.07 | F6564 |
| CC91T6 | Avian Egg | | 0.219 | 0.041 | 0.064 | F6565 |
| CC91T60 | Avian Egg | | 0.604 | 0.116 | 0.063 | F6566 |
| CC91T61 | Avian Egg | | 0.277 | 0.052 | 0.063 | F6567 |
| CC91T62 | Avian Egg | | 0.726 | 0.141 | 0.062 | F6568 |
| CC91T63A | Avian Egg | | 0.346 | 0.062 | 0.067 | F6569 |
| CC91T64 | Avian Egg | | 0.325 | 0.061 | 0.063 | F6570 |
| CC91T65 | Avian Egg | | 1.39 | 0.235 | 0.07 | F6571 |
| CC91T66 | Avian Egg | | 0.605 | 0.106 | 0.067 | F6572 |
| CC91T67 | Avian Egg | | 0.805 | 0.131 | 0.069 | F6573 |
| CC91T67A | Avian Egg | | 0.365 | 0.065 | 0.067 | F6574 |
| CC91T68 | Avian Egg | | 0.47 | 0.093 | 0.06 | F6575 |
| CC91T69 | Avian Egg | | 0.606 | 0.127 | 0.058 | F6576 |
| CC91T7 | Avian Egg | | 1.07 | 0.197 | 0.068 | F6577 |
| CC91T70 | Avian Egg | | 0.466 | 0.166 | 0.035 | F6578 |
| CC91T71 | Avian Egg | | 0.697 | 0.134 | 0.063 | F6579 |
| CC91T72 | Avian Egg | | 0.94 | 0.162 | 0.067 | F6580 |
| CC91T73 | Avian Egg | | 0.31 | 0.063 | 0.059 | F6581 |
| CC91T74 | Avian Egg | | 0.266 | 0.047 | 0.066 | F6582 |
| CC91T75 | Avian Egg | | 0.12 | 0.021 | 0.065 | F6583 |
| CC91T76 | Avian Egg | | 0.421 | 0.086 | 0.06 | F6584 |
| CC91T77 | Avian Egg | | 0.802 | 0.154 | 0.063 | F6585 |
| CC91T79 | Avian Egg | | 0.133 | 0.025 | 0.062 | F6586 |
| CC91T8 | Avian Egg | | 0.573 | 0.101 | 0.069 | F6587 |
| CC91T81 | Avian Egg | | 0.209 | 0.039 | 0.064 | F6588 |
| CC91T83 | Avian Egg | | 0.092 | 0.019 | 0.058 | F6589 |
| CC91T84 | Avian Egg | | 0.347 | 0.069 | 0.062 | F6590 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91T85 | Avian Egg | | 2.12 | 0.399 | 0.064 | F6591 |
| CC91T86 | Avian Egg | | 0.99 | 0.199 | 0.061 | F6592 |
| CC91T88 | Avian Egg | | 0.493 | 0.094 | 0.064 | F6593 |
| CC91T89 | Avian Egg | | 0.198 | 0.037 | 0.066 | F6594 |
| CC91T91 | Avian Egg | | 0.391 | 0.076 | 0.062 | F6595 |
| CC91T91A | Avian Egg | | 0.488 | 0.086 | 0.067 | F6596 |
| CC91T93 | Avian Egg | | 0.371 | 0.061 | 0.068 | F6597 |
| CC91T94 | Avian Egg | | 0.304 | 0.054 | 0.068 | F6598 |
| CC91T95 | Avian Egg | | 0.319 | 0.053 | 0.074 | F6599 |
| CC91T97 | Avian Egg | | 0.52 | 0.081 | 0.074 | F6600 |
| CC91T9B | Avian Egg | | 0.706 | 0.124 | 0.066 | F6601 |
| CC91TAA | Avian Egg | | 0.834 | 0.153 | 0.065 | F6602 |
| CC91TBB | Avian Egg | | 1.16 | 0.201 | 0.074 | F6603 |
| CC91TCCA | Avian Egg | | 0.513 | 0.094 | 0.062 | F6604 |
| CC91TDD | Avian Egg | | 0.774 | 0.14 | 0.067 | F6605 |
| CC91TEE | Avian Egg | | 1.05 | 0.194 | 0.064 | F6606 |
| CC91TFF | Avian Egg | | 0.824 | 0.148 | 0.068 | F6607 |
| CC91TGG | Avian Egg | | 0.679 | 0.144 | 0.056 | F6608 |
| CC91THH | Avian Egg | | 0.406 | 0.077 | 0.062 | F6609 |
| CC91TLL | Avian Egg | | 0.863 | 0.16 | 0.066 | F6631 |
| CC91BL04 | Kidney | | 2.79 | 0.432 | 0.212 | F6168 |
| CC91BL07 | Kidney | | 3.74 | 0.546 | 0.437 | F6171 |
| CC91BL01 | Liver | | 3.88 | 0.827 | 0.169 | F6165 |
| CC91BL02 | Liver | | 4.11 | 0.766 | 0.162 | F6166 |
| CC91BL03 | Liver | | 2.98 | 0.611 | 0.184 | F6167 |
| CC91BL05 | Liver | | 2.07 | 0.457 | 0.157 | F6169 |
| CC91BL06 | Liver | | 1.34 | 0.26 | 0.148 | F6170 |
| CC91BL09 | Liver | | 2.67 | 0.43 | 0.232 | F6172 |
| CC91BL10 | Liver | | 2.18 | 0.408 | 0.223 | F6173 |
| CC91BL11 | Liver | | 0.804 | 0.155 | 0.195 | F6174 |
| CC91BL12 | Liver | | 2.42 | 0.56 | 0.138 | F6175 |
| CC91BL13 | Liver | | 1.67 | 0.359 | 0.129 | F6176 |
| CC91BL14 | Liver | | 1.25 | 0.267 | 0.11 | F6177 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91BL15 | Liver | | 1.5 | 0.311 | 0.135 | F6178 |
| CC91BL16 | Liver | | 1.1 | 0.256 | 0.134 | F6179 |
| CC91BL17 | Liver | | 1.57 | 0.396 | 0.14 | F6180 |
| CC91BL18 | Liver | | 1.23 | 0.243 | 0.13 | F6181 |
| CC91BL19 | Liver | | 1.28 | 0.136 | 0.277 | F6182 |
| CC91BL20 | Liver | | 1.06 | 0.216 | 0.146 | F6183 |
| CC91BL21 | Liver | | 0.502 | 0.095 | 0.221 | F6184 |
| CC91BL22 | Liver | | 0.524 | 0.116 | 0.128 | F6185 |
| CC91BL23 | Liver | | 0.822 | 0.21 | 0.113 | F6186 |
| CC91BL24 | Liver | | 0.426 | 0.09 | 0.136 | F6187 |
| CC91BL25 | Liver | | 0.469 | 0.089 | 0.207 | F6188 |
| CC91BL26 | Liver | | 0.471 | 0.092 | 0.184 | F6189 |
| CC91BL27 | Liver | | 0.359 | 0.074 | 0.195 | F6190 |
| CC91BL28 | Liver | | 0.656 | 0.138 | 0.193 | F6191 |
| CC91BL29 | Liver | | 0.626 | 0.12 | 0.169 | F6192 |
| CC91BL30 | Liver | | 0.269 | 0.05 | 0.126 | F6193 |
| CC91BL31 | Liver | | 1.6 | 0.295 | 0.179 | F6194 |
| CC91EL01 | Liver | | 1.27 | 0.252 | 0.187 | F6333 |
| CC91EL02 | Liver | | 1.18 | 0.234 | 0.174 | F6334 |
| CC91EL03 | Liver | | 1.31 | 0.222 | 0.162 | F6335 |
| CC91EL04 | Liver | | 0.813 | 0.202 | 0.168 | F6336 |
| CC91EL05 | Liver | | 2.3 | 0.393 | 0.208 | F6337 |
| CC91EL06 | Liver | | 0.769 | 0.2 | 0.219 | F6338 |
| CC91EL07 | Liver | | 2.34 | 0.432 | 0.254 | F6339 |
| CC91EL08 | Liver | | 1.81 | 0.336 | 0.116 | F6340 |
| CC91EL09 | Liver | | 2.3 | 0.466 | 0.219 | F6341 |
| CC91EL10 | Liver | | 0.969 | 0.21 | 0.091 | F6342 |
| CC91EL11 | Liver | | 1.34 | 0.307 | 0.086 | F6343 |
| CC91EL12 | Liver | | 0.766 | 0.201 | 0.095 | F6344 |
| CC91EL13 | Liver | | 2.15 | 0.394 | 0.374 | F6345 |
| CC91EL14 | Liver | | 0.282 | 0.061 | 0.1 | F6346 |
| CC91EL15 | Liver | | 1.67 | 0.352 | 0.127 | F6347 |
| CC91EL16 | Liver | | 0.981 | 0.18 | 0.349 | F6348 |

ANALYTICAL REPORT (6-3)
Contaminant Concentrations - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Result (ppm Dry Wt.) | Result (ppm Wet Wt.) | Detection Limit (ppm Dry Wt.) | Lab Sample Number |
|---|---|---|---|---|---|---|
| CC91EL17 | Liver | | 1.95 | 0.443 | 0.097 | F6349 |
| CC91EL18 | Liver | | 0.386 | 0.097 | 0.045 | F6350 |
| CC91EL21 | Liver | | 0.246 | 0.064 | 0.079 | F6351 |
| CC91EL22 | Liver | | 0.648 | 0.164 | 0.165 | F6352 |
| CC91EL23 | Liver | | 1.01 | 0.268 | 0.053 | F6353 |
| CC91EL24 | Liver | | 0.517 | 0.131 | 0.065 | F6354 |
| CC91EL25 | Liver | | 0.839 | 0.207 | 0.08 | F6355 |
| CC91EL26 | Liver | | 0.623 | 0.113 | 0.146 | F6356 |
| CC91EL27 | Liver | | 0.769 | 0.214 | 0.082 | F6357 |
| CC91EL28 | Liver | | 0.661 | 0.164 | 0.056 | F6358 |
| CC91TL01 | Liver | | 1.01 | 0.24 | 0.026 | F6610 |
| CC91TL02 | Liver | | 0.626 | 0.143 | 0.016 | F6611 |
| CC91TL03 | Liver | | 0.83 | 0.19 | 0.022 | F6612 |
| CC91TL04 | Liver | | 1.2 | 0.304 | 0.052 | F6613 |
| CC91TL05 | Liver | | 0.732 | 0.169 | 0.031 | F6614 |
| CC91TL06 | Liver | | 2.55 | 0.593 | 0.098 | F6615 |
| CC91TL07 | Liver | | 1.4 | 0.319 | 0.08 | F6616 |
| CC91TL08 | Liver | | 1.03 | 0.205 | 0.137 | F6617 |
| CC91TL09 | Liver | | 1.21 | 0.264 | 0.081 | F6618 |
| CC91TL11 | Liver | | 0.199 | 0.043 | 0.021 | F6619 |
| CC91TL12 | Liver | | 0.265 | 0.057 | 0.027 | F6620 |
| CC91TL13 | Liver | | 0.13 | 0.029 | 0.017 | F6621 |
| CC91TL14 | Liver | | 1.07 | 0.215 | 0.077 | F6622 |
| CC91TL15 | Liver | | 1.37 | 0.269 | 0.136 | F6623 |
| CC91TL16 | Liver | | 1.3 | 0.34 | 0.114 | F6624 |
| CC91TL17 | Liver | | 0.326 | 0.071 | 0.03 | F6625 |
| CC91TL18 | Liver | | 0.616 | 0.133 | 0.06 | F6626 |
| CC91TL19 | Liver | | 2.15 | 0.45 | 0.352 | F6627 |
| CC91TL20 | Liver | | 0.759 | 0.166 | 0.078 | F6628 |
| CC91TL21 | Liver | | 0.879 | 0.193 | 0.132 | F6629 |
| CC91TL22 | Liver | | 0.503 | 0.136 | 0.085 | F6630 |

ANALYTICAL REPORT (6-4)
Procedural Blanks - CATALOG: 2050007

Lab Name: GERG 02/06/92 P.O.#: 85800-1-2763

Analyte: Hg

| Lab Sample No. | Result Total UG |
|---|---|
| BLANK-A | 0.004 |
| BLANK-A1 | 0.004 |
| BLANK-A2 | 0.001 |
| BLANK-B | 0.002 |
| BLANK-B1 | 0.001 |
| BLANK-B2 | 0.001 |
| BLANK-C | 0.001 |
| BLANK-C1 | 0.003 |
| BLANK-C2 | 0.002 |
| BLANK-D | 0.001 |
| BLANK-D1 | 0.001 |
| BLANK-D2 | 0.002 |
| BLANK-E | 0.007 |
| BLANK-E1 | 0.001 |
| BLANK-F | 0.001 |
| BLANK-F1 | 0.003 |
| BLANK-G | 0.001 |
| BLANK-G1 | 0.002 |
| BLANK-H | 0.001 |
| BLANK-H1 | 0.001 |
| BLANK-I | 0.001 |
| BLANK-I1 | 0.001 |
| BLANK-J | 0.004 |
| BLANK-J1 | 0.001 |
| BLANK-K | 0.004 |
| BLANK-K1 | 0.001 |
| BLANK-L | 0.001 |
| BLANK-L1 | 0.001 |
| BLANK-M | 0.001 |
| BLANK-M1 | 0.001 |
| BLANK-N | 0.001 |
| BLANK-N1 | 0.001 |
| BLANK-O | 0.002 |

ANALYTICAL REPORT (6-4)
Procedural Blanks - CATALOG: 2050007

| | |
|---|---|
| BLANK-01 | 0.001 |

ANALYTICAL REPORT (6-4)
Procedural Blanks - CATALOG: 2050007

(Continued)

| Lab Sample No. | Result Total UG |
|---|---|
| BLANK-P | 0.001 |
| BLANK-P1 | 0.001 |
| BLANK-Q | 0.002 |
| BLANK-Q1 | 0.004 |
| BLANK-R | 0.001 |
| BLANK-R1 | 0.003 |
| BLANK-S | 0.002 |
| BLANK-S1 | 0.003 |
| BLANK-T | 0.001 |
| BLANK-T1 | 0.001 |
| BLANK-U | 0.001 |
| BLANK-U1 | 0.001 |
| BLANK-V | 0.001 |
| BLANK-V1 | 0.001 |
| BLANK-W | 0.001 |
| BLANK-W1 | 0.001 |
| BLANK-X | 0.001 |
| BLANK-X1 | 0.002 |
| BLANK-Y | 0.001 |
| BLANK-Y1 | 0.001 |
| BLANK-Z | 0.004 |
| BLANK-Z1 | 0.005 |

| Average Total UG | - | Standard Deviation | - |
|---|---|---|---|
| | | | |

ANALYTICAL REPORT (6-5)
Duplicates - CATALOG: 2050007

Lab Name: GERG

02/06/92

P.O.#: 85800-1-2763

Analyte: % Moisture

| Sample Number | | Sample Matrix | Initial Result % | Duplicate Result % | Average | Relative % Difference |
|---|---|---|---|---|---|---|
| CC91B148 | Avian Egg | | 66.2 | 67.2 | 66.7 | 1.49925 |
| CC91BL20 | Liver | | 79.3 | 79.7 | 79.5 | 0.50314 |
| CC91BL24 | Liver | | 78.9 | 78.6 | 78.75 | 0.38095 |
| CC91BL30 | Liver | | 81.5 | 81.4 | 81.45 | 0.12277 |
| CC91E113 | Avian Egg | | 85.8 | 84.8 | 85.3 | 1.17233 |
| CC91EL08 | Liver | | 81.3 | 81.5 | 81.4 | 0.24570 |
| CC91EL11 | Liver | | 77.6 | 76.6 | 77.1 | 1.29701 |
| CC91EL12 | Liver | | 74.5 | 72.9 | 73.7 | 2.17096 |
| CC91F2 | Avian Egg | | 71.1 | 71.5 | 71.3 | 0.56100 |
| CC91PP7 | Avian Egg | | 40.9 | 41.8 | 41.35 | 2.17654 |
| CC91T34A | Avian Egg | | 83.3 | 84.2 | 83.75 | 1.07462 |
| CC91T37 | Avian Egg | | 81.3 | 81.4 | 81.35 | 0.12292 |
| CC91T38 | Avian Egg | | 81.4 | 81.3 | 81.35 | 0.12292 |
| CC91T39 | Avian Egg | | 82.9 | 81.9 | 82.4 | 1.21359 |
| CC91T3A | Avian Egg | | 83.7 | 83.1 | 83.4 | 0.71942 |
| CC91T4 | Avian Egg | | 82. | 81.2 | 81.6 | 0.98039 |
| CC91T42 | Avian Egg | | 82.2 | 80.9 | 81.55 | 1.59411 |
| CC91T43 | Avian Egg | | 81.1 | 80.9 | 81. | 0.24691 |
| CC91T44 | Avian Egg | | 82.5 | 81.1 | 81.8 | 1.71149 |
| CC91T46 | Avian Egg | | 83.5 | 82.6 | 83.05 | 1.08368 |
| CC91T47 | Avian Egg | | 84.4 | 83.7 | 84.05 | 0.83283 |
| CC91T48 | Avian Egg | | 83.7 | 83. | 83.35 | 0.83983 |
| CC91T54 | Avian Egg | | 83. | 82.7 | 82.85 | 0.36210 |
| CC91T55 | Avian Egg | | 81.9 | 80.9 | 81.4 | 1.22850 |
| CC91T70 | Avian Egg | | 64.4 | 63.4 | 63.9 | 1.56494 |
| CC91T85 | Avian Egg | | 81.6 | 80.6 | 81.1 | 1.23304 |
| CC91T86 | Avian Egg | | 80.4 | 79.3 | 79.85 | 1.37758 |
| CC91T88 | Avian Egg | | 81. | 81. | 81. | 0. |
| CC91T91A | Avian Egg | | 82.6 | 82.1 | 82.35 | 0.60716 |
| CC91T93 | Avian Egg | | 83.7 | 83.3 | 83.5 | 0.47904 |

ANALYTICAL REPORT (6-5)
Duplicates - CATALOG: 2050007

Lab Name: GERG 02/06/92 P.O.#: 85800-1-2763

Analyte: % Moisture

| Sample Number | | Sample Matrix | Initial Result % | Duplicate Result % | Average | Relative % Difference |
|---|---|---|---|---|---|---|
| CC91T94 | Avian Egg | | . 82.7 | . 81.9 | 82.3 | 0.97205 |
| CC91T95 | Avian Egg | | . 83.8 | . 83.3 | 83.55 | 0.59844 |
| CC91T97 | Avian Egg | | . 84.4 | . 84.4 | 84.4 | 0. |
| CC91TAA | Avian Egg | | . 81.5 | . 81.6 | 81.55 | 0.12262 |
| CC91TBB | Avian Egg | | . 83.1 | . 82.4 | 82.75 | 0.84592 |
| CC91TCCA | Avian Egg | | . 81.8 | . 81.4 | 81.6 | 0.49019 |
| CC91TFF | Avian Egg | | . 81.8 | . 82. | 81.9 | 0.24420 |
| CC91TGG | Avian Egg | | . 78.5 | . 78.8 | 78.65 | 0.38143 |
| CC91THH | Avian Egg | | . 80.9 | . 81. | 80.95 | 0.12353 |
| CC91TLL | Avian Egg | | . 81.4 | . 81.2 | 81.3 | 0.24600 |

ANALYTICAL REPORT (6-5)
Duplicates - CATALOG: 2050007

Lab Name: GERG 02/06/92 P.O.#: 85800-1-2763

Analyte: Hg

| Sample Number | Sample Matrix | Initial Result (ppm Dry Wt.) | Duplicate Result (ppm Dry Wt.) | Average | Relative % Difference |
|---|---|---|---|---|---|
| C91E130A | Avian Egg | 1.08 | 1.13 | 1.105 | 4.52488 |
| C91E131A | Avian Egg | 0.289 | 0.322 | 0.3055 | 10.80196 |
| C91E132A | Avian Egg | 0.206 | 0.223 | 0.2145 | 7.92540 |
| CC91B119 | Avian Egg | 0.292 | 0.319 | 0.3055 | 8.83797 |
| CC91B120 | Avian Egg | 0.416 | 0.45 | 0.433 | 7.85219 |
| CC91B121 | Avian Egg | 0.456 | 0.357 | 0.4065 | 24.35424 |
| CC91B59 | Avian Egg | 0.941 | 0.991 | 0.966 | 5.17598 |
| CC91B60 | Avian Egg | 0.853 | 0.89 | 0.8715 | 4.24555 |
| CC91B61 | Avian Egg | 0.251 | 0.258 | 0.2545 | 2.75049 |
| CC91B68 | Avian Egg | 0.127 | 0.154 | 0.1405 | 19.21708 |
| CC91B82 | Avian Egg | 0.284 | 0.254 | 0.269 | 11.15241 |
| CC91B83 | Avian Egg | 0.62 | 0.6 | 0.61 | 3.27868 |
| CC91B86 | Avian Egg | 0.144 | 0.138 | 0.141 | 4.25531 |
| CC91BL07 | Kidney | 3.74 | 4.14 | 3.94 | 10.15228 |
| CC91BL09 | Liver | 2.67 | 4.55 | 3.61 | 52.07756 |
| CC91BL19 | Liver | 1.28 | 0.924 | 1.102 | 32.30490 |
| CC91BL20 | Liver | 1.06 | 0.943 | 1.0015 | 11.68247 |
| CC91BL22 | Liver | 0.524 | 0.546 | 0.535 | 4.11214 |
| CC91BL24 | Liver | 0.426 | 0.526 | 0.476 | 21.00840 |
| CC91BL30 | Liver | 0.269 | 0.242 | 0.2555 | 10.56751 |
| CC91E10 | Avian Egg | 0.548 | 0.503 | 0.5255 | 8.56327 |
| CC91E54 | Avian Egg | 0.514 | 0.526 | 0.52 | 2.30769 |
| CC91E56 | Avian Egg | 0.465 | 0.467 | 0.466 | 0.42918 |
| CC91E6A | Avian Egg | 0.585 | 0.586 | 0.5855 | 0.17079 |
| CC91E71 | Avian Egg | 0.303 | 0.317 | 0.31 | 4.51612 |
| CC91E72 | Avian Egg | 0.755 | 0.688 | 0.7215 | 9.28620 |
| CC91E72A | Avian Egg | 0.501 | 0.501 | 0.501 | 0. |
| CC91E9 | Avian Egg | 1.08 | 1.05 | 1.065 | 2.81690 |
| CC91EL06 | Liver | 0.769 | 0.787 | 0.778 | 2.31362 |
| CC91EL08 | Liver | 1.81 | 1.92 | 1.865 | 5.89812 |
| CC91EL11 | Liver | 1.34 | 1.32 | 1.33 | 1.50375 |

ANALYTICAL REPORT (6-5)
Duplicates - CATALOG: 2050007

Lab Name: GERG 02/06/92 P.O.#: 85800-1-2763

Analyte: Hg

| Sample Number | Sample Matrix | Initial Result (ppm Dry Wt.) | Duplicate Result (ppm Dry Wt.) | Average | Relative % Difference |
|---|---|---|---|---|---|
| CC91EL12 | Liver | 0.766 | 0.805 | 0.7855 | 4.96499 |
| CC91EL13 | Liver | 2.15 | 2.66 | 2.405 | 21.20582 |
| CC91EL14 | Liver | 0.282 | 0.344 | 0.313 | 19.80830 |
| CC91EL16 | Liver | 0.981 | 0.886 | 0.9335 | 10.17675 |
| CC91EL22 | Liver | 0.648 | 0.737 | 0.6925 | 12.85198 |
| CC91LB3 | Avian Egg | 2.84 | 2.95 | 2.895 | 3.79965 |
| CC91LG4 | Avian Egg | 0.614 | 0.623 | 0.6185 | 1.45513 |
| CC91LG5 | Avian Egg | 1.73 | 1.68 | 1.705 | 2.93255 |
| CC91PP19 | Avian Egg | 1.56 | 1.48 | 1.52 | 5.26315 |
| CC91PP20 | Avian Egg | 0.95 | 0.922 | 0.936 | 2.99145 |
| CC91PP21 | Avian Egg | 0.914 | 0.946 | 0.93 | 3.44086 |
| CC91PS1 | Avian Egg | 1.4 | 1.49 | 1.445 | 6.22837 |
| CC91PS18 | Avian Egg | 0.752 | 0.728 | 0.74 | 3.24324 |
| CC91PS19 | Avian Egg | 2.39 | 2.31 | 2.35 | 3.40425 |
| CC91PS2 | Avian Egg | 1.55 | 1.61 | 1.58 | 3.79746 |
| CC91PS20 | Avian Egg | 1.62 | 1.57 | 1.595 | 3.13479 |
| CC91SE10 | Avian Egg | 0.279 | 0.276 | 0.2775 | 1.08108 |
| CC91SE8 | Avian Egg | 0.532 | 0.515 | 0.5235 | 3.24737 |
| CC91SE9 | Avian Egg | 0.591 | 0.606 | 0.5985 | 2.50626 |
| CC91T1 | Avian Egg | 0.473 | 0.463 | 0.468 | 2.13675 |
| CC91T27 | Avian Egg | 0.268 | 0.261 | 0.2645 | 2.64650 |
| CC91T27A | Avian Egg | 0.369 | 0.387 | 0.378 | 4.76190 |
| CC91T28 | Avian Egg | 0.339 | 0.357 | 0.348 | 5.17241 |
| CC91T34A | Avian Egg | 0.686 | 0.677 | 0.6815 | 1.32061 |
| CC91T39 | Avian Egg | 0.657 | 0.624 | 0.6405 | 5.15222 |
| CC91T3A | Avian Egg | 0.288 | 0.299 | 0.2935 | 3.74787 |
| CC91T91 | Avian Egg | 0.391 | 0.38 | 0.3855 | 2.85343 |
| CC91T91A | Avian Egg | 0.488 | 0.505 | 0.4965 | 3.42396 |

ANALYTICAL REPORT (6-6)
Reference Materials - CATALOG: 2050007

Lab Name: GERG 02/06/92 P.O.#: 85800-1-2763

Analyte: Hg

| Lab Sample Number | S.R.M. ID | S.R.M. Name | * Certified/Reference Value (ppm Dry Wt.) | 95% Conf. Interval | Result (ppm Dry Wt.) | Percent Recovery |
|---|---|---|---|---|---|---|
| DORM-A | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.775 | 97.11779 |
| DORM-A1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.776 | 97.24310 |
| DORM-B | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.761 | 95.36340 |
| DORM-B1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.842 | 105.51378 |
| DORM-C | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.746 | 93.48370 |
| DORM-C1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.833 | 104.38596 |
| DORM-D | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.787 | 98.62155 |
| DORM-D1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.778 | 97.49373 |
| DORM-E | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.772 | 96.74185 |
| DORM-E1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.805 | 100.87719 |
| DORM-F | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.807 | 101.12781 |
| DORM-F1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.824 | 103.25814 |
| DORM-G | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.745 | 93.35839 |
| DORM-G1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.829 | 103.88471 |
| DORM-H | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.814 | 102.00501 |
| DORM-H1 | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.869 | 108.89724 |
| DORM-I | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.811 | 101.62907 |
| DORM-J | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.834 | 104.51127 |
| DORM-K | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.693 | 86.84210 |
| DORM-L | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.854 | 107.01754 |
| DORM-M | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.789 | 98.87218 |
| DORM-N | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.762 | 95.48872 |
| DORM-O | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.788 | 98.74686 |
| DORM-P | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.802 | 100.50125 |
| DORM-Q | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.872 | 109.27318 |
| DORM-R | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.836 | 104.76190 |

* Only certified analytes list a confidence interval - all others are considered reference values.

ANALYTICAL REPORT (6-6)
Reference Materials - CATALOG: 2050007

(Continued)

| Lab Sample Number | S.R.M. ID | S.R.M. Name | * Certified/Reference Value (ppm Dry Wt.) | 95% Conf. Interval | Result (ppm Dry Wt.) | Percent Recovery |
|---|---|---|---|---|---|---|
| DORM-S | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.859 | 107.64411 |
| DORM-T | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.833 | 104.38596 |
| DORM-U | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.817 | 102.38095 |
| DORM-V | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.777 | 97.36842 |
| DORM-W | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.75 | 93.98496 |
| DORM-X | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.745 | 93.35839 |
| DORM-Y | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.74 | 92.73182 |
| DORM-Z | NRCC DORM-1 | Dogfish Muscle | 0.798 | 0.074 | 0.804 | 100.75187 |

ANALYTICAL REPORT (6-7)
Spike Recoveries - CATALOG: 2050007

Lab Name: GERG 02/06/92 P.O.#: 85800-1-2763

Analyte: Hg

| Sample Number | | Sample Matrix | Spike Level (ppm Dry Wt.) | Amount Recovered (ppm Dry Wt.) | * Spike/ Background | % Recovery |
|---|---|---|---|---|---|---|
| CC91B114 | Avian Egg | | 0.779 | 0.965 | 1.57373 | 123.87676 |
| CC91B115 | Avian Egg | | 0.943 | 1.003 | 3.17508 | 106.36267 |
| CC91B116 | Avian Egg | | 1.08 | 1.021 | 3.28267 | 94.53703 |
| CC91B62 | Avian Egg | | 1. | 0.965 | 4.08163 | 96.5 |
| CC91B63 | Avian Egg | | 0.977 | 1.002 | 2.23059 | 102.55885 |
| CC91B64 | Avian Egg | | 0.918 | 0.876 | 3.47727 | 95.42483 |
| CC91B79 | Avian Egg | | 0.957 | 0.874 | 3.89024 | 91.32706 |
| CC91B80 | Avian Egg | | 0.804 | 0.788 | 2.05102 | 98.00995 |
| CC91B81 | Avian Egg | | 0.974 | 1.028 | 3.71755 | 105.54414 |
| CC91E110 | Avian Egg | | 0.982 | 0.996 | 2.37198 | 101.42566 |
| CC91E111 | Avian Egg | | 0.95 | 1.12 | 0.56886 | 117.89473 |
| CC91E112 | Avian Egg | | 0.878 | 1.22 | 0.46455 | 138.95216 |
| CC91E4 | Avian Egg | | 0.81 | 0.785 | 1.13286 | 96.91358 |
| CC91E5 | Avian Egg | | 0.895 | 0.837 | 1.18857 | 93.51955 |
| CC91E6 | Avian Egg | | 1.01 | 0.97 | 1.32894 | 96.03960 |
| CC91E66A | Avian Egg | | 0.916 | 0.931 | 2.48238 | 101.63755 |
| CC91E67 | Avian Egg | | 1. | 1.03 | 0.64516 | 103. |
| CC91E70 | Avian Egg | | 0.983 | 0.866 | 2.43316 | 88.09766 |
| CC91LB1 | Avian Egg | | 1. | 1.005 | 2.53164 | 100.5 |
| CC91LB2 | Avian Egg | | 1.12 | 1.064 | 1.38957 | 95. |
| CC91LG1 | Avian Egg | | 0.644 | 0.82 | 0.92 | 127.32919 |
| CC91LG2 | Avian Egg | | 0.676 | 0.927 | 0.83148 | 137.13017 |
| CC91LG3 | Avian Egg | | 0.729 | 0.97 | 0.66880 | 133.05898 |
| CC91PS21 | Avian Egg | | 0.988 | 0.86 | 0.52553 | 87.04453 |
| CC91PS3 | Avian Egg | | 1.14 | 1.21 | 0.62637 | 106.14035 |
| CC91PS43 | Avian Egg | | 1.02 | 1.17 | 0.68456 | 114.70588 |

* - For a spike to be a valid measure of method accuracy, this ratio must be higher than 1.0.

ANALYTICAL REPORT (6-7)
Spike Recoveries - CATALOG: 2050007

(Continued)

| Sample Number | | Sample Matrix | Spike Level (ppm Dry Wt.) | Amount Recovered (ppm Dry Wt.) | * Spike/ Background | % Recovery |
|---|---|---|---|---|---|---|
| CC91PS44 | Avian Egg | | 0.804 | 0.969 | 1.05650 | 120.52238 |
| CC91PS5 | Avian Egg | | 1.08 | 1.08 | 0.77142 | 100. |
| CC91SE5 | Avian Egg | | 0.74 | 0.636 | 1.33574 | 85.94594 |
| CC91SE6 | Avian Egg | | 1.03 | 0.929 | 5.69060 | 90.19417 |
| CC91SE7 | Avian Egg | | 1.06 | 0.863 | 1.43826 | 81.41509 |
| CC91T23 | Avian Egg | | 0.889 | 0.811 | 1.85594 | 91.22609 |
| CC91T23A | Avian Egg | | 0.941 | 0.892 | 1.40868 | 94.79277 |
| CC91T24 | Avian Egg | | 0.88 | 0.763 | 0.98104 | 86.70454 |
| CC91T37 | Avian Egg | | 1.12 | 0.934 | 2.25806 | 83.39285 |
| CC91T38 | Avian Egg | | 0.903 | 0.828 | 2.30357 | 91.69435 |
| CC91T45X | Avian Egg | | 1. | 0.955 | 1.19760 | 95.5 |
| CC91T88 | Avian Egg | | 0.91 | 0.887 | 1.84584 | 97.47252 |
| CC91T89 | Avian Egg | | 0.926 | 0.892 | 4.67676 | 96.32829 |

ANALYTICAL REPORT (6-9)
Analytical Methods - CATALOG: 2050007

Lab Name: GERG 02/06/92 P.O.#: 85800-1-2763

| Method Code | Method Description |
|---|---|

# APPENDIX B-4

## ORGANOCHLORINE ANALYSIS OF SELECTED SAMPLE EGGS OF COLONIAL WATERBIRDS FOR LAVACA BAY AND REFERENCE SITES, SPRING 1991

U. S. FISH AND WILDLIFE SERVICE
PATUXENT ANALYTICAL CONTROL FACILITY

QUALITY ASSURANCE REPORT



RE: 2050007 REGION: 2 REGIONAL ID: 2253

THE ANALYSES ON THE ABOVE MENTIONED SAMPLES WERE PERFORMED AT:

TEXAS A & M RESEARCH FOUNDATION
10 SOUTH GRAHAM RD
COLLEGE STATION, TX 77840

AFTER A THOROUGH REVIEW OF THE REPORTS FROM THIS LABORATORY, I REPORT THE FOLLOWING OBSERVATIONS AND CONCLUSIONS:

THE ACCURACY, AS MEASURED BY SPIKE RECOVERY, WAS GENERALLY ACCEPTABLE. RECOVERIES OF beta BHC AND HCB IN TISSUE HAVE AVERAGED LESS THAN 80%. THE METHOD SHOULD NOT BE CONSIDERED QUANTITATIVE FOR THESE ANALYTES. THE ATTACHED TABLE CONTAINS THE AVERAGE SPIKE RECOVERIES FOR ORGANOCHLORINES IN TISSUE.

THE PRECISION, BASED ON DUPLICATE SAMPLE ANALYSES, WAS ACCEPTABLE.

THE DETECTION LIMIT FOR THESE ANALYSES IS .05ppm. ANY RESULTS REPORTED BELOW THIS LIMIT SHOULD BE CONSIDERED AS "< 0.05".

IN ORDER TO AVOID DELAY IN ISSUING THESE RESULTS, THIS REPORT IS BEING SUBMITTED IN PAPER FORMAT. HOWEVER, THESE RESULTS WILL BE ENTERED INTO ECDMS AS SOON AS POSSIBLE.

Greg A. Anderson 1-24-92
QUALITY ASSURANCE OFFICER DATE

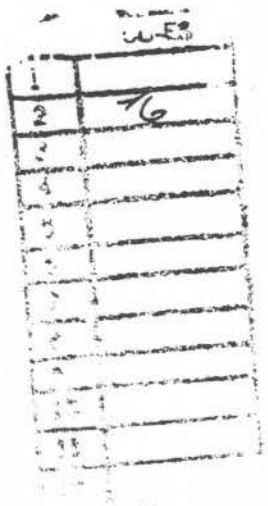

TABLE 1: GEOCHEMICAL AND ENVIRONMENTAL RESEARCH GROUP
TEXAS A&M UNIVERSITY
AVERAGE PERCENT RECOVERY OF SPIKED ANALYTE
FROM TISSUE SAMPLES ANALYZED IN 1990-91

| ANALYTE | NUMBER | MEAN | STD. DEV. |
|---|---|---|---|
| ALDRIN | 27 | 105.5 | 14.0 |
| alpha BHC | 27 | 93.9 | 13.4 |
| alpha CHLORDANE | 27 | 97.3 | 16.5 |
| beta BHC | 27 | 55.3 | 22.0 |
| delta BHC | 27 | 90.1 | 15.4 |
| DIELDRIN | 27 | 104.3 | 14.9 |
| ENDRIN | 27 | 105.8 | 14.2 |
| gamma BHC | 27 | 100.9 | 16.9 |
| gamma CHLORDANE | 27 | 97.6 | 14.5 |
| HCB | 27 | 53.4 | 24.7 |
| HEPTACHLOR EPOXIDE | 27 | 101.2 | 15.3 |
| HEPTACHLOR | 27 | 102.6 | 12.9 |
| MIREX | 27 | 105.0 | 14.6 |
| O,P'DDD | 27 | 99.4 | 22.9 |
| O,P'DDE | 27 | 94.4 | 17.9 |
| O,P'DDT | 27 | 91.2 | 21.3 |
| P,P'DDD | 27 | 101.9 | 16.6 |
| P,P'DDE | 27 | 101.7 | 14.4 |
| P,P'DDT | 27 | 105.8 | 14.5 |
| PCB | 27 | 102.1 | 8.5 |
| TRANS NONACHLOR | 27 | 99.7 | 12.8 |

ANALYTICAL REPORT INTEGRITY FORM

CATALOG #: 2050007 LAB: TAM REGIONAL ID: 2253

| DATE | INITIALS | PROBLEMS/ACTION |
|---|---|---|
| 1-6-92 | JWT | INITIAL REVIEW electronic report required OK |
| | | |
| 1-16-92 | CH | QA Review - No detection limit given - will call |
| | | |
| 1-22-92 | CH | Called Terry and he confirmed that the ~~weight~~ det. limits would be raised to .05 based on a 2.00g sample. |

CATALOG 2050007

# Summary of GERG Analytical Methods

The sediment samples were freeze-dried and extracted in a Soxhlet extraction apparatus. A flow diagram of the procedure is attached. Briefly, the freeze-dried sediment samples were homogenized and a 10-gram sample was weighed into the extraction thimble. Surrogate standards and methylene chloride were added and the samples extracted for 12 hrs. The extracts were treated with copper to remove sulfur and were purified by silica/alumina column chromatography (MacLeod *et al.*, 1985; Brooks *et al.*, 1989) to isolate the aliphatic and aromatic/pesticide/PCB fractions.

The tissue samples were extracted by the NOAA Status and Trends Method (MacLeod *et al.*, 1985) with minor revisions (Brooks *et al.*, 1989; Wade *et al.*, 1988). A flow diagram of the procedure is attached. Briefly, the tissue samples were homogenized with a Teckmar Tissumizer. A 1 to 10-gram sample (wet weight) was extracted with the Teckmar Tissumizer by adding surrogate standards, $Na_2SO_4$, and methylene chloride in a centrifuge tube. The tissue extracts were purified by silica/alumina column chromatography to isolate the aliphatic and PAH/pesticide/PCB fractions. The PAH/pesticide/PCB fraction was further purified by HPLC in order to remove interfering lipids.

The quantitative analyses were performed by capillary gas chromatography (CGC) with a flame ionization detector for aliphatic hydrocarbons, CGC with electron capture detector for pesticides and PCB's, and a mass spectrometer detector in the SIM mode for aromatic hydrocarbons (Wade *et al..*, 1988).

## REFERENCES


Brooks, J.M., T. L. Wade, E. L. Atlas, M. C. Kennicutt II, B. J. Presley, R. R. Fay, E. N. Powell, and G. Wolff (1989) **Analysis of Bivalves and Sediments for Organic Chemicals and Trace Elements.** Third Annual Report for NOAA's National Status and Trends Program, Contract 50-DGNC-5-00262.

MacLeod, W.D., D. W. Brown, A. J. Friedman, D.G. Burrow, O. Mayes, R.W. Pearce, C.A. Wigren, and R. G. Bogar (1985) **Standard Analytical Procedures of the NOAA National Analytical Facility 1985-1986.** Extractable Toxic Organic Compounds. 2nd Ed. U.S. Department of Commerce, NOAA/NMFS. NOAA Tech. Memo. NMFS F/NWC-92.

Wade, T.L., E. L. Atlas, J. M. Brooks, M. C. Kennicutt II, R. G. Fox, J. Sericano, B. Garcia, and D. DeFreitas (1988) **NOAA Gulf of Mexico Status and Trends Program: Trace Organic Contaminant Distribution in Sediments and Oysters.** Estuaries, 11, 171-179.

CATALOG #2050007

# SAMPLE ANALYSES RESULTS

for

U.S. Fish and Wildlife Service

Prepared by

Geochemical and Environmental Research Group
Texas A&M University

December 23, 1991

FISH & WILDLIFE SERVICES - CATALOG #2050007

BULK PARAMETERS

| FILE | FWS SAMPLE ID | SAMPLE TYPE S,F,B,W | COMMENTS/DESCRIPTION | SAMPLE WT. (gr) | % MOISTURE | % LIPID |
|---|---|---|---|---|---|---|
| F6023 | CC91B100 | A | AVIAN EGG | 1.99 | 81.25 | 6.47 |
| F6039 | CC91B116 | A | AVIAN EGG | 2.08 | 83.73 | 3.55 |
| F6046 | CC91B122 | A | AVIAN EGG | 2.14 | 82.45 | 4.44 |
| F6057 | CC91B132 | A | AVIAN EGG | 2.08 | 82.44 | 5.41 |
| F6058 | CC91B134 | A | AVIAN EGG | 2.09 | 81.90 | 5.57 |
| F6082 | CC91B29 | A | AVIAN EGG | 2.00 | 82.70 | 5.63 |
| F6087 | CC91B32A | A | AVIAN EGG | 2.05 | 87.26 | 2.14 |
| F6092 | CC91B37 | A | AVIAN EGG | 2.06 | 80.78 | 7.09 |
| F6094 | CC91B39 | A | AVIAN EGG | 2.09 | 82.86 | 6.23 |
| F6102 | CC91B5 | A | AVIAN EGG | 2.11 | 81.33 | 6.03 |
| F6217 | CC91E110 | A | AVIAN EGG | 2.14 | 83.12 | 4.84 |
| F6219 | CC91E112 | A | AVIAN EGG | 2.04 | 82.15 | 5.75 |
| F6220 | CC91E113 | A | AVIAN EGG | 2.00 | 85.24 | 3.44 |
| F6222 | CC91E115 | A | AVIAN EGG | 2.13 | 81.78 | 5.06 |
| F6231 | CC91E123 | A | AVIAN EGG | 2.04 | 80.19 | 6.29 |
| F6245 | CC91E16 | A | AVIAN EGG | 2.14 | 81.83 | 6.99 |
| F6259 | CC91E28A | A | AVIAN EGG | 2.08 | 81.09 | 6.08 |
| F6260 | CC91E29A | A | AVIAN EGG | 2.18 | 82.26 | 5.01 |
| F6261 | CC91E2A | A | AVIAN EGG | 2.10 | 81.37 | 6.32 |
| F6264 | CC91E31 | A | AVIAN EGG | 2.07 | 81.73 | 6.40 |

* All data on a wet weight basis.

FISH & WILDLIFE SERVICES - CATALOG #2050007
BULK PARAMETERS

| FILE | FWS SAMPLE ID | SAMPLE TYPE S,F,B,W | COMMENTS/DESCRIPTION | SAMPLE WT. (gr) | % MOISTURE | % LIPID |
|---|---|---|---|---|---|---|
| Replicates | | | | | | |
| F6102 | CC91B5 | A | AVIAN EGG | 2.11 | 81.33 | 6.03 |
| Q2017 | QA/QC | A | AVIAN EGG | 2.03 | 81.60 | 7.28 |
| F6231 | CC91E123 | A | AVIAN EGG | 2.04 | 80.19 | 6.29 |
| F6658 | QA/QC | A | AVIAN EGG | 2.01 | 80.60 | 6.76 |

* All data on a wet weight basis.

FISH & WILDLIFE SERVICES - CATALOG NO 2050007- PESTICIDE & PCB ANALYSIS

| RAW FILE # | F6023 | F6039 | F6046 | F6057 | F6058 | F6082 | F6087 | F6092 |
|---|---|---|---|---|---|---|---|---|
| STATION | CC91B100 (ppm) | CC91B116 (ppm) | CC91B122 (ppm) | CC91B132 (ppm) | CC91B134 (ppm) | CC91B29 (ppm) | CC91B32A (ppm) | CC91B37 (ppm) |
| TOTAL BHC'S | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| TOTAL CHLORDANES | 0.03 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| TOTAL DDT'S | 0.42 | 1.61 | 0.37 | 0.15 | 0.12 | 0.20 | 0.07 | 0.18 |
| TOTAL PCB'S | 0.53 | *2.07 | 0.47 | 0.61 | 0.66 | 0.53 | 0.23 | 0.27 |
| TOXAPHENE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PCB 1242 (%) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PCB 1248 (%) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PCB 1254 (%) | 97.2 | 89.7 | 89.8 | 89.7 | 88.5 | 96.4 | 99.4 | 99.0 |
| PCB 1260 (%) | 2.8 | 10.3 | 10.2 | 10.3 | 11.5 | 3.6 | 0.6 | 1.0 |
| ALPHA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HCB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| BETA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GAMMA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DELTA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HEPTACHLOR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HEPTA-EPOXIDE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OXYCHLORDANE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GAMMA-CHLORDANE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALPHA-CHLORDANE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| TRANS-NONACHLOR | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| CIS-NONACHLOR | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ALDRIN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DIELDRIN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ENDRIN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MIREX | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,4'DDE (O,P'DDE) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4,4'DDE (P,P'DDE) | 0.42 | *1.56 | 0.37 | 0.15 | 0.12 | 0.20 | 0.07 | 0.18 |
| 2,4'DDD (O,P'DDD) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4,4'DDD (P,P'DDD) | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,4'DDT (O,P'DDT) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4,4'DDT (P,P'DDT) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

* CONFIRMED BY GC/MS SIM

FISH & WILDLIFE SERVICES - CATALOG NO 2050007- PESTICIDE & PCB ANALYSIS

| RAW FILE # | F6094 | F6102 | F6217 | F6219 | F6220 | F6222 | F6231 | F6245 |
|---|---|---|---|---|---|---|---|---|
| STATION | CC91B39 (ppm) | CC91B5 (ppm) | CC91E110 (ppm) | CC91E112 (ppm) | CC91E113 (ppm) | CC91E115 (ppm) | CC91E123 (ppm) | CC91E16 (ppm) |
| TOTAL BHC'S | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 |
| TOTAL CHLORDANES | 0.00 | 0.02 | 1.99 | 0.02 | 0.16 | 0.00 | 0.01 | 0.04 |
| TOTAL DDT'S | 0.29 | 0.48 | 4.43 | 0.25 | 0.95 | 0.05 | 0.29 | 2.16 |
| TOTAL PCB'S | 0.70 | 0.84 | *3.58 | 0.71 | 2.60 | 0.22 | 0.25 | 0.58 |
| TOXAPHENE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PCB 1242 (%) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PCB 1248 (%) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PCB 1254 (%) | 91.5 | 94.0 | 92.4 | 97.7 | 99.3 | 95.0 | 91.2 | 93.8 |
| PCB 1260 (%) | 8.5 | 6.0 | 7.6 | 2.3 | 0.7 | 5.1 | 8.8 | 6.2 |
| ALPHA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HCB | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 |
| BETA-BHC | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 |
| GAMMA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DELTA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HEPTACHLOR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HEPTA-EPOXIDE | 0.00 | 0.00 | 0.20 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 |
| OXYCHLORDANE | 0.00 | 0.00 | *0.45 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 |
| GAMMA-CHLORDANE | 0.00 | 0.00 | 0.21 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| ALPHA-CHLORDANE | 0.00 | 0.00 | 0.04 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| TRANS-NONACHLOR | 0.00 | 0.01 | *0.81 | 0.01 | 0.08 | 0.00 | 0.00 | 0.02 |
| CIS-NONACHLOR | 0.00 | 0.00 | *0.28 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 |
| ALDRIN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DIELDRIN | 0.00 | 0.00 | *0.23 | 0.00 | 0.03 | 0.00 | 0.00 | 0.01 |
| ENDRIN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MIREX | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,4'DDE (O,P'DDE) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4,4'DDE (P,P'DDE) | 0.29 | 0.48 | *4.38 | 0.24 | 0.92 | 0.05 | 0.29 | 2.16 |
| 2,4'DDD (O,P'DDD) | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4,4'DDD (P,P'DDD) | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2,4'DDT (O,P'DDT) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4,4'DDT (P,P'DDT) | 0.00 | 0.00 | 0.02 | 0.01 | 0.02 | 0.00 | 0.01 | 0.00 |

* CONFIRMED BY GC/MS SIM

FISH & WILDLIFE SERVICES - CATALOG NO 2050007- PESTICIDE & PCB ANALYSIS

| RAW FILE # | F6259 | F6260 | F6261 | F6264 | F6102 | Q2017 QA/QC of F6102 | Q2019 BLANK | Q2018 SPIKE of F6102 |
|---|---|---|---|---|---|---|---|---|
| STATION | CC91E28A (ppm) | CC91E29A (ppm) | CC91E2A (ppm) | CC91E31 (ppm) | CC91B5 (ppm) | (ppm) | (ppm) | % Recov |
| TOTAL BHC'S | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | NA |
| TOTAL CHLORDANES | 0.00 | 0.00 | 0.02 | 0.01 | 0.02 | 0.00 | 0.00 | NA |
| TOTAL DDT'S | 0.57 | 0.24 | 0.24 | 0.26 | 0.48 | 0.45 | 0.00 | NA |
| TOTAL PCB'S | 0.34 | 0.36 | 0.28 | 0.79 | 0.84 | 0.65 | 0.05 | 101% |
| TOXAPHENE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | NA |
| PCB 1242 (%) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | NA |
| PCB 1248 (%) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | NA |
| PCB 1254 (%) | 90.9 | 98.6 | 89.2 | 95.1 | 94.0 | 94.2 | 0.0 | NA |
| PCB 1260 (%) | 9.1 | 1.5 | 10.9 | 4.9 | 6.0 | 5.8 | 0.0 | NA |
| ALPHA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66% |
| HCB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20% |
| BETA-BHC | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 18% |
| GAMMA-BHC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 73% |
| DELTA-BHC | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 51% |
| HEPTACHLOR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 81% |
| HEPTA-EPOXIDE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 79% |
| OXYCHLORDANE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | NA |
| GAMMA-CHLORDANE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 78% |
| ALPHA-CHLORDANE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 78% |
| TRANS-NONACHLOR | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 72% |
| CIS-NONACHLOR | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | NA |
| ALDRIN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 79% |
| DIELDRIN | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 75% |
| ENDRIN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 69% |
| MIREX | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 82% |
| 2,4'DDE (O,P'DDE) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 77% |
| 4,4'DDE (P,P'DDE) | 0.57 | 0.24 | 0.24 | 0.25 | 0.48 | 0.45 | 0.00 | 71% |
| 2,4'DDD (O,P'DDD) | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 84% |
| 4,4'DDD (P,P'DDD) | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 84% |
| 2,4'DDT (O,P'DDT) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 88% |
| 4,4'DDT (P,P'DDT) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 83% |

* CONFIRMED BY GC/MS SIM

FISH & WILDLIFE SERVICES - CATALOG NO 2050007- PESTICIDE & PCB ANALYSIS

| RAW FILE # | F6231 | F6658 QA/QC | Q2025 BLANK | Q2026 SPIKE |
|---|---|---|---|---|
| STATION | CC91E123 (ppm) | of F6231 (ppm) | (ppm) | of F6231 % Recov |
| TOTAL BHC'S | 0.00 | 0.00 | 0.00 | NA |
| TOTAL CHLORDANES | 0.01 | 0.00 | 0.00 | NA |
| TOTAL DDT'S | 0.29 | 0.32 | 0.01 | NA |
| TOTAL PCB'S | 0.25 | 0.28 | 0.07 | 98% |
| TOXAPHENE | 0.00 | 0.00 | 0.00 | NA |
| PCB 1242 (%) | 0.0 | 0.0 | 0.0 | NA |
| PCB 1248 (%) | 0.0 | 0.0 | 0.0 | NA |
| PCB 1254 (%) | 91.2 | 85.4 | 0.0 | NA |
| PCB 1260 (%) | 8.8 | 14.6 | 0.0 | NA |
| ALPHA-BHC | 0.00 | 0.00 | 0.00 | 75% |
| HCB | 0.00 | 0.00 | 0.00 | 38% |
| BETA-BHC | 0.00 | 0.00 | 0.00 | 21% |
| GAMMA-BHC | 0.00 | 0.00 | 0.00 | 80% |
| DELTA-BHC | 0.00 | 0.00 | 0.00 | 57% |
| HEPTACHLOR | 0.00 | 0.00 | 0.00 | 94% |
| HEPTA-EPOXIDE | 0.00 | 0.00 | 0.00 | 106% |
| OXYCHLORDANE | 0.00 | 0.00 | 0.00 | NA |
| GAMMA-CHLORDANE | 0.00 | 0.00 | 0.00 | 92% |
| ALPHA-CHLORDANE | 0.00 | 0.00 | 0.00 | 92% |
| TRANS-NONACHLOR | 0.00 | 0.00 | 0.00 | 84% |
| CIS-NONACHLOR | 0.00 | 0.00 | 0.00 | NA |
| ALDRIN | 0.00 | 0.00 | 0.00 | 91% |
| DIELDRIN | 0.00 | 0.00 | 0.00 | 118% |
| ENDRIN | 0.00 | 0.00 | 0.00 | 125% |
| MIREX | 0.00 | 0.00 | 0.00 | 97% |
| 2,4'DDE (O,P'DDE) | 0.00 | 0.00 | 0.00 | 90% |
| 4,4'DDE (P,P'DDE) | 0.29 | 0.32 | 0.01 | 87% |
| 2,4'DDD (O,P'DDD) | 0.00 | 0.00 | 0.00 | 93% |
| 4,4'DDD (P,P'DDD) | 0.00 | 0.00 | 0.00 | 95% |
| 2,4'DDT (O,P'DDT) | 0.00 | 0.00 | 0.00 | 105% |
| 4,4'DDT (P,P'DDT) | 0.01 | 0.01 | 0.00 | 103% |

* CONFIRMED BY GC/MS SIM

# APPENDIX B-5

## NATIONAL WILDLIFE HEALTH RESEARCH CENTER
## REPORT ON HISTOPATHOLOGICAL EXAMINATION OF GREAT BLUE HERON, GREAT EGRET, AND TRI-COLORED NESTLING BRAINS

# Tricolor Heron
# Laguna Madre

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Choroid Plexus | Neurons | Vessels | Myelin Staining | Autolysis | Cut Artifact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| TB11 | H-2 | Poor Section | 0 | C-1 | 0 | 0<br>F-1 | D-1 | 0 | A-1<br>P-1 | S-1<br>W-1 | F | 1 | 2 |
| TB12 | 0 | N-1 | E-2 | C-1 | 0 | 0 | D-1 | 0 | A-1<br>P-1 | S-1<br>V-1<br>W-1 | 0 | 1 | 1 |
| TB13 | 0 | N-1 | E-2 | C-2 | C-1<br>H-1 | C-2<br>H-1 | 0 | 0 | A-1<br>P-1 | S-1 | 0 | 2 | 2 |
| TB14 | 0 | N-1 | E-1 | 0 | 0 | Immature<br>0<br>F-1 | 0 | 0 | P-1 | S-1 | 0 | 2 | 2 |
| TB15 | 0 | Poor Section | Poor Section | 0 | 0 | Immature<br>0<br>F-1 | 0 | 0 | A-1<br>G-1<br>P-1 | 0 | Pale | 2 | 1 |
| TB16 | C-1 | 0 | 0 | 0 | 0 | Poor Section<br>Immature<br>F-1 | 0 | 0 | A-1<br>P-1 | S-1 | Pale | 2-3 | 2 |
| TB17 | 0 | N-2 | E-1 | C-1 | 0 | C-2 | 0 | 0 | A-1<br>P-1 | S-1<br>C-2 | 0 | 2 | 2 |
| TB18 | 0 | 0 | E-1 | 0 | 0 | Immature<br>0 | 0 | 0 | A-1<br>P-1 | S-1 | 0 | 1 | 2 |
| TB19 | 0 | Poor Section<br>C-1<br>N-1 | Poor Section<br>E-1 | 0 | 0 | Immature<br>0 | 0 | 0 | P-1<br>R-1 | S-1 | Pale | 4 | 2 |
| TB20 | 0 | N-1 | E-1 | 0 | 0 | Immature<br>C-1 | 0 | 0 | A-1<br>P-1 | S-1 | 0 | 2 | 2 |
| TB21 | 0 | X | X | 0 | 0 | Immature<br>0 | 0 | 0 | L-1<br>X | S-2 | 0 | 4 | 3 |
| TB22 | 0 | Poor Section<br>C-1 | E-1 | 0 | 0 | Immature<br>F-1 | 0 | 0 | G-1<br>P-1 | S-1 | 0 | 2 | 3 |

Stain: LUXOL FAST BLUE WITH PAS

Indication: Demonstrate myelinated fibers and PAS positive elements

Control: Brain or spinal cord

Solutions:
1) 0.1% Luxol Fast Blue Solution (S-24-3)
2) Schiff's Reagent (S-16-5)
3) 0.5% Periodic Acid (S-12-1)

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Procedure:
1) Depariffinize and hydrate to 95% alcohol.
2) Stain in Luxol Fast Blue solution at 60 C for 2 hours. Slides should not be left in stain any longer than prescribed.
3) Start differentiation in 70% alcohol - 10 dips.
4) Continue differentiation in Lithium Carbonate solution.
5) Return to 70% alcohol until the blue begins to run off.
6) Immediately place in tap water, wash for 2 minutes.
7) Place slide in 0.5% Periodic Acid for 5 minutes.
8) Rinse well in running water.
9) Stain in Schiff's Reagent for 15 minutes.
10) Wash in warm water for 10 minutes.
11) Stain in Harris' Hematoxylin for 5 minutes.
12) Wash in running water.
13) Differentiate briefly in 1% Acid Alcohol - 2-3 dips.
14) Blue in Ammonia Water. Wash well in water - 5-10 minutes.
15) Dehydrate quickly through alcohols. Clear in xylenes and mount with Permount.

Results: Myelinated fibers - blue
PAS positive material - pink to rose

# United States Department of the Interior

Fish and Wildlife Service
National Wildlife Health Research Center
6006 Schroeder Road
Madison, Wisconsin 53711-6223


TAKE PRIDE IN AMERICA

n Reply Refer to:

August 24, 1992

Memorandum

To: Ecological Services, Corpus Christi Field Office, Texas
Attn: David W. Potter

From: Wildlife Pathologist (NWHR - Madison) CM

Subject: Summary: Histopathology of Nestling Brains Received from Investigation of Injury to DOI Trust Resources in Lavaca Bay

Seventy-seven brains were trimmed in a consistent fashion to ensure uniform representation of different regions of the brain. Each brain was paraffin embedded in two cassettes and each of these wax blocks was cut and stained with both hematoxylin-eosin (for routine evaluation) and luxol fast blue-PAS (stain for myelin). The protocols for these staining techniques are attached. The total number of slides examined was 308. The overall condition of the brains submitted was suitable for diagnostic evaluation. Only a few nestlings were too autolyzed for detailed evaluation (BB13, BB15, BB30, BB31, EB10, EB11, EB21, TB09, TB19, TB21).

I chose to report all changes seen, regardless of my interpretation as potential artefact. This report is attached and is organized as tables of changes seen in the various areas of the brain. Each table correlates with a particular species and site. These changes are coded and the key for this diagnostic code is also attached. My interpretation of these changes are summarized in the following text and are related to specific changes that have been reported in mercury poisoning (the nestlings with the bolded ID were found dead):

Inflammation: Lymphocytic perivascular inflammation has been reported as one of the changes seen in the brains of animals exposed to mercury[3,8]. The only inflammation seen in these brain sections was heterophilic and either directly associated with bacteria (**BB11**) or associated with vessels suggesting a possible septicemia (**BB05**, BB07, BB21, EB16, EB17).

Bacteria: Bacteria were seen in sections of brain (**BB13, BB15, BB31, EB10**) without associated inflammation. This is thought to be due to postmortem overgrowth of these bacteria (these changes were seen only in birds found dead) but may suggest a prior septicemia.

Hemorrhage: Hemorrhage has been reported as a consequence of mercury toxicity[6] but personal communication with one of these authors (Locke) suggests that the hemorrhage was probably a secondary consequence of the

clinical signs (trauma due to thrashing and incoordination). In the histopathology of the nestling brains, hemorrhage was most often seen in the meninges (BB03, BB04, BB09, BB22, **BB28**, **BB30**, EB01, EB02, **EB10**, EB17, **EB26**, TB11) suggesting trauma. When hemorrhage was seen only within the brain, it was mild and usually focal and associated with congested vessels (BB12, **BB16**, **BB17**, **BB24**, **BB26**, EB03, EB07, **EB12**, **EB23**, TB01, TB02, TB03, TB05, TB07, TB08, TB13) raising some question as to significance. This change may have been secondary to the dying process.

Endothelial swelling and thickening of blood vessel walls: Necrosis of vessel walls and endothelial hypertrophy are reported changes in mercury poisoning[3,11]. This change was not seen in the nestling brains and although some vessel walls were somewhat wide (BB04, **BB05**, BB07, BB12, BB14, **BB16**, BB18, **BB20**, **BB23**, **BB27**, **BB28**, TB11, TB12) and the endothelial lining of some vessels was prominent (BB04, BB09, BB21, **BB29**, TB12) there was no necrosis and there did not appear to be a generalized problem with the vessels.

Irregular distribution of Purkinje cells: Purkinje cells have been reported to become necrotic in response to mercury poisoning[1,2,9]. No Purkinje cell necrosis was seen in the nestlings. There was variation in the distribution of Purkinje cells in almost all of the nestling brains but these changes were thought to have been due to different degrees of maturation of the cerebellum and differential migration of Purkinje cells. Irregular distribution of Purkinje cells is not uncommon in normal birds, hence the changes in the nestlings were thought to be within the wide range accepted as normal.

Granular layer of the cerebellum: Methylmercury preferentially damages granule cells of the cerebellum [1,2,8,9]. I carefully examined this layer of the cerebellum and occasionally found necrosis of scattered granule cells (BB18, **BB25**, EB04, EB05, EB06, EB08, EB15, **EB22**, **EB24**, **EB25**, **EB26**, **EB27**, TB04, TB06, TB07, TB15, TB22). This change was seen in different study groups and was not a common finding.

Optic lobe: Visual centers in mammals are reported to be particularly sensitive to mercury[6,8]. Because of this, I paid particular attention to the optic lobe in the nestling brains. The most common changes in the optic lobe consisted of separation of the lining of the ventricle (stratum fibrosum proventriculare) from the underlying parenchyma (BB03, BB04, BB06, BB09, BB10, BB11, BB12, BB13, BB14, BB16, BB18, BB19, BB21, BB22, BB23, BB24, BB26, BB30, EB01, EB02, EB03, EB04, EB05, EB08, EB13, EB14, EB15, EB16, EB17, EB18, TB01, TB02, TB04, TB12, TB13, TB14, TB17, TB18, TB19, TB20, TB22) and spaces around neurons with possible neuronal shrinkage in the stratum griseum proventriculare (BB07, BB11, BB12, BB14, BB16, BB22, BB24, BB28, BB30, EB01, EB02, EB10, EB12, EB13, EB14, EB15, EB16, EB17, EB24, EB27, TB01, TB02, TB08, TB12, TB13, TB14, TB17, TB19, TB20). These changes are so common, I feel they are probably fixation artifact.

Increased perivascular space and dilated ventricles: Brain edema and hydrocephalus have been reported as a sequela of mercury poisoning[1,2,11]. Although a few nestling brains had mildly dilated ventricles and many had small spaces around vessels, these changes were not severe enough to suggest hydrocephalus or edema and these changes can also be seen as a result of

fixation artifact in brain tissue. Increased perivascular space was commonly seen in the nestling brains, dilated ventricles were not as common (BB21, **EB12**, EB13, EB14, EB15, EB16, EB18, **EB24**, **EB26**, **EB28**, TB06, TB07, TB11, TB12).

Clear spaces within neurons: Clear spaces were seen in the cytoplasm of otherwise normal neurons primarily in the brains of the tricolor heron nestlings from Laguna Madre (EB14, EB18, EB26, TB02, TB07, TB11, TB12, TB13, TB15, TB16, TB17, TB18, TB20). The significance of this is not known but it may be caused by fixation artefact or may represent deposits of substances within the cytoplasm. Mercury is thought to be sequestered in lysosomes of large neurons in the brain[1,2,5,8] however this is not reported to be seen with light microscopy and a direct relationship cannot be made to the spaces seen in the cytoplasm of the nestling brains.

Pale myelin staining: Demyelination and axonal degeneration have been reported to occur as a result of mercury poisoning[3,6,8], although one author reports sparing of the white matter of the cerebellum[2]. Uniform pale staining myelin (**BB13**, **BB15**, **BB17**, BB18, **BB20**, BB22, **BB27**, **BB28**, **BB29**, **BB30**, EB01, EB02, EB05, **EB11**, **EB12**, EB13, **EB22**, **EB23**, **TB19**) was thought to be due to autolysis (most of the birds were dead) or the immature development of the brain[10]. There were occasional nestlings with focal pale areas in the optic lobe and cerebellum (BB21, EB02, EB03, EB08, **EB12**, **EB24**, TB04), however these areas did not appear to be associated with axons and were thought to be due to unique plane of section.

**DISCUSSION:**

Other common changes reported for mercury poisoning[3,6,7,8,11] were not seen: neuronal swelling, mineralization and necrosis with formation of eosinophilic bodies, gliosis, malacia, scar formation, vacuolation of neuropil with status spongiosis in the optic lobe, cerebral and cerebellar atrophy (although this would be difficult to evaluate in neonates).

I feel the most significant changes seen in the nestling brains examined were:

Code

G Necrosis of the granule cells in the granular layer of the cerebellum.
N Spaces around, and potential shrinkage of neurons in the stratum griseum proventriculare.
A Clear crescent shapes seen in the cytoplasm of scattered neurons.

Although these changes are interesting, no statistical analysis was performed to determine their significance relative to the location of collection of the nestling. However, my impression is that these changes were not seen more frequently in the Lavaca Bay group and I am unsure of their significance.

A few of the factors that confounded the interpretation of histologic changes were:

1. Different degrees of autolysis - causing changes in cell appearance and stain quality.

2. Different stages of brain maturation - as brains mature they become progressively larger and more myelinated and neurons migrate to their determined locations.

3. Different causes of death - this could cause hemorrhage or congestion secondary to the dying process.

4. Sectioning variation - although regions of the brain were relatively well represented in all nestlings, location of sections through these regions varied due to the small size of the brains, method of brain removal and distortion of tissue due to fixation and autolysis.

5. Fixation artifact - causing variable tissue shrinkage.

6. Variation in processing - due to the large number of slides (308), the embedded tissues were cut and stained by the different technicians on different days allowing for some variation in section thickness and stain quality.

Atrophy of the cerebellum and cerebrum can be caused by mercury poisoning[7]. There was striking variation in size and degree of maturity of the cerebellum between nestlings. This could be due to the relative developmental stage of these birds (age) but the age was not included in the data collected for these birds. If a correlation could be made between degree of maturity of the brain (i.e., an accurate weight of a completely and uniformly removed brain correlated with the histologic indicators of maturity; morphometric determination of thickness of internal and external granular layers, molecular layer and density of Purkinje cells) and the age of the bird, one might have a better feel for the potential effect of mercury to retard neurologic development in the embryo and nestling. In humans it has been reported that mercury causes marked reduction in brain weight and slowed brain maturation (as well as causing neuronal changes) when embryos and fetuses are exposed to mercury. These infants had between .575 ppm to 1.568 ppm of mercury in their blood when they died and the mothers did not show clinical signs of mercury exposure during gestation[9]. Since the nestlings in this study are potentially exposed to mercury from maternal incorporation of mercury in the egg during the egg laying process they may also show these signs of prenatal mercury intoxication. It would be interesting to know the level of mercury in eggs from these nests.

I am also pursuing a protocol for staining mercury in brain tissue. At this point it appears that the brains need to be initially fixed in glutaraldehyde, but I am trying to find a reference to see if formalin-fixed brains can be used.

It would be helpful if you had a quantifiable way of evaluating the nestling brains for subtle effects of mercury. Staining for mercury in the brain or comparing developmental stages of nestling brains with their age (as stated above) may be a useful way to document the presence of subtle effects of mercury in neural tissue.

Carol U. Meteyer

CUM:mb

REFERENCES


1. CHANG, L.W. 1977. Neurotoxic effects of mercury - a review. Environmental Research 14: 329-373.

2. CHANG, L.W. Mercury. 1980. *In* Experimental and Clinical Neurotoxicology, Spencer and Schaumburg (eds.). Williams & Wilkins, Baltimore, MD: pp. 508-223.

3. DAVIES, T.S., NIELSEN, S.W. 1977. Pathology of subacute methylmercurialism in cats. Am. J. Vet. Res. 38: 59-67.

4. FIMREITE, N., KARSTAD, L. 1971. Effects of dietary methyl mercury on red -tailed hawks. Journal of Wildlife Management 35: 293-300.

5. HARGREAVES, R.J., FOSTER, J.R., PELLING, D., MOORHOUSE, S.R., GANGOLLI, S.D., ROWLAND, I.R. 1985. Changes in the distribution of histochemically localized mercury in the cns and in tissue levels of organic and inorganic mercury during the development of intoxication in methylmercury treated rats. Neuropathology and Applied Neurobiology 11: 383-399.

6. HEINZ, G.H., LOCKE, L.N. 1976. Brain lesions in mallard ducklings from parents fed methylmercury. Avian Diseases 20: 9-16.

7. HUNTER, D., RUSSELL, D.S. 1954. Focal cerebral and cerebellar atrophy in a human subject due to organic mercury compounds. J. Neurol. Neurosurg. Psychiat. 17: 235-241.

8. KOESTNER, A., NORTON, S. 1991. Nervous system. *In* Handbook of Toxicologic Pathology, Haschek and Rousseaux (eds.). Academic Press, Inc., San Diego, CA: pp. 641-642.

9. REUHL, K.R., CHANG, L.W. 1979. Effects of methylmercury on the development of the nervous system - a review. Neurotoxicology 1: 21-55.

10. SUZUKI, K. 1980. Special vulnerabilities of the developing nervous system to toxic substances. *In* Experimental and Clinical Neurotoxicology, Spencer and Schaumburg (eds.). Williams & Wilkins, Baltimore, MD: pp. 48-59.

11. TRYPHONAS, L., NIELSEN, N.O. 1973. Pathology of chronic alkylmercurial posioning in swine. Am. J. Vet. Res. 34: 379-392.

# Histopathology of Nestling Brains Key

**KEY**:

| | |
|---|---|
| **A** | Clear crescents seen in cytoplasm of scattered neurons |
| **B** | Bacteria |
| **C** | Dilated vessels / congestion |
| **D** | Dilated ventricle |
| **E** | Increased space between ependyma and parenchyma (Stratum fibrosum proventriculare |
| **F** | Focal pale area |
| **G** | Granule cell necrosis (apoptosis) in the internal granular layer of the cerebellum |
| **H** | Hemorrhage |
| **I** | Acute inflammation (heterophils) |
| **L** | Granule cell necrosis (apoptosis) in the external granular layer of the cerebellum |
| **N** | Increased space around neurons (Stratum griseum proventriculare) |
| **P** | Disorganized distribution of Purkinje cells |
| **R** | Eosinophilic cytoplasm in Purkinje cells |
| **S** | Perivascular space |
| **V** | Endothelial swelling |
| **W** | Thick vessel walls |
| **X** | Cannot evaluate due to autolysis |
| **Y** | Focal areas which stain pale by myelin stain |

| | |
|---|---|
| **0** | Unremarkable |
| **1** | Mild |
| **2** | Moderate |
| **3** | Moderately Severe |
| **4** | Severe |
| * | Not Seen |

**Poor Section** - Artefact of cut, this section is not representative of region.

# Great Blue Heron
# Lavaca Bay

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Choroid Plexus | Neurons | Vessels | Myelin Staining | Autolysis | Cut Artifact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| BB01 | 0 | 0 | 0 | 0 | 0 | Immature C-1 | 0 | 0 | 0 | S-1 | 0 | 1 | 3 |
| BB02 | 0 | 0 | 0 | 0 | 0 | Poor Section F-1 | 0 | 0 | P-1 | 0 | F | 2 | 3 |
| BB03 | C-1 H-1 | 0 | E-1 | 0 | 0 | Immature 0 | 0 | 0 | P-2 | C-1 | 0 | 2 | 3 |
| BB04 | H-1 | 0 | E-1 | 0 | 0 | Immature H-1 | 0 | 0 | P-2 | C-1 V-1 W-1 | 0 | 1 | 1 |
| BB05 | W-1 | 0 | 0 | 0 | 0 | Immature 0 | 0 | C-1 I-1 | 0 | S-1 | 0 | 2 | 2 |
| BB06 | 0 | 0 | E-2 | 0 | 0 | Immature C-1 | 0 | 0 | P-1 | 0 | 0 | 2 | 2 |
| BB07 | 0 | N-1 | 0 | 0 | 0 | 0 | 0 | C-1 I-1 | P-1 | S-2 W-1 | 0 | 2 | 3 |
| BB09 | H-1 | 0 | E-1 | S-2 | 0 | 0 | 0 | 0 | 0 | C-1 H-1 V-1 | 0 | 2 | 2 |
| BB10 | 0 | 0 | E-3 | 0 | 0 | Immature 0 | E-2 | 0 | P-1 | 0 | 0 | 1 | 1 |

# Great Blue Heron
# Laguna Madre

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Choroid Plexus | Neurons | Vessels | Myelin Staining | Autolysis | Cut Artifact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| BB11 | I-1 | N-1 | E-2 | B-2<br>I-2 | B-2<br>I-2 | B-2<br>I-2 | 0 | I-1 | P-1 | C-1 | 0 | 2 | 1 |
| BB12 | 0 | H-1<br>N-1 | E-2 | C-1<br>H-1 | 0 | C-2 | 0 | 0 | P-1 | S-1<br>W-1 | 0 | 1 | 1 |
| BB13 | 0 | 0 | E-2 | 0 | 0 | B-3 | 0 | 0 | P-3 | B-2 | Pale | 4 | 2 |
| BB14 | C-1 | N-1 | E-1 | W-1 | 0 | Immature<br>C-1 | 0 | 0 | P-1 | S-1<br>W-1 | 0 | 1 | 2 |
| BB15 | 0 | * | * | B-2<br>0 | B-2<br>0 | * | 0 | 0 | * | S-2 | Pale | 4 | 3 |
| BB16 | W-1 | H-1<br>N-1 | E-2 | 0 | 0 | 0 | 0 | 0 | P-2 | C-1 | 0 | 3 | 2 |
| BB17 | 0 | 0 | 0 | H-1 | 0 | Immature<br>0 | 0 | 0 | P-1 | H-1 | Pale | 3 | 2 |
| BB18 | C-1<br>W-1 | 0 | E-1 | 0 | 0 | Immature<br>C-1 | 0 | 0 | G-1<br>P-1 | C-1 | Pale | 2 | 2 |
| BB19 | 0 | 0 | E-2 | 0 | 0 | C-2 | 0 | 0 | P-1 | S-2 | 0 | 1 | 1 |
| BB20 | 0 | * | * | 0 | 0 | C-1 | 0 | 0 | P-1 | S-2<br>W-1 | Pale | 3 | 2 |

# Great Blue Heron
## Second Chain

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Chorold Plexus | Neurons | Vessels | Myelin Staining | Autolysis | Cut Artifact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| BB21 | C-1 | 0<br>F-1 | E-1 | 0 | 0 | Immature<br>Thrombus | D-2 | * | L-1<br>P-1 | S-1<br>V-1 | Pale | 1 | 3 |
| BB22 | C-1<br>H-1 | N-1 | E-3 | 0 | 0 | Immature<br>C-1 | 0 | C-2 | 0 | S-1 | Pale | 2 | 2 |
| BB23 | W-1 | 0 | E-1 | 0 | 0 | Immature<br>0<br>F-2 | 0 | 0 | 0 | 0 | F | 3 | 3 |
| BB24 | C-2 | N-2 | E-1 | H-1 | 0 | C-2 | 0 | * | 0 | S-3 | 0 | 3 | 2 |
| BB25 | C-1 | 0 | 0 | 0 | 0 | Immature<br>0<br>F-1 | 0 | 0 | G-1<br>P-1 | 0 | F | 3 | 2 |
| BB26 | C-2 | Poor Section | E-2 | C-1 | 0 | Immature<br>C-1 | 0 | C-1<br>H-1 | P-1 | S-1 | 0 | 3 | 2 |
| BB27 | C-1<br>W-1 | * | * | 0 | 0 | Immature<br>0 | 0 | 0 | 0 | 0 | Pale | 3 | 3 |
| BB28 | C-1<br>H-1<br>W-1 | H-1<br>0 | 0 | C-2 | 0 | Poor Section<br>C-2 | H-2 | C-3<br>H-2 | 0 | S-2 | Pale | 3 | 2 |
| BB29 | C-1 | Poor Section | 0 | 0 | 0 | * | 0 | 0 | 0 | S-2<br>V-1 | Pale | 3 | 3 |
| BB30 | H-3 | N-1 | E-1 | C-1 | H-1 | H-2<br>N-1 | H-1 | * | N-2<br>P-1 | S-1 | Pale | 3-4 | 3 |
| BB31 | 0 | * | * | B-2 | * | Poor Section<br>B-2 | 0 | 0 | 0 | 0 | X | 4 | 4 |

**Great Egret**
**Lavaca Bay**

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Choroid Plexus | Neurons | Vessels | Myelin Staining | Autolysis | Cut Artifact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| EB01 | H-1 | N-1<br>H-1 | E-1 | H-1 | * | C-1<br>H-2 | H-1 | * | P-1 | S-1 | Pale | 1 | 2 |
| EB02 | H-1 | N-1<br>F-1 | E-1 | 0 | 0 | Immature<br>0 | 0 | 0 | P-1 | S-2 | Pale<br>F | 1 | 2 |
| EB03 | C-1 | 0<br>F-1 | E-1 | H-1 | H-1 | Immature<br>C-1 | 0 | C-1 | 0 | S-2 | F | 2 | 2 |
| EB04 | 0 | H-1 | E-1 | 0 | 0 | Immature<br>0 | 0 | 0 | G-1 | 0 | 0 | 1 | 1 |
| EB05 | 0 | 0 | E-1 | 0 | 0 | Immature | 0 | 0 | G-1<br>P-1 | S-1 | Pale | 2 | 1 |
| EB06 | 0 | 0 | 0 | 0 | Neurons with Lg Nuclei | Immature<br>0 | 0 | I-1 | G-1<br>R-1 | 0 | 0 | 1 | 2 |
| EB07 | 0 | 0 | 0 | H-1 | 0 | Immature<br>0 | 0 | 0 | P-1 | 0 | 0 | 2 | 2 |
| EB08 | 0 | 0<br>F-1 | E-1 | 0 | 0 | Immature<br>0 | 0 | 0 | G-1<br>P-1 | S-1 | 0 | 1 | 2 |
| EB09 | 0 | N-1 | 0 | 0 | 0 | Immature<br>0 | 0 | 0 | P-1 | 0 | 0 | 2 | 2 |
| EB10 | H-2 | Poor Section | Poor Section | B-2<br>C-2 | 0 | * | H-2 | H-1 | Poor Section | H-1 | 0 | 4 | 3 |

# Great Egret
# Laguna Madre

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Choroid Plexus | Neurons | Vessels | Myelin Staining | Autolysis | Cut Artifact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| EB11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | * | P-1 | S-1 | Pale | 4 | 2 |
| EB12 | 0 | F-1<br>N-1 | 0 | 0 | H-1 | Immature<br>0 | D-1 | 0 | P-1 | S-1 | Pale | 3 | 2 |
| EB13 | 0 | N-1 | E-1 | 0 | 0 | Immature<br>C-2 | D-1 | C-1 | P-1 | S-1 | Pale | 1 | 2 |
| EB14 | 0 | C-1<br>N-1 | E-1 | 0 | 0 | 0 | D-1 | C-1 | A-1<br>P-1 | 0 | 0 | 1 | 1 |
| EB15 | 0 | N-1 | E-1 | 0 | 0 | Immature<br>0 | D-1 | 0 | G-1<br>P-1 | S-1 | 0 | 1 | 2 |
| EB16 | 0 | N-1 | E-1 | 0 | 0 | Immature<br>C-1 | D-1 | Leuko-thrombus<br>0 | 0 | S-1 | 0 | 2 | 2 |
| EB17 | H-2 | Poor Section<br>C-1<br>H-1 | E-1 | C-1 | 0 | Immature<br>C-2 | 0 | Leuko-thrombus<br>C-1 | R-1 | C-1<br>S-1 | 0 | 2 | 3 |
| EB18 | 0 | 0 | E-1 | 0 | 0 | Immature<br>0 | D-1 | 0 | A-1<br>P-1 | 0 | 0 | 1 | 2 |

# Great Egret
## Second Chain

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Choroid Plexus | Neurons | Vessels | Myelin Staining | Autolysis | fact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| EB21 | 0 | * | * | 0 | * | Poor Section X | 0 | 0 | 0 | S-3 | X | 4 | 3 |
| EB22 | C-2 | C-1 | 0 | C-1 | 0 | Poor Section Immature | 0 | 0 | G-1 L-1 P-1 | S-1 | Pale | 3 | 3 |
| EB23 | 0 | 0 | 0 | H-1 | 0 | Immature 0 | 0 | 0 | P-1 Foamy Nuclei & Cytoplasm | 0 | Pale | 2 | 2 |
| EB24 | 0 | N-2 F-1 | 0 | C-1 | 0 | Poor Section Immature | D-1 | 0 | G-1 P-1 R-1 | S-1 | Pale | 2 | 2 |
| EB25 | C-1 | Poor Section C-1 | 0 | 0 | 0 | Poor Section Immature | 0 | C-1 | G-1 P-1 | 0 | 0 | 3 | 2 |
| EB26 | C-2 H-1 | C-1 | 0 | 0 | A-1 | Poor Section Immature | D-1 | C-1 | G-1 P-1 R-1 | S-1 | 0 | 3 | 2 |
| EB27 | C-1 | Poor Section C-1 N-1 | 0 | Poor Section 0 | 0 | Poor Section Immature | 0 | 0 | G-1 P-1 | S-2 | 0 | 3 | 3 |
| EB28 | 0 | C-1 | 0 | 0 | 0 | Immature C-1 | D-2 | C-1 | P-2 | S-1 | 0 | 2 | 2 |

# Tricolor Heron
## Lavaca Bay

| ID Number | Meninges | Optic Lobe | | Cerebrum | Brain Stem | Cerebellum | Ventricle | Chorold Plexus | Neurons | Vessels | Myelin Staining | Autolysis | Cut Artifact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stratum Griseum Proventriculare | Stratum Fibrosum Proventriculare | | | | | | | | | | |
| TB01 | 0 | C-1<br>N-1 | E-2 | H-1 | 0 | C-1<br>F-1<br>H-1 | 0 | 0 | P-1 | S-1 | 0 | 1 | 2 |
| TB02 | 0 | N-1 | E-1 | 0 | H-1 | A-1 | 0 | * | P-1 | 0 | 0 | 1 | 2 |
| TB03 | C-1 | 0 | 0 | 0 | H-1 | Immature<br>C-1 | H-2 | 0 | P-1 | 0 | 0 | 2 | 3 |
| TB04 | 0 | C-1<br>F-1 | E-1 | 0 | 0 | Immature<br>0 | 0 | 0 | G-1<br>P-1 | 0 | 0 | 1 | 2 |
| TB05 | 0 | Poor Section<br>0 | 0 | H-1 | C-1 | C-1 | 0 | * | P-1 | S-1 | 0 | 2 | 3 |
| TB06 | 0 | 0 | 0 | 0 | 0 | Immature<br>0<br>F-1 | D-1 | 0 | G-1<br>P-1 | 0 | F | 1 | 3 |
| TB07 | 0 | C-1 | 0 | H-1 | 0 | Immature<br>0<br>F-1 | D-1 | 0 | A-1<br>G-1<br>P-1 | S-1 | 0 | 2 | 2 |
| TB08 | 0 | N-1 | 0 | H-1 | 0 | Immature<br>0 | 0 | 0 | P-1 | 0 | 0 | 1 | 3 |
| TB09 | 0 | X | 0 | X | X | X | 0 | X | X | X | X | 4 | 3 |

**Model 172 Stain Procedure Log**

Stain Procedure Title UNIVERSITY OF WISC. VET SCHOOL

Operator's Name KERMIT GROOTHUIS Date 8-14-92

Program Storage Code [B]

| Event | Station | Time | Solution | Comments |
|---|---|---|---|---|
| 01 | 1 | 4 MINUTES | XYLENE | |
| 02 | 2 | 4 MIN | XYLENE | |
| 03 | 3 | 3 MIN | XYLENE | |
| 04 | 4 | 1 MIN | ALC ABS | |
| 05 | 5 | 2 MIN | ALC ABS | |
| 06 | 9 | 1 MIN | ALC 95% | |
| 07 | 10 | 2 MIN | ALC 95% | |
| 08 | RINSE | 2 MIN | RUNNING H2O | |
| 09 | 12 | 10 MIN | HEMATOXYLIN | HARRIS, AFIP GREEN pg 34 SODIUM IODATE IN PLACE OF MERC |
| 10 | RINSE | 2 MIN | RUNNING H2O | |
| 11 | 6 | 0.1 MIN | ACID ALC | |
| 12 | RINSE | 1 MIN | RUNNING H2O | |
| 13 | 11 | 1.0 MIN | LITH. CARB. | |
| 14 | RINSE | 5 MIN | RUNNING H2O | |
| 15 | 8 | 1 MIN | 80% ALC | |
| 16 | 7 | 1 MIN | WORKING EOSIN | MADE, AFIP GREEN pg 35-36 |
| 17 | 13 | 0.2 MIN | ALC 95% | |
| 18 | 14 | 0.2 MIN | ALC 95% | |
| 19 | 15 | 0.2 MIN | ALC ABS | |
| 20 | 16 | 1 MIN | ALC ABS | |
| 21 | 17 | 2 MIN | XYLENE | |
| 22 | 18 | 2 MIN | XYLENE | |
| 23 | | | | |
| 24 | | | | |
| 25 | | | | |

# APPENDIX C-1

## LABORATORY REPORT OF MERCURY ANALYSIS OF DOUBLE-CRESTED CORMORANT AND LEESER SCAUP LIVERS IN LAVACA BAY, FALL AND WINTER 1991-1992

U. S. FISH AND WILDLIFE SERVICE
PATUXENT ANALYTICAL CONTROL FACILITY

QUALITY ASSURANCE REPORT

RE: 2050019 REGION: 2

THE ANALYSES ON THE ABOVE MENTIONED SAMPLES WERE PERFORMED AT:

GEOCHEMICAL AND ENVIRONMENTAL RESEARCH GROUP
TEXAS A & M RESEARCH FOUNDATION
10 SOUTH GRAHAM RD
COLLEGE STATION, TX 77840

AFTER A THOROUGH REVIEW OF THIS REPORT, I REPORT THE FOLLOWING OBSERVATIONS AND CONCLUSIONS:

THE ACCURACY, AS MEASURED BY SPIKE RECOVERY AND STANDARD REFERENCE MATERIAL ANALYSIS, WAS ACCEPTABLE.

THE PRECISION, AS MEASURED BY DUPLICATE SAMPLE ANALYSIS, WAS ACCEPTABLE.

WE HAVE NOT RECEIVED SUFFICIENT DATA FROM THIS LABORATORY TO ESTIMATE CONFIDENCE INTERVALS.

John Moore 9-8-92

QUALITY ASSURANCE OFFICER DATE

Catalog 2050019

# SAMPLE ANALYSES RESULTS
# for
# TRACE METALS

for

U.S. Fish and Wildlife Service

Prepared by

Geochemical and Environmental Research Group
Texas A&M University

June 19, 1992

| Sample No. | P.O. Number | Lab Sample I | Lab Sample Matrix | Lab Sample Wet Wt. | QA/QC Type | Analyte | An.Type Method Descr | Sample No | P.O. Number | Result Dry | DL Dry | Result Wet | DL Wet | Re | SRM ID | Spike | Result % | Result Tot.MCG | Result Modifier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91CE01LT | 85830-2-2502 | 7849 | Animal Tissue | 83 | Not App. | Hg | | 91CE01LT | 85830-2-2502 | 92.2 | 0.09 | 26.3 | 0.03 | . | | | | | |
| 91CE02LT | 85830-2-2502 | 7850 | Animal Tissue | 71 | Not App. | Hg | | 91CE02LT | 85830-2-2502 | 223. | 0.09 | 63.8 | 0.03 | . | | | | | |
| 91CE02LT | 85830-2-2502 | 7850-DUP | Animal Tissue | 71 | Duplicate | Hg | | 91CE02LT | 85830-2-2502 | 207. | 0.09 | 59.4 | 0.03 | . | | | | | |
| 91CE03LT | 85830-2-2502 | 7851 | Animal Tissue | 64 | Not App. | Hg | | 91CE03LT | 85830-2-2502 | 106. | 0.09 | 32.6 | 0.03 | . | | | | | |
| 91CE03LT | 85830-2-2502 | 7851-DUP | Animal Tissue | 64 | Duplicate | Hg | | 91CE03LT | 85830-2-2502 | 114. | 0.09 | 34.9 | 0.03 | . | | | | | |
| 91CE04LT | 85830-2-2502 | 7852 | Animal Tissue | 91 | Not App. | Hg | | 91CE04LT | 85830-2-2502 | 31.7 | 0.10 | 8.58 | 0.03 | . | | | | | |
| 91CE05LT | 85830-2-2502 | 7853 | Animal Tissue | 63 | Not App. | Hg | | 91CE05LT | 85830-2-2502 | 14.8 | 0.09 | 4.33 | 0.03 | . | | | | | |
| 91CE06LT | 85830-2-2502 | 7854 | Animal Tissue | 61 | Not App. | Hg | | 91CE06LT | 85830-2-2502 | 497. | 0.09 | 146. | 0.03 | . | | | | | |
| 91CE06LT | 85830-2-2502 | 7854-DUP | Animal Tissue | 61 | Duplicate | Hg | | 91CE06LT | 85830-2-2502 | 484. | 0.09 | 142. | 0.03 | . | | | | | |
| 91CE07LT | 85830-2-2502 | 7855 | Animal Tissue | 69 | Not App. | Hg | | 91CE07LT | 85830-2-2502 | 35.2 | 0.09 | 10.2 | 0.03 | . | | | | | |
| 91CE08LT | 85830-2-2502 | 7856 | Animal Tissue | 75 | Not App. | Hg | | 91CE08LT | 85830-2-2502 | 327. | 0.09 | 88.7 | 0.03 | . | | | | | |
| 91CE09LT | 85830-2-2502 | 7857 | Animal Tissue | 60 | Not App. | Hg | | 91CE09LT | 85830-2-2502 | 11.5 | 0.09 | 3.46 | 0.03 | . | | | | | |
| 91CE09LT | 85830-2-2502 | 7857-DUP | Animal Tissue | 60 | Duplicate | Hg | | 91CE09LT | 85830-2-2502 | 10.9 | 0.09 | 3.26 | 0.03 | . | | | | | |
| 91CE10LT | 85830-2-2502 | 7858 | Animal Tissue | 68 | Not App. | Hg | | 91CE10LT | 85830-2-2502 | 18.4 | 0.09 | 5.51 | 0.03 | . | | | | | |
| 91CE11LT | 85830-2-2502 | 7859 | Animal Tissue | 87 | Not App. | Hg | | 91CE11LT | 85830-2-2502 | 41.3 | 0.09 | 12.3 | 0.03 | . | | | | | |
| 91CE11LT | 85830-2-2502 | 7859-DUP | Animal Tissue | 87 | Duplicate | Hg | | 91CE11LT | 85830-2-2502 | 41.4 | 0.09 | 12.4 | 0.03 | . | | | | | |
| 91CE12LT | 85830-2-2502 | 7860 | Animal Tissue | 77 | Not App. | Hg | | 91CE12LT | 85830-2-2502 | 250. | 0.09 | 66.4 | 0.03 | . | | | | | |
| 91CE12LT | 85830-2-2502 | 7860-DUP | Animal Tissue | 77 | Duplicate | Hg | | 91CE12LT | 85830-2-2502 | 223. | 0.10 | 59.2 | 0.03 | . | | | | | |
| 91CE13LT | 85830-2-2502 | 7861 | Animal Tissue | 73 | Not App. | Hg | | 91CE13LT | 85830-2-2502 | 12.8 | 0.09 | 3.56 | 0.03 | . | | | | | |
| 91CE13LT | 85830-2-2502 | 7861-DUP | Animal Tissue | 73 | Duplicate | Hg | | 91CE13LT | 85830-2-2502 | 13.1 | 0.09 | 3.62 | 0.03 | . | | | | | |
| 91CE14LT | 85830-2-2502 | 7862 | Animal Tissue | 63 | Not App. | Hg | | 91CE14LT | 85830-2-2502 | 8.59 | 0.09 | 2.50 | 0.03 | . | | | | | |
| 91CE14LT | 85830-2-2502 | 7862-DUP | Animal Tissue | 63 | Duplicate | Hg | | 91CE14LT | 85830-2-2502 | 9.25 | 0.09 | 2.69 | 0.03 | . | | | | | |
| 91CE15LT | 85830-2-2502 | 7863 | Animal Tissue | 68 | Not App. | Hg | | 91CE15LT | 85830-2-2502 | 45.9 | 0.10 | 12.9 | 0.03 | . | | | | | |
| 91CE16LT | 85830-2-2502 | 7864 | Animal Tissue | 72 | Not App. | Hg | | 91CE16LT | 85830-2-2502 | 10.8 | 0.09 | 3.28 | 0.03 | . | | | | | |
| 91CE16LT | 85830-2-2502 | 7864-DUP | Animal Tissue | 72 | Duplicate | Hg | | 91CE16LT | 85830-2-2502 | 11.3 | 0.09 | 3.45 | 0.03 | . | | | | | |
| 91CE17LT | 85830-2-2502 | 7865 | Animal Tissue | 89 | Not App. | Hg | | 91CE17LT | 85830-2-2502 | 10.0 | 0.10 | 2.64 | 0.03 | . | | | | | |
| 91CE17LT | 85830-2-2502 | 7865-DUP | Animal Tissue | 89 | Duplicate | Hg | | 91CE17LT | 85830-2-2502 | 10.4 | 0.10 | 2.74 | 0.03 | . | | | | | |
| 91CE18LT | 85830-2-2502 | 7866 | Animal Tissue | 92 | Not App. | Hg | | 91CE18LT | 85830-2-2502 | 10.3 | 0.10 | 2.75 | 0.03 | . | | | | | |
| 91CE19LT | 85830-2-2502 | 7867 | Animal Tissue | 83 | Not App. | Hg | | 91CE19LT | 85830-2-2502 | 6.04 | 0.09 | 1.82 | 0.03 | . | | | | | |
| 91CE19LT | 85830-2-2502 | 7867-DUP | Animal Tissue | 83 | Duplicate | Hg | | 91CE19LT | 85830-2-2502 | 5.82 | 0.09 | 1.76 | 0.03 | . | | | | | |
| 91SE01LT | 85830-2-2502 | 7868 | Animal Tissue | 21 | Not App. | Hg | | 91SE01LT | 85830-2-2502 | 1.27 | 0.09 | 0.355 | 0.03 | . | | | | | |
| 91SE02LT | 85830-2-2502 | 7869 | Animal Tissue | 7 | Not App. | Hg | | 91SE02LT | 85830-2-2502 | 3.59 | 0.09 | 1.07 | 0.03 | . | | | | | |
| 91SE03LT | 85830-2-2502 | 7870 | Animal Tissue | 16 | Not App. | Hg | | 91SE03LT | 85830-2-2502 | 1.99 | 0.09 | 0.647 | 0.03 | . | | | | | |
| 91SE04LT | 85830-2-2502 | 7871 | Animal Tissue | 19 | Not App. | Hg | | 91SE04LT | 85830-2-2502 | 2.35 | 0.09 | 0.671 | 0.03 | . | | | | | |
| 91SE05LT | 85830-2-2502 | 7872 | Animal Tissue | 18 | Not App. | Hg | | 91SE05LT | 85830-2-2502 | 2.54 | 0.09 | 0.730 | 0.03 | . | | | | | |
| 91SE06LT | 85830-2-2502 | 7873 | Animal Tissue | 11 | Not App. | Hg | | 91SE06LT | 85830-2-2502 | 1.00 | 0.09 | 0.266 | 0.03 | . | | | | | |
| 91SE07LT | 85830-2-2502 | 7874 | Animal Tissue | 7 | Not App. | Hg | | 91SE07LT | 85830-2-2502 | 1.96 | 0.09 | 1.04 | 0.03 | . | | | | | |
| 91SE08LT | 85830-2-2502 | 7875 | Animal Tissue | 11 | Not App. | Hg | | 91SE08LT | 85830-2-2502 | 6.56 | 0.09 | 1.93 | 0.03 | . | | | | | |
| 91SE09LT | 85830-2-2502 | 7876 | Animal Tissue | 18 | Not App. | Hg | | 91SE09LT | 85830-2-2502 | 3.07 | 0.09 | 0.889 | 0.03 | . | | | | | |
| 91SE10LT | 85830-2-2502 | 7877 | Animal Tissue | 11 | Not App. | Hg | | 91SE10LT | 85830-2-2502 | 1.96 | 0.10 | 0.525 | 0.03 | . | | | | | |
| 91SE11LT | 85830-2-2502 | 7878 | Animal Tissue | 18 | Not App. | Hg | | 91SE11LT | 85830-2-2502 | 1.60 | 0.09 | 0.457 | 0.03 | . | | | | | |
| 91SE11LT | 85830-2-2502 | 7878-Spike | Animal Tissue | 18 | SPIKE | Hg | | 91SE11LT | 85830-2-2502 | 2.36 | 0.09 | | | . | | 0.67 | | | |
| 91SE12LT | 85830-2-2502 | 7879 | Animal Tissue | 13 | Not App. | Hg | | 91SE12LT | 85830-2-2502 | 0.893 | 0.09 | 0.246 | 0.03 | . | | | | | |
| 91SE12LT | 85830-2-2502 | 7879-Spike | Animal Tissue | 13 | SPIKE | Hg | | 91SE12LT | 85830-2-2502 | 1.59 | 0.10 | | | . | | 0.76 | | | |
| 91SE13LT | 85830-2-2502 | 7880 | Animal Tissue | 15 | Not App. | Hg | | 91SE13LT | 85830-2-2502 | 2.51 | 0.09 | 0.740 | 0.03 | . | | | | | |
| 91SE14LT | 85830-2-2502 | 7881 | Animal Tissue | 15 | Not App. | Hg | | 91SE14LT | 85830-2-2502 | 1.42 | 0.09 | 0.426 | 0.03 | . | | | | | |
| 91SE15LT | 85830-2-2502 | 7882 | Animal Tissue | 13 | Not App. | Hg | | 91SE15LT | 85830-2-2502 | 2.16 | 0.09 | 0.704 | 0.03 | . | | | | | |
| 91SE16LT | 85830-2-2502 | 7883 | Animal Tissue | 8 | Not App. | Hg | | 91SE16LT | 85830-2-2502 | 2.68 | 0.09 | 0.758 | 0.03 | . | | | | | |
| 91SE17LT | 85830-2-2502 | 7884 | Animal Tissue | 11 | Not App. | Hg | | 91SE17LT | 85830-2-2502 | 2.55 | 0.09 | 0.795 | 0.03 | . | | | | | |
| 91SE18LT | 85830-2-2502 | 7885 | Animal Tissue | 15 | Not App. | Hg | | 91SE18LT | 85830-2-2502 | 1.20 | 0.10 | 0.314 | 0.03 | . | | | | | |
| 91SE18LT | 85830-2-2502 | 7885-Spike | Animal Tissue | 15 | SPIKE | Hg | | 91SE18LT | 85830-2-2502 | 2.05 | 0.10 | | | . | | 0.79 | | | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91SE19LT | 85830-2-2502 | 7886 | Animal Tissue | 7 | Not App. | Hg | | 91SE19LT | 85830-2-2502 | 0.388 | 0.09 | 0.107 | 0.03 | . | | | | | |
| 91SE20LT | 85830-2-2502 | 7887 | Animal Tissue | 18 | Not App. | Hg | | 91SE20LT | 85830-2-2502 | 2.43 | 0.09 | 0.664 | 0.03 | . | | | | | |
| 91SE20LT | 85830-2-2502 | 7887-Spike | Animal Tissue | 18 | SPIKE | Hg | | 91SE20LT | 85830-2-2502 | 3.08 | 0.09 | | | . | | 0.74 | | | |
| 92CL01LT | 85830-2-2502 | 7888 | Animal Tissue | 62 | Not App. | Hg | | 92CL01LT | 85830-2-2502 | 12.3 | 0.09 | 3.43 | 0.03 | . | | | | | |
| 92CL02LT | 85830-2-2502 | 7889 | Animal Tissue | 59 | Not App. | Hg | | 92CL02LT | 85830-2-2502 | 60.5 | 0.09 | 16.9 | 0.03 | . | | | | | |
| 92CL03LT | 85830-2-2502 | 7890 | Animal Tissue | 48 | Not App. | Hg | | 92CL03LT | 85830-2-2502 | 148. | 0.09 | 43.9 | 0.03 | . | | | | | |
| 92CL04LT | 85830-2-2502 | 7891 | Animal Tissue | 50 | Not App. | Hg | | 92CL04LT | 85830-2-2502 | 6.39 | 0.09 | 1.95 | 0.03 | . | | | | | |
| 92CL05LT | 85830-2-2502 | 7892 | Animal Tissue | 63 | Not App. | Hg | | 92CL05LT | 85830-2-2502 | 17.0 | 0.09 | 4.85 | 0.03 | . | | | | | |
| 92CL08LT | 85830-2-2502 | 7893 | Animal Tissue | 50 | Not App. | Hg | | 92CL08LT | 85830-2-2502 | 29.4 | 0.17 | 4.46 | 0.03 | . | | | | | |
| 92CL09LT | 85830-2-2502 | 7894 | Animal Tissue | 11 | Not App. | Hg | | 92CL09LT | 85830-2-2502 | 48.9 | 0.09 | 14.5 | 0.03 | . | | | | | |
| 92CL10LT | 85830-2-2502 | 7895 | Animal Tissue | 27 | Not App. | Hg | | 92CL10LT | 85830-2-2502 | 536. | 0.09 | 157. | 0.03 | . | | | | | |
| 92CL10LT | 85830-2-2502 | 7895-DUP | Animal Tissue | 27 | Duplicate | Hg | | 92CL10LT | 85830-2-2502 | 435. | 0.09 | 127. | 0.03 | . | | | | | |
| 92CL11LT | 85830-2-2502 | 7896 | Animal Tissue | 31 | Not App. | Hg | | 92CL11LT | 85830-2-2502 | 712. | 0.09 | 221. | 0.03 | . | | | | | |
| 92CL11LT | 85830-2-2502 | 7896-DUP | Animal Tissue | 31 | Duplicate | Hg | | 92CL11LT | 85830-2-2502 | 700. | 0.09 | 217. | 0.03 | . | | | | | |
| 92CL12LT | 85830-2-2502 | 7897 | Animal Tissue | 55 | Not App. | Hg | | 92CL12LT | 85830-2-2502 | 9.76 | 0.09 | 2.84 | 0.03 | . | | | | | |
| 92CL31LT | 85830-2-2502 | 7898 | Animal Tissue | 50 | Not App. | Hg | | 92CL31LT | 85830-2-2502 | 488. | 0.10 | 135. | 0.03 | . | | | | | |
| 92CL32LT | 85830-2-2502 | 7899 | Animal Tissue | 49 | Not App. | Hg | | 92CL32LT | 85830-2-2502 | 31.3 | 0.09 | 9.38 | 0.03 | . | | | | | |
| 92CL33LT | 85830-2-2502 | 7900 | Animal Tissue | 41 | Not App. | Hg | | 92CL33LT | 85830-2-2502 | 10.1 | 0.10 | 2.81 | 0.03 | . | | | | | |
| 92CL33LT | 85830-2-2502 | 7900-DUP | Animal Tissue | 41 | Duplicate | Hg | | 92CL33LT | 85830-2-2502 | 10.6 | 0.10 | 2.93 | 0.03 | . | | | | | |
| 92CL34LT | 85830-2-2502 | 7901 | Animal Tissue | 42 | Not App. | Hg | | 92CL34LT | 85830-2-2502 | 5.83 | 0.09 | 1.82 | 0.03 | . | | | | | |
| 92CL34LT | 85830-2-2502 | 7901-DUP | Animal Tissue | 42 | Duplicate | Hg | | 92CL34LT | 85830-2-2502 | 6.26 | 0.09 | 1.95 | 0.03 | . | | | | | |
| 92CL35LT | 85830-2-2502 | 7902 | Animal Tissue | 42 | Not App. | Hg | | 92CL35LT | 85830-2-2502 | 29.5 | 0.09 | 8.36 | 0.03 | . | | | | | |
| 92CL35LT | 85830-2-2502 | 7902-DUP | Animal Tissue | 42 | Duplicate | Hg | | 92CL35LT | 85830-2-2502 | 29.5 | 0.10 | 8.35 | 0.03 | . | | | | | |
| 92CL36LT | 85830-2-2502 | 7903 | Animal Tissue | 45 | Not App. | Hg | | 92CL36LT | 85830-2-2502 | 21.2 | 0.10 | 5.45 | 0.03 | . | | | | | |
| 92CL36LT | 85830-2-2502 | 7903-DUP | Animal Tissue | 45 | Duplicate | Hg | | 92CL36LT | 85830-2-2502 | 19.1 | 0.10 | 4.91 | 0.03 | . | | | | | |
| 92CL37LT | 85830-2-2502 | 7904 | Animal Tissue | 60 | Not App. | Hg | | 92CL37LT | 85830-2-2502 | 7.81 | 0.10 | 2.04 | 0.03 | . | | | | | |
| 92CL37LT | 85830-2-2502 | 7904-DUP | Animal Tissue | 60 | Duplicate | Hg | | 92CL37LT | 85830-2-2502 | 7.36 | 0.10 | 1.92 | 0.03 | . | | | | | |
| 92CL38LT | 85830-2-2502 | 7905 | Animal Tissue | 39 | Not App. | Hg | | 92CL38LT | 85830-2-2502 | 6.00 | 0.10 | 1.62 | 0.03 | . | | | | | |
| 92CL38LT | 85830-2-2502 | 7905-DUP | Animal Tissue | 39 | Duplicate | Hg | | 92CL38LT | 85830-2-2502 | 6.33 | 0.10 | 1.71 | 0.03 | . | | | | | |
| 92CL39LT | 85830-2-2502 | 7906 | Animal Tissue | 43 | Not App. | Hg | | 92CL39LT | 85830-2-2502 | 6.47 | 0.09 | 1.90 | 0.03 | . | | | | | |
| 92CL40LT | 85830-2-2502 | 7907 | Animal Tissue | 38 | Not App. | Hg | | 92CL40LT | 85830-2-2502 | 10.3 | 0.10 | 2.90 | 0.03 | . | | | | | |
| 92CL40LT | 85830-2-2502 | 7907-DUP | Animal Tissue | 38 | Duplicate | Hg | | 92CL40LT | 85830-2-2502 | 9.31 | 0.09 | 2.60 | 0.03 | . | | | | | |
| 92SL01LT | 85830-2-2502 | 7908 | Animal Tissue | 6 | Not App. | Hg | | 92SL01LT | 85830-2-2502 | 3.09 | 0.09 | 0.859 | 0.03 | . | | | | | |
| 92SL01LT | 85830-2-2502 | 7908-DUP | Animal Tissue | 6 | Duplicate | Hg | | 92SL01LT | 85830-2-2502 | 2.80 | 0.09 | 0.779 | 0.03 | . | | | | | |
| 92SL03LT | 85830-2-2502 | 7909 | Animal Tissue | 6 | Not App. | Hg | | 92SL03LT | 85830-2-2502 | 3.06 | 0.09 | 0.934 | 0.03 | . | | | | | |
| 92SL03LT | 85830-2-2502 | 7909-DUP | Animal Tissue | 6 | Duplicate | Hg | | 92SL03LT | 85830-2-2502 | 3.13 | 0.09 | 0.956 | 0.03 | . | | | | | |
| 92SL04LT | 85830-2-2502 | 7910 | Animal Tissue | 8 | Not App. | Hg | | 92SL04LT | 85830-2-2502 | 0.421 | 0.10 | 0.110 | 0.03 | . | | | | | |
| 92SL04LT | 85830-2-2502 | 7910-DUP | Animal Tissue | 8 | Duplicate | Hg | | 92SL04LT | 85830-2-2502 | 0.452 | 0.10 | 0.118 | 0.03 | . | | | | | |
| 92SL05LT | 85830-2-2502 | 7911 | Animal Tissue | 8 | Not App. | Hg | | 92SL05LT | 85830-2-2502 | 1.79 | 0.09 | 0.506 | 0.03 | . | | | | | |
| 92SL05LT | 85830-2-2502 | 7911-DUP | Animal Tissue | 8 | Duplicate | Hg | | 92SL05LT | 85830-2-2502 | 1.85 | 0.09 | 0.523 | 0.03 | . | | | | | |
| 92SL06LT | 85830-2-2502 | 7912 | Animal Tissue | 7 | Not App. | Hg | | 92SL06LT | 85830-2-2502 | 1.20 | 0.09 | 0.437 | 0.03 | . | | | | | |
| 92SL06LT | 85830-2-2502 | 7912-DUP | Animal Tissue | 7 | Duplicate | Hg | | 92SL06LT | 85830-2-2502 | 1.19 | 0.09 | 0.435 | 0.03 | . | | | | | |
| 92SL07LT | 85830-2-2502 | 7913 | Animal Tissue | 6 | Not App. | Hg | | 92SL07LT | 85830-2-2502 | 1.90 | 0.09 | 0.531 | 0.03 | . | | | | | |
| 92SL07LT | 85830-2-2502 | 7913-DUP | Animal Tissue | 6 | Duplicate | Hg | | 92SL07LT | 85830-2-2502 | 1.85 | 0.09 | 0.518 | 0.03 | . | | | | | |
| 92SL08LT | 85830-2-2502 | 7914 | Animal Tissue | 10 | Not App. | Hg | | 92SL08LT | 85830-2-2502 | 2.47 | 0.09 | 0.716 | 0.03 | . | | | | | |
| 92SL08LT | 85830-2-2502 | 7914-DUP | Animal Tissue | 10 | Duplicate | Hg | | 92SL08LT | 85830-2-2502 | 2.36 | 0.09 | 0.684 | 0.03 | . | | | | | |
| 92SL09LT | 85830-2-2502 | 7915 | Animal Tissue | 6 | Not App. | Hg | | 92SL09LT | 85830-2-2502 | 1.43 | 0.09 | 0.403 | 0.03 | . | | | | | |
| 92SL09LT | 85830-2-2502 | 7915-DUP | Animal Tissue | 6 | Duplicate | Hg | | 92SL09LT | 85830-2-2502 | 1.27 | 0.10 | 0.357 | 0.03 | . | | | | | |
| 92SL10LT | 85830-2-2502 | 7916 | Animal Tissue | 10 | Not App. | Hg | | 92SL10LT | 85830-2-2502 | 1.42 | 0.10 | 0.402 | 0.03 | . | | | | | |
| 92SL10LT | 85830-2-2502 | 7916-DUP | Animal Tissue | 10 | Duplicate | Hg | | 92SL10LT | 85830-2-2502 | 1.51 | 0.09 | 0.427 | 0.03 | . | | | | | |
| BLANK-A | 85830-2-2502 | BLANK-A | | | Blank | Hg | | BLANK-A | 85830-2-2502 | | | | | < | | | | | 0 |
| BLANK-B | 85830-2-2502 | BLANK-B | | | Blank | Hg | | BLANK-B | 85830-2-2502 | | | | | < | | | | | 0 |
| BLANK-C | 85830-2-2502 | BLANK-C | | | Blank | Hg | | BLANK-C | 85830-2-2502 | | | | | < | | | | | 0 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BLANK-D | 85830-2-2502 | BLANK-D | | | Blank | Hg | | BLANK-D | 85830-2-2502 | | | | | < | | | | 0 | |
| BLANK-E | 85830-2-2502 | BLANK-E | | | Blank | Hg | | BLANK-E | 85830-2-2502 | | | | | < | | | | 0 | |
| BLANK-F | 85830-2-2502 | BLANK-F | | | Blank | Hg | | BLANK-F | 85830-2-2502 | | | | | < | | | | 0 | |
| BLANK-G | 85830-2-2502 | BLANK-G | | | Blank | Hg | | BLANK-G | 85830-2-2502 | | | | | < | | | | 0 | |
| BLANK-H | 85830-2-2502 | BLANK-H | | | Blank | Hg | | BLANK-H | 85830-2-2502 | | | | | < | | | | 0 | |
| BLANK-I | 85830-2-2502 | BLANK-I | | | Blank | Hg | | BLANK-I | 85830-2-2502 | | | | | < | | | | 0 | |
| DORM-A | 85830-2-2502 | DORM-A | Animal Tissue | | S.R.M. | Hg | | DORM-A | 85830-2-2502 | 0.665 | 0.12 | | | . | NRCC DORM | | | | |
| DORM-B | 85830-2-2502 | DORM-B | Animal Tissue | | S.R.M. | Hg | | DORM-B | 85830-2-2502 | 0.649 | 0.12 | | | . | NRCC DORM | | | | |
| DORM-C | 85830-2-2502 | DORM-C | Animal Tissue | | S.R.M. | Hg | | DORM-C | 85830-2-2502 | 0.574 | 0.12 | | | . | NRCC DORM | | | | |
| DORM-D | 85830-2-2502 | DORM-D | Animal Tissue | | S.R.M. | Hg | | DORM-D | 85830-2-2502 | 0.637 | 0.12 | | | . | NRCC DORM | | | | |
| DORM-E | 85830-2-2502 | DORM-E | Animal Tissue | | S.R.M. | Hg | | DORM-E | 85830-2-2502 | 0.625 | 0.12 | | | . | NRCC DORM | | | | |
| 91CE01LT | 85830-2-2502 | 7849 | Animal Tissue | 83 | Not App. | Moisture | | 91CE01LT | 85830-2-2502 | | | | | | | | 71.45 | | |
| 91CE02LT | 85830-2-2502 | 7850 | Animal Tissue | 71 | Not App. | Moisture | | 91CE02LT | 85830-2-2502 | | | | | | | | 71.43 | | |
| 91CE03LT | 85830-2-2502 | 7851 | Animal Tissue | 64 | Not App. | Moisture | | 91CE03LT | 85830-2-2502 | | | | | | | | 69.40 | | |
| 91CE04LT | 85830-2-2502 | 7852 | Animal Tissue | 91 | Not App. | Moisture | | 91CE04LT | 85830-2-2502 | | | | | | | | 72.97 | | |
| 91CE05LT | 85830-2-2502 | 7853 | Animal Tissue | 63 | Not App. | Moisture | | 91CE05LT | 85830-2-2502 | | | | | | | | 70.80 | | |
| 91CE06LT | 85830-2-2502 | 7854 | Animal Tissue | 61 | Not App. | Moisture | | 91CE06LT | 85830-2-2502 | | | | | | | | 70.60 | | |
| 91CE07LT | 85830-2-2502 | 7855 | Animal Tissue | 69 | Not App. | Moisture | | 91CE07LT | 85830-2-2502 | | | | | | | | 71.07 | | |
| 91CE08LT | 85830-2-2502 | 7856 | Animal Tissue | 75 | Not App. | Moisture | | 91CE08LT | 85830-2-2502 | | | | | | | | 72.86 | | |
| 91CE09LT | 85830-2-2502 | 7857 | Animal Tissue | 60 | Not App. | Moisture | | 91CE09LT | 85830-2-2502 | | | | | | | | 70.00 | | |
| 91CE10LT | 85830-2-2502 | 7858 | Animal Tissue | 68 | Not App. | Moisture | | 91CE10LT | 85830-2-2502 | | | | | | | | 70.18 | | |
| 91CE11LT | 85830-2-2502 | 7859 | Animal Tissue | 87 | Not App. | Moisture | | 91CE11LT | 85830-2-2502 | | | | | | | | 70.07 | | |
| 91CE12LT | 85830-2-2502 | 7860 | Animal Tissue | 77 | Not App. | Moisture | | 91CE12LT | 85830-2-2502 | | | | | | | | 73.49 | | |
| 91CE13LT | 85830-2-2502 | 7861 | Animal Tissue | 73 | Not App. | Moisture | | 91CE13LT | 85830-2-2502 | | | | | | | | 72.35 | | |
| 91CE13LT | 85830-2-2502 | 7861-Dup | Animal Tissue | 73 | Duplicate | Moisture | | 91CE13LT | 85830-2-2502 | | | | | | | | 72.94 | | |
| 91CE14LT | 85830-2-2502 | 7862 | Animal Tissue | 63 | Not App. | Moisture | | 91CE14LT | 85830-2-2502 | | | | | | | | 70.89 | | |
| 91CE14LT | 85830-2-2502 | 7862-Dup | Animal Tissue | 63 | Duplicate | Moisture | | 91CE14LT | 85830-2-2502 | | | | | | | | 70.97 | | |
| 91CE15LT | 85830-2-2502 | 7863 | Animal Tissue | 68 | Not App. | Moisture | | 91CE15LT | 85830-2-2502 | | | | | | | | 71.79 | | |
| 91CE15LT | 85830-2-2502 | 7863-Dup | Animal Tissue | 68 | Duplicate | Moisture | | 91CE15LT | 85830-2-2502 | | | | | | | | 71.27 | | |
| 91CE16LT | 85830-2-2502 | 7864 | Animal Tissue | 72 | Not App. | Moisture | | 91CE16LT | 85830-2-2502 | | | | | | | | 69.59 | | |
| 91CE16LT | 85830-2-2502 | 7864-Dup | Animal Tissue | 72 | Duplicate | Moisture | | 91CE16LT | 85830-2-2502 | | | | | | | | 69.90 | | |
| 91CE17LT | 85830-2-2502 | 7865 | Animal Tissue | 89 | Not App. | Moisture | | 91CE17LT | 85830-2-2502 | | | | | | | | 73.79 | | |
| 91CE17LT | 85830-2-2502 | 7865-Dup | Animal Tissue | 89 | Duplicate | Moisture | | 91CE17LT | 85830-2-2502 | | | | | | | | 73.87 | | |
| 91CE18LT | 85830-2-2502 | 7866 | Animal Tissue | 92 | Not App. | Moisture | | 91CE18LT | 85830-2-2502 | | | | | | | | 73.50 | | |
| 91CE18LT | 85830-2-2502 | 7866-Dup | Animal Tissue | 92 | Duplicate | Moisture | | 91CE18LT | 85830-2-2502 | | | | | | | | 73.87 | | |
| 91CE19LT | 85830-2-2502 | 7867 | Animal Tissue | 83 | Not App. | Moisture | | 91CE19LT | 85830-2-2502 | | | | | | | | 69.70 | | |
| 91SE01LT | 85830-2-2502 | 7868 | Animal Tissue | 21 | Not App. | Moisture | | 91SE01LT | 85830-2-2502 | | | | | | | | 72.05 | | |
| 91SE02LT | 85830-2-2502 | 7869 | Animal Tissue | 7 | Not App. | Moisture | | 91SE02LT | 85830-2-2502 | | | | | | | | 70.15 | | |
| 91SE03LT | 85830-2-2502 | 7870 | Animal Tissue | 16 | Not App. | Moisture | | 91SE03LT | 85830-2-2502 | | | | | | | | 67.47 | | |
| 91SE04LT | 85830-2-2502 | 7871 | Animal Tissue | 19 | Not App. | Moisture | | 91SE04LT | 85830-2-2502 | | | | | | | | 71.50 | | |
| 91SE05LT | 85830-2-2502 | 7872 | Animal Tissue | 18 | Not App. | Moisture | | 91SE05LT | 85830-2-2502 | | | | | | | | 71.34 | | |
| 91SE06LT | 85830-2-2502 | 7873 | Animal Tissue | 11 | Not App. | Moisture | | 91SE06LT | 85830-2-2502 | | | | | | | | 73.46 | | |
| 91SE07LT | 85830-2-2502 | 7874 | Animal Tissue | 7 | Not App. | Moisture | | 91SE07LT | 85830-2-2502 | | | | | | | | 46.56 | | |
| 91SE08LT | 85830-2-2502 | 7875 | Animal Tissue | 11 | Not App. | Moisture | | 91SE08LT | 85830-2-2502 | | | | | | | | 70.57 | | |
| 91SE09LT | 85830-2-2502 | 7876 | Animal Tissue | 18 | Not App. | Moisture | | 91SE09LT | 85830-2-2502 | | | | | | | | 71.03 | | |
| 91SE10LT | 85830-2-2502 | 7877 | Animal Tissue | 11 | Not App. | Moisture | | 91SE10LT | 85830-2-2502 | | | | | | | | 73.26 | | |
| 91SE11LT | 85830-2-2502 | 7878 | Animal Tissue | 18 | Not App. | Moisture | | 91SE11LT | 85830-2-2502 | | | | | | | | 71.50 | | |
| 91SE12LT | 85830-2-2502 | 7879 | Animal Tissue | 13 | Not App. | Moisture | | 91SE12LT | 85830-2-2502 | | | | | | | | 72.43 | | |
| 91SE13LT | 85830-2-2502 | 7880 | Animal Tissue | 15 | Not App. | Moisture | | 91SE13LT | 85830-2-2502 | | | | | | | | 70.57 | | |
| 91SE14LT | 85830-2-2502 | 7881 | Animal Tissue | 15 | Not App. | Moisture | | 91SE14LT | 85830-2-2502 | | | | | | | | 70.15 | | |
| 91SE15LT | 85830-2-2502 | 7882 | Animal Tissue | 13 | Not App. | Moisture | | 91SE15LT | 85830-2-2502 | | | | | | | | 67.41 | | |
| 91SE16LT | 85830-2-2502 | 7883 | Animal Tissue | 8 | Not App. | Moisture | | 91SE16LT | 85830-2-2502 | | | | | | | | 71.76 | | |
| 91SE17LT | 85830-2-2502 | 7884 | Animal Tissue | 11 | Not App. | Moisture | | 91SE17LT | 85830-2-2502 | | | | | | | | 68.85 | | |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91SE18LT | 85830-2-2502 | 7885 | Animal Tissue | 15 | Not App. | Moisture | | 91SE18LT | 85830-2-2502 | | | | | | | | 73.84 | | |
| 91SE19LT | 85830-2-2502 | 7886 | Animal Tissue | 7 | Not App. | Moisture | | 91SE19LT | 85830-2-2502 | | | | | | | | 72.37 | | |
| 91SE20LT | 85830-2-2502 | 7887 | Animal Tissue | 18 | Not App. | Moisture | | 91SE20LT | 85830-2-2502 | | | | | | | | 72.69 | | |
| 92CL01LT | 85830-2-2502 | 7888 | Animal Tissue | 62 | Not App. | Moisture | | 92CL01LT | 85830-2-2502 | | | | | | | | 72.26 | | |
| 92CL02LT | 85830-2-2502 | 7889 | Animal Tissue | 59 | Not App. | Moisture | | 92CL02LT | 85830-2-2502 | | | | | | | | 72.08 | | |
| 92CL03LT | 85830-2-2502 | 7890 | Animal Tissue | 48 | Not App. | Moisture | | 92CL03LT | 85830-2-2502 | | | | | | | | 70.50 | | |
| 92CL04LT | 85830-2-2502 | 7891 | Animal Tissue | 50 | Not App. | Moisture | | 92CL04LT | 85830-2-2502 | | | | | | | | 69.51 | | |
| 92CL05LT | 85830-2-2502 | 7892 | Animal Tissue | 63 | Not App. | Moisture | | 92CL05LT | 85830-2-2502 | | | | | | | | 71.52 | | |
| 92CL08LT | 85830-2-2502 | 7893 | Animal Tissue | 50 | Not App. | Moisture | | 92CL08LT | 85830-2-2502 | | | | | | | | 84.85 | | |
| 92CL09LT | 85830-2-2502 | 7894 | Animal Tissue | 11 | Not App. | Moisture | | 92CL09LT | 85830-2-2502 | | | | | | | | 70.35 | | |
| 92CL10LT | 85830-2-2502 | 7895 | Animal Tissue | 27 | Not App. | Moisture | | 92CL10LT | 85830-2-2502 | | | | | | | | 70.67 | | |
| 92CL11LT | 85830-2-2502 | 7896 | Animal Tissue | 31 | Not App. | Moisture | | 92CL11LT | 85830-2-2502 | | | | | | | | 68.91 | | |
| 92CL12LT | 85830-2-2502 | 7897 | Animal Tissue | 55 | Not App. | Moisture | | 92CL12LT | 85830-2-2502 | | | | | | | | 70.82 | | |
| 92CL31LT | 85830-2-2502 | 7898 | Animal Tissue | 50 | Not App. | Moisture | | 92CL31LT | 85830-2-2502 | | | | | | | | 72.29 | | |
| 92CL32LT | 85830-2-2502 | 7899 | Animal Tissue | 49 | Not App. | Moisture | | 92CL32LT | 85830-2-2502 | | | | | | | | 70.03 | | |
| 92CL33LT | 85830-2-2502 | 7900 | Animal Tissue | 41 | Not App. | Moisture | | 92CL33LT | 85830-2-2502 | | | | | | | | 72.26 | | |
| 92CL34LT | 85830-2-2502 | 7901 | Animal Tissue | 42 | Not App. | Moisture | | 92CL34LT | 85830-2-2502 | | | | | | | | 68.75 | | |
| 92CL35LT | 85830-2-2502 | 7902 | Animal Tissue | 42 | Not App. | Moisture | | 92CL35LT | 85830-2-2502 | | | | | | | | 71.68 | | |
| 92CL36LT | 85830-2-2502 | 7903 | Animal Tissue | 45 | Not App. | Moisture | | 92CL36LT | 85830-2-2502 | | | | | | | | 74.37 | | |
| 92CL37LT | 85830-2-2502 | 7904 | Animal Tissue | 60 | Not App. | Moisture | | 92CL37LT | 85830-2-2502 | | | | | | | | 73.82 | | |
| 92CL38LT | 85830-2-2502 | 7905 | Animal Tissue | 39 | Not App. | Moisture | | 92CL38LT | 85830-2-2502 | | | | | | | | 73.00 | | |
| 92CL39LT | 85830-2-2502 | 7906 | Animal Tissue | 43 | Not App. | Moisture | | 92CL39LT | 85830-2-2502 | | | | | | | | 70.62 | | |
| 92CL40LT | 85830-2-2502 | 7907 | Animal Tissue | 38 | Not App. | Moisture | | 92CL40LT | 85830-2-2502 | | | | | | | | 71.99 | | |
| 92SL01LT | 85830-2-2502 | 7908 | Animal Tissue | 6 | Not App. | Moisture | | 92SL01LT | 85830-2-2502 | | | | | | | | 72.25 | | |
| 92SL03LT | 85830-2-2502 | 7909 | Animal Tissue | 6 | Not App. | Moisture | | 92SL03LT | 85830-2-2502 | | | | | | | | 69.50 | | |
| 92SL04LT | 85830-2-2502 | 7910 | Animal Tissue | 8 | Not App. | Moisture | | 92SL04LT | 85830-2-2502 | | | | | | | | 73.81 | | |
| 92SL05LT | 85830-2-2502 | 7911 | Animal Tissue | 8 | Not App. | Moisture | | 92SL05LT | 85830-2-2502 | | | | | | | | 71.78 | | |
| 92SL06LT | 85830-2-2502 | 7912 | Animal Tissue | 7 | Not App. | Moisture | | 92SL06LT | 85830-2-2502 | | | | | | | | 63.52 | | |
| 92SL07LT | 85830-2-2502 | 7913 | Animal Tissue | 6 | Not App. | Moisture | | 92SL07LT | 85830-2-2502 | | | | | | | | 72.08 | | |
| 92SL08LT | 85830-2-2502 | 7914 | Animal Tissue | 10 | Not App. | Moisture | | 92SL08LT | 85830-2-2502 | | | | | | | | 71.04 | | |
| 92SL09LT | 85830-2-2502 | 7915 | Animal Tissue | 6 | Not App. | Moisture | | 92SL09LT | 85830-2-2502 | | | | | | | | 71.98 | | |
| 92SL10LT | 85830-2-2502 | 7916 | Animal Tissue | 10 | Not App. | Moisture | | 92SL10LT | 85830-2-2502 | | | | | | | | 71.80 | | |

# APPENDIX C-2

## LABORATORY REPORT OF METHYLMERCURY ANALYSIS OF LESSER SCAUP LIVER AND MUSCLE TISSUE IN LAVACA BAY, FALL 1991

BROOKS RAND, LTD.
Environmental Sciences Division
3950 Sixth Avenue Northwest
Seattle, WA 98107

APR - 7

April 5, 1992

David W Potter
U.S. Fish and Wildlife Service
6300 Ocean Drive, Campus Box 338
Corpus Christi, Texas 78412

Dear Dr. Potter,

Please find enclosed the methylmercury concentrations in 20 bird muscle and liver tissues from Lavaca Bay (cat.# 2050011). The samples were received frozen on March 24, 1992, and digested for analysis the following day. Approximately 1 gram aliquots were weighed to the nearest milligram into 18.2 mL teflon vials, and 10 mL of 25% KOH in methanol added. The samples were digested for 3 hours at 70oC, and then diluted to 18.2 mL with methanol. Small aliquots (0.025 mL) were added to deionized water, and analysed by aqueous phase ethylation, GC separation, and cold vapour atomic fluorescence detection (Bloom, *Can J. Fish. Aq. Sci*, 1989). The method of standard additions showed no interferences with these tissues. No problems were encountered in the analysis of these samples.

Thank you very much for selecting Brooks Rand Ltd., for this project. We look forward to working with you in the future.

Sincerely,

Nicolas Bloom

Brooks Rand Ltd.
3950 6th Avenue Northwest
Seattle, WA 98107

System: **Lavaca Bay Winter Bird Contaminent Survey**
Catalog #: **2050011**
Sample Reciept: **March 24, 1992**

| | [$CH_3Hg$] µg/g (wet wt.) | |
|---|---|---|
| sample # | muscle (BM) | liver (LM) |
| 91SE01 | 0.052 | 0.412; 0.436; 0.406 |
| 91SE02 | 0.124 | 0.824 |
| 91SE03 | 0.069 | 0.345 |
| 91SE04 | 0.094 | 0.605 |
| 91SE05 | 0.074 | 0.464 |
| 91SE06 | 0.032 | 0.227 |
| 91SE07 | 0.116 | 1.11 |
| 91SE08 | 0.154 | 2.17; 2.13; 2.06 |
| 91SE09 | 0.055 | 0.743 |
| 91SE10 | 0.099 | 0.413 |
| 91SE11 | 0.062 | 0.379 |
| 91SE12 | 0.035 | 0.200 |
| 91SE13 | 0.103 | 0.521 |
| 91SE14 | 0.084 | 0.250 |
| 91SE15 | 0.154 | 0.588 |
| 91SE16 | 0.110; 0.108; 0.118 | 0.957 |
| 91SE17 | 0.115 | 0.619 |
| 91SE18 | 0.056 | 0.358 |
| 91SE19 | 0.047 | 0.110 |
| 91SE20 | 0.099; 0.102; 0.100 | 0.605 |
| | | |
| blanks | 0.003 ± 0.001 (n=5) | |
| | | |
| DOLT-1* | 0.074; 0.066 | |

*NRCC certified dogfish liver (0.080 ± 0.011 µg/g $CH_3Hg$)

# APPENDIX C-3

## LABORATORY REPORT OF METHYMERCURY ANALYSIS OF LESSER SCAUP LIVER AND BREAST TISSUE IN LAVACA BAY, WINTER 1992

BROOKS RAND, LTD.
Environmental Sciences Division
3950 Sixth Avenue Northwest
Seattle, WA 98107

April 21, 1992

David W Potter
U.S. Fish and Wildlife Service
6300 Ocean Drive, Campus Box 338
Corpus Christi, Texas 78412

Dear Dr. Potter,

Please find enclosed the methylmercury concentrations in 8 additional bird muscle and liver tissues from Lavaca Bay (cat.# 2050029). The samples were received frozen on April 18, 1992, and digested for analysis the following day. Approximately 1 gram aliquots were weighed to the nearest milligram into 18.2 mL teflon vials, and 10 mL of 25% KOH in methanol added. The samples were digested for 3 hours at 70oC, and then diluted to 18.2 mL with methanol. Small aliquots (0.025 mL) were added to deionized water, and analysed by aqueous phase ethylation, GC separation, and cold vapour atomic fluorescence detection (Bloom, *Can J. Fish. Aq. Sci*, 1989). The method of standard additions showed no interferences with these tissues. No problems were encountered in the analysis of these samples.

Thank you very much for selecting Brooks Rand Ltd., for this project. We look forward to working with you in the future.

Sincerely,

Nicolas Bloom

**Brooks Rand Ltd.**
**3950 6th Avenue Northwest**
**Seattle, WA 98107**

System: **Lavaca Bay Winter Bird Contaminent Survey**
Catalog #: **2050029**
Sample Reciept: **April 15 1992**

| | [$CH_3Hg$] µg/g (wet wt.) | |
|---|---|---|
| sample # | muscle (BM) | liver (LM) |
| 92SL01 | 0.101 | 0.765 |
| 92SL03 | 0.143 | 1.002 |
| 92SL04 | 0.022 | 0.130 |
| 92SL05 | 0.038 | 0.487 |
| 92SL06 | 0.060 | 0.342 |
| 92SL07 | 0.040; 0.040 | 0.406 |
| 92SL08 | 0.108; 0.112; 0.116 | 0.640; 0.631; 0.647 |
| 92SL09 | 0.049 | 0.383 |
| 92SL10 | 0.025 | 0.345 |
| | | |
| blanks | 0.0004 | |
| | | |
| DORM-1* | 0.697, 0.737 | |

*NRCC certified dogfish muscle(0.732± 0.076 µg/g $CH_3Hg$)