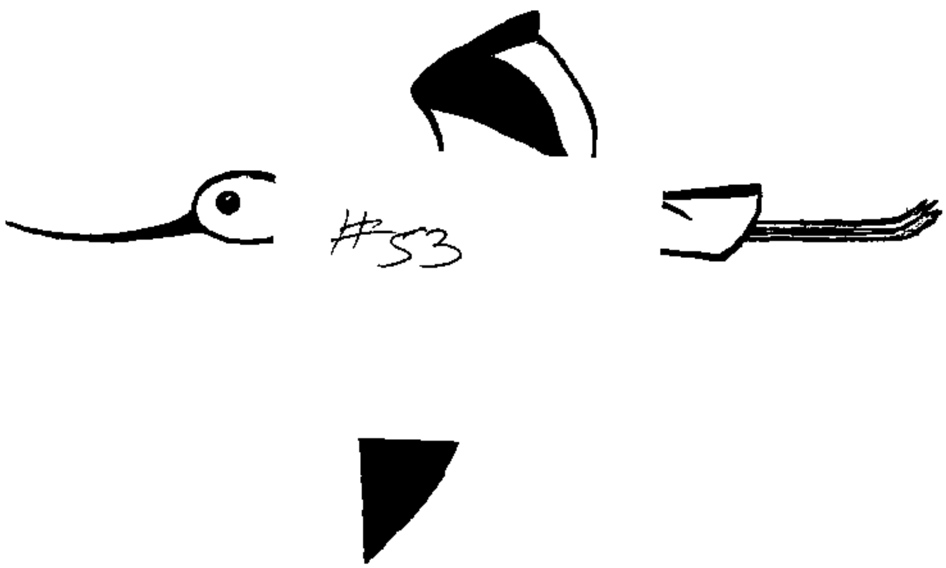
SELENIUM VERIFICATION STUDY

1986

A REPORT TO THE

STATE WATER RESOURCES CONTROL BOARD



STATE OF CALIFORNIA

THE RESOURCES AGENCY

DEPARTMENT OF FISH AND GAME

MAY 1987

SELENIUM VERIFICATION STUDY[1/]

1986

A REPORT TO THE
CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

FROM THE
CALIFORNIA DEPARTMENT OF FISH AND GAME[2/]

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INTRODUCTION

The Selenium Verification Study was begun in December, 1985 as one element of the State Water Resources Control Board (State Board) study entitled "Selenium and Other Trace Elements in California". The purpose of the Verification Study is to provide an intensive assessment of selenium and trace elements in biota from previously identified areas of potential concern.

The Selenium Verification Study was conducted by the California Department of Fish and Game under an interagency agreement with the State Board. Two laboratories within the Department of Fish and Game were involved in this study. Sample collection and interpretation of the results were performed by the biologists at the Bay-Delta Project in Stockton. Sample preparation and analyses were performed by the analytical chemistry unit of the Fish and Wildlife Water Pollution Control Laboratory (WPCL) in Rancho Cordova. Collection of bird, fish, aquatic invertebrate, and water samples was begun in January, 1986; by August, 1986 about 1300 samples were collected from five suspected problem areas and, for comparison, from several areas where there was no evidence suggesting selenium or trace element contamination.

The areas investigated were: the San Francisco Bay-Estuary, including the Suisun Marsh; subsurface agricultural drainage evaporation ponds in Kern County; Salton Sea, including several surface water systems tributary to the Salton Sea and tributaries to the Colorado River in Imperial and Riverside counties; the Stony Creek Drainage, including Black Butte Reservoir in Glenn and Tehama counties; and the San Joaquin River and selected tributaries in western Merced County. These areas were selected for investigation based on data from the Toxic Substances Monitoring Program (TSMP), State Mussel Watch (SMW), Regional Water Quality Control Boards (RWQCBs), the Department of Fish and Game (DFG), and the U.S. Fish and Wildlife Service (USFWS). During the planning process, coordination meetings were held providing opportunities for input to the program design. Findings from these areas were compared with results from samples collected at Humboldt Bay, Gray Lodge State Wildlife Area and the Sacramento National Wildlife Refuge where human activities have not altered selenium levels in the environment and therefore concentrations in animal tissues would reflect exposure to background levels of selenium. For freshwater fish no "background" site was sampled; these data are compared with published data.

Species were selected to reflect the variety of trophic pathways through which animals may be exposed to selenium. Since tissue selenium burdens apparently reach elevated levels through bioaccumulation and bioconcentration, species at several trophic levels and with diverse food habits were chosen. Birds included several species of diving ducks, dabbling ducks, and shorebirds, the American coot (<u>Fulica</u> <u>americana</u>) and double-crested cormorant

(Phalacrocorax auritus). From coastal estuaries both pelagic and benthic fish species associated with marine and brackish water environments were collected, in addition to several commonly occurring molluscs and crustaceans. Freshwater fish collections included an omnivorous species and a predominantly herbivorous species. Species substitutions were made when target species were not available. Water samples were collected at selected sites.

The presence of selenium in biota was determined by analyzing specific tissues. Selenium was measured in liver tissue of fish and birds to be consistent with previous studies and other on-going investigations of trace elements in biota. Liver was third behind spleen and heart in a study of the relative accumulation of selenium in specific tissues in two freshwater fish species (Lemly 1982); hence, it is a good indicator of an animal's exposure to selenium. Selenium was measured in the breast muscle of bird species known to be consumed by humans and in the skeletal muscle of most fish species because of potential public health concerns. Whole fish were analyzed when dissection of specific tissues was impractical because specimens were small. This procedure was necessary for several estuarine species. Selenium was measured in whole shrimp and in the soft tissue of crabs and clams.

Selenium was measured in the tissues of each individual bird. Muscle tissue of individual striped bass, white sturgeon, some starry flounder, and all the fish from the Salton Sea and other sites in Imperial and Riverside counties, and the San Joaquin River and tributaries in Merced County was analyzed. Livers from these fish were analyzed individually except in cases where livers from several individuals were composited to provide enough tissue for analysis. Analysis of individual organisms yields more information than analysis of the same organisms combined in a single sample. Nevertheless, some fish were analyzed in composite samples of six or more individuals to accommodate the constraint on total analyses.

This report covers results from biota collected from January to August, 1986. Findings are interpreted in relation to the continuously growing body of knowledge of selenium and its effects on biological systems. Tissue burdens measured in sampled organisms depend on the exposure history of organisms to selenium in terms of concentration and duration; on species-specific rates of uptake and depuration; and on the age, sex and reproductive condition of individuals. Relating tissue burdens to local environmental conditions depends on an understanding of factors affecting the speciation and bioavailability of selenium in natural systems; trophic pathways through which uptake of selenium occurs; processes of biological accumulation in individuals and biomagnification through food chains which produce high tissue concentrations of selenium from low ambient levels; and, particularly for migratory species, knowledge of selenium exposure at different locations in other seasons. Determining the implications of tissue burdens for the health of individual organisms and populations requires documenting adverse effects associated with above-normal tissue burdens yet for most species normal levels are not well defined. Only a few studies have documented the toxic effects of selenium to fish and wildlife, most notably in wetlands contaminated with agricultural drain water (Ohlendorf et al. 1986 a, b) and in cooling water reservoirs receiving effluent from ash settling basins at coal-fired power plants (Lemly 1985). Selenium may impact individual organisms through impairment of various physiological functions and, even without mortality of individual adults, may eliminate populations by making individuals functionally sterile (Lemly, 1987).

Protection of fish and wildlife from the toxic effects of selenium will involve establishing criteria for concentrations in water, a difficult task given the small differences between essential levels and toxic levels of selenium in some animals and the tendency for biological accumulation in food chains from low levels in water. This study has measured tissue burdens in biota, with no intent to evaluate reproductive success or effects on target species at the population level. Measured levels of selenium in biota are compared with data from other sources and conclusions are drawn, appropriately qualified in the context of the uncertainties described above. In the absence of complete information, hypotheses are stated to stimulate thought and identify needs for additional information.

SUMMARY OF FINDINGS

San Francisco Bay-Estuary and Suisun Marsh

Selenium concentrations measured in diving ducks, some species of fish, and benthic invertebrates from the San Francisco Bay-Estuary were significantly higher than background levels measured in the same species from Humboldt Bay.

Selenium concentrations in surf scoters, scaup, starry flounder, dungeness crab, and bay shrimp also were higher in specimens from Suisun Bay than from other parts of the estuary suggesting either input from sources in that area or enhanced bioavailability of selenium due to localized physical, chemical, or biological processes.

Based on preliminary data from this study, the Department of Health Services in September, 1986 issued an advisory recommending limited consumption of scaup and surf scoters from Suisun Bay.

The species with elevated tissue selenium levels compared to background levels were either bottom-dwellers or species with diets comprised largely of benthic organisms. This finding suggests physical or chemical factors at the water-sediment interface may make selenium more available for uptake by benthic organisms than it is for species inhabiting the water column. Selenium taken up by low trophic level benthic organisms may then be magnified in subsequent consumer levels in the food chain. Alternatively, the sediments may be a source of selenium to the system and its biota.

Selenium levels in shorebirds (American avocet, willet), double-crested cormorants and pelagic fishes in the San Francisco Bay-Estuary were not above background levels. Birds in the Suisun Marsh had low levels of selenium, notwithstanding the proximity and hydrologic connection of the marsh to Suisun Bay and the occasional use of the bay by species collected in the marsh. Food habit relationships distinguish the species in this group from those with tissue selenium concentrations exceeding background levels.

The average selenium concentration in the muscle of white sturgeon, an anadromous species which feeds primarily on benthic crustaceans and molluscs, was five times higher than in striped bass, an anadromous species which feeds mostly on fish.

More data are needed to evaluate hypotheses regarding the sources and significance of selenium levels measured in San Francisco Bay biota. Selenium levels in migratory individuals arriving in the area, the extent of their movements within the estuary, and species-specific threshold levels causing toxicity are significant unknowns.

Salton Sea

Our findings indicated selenium levels in orangemouth corvina and croaker from the Salton Sea were essentially unchanged from levels measured by the Toxic Substances Monitoring Program in 1984 and 1985. Selenium levels in tilapia apparently doubled since 1985. Selenium levels in these species outside the Salton Sea are unknown.

Double-crested cormorants from the Salton Sea had significantly higher selenium concentrations than those from San Francisco Bay and Humboldt Bay probably due to high levels in their diet comprised mostly of fishes from the Salton Sea (tilapia, croakers).

Lesser scaup, apparently feeding on barnacles at the Salton Sea did not contain proportionately elevated selenium levels compared to levels in water, fish, and fish-eating birds. Levels in scaup were similar to scaup from Humboldt Bay and parts of the San Francisco Bay system, and significantly less than scaup from Suisun Bay. American wigeon from the Salton Sea had higher selenium levels in muscle than reported in the literature for other dabbling ducks but less than one third average levels in ducks (no wigeon) at Kesterson NWR in 1983 and 1984. Comparative data for wigeon were lacking.

Selenium levels in black-necked stilts from the Salton Sea were significantly higher than in stilts from Grizzly Island and Gray Lodge Wildlife Areas and Sacamento National Wildlife Refuge but less than in stilts from Kesterson NWR where stilt reproduction was impacted by selenium.

Sources of selenium to the Salton Sea are agricultural runoff and subsurface drainage, natural runoff, and perhaps selenium in the irrigation water supply imported from the Colorado River.

Surface Waters and Agricultural Drains, Riverside and Imperial Counties

Carp and channel catfish from the Whitewater River which receives subsurface agricultural drainwater from the Coachella Valley contained only slightly elevated selenium levels compared to levels reported in the literature. Freshwater species in the Whitewater River accumulated less selenium in their tissues than the marine species in the Salton Sea in spite of similar levels in water. Water samples indicated the Lincoln Street Drain may be a source of selenium to the Lower Whitewater River. In the Coachella Canal, where no selenium was detected in a single water sample, selenium levels were fifty percent higher in catfish and nearly two and one half times higher in carp than in catfish and carp from the Whitewater River. Fish in the Coachella Canal may have migrated from an area with higher selenium levels or water in the canal may have contained a higher selenium concentration in the past.

Carp from the Palo Verde Outfall Drain which received surface tailwater from agriculture in the Palo Verde Valley contained half the selenium found in Whitewater River carp and one-fourth the levels in carp from the Coachella Canal. Largemouth bass had levels higher than in bass from Sierra Reservoirs (eg. Don Pedro Reservoir and Lake McClure) but fifty percent less than in bass from waters receiving subsurface drainwater (eg. Mud Slough) in the San Joaquin Valley. Water samples indicated selenium declined from about three ppb in February to undetectable levels in May.

Carp from Reservation Drain which carries agricultural drainwater from Bard Valley to the Colorado River had very low levels of selenium. Water samples contained detectable levels only in May when flow in the drain had increased compared to February and April.

Kern County Agricultural Drainage Evaporation Ponds And Water Storage Facilities

Selenium levels in biota were related to selenium concentrations in water at three subsurface agricultural drainage evaporation ponds and a water storage reservoir in Kern County. Ducks, coots, and shorebirds associated with the highest selenium concentrations in water contained the highest selenium levels in tissues. Limited sampling of invertebrates indicated no dependence of their tissue selenium levels on concentrations in water.

Selenium levels in cinnamon teal from the Tulare Lake Drainage District South Evaporation Basin were in the upper end of the range of concentrations measured in cinnamon teal from several sites in the Grasslands from 1983 to 1985. Average levels at TLDD were about a third of the average measured in cinnamon teal from Kesterson NWR in 1983. The probability of toxicity at levels measured in teal at TLDD is unknown.

Coots at the Tulare Lake Drainage District South Evaporation Basin had an average selenium concentration in muscle twenty percent lower than in coots at Kesterson NWR in 1983. The highest concentrations in individual coots at TLDD exceeded the average level at Kesterson but were only about half the maximum level in coots at Kesterson. Selenium occured at apparently benign levels in most coots at TLDD but some coots there may contain harmful levels.

Selenium concentrations in livers of black-necked stilts collected from the Westfarmer evaporation pond complex in May were similar to levels in stilts from Kesterson NWR where severe reproductive effects in stilts were associated with selenium in 1983 and 1984. Comparable levels in stilts at the Westfarmer ponds and Kesterson NWR suggest effects on stilt reproduction were likely at Westfarmer evaporation ponds in 1986.

Average selenium levels in avocets at the Westfarmer ponds and at the Tulare Lake Drainage District South Evaporation Basin in May were 35 to 40 percent higher than levels in avocets at Kesterson in 1984 when no reproductive effects in avocets were observed, but were only about half the levels measured in 1985 when embryotoxic effects were first observed in avocets at Kesterson. The significance of selenium levels in avocets at these Kern County sites is not known.

Aquatic invertebrates in separate evaporation ponds with 10 ppb and 110 ppb selenium in water accumulated selenium to the same tissue concentration. Selenium levels in these water boatmen were intermediate between levels in aquatic insects at Volta Wildlife Area (control site) and those at Kesterson Reservoir.

Selenium levels in mosquitofish from a pond with 35 ppb in water were ten times the concentration of mosquitofish from Volta Wildlife Area but less than one-sixth those from Kesterson Reservoir.

Stony Creek and Black Butte Reservoir

Selenium concentrations in fishes from Stony Creek and Black Butte Reservoir were slightly higher than in the same species from west-slope Sierra impoundments and rivers, but lower than most other published data.

Channel catfish, largemouth bass, carp, and Sacramento suckers all had selenium levels far less than levels measured in three of these species at Belews Lake in North Carolina where fish populations were eliminated by reproductive failures caused by selenium.

Selenium derived from natural deposits in the watershed exceeded the detection limit (0.5 ppb) in only one water sample (1.0 ppb in Black Butte Reservoir). At concentrations five to ten percent of levels known to affect these species, selenium levels in fishes in Stony Creek and Black Butte Reservoir are likely below harmful levels.

San Joaquin River and Grasslands Tributaries, Merced County

Selenium concentrations measured in composite samples of channel catfish and white catfish were higher in fish from Camp 13 Ditch than in fish from Mud Slough, Salt Slough and the San Joaquin River downstream of the mouth of the Merced River.

Selenium concentrations in channel catfish from Camp 13 Ditch in the South Grasslands were fifty percent higher than those in Mud Slough near Kesterson NWR which were twice the levels in channel catfish from the San Joaquin River.

Water samples collected and analyzed by the U.S. Geological Survey averaged 21 ppb dissolved selenium in Mud Slough, 5.5 ppb in Salt Slough, and 4.0 ppb in the San Joaquin River from June through September, 1985, indicative of the use of these waterways as conduits for subsurface agricultural drainage in the recent past.

Selenium levels in these catfish are far below documented toxic levels in these species, however, concentrations in the range measured in catfish from Camp 13 Ditch and Mud Slough are found only in selenium enriched environments. The significance of these levels to catfish has not been determined.

FIELD AND LABORATORY OPERATIONS

FIELD METHODS

Sample Collections

Eleven species of birds (Table 1), 19 species of fish (Table 2) and four species of invertebrates (Table 3) were collected from January to August, 1986 (Tables 4a, 4b). Samples were collected from 26 locations statewide (Figure 1, Table 5). Specific sites are depicted in Figures 2 through 9 and described in Appendix A.

Bird Collection and Processing

Most of the birds were collected using 12 gauge shotguns and steel shot. A few ducks were obtained from a trap operated for a banding study at Grizzly Island State Wildlife area. To reduce intraspecific variation among individuals, we collected adult males when identification and availability permitted. Female and immature birds collected inadvertently were analyzed and included in our results.

Birds were weighed using spring scales. Age was determined based on plumage; sex was determined from plumage or examination of gonads. The liver was removed from all birds; a breast muscle sample was obtained in accordance with the study plan.

Disposable polyethylene gloves were worn during field dissections to prevent sample contamination through contact with human skin. After the skin was peeled from the breast muscle, the furcula and ribs were cut with stainless steel shears, the whole breast with sternum attached was removed and placed in a 4 mil plastic Ziploc bag. The liver was removed with Tefzel forceps and a scalpel and placed in a separate bag. The two sample bags were placed in a third bag with a sample label. Samples were put on dry ice immediately and frozen; they were subsequently stored in a chest freezer at $-12^{o}C$, usually for a few weeks but at most six months, until they were delivered to the DFG Fish and Wildlife Water Pollution Control Laboratory (WPCL) in Rancho Cordova. Sample storage conditions at WPCL are described in the section on laboratory operations.

Fish and Aquatic Invertebrate Collection and Processing

Fish and invertebrate sampling gear included otter and mid-water trawls, a sled-mounted egg and larval sampling net, boat-mounted electrofisher (Smith-Root SR-16E), hoop nets, variable mesh monofilament gillnets, beach seines, and hook and line. A small-mesh kicknet was used to collect waterboatmen. Clams and mussels were gathered by hand and with shovels.

TABLE 1
COMMON NAME, SCIENTIFIC NAME, FAMILY AND SPECIES NAME CODE
OF BIRDS COLLECTED IN 1986

Common Name	Species	Family	Code
American wigeon	*Anas americana*	Anatidae	WIGEON
cinnamon teal	*Anas cyanoptera*	"	CNTEAL
mallard	*Anas platyrhynchos*	"	MALLRD
lesser scaup	*Aythya affinis*	"	LSCAUP
greater scaup	*Aythya marila*	"	GSCAUP
surf scoter	*Melanitta perspicillata*	"	SCOTER
double-crested cormorant	*Phalacrocorax auritus*	Phalacrocoracidae	DCCORM
American coot	*Fulica americana*	Rallidae	AMCOOT
black-necked stilt	*Himantopus mexicanus*	Recurvirostridae	BNSTLT
American avocet	*Recurvirostra americana*	"	AVOCET
willet	*Catoptrophorus semipalmatus*	Scolopacidae	WILLET

TABLE 2
COMMON NAME, SCIENTIFIC NAME, FAMILY AND SPECIES NAME CODE
OF FISHES COLLECTED IN 1986

Common Name	Species	Family	Code
white sturgeon	Acipenser transmontanus	Acipenseridae	WSTRGN
speckled sanddab	Citharichthys stigmaeus	Bothidae	SPSNDB
Sacramento sucker	Catostomus occidentalis	Catostomidae	WSUCKR
largemouth bass	Micropterus salmoides	Centrarchidae	LMBASS
tilapia	Tilapia sp.	Cichlidae	TILPIA
Pacific herring	Clupea harengus pallasi	Clupeidae	HERRNG
Pacific staghorn sculpin	Leptocottus armatus	Cottidae	STGSCU
common carp	Cyprinus carpio	Cyprinidae	CARPPP
northern anchovy	Engraulis mordax	Engraulidae	NANCHV
yellowfin goby	Acanthogobius flavimanus	Gobiidae	YFGOBY
white catfish	Ictalurus catus	Ictaluridae	WHTCAT
channel catfish	Ictalurus punctatus	"	CHNCAT
longfin smelt	Spirinchus thaleichthys	Osmeridae	LFSMLT
striped bass	Morone saxatilis	Percichthyidae	STBASS
English sole	Parophrys vetulus	Pleuronectidae	ENGSOL
starry flounder	Platichthys stellatus	"	SFLNDR
mosquitofish	Gambusia affinis	Poeciliidae	GAMBSA
bairdiella (croaker)	Bairdiella icistia	Sciaenidae	CROAKR
orangemouth corvina	Cynoscion xanthulus	"	CORVNA

TABLE 3
COMMON NAME, SCIENTIFIC NAME, FAMILY AND SPECIES NAME CODE
OF INVERTEBRATES COLLECTED IN 1986

Common Name	Species	Family	Code
dungeness crab	*Cancer magister*	Cancridae	DNCRAB
waterboatman	undetermined	Corixidae	BOATMN
bay shrimp	*Crangon* spp.	Crangonidae	SHRIMP
softshell clam	*Mya arenaria*	Myacidae	SSCLAM

TABLE 4A
SELENIUM VERIFICATION COLLECTION PROGRAM, 1986

BIRDS

LOCATION[1/]	SPP. COLLECTED[2/]	DATE COLLECTED
CNSFB	SCOTER, DCCORM, LSCAUP	2/28
"	DCCORM	6,7/86
GRYLG	AMCOOT, MALLRD	1/86, 6/86
"	BNSTLT	3/86
HMBLT	DCCORM, GSCAUP, LSCAUP, SCOTER, WILLET	2/86
"	DCCORM	6/86
LSTHL	AMCOOT, BNSTLT	3/86
"	CNTEAL	5/86
SALTN	BNSTLT, DCCORM, LSCAUP, WIGEON	2/86
"	BNSTLT, DCCORM	5/86
SCNWR	AVOCET, BNSTLT	6/86
SEMIT	AVOCET, AMCOOT, CNTEAL	3/86, 5/86
SNPBB	AVOCET, DCCORM, GSCAUP, SCOTER, WILLET	3,4/86
"	AVOCET, WLLET	6/86
SOSFB	DCCORM, GSCAUP, LSCAUP, SCOTER	2,4/86
"	AVOCET, WILLET	3/86, 6/86
SUISB	LSCAUP, SCOTER	1/86
"	DCCORM	7/86
SUISM	AMCOOT, BNSTLT, MALLRD	2,3/86, 6,7/86
TLDDS	AMCOOT, AVOCET, CNTEAL	3/86,5/86
TWISS	AVOCET, BNSTLT, CNTEAL	3/86, 5/86

1/ See Table 5 for key to location codes.
2/ See Table 1 for key to species codes.

TABLE 4B
SELENIUM VERIFICATION COLLECTION PROGRAM, 1986

FISH

LOCATION[1/]	SPP. COLLECTED[2/]	DATE COLLECTED
ANTCH	STBASS	4/86, 5/86
BBRES	LMBASS, CARPPP, CHNCAT, WSUCKR	6/86
CLKBG	STBASS	4/86, 5/86
CMP13	CHNCAT	8/86
CNSFB	LFSMLT, NANCHV, ENGSOL, SFLNDR, HERRNG, SPSNDB	1/86, 5/86
CNSFB	STGSCU, HERRNG	2/86
COACH	CARPPP, CHNCAT	5/86
HMBLT	HERRNG, ENGSOL, SPSNDB, STGSCU, LFSMLT	2/86
HMBLT	HERRNG, ENGSOL, SPSNDB, STGSCU, SFLNDR	6/86
MUDSL	CHNCAT	8/86
PVODR	CARPPP, LMBASS	4/86
RESDR	CARPPP	4/86
SALTN	CORVNA, CROAKR, TILPIA	5/86
SALTS	CHNCAT, WHTCAT	8/86
SJRMR	CHNCAT, WHTCAT	8/86
SNPBB	ENGSOL, LFSMLT, SFLNDR, STGSCU	1/86
SNPBB	HERRNG, YFGOBY	2/86
SNPBB	WSTRGN	3/86, 4/86
SNPBB	ENGSOL, HERRNG, LFSMLT, NANCHV, SFLNDR, SPSNDB, STGSCU, YFGOBY, WSTRGN	5/86
SOSFB	ENGSOL, LFSMLT, NANCHV, STGSCU	1/86
SOSFB	HERRNG	2/86
SOSFB	ENGSOL, HERRNG, LFSMLT, NANCHV, STGSCU, SPSNDB	5/86
SOSFB	SFLNDR	6/86
STNYA	CARPPP, CHNCAT	4/86
STNYA	CARPPP	5/86
STNYB	CARPPP, CHNCAT	5/86
SUISB	LFSMLT, SFLNDR, STGSCU	1/86
SUISB	YFGOBY	2/86
SUISB	HERRNG, LFSMLT, SFLNDR, STGSCU, YFGOBY	5/86
SUISB	NANCHV	6/86
TLDDS	GAMBSA	5/86
WWRIV	CARPPP, CHNCAT	5/86

1/ See Table 5 for key to location codes.
2/ See Table 2 for key to species codes.

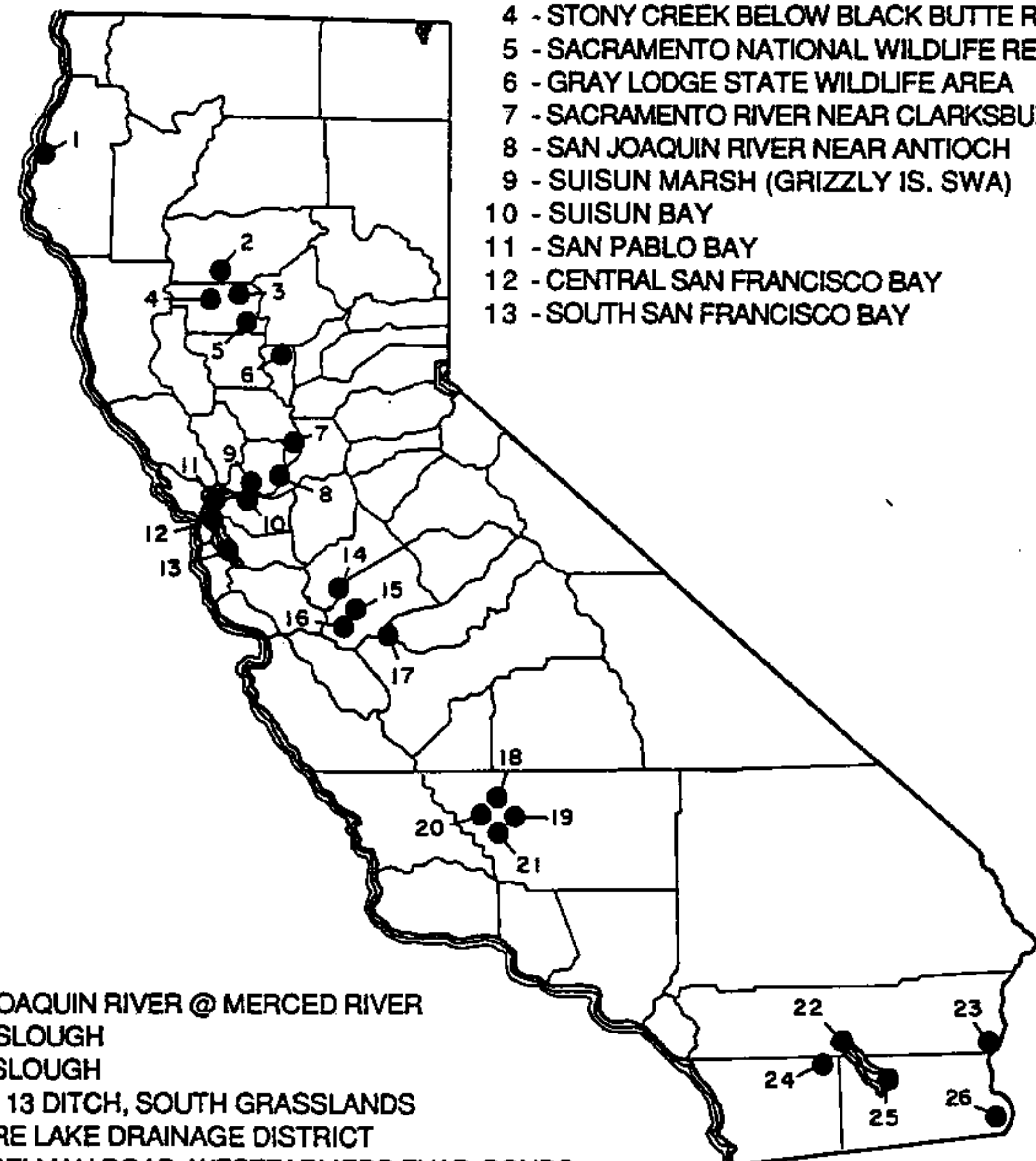
TABLE 5
SELENIUM VERIFICATION STUDY
SAMPLING LOCATIONS AND LOCATION NAME CODES

Location Code	Location[1/]
ANTCH	San Joaquin River near Antioch, Contra Costa County
BBRES	Black Butte Reservoir, Glenn County
CLKBG	Sacramento River near Clarksburg, Yolo County
CMP13	Camp 13 Ditch, near Los Banos, Merced County
CNSFB	Central San Francisco Bay
COACH	Coachella Canal, near La Quinta, Riverside County
GRYLG	Gray Lodge Wildlife Area, near Gridley, Butte County
HMBLT	Humboldt Bay, Humboldt County
LSTHL	Lost Hills Ranch Evaporation Ponds, near Lost Hills, Kern Co.
MUDSL	Mud Slough, at Kesterson NWR, Merced County
PVODR	Palo Verde Outfall Drain, near Blythe, Imperial County
RESDR	Reservation Drain, near Winterhaven, Imperial County
SALTN	Salton Sea, Imperial County
SALTS	Salt Slough, near Stevinson, Merced County
SCNWR	Sacramento National Wildlife Refuge, near Willows, Glenn Co.
SEMIT	Semitropic Water Storage Dist. Ponds, near Lost Hills, Kern Co.
SJRMR	San Joaquin River downstream of Merced River confluence, Merced County
SNPBB	San Pablo Bay
SOSFB	South San Francisco Bay
STNYA	Stony Creek above Black Butte Reservoir, Glenn County
STNYB	Stony Creek below Black Butte Reservoir, Glenn County
SUISB	Suisun Bay, including Grizzly Bay
SUISM	Suisun Marsh, near Fairfield, Solano County
TLDDS	Tulare Lake Drainage District Ponds, near Kern NWR, Kern Co.
TWISS	Westfarmer Evaporation Ponds, Twisselman Road, Kern County
WWRIV	Whitewater River, near Indio, Riverside County

1/ See Appendix A for location description.

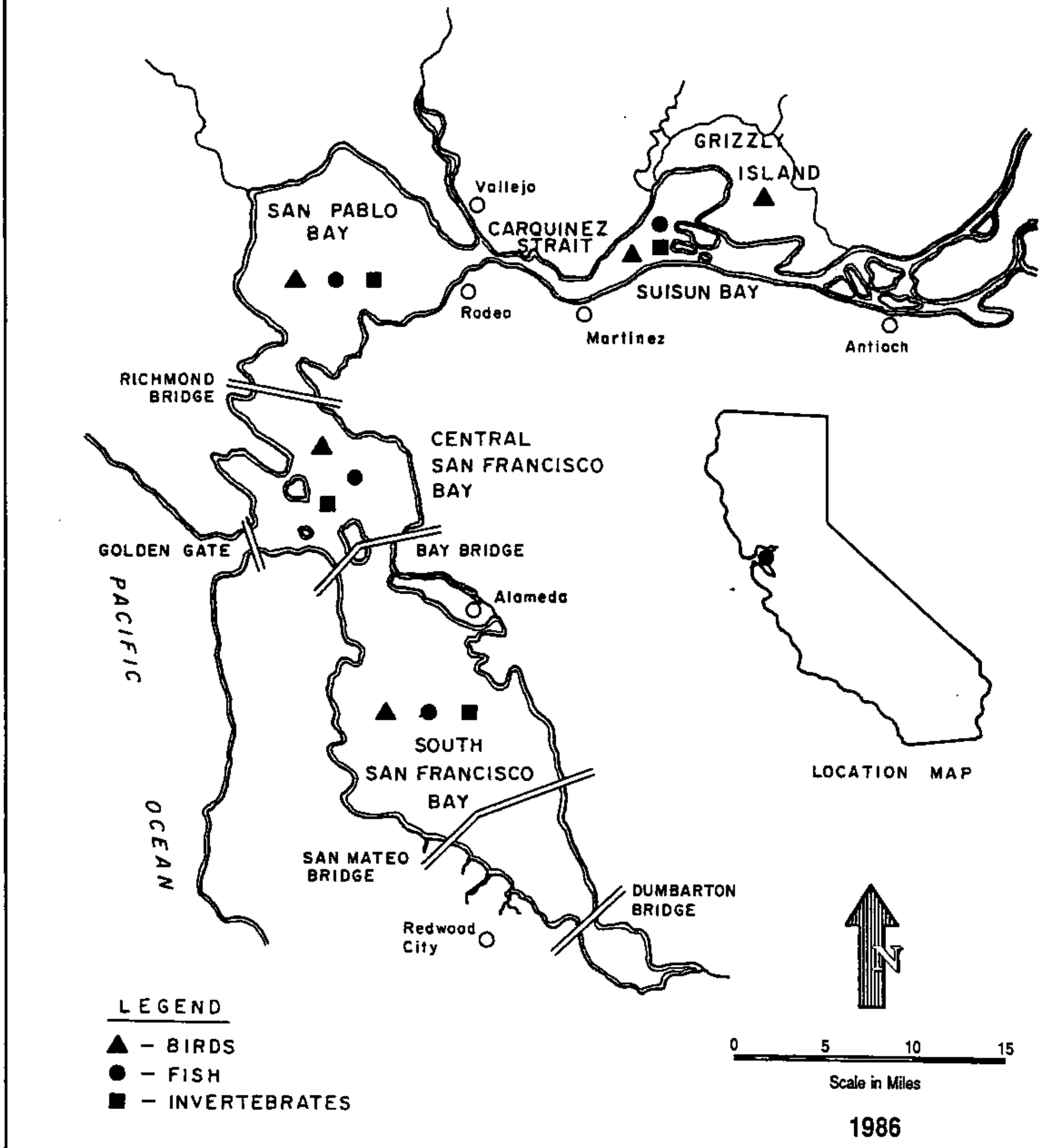
FIGURE - I

1 - HUMBOLDT BAY
2 - BLACK BUTTE RESERVOIR
3 - STONY CREEK ABOVE BLACK BUTTE RESERVOIR
4 - STONY CREEK BELOW BLACK BUTTE RESERVOIR
5 - SACRAMENTO NATIONAL WILDLIFE REFUGE
6 - GRAY LODGE STATE WILDLIFE AREA
7 - SACRAMENTO RIVER NEAR CLARKSBURG
8 - SAN JOAQUIN RIVER NEAR ANTIOCH
9 - SUISUN MARSH (GRIZZLY IS. SWA)
10 - SUISUN BAY
11 - SAN PABLO BAY
12 - CENTRAL SAN FRANCISCO BAY
13 - SOUTH SAN FRANCISCO BAY



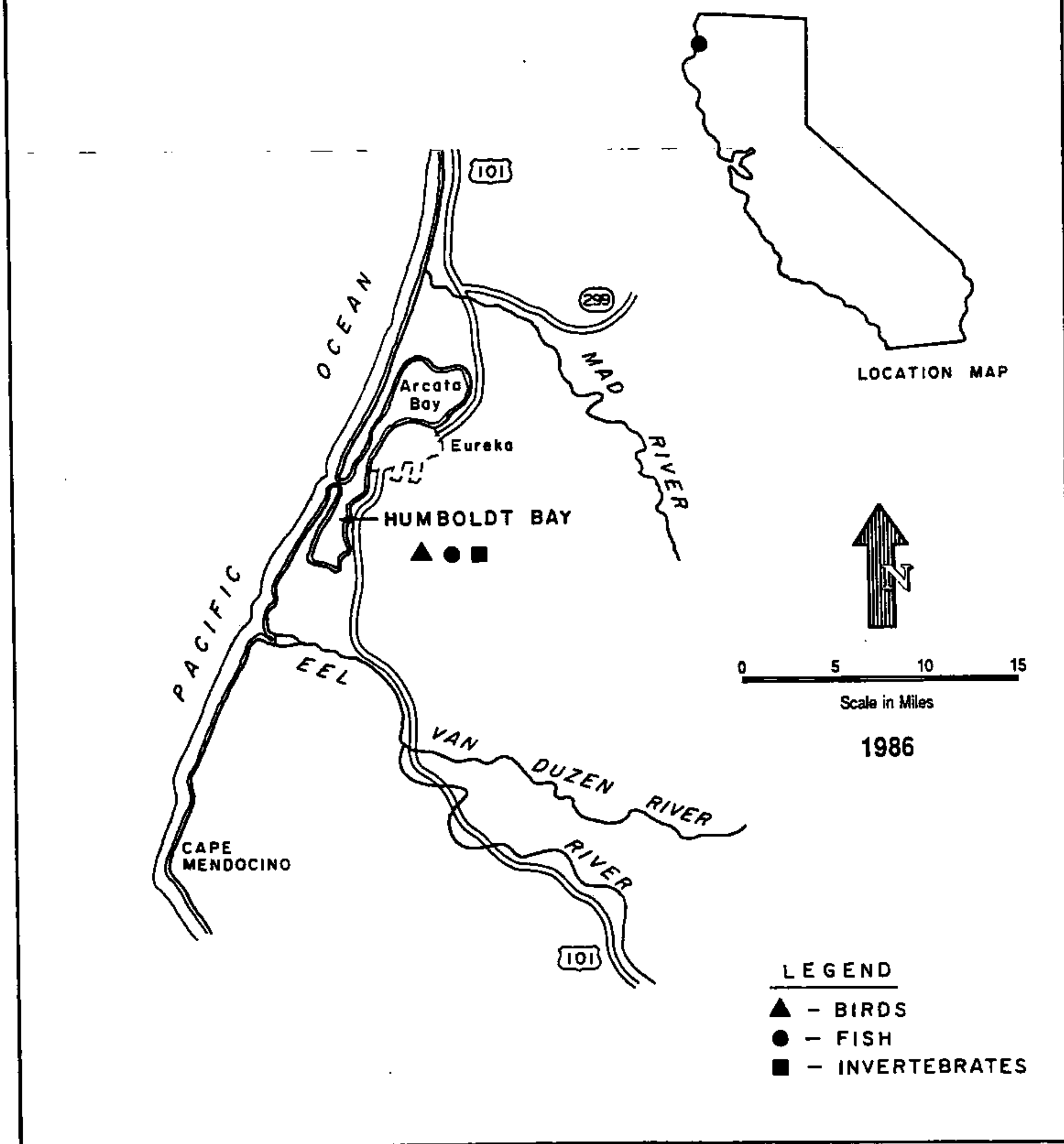
14 - SAN JOAQUIN RIVER @ MERCED RIVER
15 - SALT SLOUGH
16 - MUD SLOUGH
17 - CAMP 13 DITCH, SOUTH GRASSLANDS
18 - TULARE LAKE DRAINAGE DISTRICT
19 - TWISSELMAN ROAD, WESTFARMERS EVAP. PONDS
20 - LOST HILLS RANCH EVAP. PONDS
21 - SEMITROPIC WATER STORAGE DISTRICT PONDS
22 - WHITEWATER RIVER AT MOUTH
23 - PALO VERDE OUTFALL DRAIN
24 - COACHELLA CANAL NEAR LA QUINTA, CA.
25 - SALTON SEA
26 - RESERVATION DRAIN

SELENIUM VERIFICATION STUDY: STATEWIDE DISTRIBUTION OF SAMPLING SITES - 1986



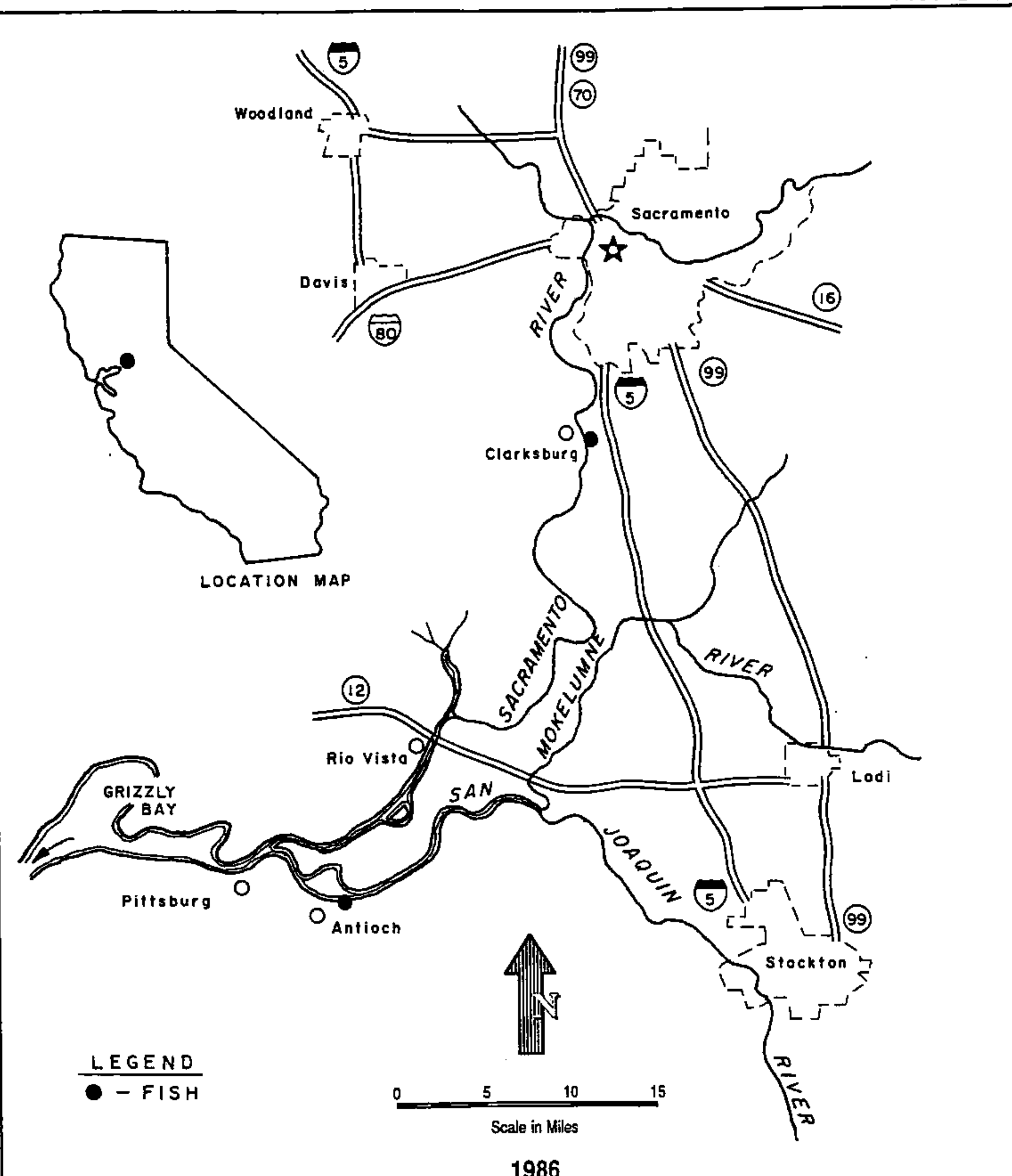
SELENIUM VERIFICATION STUDY: SAN FRANCISCO BAY-ESTUARY SAMPLING SITES

FIGURE - 3

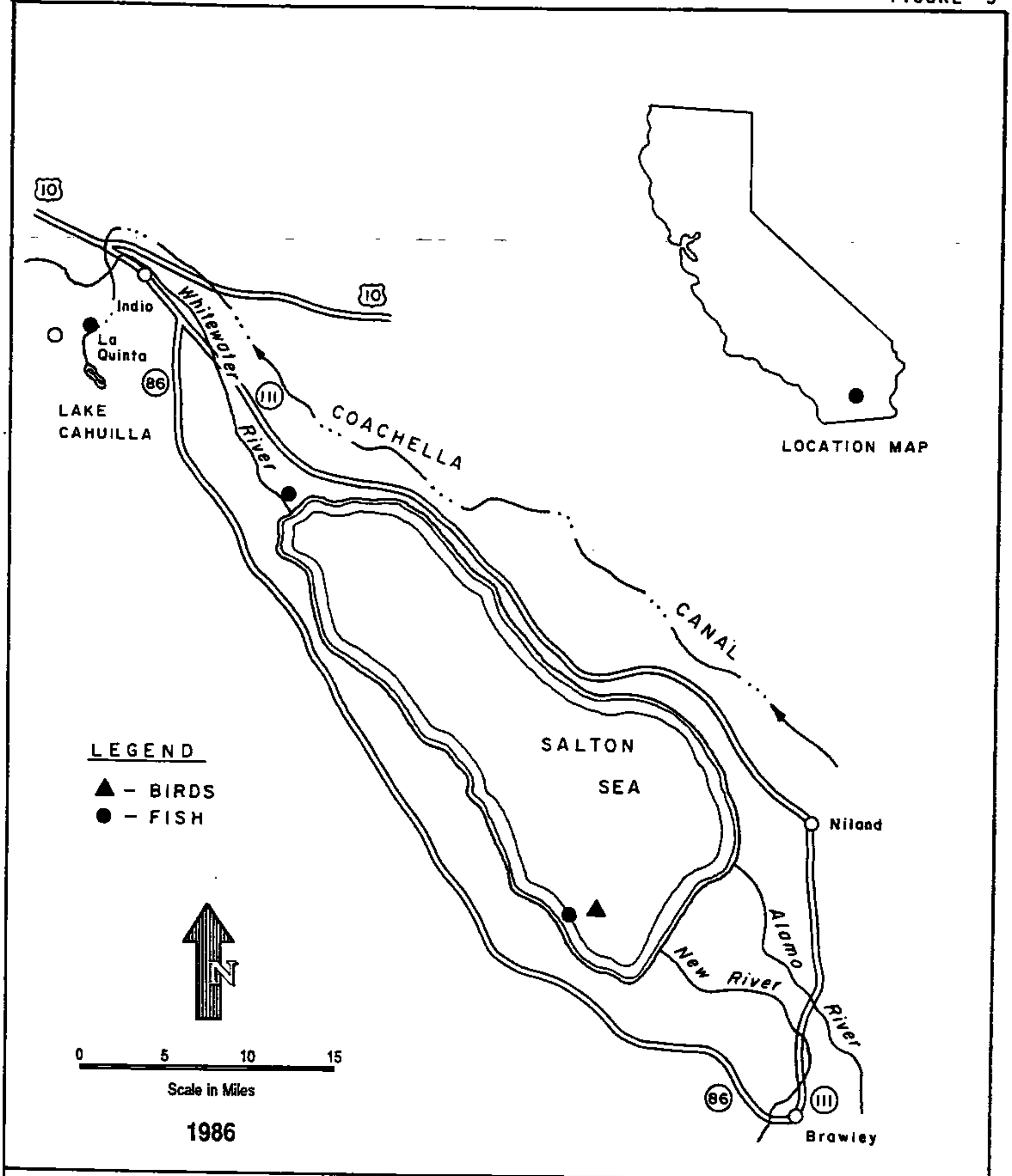


SELENIUM VERIFICATION STUDY: HUMBOLDT BAY SAMPLING SITES

FIGURE - 4

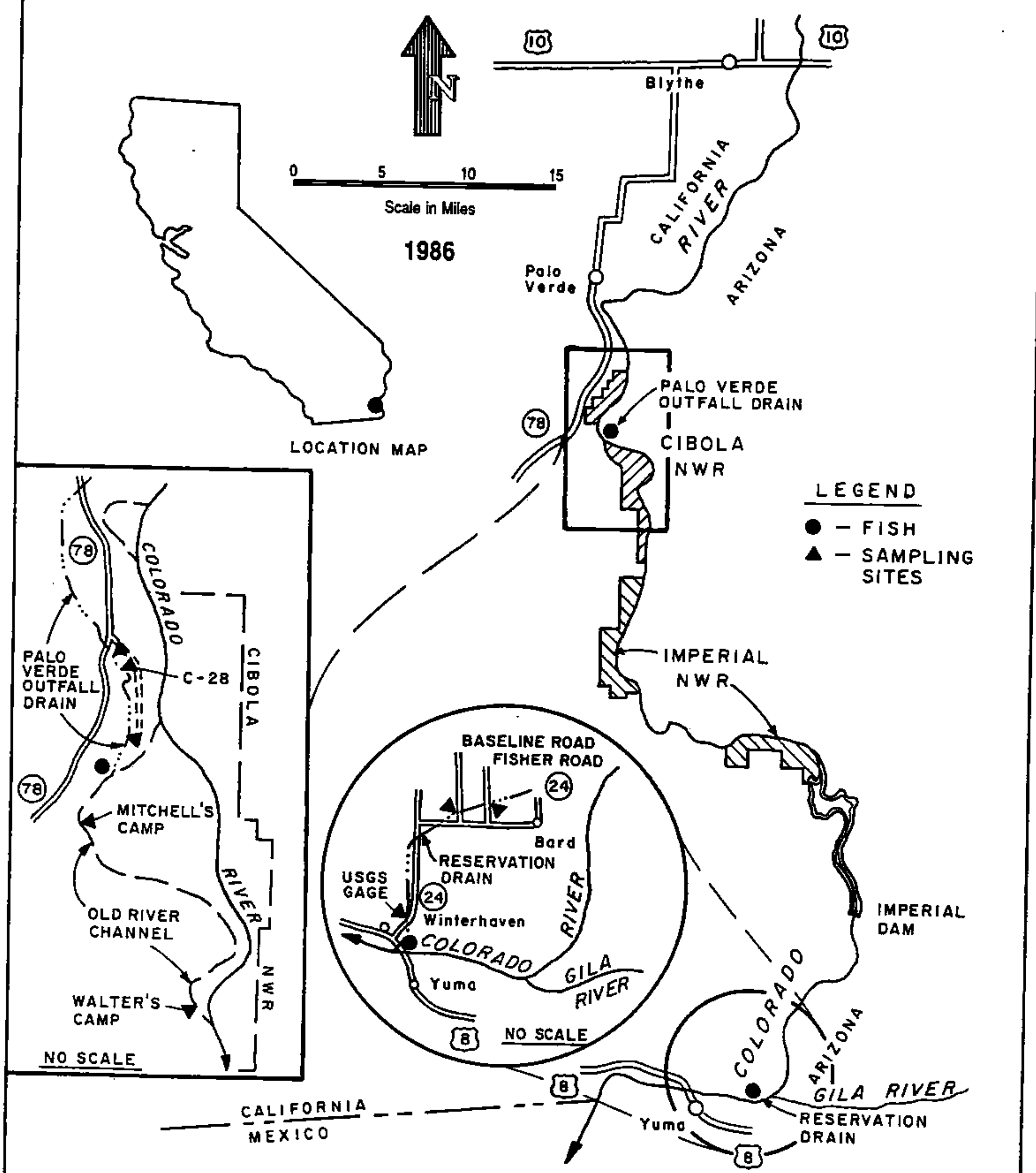


SELENIUM VERIFICATION STUDY: STRIPED BASS COLLECTION SITES



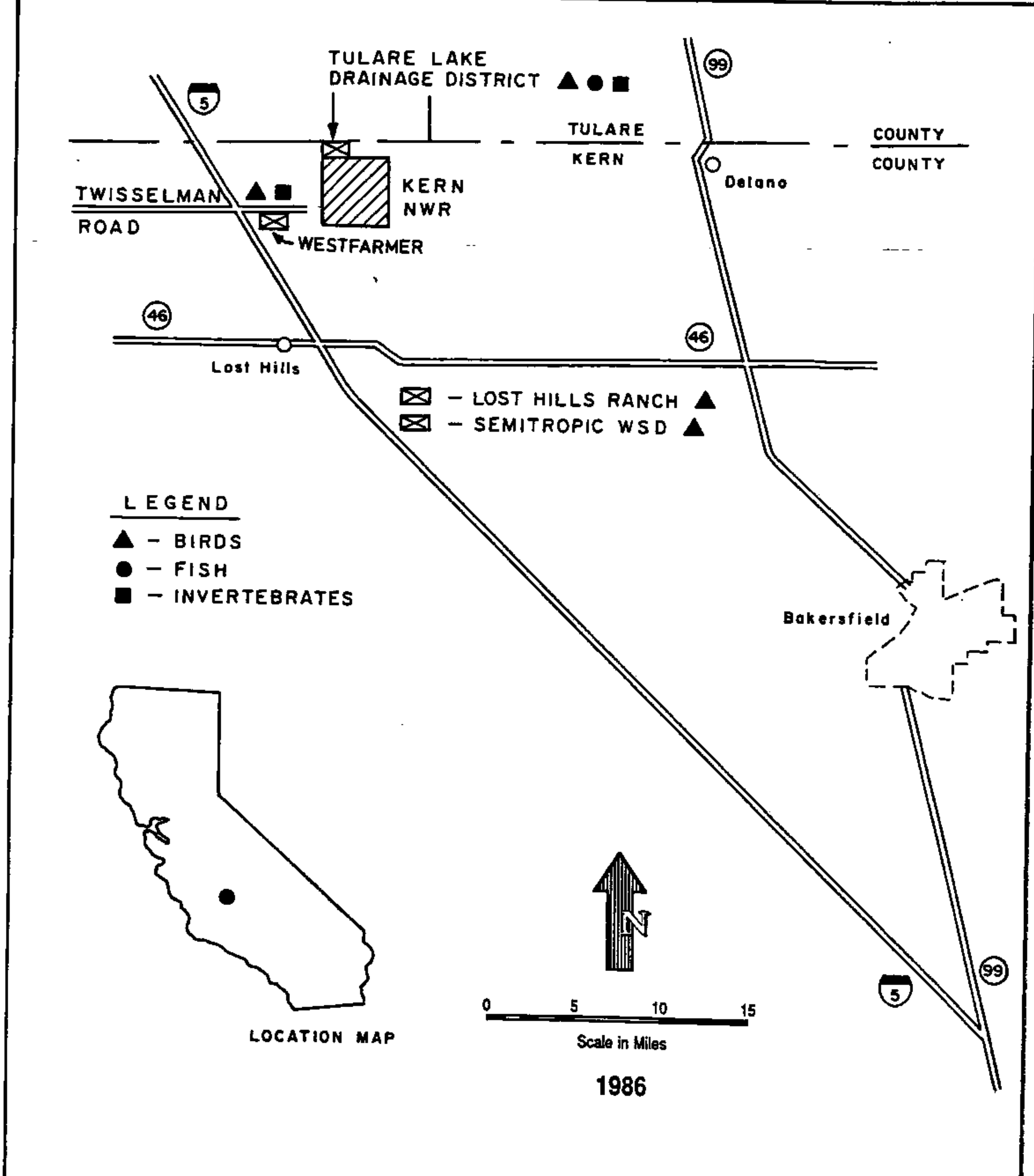
SELENIUM VERIFICATION STUDY: SALTON SEA, WHITEWATER RIVER, AND COACHELLA CANAL SAMPLING SITES

FIGURE – 6



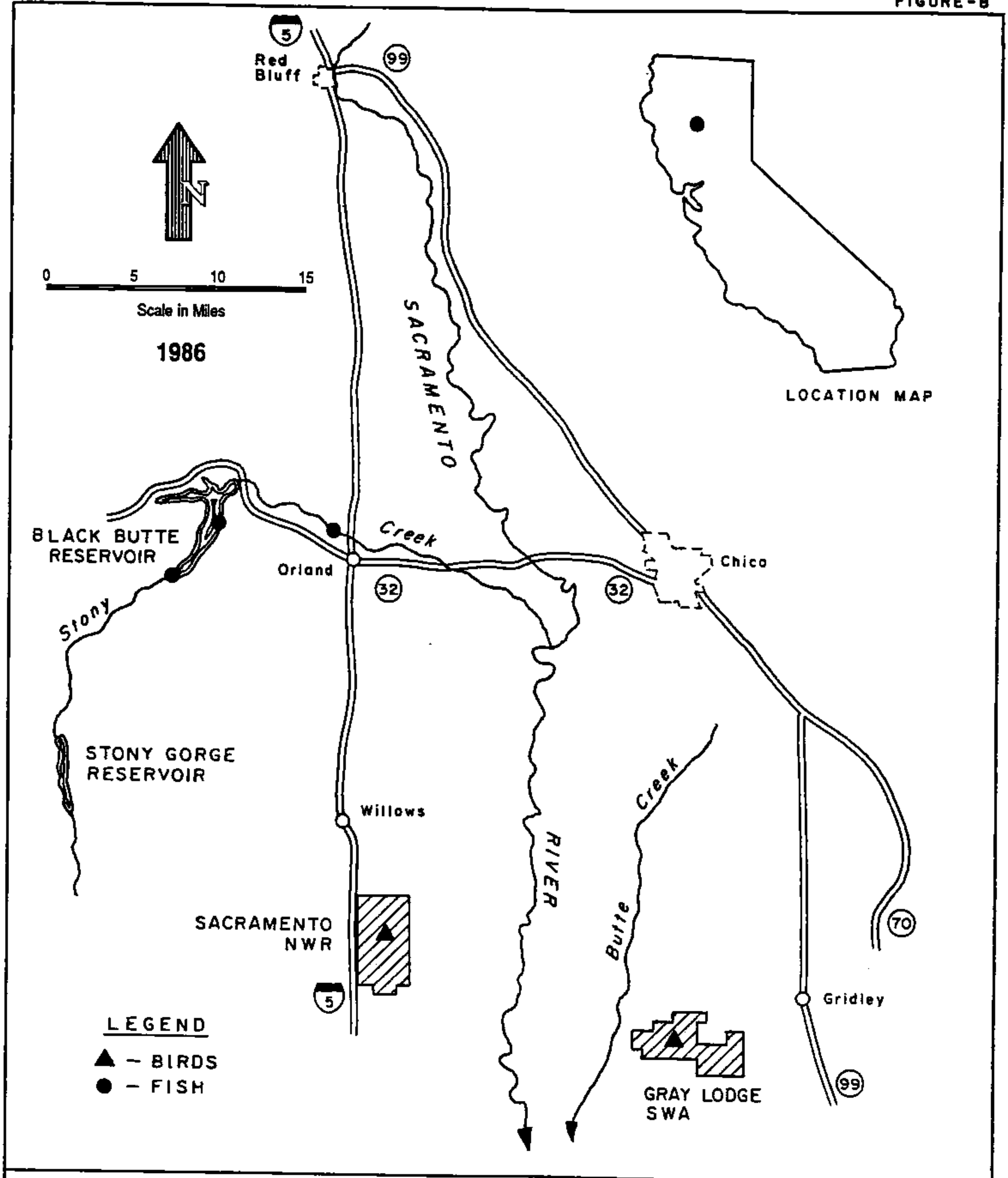
SELENIUM VERIFICATION STUDY: PALO VERDE OUTFALL DRAIN AND RESERVATION DRAIN SAMPLING SITES

FIGURE - 7



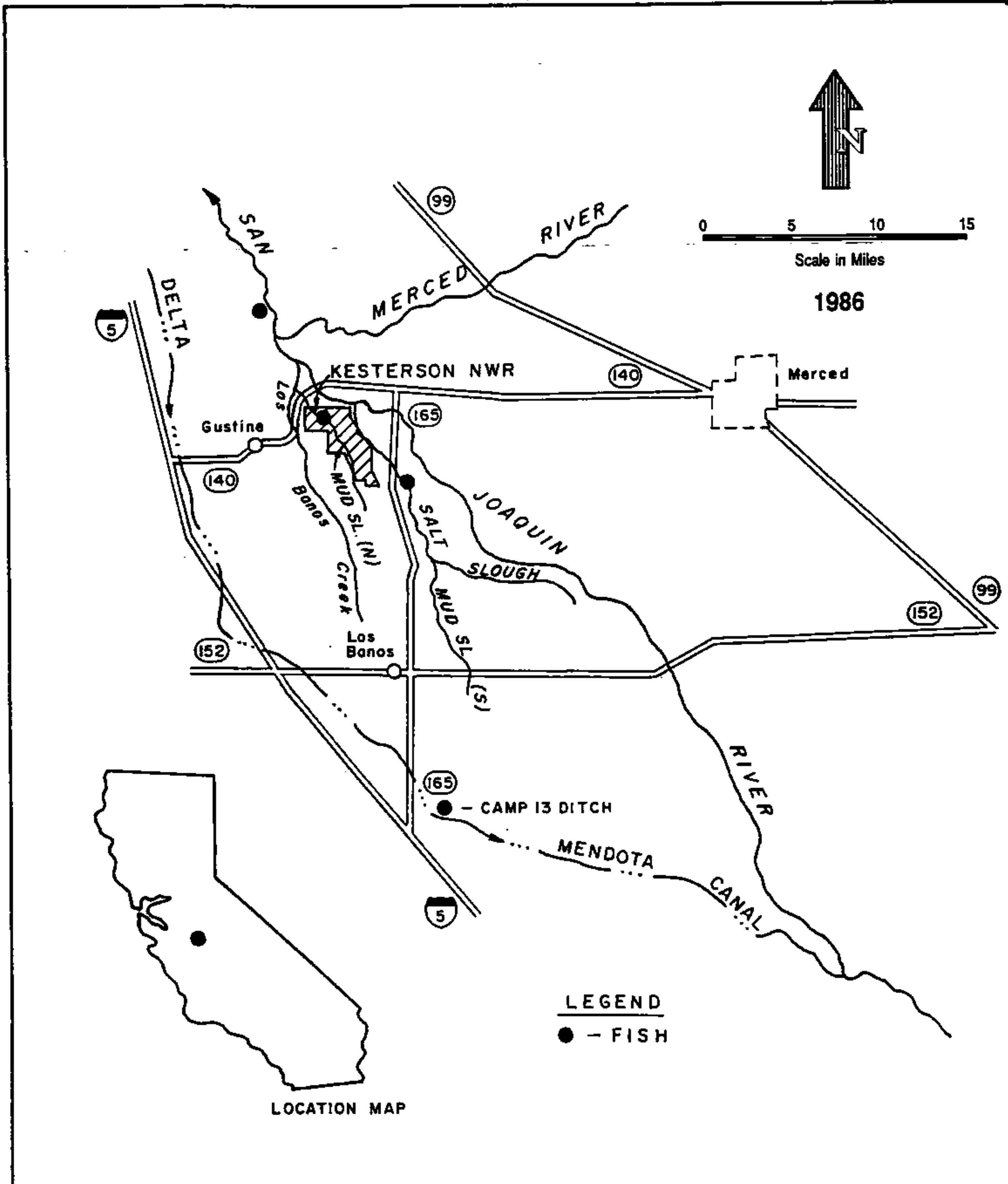
SELENIUM VERIFICATION STUDY: KERN COUNTY EVAPORATION POND AND WATER STORAGE FACILITY SAMPLING SITES

FIGURE-8



SELENIUM VERIFICATION STUDY: STONY CREEK/BLACK BUTTE RESERVOIR, SACRAMENTO NWR, AND GRAY LODGE WA SAMPLING SITES

FIGURE - 9



SELENIUM VERIFICATION STUDY: SAN JOAQUIN RIVER AND TRIBUTARIES SAMPLING SITES

As soon as possible after collection, fish and invertebrate samples were placed in Ziploc bags, frozen with dry ice and subsequently stored in a chest freezer at $-12^{o}C$ until delivered to WPCL for dissection, sample preparation, and analysis.

STATISTICAL METHODS

Analysis of variance was used to compare mean selenium concentrations among areas. When sample variances were not equal, as determined by Cochran's C test, data were transformed to natural logarithms, tested again for equality of variances and means were compared with ANOVA if the variances of transformed data were homogeneous; untransformed data were tested with a Kruskal-Wallis non-parametric ANOVA if variances of transformed data were not equal. A Tukey (honestly significant difference) or Tukey-type nonparametric multiple comparison test was used to separate means when ANOVA was significant. Seasonal comparisons were made using t-tests or Mann-Whitney tests. Cochran's C, ANOVA, Kruskal-Wallis, Tukey Multiple Comparison, and t-tests were performed using SPSS/PC+ (Norusis 1986) computer software; nonparametric multiple comparison and Mann-Whitney tests were performed by hand (Zar 1984).

Fish and invertebrate data were subjected to less statistical analysis than bird data because species-location-date collections were incomplete.

Statistical significance was determined at $P=0.05$; references in the text such as "significantly different" imply statistical significance at this or a higher level.

Tissue selenium concentrations are expressed in parts per million (ppm) on a wet weight or fresh tissue basis. Percent moisture of tissue samples and concentrations on a dry weight basis calculated using the percent moisture are included in Appendix F.

LABORATORY OPERATIONS

Tissue Sample Preparation

All whole body samples and field dissected birds were received frozen at the Fish and Wildlife Water Pollution Control Laboratory (WPCL) in Rancho Cordova. Samples remained frozen at $-15^{o}C$ until preparation was begun (within 6 months).

All samples were prepared for analysis in a "clean room" to minimize contamination. All glassware, tools, and work surfaces were cleaned as described in Appendix B (Hammond, 1986). Samples were then dissected and homogenized in the clean room as described in Appendix B.

After homogenization, the samples were refrozen until they were subsampled for analysis. Once the analysis was complete, a portion of each sample was transferred to a clean 30 ml linear polyethylene wide-mouth bottle (see Sample Container Preparation, Appendix B). These samples were then sent to the University of California, Davis (UCD) and archived at -80 ^{o}C.

Analytical Techniques for Selenium in Tissues

All tissue samples were analyzed by hydride generation atomic absorption spectrophotometry (HGAA) at WPCL. Approximately 50% of the samples were also analyzed at WPCL using Zeeman-corrected graphite furnace atomic absorption spectrophotometry (GFAA). Analytical procedures used at WPCL are described in detail in Appendix C (Hammond, 1986). In addition, approximately 20% of the samples were analyzed in duplicate by Neutron Activation Analysis (NAA) at the University of Missouri Research Reactor (UMRR) using the method described by McKown and Morris (1978). Samples were also analyzed for moisture content at WPCL. These moisture values were used to convert NAA dry weight results to wet (fresh) weight values for comparison with WPCL results (Appendix G).

To determine intra-laboratory precision, approximately 10% of the samples analyzed by HGAA and GFAA were done in duplicate (Appendix D). The relative standard deviation [RSD=(standard deviation/mean) x 100; also called the coefficient of variation (Zar 1984)] for duplicate sample analyses by HGAA averaged 1.7 percent (range 0 to 14) (Appendix D). RSD for duplicate samples analyzed by GFAA averaged 4.2 percent (range 0 to 22). HGAA produced results with higher precision than GFAA, however, both methods provide acceptable levels of precision for analysis of selenium in tissue at WPCL.

National Bureau of Standards (NBS) reference materials were analyzed with every batch of samples to verify accuracy (Table 6). Analysis of NBS reference materials indicated accuracy within 5 percent (0.2 standard deviation) of the certified selenium concentration in oyster tissue (NBS 1566) by both HGAA and GFAA (Table 6). Both methods demonstrated a minor negative bias in the analysis of selenium in oyster tissue. A smaller, positive bias was found in results of analyses of bovine liver (NBS 1577a) which averaged 1.4 percent higher than the reference sample concentration with HGAA and with GFAA. HGAA results for NBS 50 (tuna) averaged about 6 percent above the reference concentration and the RSD of 3.3 percent was intermediate between the HGAA RSD for oyster (2.5 percent) and bovine liver (5.2 percent). Mean RSD for GFAA analyses of tuna reference samples also was intermediate between RSD's for the other two matrices, although the results averaged 25 percent higher than the reference level.

Table 6. WPCL analysis of NBS reference materials in ug/g dry weight.

Certified[1/] Se values	NBS 1566 (oyster) 2.1±0.5			NBS 50[2/] (tuna) 3.6+0.4			NBS 1577a (bovine liver) 0.71+0.07		
HGAA results:	2.1	2.1		4.0	3.7	3.9	0.78	0.73	0.71
	2.0	2.0		3.8	3.5	3.8	0.79	0.72	0.70
	2.1	2.0		3.8	3.8	3.7	0.70	0.75	0.68
	2.0	2.1		4.1	3.8	3.8	0.74	0.66	0.68
	2.0	2.0		3.7	3.8	3.8	0.68	0.71	0.77
	2.0	2.0		3.9	3.8	3.8	0.78	0.69	0.71
	2.1			3.7	3.7		0.74	0.71	
Mean	2.0			3.8			0.72		
Std. error	0.014			0.028			0.008		
RSD[3/] (%)	2.5			3.3			5.2		
Bias[4/] (%)	-4.8			5.6			1.4		
GFAA results:	1.8	2.0	2.2	4.9			0.77	0.73	
	2.0	1.8	2.5	4.1			0.81		
	1.9	1.9	2.1	4.0			0.65		
	1.9	2.0	2.5	4.7			0.65		
	1.7	1.9	1.5	4.7			0.70		
	1.9	1.8	1.9				0.77		
Mean	2.0			4.5			0.72		
Std. error	0.058			0.18			0.024		
RSD (%)	13			8.9			8.6		
Bias (%)	-4.8			25.0			1.4		

1/ U. S. Department of Commerce, National Bureau of Standards, Washington, D.C. 20234.

2/ Noncertified values of constituent element.

3/ Relative standard deviation RSD = (standard deviation/mean) x 100, also called the coefficient of variation.

4/ Bias = [(experimental value - accepted value)/(accepted value)] x 100.

These results indicated HGAA and GFAA provide acceptable accuracy for the analysis of selenium in tissue at WPCL. They also indicated the accuracy of selenium analyses by HGAA and GFAA depended on the type of tissue being analyzed. Both methods were sensitive to tissue-type effects, exhibited similar tendencies for positive and negative bias, and produced equally accurate results with oyster and liver samples, respectively. HGAA results were more accurate than GFAA results for selenium in tuna. As indicated from duplicate sample analyses described above, HGAA provided slightly higher precision than GFAA in the analysis of reference materials.

Analytical Techniques for Trace Elements in Tissues

In addition to previously described analyses, 272 of the total are to be analyzed by the Veterinary Diagnostic Toxicology Laboratory (VDTL) at UCD for selenium and other trace elements including: silver (Ag), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg) and zinc (Zn). These data will be submitted in a subsequent report.

As part of analytical quality control for both WPCL and VDTL the USFWS analyzed 7 samples for selenium and 21 samples for previously mentioned trace elements. The USFWS Patuxent Wildlife Research Center performed analyses on 11 bird samples while the USFWS National Fisheries Contaminant Research Center analyzed 10 fish samples. WPCL performed the arsenic determinations on the same 21 samples as part of VDTL quality control (procedure described in Appendix C). Selenium results from 7 of the 21 QC samples are listed for comparison (Table 7). The remaining trace element results are reported in Apendix E.

Table 7. California Selenium Verification Study Comparison of Quality Control Analyses

	California Department of Fish and Game			U. S. Fish and Wildlife Service		
	Se (ug/g) wet wt.			Se (ug/g) wet wt.		
Sample #	HGAA	GFAA	NAA[1/]	HGAA	GFAA	NAA[1/]
F53L1	1.8	-	1.5	1.57	-	1.59
F156L	3.1	-	2.8	2.97	-	2.92
F162L	2.7	-	-	2.64	-	2.60
F192L1	1.6	-	1.6	1.51	-	1.54
B27L	26	27	25	-	24	-
B150L	3.0	-	2.9	-	3.0	-
B484L	1.4	-	-	-	1.6	-

1/Neutron Activation Analysis at University of Missouri Research Reactor

Analytical Techniques for Selenium in Water

All water samples were collected in polyethylene bottles which had been previously cleaned with 1.0 M nitric acid and rinsed with Type I water (ASTM 1986). The one-gallon unfiltered water samples were preserved at the time of collection with 6 ml of concentrated nitric acid (ultra pure grade). Samples W-1 through W-20 were divided into two portions at WPCL. This was accomplished by shaking the original sample and pouring into a second clean container labeled with the same number plus a "d" designation for duplicate. The remaining samples were collected in duplicate in the field (field replicates) and given the same sample number plus an "A" or "B" designation. This was done to distinguish between field replicates and WPCL subsampled duplicates.

All water samples including the duplicates for W-1 through W-20 were sent to UMRR in clean 125 ml linear polyethylene bottles for NAA. The NAA analyses were completed in duplicate as described in Appendix C and the average values reported in Table 16.

As part of quality control for NAA, the Department of Water Resources (DWR) Bryte Laboratory completed selenium analysis of 18 water samples and a field blank using a wet digestion method (Presser and Barnes 1984) with HGAA. In addition, a new method developed by WPCL for the analysis of selenium in water was used for 21 QC samples. These 21 water samples were analyzed in duplicate by dry ashing with HGAA and reported in Appendix I. The method used is identical to that of tissue in Appendix C except that 25 g of water was subsampled instead of 0.5 g of tissue. WPCL used "dry ashing" for water samples because the technique had a low detection limit with no background effects, produced consistent results, and performed well on U.S. Environmental Protection Agency Water Pollution Laboratory Performance Evaluation Samples (Hammond, in preparation).

Analytical Techniques for Trace Elements In Water

The VDTL will perform analysis on 36 water samples for As, Ag, Cd, Cr, Cu, Hg, manganese (Mn), molybdenum (Mo), and Zn. These trace element results will be presented in a subsequent report. The DWR Bryte Laboratory analyzed 18 samples of the 36 as QC for VDTL and the results are tablulated in Appendix H.

Inter-Laboratory Comparison of Analytical Methods for Selenium

To compare results of selenium analyses by HGAA and GFAA at WPCL with results from NAA at UMRR, least-squares linear regression equations (Joiner et al. 1985) were calculated for three sets of results from paired samples analyzed by at least two of these methods (Table 8). Although all three regression lines had Y-intercepts near zero, new regression equations were calculated for the best-fit line passing through the origin. Regression

Table 8. Comparison of HGAA, GFAA, and NAA (UMRR) from results of selenium analysis of paried tissue samples.

REGRESSION ANALYSIS

Number of Pairs	Least-Square Linear Regression Equation	Coeff. of Determination
261	HGAA=0.060 + 1.02 NAA	0.991
142	GFAA=-0.054 + 1.02 NAA	0.975
601	HGAA=0.083 + 0.96 GFAA	0.977

	Regression Equation Through Origin	Regression Coeff. = 1?	
		t	p
261	HGAA=1.02 NAA	4.14	<0.001
142	GFAA=1.01 NAA	1.29	>0.05
601	HGAA=0.98 GFAA	3.79	<0.001

Percent Difference Between Paired Values[1/]

Method A	Method B	Median Percent	95 Percent Confidence Interval
HGAA	NAA	4.5	3.3 to 5.6
GFAA	NAA	-2.3	-4.9 to 0.3
HGAA	GFAA	1.8	0.8 to 2.6

1/ $\frac{\text{Method A - Method B}}{\text{Method B}} \times 100$

coefficients from these equations were tested for a significant difference from a slope of one (1), the hypothetical regression coefficient of perfectly comparable sets of paired data.

These regression analyses indicated HGAA results were slightly higher than NAA values and lower than GFAA results. GFAA results were not significantly different from NAA values. Although HGAA and GFAA (WPCL) and NAA (UMRR) did not produce identical results, coefficients of determination ranging from 0.975 to 0.991 indicate a strong relationship between paired results and a consistent performance by the respective analytical instruments across the range of selenium concentrations measured. The median and the 95 percent confidence interval for the percent difference between paired values also indicated an acceptable level of agreement among the three analytical methods (Table 8).

Based on results of duplicate analyses, analysis of reference materials, and comparison with results from NAA, HGAA and GFAA are both acceptable methods for the analysis of selenium in tissue. WPCL prefers HGAA to GFAA because HGAA has a lower detection limit, greater precision, less matrix effects, and requires one-third as much time per sample analysis.

RESULTS AND DISCUSSION

Major divisions in this section begin with an explanation of why each area was included in this study. Results are presented for each species or group of species examined in the area. The first time a species is included, a brief description of its life history is presented to provide a basis for interpreting findings in relation to levels measured at "background" sites and results from other studies.

All selenium results generated by this study and presented in the text and tables of this report are expressed on a wet weight or fresh tissue weight basis, in ug/g (parts per million, ppm) for tissue samples. Percent moisture of tissue samples is reported; results on a dry weight basis were calculated and presented in Appendix F.

Selenium concentrations were measured to two significant figures. Tabulated results indicating greater accuracy are artifacts of data processing software formats.

SAN FRANCISCO BAY REGION

The San Francisco Bay-Estuary was included in this study based on the reporting of selenium and heavy metals in greater scaup (Aythya marila) and surf scoters (Melanitta perspicillata) taken from southern San Francisco Bay in 1982 (Ohlendorf et al. 1986c). These data, evaluated in the context of documented reproductive problems in birds at Kesterson National Wildlife Refuge apparently associated with selenium in subsurface agricultural drainage water, were a catalyst for discussions which revealed the need for more information on selenium and other trace elements. Initial planning efforts focused on San Francisco Bay soon were expanded to include a statewide perspective.

SAN FRANCISCO BAY BIRDS

Surf Scoters

The surf scoter is a sea duck common in winter along both coasts of North America. In California, Tomales, Drake's, and San Francisco Bay hold almost half the wintering population (Bellrose 1978). Scoters are found along the coast and in harbors, bays and estuaries from October to May (Small 1974). Their breeding range is the closed and open boreal forests of Canada and Alaska. They feed by diving to the bottom to obtain food. Comprised mostly of animal matter, their diet includes bivalve molluscs (mussels, clams), crustaceans (barnacles), and small percentages of aquatic insects and plant material (eelgrass, wigeon grass). Surf scoters, although taken by hunters, are probably not sought after with the enthusiasm directed to other waterfowl species found together on California bays.

Surf scoters were collected from the four major embayments in the San Francisco Bay-Estuary and from Humboldt Bay between January 31 and March 6, 1986. Selenium concentrations in scoters from Humboldt Bay averaged 0.8 ppm wet weight in muscle and 3.1 ppm in liver (Table 9). Mean selenium levels in muscle and liver of scoters from each embayment in the San Francisco Bay system were significantly higher than levels in scoters from Humboldt Bay, ranging from about two to four and one-half times higher in muscle and from about three to seven times higher in liver. Scoters from Suisun Bay had significantly higher Se concentrations in both tissues ($\bar{x}$=3.6 ppm in muscle, $\bar{x}$=23 ppm in liver) compared to scoters from South and Central San Francisco Bays and San Pablo Bay. Selenium levels in surf scoters did not differ significantly among the latter three locations.

Similar concentrations were reported by Ohlendorf et al. (1986c) for surf scoters collected from South San Francisco Bay in March and April 1982. They reported nearly identical mean (10.5 ppm wet weight converted from dry weight using mean percent moisture of 69.5%) and maximum (18 ppm, same conversion) selenium levels in scoter liver as we found in South San Francisco Bay scoters in 1986.

Scaup

Greater scaup and lesser scaup (Aythya affinis) are winter visitors to California saltwater bays, lagoons, and estuaries with lessers also using fresh-water lakes, ponds and rivers. Most greater scaup wintering in California concentrate in San Francisco Bay with small numbers in Morro Bay and San Diego Bay; most lesser scaup in California also are found in the San Francisco Bay area with smaller numbers along the north coast, south coast, Imperial Valley and Central Valley (Bellrose 1978). Greater scaup follow a coastal and offshore migration corridor to primary breeding grounds in the Yukon Delta where they mix with greaters that winter on the Atlantic and Gulf coasts. Lesser scaup in California may have migrated as far south as Guatemala along a coastal corridor. Banding data suggest half the lesser scaup in California originate in British Columbia with most of the balance coming from breeding grounds in Alberta and Alaska. Lesser scaup occur in California from September to May (Small 1974); greaters may arrive later and leave sooner (Bellrose 1978). Both species feed by diving and consume both animal (molluscs, crustaceans) and plant (eelgrass, wigeon grass) foods. Greater scaup consume more animal foods (90 percent molluscs in Humboldt Bay; Yocum and

TABLE 9
SUMMARY OF SELENIUM CONCENTRATIONS
IN DIVING DUCKS COLLECTED IN WINTER, 1986
(ppm, wet weight)

SPECIES	LOCATION	MUSCLE N	MUSCLE $\bar{x}$	MUSCLE SD	MUSCLE RANGE	LIVER N	LIVER $\bar{x}$	LIVER SD	LIVER RANGE
Surf Scoter	Humboldt Bay	10	0.8	0.19	0.5-1.0	10	3.1	0.95	2.4-5.6
	Suisun Bay	10	3.6	1.24	1.6-5.3	10	23	7.7	10-35
	San Pablo Bay	10	1.6	0.21	1.4-2.0	10	15	2.1	12-18
	Central SF Bay	10	2.3	0.86	1.4-4.3	10	12	5.1	6.8-22
	South SF Bay	11	1.9	0.48	1.0-2.8	10	10	3.1	6.9-17
Scaup[1/]	Humboldt Bay	2	1.2	0.64	0.7-1.6	2	2.9	1.77	1.7-4.2
	Suisun Bay	10	2.3	1.24	0.9-4.8	10	8.0	4.22	3.6-19
	San Pablo Bay	11	1.4	0.36	1.1-2.4	11	5.0	1.34	3.4-7.1
	Central SF Bay	2	2.8	0.07	2.7-2.8	2	4.9	0.21	4.8-5.1
	South SF Bay	12	1.3	0.51	0.7-2.5	12	3.8	1.13	1.6-5.5
	Salton Sea	12	1.2	0.43	0.4-2.0	12	3.1	1.05	1.5-5.6

1/ Includes greater scaup and lesser scaup.

Keller 1961) whereas lesser scaup consume a higher percentage of plant material (35% plants in Humboldt Bay, 45% clams, 9% unidentified molluscs, 5% unidentified crustaceans and 5% wheat (bait)). Along with canvasback (Aythya valisineria), greater and lesser scaup are probably the favored diving ducks of waterfowl hunters.

Greater scaup and lesser scaup were combined in this analysis. Sometimes occurring together in flocks usually dominated by one species or the other, the two species are almost impossible to distinguish sitting on the water and difficult to separate in flight. Thus, nine greater and three lesser scaup were obtained from South San Francisco Bay, greater scaup comprised the entire sample from San Pablo Bay, and only lesser scaup were collected in Suisun Bay and Central San Francisco Bay. Only two scaup, one of each species, were collected from Humboldt Bay. Statistical comparisons of all greater scaup with all lesser scaup and comparisons of individuals collected at the same time and place, revealed no significant difference in tissue selenium levels between the two species. Thus, data for greater and lesser scaup were pooled when making comparisons among areas and with other species.

Scaup were collected from the San Francisco Bay-Estuary between January 31 and April 10, 1986. Statistical analysis of scaup muscle tissue selenium levels indicated significant differences among the bays in the San Francisco Bay system. Average selenium concentrations in muscle tissue were highest in scaup from Central San Francisco Bay ($\bar{x}$=2.8 ppm) and Suisun Bay ($\bar{x}$=2.3 ppm) and lower in scaup from San Pablo Bay ($\bar{x}$=1.4 ppm) and South San Francisco Bay ($\bar{x}$=1.3 ppm) (Table 9). Selenium in liver was highest in scaup from Suisun Bay, with progressively lower average levels in scaup from San Pablo, Central, and South San Francisco bays (Table 9). Average liver selenium concentration in Suisun Bay scaup ($\bar{x}$=8.0 ppm) was twice that from South San Francisco Bay scaup; this was the only statistically significant difference in mean liver selenium levels in scaup from the embayments of the San Francisco Bay system.

Two scaup collected from Humboldt Bay in February 1986 averaged 1.2 ppm in muscle and 2.9 ppm in liver. More samples are required to determine background levels to compare with selenium levels in scaup from San Francisco-area bays.

Scaup from South San Francisco Bay had lower mean (3.8 ppm) and maximum (5.5 ppm) selenium levels in liver than scaup collected there in 1982 by Ohlendorf et al. (1986c) (mean=5.7 ppm, wet weight converted from dry weight using 70.6 percent moisture; maximum 9.1 ppm). Scaup had lower selenium levels than surf scoters in both their study (1982) and ours (1986).

If selenium levels in diving duck tissues are due to uptake of selenium from sources in the estuary, tissue levels should increase during the time they are using and feeding in the Bay. Such increases have not been documented. Diving ducks such as scaup and surf scoters are winter visitors to the San Francisco Bay area, most arriving in November and leaving by April. Because our bird sample collections did not begin until late January 1986, there was no intent to evaluate temporal differences in diving duck selenium levels with two separate collection periods. However, scaup were collected from the estuary over a period of more than two months causing concern that apparent geographic differences (among bays) were temporal differences instead. Few data were available to evaluate this hypothesis. However, no significant difference was found between selenium levels in scaup collected February 10, 1986 and April 10, 1986 in South San Francisco Bay suggesting unchanging selenium levels in scaup during the two month interval and providing no evidence to refute the inference that selenium in duck tissues differed among bays. Ohlendorf et al. (1987a) found no overall difference between January and March selenium levels in surf scoters collected from six areas in San Francisco Bay. They hypothesized, based on evidence of rapid uptake of organic selenium fed to mallards (Anas platyrhynchos), that by January scoters may have accumulated "plateau" concentrations of selenium. Earlier collections are needed to determine if selenium concentrations increase in the tissues of wintering diving ducks. We collected diving ducks beginning in November, 1986 to compare with others collected in March 1987. When these data are available this hypothesis will be evaluated.

Relating tissue levels in birds to conditions in their habitat requires assumptions about their movements and use of the area. Ohlendorf et al. (1987a) cited circumstantial evidence of limited movement of surf scoters in the bay based on similarities between local contamination patterns and contaminant profiles in ducks and deferred further discussion pending analysis of additional data. Bird movements and long range migrations are usually determined from banding studies. Since banding studies have not and likely will not be conducted, extensive direct observation may be needed to provide some insight into movement patterns of diving ducks in the Bay area.

Biological accumulation of selenium by aquatic organisms such as clams and mussels consumed by diving ducks may be the mechanism for accumulation of high tissue levels of selenium in diving ducks from an environment with lower levels in water. Softshell clams (Mya arenaria) were collected from several locations in the San Francisco Bay system and from Humboldt Bay, however diving ducks were not observed feeding at these specific sites. Future studies (already implemented) will address this need for chemical analysis of food organisms collected at feeding sites.

The implications of tissue selenium concentrations measured in scoters and scaup for their physiological function are unknown. Selenium concentrations in the range measured in San Francisco Bay birds have not been shown to cause mortality in adult scaup or scoters. Investigation of possible reproductive problems in scoters and scaup such as abnormalities and mortality of embryos and chicks associated with selenium contamination in other aquatic bird species (Ohlendorf et al. 1986a) would require field studies at breeding grounds in Alaska and Canada.

American Avocets

The American avocet (Recurvirostra americana) is a summer visitor in northern California and a resident in the southern half of the state. Avocets normally do not winter north of the San Francisco area, but winter in large numbers in southern California. Avocets feed on mud flats and in shallow pools by skimming the water with their long curved bills, consuming swimming aquatic insects and crustaceans (Small 1974). Avocets nest in the spring at interior alkaline lakes, freshwater ponds and sloughs. Avocets are not hunted but probably are vulnerable to terrestrial and avian predators and consumed by scavengers.

Avocets collected from diked areas around the edge of South San Francisco and San Pablo bays averaged 2.2 ppm and 2.7 ppm selenium in liver, respectively, in March and 2.1 ppm and 2.6 ppm, respectively, in June (Table 10). South San Francisco Bay collections were made at salt ponds in March and June, while San Pablo Bay avocets were taken from a seasonal wetland in the Napa Marsh adjacent to salt ponds in March and from the edge of the Bay between Sonoma and Petaluma creeks in June. There was no significant difference in mean liver selenium concentrations between avocets from South San Francsico Bay and San Pablo Bay or between seasons in either bay. Avocets were not collected from Central San Francisco Bay or Suisun Bay; they are not common in either location because the habitat they prefer is limited in these areas.

We were unable to collect avocets at Humboldt Bay or any other coastal site, hence comparisons of selenium in avocets from San Francisco Bay are with avocets from inland areas. Selenium levels in livers of San Francisco Bay area avocets were not significantly different from levels in avocets collected at Sacramento National Wildlife Refuge ($\bar{x}$=2.4 ppm, June, 1986) or from the Semitropic Water Storage District wetland site in Kern County ($\bar{x}$=2.6 ppm, March; 3.0 ppm, May, 1986). Furthermore, all these levels were low compared to levels in avocets at Kesterson (mean=22 ppm wet weight converted from dry weight using 72% moisture) when reproductive effects in avocets were first observed in 1985 (Ohlendorf et al. 1987b).

TABLE 10
SUMMARY OF SELENIUM CONCENTRATIONS IN SHOREBIRD AND CORMORANT LIVERS IN WINTER AND SPRING, 1986
(ppm, wet weight)

		WINTER				SPRING			
SPECIES	LOCATION	N	$\bar{x}$	SD	RANGE	N	$\bar{x}$	SD	RANGE
American Avocets	San Pablo Bay	10	2.7	1.34	0.9-5.2	10	2.6	0.57	1.9-3.8
	South SF Bay	10	2.2	0.75	1.4-3.4	10	2.1	0.84	1.1-4.0
	Sacramento NWR					10	2.4	0.79	1.3-3.8
	TLDD Ponds	10	5.9	3.25	1.9-12	10	10.9	3.62	6.4-17
	Westfarmers at Twisselman Rd.	10	5.9	4.27	2.0-17	10	11.4	5.70	5.5-26
	Semitropic WSD	5	2.6	0.91	1.4-3.7	5	3.0	0.15	2.5-3.8
	Lost Hills Ranch	5	3.8	1.81	2.1-6.3	10	3.5	1.09	2.2-6.1
Black-necked Stilts	Gray Lodge WA	10	3.4	2.30	1.8-9.2				
	Grizzly Is. WA	10	2.0	0.80	1.1-3.8	10	1.7	0.46	1.1-2.7
	Sacramento NWR					10	2.5	0.73	1.8-4.1
	Westfarmer	1	15		15	10	14.3	6.95	4.6-26
	Lost Hills Ranch	2	5.1	3.32	2.8-7.5				
	Salton Sea NWR	10	6.4	2.38	2.7-10	10	3.9	1.60	1.7-6.2
Willets	Humboldt Bay	13	1.8	0.52	1.1-2.6				
	San Pablo Bay	5	2.6	0.46	1.9-3.1	5	1.6	0.30	1.3-2.0
	South SF Bay	5	2.4	1.20	1.2-3.9	5	1.4	0.23	1.2-1.7
Double-crested Cormorant	Humboldt Bay	10	6.4	1.53	4.1-8.7	10	3.8	0.72	2.8-5.0
	Suisun Bay					5	5.5	2.50	3.4-9.7
	San Pablo Bay	3	5.1	0.78	4.2-5.6				
	Central SF Bay	4	5.0	0.52	4.4-5.6	5	3.9	1.81	1.2-5.6
	South SF Bay	4	4.5	0.39	4.1-5.0				
	Salton Sea NWR	9	10.3	3.72	6.7-18	10	9.1	2.17	5.2-13

Willets

The willet (Catoptrophorus semipalmatus), a large member of the sandpiper family, winters along the Pacific coast from Oregon to Mexico and migrates north and inland during the summer, nesting in marshes, wet meadows, and lakeshores.

The willet is a winter visitor to California coastal beaches, mudflats, estuaries and saltwater marshes, a spring and fall transient, and a breeder in grassy meadows close to lakes in Modoc, Lassen, and Plumas counties in northeastern California (Small 1974). Willets feed on mudflats and sandy beaches, probing for marine worms, small crustaceans, molluscs and insects. Willets are not hunted; they may be consumed by predators and scavengers.

There was no significant difference in liver selenium levels between willets collected from South San Francisco Bay ($\bar{x}$=2.4 ppm) and San Pablo Bay ($\bar{x}$=2.6 ppm) (same sites as avocets) in March, or between San Francisco Bay willets and willets from Humboldt Bay (February 1986, $\bar{x}$=1.8 ppm) (Table 10). No significant difference was detected between willets from South San Francisco Bay and San Pablo Bay in June. Selenium levels in San Pablo Bay willets were significantly lower in June than in March. A similar seasonal decline in mean selenium levels in South San Francisco Bay willets was not quite statistically significant probably because of variability in the winter data. Thus, by June, the average selenium concentration in willets (1.5 ppm) approached the lowest level (1.2 ppm) measured in an individual bird in March. The highest level in an individual bird in June (2.0 ppm) was half the highest level in March (3.9 ppm). Possible explanations for this apparent decrease in selenium in wintering willets in the San Francisco Bay area are: depuration of selenium resulting from lower levels in the winter food supply than in food items consumed at summer nesting areas; a decrease in selenium in food organisms in San Francisco Bay in winter attributable to flushing by unprecedented outflows to the bay beginning in February; and immigration of willets with low levels of selenium or emigration of willets with high levels between sampling periods. These hypotheses cannot be evaluated with available data.

Double-crested Cormorant

The double-crested cormorant (Phalacrocorax auritus) is found along rocky coasts, in bays, estuaries, and at larger inland lakes, rivers and marshes. A colonial nester, they breed along the coast as well as at a few larger inland lakes from Modoc County to Imperial County (Small 1974). However, they no longer breed in some areas due to habitat destruction and human disturbance (Remsen 1978). Like all species of cormorants, the double-crested's diet is comprised almost entirely of fish, plus some crustaceans and marine worms. They feed by diving from a swimming position on the surface and swimming underwater. Cormorants are not hunted; being large birds, adults probably have few avian predators.

Because the double-crested cormorant is listed in "Bird Species of Special Concern in California" (Remsen 1978), we limited our San Francisco Bay area collection of this fish-eating species to a total of 10 or 11 per season. In February-March, 1986, we collected three from San Pablo Bay and four each from Central San Francisco and South San Francisco bays. Selenium concentration in the liver of individual cormorants ranged from 4.1 ppm to 5.6 ppm; there was no significant difference in average selenium levels in cormorants from the three sites (Table 10). In June, five cormorants were collected from Central San Francisco Bay ($\bar{x}$=3.9 ppm) and five from Suisun Bay ($\bar{x}$=5.5 ppm) since most cormorants were using these areas in the spring. No significant difference in mean liver selenium levels was found between these two sites or between these spring cormorants and those taken from the San Francisco Bay area in the winter.

Ten double-crested cormorants also were collected at Humboldt Bay in February and in June, 1986. Average liver selenium concentration was significantly higher in the winter ($\bar{x}$=6.4 ppm) than in spring ($\bar{x}$=3.8 ppm) (Table 10). Furthermore, Humboldt Bay cormorants had mean selenium levels significantly greater than in San Francisco Bay cormorants during the winter and less than, but not significantly different from San Francisco Bay cormorants in spring. Average levels in cormorants from San Francisco ($\bar{x}$=4.8 ppm) and Humboldt ($\bar{x}$=5.1 ppm) bays were much lower than levels in cormorants from the Salton Sea, discussed in a later section.

A possible explanation for higher selenium concentrations in cormorants from Humboldt Bay than San Francisco Bay during the winter is higher selenium levels in fish consumed by cormorants at Humboldt Bay. The species composition of the cormorant's diet was not documented, however, our data on selenium concentrations from fish sampling in both areas do not support this explanation. Unless the species in the diet varied seasonally, lower selenium levels in spring compared to winter for cormorants at Humboldt Bay cannot be explained by reduced dietary intake because no analogous seasonal decrease was measured in selenium levels in fish.

The significance of selenium levels measured in double-crested cormorants is unclear. Compared to other species of birds we studied, the fish-eating cormorant had relatively high selenium residues in liver. King and Cromartie (1986) reported 0.8 to 5.4 ppm (wet weight) selenium in kidney of olivaceous cormorants (Phalacrocorax olivaceus) in Galveston Bay, Texas. These concentrations were somewhat lower on average than levels we measured in livers from double-crested cormorants in California. King and Cromartie hypothesized body burdens they measured in olivaceous cormorants may be sufficient to impair reproduction based on evidence from other bird species.

Double-crested cormorants have been declining in California and in much of its North American range, however, no connection has been made between population declines and selenium in cormorants. The decline in California has been attributed to habitat destruction (particularly for nesting) and human disturbance of nesting sites (Remsen, 1978). Eggshell thinning from DDE contamination was implicated in declining cormorant populations at the Channel Islands. A Farallon Islands population declined due to human disturbance of nest sites and disappearance of sardine populations (Ainley and Lewis, 1974). Their disappearance as a breeding bird in the San Joaquin Valley was attributed to the destruction of suitable nesting habitat, however, this occurred before effects of selenium on avian reproduction were identified. Selenium was not investigated as a contributing factor.

SAN FRANCISCO BAY FISH

Marine, estuarine, and anadromous species representing the various ways fish use the estuary were collected from the San Francisco Bay system. Benthic and pelagic species were included to represent different feeding habits and dietary composition.

Collections were made in January and February and repeated in May and June to investigate effects of potential seasonal loading to the Bay from agricultural runoff. Fall and spring sampling would have been preferred, however, the program was not begun until mid-December, 1985.

Pelagic Fishes

Pacific herring (*Clupea harengus*) and northern anchovy (*Engraulis mordax*) are marine species which migrate into the Bay seasonally and spawn in the Bay. Juvenile herring and anchovies remain in the Bay for a few months before most return to the ocean. Anchovies also enter the Bay as juveniles from ocean spawning. Our samples were comprised of both adults and young-of-the-year which feed on plankton. Longfin smelt (*Spirinchus thaleichthys*) is a euryhaline species that occurs in the lower estuary in early summer, moves into the upper estuary in the fall, and spawns and dies in the winter at age 2. Longfin smelt feed on opposum shrimp (*Neomysis mercedis*) and copepods.

Selenium concentrations in muscle composites of adult Pacific herring from San Francisco Bay in the winter ranged from 0.32 ppm to 0.39 ppm and were not different between bays or compared to samples from Humboldt Bay ($\bar{x}$=0.41 ppm). Two composite samples of whole immature herring averaged 0.70 ppm selenium. Only young-of-the-year herring were caught in May-June sampling; analyzed whole, selenium levels ranged from 0.57 ppm to 0.68 ppm. It is unclear whether levels were higher in juvenile herring than in adult herring since concentrations are usually higher in whole body analyses than in muscle. The seasonal comparison also was obscured by age and tissue type differences.

Selenium levels in composite whole-body samples of northern anchovies from South and Central San Francisco Bays averaged 0.60 ppm in January-February and 0.47 ppm in May-June (Table 11). Levels in Suisun Bay ($\bar{x}$=0.49 ppm) and San Pablo Bay ($\bar{x}$=0.54 ppm) anchovies in the spring were not significantly different from South and Central San Francisco Bay. Lower concentrations in spring samples may be related to spawning, the body burden in females anchovies may be reduced by elimination of selenium in eggs.

Selenium levels in composites of whole longfin smelt ranged from 0.22 ppm to 0.36 ppm and were not significantly different among the bays, including Humboldt Bay, or between seasons (Table 11).

<u>Benthic Fishes</u>

English sole (<u>Parophrys</u> <u>vetulus</u>) and speckled sanddab (<u>Citharichthys</u> <u>stigmaeus</u>) are coastal marine flatfish. Juvenile sole and sanddabs are carried by bottom currents into the Bay in the winter where they remain, feeding on amphipods and other small benthic invertebrates, until most migrate to deeper waters offshore by the fall. Starry flounder (<u>Platichthys</u> <u>stellatus</u>) is a marine-estuarine flatfish with a greater tolerance of lower salinities. Starry flounder spawn in the ocean and juveniles move into the bay and to the upper estuary. They may remain in the estuary for several years, feeding on a wide range of benthic organisms, gradually moving downstream to the ocean.

Pacific staghorn sculpin (<u>Leptocottus</u> <u>armatus</u>) and yellowfin goby (<u>Acanthogobius</u> <u>flavimanus</u>) are bottom oriented euryhaline species, found in water ranging from fresh to salt (34 ppt). Juvenile staghorn sculpin move in to fresh water in the spring and migrate upstream, followed by younger juveniles, establishing a gradient of increasing size moving upstream. Maturing in one year, most staghorn sculpin return to saltwater to spawn. Amphipods, insects, crabs, shrimp and fish are included in the diet. Yellowfin gobies also tolerate high salinities; however, we collected them only in San Pablo and Suisun bays. Gobies spawn in the winter and spring; February samples were mostly adults and May samples were a combination of adults and young-of-the-year. Gobies feed on crustaceans and small fishes associated with the bottom and also may consume algae.

Among the benthic fishes collected in trawls, starry flounder had the highest levels of selenium, averaging 1.1 ppm in three muscle composites of starry flounder from Suisun Bay (Table 11). Differences in flounder selenium levels among bays were not quite statistically significant in either season, however, regression analysis of selenium concentrations in muscle of all flounder samples collected from Central San Francisco (7 individuals), San Pablo (3 composites of 3 fish plus 2 individuals) and Suisun Bays (composites of 5, 5, and 4 fish each) indicated a significant increasing trend in flounder selenium levels moving upstream from Central Bay through San Pablo Bay to Suisun Bay.

TABLE 11
SELENIUM CONCENTRATION IN COMPOSITE SAMPLES OF FISH
FROM THE SAN FRANCISCO BAY SYSTEM AND HUMBOLDT BAY, 1986
(ppm wet weight)

		WINTER							SPRING						
		MUSCLE/WHOLE				LIVER			MUSCLE/WHOLE				LIVER		
SPECIES	LOCATION	M/W	N	MEAN	RANGE	N	MEAN	RANGE	M/W	N	MEAN	RANGE	N	MEAN	RANGE
English Sole	San Pablo Bay	M	2	0.53	0.47-0.58				M	2	0.64	0.58-0.69			
	Central SF Bay	M	2	0.47	0.41-0.52				M	2	0.45	0.44-0.44	2	1.6	1.5-1.7
	South SF Bay	M	2	0.51	0.51-0.51				M	2	0.42	0.41-0.42	2	1.55	1.5-1.6
	Humboldt Bay	M	1	0.27					M	2	0.39	0.36-0.41	1	2.1	
Speckled Sanddab	San Pablo Bay	W	2	0.37	0.35-0.38										
	Central SF Bay	W	2	0.47	0.46-0.47				W	2	0.46	0.45-0.47			
	South SF Bay	W	2	0.42	0.41-0.43										
	Humboldt Bay	W	2	0.30	0.29-0.31				W	2	0.39	0.36-0.42			
Starry Flounder	Suisun Bay	M	2	1.1	1.0-1.2	2	3.1	2.8-3.4	M	1	1.2		1	2.7	
	San Pablo Bay	M	1	0.82		1	1.9		M	1	0.88		1	2.2	
	San Pablo Bay	M	1*	0.70		1*	1.6		M	1*	0.58		1*	2.1	
	Central SF Bay	M	3*	0.33	0.25-0.39	3*	1.5	1.1-1.8	M	4*	0.40	0.33-0.48	3*	1.9	1.5-2.5
	South SF Bay								M	1*	0.44		1	1.7	
	Humboldt Bay								M	1*	0.19		1	0.97	
Staghorn Sculpin	Suisun Bay	M	2	0.49	0.44-0.53	2	1.60	1.6-1.6	M	2	0.43	0.40-0.45	2	1.50	1.4-1.6
	San Pablo Bay	M	2	0.44	0.42-0.46	2	1.60	1.5-1.7	M	2	0.47	0.47-0.47	2	1.75	1.7-1.8
	Central SF Bay	M	2	0.39	0.34-0.43	2	1.20	1.2-1.2							
	South SF Bay	M	2	0.40	0.39-0.40	2	1.20	1.2-1.2	M	4	0.47	0.36-0.56	2	1.45	1.3-1.6
	Humboldt Bay	M	2	0.25	0.24-0.25				M	2	0.28	0.28-0.28	2	1.0	.89-1.1
Yellow-fin Goby	Suisun Bay	W	2	0.47	0.46-0.47				W	2	0.41	0.35-0.47			
	San Pablo Bay	W	1	0.48					W	2	0.47	0.46-0.47			
Pacific Herring	Suisun Bay								W	1	0.53				
	San Pablo Bay	W	1*	0.52					W	2	0.65	0.63-0.67			
	Central SF Bay	W	2	0.70	0.69-0.70				W	2	0.65	0.62-0.68			
	Central SF Bay	M	2	0.39	0.39-0.39										
	South Bay	M	2	0.34	0.32-0.35				W	2	0.58	0.57-0.58			
	Humboldt	M	2	0.41	0.40-0.41										
Northern Anchovy	Suisun Bay								W	2	0.49	0.47-0.50			
	San Pablo Bay								W	2	0.54	0.52-0.56			
	Central SF Bay	W	1	0.62					W	2	0.47	0.46-0.47			
	South SF Bay	W	2	0.58	0.56-0.60				W	2	0.47	0.45-0.48			
Longfin Smelt	Suisun Bay	W	2	0.31	0.26-0.36				W	2	0.34	0.34-0.34			
	San Pablo Bay	W	2	0.33	0.32-0.34				W	2	0.34	0.33-0.34			
	Central SF Bay	W	2	0.32	0.31-0.32				W	2	0.25	0.24-0.26			
	South SF Bay	W	2	0.32	0.27-0.36				W	2	0.25	0.23-0.27			
	Humboldt Bay	W	2	0.23	0.22-0.24										

* Analyzed as individuals.

Flounder collected in Suisun Bay (range 150 to 210 mm) were smaller than in the lower estuary (range 213 to 550 mm) and muscle selenium level was negatively correlated with flounder size ($r=-0.80$). Flounder migrate to the upper estuary as juveniles and move downstream gradually during the next several years. These data suggest accumulation of selenium in young flounder in Suisun Bay followed by depuration as they grow and move downstream perhaps due to a reduction in dietary intake of selenium during this transition downstream towards the ocean. Reduced dietary intake could result from a shift to different food organisms or lower selenium levels in all food organisms in downstream bays compared to Suisun Bay. Data are inadequate to evaluate these hypotheses.

A starry flounder collected from Humboldt Bay contained 0.19 ppm selenium in muscle, about half the average level in flounder of similar size in San Francisco Bay.

The highest selenium levels in composite muscle samples of English sole were in sole from San Pablo Bay ($\bar{x}=0.53$ in winter, $\bar{x}=0.64$ in spring), and the lowest concentrations were from sole from Humboldt Bay ($\bar{x}=0.27$ in winter, $\bar{x}=0.39$ in spring) (Table 11). Overall, however, there were no statistically significant differences in English sole selenium levels among bays in winter or spring.

The lowest selenium concentrations in speckled sanddabs ($\bar{x}=0.30$ ppm) and staghorn sculpin ($\bar{x}=0.25$ ppm) were in samples from Humboldt Bay (Table 11). Highest levels in sanddabs (0.47 ppm) were in fish from Central San Francisco Bay; a Suisun Bay sample had the highest concentration (0.53 ppm) in staghorn sculpin. Statistical comparisons of mean levels in sanddabs and sculpins revealed no significant differences among the bays, including Humboldt Bay, for either species.

Yellowfin gobies, collected only from San Pablo Bay and Suisun Bay, contained 0.35 ppm to 0.47 ppm selenium with no difference between bays or seasons.

Anadromous Fishes

Tissues from two anadromous fish species found in the San Francisco Bay-Estuary were analyzed for selenium. Tissue samples were obtained from sport-caught white sturgeon (*Acipenser transmontanus*) and from adult female striped bass (*Morone saxatilis*) collected by DFG for the Striped Bass Health Index Program (another State Board program).

White sturgeon spawn primarily during March and April in the Sacramento River and probably in the San Joaquin River and use the rivers, Delta, and estuary as a nursery. Most white sturgeon remain in the estuary, although coastal migrations have been documented (Chadwick 1959). Sturgeon are long-lived; those in our sample were 8 to 15 years old (Kohlhorst et al. 1980). Benthic invertebrates dominate the diet of white sturgeon with clams, barnacles, crabs, shrimp and herring eggs being seasonally important (McKechnie and Fenner 1971). Some small fish are also consumed.

Ten white sturgeon caught in San Pablo Bay between March 5, 1986 and May 24, 1986 averaged 1.9 ppm selenium in muscle (Table 12). Selenium in muscle exceeded 1.0 ppm in all ten and equalled or exceeded 2.0 ppm in 4 of these legal-size white sturgeon (mean length = 116 cm (45.7 in)). The maximum level measured in muscle was 4.0 ppm. Selenium in the liver of these sturgeon averaged 2.8 ppm.

TABLE 12
SELENIUM CONCENTRATION IN ADULT WHITE STURGEON
AND STRIPED BASS FROM THE SAN FRANCISCO BAY-DELTA SYSTEM, 1986
(ppm, wet weight)

SPECIES	LOCATION	DATE	SELENIUM CONCENTRATION (ppm) MUSCLE	LIVER
White sturgeon	San Pablo Bay	3/09/86	1.1	1.2
	"	3/09/86	4.0	3.1
	"	3/17/86	2.0	2.30
	"	3/17/86	1.3	2.40
	"	3/17/86	1.6	3.90
	"	4/04/86	1.6	2.70
	"	4/04/86	1.7	3.70
	"	4/05/86	2.2	2.60
	"	4/06/86	2.0	3.70
	"	5/24/86	1.1	2.30
	$\bar{x} \pm$ S.D.		1.9±0.84	2.8±0.83
Striped bass	Clarksburg	4/11/86	0.39	1.9
	"	4/16/86	0.34	1.7
	"	4/16/86	0.37	1.4
	"	4/29/86	0.41	1.6
	"	5/20/86	0.29	1.0
	$\bar{x} \pm$ S.D.		0.36±0.047	1.5±0.34
	Antioch	4/15/86	0.40	1.8
	"	4/22/86	0.32	1.7
	"	4/28/86	0.27	1.6
	"	4/28/86	0.32	0.94
	"	5/22/86	0.26	1.10
	$\bar{x}$+ S.D.		0.31±.055	1.4±0.38

Comparative data for selenium levels in white sturgeon from other systems are lacking. The biological significance of these levels to adult white sturgeon is unknown. Muscle tissue in 2 of 10 sturgeon exceeded the current Department of Health Services "level of concern" for selenium (2 ppm wet weight) in edible tissue.

Striped bass spawn at age 3 (males) or 4 (females) in the Sacramento and San Joaquin rivers and Delta. Young bass remain in the upper estuary, moving downstream to the lower bays and the ocean as adults. Young bass are dependent on the opposum shrimp (*Neomysis mercedis*) for food; juvenile bass feed primarily on invertebrates but gradually shift to a diet dominated by fish as adults in the lower bays and ocean (Stevens 1966).

Adult striped bass, collected from the Sacramento River near Clarksburg and the San Joaquin River near Antioch between April 11 and May 22, 1986, averaged 0.34 ppm selenium in muscle tissue (Table 12). Selenium level measured in muscle samples from individual bass ranged from 0.26 to 0.41 ppm. Liver concentration of selenium averaged 1.5 ppm. There was no difference in selenium levels between bass captured at Clarksburg ($\bar{x}$=0.36 ppm in muscle) and those collected at Antioch ($\bar{x}$=0.31 in muscle).

The significance of these levels to adult striped bass has not been determined. The striped bass population has declined in recent years but selenium has not been identified specifically as a cause. Selenium concentrations measured by the Striped Bass Health Index in livers of striped bass collected from the San Joaquin River at Antioch averaged 1.8 ppm in 1984 and 1.9 ppm in 1985 (Knudsen and Kohlhorst 1987), similar to levels in 1986.

Selenium levels in sturgeon muscle were over 5 times higher than striped bass on the average and almost ten times higher at the extreme. This difference is most likely due to higher uptake of selenium by sturgeon feeding entirely on benthic organisms (molluscs, crustaceans, etc.) compared to predominantly piscivorous adult striped bass feeding on pelagic fish in the ocean, Bay and delta, depending on the season.

SAN FRANCISCO BAY INVERTEBRATES

Three species of invertebrates were collected from the San Francisco Bay system and Humboldt Bay in January-February and in May-June, 1986.

Dungeness Crab

Dungeness crab (*Cancer magister*) larvae are carried into the bay by gravitational circulation in April through June. Juvenile crabs are most abundant in Central San Francisco Bay and San Pablo Bay, although a few were found in Suisun Bay in winter and in South Bay in winter and spring sampling. Young crabs spend about a year in the Bay before migrating back to the ocean. Crabs in the Bay eat bivalve molluscs, various crustaceans, some fish, algae and detritus, and are eaten by many fishes including flounders, soles, sharks, skates, sculpin, and perch (Tasto 1983).

Dungeness crabs (composites of soft tissues in body) had the highest selenium levels among the invertebrate species, with the highest concentrations found in crabs from San Pablo Bay (1.9 ppm) and Suisun Bay (1.8 ppm) in January, 1986 (Table 13). Selenium levels in crabs from these areas were significantly higher than in dungeness crabs from Humboldt Bay ($\bar{x}$=0.63 ppm winter; $\bar{x}$=0.70 ppm, spring). Seasonal comparisons within bays showed substantial differences but no consistent pattern.

Haugen (1983) measured selenium in dungeness crabs from San Francisco Bay and Humboldt Bay in 1975 and 1978-79. In 1975 juvenile crabs (similar size to our samples, 70-105 mm carapace width) averaged 0.66 ppm (wet weight, converted from dry weight, estimated 80% moisture) in San Francisco-San Pablo Bay compared to 0.28 ppm in Humboldt Bay. There was no change in juvenile crabs in San Francisco Bay by 1978 ($\bar{x}$=0.72 ppm), however selenium in Humboldt Bay juvenile crabs had increased to an average of 0.48 ppm by 1979. The equivalence of measuring selenium in hepatopancreas (Haugen) as opposed to all the soft tissue in the body (this study) is unknown; however, we have measured higher selenium levels in juvenile dungeness crabs from both San Francisco and Humboldt Bay than were found by Haugen in 1975 or 1978-79.

Bay Shrimp

Bay shrimp (Crangon sp.) occur throughout the estuary. Shrimp spawn in San Francisco Bay and offshore in the winter and spring. Larvae develop, settle to the bottom and juveniles migrate to shallower, less saline areas upstream in San Pablo and Suisun bays. They complete their life cycle in one to one and a half years. Shrimp are omnivores, consuming a wide variety of small food organisms.

Bay shrimp from Suisun Bay in January contained the highest levels of selenium measured in shrimp (0.67 ppm) (Table 13). These were larger shrimp (81 mm) than in the spring samples (48 mm) from Suisun Bay which contained 0.37 ppm. Large shrimp (83 mm) from San Pablo Bay contained 0.53 ppm in both January and May samples, suggesting at least some of the apparent seasonal difference in selenium in Suisun Bay shrimp was size related. Otherwise, no seasonal differences were observed. Bay shrimp from Humboldt Bay ($\bar{x}$ = 0.35 ppm) contained significantly lower levels of selenium compared to the higher levels found in shrimp from San Pablo and Suisun bays. Bay shrimp had lower selenium residues than dungeness crab.

The biological significance of selenium levels measured in bay shrimp is not known. Shrimp are an important food organism for fishes in the Bay, including white sturgeon and starry flounder

TABLE 13
SELENIUM CONCENTRATION IN COMPOSITE SAMPLES OF INVERTEBRATES
FROM SAN FRANCISCO BAY SYSTEM AND HUMBOLDT BAY, 1986
(ppm, wet weight)

SPECIES	LOCATION	WINTER N	WINTER MEAN	WINTER RANGE	SPRING N	SPRING MEAN	SPRING RANGE
Dungeness Crab1/	Suisun Bay	2	1.8	1.7-1.8			
	San Pablo Bay	2	1.9	1.8-2.0	2	1.2	1.1-1.2
	Central SF Bay	2	0.85	0.74-0.96	2	1.0	0.96-1.1
	South SF Bay	1	1.4		1	0.62	
	Humboldt Bay	2	0.63	0.59-0.67	2	0.70	0.68-0.72
Bay Shrimp2/	Suisun Bay	2	0.67	0.66-0.68	2	0.37	0.35-0.38
	San Pablo Bay	2	0.53	0.52-0.53	2	0.52	0.52-0.52
	Central SF Bay	2	0.51	0.50-0.52			
	South SF Bay	2	0.47	0.46-0.47	2	0.44	0.42-0.45
	Humboldt Bay	2	0.37	0.36-0.37	2	0.34	0.33-0.34
Softshell Clams3/	San Pablo Bay	2	0.39	0.36-0.42	2	0.30	0.27-0.32
	Central SF Bay	2	0.37	0.35-0.38	2	0.35	0.34-0.35
	South SF Bay	1	0.36		2	0.45	0.40-0.50
	Humboldt Bay	2	0.28	0.28-0.28	2	0.23	0.22-0.23

1/ Analysis of soft tissue in crab body only, not appendages.

2/ Analyzed composites of whole shrimp.

3/ Analyzed all soft tissue of clams.

and may be a pathway for selenium uptake in these and other species.

Softshell Clam

The softshell clam (*Mya arenaria*) occurs in the more saline parts of the estuary. They cannot tolerate the lower salinities which occur seasonally in Suisun Bay and are not established there. *Mya* is found in the higher intertidal zone, often in the muddy banks and bottoms of tidal channels. Softshell clams feed on suspended material filtered from the water.

Selenium levels in softshell clams were less variable among areas and between seasons than in either dungeness crabs or bay shrimp, in spite of clam size differences and changes in collection sites. No differences were found in selenium levels in soft tissue of clams from San Pablo Bay and South and Central San Francisco Bays (Table 13). The highest levels found in San Francisco bay clams (.36-.45 ppm, South S.F. Bay) were significantly higher than levels in softshell clams collected at Humboldt Bay (.23-.28 ppm).

Johns and Luoma (1987) reported preliminary data on selenium levels in freshwater clams (*Corbicula*) which averaged about 0.6 ppm (wet weight, converted from dry weight, 88% moisture) in lower Suisun Bay. These levels were higher than concentrations we measured in softshell clams from San Pablo, South and Central San Francisco bays. We did not collect clams from Suisun Bay but since they are food for diving ducks future collections will include *Corbicula* from Suisun Bay, specifically in areas where diving ducks are observed feeding.

One objective of collecting samples in two seasons was to determine if selenium in tissues of bay organisms reflected seasonal loading to the bay from agricultural runoff. Drainwater containing selenium flows into the San Joaquin River all year, however, maximum selenium loading occurs in March through May (D. Watkins, pers. comm.). Thus sampling in January-February and in May-June bracketed the peak loading period. We found no evidence of significant increases in selenium levels in bay biota from January-February to May-June samples. Possible loading-related effects on tissue levels may have been obscured by other factors determining environmental levels of selenium and its accumulation in biota. Collecting the same lifestage in both seasons often was not possible, hence adults in winter were compared with young in spring in some cases. Variation in selenium levels related to size and age of specimens may be greater than seasonal differences. Record outflow beginning in February 1986, and continuing through the spring provided more dilution and flushing of the estuary than occurs in most years and may have minimized the chance of detecting potential impacts. Evaluation of seasonal effects may require selection of other species and adjustment of collection periods. Collection of sedentary species or deployment of caged specimens may be appropriate.

Our sampling has identified levels of selenium in some of the biota in the San Francisco Bay-Estuary that are significantly higher than background levels at Humboldt Bay. Selenium levels in tissues of some species, whether elevated compared to background levels or not, differed among bays within the estuary, suggesting differentiation in the input or bioavailability of selenium within areas of the estuary. Many factors probably influence the bioavailability of selenium, including proximity to a source. Water sample analyses by Cutter (1987) indicate low levels of selenium (0.01 to 0.72 ppb) in bay water, most in dissolved form. From such a low level in water significant bioaccumulation of selenium must occur to reach the levels measured in resident bay biota and in migratory species using the Bay seasonally. Our findings indicate processes occurring near, on, or in the bottom and in the organisms found there may be crucial to the biological accumulation of selenium. The species from the San Francisco Bay system with elevated tissue selenium levels compared to levels in counterparts from Humboldt Bay and other areas have in common a bottom-oriented existence (starry flounder, dungeness crab, bay shrimp) or an obligatory association with benthic organisms for food (scaup, surf scoters, white sturgeon). Physical, chemical, and biological processes at the water-sediment interface may increase the bioavailability of selenium facilitating bioaccumulation in food chain organisms.

SUISUN MARSH

The Suisun Marsh was included in this study because of its proximity to Suisun Bay and Grizzly Bay, its dependence on water from the Sacramento and San Joaquin rivers and these adjacent bays to maintaining the quality of wetland habitat in the marsh, and the importance of the Suisun Marsh to wintering and nesting waterfowl in the Pacific Flyway. Samples were collected on the Grizzly Island State Wildlife Area. Mallards, coots and black-necked stilts (*Himantopus mexicanus*) were collected in winter and spring, each species representing a different potential dietary pathway for the uptake of selenium. To compare with results from the Suisun Marsh, the same species were collected at Gray Lodge State Wildlife Area in Butte County, representing an area with background levels of selenium with no identified human activity affecting selenium availability.

Mallards

The mallard (*Anas platyrhynchos*), a dabbling duck, is the most abundant and widely distributed duck in the northern hemisphere and a common resident throughout much of the United States and a winter visitor to the southern half. In California, mallards are found all year in freshwater lakes, ponds, river and marshes as resident breeding birds. Large numbers of mallards migrate from breeding areas in U.S. and Canadian prairies and other northern areas to winter in California, primarily in the marshes of the

Central Valley and of San Francisco Bay (Bellrose 1978). Mallards are primarily vegetarians, feeding on the seeds (some stems and leaves) of marsh plants. They have also adapted to the availability of agricultural grains (corn, rice, barley). Rice is the most important domestic food source for mallards in the Central Valley. The mallard is an important game species, usually ranking first or second in annual harvest statistics.

Mallards were collected in March and June 1986 at Grizzly Island State Wildlife Area in the Suisun Marsh. There was no significant difference between these time periods in selenium levels of muscle ($\bar{x}$=0.30 ppm, March; 0.40 ppm, June) or liver ($\bar{x}$=1.2 ppm, March; 0.91 ppm, June) (Table 14). There were no differences in selenium levels between seasons at Gray Lodge for either tissue (muscle: $\bar{x}$=0.33 ppm, February; 0.43 ppm, June and liver: $\bar{x}$=1.1 ppm, February; 1.1 ppm, June). Finally, there were no significant differences between Gray Lodge and Grizzly Island mallards for comparable time periods and tissues.

Mallards and other dabbling ducks are often seen on Grizzly and Suisun bays with diving ducks such as surf scoters, scaup, and canvasbacks, particularly on waterfowl hunting days in the Suisun Marsh when dabbling ducks leave the marsh for the relative safety of the open waters of the nearby bays. Notwithstanding this common use of the bay, mallards collected on Grizzly Island had significantly lower selenium levels than the scoters and scaup collected from Suisun/Grizzly Bay. Animals can accumulate selenium directly from water but the primary pathway for uptake is probably dietary. Diving ducks feed on benthic organisms, mostly clams in Suisun Bay, and thus are exposed to selenium which may biologically accumulate in bay benthos. Dabbling ducks like the mallard feed either in the marsh on plants, their seeds, and aquatic invertebrates, or, in some seasons, outside the marsh on waste grain in harvested fields on Sacramento-San Joaquin Delta islands. Thus, mallards are probably not exposed to dietary selenium levels comparable to that in organisms consumed by diving ducks resulting from biomagnification in aquatic food chains. Physiological and metabolic differences between species may also influence tissue selenium levels.

Mallards from the Suisun Marsh and Gray Lodge Wildlife Area, the "background" site, had very low levels of selenium compared to mallards from other sites. Lower average selenium levels have been documented only for mallards from Honey Lake State Wildlife Area (September 1984) in northeastern California ($\bar{x}$=0.2 ppm, wet weight in muscle, DFG unpublished) and at Malheur National Wildlife Refuge (October 1984) in southeastern Oregon ($\bar{x}$=0.24 ppm, wet weight in muscle). In contrast, mallards collected by the U.S. Fish and Wildlife Service at Kesterson National Wildlife Refuge in July, 1983 averaged 3.4 ppm wet weight in muscle (H. Ohlendorf, pers. comm.) and in July, 1984 averaged 5.8 ppm wet weight in muscle (USFWS, unpublished data). Selenium concentrations in

TABLE 14
SUMMARY OF SELENIUM CONCENTRATIONS OF
DABBLING DUCKS AND COOTS IN WINTER AND SPRING, 1986
(ppm wet weight)

		WINTER 1/							SPRING 2/						
			MUSCLE			LIVER				MUSCLE			LIVER		
SPECIES	LOCATION	N	MEAN	SD	RANGE	MEAN	SD	RANGE	N	MEAN	SD	RANGE	MEAN	SD	RANGE
Mallards	Gray Lodge	11	0.33	0.112	0.16-0.49	1.1 3/	0.47	0.60-2.2	9	0.43	0.187	0.13-0.76	1.1	0.44	0.40-1.5
	Grizzly Is.	9	0.30	0.108	0.16-0.49	1.2 3/	1.2	0.88-1.6	10	0.40	0.152	0.25-0.76	0.91	0.621	0.33-2.3
Cinnamon Teal	TLDD Ponds	9	1.5	0.76	0.59-2.8	5.7 3/	3.13	2.3-11.0	10	1.3	0.64	0.50-2.5	5.4	2.13	2.1-9.3
	Westfarmers	8	0.92	0.533	0.53-2.1	4.9 3/	2.39	2.6-11.0							
	Semitropic WSD	9	0.58	0.212	0.38-1.1	2.5	0.56	1.7-3.4	6	0.59	0.190	0.32-0.84	2.8	1.24	1.3-4.9
	Lost Hills Ranch								4	0.90	0.137	0.71-1.0	5.1	3.02	1.6-7.8
American Wigeon	Salton Sea	10	1.0	0.25	0.73-1.3		1.3	0.22	1.0-1.7						
American Coots	Gray Lodge	10	0.47	0.080	0.34-0.63	0.87	0.222	0.62-1.4	10	0.39	0.149	0.18-0.69	0.58	0.236	0.22-0.99
	Grizzly Is.	11	0.39	0.108	0.23-0.54	0.64	0.147	0.42-0.94	8	0.59	0.152	0.34-0.78	1.2	0.32	0.78-1.7
	TLDD Ponds	9	2.0	1.58	0.42-5.8	3.6	2.10	1.1-8.3	3	2.5	1.95	1.1-4.7	6.7	3.86	3.6-11.0
	Semitropic WSD	10	1.0	0.62	0.5-2.6	1.4	0.40	0.86-2.2	2	1.4	0.87	0.77-2.0	2.4	0.92	1.8-3.1
	Lost Hills Ranch	1	0.26		0.26	0.92		0.92							

1/ February and March

2/ May and June

3/ N=10

waterfowl food plants and animals in the Suisun Marsh were not measured. Assuming mallards in our samples were either resident or, if wintering, had been feeding in the marsh for several months, it seems unlikely that mallard food organisms in the marsh are contaminated with selenium. Mallards feeding off-site or recently arriving at Grizzly Island would be poor indicators of the status of duck food organisms in the marsh.

American Coots

The American coot (Fulica americana) is a common breeding bird in freshwater marshes and at lakes and ponds with suitable shoreline habitat. Small (1974) describes a southward and coastward shift in coot distribution in fall to wintering areas in both freshwater and saltwater habitats. Coots are omnivorous, consuming the leaves, fronds, and roots of submerged aquatic plants and marsh plant seeds. Fifteen percent of the diet may be animal food (aquatic insects, univalve and bivalve molluscs, and crustaceans), increasing to over 40 percent during summer (Martin et al. 1951). Coots also graze on upland grasses or feed on algae in tidal habitats (Small 1974). Coots are occasionally taken by waterfowl hunters.

Coots were collected at Grizzly Island (Suisun Marsh) and Gray Lodge State Wildlife areas in late January-early February and again in mid-June. Coots at Grizzly Island had significantly lower selenium levels in winter ($\bar{x}$=0.39 ppm in muscle; $\bar{x}$=0.64 ppm in liver) than in spring ($\bar{x}$=0.59 ppm in muscle; $\bar{x}$=1.2 ppm in liver). Muscle selenium levels were not significantly different between seasons in coots from Gray Lodge but levels in coot livers were significantly lower in spring ($\bar{x}$=0.58 ppm compared to $\bar{x}$=0.87 ppm in winter) (Table 14). In winter, average muscle selenium levels were not significantly different between areas but levels in liver were significantly lower in Grizzly Island coots than in Gray Lodge coots. In spring, selenium concentrations in both tissues were significantly higher in Grizzly Island coots than in Gray Lodge coots.

Selenium concentrations in coots from Grizzly Island (Suisun Marsh) were below recognized harmful levels. Average concentrations of selenium in liver were less than one-tenth levels in coots at Kesterson NWR in 1983 (DFG, unpublished $\bar{x}$=9.95 ppm wet weight; Ohlendorf et al. 1986a, $\bar{x}$=9.3 ppm wet weight, converted from dry weight using 75 percent moisture). Severe abnormalities in coot embryos and chicks, reduced hatching success and poor survival of young were related to elevated selenium levels at Kesterson in 1983 (Ohlendorf et al. 1986 a,b).

The inference of an increase in selenium tissue burden for coots wintering at Grizzly Island involves the same assumptions as for other species. The origin and residence time of individual birds are unknown. On-site feeding is probable with coots; although capable fliers, coots are more sedentary than ducks and are not known to feed on the grain in harvested fields that draws mallards and other ducks out of the marsh to feed. Thus increased tissue selenium concentrations in coots over time are likely due to accumulation from foods obtained in the marsh. It is not known if the seasonal increase measured in selenium levels in coots is an adjustment to higher dietary levels in the Suisun Marsh than in food consumed prior to arrival, to seasonal increases in selenium in certain food organisms within the marsh, or to a seasonal dietary shift to foods with higher levels. Martin et al. (1951) describes a seasonal diet shift from almost no animal food in fall and winter, increasing to fifteen percent during the spring and to over forty percent in the summer. In January, coots at Grizzly Island were grazing on green upland vegetation. In June most fields, flooded since the previous fall, had been drained and coots were found only in permanent channels. Submerged aquatic vegetation and especially aquatic invertebrates in these ditches are a more likely source of selenium than the upland vegetation coots were eating in the winter. Food items of coots collected in June were not documented, but dietary patterns could be examined and food organisms collected and analyzed in the future.

Black-necked stilts

The black-necked stilt (Himantopus mexicanus), a semi-tropical shorebird, is primarily a summer visitor to California occurring at the margins of shallow fresh, brackish, or salt water pools, sloughs, and ponds (Small 1974). Stilts occur throughout the year in extreme southern areas (e.g. Salton Sea) and from April to October in the rest of their range in California. Few stilts breed north of San Francisco. They feed in very shallow waters, consuming insects, molluscs, small fish, and crustaceans (Martin et al. 1951). Black-necked stilts are not hunted; they may be consumed by avian or terrestrial predators and scavengers.

No significant difference was found in liver selenium levels between black-necked stilts collected in March ($\bar{x}$=2.0 ppm) and June ($\bar{x}$= 1.7 ppm) at Grizzly Island (Table 10). Stilts collected at Gray Lodge in March to represent background levels had significantly higher selenium concentrations ($\bar{x}$=3.4 ppm) than the stilts from Grizzly Island. Gray Lodge personnel noted an influx of stilts prior to our collections, hence the sample may include birds from other areas. Absent from Gray Lodge in June, stilts were collected instead at Sacramento National Wildlife Refuge. Levels in Sacramento NWR stilts ($\bar{x}$=2.5 ppm in liver) were significantly higher than Grizzly Island stilts in spring. Recent migrations to Sacramento NWR were not documented.

Normal levels of selenium in livers of black-necked stilts are not known; however, levels in stilts at Grizzly Island were the lowest we measured and less than one-sixth of levels associated with embryotoxic effects. Selenium levels in livers of stilts at Kesterson NWR doubled from April-May to June-July (12.5 ppm to 28.6 ppm, wet weight converted from dry weight using 70 percent moisture) (Ohlendorf et al 1986b). Selenium concentration in stilt eggs was linked to embryotoxicity at Kesterson; one-fourth of the nests monitored contained at least one dead or deformed embryo. Selenium levels in stilts at Volta State Wildlife Area were lower and decreased by half (3.2 ppm to 1.6 ppm, wet weight) from April-May to June-July. Only one dead embryo was found in stilt nests at Volta. The threshold between safe and potentially harmful levels of selenium in stilts is apparently between 3 ppm and about 12 ppm. Selenium levels in stilts in the Suisun Marsh probably are not harmful.

SALTON SEA/SURFACE WATERS AND AGRICULTURAL DRAINS IN RIVERSIDE AND IMPERIAL COUNTIES

A composite sample of orangemouth corvina taken from the Salton Sea in 1984 contained 3.1 ppm wet weight in muscle (Watkins et al. 1985). The Salton Sea was included in this study to verify levels in orangemough corvina and other fish species and to determine selenium levels in birds using the Salton Sea and wetlands in the basin.

The Salton Sea is a closed system with inflow comprised primarily of return flow from agricultural irrigation using water imported from the Colorado River. An increasing percentage of the agricultural return flow is from tile drainage systems in the Imperial Valley. The entire Coachella Valley has tile drainage systems.

SALTON SEA BIRDS

Double-crested Cormorants

Selenium levels in double-crested cormorants from Salton Sea National Wildlife Refuge averaged 60% and 138% higher than Humboldt Bay cormorants in winter and spring, respectively. The larger difference in spring was due to a significant decline in selenium concentrations in Humboldt Bay birds from winter to spring (Table 10). Salton Sea cormorant selenium levels also were significantly higher than levels in cormorants from the San Francisco Bay region both in winter and spring. Measured only in liver, there was no significant difference in liver selenium concentration between February ($\bar{x}$=10.3 ppm) and May ($\bar{x}$=9.1 ppm) (Table 10).

The significance of these levels to cormorants is not known. Remsen (1978) indicated the double-crested cormorant had disappeared as a breeding bird from the Salton Sea, however selenium was not studied as a cause. We observed a nesting colony at the Salton Sea NWR in spring 1986, but have no information on reproductive success. Selenium concentrations in Salton Sea cormorants are probably due to high levels in their diet comprised of fish from the Sea.

Selenium concentrations in double-crested cormorants from all locations seem higher than apparently "normal" levels in other bird species, but there is no evidence indicating concentrations we measured are above normal levels for cormorants. Clarification of safe levels in cormorants might result from a study of breeding success in the Salton Sea colony since adult cormorants there had the highest tissue burden.

Black-necked Stilt

Selenium was measured in the liver of black-necked stilts collected from Salton Sea NWR in February and May, 1986, and found to be significantly higher in winter ($\bar{x}$=6.4 ppm) than spring ($\bar{x}$=3.9 ppm) (Table 10). In a comparison of winter selenium levels between stilts from different locations, Salton Sea stilts had significantly higher levels than stilts from the Suisun Marsh (Grizzly Island) ($\bar{x}$=2.0 ppm in March) and Gray Lodge Wildlife Area ($\bar{x}$=3.4 ppm in March). In spring, levels in Salton Sea stilts were also higher than stilts from Suisun Marsh ($\bar{x}$=1.7 ppm in June) and Sacramento NWR ($\bar{x}$=2.5 ppm).

The significance of these findings to stilts is not known. Although higher than levels in stilts in Sacramento Valley wetlands, selenium concentrations in stilts at the Salton Sea are still less than the levels in stilts at Kesterson where stilt reproduction was impacted by selenium (see discussion of black-necked stilts in Suisun Marsh). Studies of shorebird reproduction at the Salton Sea may be appropriate.

Possible explanations for the decrease in the average selenium level from 6.4 ppm in February to 3.9 ppm in May include: a decrease in selenium in food items, a shift to food items with less selenium, and recent arrivals in either sample with selenium levels not representative of the area. Stilt food organisms were not identified or collected to evaluate hypotheses related to dietary selenium levels. Observations of abundance changes or migrations were inadequate to refute the hypothesis of new arrivals. No relationship of age, sex, or reproductive status to selenium levels in stilts were suggested by our limited data.

American Wigeon

The American wigeon (Anas americana) is an abundant dabbling duck for which the Central Valley of California and coastal marshes of Louisiana are the principal wintering grounds. The Imperial Valley and the west coast of Mexico are other important wintering areas in the Pacific flyway (Bellrose 1978). Wigeon wintering in

California are produced mostly in Alaska and the Canadian provinces. They are found in this state from August to April in freshwater marshes, ponds, and lakes and saltwater bays and estuaries. Many are fall and spring transients migrating to and from Mexico (Small 1974). Unlike most dabbling ducks, wigeon concentrate on the vegetative parts of aquatic plants rather than the seeds for food, resembling coots in this aspect of their feeding behavior. They will graze on upland grasses and clovers, feed on waste grain in harvested fields, and have damaged irrigated crops, consuming lettuce, alfalfa and pasture grasses (Bellrose 1978). Small quantities of animal food are mostly molluscs and insects. Wigeon are an important component of annual waterfowl harvest by hunters.

Selenium levels in muscle tissue of American wigeon collected in February from Salton Sea averaged 1.0 ppm, 2.5 to 3 times higher than muscle selenium levels in mallards from Grizzly Island and Gray Lodge State Wildlife Areas ($\bar{x}$'s=0.30 to 0.43 ppm). The average level measured in liver ($\bar{x}$=1.3 ppm) was only slightly higher in wigeon than in mallards (Table 14).

The Salton Sea study plan called for collection of a dabbling duck species, preferably mallards or cinnamon teal because these species were collected at other sites. When collections were made in late February, most mallards had migrated north leaving too few at the sea to collect an adequate sample. Cinnamon teal had just begun arriving at the Sea from wintering grounds to the south (G. Kramer, Salton Sea NWR Manager, pers. comm.). They were not collected because of uncertainty about how well their tissue levels would reflect local conditions. Some degree of uncertainty about the residence time and duration of exposure applies to every bird collected, but in this case current information about cinnamon teal movements dictated collection of an alternate species. American wigeon had been observed using the area for several months and were still sufficiently abundant to provide enough specimens. Although wigeon are a grazing feeder, their food habits partially overlap those of typical dabbling ducks. Wigeon raft on the Salton Sea but were feeding predominantly on aquatic vegetation in freshwater wetlands adjacent to the Sea. Ducks seldom spend the summer at the Salton Sea and nesting ducks are rare. Consequently a spring collection of watefowl was not attempted.

The significance of these selenium burdens to American wigeon is not known. The only data found for wigeon was for single birds collected by DFG at Los Banos in October and December, 1984, each with 0.4 ppm selenium wet weight in muscle. An average of 1.0 ppm in Salton Sea wigeon (muscle) is higher than most data reported for dabbling ducks but less than at Kesterson NWR where average selenium levels in duck muscle in 1983 and 1984 exceeded 3 ppm wet weight.

Scaup

The scaup collected at Salton Sea NWR were all lesser scaup. Selenium measured in muscle of these scaup ($\bar{x}$=1.2 ppm) was not significantly different than levels in scaup from South San Francisco ($\bar{x}$=1.3 ppm), San Pablo ($\bar{x}$=1.4 ppm), or Humboldt Bays ($\bar{x}$=1.2 ppm) (Table 9), but was only about half the level in Suisun Bay scaup, a significant difference. The two scaup ($\bar{x}$=2.8 ppm) from Central San Francisco Bay were not different from Salton Sea scaup in a multiple comparison test because of the small sample. Liver selenium levels in Salton Sea scaup ($\bar{x}$=3.1 ppm) were lower than average levels from the San Francisco Bay area scaup.

The significance of these levels to scaup are not known. (See discussion of scaup from San Francisco Bay). Considering the levels of selenium measured in water and fish in the Salton Sea, these levels in scaup, were surprisingly low. Scaup were observed at the refuge all winter and fed on barnacles in the sea, but it is possible scaup in our sample were new to the area and only beginning to feed in the Sea. No barnacles were collected; selenium levels in scaup food items are not known.

SALTON SEA FISH

Orangemouth Corvina, Croaker, Tilapia, and Sargo

Orangemouth corvina (*Cynoscion xanthulus*), croaker (*Bairdiella icistius*), and sargo (*Anisotremus davidsoni*) are marine species relocated from the Gulf of California in the early 1950's to establish a fishery in the increasingly saline water of the Salton Sea. More recently, tilapia (*Tilapia* sp.) were introduced to the system, primarily to control vegetation in drains. All four fishes became well established and a large recreational fishery developed. Current concerns at the Salton Sea focus on the effect of increasing salinity on the viability of fish populations and the impact of contaminants in the system on public participation in the sport fishery.

Croaker and sargo feed primarily on benthic polychaete worms (*Neanthes*) and crustaceans (barnacles). Orangemouth corvina consume a variety of foods during early development but quickly change to a diet consisting exclusively of fish, including croaker, sargo, and tilapia. Analysis of stomach contents indicate tilapia eat algae and detritus (G. Black, pers. comm.).

Orangemouth corvina, tilapia, and croaker were collected from the Salton Sea in May 1986. Muscle tissue levels averaged 3.1 ppm for orangemouth corvina, 3.6 ppm for tilapia, and 3.9 ppm for croaker. Each corvina and tilapia had at least 2.8 ppm selenium in muscle and each croaker had at least 3.1 ppm. The highest concentration of selenium in Salton Sea fish was in croaker muscle (5.7 ppm).

In tilapia and croaker, as in most species of fish, selenium was found in liver tissue at higher levels than in muscle (Table 15). In orangemouth corvina, however, mean selenium in liver of 11 individuals (2.4 ppm) was less than in muscle (3.1 ppm). Corvina livers had unusually low moisture content, averaging about 52 percent compared to the typical moisture content in fish liver of 65 to 80 percent.

The mean selenium level in 11 corvina we collected in 1986 was identical to the concentration measured in a composite sample of corvina from the Salton Sea in 1984 (3.1 ppm) (Watkins et al. 1985). The next highest selenium measurement in 12 samples of fish muscle filets taken statewide in 1984 was 1.1 ppm in carp from Nacimiento Reservoir (Agee 1986). Toxic Substances Monitoring Program testing of Salton Sea fish in 1985 found 3.6 ppm in six orangemouth corvina (composite), whereas seven croakers contained 3.8 ppm, six sargo measured 2.1 ppm, and five tilapia had 1.7 ppm (Linn et al. 1986). The average selenium concentration in the muscle of corvina in 1986 was 14 percent lower than in the 1985 composite sample. None of the eleven corvina analyzed in 1986 had more than the 3.6 ppm in the 1985 composite sample. Croaker selenium levels were unchanged, but tilapia contained more than twice as much selenium in 1986 as in 1985. Sargo were not sampled in 1986.

The significance of these levels to populations of these species is unknown. There is no comparative data for these species from the Gulf of California to indicate normal selenium levels. There is no evidence to suggest a decline in abundance of these species or any empirical evidence establishing selenium levels that are toxic to these or similar species.

In response to TSMP findings in 1985, the State Department of Health Services (DHS) issued an advisory in May 1986, recommending limited consumption of croaker, orangemouth corvina, sargo, and tilapia from the Salton Sea. The DHS "level of concern" was 2 ppm wet weight in edible tissue.

Water samples taken from the Salton Sea in February 1986 averaged about six ppb total selenium, declined to 5 ppb in April and to 3 ppb in May when fish were collected. Our findings indicate bioaccumulation in fish muscle of approximately 500 to 1,000 times the concentration in the water (3 ppm in tissue from 3-6 ppb in water).

SURFACE WATERS AND AGRICULTURAL DRAINS RIVERSIDE AND IMPERIAL COUNTIES

Three surface water systems receiving agricultural runoff or subsurface drainwater were included in this study based on water or fish sample data suggesting potential problems with selenium in these systems. The sites were:

TABLE 15
SELENIUM CONCENTRATIONS IN FISH FROM THE SALTON SEA AND TRIBUTARIES, COLORADO RIVER TRIBUTARIES, SAN JOAQUIN RIVER AND TRIBUTARIES AND STONY CREEK, 1986
(ppm, wet weight)

		MUSCLE			LIVER		
SPECIES	LOCATION	N	$\bar{x}$	RANGE	N	$\bar{x}$	RANGE
Orangemouth corvina	Salton Sea	11*	3.1	2.8-3.6	12*	2.4	1.6-5.0
Croaker	Salton Sea	9*	3.9	3.10-4.5	9*	4.6	3.9-5.7
Tilapia	Salton Sea	15*	3.6	2.80-4.5	4	6.8	4.7-8.3
Largemouth bass	Palo Verde Outfall	5*	0.90	0.73-1.1	5*	1.6	1.2-2.0
	Black Butte Res.	2	0.58	0.57-0.59	2	1.5	1.3-1.7
Common carp	Palo Verde Outfall	4*	0.81	0.64-1.2			
	Reservation Drain	7*	0.39	0.33-0.45			
	Whitewater River	6*	1.2	1.1-1.3			
	Coachella Canal	6*	2.9	2.0-4.2			
	Stony Creek above Black Butte	2	0.43	0.39-0.46			
	Black Butte Res.	2	0.60	0.51-0.68			
	Stony Creek below Black Butte	2	0.49	0.48-0.50			
White catfish	Salt Slough	6*	0.20	0.17-0.25	1	1.5	
	San Joaquin River at Merced River	6*	0.29	0.20-0.34	1	2.5	
Channel catfish	Whitewater River	3*	0.60	0.52-0.75	3*	3.0	2.5-3.8
	Whitewater River	1	0.52		1	2.0	
	Coachella Canal	5*	0.75	0.1-1.2	1	2.0	
	Stony Creek above Black Butte	2	0.31	0.31-0.31	2	1.8	1.7-1.8
	Stony Creek below Black Butte	2	0.19	0.18-0.20	2	2.0	1.9-2.1
	Black Butte Res.	2	0.27	0.26-0.27	2	1.6	1.5-1.6
	San Joaquin River at Merced River	4*	0.24	0.21-0.28	1	1.9	
	Salt Slough	5*	0.26	0.17-0.36	1	1.7	
	Mud Slough	4*	0.50	0.42-0.58	1	2.6	
	Camp 13 Ditch	4*	0.75	0.57-0.90	1	2.4	
Sacramento sucker	Black Butte Res.	2	0.51	0.51-0.51			

*Individual fish analyzed.

- Whitewater River (also referred to as the Coachella Valley Stormwater Channel in the lower reach), a tributary to the Salton Sea, receiving subsurface tile drainage and municipal effluent from the Coachella Valley (P. Gruenberg, RWQCB, pers. comm). Samples were also collected in the Coachella Canal (near La Quinta), a conveyance system for Colorado River water to the Coachella Valley, to represent conditions in an aquatic system prior to use of the water in the Valley and its return to the lower Whitewater River as irrigation drainage (Figure 5).

- Palo Verde Outfall Drain, a tributary to the Colorado River, receiving surface tailwaters from irrigated agriculture in the Palo Verde Valley (Figure 6).

- Reservation Drain, a tributary to the Colorado River receiving drainwater from agricultural lands in Bard Valley Figure 6).

Water samples were collected in February, April, and May at several sites in each system. Channel catfish (Ictalurus punctatus) or largemouth bass (Micropterus salmoides) and common carp (Cyprinus carpio) were collected in April or May. Catfish and bass are omnivores; carp feed primarily on algae, plant parts, and some animal food.

WHITEWATER RIVER AND COACHELLA CANAL

Channel Catfish and Carp

Selenium in muscle tissue was 0.52 ppm in a composite sample of six channel catfish collected near the mouth of the Whitewater River in May, 1986 (Table 15). Three channel catfish analyzed individually averaged 0.60 ppm. The composite sample of liver measured 2.0 ppm and the three individual catfish livers averaged 3.0 ppm. Carp muscle averaged 1.2 ppm selenium for six individuals. Selenium in water samples from sites in the lower ten kilometers of the Whitewater River ranged from 2.3 ppb to 6.9 ppb in February and from 2.6 ppb to 7.0 ppb in April (Table 16). Samples were collected at fewer sites in May; concentrations ranged from 0.8 ppb to 3.6 ppb and were 40 to 60 percent lower than in April. The highest concentrations in water were at the Lincoln Street crossing where the Lincoln Street Drain empties into the Whitewater River at the east bank. Lower concentrations in water samples from above and below Lincoln Street suggest the drain is a source of selenium to the river.

Channel catfish and carp were collected from the Coachella Canal near LaQuinta to measure selenium levels in the water supply before it was used to irrigate Coachella Valley lands. Water samples taken in May contained no detectable selenium (<0.5 ppb). Channel catfish collected from the canal averaged 0.75 ppm selenium in muscle and 2.0 ppm in liver. Carp muscle averaged 2.9 ppm with a maximum concentration of 4.2 ppm.

TABLE 16
SELENIUM CONCENTRATIONS IN WATER SAMPLES, 1986
(parts per billion, ppb)

	FEB1/	MAR1/	APR2/	MAY2/	JUN2/
Palo Verde Outfall Drain,					
Hwy 78 Crossing	1.0		1.0	<0.5	
	<0.5		<0.5	<0.5	
C-28 Outlet	1.8		0.6	<0.5	
	1.1		1.6	<1.7	
Truck bridge	0.7		<0.5	<0.5	
	2.3		1.5	<0.5	
Mitchell's Camp	1.2		<0.5	<0.5	
	1.6		1.3	<0.5	
Walter's Camp	3.2				
	1.4				
Reservation Drain,					
S-24 Crossing	<0.5		<0.5	<0.5	
	<0.5		<0.5	<0.5	
Fisher Road Crossing			<0.5	<0.5	
			<0.5	1.2	
Baseline Road Crossing				<0.5	
				<0.5	
Coachella Canal near La Quinta				<0.5	
				<0.5	
Whitewater River					
Intersection Hwy 195 & Pierce Rd.	4.0		3.0	1.6	
	4.1		3.1	0.8	
300 m above Lincoln St., East side	3.7		3.2		
	4.7		3.0		
300 m above Lincoln St., West side	4.5		3.3		
	3.4		2.6		
Lincoln St., East side	6.3		7.0		
	6.9		6.1		
Lincoln St., West side	4.0		4.2		
	6.1		3.6		
200 m below Lincoln St., East side	4.6		4.4	3.0	
	2.3		3.2	1.8	
200 m below Lincoln St., West side	4.5		3.1		
	4.6		4.0		
Mouth at Salton Sea				3.6	
				2.2	
Salton Sea					
National Wildlife Refuge	5.4		4.8	2.9	
	6.8		<0.5	3.4	
Navy base				2.5	
				2.4	
Tulare Lake Drainage District					
Intake Canal		39.0		31.4	
		33.0		29.6	
Interior cell		14.0		14.1	
		8.4		10.0	
Twisselman Rd/Westfarmers					
Northwest edge		3.2		110.0	
		5.7		101.0	
Interior cell		71.0		108.3	
		68.0		110.1	
Semitropic Water Storage Dist. Ponds		<0.5		<0.5	
		<0.5		1.4	
Lost Hills Ranch Evap. Ponds		5.1		2.3	
		6.4		2.8	
Stony Creek					
Above Black Butte Res.			<0.5		
			<0.5		
Below Black Butte Res.				<0.5	
				<0.5	
Black Butte Reservoir					<0.5
					1.0

1/ Single sample collected, split at WPCL, each analyzed in duplicate by NAA at UMRR and mean concentration reported for sample splits.

2/ Replicate samples collected, each analyzed in duplicate by NAA at UMRR and mean concentration reported for each replicate sample.

Channel catfish and carp in the lower Whitewater River were exposed to similar selenium concentrations in water as fish in the Salton Sea but did not accumulate comparably high tissue levels. Channel catfish in the river accumulated selenium in muscle tissue at about 80 to 150 times waterborne levels (0.5 ppm from a range of 3 to 6 ppb in water) compared to 500 to 1,000 times for fish in the Sea. Carp accumulated levels 200 to 400 times water concentrations (1.2 ppm from 3 to 6 ppb), higher than channel catfish but less than the Salton Sea fish. Orangemouth corvina, croaker, and sargo are all marine species which generally have higher selenium levels than freshwater counterparts (Eisler 1985).

Accumulation of selenium to higher concentrations in carp than channel catfish in both the Whitewater River and Coachella Canal may be due to dietary differences between species. Stomach contents were not inspected but channel catfish are omnivorous and probably were consuming more animal material than the predominantly herbivorous carp. Species differences in selenium accumulation are not due exclusively to food habits. Exposed to equal concentrations of selenium in water and fed the same low-selenium diet (0.09-0.15 ppm), juvenile bluegill (Lepomis macrochirus) accumulated 88 percent more selenium than juvenile largemouth bass after 120 days (Lemly 1982).

Higher selenium levels in fishes in the Coachella Canal than in the Whitewater River were unexpected since selenium was below detection levels in the canal water. Two possible explanations are: 1) the fish migrated into the canal system from another area with higher ambient selenium levels, or 2) selenium concentrations in the canal were higher in the past than our single water sample in May indicated. Selenium persisted in the muscle tissue of bluegill and largemouth bass in 30 day elimination trials following 120 days in 10 ppb selenium water (Lemly 1982). Hence we may have measured the effect of prior uptake of selenium from water or food.

The significance of these levels to the health of individual fish and fish populations is not known for channel catfish and carp.

Fish eating birds including white pelicans (Pelecanus erythrorhynchos) were observed in the wetlands along the edge of the Salton Sea and adjacent to the Whitewater River. Double-crested cormorants at the south end of the Sea had higher selenium burdens than cormorants from other areas in the State; pelicans may also accumulate selenium if their diet includes fish from the Sea.

PALO VERDE OUTFALL DRAIN

Largemouth Bass and Carp

Selenium in five largemouth bass from the Palo Verde Outfall Drain averaged 0.90 ppm in muscle and 1.6 ppm in liver. Four carp contained an average 0.81 ppm selenium in muscle (Table 15).

Selenium in water samples from five sites ranged from below the detection limit (<0.5 ppb) to 3.2 ppb. Selenium in the drain decreased between February and April and was detected at only one of four sites in May, suggesting seasonally fluctuating input of selenium. It is not known if February samples reflect peak concentrations of waterborne selenium in the drain.

Selenium levels in largemouth bass were slightly higher than in Sierra reservoirs (e.g. Don Pedro Res., 1 ppm in liver) but were less than half of levels in liver of bass from west-slope Coast Range impoundments with natural selenium input (L. San Antonio and L. Nacimiento, 3.2 ppm) or other waterways receiving agricultural drainwater (Mud Slough, 3.3 ppm) (Linn et al. 1986).

The significance of these selenium levels to largemouth bass and carp are not known. Selenium in liver tissue of Palo Verde Outfall Drain bass was less than half the concentration in largemouth bass carcasses (minus gonads) (4 ppm, wet weight) from power plant cooling reservoirs with 9 to 12 ppb selenium in water (Baumann and Gillespie 1986). Selenium concentrations in water in this range were associated with reproductive failures and elimination of fish populations from reservoirs (Lemly 1985, Gillespie and Baumann 1986). In bluegill, selenium was transferred from females to offspring and caused edema in larvae which did not survive (Gillespie and Baumann 1986). The threshold concentration of selenium associated with this abnormality is not known, but probably varies among species.

Carp from the Palo Verde Outfall Drain had lower selenium levels in muscle than carp from the Whitewater River or the Coachella Canal. Minimum levels of selenium producing toxic effects in carp have not been identified.

RESERVATION DRAIN

Common Carp

Seven carp from Reservation Drain averaged 0.39 ppm in muscle tissue. Water contained no detectable selenium (<0.5 ppb) in 11 of 12 samples collected in February, April, and May. Levels in these carp were low compared to all others collected in this study. Channel catfish were collected from Reservation Drain but were lost prior to or during analysis. Channel catfish collected by Toxic Substances Monitoring Program from the Colorado River nearby in July, 1984 contained 3.1 ppm in liver (Watkins et al. 1985). Based on the levels we measured in carp and the relationship of carp to catfish selenium concentrations found elsewhere in this study,, channel catfish in Reservation Drain probably have levels considerably less than 3 ppm.

KERN COUNTY AGRICULTURAL DRAINAGE EVAPORATION PONDS AND WATER STORAGE FACILITIES

Many farming operations in Kern County have built basins to store and evaporate subsurface agricultural drainage water from their lands. Evaporation basins range in size from a few acres of ponds serving a single farm to large complexes of ponds covering several square miles and receiving drainwater from hundreds of square miles of irrigated land. These basins attract waterfowl and other birds.

In 1985 water samples from evaporation basins in Kern County were analyzed for selenium by the Department of Water Resources and the Central Valley Regional Water Quality Control Board. Selenium ranged from 0 ppb to 865 ppb. From these sites, three were selected for verification sampling of selenium in biota based on selenium in water samples, information on bird use, and accessability for sampling. The Lost Hills Ranch (10 ppb in 1985), Tulare Lake Drainage District South Evaporation Basin (TLDD) (25 ppb), and Westfarmer (581 ppb) sites, representing the range of selenium concentrations measured in 1985 water samples were chosen (Figure 7).

In March 1986, the Lost Hills Ranch evaporation ponds which usually hold water all year were nearly dry because equipment problems had prevented pumping water from the sump. Water remained only in borrow ditches inside pond levees. Lost Hills Ranch ponds were being refilled in May during our second sampling period; collections were incomplete at Lost Hills because operational conditions limited bird use. Heavy rains in February, 1986 and subsequent runoff led to inundation of a nearby area owned by the Semitropic Water Storage District and used to store seasonal flows exceeding canal capacity and local needs. Substantial numbers of waterfowl and shorebirds were using this area, hence, birds and water were collected there in March and again in May.

KERN COUNTY EVAPORATION PONDS WATER, BIRDS

Water samples at the Westfarmer ponds contained the highest selenium concentrations, averaging 70 ppb in March and 109 ppb in May in an interior pond in the complex. Water from the edge of an otherwise dry pond (probably rainwater) contained an average 4.5 ppb in March and, from an adjacent pond that was also drying up in May, two samples averaged 105 ppb. These marginal waters were used by the shorebirds at the site more than were the full ponds.

Water from the intake canal at TLDD's South Evaporation Basin contained 36 ppb selenium in March and 31 ppb in May; concentrations in an interior cell averaged 11 ppb in March and 12 ppb in May.

Lost Hills Ranch ponds contained an average 5.8 ppb in residual water in borrow ditches in March and 2.6 ppb in May while the ponds were being refilled. The Semitropic WSD reservoir water contained no detectable selenium (<0.5 ppb) in March samples and 1.5 ppb selenium in one May sample and none in another sample.

Cinnamon Teal

The cinnamon teal (Anas cyanoptera) is a dabbling duck that breeds in the western United States and winters in Mexico and Central America (Bellrose 1978). About half of the breeding population is found in Utah in marshes surrounding the Great Salt Lake. In California, most cinnamon teal breed in the Central Valley and in the northeastern part of the State (Bellrose 1978) although Small (1974) classified them as a breeding bird throughout the length of the state, including the Salton Sea. Cinnamon teal are uncommon in the northern half of California in winter; those wintering in the southern half comprise 95 percent of cinnamon teal wintering north of Mexico (Bellrose 1978). Small (1974) indicated in California cinnamon teal are found on freshwater lakes, rivers, ponds and streams, but are rare on salt water, notwithstanding their use of salt marshes in Utah for nesting (Bellrose 1978). Cinnamon teal feed commonly along the margins of lakes and ponds, consuming seeds and vegetative parts of plants (Martin et al. 1951). A limited amount of animal food is consumed, about half insects and half snails and bivalve molluscs. Occurring in relatively small numbers in northern California during the hunting season, few cinnamon teal are taken by hunters. Locally abundant in southern areas of the State, more cinnamon teal may be taken by hunters there.

Cinnamon teal were collected at the Tulare Lake Drainage District (TLDD) South Evaporation Basin, the Westfarmer evaporation ponds (Twisselman Road and Interstate 5), and the Semitropic Water Storage District reservoir site in March 1986, and at TLDD, Semitropic WSD, and the Lost Hills Ranch evaporation ponds in May 1986.

Cinnamon teal selenium levels showed significant differences among sites in March (Table 14). For muscle tissue, mean selenium concentration was higher in teal from TLDD ponds ($\bar{x}$=1.5 ppm) than from the Semitropic WSD reservoir ($\bar{x}$=0.58 ppm). Levels in teal muscle from the Westfarmer ponds ($\bar{x}$=0.92 ppm) were intermediate and not significantly different from the other two sites. Concentrations in liver tissue indicated no difference between teal from TLDD ($\bar{x}$=5.7 ppm) and Westfarmer ($\bar{x}$=4.9 ppm) sites, however teal from both sites had average selenium levels significantly higher than teal from the Semitropic site ($\bar{x}$=2.5 ppm).

In May, teal from TLDD had a significantly higher average selenium concentration in muscle tissue ($\bar{x}$=1.3 ppm) than teal from the Semitropic WSD site ($\bar{x}$=0.59 ppm). Mean selenium level in teal from the Lost Hills Ranch evaporation ponds was intermediate ($\bar{x}$=0.90 ppm) and not significantly different from the other two sites. No difference was found among these three sites in the average selenium concentration in liver samples from cinnamon teal collected in May.

Selenium concentrations in cinnamon teal were not significantly different between March and May at either TLDD or at Semitropic WSD. Limited water sampling also indicated little change in selenium in the water. Together these data suggest the teal were at least temporary residents in these areas and tissue selenium levels were in equilibrium with selenium in the respective environments. No cinnamon teal were using the Westfarmer ponds in May and thus no teal data are available to test for a response to increased selenium in ponds at the Westfarmer site. The absence of teal in May is unexplained, however, the pond dikes are purposefully kept clear of vegetation to discourage bird use and there was no nesting habitat for ducks within the pond complex.

Cinnamon teal from the Tulare Lake Drainage District South Evaporation Basin had average selenium muscle residues (1.5 ppm in March, 1.3 ppm in May) in the upper end of the range measured in cinnamon teal from sites in the Grasslands, including duck clubs and the Los Banos WA, from 1983 to 1985 (0.1 to 1.5 ppm wet weight; DFG, unpublished data). However, the average level in teal from TLDD was only one third of the average selenium level (4.4 ppm) in cinnamon teal from Kesterson NWR in 1983. No data were found on selenium concentrations in cinnamon teal from other areas.

Selenium residues in cinnamon teal muscle were similar to levels in northern shovelers ($\bar{x}$'s=0.45-1.53 ppm) collected in the Grasslands in the winter, 1984-85, and slightly less than shovelers at the same TLDD site ($\bar{x}$=1.9 ppm) from 1982 to 1984 (Gilmer, manuscript in preparation). Cinnamon teal dietary preferences are more similar to those of shovelers than to the food habits of other dabbling ducks commonly found in California.

Cinnamon teal from the Semitropic Water Storage District site had the lowest tissue selenium residues of all Kern County sites, lower than most of the other published data for cinnamon teal. The site serves as a good contrast with subsurface drainwater evaporation ponds in the area since it receives overflow water from irrigation supply canals and stores the water for later use. Water samples contained very low or undetectable concentrations of selenium.

The minimum tissue level of selenium that produces toxic effects in cinnamon teal is unknown and no conclusions were made about the biological significance of levels measured in cinnamon teal at Kern County evaporation ponds.

American Coot

American coots were collected at TLDD and Semitropic WSD in late March to early April; they were much less abundant in May and only three and two coots were collected at these sites, respectively. No coots were seen on or near the Westfarmer ponds during either period, or on the Lost Hills Ranch evaporation ponds which were nearly dry due to a malfunction in a tile drainage sump pipeline.

A significant difference was found between the TLDD and Semitropic sites in both muscle and liver selenium levels of coots collected in March. Compared to coots from the Semitropic WSD reservoir ($\bar{x}$=1.0 ppm in muscle, $\bar{x}$=1.4 ppm in liver), coots from TLDD ponds had average selenium levels two times higher in muscle ($\bar{x}$=2.0 ppm) and 2.5 times higher ($\bar{x}$=3.6 ppm) in liver (Table 14). Selenium levels in tissues of coots from both sites appeared to increase by May, but small sample sizes made statistical comparisons or conclusions tenuous.

Selenium levels in coots from these Kern County sites were compared with coots from the Suisun Marsh and Gray Lodge Wildlife Area. In both winter and spring comparisons, TLDD coots had significantly higher average selenium levels in both tissues ($\bar{x}$'s=2.0-2.5 ppm in muscle, $\bar{x}$'s=3.6-6.7 ppm in liver) than coots from Grizzly Island or Gray Lodge (Table 14). Levels in coots from Semitropic WSD ($\bar{x}$'s=1.0-1.4 ppm in muscle, $\bar{x}$'s=1.4-2.4 ppm in liver) were higher than coots from Grizzly Island, but not significantly different from coots from Gray Lodge. The same pattern was found when comparing birds from these areas in the spring; statistically significant differences were indicated, even though sample sizes were small for some areas. The Semitropic WSD site was not inundated until February storms produced high runoff. Coots using the site in March necessarily were somewhere else in February and probably accumulated selenium at their former location.

Like cinnamon teal, selenium residues in coot tissues reflected the difference in waterborne selenium between the TLDD evaporation ponds and the seasonal wetland at the Semitropic WSD site. Coots at TLDD in May had an average selenium residue in muscle ($\bar{x}$=2.5 ppm) approaching that in coots at Kesterson NWR in 1983 ($\bar{x}$=3.2 ppm; DFG, unpublished). Coots at Kesterson NWR experienced high embryo and hatchling mortality and severe developmental abnormalities in 1983 (Ohlendorf et al. 1986a). The highest concentrations in individual coots (5.8 ppm in March and 4.7 ppm in May) at TLDD exceeded the average at Kesterson but were only about half the maximum levels there (11.0 ppm). Coots at two sites in the Grasslands had selenium residues ($\bar{x}$'s=2.3, 2.5 ppm) similar to coots at TLDD while at a third Grasslands site, residues in coots were lower ($\bar{x}$=1.1 ppm) (DFG unpublished). The concentration at which selenium in coots first produces recognized symptoms of toxicity has not been identified. Most of the coots at TLDD Evaporation Ponds contained selenium levels that are probably benign, however, based on comparisons with available data, some of the coots at TLDD may contain harmful tissue levels.

American Avocet and Black-necked Stilt

American avocets were collected at the four Kern County sites in March and May, 1986. In the March samples, there were no statistically significant differences in selenium levels in avocet liver among the four areas (Table 10). Mean selenium levels almost doubled from March to May in avocets at both TLDD and Westfarmers but did not change significantly in avocets at Lost Hills Ranch and Semitropic WSD. Thus, in May avocets from both TLDD ($\bar{x}$=10.9 ppm) and Westfarmers ($\bar{x}$=11.4 ppm) had significantly higher selenium levels (3-4 times) than avocets from both Lost Hills Ranch ($\bar{x}$=3.5 ppm) and Semitropic WSD ($\bar{x}$=3.0 ppm).

Black-necked stilts were collected at the Westfarmer evaporation ponds in May. Mean selenium concentration in these stilts ($\bar{x}$=14.3 ppm) and avocets ($\bar{x}$=11.4 ppm) collected at the same time were not significantly different. Similarity between these two species was also observed in avocets ($\bar{x}$=2.4 ppm) and black-necked stilts ($\bar{x}$=2.5 ppm) collected in June 1986 at the Sacramento National Wildlife Refuge (Table 10), although selenium levels in birds from Sacramento NWR were much lower. Stilts at the Westfarmer ponds had significantly higher selenium levels than stilts from Sacramento NWR (5.7 times), Grizzly Island (8.6 times) or the Salton Sea (3.7 times).

Tissue selenium levels in American avocets and black-necked stilts, like cinnamon teal and coots, reflected the selenium levels in their aquatic habitat. Although mean selenium concentrations in avocets in March were not significantly different and minimum values were similar among the four sites (1.4 ppm to 2.1 ppm), maximum concentrations were higher at TLDD (12 ppm) and Westfarmer (17 ppm) than at Lost Hills Ranch (6.3 ppm) and Semitropic WSD (3.7 ppm), consistent with concentrations of selenium in water. In May, there was a clear distinction between selenium levels in avocets at ponds containing 30 to 110 ppb selenium (TLDD, Westfarmer) and sites with 5-6 ppb or less in water (Lost Hills Ranch, Semitropic WSD).

Avocets at Westfarmer ponds with 100-110 ppb selenium in water did not accumulate higher tissue levels than avocets at TLDD where water samples contained 8-39 ppb. Possible explanations are 1) water:bird equilibrium concentrations had not been reached, 2) avocets cannot accumulate higher levels, i.e., a tissue saturation level had been reached, 3) avocet food organisms contained saturation levels at both sites and dietary uptake was equal, 4) limited water sampling did not adequately reflect the range of environmental conditions at each site, or 5) avocets were part of a single population with frequent migrations between the two sites which are about 10 kilometers apart. Data are inadequate to evaluate these hypotheses.

Selenium levels in black-necked stilts from the Westfarmer evaporation ponds in May ($\bar{x}$=14.3, range 4.6 to 26 ppm) were similar to levels in stilts from Kesterson NWR ($\bar{x}$=13.0 ppm, range 5.3 to 22 ppm, wet weight converted from dry weight using 72% moisture) (Ohlendorf et al. 1987b). Selenium also was measured in stilt eggs at Kesterson and related to embryotoxicity in stilts in 1983 and 1984 (Ohlendorf et al. 1986b). The similarity in selenium levels in stilts between the Westfarmer ponds and Kesterson suggests possible effects on reproduction at the Westfarmer site in 1986.

Selenium levels in avocets collected in May from the Westfarmer evaporation ponds ($\bar{x}$=11.4 ppm, range 5.5 to 26 ppm) and the TLDD South Evaporation Basin ($\bar{x}$=10.9 ppm, range 6.4 to 17 ppm) were higher than in avocets from Kesterson NWR in 1984 ($\bar{x}$=8.0 ppm, range 7.0 to 10.4 ppm, wet weight converted from dry weight using 72% moisture) (Ohlendorf et al. 1987b). No adverse reproductive effects were observed in avocets at Kesterson in 1984. When embryotoxic effects in avocets were observed at Kesterson in 1985, selenium concentrations in avocet livers averaged 22 ppm (wet weight converted from dry weight using 72% moisture) (Ohlendorf et al. 1987b). The minimum tissue selenium concentration causing reproductive effects in avocets and thus the likelihood of problems for avocets at the Westfarmer and TLDD ponds are unknown. The USFWS currently is conducting further studies of drainage evaporation ponds in Kern County.

KERN COUNTY EVAPORATION PONDS FISH, INVERTEBRATES

Mosquitofish

The mosquitofish (*Gambusia affinis*) is a small fish introduced into California as a mosquito control agent and now found throughout the State in warm ponds, lakes, streams and brackish sloughs (Moyle 1976). Mosquitofish can survive a wide range of environmental conditions. They are prolific breeders bearing live young up to four times per summer; few fish live more than 15 months. Mosquitofish are omnivorous and opportunistic feeders. They feed on whatever is most abundant, sometimes mosquito larvae and pupae but also algae, zooplankton, fishes, terrestrial insects and other aquatic invertebrates (Moyle 1976).

Composite samples of whole mosquitofish from TLDD contained 3.6 ppm and 4.2 ppm. Saiki (1985) found an average of 0.29 ppm (wet weight) in whole mosquitofish from Volta Wildlife Area (range 0.24 to 0.36 ppm), a control site for a study of aquatic food chain contamination at Kesterson Reservoir on the Kesterson NWR. TLDD mosquitofish had ten times the concentration of those at Volta, but less than one-sixth of concentrations in mosquitofish from Kesterson Reservoir (24 to 98 ppm) (Saiki 1985). The significance of these levels to mosquitofish at TLDD is unknown; however, their abundance would indicate no impacts on reproductive potential. No other fish are known to occur in the ponds. Mosquitofish may be eaten by piscivorous birds such as grebes, herons, and egrets which could accumulate selenium from this dietary source.

Water Boatmen

Water boatmen (family Corixidae) are the most numerous of aquatic hemiptera, both in species and individuals (Usinger 1956). Underwater aquatic insects adapted to a wide range of habitats world-wide, various species show strong habitat preferences. Water boatmen occur commonly in brackish and saline waters with brine shrimp (*Artemia salina*) and brine flies (*Ephytdra gracilis*). Corixids play an important ecological role as primary converters of plant material, but they also ingest small benthic organisms and small insect larvae (Usinger 1973) and are themselves consumed by fish and birds.

At TLDD, water boatmen contained 1.6 ppm selenium in the first cell near the inlet channel where water contained 31 to 36 ppb selenium; boatmen contained 3.0 and 3.6 ppm selenium in two samples from an interior cell with 11 to 12 ppb selenium in the water. Thus water boatmen accumulated selenium at about 50 times levels in water in the intake channel (1.6 ppm 32 ppb) and at about 300 times in the interior cell (3.3 ppm from 11 ppb). A possible explanation for the difference in accumulation is that larger water boatmen at the latter site were older and therefore had been accumulating selenium longer, whereas water boatmen in the intake channel had not accumulated equilibrium levels.

At Westfarmer's Evaporation Ponds, water boatmen average 2.1 ppm in residual water at the edge of a cell and 2.6 ppm in an interior cell, indicating bioaccumulation of selenium at 20 to 25 times concentrations in water, about half the accumulation factor derived for the same sized water boatmen at TLDD. Equivalent sized water boatmen contained similar levels of selenium in spite of a ten-fold difference in selenium in the water between Westfarmers (110 ppb) and TLDD (11 ppb).

These selenium levels in the range of 1.6 to 3.6 ppm for water boatmen in drainwater evaporation ponds are intermediate between levels in aquatic insects from Volta Wildlife Area (0.16 to 1.0 ppm in 25 samples) and those from Kesterson NWR (6.2 to 57 ppm in 39 samples) (Saiki 1985). Water boatmen may be included in the diet of mosquitofish and perhaps avocets feeding on brine shrimp by sweeping the bill through shallow waters. Further clarification of food habits of resident biota would be useful in evaluating the potential significance of selenium in food chains at evaporation ponds.

STONY CREEK/BLACK BUTTE RESERVOIR
GLENN AND TEHAMA COUNTIES

Stony Creek and Black Butte Reservoir were included in this study based on findings of the Toxic Substances Monitoring Program in 1984 and 1985. Watkins et al. (1985) reported 1.9 ppm in largemouth bass liver and 1.3 ppm in white crappie (Pomoxis annularis) liver from Black Butte Reservoir in 1984. Selenium in Stony Creek, a triutary to the Sacramento River, is from natural deposits in this eastern slope Coast Range drainage (Figure 8).

Common carp, channel catfish and water samples were collected from two sites in Stony Creek and from Black Butte Reservoir, a low elevation impoundment on Stony Creek, in late-April through early June. Largemouth bass and Sacramento suckers (Catostomus occidentalis) also were collected from the reservoir.

Selenium in water was below the detection limit (0.5 ppb) in samples from Stony Creek upstream (near Elk Creek) and downstream (near Interstate 5) from Black Butte Reservoir. Water from Black Butte Reservoir contained 1.0 ppb selenium in one sample and was below the detection limit in a replicate sample.

Common Carp

Selenium concentration in two composite samples of muscle averaged 0.43 ppm in carp from Stony Creek above Black Butte Reservoir, 0.60 ppm in carp from the Reservoir, and 0.49 ppm in carp from the Stony Creek below the Reservoir (Table 15). Differences between samples at individual sites were as great as differences between sites. These concentrations are low compared to most data published for carp. Carp with 10 ppm selenium in muscle and 30 ppm in viscera persisted as adults for ten years in Belews Lake, but were rendered effectively sterile (Lemly 1985). Saiki (1985) measured 14 to 60 ppm (wet weight) in twelve carp from the San Luis Drain. Specific minimum selenium tissue burdens associated with toxic effects in carp have not been established.

Channel Catfish

Selenium concentrations in composite samples of channel catfish ranged from 0.18 ppm to 0.31 ppm in muscle and from 1.5 to 2.1 ppm in liver. Within site variation was small and differences between sites were not significant (Table 15). Selenium in muscle of channel catfish from Black Butte Reservoir ($\bar{x}$=0.27 ppm) was significantly lower than concentrations in muscle of carp, ($\bar{x}$=0.60 ppm), largemouth bass ($\bar{x}$=0.58 ppm) and Sacramento suckers ($\bar{x}$=0.51 ppm) collected there. These selenium levels are low compared to most published data but higher than levels measured by the Toxic Substances Monitoring Program in channel catfish in the Tuolumne River (0.9 ppm in liver) or the Merced River (0.6 ppm in liver) (Watkins et al. 1985), tributaries to the San Joaquin River without significant selenium input. Saiki (1985) measured selenium levels from 9.3 ppm to 17 ppm in whole channel catfish from the San Luis Drain. Threshold concentrations of selenium producing toxic effects in catfish have not been determined.

Largemouth Bass

Selenium residues in largemouth bass from Black Butte Reservoir ($\bar{x}$=0.58 ppm in muscle, $\bar{x}$=1.50 ppm in liver) were higher than in bass (0.4 ppm, muscle; 0.9 ppm liver) and white crappie (0.3 ppm, muscle; 0.7 ppm, liver) collected there in 1985 (Linn et al. 1986), but lower than in bass in 1984 (1.9 ppm, liver) (Watkins et al. 1985). Largemouth bass from Stony Gorge Reservoir, upstream on Stony Creek, had 1.3 ppm in liver (Linn et al. 1986).

In Lake San Antonio (Monterey County) and Lake Nacimiento (San Luis Obispo County), both western-slope Coast Range impoundments, largemouth bass selenium residues in muscle (1.1 ppm) and liver (3.2 ppm) (Linn et al. 1986) were about two times those at Black Butte Reservoir. Selenium levels in largemouth bass from Black Butte also were lower than levels in largemouth bass from Mud Slough in Merced County (3.3 ppm, liver), San Diego River, San Diego County (3.2 ppm, liver), and the Alamo River, Imperial County (4.4 ppm, liver) but higher than selenium concentrations in largemouth bass from Beach Lake, Sacramento County (1.2 ppm, liver), Rollins Lake (Placer-Nevada Counties) (1.4 ppm, liver), and Don Pedro Reservoir (Tuolumne County) and McClure Reservoir (Mariposa County) (each 1.0 ppm, liver) (Linn et al. 1986).

Sacramento Sucker

The Sacramento sucker is a native fish species, common in the Sacramento-San Joaquin river system and found in a wide variety of waters. Adult suckers have subterminal mouths and feed primarily on filamentous algae, diatoms and detritus, although some invertebrates are consumed (Moyle 1976).

Sacramento suckers from Black Butte Reservoir contained 0.51 ppm selenium in each of two composite samples of muscle tissue. Selenium concentration in muscle of white suckers (Catostomus commersoni) at Belews Lake, North Carolina increased from less than 1 ppm to about 12 ppm within two years as selenium-rich coal ash settling basin effluent raised selenium concentrations in the lake to 10 ppb (Lemly 1985). No other data on selenium in suckers were found.

Selenium concentrations in fish tissue at Black Butte Reservoir were much lower than levels measured in largemouth bass (>20 ppm), and channel catfish (>10 ppm) in Belews Lake where they and 14 other species were eliminated within three years after selenium-rich ash settling basin effluent began flowing into the lake (Lemly 1985). Selenium averaging 10 ppb in water was biomagnified in planktonic and detrital food webs producing dietary toxicity and reproductive failure. There are no data to indicate selenium levels measured in largemouth bass, channel catfish, carp and Sacramento suckers in lower Stony Creek and Black Butte Reservoir are likely to impact these fish populations.

SAN JOAQUIN RIVER AND GRASSLANDS TRIBUTARIES MERCED COUNTY

Sites on the San Joaquin River and its tributaries flowing through the Grasslands in Merced County were included in this study to provide information needed to develop water quality criteria which can be applied to regulate agricultural drainage to the San Joaquin River.

In August, 1986, channel catfish and/or white catfish (*Ictalurus catus*) were collected from four sites in western Merced County: Camp 13 Ditch south of Los Banos; Mud Slough at Kesterson NWR; Salt Slough at state Highway 165; and the San Joaquin River downstream of the Merced River confluence. Flow in these waterways is comprised of a seasonally and annually variable percentage of agricultural return flow from a wide area.

Channel Catfish - White Catfish

Mean selenium level in channel catfish (165-260 mm, FL) from Camp 13 Ditch (0.75 ppm, muscle) was significantly higher than in channel catfish from the San Joaquin River (0.24 ppm) but was not different from mean levels in catfish from Mud Slough (0.50 ppm) or Salt Slough (0.32 ppm) (Table 15). Two larger channel catfish (450, 500 mm, FL) from Salt Slough had lower selenium levels in muscle tissue (0.18 ppm) than smaller channel catfish collected there. White catfish (165-220 mm, FL) had selenium levels comparable to channel catfish in the San Joaquin River, whereas in Salt Slough , the selenium concentration in white catfish (0.19 ppm) was lower than in channel catfish (0.32 ppm). Liver selenium levels were higher in channel catfish from Camp 13 Ditch (2.4 ppm) and Mud Slough (2.6 ppm) than from Salt Slough (1.8 ppm) or the San Joaquin River (1.9 ppm).

Tissue selenium levels in Camp 13 Ditch and Mud Slough channel catfish were similar to levels measured in channel catfish from the Whitewater River and Coachella Canal where selenium in water samples ranged up to 7.0 ppb. In contrast, selenium concentrations in white catfish and channel catfish from Salt Slough and the San Joaquin River were similar to levels in channel catfish from Stony Creek and Black Butte Reservoir where selenium in water was 1 ppb or less.

Selenium residues in catfish at these sites were higher than in catfish collected in 1984 in the San Joaquin River at Twitchell Island (1.1 ppm, liver, white catfish) and Vernalis (1.4 ppm, white catfish; 1.0 ppm, channel catfish) and in Old River (1.1 ppm, channel catfish) (Watkins et al. 1985). Higher selenium residues in catfish from Camp 13 Ditch and Mud Slough suggest exposure over a longer period or to higher levels of selenium in water or food organisms than in Salt Slough or the San Joaquin River downstream. All of these waterways have received some subsurface agricultural drainwater containing high selenium levels in recent years. From June through September, 1985, dissolved selenium averaged 21 ppb in Mud Slough near Gustine, 5.5 ppb in Salt Slough near Stevinson, and 4 ppb in the San Joaquin River downstream of the Merced River confluence (Gilliom 1986). Selenium residues in catfish reflect this recent exposure history. These concentrations are far below those measured in channel catfish (>10 ppm) at Belews Lake where they were eliminated by dietary toxicity and/or reproductive failure caused by selenium (Lemly 1985). The threshold concentration at which impacts of selenium on catfish may occur is not known. Hence the significance of selenium levels measured in channel and white catfish in the San Joaquin River and Grasslands tributaries is unknown.

Evidence of fishing activity was apparent at all sites except on Kesterson NWR (Mud Slough). As with most waters in the State with public access, people fish these waters and consume the fish they catch.

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APPENDICES

Appendix A. Locations of Sampling Sites, January-August, 1986.

Antioch - 38°03'N, 121°42'W. The San Joaquin River near Schad Landing, approximately 7 km upstream of the Antioch Bridge, Contra Costa County.

Black Butte Reservoir - 39°48'N, 122°21'W. Black Butte Reservoir, West of Orland, Glenn County.

Clarksburg - 38°26'N, 121°31'W. Sacramento River adjacent to Clarksburg, Yolo County.

Camp 13 - 38°56'N, 120°42'W. The Camp 13 Ditch, just downstream from its intersection with the C.C.I.D. Main Canal, approximately 17 km south of Los Banos, Merced County.

Central San Francisco Bay - 37°54'N, 122°25'W. The portion of San Francisco Bay bordered by the Richmond-San Rafael Bridge to the north, the Golden Gate Bridge to the west and the Oakland-Bay Bridge to the south.

Coachella Canal - 33°40'N, 116°17W. The Coachella Canal, approximately 2 km upstream from Lake Cahuilla, Riverside County.

Gray Lodge Wildlife Area - 39°29'N, 121°48'W. Off Pennington Road approximately 16 km southwest of Gridley, Butte County.

Humboldt Bay - 40°43'N, 124°14'W. Humboldt Bay, Humboldt County.

Lost Hills Ranch Evaporation Ponds - 35°34'N, 119°33'W. Evaporation ponds on Lost Hills Ranch, in the Old Goose Lake bed, approximately 2 km southwest of the intersection of Wedel and Jackson Avenues, approximately 10 km southwest of Lost Hills, Kern County.

Mud Slough - 37°16'N, 12°55'W. Mud Slough on Kesterson National Wildlife Refuge, approximately 200 m. north of the end of the San Luis Drain, Merced County.

Palo Verde Outfall Drain - 33°24'N, 114°43'W. Palo Verde Outfall Drain from the South Highway 78 crossing, south to Mitchell's Camp, Imperial County.

Reservation Drain - 32°74'N, 114°43'W. Reservation Drain where it crosses Fisher Road, northeast of Winterhaven, Imperial County.

Salton Sea - 33°10'N, 115°42'W. The Salton Sea, including Salton Sea National Wildlife Refuge, Imperial County.

Salt Slough - 37°15'N, 120°51'W. Salt Slough upstream from the Lander Avenue (Highway 165) crossing, Merced County.

Sacramento National Wildlife Refuge - 39°27'N, 122°10'W. Sacramento N.W.R., approximately 10 km south of Willows, Glenn County.

Semitropic Water Storage District Ponds - 35°34'N, 119°33'W. Ponds in the old Goose Lake Bed, approximately 2 km southwest of the intersection of Wedel and Jackson Avenues, 10 km southeast of Lost Hills, Kern County.

San Joaquin River at Merced River - 37°21'N, 120°58'W. San Joaquin River just downstream from its confluence with the Merced River, Merced County.

San Pablo Bay - 38°03'N, 122°23'W. San Pablo Bay north of the Richmond-San Rafael Bridge and west of the Carquinez Bridge.

South San Francisco Bay - 37°38'N, 122°15'W. San Francisco Bay south of the Oakland-Bay Bridge.

Stony Creek A - 39°44'N, 122°24'W. Stony Creek, approximately 5 km above Black Butte Reservoir, Glenn County.

Stony Creek B - 39°47'N, 122°12'W. Stony Creek, where it is crossed by Interstate 5, 2 km north of Orland, Glenn County.

Suisun Bay - 38°04'N, 122°03'W. Suisun Bay between the Carquinez Bridge and Antioch, including Grizzly Bay.

Suisun Marsh - 38°08'N, 121°57'W. That portion of the Suisun Marsh on Grizzly Island Wildlife Area, south of Fairfield, Solano County.

Tulare Lake Drainage District Ponds - 35°47'N, 119°40'W. Ponds located north of Kern National Wildlife Refuge and just south of the Kings County line, 6 km west of Corcoran Rd., Kern County.

Twisselman Road, Westfarmers Evaporation Ponds - 35°44'N, 119°44'W Evaporation ponds located southeast of the intersection of Twisselman Road and Interstate 5, Kern County.

Whitewater River - 33°31'N, 116°04'W. The Whitewater River south of Indio, approximately 0.5 km upstream from the Salton Sea, Riverside County.

APPENDIX B. Sample Preparation.

Sample Container Preparation

Glass milk dilution bottles (160 mL) with Teflon-lined screw lids serve as sample containers. Bottles and lids are washed with warm water and soap (Haemo-sol) manually or by dishwasher. Care must be taken using the dishwasher because soap residue may adhere to the inner surface of the bottles and/or lids. Usually a second rinse will correct this problem. After thoroughly rinsing both bottle and lid with tap water, rinse the inner surfaces as follows:

1) 25mL of 1.0 M nitric acid (analytical reagent grade);
2) 25mL of Type I reagent grade water (ASTM 1986);
3) 25mL of 2-propanol (analytical reagent grade).

To ensure all surfaces are exposed to solvents, rotate bottles when pouring out solvents. Allow 15 minutes for bottles to air-dry before using.

If linear polyethylene (LPE) bottles are to be used, fill with 1.0 M nitric acid and allow to soak for at least 24 hours and rinse with Type I water.

Clean Room Preparation for Dissection and Homogenization

Before entering the clean room, set the fan to the highest speed. This will create a positive pressure of filtered air to prevent contaminants from entering the room. Hands must be washed throughly before handling any samples or equipment used in dissection. Allow deionized water to run 5 to 10 minutes to purge the pipes. All counter tops and glass surfaces must be wiped with Kimwipes and Type III general laboratory water (ASTM 1986). Finally, the glass surfaces used for dissection must be covered with aluminum foil with the dull face of the foil exposed. Use the following list for equipment check:

aluminum foil
chromium coated nickel-silver scalpel handles
carbon steel scalpel
Teflon forceps
large and small "v" tissue forceps
pliers, cutting
glass milk dilution bottles (160 mL) with Teflon lined lids
1.0 M nitric acid (analytical reagent grade)
2-propanol (analytical reagent grade)
Teflon tape
vernier caliper
deionized water (Type I and Type III)

APPENDIX B (Continued)

Dissection Tool Preparation

All dissecting tools must be chemically cleaned before touching the sample(s). All tools must be recleaned and blades changed after each composite or individual sample.

Wash tools (except blades) using warm soapy water and toothbrush. Attach clean blades to scalpels, then briefly rinse all tools in 1.0 M nitric acid, Type I water, and 2-propanol. Place tool handles on a foil covered box so blades are suspended over the edge on the box.

Periodic washing of the solvent bottles and changing of the solvents will be necessary to reduce the possibility of contaminating subsequent samples. Solvent bottles must be washed at least once a week and solvents changed about every tenth sample or after each day.

Sample portions to be used for analysis may only be touched by dissecting tools and the inside of the bottle. Contaminated equipment must be recleaned. Minimize solvent contact with skin. Wash skin after contact with solvents.

Dissection Procedures

General

Remove frozen samples from freezer and thaw just enough to allow dissection. Packages may be thawed overnight in the refrigerator, or to accelerate thawing the package is opened and the exposed samples are placed under running Type III deionized water. If whole body samples are to be used, Type I water is used to thaw samples (see Whole Body Samples). Record length (to nearest mm) and weight (to nearest 0.1 g) for each individual. For example, fork length is used for fish and the length of beak to tail is used for birds. Samples to be dissected are then placed on aluminum foil to air dry. If there is excess mucous, a toothbrush and Type I water may be used to scrub the fish (for non-whole body samples only). Whole body samples can be cleaned by holding the individual(s) with chemically cleaned Teflon forceps under a stream of Type I water.

All dissected portions of the sample are placed in a chemically cleaned milk dilution bottle and labeled with the sample number. The bottle weight and the weight of the bottle plus the dissected material must be recorded on a dissection data sheet. The sample is then ready for homogenization.

Fish Flesh

Dissect the smallest fish of a composite first. The weight of this tissue sample will determine the weight of the tissue core

APPENDIX B (Continued)

to be taken from other fish in the composite: these should be equal. The weight contribution of each fish in the composite is recorded. Ideally, a total of 50 g of flesh is needed for analysis. Blade changes or instrument washing is not necessary when cutting fish from same composite unless instruments become contaminated.

Make a U-shaped incision in the skin using a clean scalpel (Figure 1). The curved portion of the incision is just posterior of the operculum. The legs of the U-shaped incision run the length of the body just ventral to the dorsal fin and just ventral of the lateral line and should be just deep enough to cut only the skin. Grasp the skin near the operculum with the tissue forceps and pull the skin caudally, exposing the flesh. If the fish is unusually large or the skin unusually hard to peel back, the pliers used to remove the scalpel blades can be used to remove the skin. Naturally, the pliers must be chemically cleaned before this use.

Make an oval incision with a second scalpel (coring scalpel) in the flesh inside the "U" formed by the previous incision. This new incision should be well inside the area touched by either the incision scalpel or the forceps as described in previous steps. Ideally, take the inner core 1 cm inside the anterior end of the incision scalpel cut and 5 mm inside the remaining portion of the "U". Small fish do not allow the luxury of these buffering zones and may require that flesh from both sides of fish be taken.

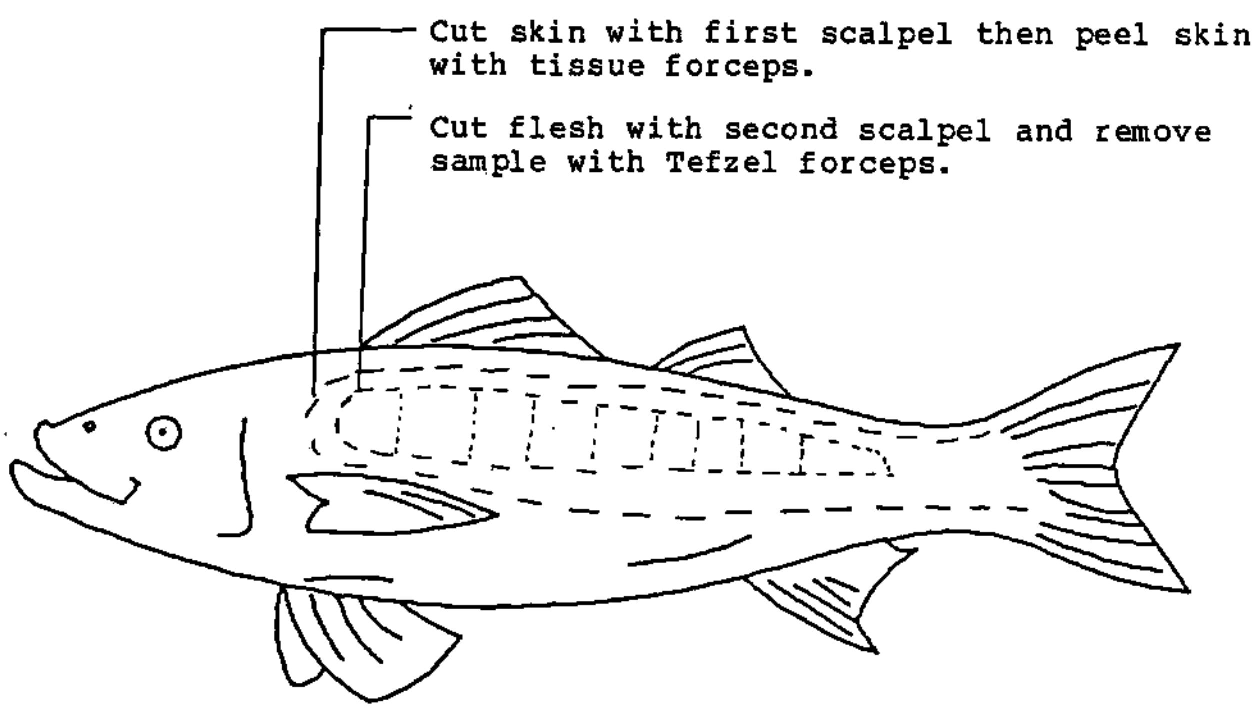

FIGURE 1. Diagram of fish dissection.

APPENDIX B (Continued)

Care must be taken to minimize the contact of flesh samples from small fish with the incision cut. Use clean Teflon forceps to hold the core while the coring scalpel is used to free it from the skeleton. Subsamples from the core should represent the entire length of the fish; these should be cut in small pieces (5 to 10 g) and rinsed with Type I water before being placed in the bottle. Weigh the empty bottle and the flesh from each individual for composite samples. Any sample pieces dropped must be thrown away. Any irregularities like tumors, parasites, or wounds should be noted on the data sheet.

Bird Flesh

After the flesh has been fluoroscoped to locate lead or steel shot, the portions not contaminated by pellets are ready for dissection. Use only the portions of breast that have not been exposed to the air (inner core) to make up the sample. Using a scalpel, dissect strips of flesh from the length of the breast for a total weight of approximately 50 g. These strips are then placed in a sample bottle. Use chemically cleaned instruments for dissection of each new sample to avoid cross contamination.

Liver

Livers of birds and some species of fish are removed for analysis. This is achieved by opening the thoracic and abdominal area using the incision scalpel and removing the liver using a coring scalpel and Teflon forceps. The liver is then rinsed with Type I water, and placed in the sample bottle. When preparing composite liver samples, each individual liver is weighed and values are recorded on the dissection sheet.

Whole Body Samples

If whole body samples are to be prepared, a slightly different technique is required. Only chemically clean Teflon instruments can touch whole body samples. Samples are removed from the freezer and allowed to thaw. Only Type I water is used to clean or thaw samples. Two Teflon forceps are used to handle and rinse (clean) samples. To accelerate thawing the whole sample of individuals can be rinsed with Type I water. Record the length of each individual using a vernier caliper and place in sample bottle. The weight of each individual of the composite is recorded.

Shellfish

The soft portions excluding the shell (carapace) are used for shellfish samples. The individual is weighed and the length is

APPENDIX B (Continued)

measured at its longest point before it is rinsed with Type I water. The outer shell may be touched by hand but the inner parts may not. The shell is then broken open by hand and tissue inside the shell is removed with the use of Teflon forceps and a scapel. Dissected portions of the shellfish are placed in a sample bottle and measurements are recorded on the sample disection sheet.

Homogenization Procedures

Samples are first thawed. A measured amount of Type I water may be added to flesh and whole body samples to help facilitate homogenization. Water is not added to liver samples. Equipment needed in the homogenization procedure include:

Polytron with titanium shaft and Teflon bearing
Safety goggles and ear protectors
3 1000 mL beakers
2 400 mL beakers
1 160 mL milk dilution bottle
Teflon wash bottle
Teflon policemen
stainless steel forceps

The two 400 mL beakers and the 160 mL milk dilution bottle are chemically cleaned (see Sample Container Preparation, pg. 2). The Polytron titanium shaft must be cleaned before and after each sample to eliminate possibility of cross contamination. Cleaning of the titanium shaft is accomplished as follows:

1) operate polytron for 3 minutes in a 1000 mL beaker filled with Type III water 6 to 20 changes or until water remains clear (use a toothbrush, stainless steel forceps and wash bottle to remove macro-sized particles only after turning main switch off);
2) rinse shaft with 1.0 M nitric acid (analytical reagent grade) by pouring acid in a 160 mL milk dilution bottle and placing the shaft in the bottle (note: replace acid after about 5 rinses);
3) operate unit in a 400 mL beaker filled with Type I water;
4) rinse shaft with 2-propanol (analytical reagent grade) by squirting solvent from a Teflon wash bottle;
5) allow unit to air dry for 5 minutes minimum before use.

APPENDIX B (Continued)

Caution

Homogenization of flesh and liver samples with a Polytron can be dangerous. Ear protection and safety goggles must be used at all times when operating the polytron. Place sample bottles in a LPE potective sleeve to protect operator from glass if the bottle shatters. Keep a firm grip on the beaker or bottle. High speeds should not be used because friction will cause the samples to burn; use only the minimal amount of power needed to homogenize the sample. Inspect the machine before and after each day's work for any loose play in the generator. The bushing in the shaft will have to be changed when the play becomes excessive and the generator sounds noticeably louder during operation.

APPENDIX C. Analysis

General

All tissue samples are analyzed by hydride generation atomic absorption spectrophotometry (HGAA). Selenium values may be double checked using an alternate method with Zeeman corrected graphite furnace atomic spectrophotometry (GFAA). If, during the course of analysis, Se values derived from HGAA and GFAA can not be reconciled (within 20 % of each other), the sample will be sent to the University of Missouri, Research Reactor Facility (UMRR), for neutron activation. Further, WPCL will initiate and participate in round-robin analyses with other involved laboratories for the purpose of gathering additional information on WPCL accuracy and precision.

Selenium HGAA Analysis Procedure

Dry Ashing Procedure[1/]

1. In a 100 mL Pyrex beaker with watch glass cover, place approximately 0.25 g to 0.50 g of wet tissue or 0.20 g of lyophilized tissue wetted with methanol.
2. Add 10mL of reagent grade 40% $Mg(NO_3)_2 \cdot 6H_2O$, 60% H_2O (w/w).
3. Add 100-300 uL Dow Corning DB150A antifoam emulsion.
4. Place samples in Thermolyne programmable ashing furnace Model #F30430C. Program furnace to dry samples at 115°C for 800 minutes and ash at 500°C for 90 minutes with a 3°C/min ramp for both dwell temperatures.

Reduction Procedure

1. Add 10 mL Type I water to ashed samples.
2. Add 15 mL concentrated hydrochloric acid (analytical reagent grade).
3. Dissolve residue by heating (do not boil) for 10 minutes on hot plate set at a temperature of 200°C.
4. Quantitatively transfer samples to 100 mL volumetric flasks. Samples must be analyzed within 24 hours.

Instrumental Conditions

Selenium samples are analyzed on a Varian Spectra 30 Atomic Absorption Spectrophotometer with a Vapor Generation Accessory (VGA) Model 76. The light source is provided by a Westinghouse electrodeless discharge lamp (EDL). Instrument parameters and selenite standard concentrations are described below (Table C-1).

1/ (May, T., 1982)

APPENDIX C (Continued)

Table C-1. Analytical Parameters for Hydride Generation Atomic Absorption Spectrophotometry

Varian Spectra 30 AA System parameters:

Instrument Parameters

Element	Se
Lamp Position	1
Lamp Current (mA)	5
Slit Width (nm)	1.0
Slit Height	Normal
Wavelength (nm)	196.0
Flame	Air-Acetylene
Sample Introduction	Auto Normal
Replicates	3
Measurement Time (sec)	8
Delay Time (sec)	40
Background Correction	on

Sample Changer

Rinse Rate	1
Rinse Time (sec)	30.0
Recalibration	8
Reslope Rate	0

Standards

Standard 1	0.0050
Standard 2	0.0100
Standard 3	0.0150
Standard 4	0.0200
Concentration units	ug/mL (PPM)

Reagents used with the VGA include concentrated hydrochloric acid (analytical reagent grade) and 0.33% sodium borohydride (w/w) stablized with 0.5 percent sodium hydroxide (w/w) in Type I water.

For every batch of samples, the blank, sensitivity check, control materials, and duplicates are completed as described below. In addition, one or more samples of each kind of matrix in a batch are analyzed by standard addition to determine the matrix effect and the necessity to "spike" remaining samples.

APPENDIX C (Continued)

Blank

An analytical or procedural blank is carried through with each group of samples to determine Se contamination by reagents. Appropriate corrections are made to analytical results for samples based on the blank response.

Instrument Sensitivity Check

The sensitivity of the spectrophotometer is checked at the beginning of each group of samples. For an adequate sensitivity response, the resulting sensitivity check must be within 2 times of the manufacturer's specifications. If not, the instrument is again optimized and recalibrated using appropriate Se standards made to achieve maximum sensitivity.

Control Materials

Two or more different types of control materials are analyzed with each sample group. Control materials include (i) National Bureau of Standards (NBS) 50 tuna, (ii) NBS 1566 oyster, and (iii) NBS 1577a bovine liver. Reference material results are acceptable only when they are within the 95% confidence level.

Duplicates

A total of 10% of the samples are selected at random and analyzed in duplicate as a check of analytical precision.

Arsenic HGAA Analysis Procedure

The HGAA arsenic procedure is identical to the selenium procedure described above except for the following: an arsenic EDL at 193.7 nm is used, arsenic (III) is used for the standards, and 2 mL of 50% potassium iodide (analytical reagent grade) is added to the volumetric flasks after step 4 of the reduction procedure and allowed to sit in the dark for at least 1 hour. The VGA 76 has two sets of tubing, connections, and quartz cells. The set exposed to potassium iodide can only be used for arsenic. Also, any glassware that comes in contact with potassium iodide must be rinsed at least 5 times with Type III water and stored in 0.5 M nitric acid for at least 24 hours.

APPENDIX C (Continued)

Selenium GFAA Analysis Procedure

Analysis Sample Bottle Cleaning Procedure

1. Add 2 mL concentrated nitric acid (analytical reagent grade) to 30 mL narrow neck LPE bottles.
2. Fill with Type I water, screw on cap, and shake.
3. Allow to stand at least 24 hours.
4. Discard nitric acid solution and rinse with Type I water. Use bottle in Sample Preparation.

Sample Preparation

1. Weigh 0.50 g of sample into a clean LPE bottle.
2. Add 2.0 mL concentrated Ultrex nitric acid.
3. Cap and place in hot water bath (60 to 70°C) for 2 hours.
4. Cool to room temperature.
5. Open under hood with a towel around the cap.
6. Squeeze the bottle to remove nitrogen dioxide fumes.
7. Add 17.5 mL of Type I water.
8. Cap and tumble in hot water bath for 30 minutes.
9. Cool to room temperture.

Instrument Conditions

Selenium samples are analyzed with the following Perkin-Elmer equipment: Zeeman 3030 GFAA, Heated Graphite Atomizer 600, Autosampler 60, an EDL set at 6.0 watts, and pyrolytic coated graphite tubes with the L'vov platform. Prior to analysis, samples are premixed with nickel nitrate (analytical reagent grade) to obtain a final concetration of 0.064 M of this matrix modifier. One or more samples of each kind of matrix in a batch are analyzed with at least two levels of standard addition using instrumental parameters described below (Table C-2). The matrix effect established by standard addition with the first sample in a group (samples of a similar matrix) determines the matrix correction factor by which the remaining samples are calculated. In addition, blanks, sensitivity checks, control materials, and duplicates are done with every batch as previously described.

Table C-2. Analytical Parameters for Graphite Furnace Atomic Absorption Spectrophotometry

PROGRAMMING MODE INSTURMENT

ELEMENT: SE, WAVELENGTH (NM): 196.0, SLIT (NM): 0.7 PYRO COATED TUBE WITH PLATFORM-MAX POWER HEATING-GAS STOP-MATRIX MOD. PRETREAT TEMP: 900, ATOMIZE TEMP: 2100, CHARACT. MASS (PG): 30.0

1. TECHNIQUE: ZEEMAN
2. LAMP CURRENT (MA): 0
3. SIGNAL PROCESSING: PEAK AREA
4. CALIBRATION: ADDITION CALIB.
5. TIME (SECONDS): 4.0
6. READ DELAY (SECONDS): 0.0
7. SCREEN FORMAT: 0.3 GRAPHICS
8. PRINTER: MAIN SUPPL PEAK
9. RECORDER SIGNAL: 0.2 CONT ABS
10. RECORDER EXP: 1000
11. STATISTICS: 2 AVE. & SD & CV
12. NOMINAL WEIGHT 1.0
13. ROLLOVER(ABS): 1.400
14. BG SCALE: 0.3
15. S1: 2.00
16. S2: 4.00

PROGRAMMING MODE HGA 600

STEP NUMBER	FURNACE TEMPERATURE	TIME RAMP	TIME HOLD	INTERNAL GAS FLOW	READ
1	90	1	40	300	
2	100	1	20	300	
3	140	5	20	300	
4	900	20	20	300	
5	900	1	4	0	
6	2000	0	5	0	*
7	2500	1	3	300	
8	20	1	10	300	

PROGRAMMING MODE AUTOSAMPLER

ADDITION CALIBRATION: PREMIXED

SOLUTIONS	LOCATION	VOLUME	BLANK VOLUME
BLANK	01	--	20
SAMPLE	02 TO 25 WITH MODIFIER - + -	20	--

NUMBER OF INJECTION: 01

Sample Moisture Determination

Samples are sub-sampled into a pre-weighed aluminum weighing dish. The dish with the wet sample is weighed and placed in an oven for 48 hours at 80°C. After drying, the weight of the dry dish with the sample is taken and recorded for moisture calculations.

APPENDIX C (Continued)

Neutron Activation Analysis of Selenium in Water

The analysis consists of pipetting 10 mL of water sample (in duplicate) into an Erlenmeyer flask and adding 6 mL of concentrated hydrochloric acid, arsenic carrier and a Se-75 tracer. The samples and blanks are heated on a hot plate until they reached 80 ^{o}C. The arsenic and selenium are co-precipitated with hypophosphorous acid. After precipitation the samples are then filtered on a Nucleopore filter and packaged into polyethene vials. All samples are counted for Se-75 tracer to determine the percent yield. The samples are then irradiated and analysed as described by McKown and Morris, (1978). Finally, calculations are made to correct for the contributions due to blank and percent yeild.

APPENDIX D. Results of (WPCL) selenium duplicate analyses in ug/g wet weight.

Sample #	HGAA Duplicates	Mean	% RSD[1/]
B21F	0.47, 0.46	0.46	1.5
B22F	3.7, 3.7	3.7	0
B24F	1.6, 1.5	1.6	4.6
B31F	4.3, 4.4	4.4	1.6
B32F	2.3, 2.4	2.4	3.0
B61F	0.72, 0.69	0.70	3.0
B93F	1.0, 1.1	1.0	6.7
B106F	1.6, 1.6	1.6	0
B108F	1.6, 1.6	1.6	0
B109F	2.7, 2.7	2.7	0
B126F	0.24, 0.24	0.24	0
B192F	1.6, 1.6	1.6	0
B276F	2.0, 2.0	2.0	0
B325F	0.71, 0.71	0.71	0
B332F	2.3, 2.4	2.4	0
B334F	1.5, 1.5	1.5	0
B343F	1.2, 1.2	1.2	0
B381F	0.57, 0.58	0.58	1.2
B405F	0.89, 0.89	0.89	0
B451F	0.56, 0.56	0.56	0
B456F	0.33, 0.39	0.35	12
B485F	0.50, 0.46	0.48	5.9
B486F	0.77, 0.75	0.76	1.9
B490F	0.76, 0.76	0.76	0
B491F	0.28, 0.28	0.28	0
B500F	0.77, 0.78	0.78	.91
B3L	0.89, 0.90	0.90	.79
B24L	10, 11	10	6.7
B29L	22, 21	22	3.3
B40L	7.7, 7.4	7.6	2.8
B41L	4.5, 4.5	4.5	0
B42L	1.4, 1.4	1.4	0
B52L	1.7, 1.7	1.7	0
B56L	4.2, 4.2	4.2	0
B67L	3.2, 3.2	3.2	0
B69L	7.1, 7.2	7.2	.99
B73L	6.0, 5.8	5.9	2.4
B74L	7.2, 7.1	7.2	.99
B81L	4.4, 4.3	4.4	1.6
B92L	7.6, 7.3	7.4	2.8
B103L	9.1, 8.9	9.0	1.6
B110L	4.8, 4.8	4.8	0
B119L	0.56, 0.55	0.56	1.3
B134L	7.9, 8.3	8.1	3.5

1/ Relative Standard Deviation RSD = (standard deviation / mean) x 100.

APPENDIX D (Continued)

Sample #	HGAA Duplicates	Mean	% RSD[1/]
B155L	2.8, 2.9	2.8	2.5
B160L	10, 10	10	0
B162L	15, 15	15	0
B183L	3.5, 3.4	3.4	2.0
B200L	4.1, 4.2	4.2	1.7
B221L	4.9, 4.5	4.7	6.0
B224L	2.4, 24.4	2.4	0
B237L	3.3, 3.3	3.3	0
B243L	3.4, 3.4	3.4	0
B271L	3.4, 3.5	3.4	2.0
B282L	3.8, 3.9	3.8	2.0
B288L	3.2, 3.1	3.2	2.2
B297L	2.5, 2.6	2.6	2.8
B298L	3.0, 2.8	2.9	4.9
B307L	3.8, 3.6	3.7	3.8
B318L	1.7, 1.7	1.7	0
B333L	3.4, 3.5	3.4	2.0
B341L	4.8, 4.8	4.8	0
B345L	4.6, 4.5	4.6	1.6
B346L	5.5, 5.5	5.5	0
B349L	6.8, 6.8	6.8	0
B351L	8.6, 8.7	8.6	1.6
B354L	7.8, 7.9	7.8	.90
B355L	9.8, 9.5	9.6	2.2
B356L	9.3, 9.4	9.4	.76
B357L	5.1, 5.2	5.2	1.4
B358L	9.5, 9.2	9.4	2.3
B410L	2.0, 2.0	2.0	0
B442L	4.2, 4.2	4.2	0
B444L	3.3, 3.4	3.4	2.1
B445L	3.3, 3.3	3.3	0
B446L	4.3, 4.3	4.3	0
B485L	1.5, 1.5	1.5	0
B489L	0.78, 0.79	0.78	.90
B492L	0.56, 0.52	0.54	5.2
B495L	1.6, 1.6	1.6	0
B496L	0.65, 0.65	0.65	0
B557L	4.3, 4.0	4.2	5.1
B560L	4.4, 4.4	4.4	0
F19F1	0.41, 0.40	0.40	1.7
F25F	0.48, 0.48	0.48	0
F26W	0.52, 0.52	0.52	0
F28F2	0.39, 0.39	0.39	0
F31F	1.2, 1.1	1.2	6.1
F35F	0.82, 0.80	0.81	1.7
F39F	0.33, 0.34	0.34	2.1
F56W2	0.46, 0.44	0.45	3.1
F69F2	0.48, 0.45	0.46	4.6
F71F	0.58, 0.57	0.58	1.2

APPENDIX D (Continued)

Sample #	HGAA Duplicates	Mean	% RSD[1/]
F74W	0.34, 0.33	0.34	2.1
F84F	2.9, 2.9	2.9	0
F102F	3.1, 3.1	3.1	0
F117F	1.0, 1.1	1.0	6.7
F118F	1.1, 1.1	1.1	0
F151W2	4.3, 4.2	4.2	1.7
F156F	4.1, 3.8	4.0	5.4
F162F	1.7, 1.6	1.6	4.3
F165F	1.1, 1.1	1.1	0
F182F1	0.42, 0.42	0.42	0
F192F2	0.25, 0.27	0.26	5.4
F193F1	0.56, 0.46	0.51	14
F241F	0.58, 0.57	0.58	1.2
F305F	0.52, 0.52	0.52	0
B325F	1.7, 1.7	1.7	0
F2L1	3.4, 3.4	3.4	0
F6W1	0.34, 0.31	0.32	6.5
F16L1	1.2, 1.2	1.2	0
F18L1	1.6, 1.6	1.6	0
F34L	1.6, 1.5	1.6	4.6
F156L	3.1, 2.9	3.1	4.7
F162L	2.7, 2.7	2.7	0
F165L	2.3, 2.3	2.3	0
F166L	1.7, 1.7	1.7	0
F228L	1.5, 1.5	1.5	0
I7W2	0.46, 0.46	0.46	0
I13F2	0.28, 0.30	0.29	4.9
I20F1	0.96, 0.96	0.96	0
I22W2	1.6, 1.6	1.6	0
I24W1	2.7, 2.7	2.7	0
I24WB	2.6, 2.5	2.6	2.8
I31F2	0.72, 0.72	0.72	0
I32F1	0.49, 0.50	0.50	1.

Mean RSD for HGAA = 1.7 percent

APPENDIX D (Continued). Results of (WPCL) selenium GFAA duplicate analyses in ug/g wet weight.

Sample #	GFAA Duplicates	Mean	% RSD[1/]
B25F	1.7, 1.7	1.7	0
B32F	1.8, 1.8	1.8	0
B41F	1.2, 1.4	1.3	11
B93F	1.0, 1.1	1.0	6.7
B147F	1.4, 1.4	1.4	0
B149F	2.0, 2.1	2.0	3.4
B325F	0.72, 0.98	0.85	22
B381F	0.66, 0.60	0.63	6.7
B451F	0.54, 0.54	0.54	0
B2L	0.86, 0.75	0.80	9.7
B3L	0.94, 0.98	0.96	2.9
B21L	1.5, 1.5	1.5	0
B24L	10, 10	10	0
B31L	30, 25	28	13
B34L	10, 10	10	0
B56L	4.2, 4.0	4.1	3.4
B67L	3.7, 3.7	3.7	0
B81L	4.5, 4.9	4.7	6.0
B110L	4.7, 5.0	4.8	4.4
B200L	4.2, 4.7	4.4	7.9
B298L	3.1, 3.0	3.0	2.3
B324L	1.3, 1.2	1.2	5.7
B333L	3.8, 3.6	3.7	3.8
B341L	4.7, 4.5	4.6	3.1
B346L	4.8, 4.8	4.8	0
B349L	7.9, 7.2	7.6	6.6
B351L	8.6, 9.5	9.0	7.0
B354L	8.1, 8.1	8.1	0
B355L	9.7, 9.6	9.6	.73
B356L	11, 12	12	6.1
B357L	5.9, 5.6	5.8	3.7
B358L	7.7, 8.6	8.2	7.8
B377L	10, 9.8	9.9	1.4
B410L	2.0, 2.1	2.0	3.4
F114F	4.5, 4.4	4.4	1.6
F122L	4.1, 4.2	4.2	1.7
I24W2	3.3, 3.4	3.4	2.1

Mean RSD for GFAA = 4.2 percent

APPENDIX D (Continued). Results of (WPCL) duplicate moisture determinations.

Sample #	% Moisture Duplicates	Mean	% RSD[1/]
B110L	71, 71	71	0
B288L	71, 73	72	2.0
B338L	71, 72	72	.99
B334F	72, 72	72	0
B343F	70, 70	70	0
B345L	65, 77	71	12
B346L	70, 70	70	0
B349L	73, 73	73	0
B351L	71, 71	71	0
B354L	75, 74	74	.95
B355L	72, 72	72	0
B356L	74, 74	74	0
B357L	72, 72	72	0
B381F	74, 74	74	0
B405F	73, 73	73	0
B444L	70, 70	70	0
B446L	70, 69	70	1.0
B451F	71, 71	71	0
B456F	73, 73	73	0
B489L	65, 66	66	1.1
B490F	70, 70	70	0
B500F	71, 71	71	0
F6W2	81, 81	81	0
F19F1	76, 76	76	0
F25W	81, 81	81	0
F26W	74, 74	74	0
F28F2	75, 75	75	0
F56W2	77, 77	77	0
F71F	81, 81	81	0
F74W1	72, 71	72	.99
F84L	48, 52	50	5.7
F102F	80, 80	80	0
F166L	68, 68	68	5.7
F182W	79, 79	79	0
F325L	72, 72	72	0
I13F2	92, 92	92	0
I20F1	80, 81	80	.88
I32F1	89, 89	89	0

Mean RSD of moisture = 0.82 percent

APPENDIX E. TRACE ELEMENT CONCENTRATIONS IN ug/g WET WEIGHT.1/

Sample Number	Tissue Type	Location	Date	Species	Ag	As2/	Cd	Cr	Cu	Hg	Pb	Zn
F53	F	STNYB	05/14/86	CHNCAT	<.008	0.05	<.003	<.04	0.4	.24	<.03	5.9
F53	L	"	"	"	<.008	0.08	.226	<.04	4.6	.18	<.03	24.4
F86 3/	F	SALTN	05/19/86	CORVNA	<.008	0.97	<.003	<.04	<0.2	<.03	<.03	3.2
F86	L	"	"	"	<.008	0.42	.005	<.04	0.8	<.03	<.03	10.0
F156	F	SNPBB	03/09/86	WSTRGN	<.008	1.3	<.003	<.04	0.5	.14	<.03	3.1
F156	L	"	"	"	<.008	1.2	.160	.04	12.6	.07	.09	26.2
F162	F	"	04/04/86	"	<.008	1.2	<.003	<.04	<0.2	.17	.06	2.5
F162	L	"	"	"	.979	1.2	.270	<.04	38.2	.14	.12	53.4
F192	F	BBRES	06/11/86	CHNCAT	<.008	<.04	<.003	<.04	<0.2	.29	<.03	7.0
F192	L	"	"	"	<.008	0.08	.355	.04	3.8	.40	.06	20.8
B25	L	SUISB	01/31/86	SCOTER	----	0.22	1.6	<0.12	9.7	1.1	<0.25	30
B27	L	"	"	"	----	0.25	1.8	<0.24	19	0.65	<0.48	29
B76	L	HMBLT	02/07/86	DCCORM	----	0.34	0.39	<0.099	3.9	2.3	<0.20	22
B85	L	SOSFB	02/10/86	SCOTER	----	0.49	1.1	<0.099	11	3.5	<0.20	24
B105	L	CNSFB	02/11/86	SCOTER	----	0.39	1.6	<0.10	14	1.5	0.32	39
B143	L	SALTN	02/24/86	DCCORM	----	0.50	0.14	<0.098	3.7	4.0	<0.20	21
B150	L	SALTN	02/25/86	LSCAUP	----	0.48	<0.25	<0.25	7.4	0.34	<0.49	33
B153	L	SALTN	02/25/86	"	----	0.48	<0.13	<0.13	12	0.94	<0.26	42
B160	L	SALTN	02/25/86	DCCORM	----	0.43	0.14	<0.098	3.5	4.3	<0.20	22
B194	L	SNPBB	03/06/86	SCOTER	----	0.23	0.30	<0.11	15	3.1	<0.22	33
B484	L	GRYLG	06/19/86	MALLRD	----	0.24	<0.04	<0.24	23	<0.19	<0.48	30

1/ Instrumental analysis: Fish analyses of Ag, Cd, Cr, Cu, and Pb done by GFAA. Fish analyses of Zn done by Flame Atomic Absorption. All Hg accomplished with cold vapor AA. All bird trace element analyses done by Inductively Coupled Plasma Emission Spectroscopy.
2/ Analyses completed at WPCL by HGAA.
3/ Approximately 10% water was added to facilitate homogenization.

APPENDIX F. DESCRIPTIVE DATA AND SELENIUM CONCENTRATIONS IN ug/g (PPM) WET WEIGHT AND DRY WEIGHT FOR ALL TISSUE SAMPLES. SELENIUM ANALYSES DONE BY HGAA AT WPCL. ZEROS REPRESENT VALUES NOT DETERMINED OR ANALYSES NOT CONDUCTED.

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554	CNSFB	06/30/86	DCCORM	F	A	2800.0	73	2.90	10.74	0	0.00	0.00
561	CNSFB	07/11/86	DCCORM	M	A	1950.0	74	1.20	4.62	0	0.00	0.00
562	CNSFB	07/11/86	DCCORM	F	A	2100.0	72	5.60	20.00	0	0.00	0.00
114	CNSFB	02/11/86	DCCORM	M	S	2560.0	70	4.90	16.33	0	0.00	0.00
113	CNSFB	02/11/86	DCCORM	M	A	2550.0	71	4.40	15.17	0	0.00	0.00
112	CNSFB	02/11/86	DCCORM	F	J	2310.0	70	5.30	17.67	0	0.00	0.00
111	CNSFB	02/11/86	DCCORM	M	A	2885.0	69	5.60	18.06	0	0.00	0.00
553	CNSFB	06/30/86	DCCORM	M	A	2350.0	72	4.60	16.43	0	0.00	0.00
555	CNSFB	06/30/86	DCCORM	F	J	1850.0	73	5.10	18.89	0	0.00	0.00
109	CNSFB	02/11/86	LSCAUP	M	A	1000.0	71	5.10	17.59	70	2.70	9.00
110	CNSFB	02/11/86	LSCAUP	M	A	720.0	71	4.80	16.55	71	2.80	9.66
105	CNSFB	02/11/86	SCOTER	M	A	1180.0	72	7.50	26.79	70	1.60	5.33
104	CNSFB	02/11/86	SCOTER	M	A	1160.0	72	11.00	39.29	71	2.10	7.24
103	CNSFB	02/11/86	SCOTER	M	A	1110.0	72	9.00	32.14	70	1.40	4.67
102	CNSFB	02/11/86	SCOTER	M	A	1160.0	73	11.00	40.74	73	2.80	10.37
106	CNSFB	02/11/86	SCOTER	M	A	1100.0	73	7.10	26.30	71	1.60	5.52
100	CNSFB	02/11/86	SCOTER	M	A	1130.0	70	22.00	73.33	70	2.60	8.67
108	CNSFB	02/11/86	SCOTER	M	A	1220.0	72	6.80	24.29	71	1.60	5.52
99	CNSFB	02/11/86	SCOTER	M	A	1310.0	71	18.00	62.07	70	4.30	14.33
101	CNSFB	02/11/86	SCOTER	M	A	1130.0	72	15.00	53.57	71	2.40	8.28
107	CNSFB	02/11/86	SCOTER	M	A	1270.0	73	9.00	33.33	72	2.40	8.57
474	GRYLG	06/18/86	AMCOOT	M	U	600.0	73	0.57	2.11	73	0.30	1.11
473	GRYLG	06/18/86	AMCOOT	M	U	720.0	75	0.35	1.40	74	0.38	1.46
472	GRYLG	06/18/86	AMCOOT	M	U	600.0	74	0.39	1.50	76	0.29	1.21
17	GRYLG	01/28/86	AMCOOT	M	U	590.0	74	0.89	3.42	73	0.49	1.81
470	GRYLG	06/18/86	AMCOOT	M	U	680.0	72	0.65	2.32	74	0.50	1.92
18	GRYLG	01/28/86	AMCOOT	F	U	480.0	74	0.62	2.38	75	0.49	1.96
468	GRYLG	06/18/86	AMCOOT	F	U	520.0	72	0.22	0.79	76	0.18	0.75

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467	GRYLG	06/18/86	AMCOOT	M	U	740.0	72	0.62	2.21	73	0.26	0.96
16	GRYLG	01/28/86	AMCOOT	F	U	550.0	74	0.90	3.46	74	0.41	1.58
15	GRYLG	01/28/86	AMCOOT	M	U	790.0	73	0.92	3.41	70	0.42	1.40
14	GRYLG	01/28/86	AMCOOT	F	U	560.0	75	0.76	3.04	74	0.44	1.69
13	GRYLG	01/28/86	AMCOOT	F	U	580.0	73	1.00	3.70	70	0.34	1.13
12	GRYLG	01/28/86	AMCOOT	M	U	710.0	74	0.67	2.58	73	0.49	1.81
469	GRYLG	06/18/86	AMCOOT	M	U	620.0	76	0.99	4.12	74	0.69	2.65
11	GRYLG	01/28/86	AMCOOT	M	U	830.0	77	0.71	3.09	72	0.63	2.25
19	GRYLG	01/28/86	AMCOOT	M	U	700.0	73	1.40	5.19	72	0.55	1.96
20	GRYLG	01/28/86	AMCOOT	F	U	610.0	79	0.87	4.14	72	0.45	1.61
471	GRYLG	06/18/86	AMCOOT	M	U	560.0	78	0.43	1.95	76	0.32	1.33
475	GRYLG	06/18/86	AMCOOT	M	U	570.0	72	0.83	2.96	73	0.48	1.78
476	GRYLG	06/18/86	AMCOOT	M	U	540.0	76	0.73	3.04	72	0.46	1.64
222	GRYLG	03/11/86	BNSTLT	F	A	160.0	71	2.10	7.24	0	0.00	0.00
223	GRYLG	03/11/86	BNSTLT	M	A	185.0	70	2.30	7.67	0	0.00	0.00
224	GRYLG	03/11/86	BNSTLT	F	A	180.0	69	2.40	7.74	0	0.00	0.00
221	GRYLG	03/11/86	BNSTLT	F	A	160.0	70	4.70	15.67	0	0.00	0.00
229	GRYLG	03/11/86	BNSTLT	M	A	185.0	0	2.20	0	0	0.00	0.00
228	GRYLG	03/11/86	BNSTLT	M	A	195.0	74	1.80	6.92	0	0.00	0.00
227	GRYLG	03/11/86	BNSTLT	M	A	185.0	0	1.80	0	0	0.00	0.00
226	GRYLG	03/11/86	BNSTLT	F	A	185.0	70	4.70	15.67	0	0.00	0.00
225	GRYLG	03/11/86	BNSTLT	F	A	165.0	66	2.80	8.24	0	0.00	0.00
220	GRYLG	03/11/86	BNSTLT	M	A	180.0	69	9.20	29.68	0	0.00	0.00
486	GRYLG	06/19/86	MALLRD	M	A	1460.0	68	1.50	4.69	71	0.76	2.62
485	GRYLG	06/19/86	MALLRD	M	A	1240.0	73	1.50	5.56	73	0.48	1.78
484	GRYLG	06/19/86	MALLRD	M	A	1360.0	75	1.40	5.60	72	0.46	1.64
480	GRYLG	06/18/86	MALLRD	F	A	1160.0	70	1.40	4.67	74	0.48	1.85
479	GRYLG	06/18/86	MALLRD	M	A	1160.0	72	1.00	3.57	72	0.30	1.07

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478	GRYLG	06/18/86	MALLRD	M	A	1120.0	74	1.10	4.23	73	0.42	1.56
2	GRYLG	01/28/86	MALLRD	M	A	1350.0	71	0.72	2.48	72	0.30	1.07
487	GRYLG	06/19/86	MALLRD	M	A	1340.0	66	0.47	1.38	72	0.27	0.96
10	GRYLG	01/28/86	MALLRD	M	A	1360.0	73	0.60	2.22	72	0.16	0.57
9	GRYLG	01/28/86	MALLRD	M	U	1230.0	71	1.50	5.17	71	0.34	1.17
8	GRYLG	01/28/86	MALLRD	M	J	1290.0	76	0.93	3.88	72	0.48	1.71
7	GRYLG	01/28/86	MALLRD	M	J	1280.0	74	0.62	2.38	72	0.27	0.96
6	GRYLG	01/28/86	MALLRD	M	J	1030.0	72	2.20	7.86	74	0.49	1.88
5	GRYLG	01/28/86	MALLRD	M	J	1300.0	74	0.99	3.81	73	0.37	1.37
4	GRYLG	01/28/86	MALLRD	M	J	1290.0	71	1.10	3.79	73	0.33	1.22
21	GRYLG	01/28/86	MALLRD	M	A	1100.0	73	1.30	4.81	72	0.46	1.64
3	GRYLG	01/28/86	MALLRD	M	A	1400.0	70	0.90	3.00	72	0.19	0.68
483	GRYLG	06/19/86	MALLRD	M	A	1260.0	70	1.50	5.00	73	0.61	2.26
488	GRYLG	06/19/86	MALLRD	F	A	820.0	76	0.40	1.67	76	0.13	0.54
1	GRYLG	01/28/86	MALLRD	M	A	1380.0	68	0.82	2.56	73	0.26	0.96
72	HMBLT	02/07/86	DCCORM	F	J	2320.0	74	8.70	33.46	0	0.00	0.00
73	HMBLT	02/07/86	DCCORM	F	J	2340.0	72	5.90	21.07	0	0.00	0.00
75	HMBLT	02/07/86	DCCORM	M	J	2590.0	75	4.60	18.40	0	0.00	0.00
76	HMBLT	02/07/86	DCCORM	F	J	2640.0	76	4.90	20.42	0	0.00	0.00
77	HMBLT	02/07/86	DCCORM	F	J	2520.0	74	7.90	30.38	0	0.00	0.00
70	HMBLT	02/07/86	DCCORM	M	A	2605.0	71	7.40	25.52	0	0.00	0.00
68	HMBLT	02/07/86	DCCORM	M	A	2570.0	74	5.80	22.31	0	0.00	0.00
443	HMBLT	06/09/86	DCCORM	M	A	2250.0	70	3.10	10.33	0	0.00	0.00
444	HMBLT	06/09/86	DCCORM	M	A	2355.0	70	3.40	11.33	0	0.00	0.00
71	HMBLT	02/07/86	DCCORM	M	A	2960.0	72	4.10	14.64	0	0.00	0.00
441	HMBLT	06/09/86	DCCORM	M	A	2240.0	71	3.60	12.41	0	0.00	0.00
442	HMBLT	06/09/86	DCCORM	F	S	2235.0	68	4.20	13.13	0	0.00	0.00
69	HMBLT	02/07/86	DCCORM	F	A	2610.0	72	7.20	25.71	0	0.00	0.00

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440	HMBLT	06/09/86	DCCORM	M	A	2630.0	73	4.70	17.41	0	0.00	0.00
445	HMBLT	06/09/86	DCCORM	M	A	2700.0	72	3.30	11.79	0	0.00	0.00
446	HMBLT	06/09/86	DCCORM	F	A	2120.0	70	4.30	14.33	0	0.00	0.00
448	HMBLT	06/09/86	DCCORM	F	A	2130.0	69	3.70	11.94	0	0.00	0.00
449	HMBLT	06/09/86	DCCORM	F	A	2300.0	70	2.80	9.33	0	0.00	0.00
450	HMBLT	06/09/86	DCCORM	F	S	2050.0	70	5.00	16.67	0	0.00	0.00
74	HMBLT	02/07/86	DCCORM	F	J	2160.0	72	7.20	25.71	0	0.00	0.00
56	HMBLT	02/05/86	GSCAUP	F	A	870.0	70	4.20	14.00	71	1.60	5.52
55	HMBLT	02/04/86	LSCAUP	M	A	0.0	74	1.70	6.54	72	0.73	2.61
61	HMBLT	02/04/86	SCOTER	M	A	1090.0	72	3.00	10.71	71	0.70	2.41
67	HMBLT	02/04/86	SCOTER	M	A	1200.0	70	3.20	10.67	71	0.94	3.24
59	HMBLT	02/04/86	SCOTER	M	A	1060.0	71	2.50	8.62	71	0.89	3.07
60	HMBLT	02/04/86	SCOTER	M	A	960.0	72	3.00	10.71	69	0.71	2.29
58	HMBLT	02/04/86	SCOTER	F	A	890.0	72	3.60	12.86	72	0.67	2.39
66	HMBLT	02/04/86	SCOTER	M	A	1080.0	71	2.40	8.28	69	0.48	1.55
65	HMBLT	02/04/86	SCOTER	M	A	1100.0	69	5.60	18.06	72	0.97	3.46
64	HMBLT	02/04/86	SCOTER	M	A	1260.0	73	2.70	10.00	71	0.99	3.41
63	HMBLT	02/04/86	SCOTER	M	A	1120.0	67	2.40	7.27	72	0.55	1.96
62	HMBLT	02/04/86	SCOTER	M	A	1220.0	72	2.90	10.36	72	0.98	3.50
43	HMBLT	02/04/86	WILLET	F	U	220.0	69	1.90	6.13	0	0.00	0.00
54	HMBLT	02/05/86	WILLET	M	U	230.0	70	2.60	8.67	0	0.00	0.00
47	HMBLT	02/04/86	WILLET	F	A	295.0	72	1.40	5.00	0	0.00	0.00
51	HMBLT	02/05/86	WILLET	M	U	240.0	67	2.10	6.36	0	0.00	0.00
50	HMBLT	02/05/86	WILLET	M	U	240.0	72	2.00	7.14	0	0.00	0.00
52	HMBLT	02/05/86	WILLET	F	U	275.0	71	1.70	5.86	0	0.00	0.00
42	HMBLT	02/03/86	WILLET	F	U	255.0	73	1.40	5.19	0	0.00	0.00
53	HMBLT	02/05/86	WILLET	M	U	250.0	67	2.60	7.88	0	0.00	0.00
48	HMBLT	02/04/86	WILLET	F	U	325.0	70	1.10	3.67	0	0.00	0.00

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44	HMBLT	02/04/86	WILLET	F	U	310.0	71	1.40	4.83	0	0.00	0.00
45	HMBLT	02/04/86	WILLET	F	A	335.0	72	1.40	5.00	0	0.00	0.00
46	HMBLT	02/04/86	WILLET	F	A	330.0	73	1.10	4.07	0	0.00	0.00
49	HMBLT	02/05/86	WILLET	F	U	260.0	68	2.20	6.88	0	0.00	0.00
299	LSTHL	03/26/86	AVOCET	F	U	320.0	69	6.30	20.32	0	0.00	0.00
298	LSTHL	03/26/86	AVOCET	F	U	330.0	73	2.90	10.74	0	0.00	0.00
297	LSTHL	03/26/86	AVOCET	M	U	270.0	73	2.60	9.63	0	0.00	0.00
400	LSTHL	05/29/86	AVOCET	M	U	325.0	0	3.50	0	0	0.00	0.00
399	LSTHL	05/29/86	AVOCET	F	U	310.0	72	2.20	7.86	0	0.00	0.00
398	LSTHL	05/29/86	AVOCET	F	U	395.0	72	2.80	10.00	0	0.00	0.00
397	LSTHL	05/29/86	AVOCET	M	U	360.0	69	3.70	11.94	0	0.00	0.00
396	LSTHL	05/29/86	AVOCET	F	U	310.0	66	3.30	9.71	0	0.00	0.00
395	LSTHL	05/29/86	AVOCET	F	U	305.0	69	3.40	10.97	0	0.00	0.00
394	LSTHL	05/29/86	AVOCET	M	U	345.0	69	6.10	19.68	0	0.00	0.00
393	LSTHL	05/29/86	AVOCET	M	U	375.0	0	2.80	0	0	0.00	0.00
296	LSTHL	03/26/86	AVOCET	F	U	340.0	72	2.10	7.50	0	0.00	0.00
295	LSTHL	03/26/86	AVOCET	M	U	355.0	72	5.10	18.21	0	0.00	0.00
402	LSTHL	05/29/86	AVOCET	F	U	365.0	72	2.80	10.00	0	0.00	0.00
401	LSTHL	05/29/86	AVOCET	F	U	285.0	69	4.30	13.87	0	0.00	0.00
310	LSTHL	03/27/86	BNSTLT	M	U	180.0	78	7.50	34.09	0	0.00	0.00
311	LSTHL	03/27/86	BNSTLT	F	U	190.0	68	2.80	8.75	0	0.00	0.00
406	LSTHL	05/29/86	CNTEAL	M	U	360.0	73	7.40	27.41	73	1.00	3.70
405	LSTHL	05/29/86	CNTEAL	M	U	375.0	68	3.50	10.94	73	0.89	3.30
403	LSTHL	05/29/86	CNTEAL	M	U	325.0	78	1.60	7.27	73	0.71	2.63
404	LSTHL	05/29/86	CNTEAL	M	U	350.0	0	7.80	0	72	1.00	3.57
138	SALTN	02/24/86	BNSTLT	M	A	130.0	71	2.70	9.31	0	0.00	0.00
139	SALTN	02/24/86	BNSTLT	M	A	170.0	69	5.10	16.45	0	0.00	0.00
135	SALTN	02/24/86	BNSTLT	M	A	155.0	69	4.20	13.55	0	0.00	0.00

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SAMPLE NUMBER	LOCATION	DATE OF SAMPLE COLLECTION	SPECIES	SEX	AGE	BIRD WEIGHT	LIVER, PCT. MOIST.	LIVER, SE.ppm wet wt.	LIVER, SE.ppm dry wt.	FLESH, PCT. MOIST.	FLESH, SE.ppm wet wt.	FLESH, SE.ppm dry wt.
133	SALTN	02/24/86	BNSTLT	F	J	180.0	67	4.60	13.94	0	0.00	0.00
130	SALTN	02/24/86	BNSTLT	F	J	170.0	64	8.90	24.72	0	0.00	0.00
136	SALTN	02/24/86	BNSTLT	M	A	180.0	68	7.90	24.69	0	0.00	0.00
134	SALTN	02/24/86	BNSTLT	M	A	170.0	67	8.10	24.55	0	0.00	0.00
132	SALTN	02/24/86	BNSTLT	F	J	165.0	68	7.70	24.06	0	0.00	0.00
131	SALTN	02/24/86	BNSTLT	F	J	160.0	69	5.20	16.77	0	0.00	0.00
137	SALTN	02/24/86	BNSTLT	M	A	170.0	0	10.00	0	0	0.00	0.00
359	SALTN	05/19/86	BNSTLT	M	U	185.0	0	5.30	0	0	0.00	0.00
368	SALTN	05/19/86	BNSTLT	F	U	175.0	0	2.80	0	0	0.00	0.00
361	SALTN	05/19/86	BNSTLT	M	U	160.0	0	4.70	0	0	0.00	0.00
367	SALTN	05/19/86	BNSTLT	M	U	160.0	0	2.70	0	0	0.00	0.00
362	SALTN	05/19/86	BNSTLT	M	U	145.0	0	6.20	0	0	0.00	0.00
363	SALTN	05/19/86	BNSTLT	F	U	150.0	0	3.30	0	0	0.00	0.00
364	SALTN	05/19/86	BNSTLT	M	U	175.0	0	2.20	0	0	0.00	0.00
365	SALTN	05/19/86	BNSTLT	M	U	160.0	0	4.80	0	0	0.00	0.00
360	SALTN	05/19/86	BNSTLT	M	U	155.0	0	5.40	0	0	0.00	0.00
366	SALTN	05/19/86	BNSTLT	M	U	175.0	0	1.70	0	0	0.00	0.00
161	SALTN	02/25/86	DCCORM	F	A	2150.0	75	8.60	34.40	0	0.00	0.00
162	SALTN	02/25/86	DCCORM	M	A	2500.0	70	15.00	50.00	0	0.00	0.00
158	SALTN	02/25/86	DCCORM	F	S	2200.0	70	7.90	26.33	0	0.00	0.00
159	SALTN	02/25/86	DCCORM	F	J	2200.0	69	9.80	31.61	0	0.00	0.00
160	SALTN	02/25/86	DCCORM	M	S	2350.0	68	10.00	31.25	0	0.00	0.00
353	SALTN	05/19/86	DCCORM	M	S	2450.0	71	13.00	44.83	0	0.00	0.00
354	SALTN	05/19/86	DCCORM	M	S	1800.0	74	7.80	30.00	0	0.00	0.00
355	SALTN	05/19/86	DCCORM	F	A	2100.0	72	9.60	34.29	0	0.00	0.00
356	SALTN	05/19/86	DCCORM	M	A	2500.0	74	9.40	36.15	0	0.00	0.00
357	SALTN	05/19/86	DCCORM	M	A	2150.0	72	5.20	18.57	0	0.00	0.00
352	SALTN	05/19/86	DCCORM	F	S	1850.0	70	10.00	33.33	0	0.00	0.00

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349	SALTN	05/19/86	DCCORM	M	S	2250.0	73	6.80	25.19	0	0.00	0.00
351	SALTN	05/19/86	DCCORM	M	S	2250.0	71	8.60	29.66	0	0.00	0.00
350	SALTN	05/19/86	DCCORM	M	S	2150.0	72	11.00	39.29	0	0.00	0.00
358	SALTN	05/19/86	DCCORM	M	A	2400.0	72	9.40	33.57	0	0.00	0.00
142	SALTN	02/24/86	DCCORM	M	J	2350.0	70	6.70	22.33	0	0.00	0.00
145	SALTN	02/24/86	DCCORM	F	A	2250.0	67	7.80	23.64	0	0.00	0.00
144	SALTN	02/24/86	DCCORM	M	A	2500.0	70	18.00	60.00	0	0.00	0.00
143	SALTN	02/24/86	DCCORM	M	S	2250.0	70	9.20	30.67	0	0.00	0.00
146	SALTN	02/25/86	LSCAUP	M	A	800.0	73	3.00	11.11	72	0.93	3.32
153	SALTN	02/25/86	LSCAUP	F	J	840.0	74	2.80	10.77	68	1.20	3.75
151	SALTN	02/25/86	LSCAUP	M	A	780.0	73	1.50	5.56	70	0.43	1.43
147	SALTN	02/25/86	LSCAUP	M	J	780.0	72	3.40	12.14	69	1.20	3.87
148	SALTN	02/25/86	LSCAUP	M	A	660.0	74	2.00	7.69	69	0.71	2.29
149	SALTN	02/25/86	LSCAUP	M	J	800.0	71	5.60	19.31	63	2.00	5.41
150	SALTN	02/25/86	LSCAUP	M	J	740.0	73	3.00	11.11	71	1.50	5.17
157	SALTN	02/25/86	LSCAUP	F	A	700.0	74	3.80	14.62	70	1.40	4.67
156	SALTN	02/25/86	LSCAUP	F	J	700.0	73	3.00	11.11	69	1.10	3.55
155	SALTN	02/25/86	LSCAUP	F	A	740.0	72	2.80	10.00	71	0.93	3.21
154	SALTN	02/25/86	LSCAUP	F	A	720.0	71	4.20	14.48	70	1.70	5.67
152	SALTN	02/25/86	LSCAUP	M	A	880.0	72	2.60	9.29	69	1.30	4.19
140	SALTN	02/24/86	PNTAIL	M	A	960.0	66	2.70	7.94	72	2.30	8.21
163	SALTN	02/26/86	WIGEON	M	J	710.0	70	1.00	3.33	73	0.88	3.26
172	SALTN	02/26/86	WIGEON	M	A	740.0	71	1.20	4.14	73	0.79	2.93
170	SALTN	02/26/86	WIGEON	M	A	740.0	71	1.20	4.14	72	0.73	2.61
169	SALTN	02/26/86	WIGEON	M	A	740.0	70	1.20	4.00	74	0.98	3.77
168	SALTN	02/26/86	WIGEON	M	A	760.0	71	1.10	3.79	73	0.85	3.15
167	SALTN	02/26/86	WIGEON	M	J	700.0	68	1.20	3.75	72	1.10	3.93
166	SALTN	02/26/86	WIGEON	M	J	770.0	69	1.20	3.87	73	0.87	3.22

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165	SALTN	02/26/86	WIGEON	M	J	720.0	72	1.70	6.07	74	1.30	5.00
164	SALTN	02/26/86	WIGEON	M	J	780.0	70	1.30	4.33	73	0.84	3.11
171	SALTN	02/26/86	WIGEON	M	A	750.0	71	1.60	5.52	73	1.50	5.56
552	SCNWR	06/27/86	AVOCET	M	A	370.0	65	1.80	5.14	0	0.00	0.00
551	SCNWR	06/27/86	AVOCET	M	A	345.0	70	1.30	4.33	0	0.00	0.00
549	SCNWR	06/27/86	AVOCET	F	A	315.0	71	2.70	9.31	0	0.00	0.00
548	SCNWR	06/27/86	AVOCET	M	A	310.0	72	3.80	13.57	0	0.00	0.00
547	SCNWR	06/27/86	AVOCET	M	A	300.0	71	3.10	10.69	0	0.00	0.00
546	SCNWR	06/27/86	AVOCET	M	A	315.0	69	2.50	8.06	0	0.00	0.00
545	SCNWR	06/27/86	AVOCET	F	A	325.0	70	1.90	6.33	0	0.00	0.00
544	SCNWR	06/27/86	AVOCET	M	A	275.0	74	1.80	6.92	0	0.00	0.00
543	SCNWR	06/27/86	AVOCET	F	A	315.0	71	3.00	10.34	0	0.00	0.00
550	SCNWR	06/27/86	AVOCET	U	J	280.0	73	1.70	6.30	0	0.00	0.00
541	SCNWR	06/27/86	BNSTLT	F	A	170.0	0	2.50	0	0	0.00	0.00
542	SCNWR	06/27/86	BNSTLT	M	A	170.0	71	2.40	8.28	0	0.00	0.00
533	SCNWR	06/27/86	BNSTLT	F	A	170.0	0	1.90	0	0	0.00	0.00
535	SCNWR	06/27/86	BNSTLT	F	A	185.0	0	2.20	0	0	0.00	0.00
536	SCNWR	06/27/86	BNSTLT	F	A	150.0	0	2.00	0	0	0.00	0.00
540	SCNWR	06/27/86	BNSTLT	F	A	165.0	0	2.20	0	0	0.00	0.00
539	SCNWR	06/27/86	BNSTLT	M	A	190.0	73	4.10	15.19	0	0.00	0.00
538	SCNWR	06/27/86	BNSTLT	F	A	165.0	0	3.50	0	0	0.00	0.00
534	SCNWR	06/27/86	BNSTLT	F	A	165.0	0	1.80	0	0	0.00	0.00
537	SCNWR	06/27/86	BNSTLT	M	A	170.0	0	2.60	0	0	0.00	0.00
328	SEMIT	04/02/86	AMCOOT	F	U	620.0	81	0.99	5.21	76	0.84	3.50
411	SEMIT	05/29/86	AMCOOT	M	U	560.0	0	3.10	0	74	2.00	7.69
326	SEMIT	04/02/86	AMCOOT	M	U	720.0	72	2.20	7.86	73	2.60	9.63
327	SEMIT	04/02/86	AMCOOT	M	U	680.0	72	1.60	5.71	73	1.40	5.19
325	SEMIT	04/02/86	AMCOOT	F	U	460.0	76	1.20	5.00	77	0.71	3.09

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316	SEMIT	03/27/86	AMCOOT	F	U	475.0	72	0.92	3.29	70	0.26	0.87
329	SEMIT	04/02/86	AMCOOT	M	U	680.0	72	1.40	5.00	73	0.95	3.52
330	SEMIT	04/02/86	AMCOOT	M	U	600.0	75	0.86	3.44	75	0.70	2.80
323	SEMIT	04/02/86	AMCOOT	F	U	460.0	73	1.80	6.67	70	0.80	2.67
324	SEMIT	04/02/86	AMCOOT	F	U	540.0	71	1.30	4.48	73	0.67	2.48
331	SEMIT	04/02/86	AMCOOT	F	U	540.0	74	1.20	4.62	74	0.47	1.81
322	SEMIT	04/02/86	AMCOOT	M	U	640.0	73	1.70	6.30	72	0.77	2.75
429	SEMIT	05/30/86	AMCOOT	F	U	520.0	74	1.80	6.92	75	0.77	3.08
408	SEMIT	05/29/86	AVOCET	F	U	330.0	72	2.80	10.00	0	0.00	0.00
424	SEMIT	05/30/86	AVOCET	M	U	315.0	64	3.20	8.89	0	0.00	0.00
422	SEMIT	05/30/86	AVOCET	F	U	330.0	71	3.80	13.10	0	0.00	0.00
423	SEMIT	05/30/86	AVOCET	M	U	320.0	73	2.70	10.00	0	0.00	0.00
407	SEMIT	05/29/86	AVOCET	M	U	375.0	72	2.50	8.93	0	0.00	0.00
305	SEMIT	03/27/86	AVOCET	M	U	315.0	71	1.40	4.83	0	0.00	0.00
306	SEMIT	03/27/86	AVOCET	F	U	375.0	71	2.20	7.59	0	0.00	0.00
307	SEMIT	03/27/86	AVOCET	M	U	340.0	69	3.70	11.94	0	0.00	0.00
309	SEMIT	03/27/86	AVOCET	M	U	340.0	70	3.30	11.00	0	0.00	0.00
308	SEMIT	03/27/86	AVOCET	F	U	330.0	70	2.40	8.00	0	0.00	0.00
428	SEMIT	05/30/86	CNTEAL	M	U	395.0	70	1.30	4.33	72	0.32	1.14
300	SEMIT	03/27/86	CNTEAL	M	U	375.0	72	2.70	9.64	74	0.48	1.85
321	SEMIT	03/28/86	CNTEAL	F	U	325.0	0	0.00	0.00	74	1.10	4.23
320	SEMIT	03/28/86	CNTEAL	M	U	390.0	72	2.50	8.93	73	0.61	2.26
319	SEMIT	03/28/86	CNTEAL	M	U	400.0	71	2.40	8.28	71	0.58	2.00
318	SEMIT	03/28/86	CNTEAL	M	U	360.0	70	1.70	5.67	73	0.48	1.78
304	SEMIT	03/27/86	CNTEAL	F	U	370.0	69	2.50	8.06	74	0.50	1.92
302	SEMIT	03/27/86	CNTEAL	M	U	355.0	72	3.40	12.14	73	0.64	2.37
301	SEMIT	03/27/86	CNTEAL	M	U	415.0	72	1.90	6.79	73	0.38	1.41
409	SEMIT	05/29/86	CNTEAL	M	U	390.0	70	4.90	16.33	74	0.84	3.23

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426	SEMIT	05/30/86	CNTEAL	M	U	360.0	68	3.20	10.00	73	0.62	2.30
425	SEMIT	05/30/86	CNTEAL	M	U	335.0	69	2.50	8.06	73	0.55	2.04
303	SEMIT	03/27/86	CNTEAL	M	U	355.0	70	3.30	11.00	71	0.45	1.55
317	SEMIT	03/28/86	CNTEAL	M	U	335.0	70	2.50	8.33	0	0.00	0.00
427	SEMIT	05/30/86	CNTEAL	M	U	325.0	69	3.20	10.32	74	0.75	2.88
410	SEMIT	05/29/86	CNTEAL	M	U	375.0	75	2.00	8.00	74	0.46	1.77
241	SNPBB	03/20/86	AVOCET	M	A	375.0	72	5.20	18.57	0	0.00	0.00
237	SNPBB	03/20/86	AVOCET	F	A	340.0	71	3.30	11.38	0	0.00	0.00
240	SNPBB	03/20/86	AVOCET	M	A	365.0	71	1.80	6.21	0	0.00	0.00
238	SNPBB	03/20/86	AVOCET	F	A	330.0	75	3.80	15.20	0	0.00	0.00
236	SNPBB	03/20/86	AVOCET	F	A	400.0	71	0.89	3.07	0	0.00	0.00
244	SNPBB	03/20/86	AVOCET	F	A	390.0	70	2.60	8.67	0	0.00	0.00
242	SNPBB	03/20/86	AVOCET	F	A	400.0	74	3.00	11.54	0	0.00	0.00
243	SNPBB	03/20/86	AVOCET	F	A	355.0	72	3.40	12.14	0	0.00	0.00
235	SNPBB	03/20/86	AVOCET	F	A	365.0	73	1.50	5.56	0	0.00	0.00
532	SNPBB	06/26/86	AVOCET	F	A	365.0	72	1.90	6.79	0	0.00	0.00
531	SNPBB	06/26/86	AVOCET	F	A	345.0	73	2.10	7.78	0	0.00	0.00
530	SNPBB	06/26/86	AVOCET	F	A	325.0	72	2.60	9.29	0	0.00	0.00
239	SNPBB	03/20/86	AVOCET	F	A	440.0	74	1.20	4.62	0	0.00	0.00
529	SNPBB	06/26/86	AVOCET	F	A	395.0	70	2.10	7.00	0	0.00	0.00
528	SNPBB	06/26/86	AVOCET	F	A	335.0	72	2.80	10.00	0	0.00	0.00
527	SNPBB	06/26/86	AVOCET	M	A	345.0	72	2.90	10.36	0	0.00	0.00
523	SNPBB	06/26/86	AVOCET	F	A	315.0	73	3.80	14.07	0	0.00	0.00
526	SNPBB	06/26/86	AVOCET	M	A	360.0	71	3.00	10.34	0	0.00	0.00
525	SNPBB	06/26/86	AVOCET	F	A	325.0	73	2.30	8.52	0	0.00	0.00
524	SNPBB	06/26/86	AVOCET	M	A	385.0	73	3.00	11.11	0	0.00	0.00
246	SNPBB	03/20/86	BNSTLT	F	A	175.0	74	1.00	3.85	0	0.00	0.00
245	SNPBB	03/20/86	BNSTLT	F	A	180.0	70	1.40	4.67	0	0.00	0.00

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247	SNPBB	03/20/86	BNSTLT	M	A	170.0	74	2.20	8.46	0	0.00	0.00
201	SNPBB	03/06/86	DCCORM	F	A	2150.0	72	5.50	19.64	0	0.00	0.00
202	SNPBB	03/06/86	DCCORM	F	A	2500.0	70	5.60	18.67	0	0.00	0.00
200	SNPBB	03/06/86	DCCORM	F	J	2050.0	71	4.20	14.48	0	0.00	0.00
342	SNPBB	04/10/86	GSCAUP	F	U	1030.0	68	7.00	21.88	71	1.30	4.48
341	SNPBB	04/10/86	GSCAUP	F	U	900.0	68	4.80	15.00	70	1.20	4.00
338	SNPBB	04/10/86	GSCAUP	M	U	1160.0	67	4.00	12.12	71	1.40	4.83
337	SNPBB	04/10/86	GSCAUP	M	U	1250.0	72	3.70	13.21	71	1.30	4.48
334	SNPBB	04/10/86	GSCAUP	M	U	1060.0	73	4.60	17.04	72	1.50	5.36
333	SNPBB	04/10/86	GSCAUP	M	U	1060.0	72	3.40	12.14	71	1.10	3.79
332	SNPBB	04/10/86	GSCAUP	M	U	1050.0	69	7.10	22.90	71	2.40	8.28
340	SNPBB	04/10/86	GSCAUP	M	U	1120.0	68	6.40	20.00	70	1.50	5.00
339	SNPBB	04/10/86	GSCAUP	M	U	1120.0	69	5.70	18.39	70	1.60	5.33
335	SNPBB	04/10/86	GSCAUP	M	U	1020.0	70	4.60	15.33	71	1.20	4.14
336	SNPBB	04/10/86	GSCAUP	M	U	1000.0	69	3.80	12.26	72	1.20	4.29
191	SNPBB	03/06/86	SCOTER	M	A	1150.0	69	18.00	58.06	72	1.60	5.71
193	SNPBB	03/06/86	SCOTER	M	A	1100.0	70	17.00	56.67	72	1.80	6.43
195	SNPBB	03/06/86	SCOTER	M	A	1140.0	70	17.00	56.67	69	1.40	4.52
199	SNPBB	03/06/86	SCOTER	M	A	1220.0	69	16.00	51.61	72	1.40	5.00
194	SNPBB	03/06/86	SCOTER	M	J	1170.0	72	13.00	46.43	71	1.50	5.17
192	SNPBB	03/06/86	SCOTER	M	A	1240.0	71	12.00	41.38	70	1.60	5.33
196	SNPBB	03/06/86	SCOTER	M	A	1200.0	69	13.00	41.94	70	2.00	6.67
197	SNPBB	03/06/86	SCOTER	M	A	1160.0	71	14.00	48.28	66	1.90	5.59
198	SNPBB	03/06/86	SCOTER	M	A	1020.0	71	16.00	55.17	78	1.40	6.36
190	SNPBB	03/06/86	SCOTER	M	A	1130.0	72	14.00	50.00	71	1.60	5.52
521	SNPBB	06/26/86	WILLET	M	A	275.0	74	1.40	5.38	0	0.00	0.00
520	SNPBB	06/26/86	WILLET	M	A	305.0	77	1.40	6.09	0	0.00	0.00
234	SNPBB	03/19/86	WILLET	M	A	280.0	68	3.10	9.69	0	0.00	0.00

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SAMPLE NUMBER	LOCATION	DATE OF SAMPLE COLLECTION	SPECIES	SEX	AGE	BIRD WEIGHT	LIVER, PCT. MOIST.	LIVER, SE.ppm wet wt.	LIVER, SE.ppm dry wt.	FLESH, PCT. MOIST.	FLESH, SE.ppm wet wt.	FLESH, SE.ppm dry wt.
233	SNPBB	03/19/86	WILLET	F	A	315.0	70	2.60	8.67	0	0.00	0.00
232	SNPBB	03/19/86	WILLET	F	A	340.0	71	2.50	8.62	0	0.00	0.00
230	SNPBB	03/19/86	WILLET	F	A	300.0	70	1.90	6.33	0	0.00	0.00
519	SNPBB	06/26/86	WILLET	F	A	345.0	74	2.00	7.69	0	0.00	0.00
231	SNPBB	03/19/86	WILLET	M	A	295.0	70	2.90	9.67	0	0.00	0.00
522	SNPBB	06/26/86	WILLET	M	A	295.0	73	1.80	6.67	0	0.00	0.00
518	SNPBB	06/25/86	WILLET	F	A	320.0	72	1.30	4.64	0	0.00	0.00
510	SOSFB	06/23/86	AVOCET	M	A	350.0	70	1.50	5.00	0	0.00	0.00
509	SOSFB	06/23/86	AVOCET	F	A	360.0	74	4.00	15.38	0	0.00	0.00
503	SOSFB	06/23/86	AVOCET	F	A	290.0	72	2.00	7.14	0	0.00	0.00
512	SOSFB	06/23/86	AVOCET	F	A	340.0	72	1.10	3.93	0	0.00	0.00
507	SOSFB	06/23/86	AVOCET	M	A	360.0	70	1.80	6.00	0	0.00	0.00
508	SOSFB	06/23/86	AVOCET	M	A	320.0	71	2.10	7.24	0	0.00	0.00
506	SOSFB	06/23/86	AVOCET	M	A	300.0	83	2.10	12.35	0	0.00	0.00
180	SOSFB	03/05/86	AVOCET	M	A	395.0	72	1.50	5.36	0	0.00	0.00
181	SOSFB	03/05/86	AVOCET	F	A	380.0	0	2.90	0	0	0.00	0.00
182	SOSFB	03/05/86	AVOCET	F	U	355.0	73	1.80	6.67	0	0.00	0.00
504	SOSFB	06/23/86	AVOCET	F	A	280.0	66	2.10	6.18	0	0.00	0.00
505	SOSFB	06/23/86	AVOCET	F	A	300.0	71	2.80	9.66	0	0.00	0.00
511	SOSFB	06/23/86	AVOCET	M	A	340.0	70	1.20	4.00	0	0.00	0.00
185	SOSFB	03/05/86	AVOCET	F	A	340.0	75	3.20	12.80	0	0.00	0.00
184	SOSFB	03/05/86	AVOCET	M	A	340.0	0	2.70	0	0	0.00	0.00
188	SOSFB	03/05/86	AVOCET	F	A	365.0	74	1.40	5.38	0	0.00	0.00
189	SOSFB	03/05/86	AVOCET	M	A	345.0	76	1.70	7.08	0	0.00	0.00
183	SOSFB	03/05/86	AVOCET	M	A	395.0	74	3.40	13.08	0	0.00	0.00
186	SOSFB	03/05/86	AVOCET	M	A	370.0	74	1.70	6.54	0	0.00	0.00
187	SOSFB	03/05/86	AVOCET	F	U	310.0	71	1.80	6.21	0	0.00	0.00
97	SOSFB	02/10/86	DCCORM	F	J	2400.0	68	4.50	14.06	0	0.00	0.00

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96	SOSFB	02/10/86	DCCORM	F	A	2350.0	68	4.10	12.81	0	0.00	0.00
95	SOSFB	02/10/86	DCCORM	F	J	2200.0	70	5.00	16.67	0	0.00	0.00
98	SOSFB	02/10/86	DCCORM	F	A	2500.0	72	4.30	15.36	0	0.00	0.00
346	SOSFB	04/10/86	GSCAUP	M	U	1220.0	70	5.50	18.33	71	1.40	4.83
347	SOSFB	04/10/86	GSCAUP	M	U	1040.0	70	4.50	15.00	70	1.60	5.33
348	SOSFB	04/10/86	GSCAUP	M	U	1300.0	71	3.40	11.72	69	1.30	4.19
344	SOSFB	04/10/86	GSCAUP	M	U	1200.0	70	4.00	13.33	70	1.60	5.33
81	SOSFB	02/10/86	GSCAUP	M	A	900.0	71	4.40	15.17	72	1.70	6.07
343	SOSFB	04/10/86	GSCAUP	M	U	1260.0	72	3.90	13.93	70	1.20	4.00
345	SOSFB	04/10/86	GSCAUP	M	U	1300.0	71	4.60	15.86	71	1.20	4.14
82	SOSFB	02/10/86	GSCAUP	M	J	780.0	72	2.40	8.57	74	0.71	2.73
83	SOSFB	02/10/86	GSCAUP	M	A	1020.0	73	4.90	18.15	71	2.50	8.62
78	SOSFB	02/10/86	LSCAUP	M	A	780.0	72	1.60	5.71	71	0.65	2.24
79	SOSFB	02/10/86	LSCAUP	M	U	840.0	74	3.20	12.31	69	1.30	4.19
80	SOSFB	02/10/86	LSCAUP	F	A	780.0	73	2.70	10.00	72	0.77	2.75
86	SOSFB	02/10/86	SCOTER	M	A	1220.0	73	12.00	44.44	72	2.10	7.50
85	SOSFB	02/10/86	SCOTER	M	A	1150.0	74	9.40	36.15	69	2.10	6.77
84	SOSFB	02/10/86	SCOTER	M	A	1100.0	72	13.00	46.43	69	1.80	5.81
88	SOSFB	02/10/86	SCOTER	M	A	880.0	74	7.40	28.46	72	1.80	6.43
87	SOSFB	02/10/86	SCOTER	M	A	1220.0	73	17.00	62.96	70	2.80	9.33
90	SOSFB	02/10/86	SCOTER	M	A	1070.0	72	9.50	33.93	72	1.40	5.00
89	SOSFB	02/10/86	SCOTER	M	A	1140.0	69	11.00	35.48	71	1.70	5.86
92	SOSFB	02/10/86	SCOTER	M	J	1120.0	73	7.40	27.41	77	2.80	12.17
93	SOSFB	02/10/86	SCOTER	M	J	1100.0	72	6.90	24.64	71	1.00	3.45
94	SOSFB	02/10/86	SCOTER	M	A	1070.0	74	12.00	46.15	74	2.10	8.08
91	SOSFB	02/10/86	SCOTER	M	A	820.0	73	7.20	26.67	70	2.00	6.67
179	SOSFB	03/05/86	WILLET	F	U	355.0	72	1.20	4.29	0	0.00	0.00
516	SOSFB	06/23/86	WILLET	M	A	320.0	71	1.60	5.52	0	0.00	0.00

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513	SOSFB	06/23/86	WILLET	M	A	260.0	74	1.30	5.00	0	0.00	0.00
514	SOSFB	06/23/86	WILLET	M	A	280.0	74	1.70	6.54	0	0.00	0.00
515	SOSFB	06/23/86	WILLET	M	A	280.0	69	1.20	3.87	0	0.00	0.00
517	SOSFB	06/23/86	WILLET	F	A	280.0	72	1.20	4.29	0	0.00	0.00
175	SOSFB	03/05/86	WILLET	M	A	300.0	74	2.50	9.62	0	0.00	0.00
178	SOSFB	03/05/86	WILLET	M	A	255.0	73	3.90	14.44	0	0.00	0.00
177	SOSFB	03/05/86	WILLET	M	U	290.0	74	3.20	12.31	0	0.00	0.00
176	SOSFB	03/05/86	WILLET	F	U	310.0	72	1.20	4.29	0	0.00	0.00
556	SUISB	07/09/86	DCCORM	F	A	2100.0	72	3.40	12.14	0	0.00	0.00
557	SUISB	07/09/86	DCCORM	M	A	2200.0	72	4.20	15.00	0	0.00	0.00
558	SUISB	07/09/86	DCCORM	F	A	2200.0	73	5.70	21.11	0	0.00	0.00
559	SUISB	07/09/86	DCCORM	M	A	2350.0	70	9.70	32.33	0	0.00	0.00
560	SUISB	07/09/86	DCCORM	M	A	2300.0	73	4.40	16.30	0	0.00	0.00
38	SUISB	01/31/86	LSCAUP	M	A	1010.0	74	3.60	13.85	71	0.87	3.00
37	SUISB	01/31/86	LSCAUP	M	A	960.0	72	6.00	21.43	72	1.90	6.79
33	SUISB	01/31/86	LSCAUP	M	J	0.0	73	6.60	24.44	69	1.80	5.81
34	SUISB	01/31/86	LSCAUP	M	A	940.0	71	8.80	30.34	72	4.00	14.29
41	SUISB	01/31/86	LSCAUP	F	A	880.0	74	4.50	17.31	72	1.20	4.29
36	SUISB	01/31/86	LSCAUP	M	A	900.0	72	19.00	67.86	73	4.80	17.78
39	SUISB	01/31/86	LSCAUP	M	A	970.0	73	8.10	30.00	70	1.80	6.00
35	SUISB	01/31/86	LSCAUP	M	A	910.0	72	8.70	31.07	72	2.70	9.64
40	SUISB	01/31/86	LSCAUP	M	J	970.0	70	7.60	25.33	70	1.50	5.00
32	SUISB	01/31/86	LSCAUP	M	A	0.0	70	7.60	25.33	70	2.40	8.00
26	SUISB	01/31/86	SCOTER	M	A	1160.0	69	30.00	96.77	71	3.80	13.10
25	SUISB	01/31/86	SCOTER	M	A	0.0	72	15.00	53.57	71	2.00	6.90
24	SUISB	01/31/86	SCOTER	M	A	0.0	73	10.00	37.04	71	1.60	5.52
28	SUISB	01/31/86	SCOTER	M	A	1220.0	70	28.00	93.33	67	4.50	13.64
23	SUISB	01/31/86	SCOTER	M	A	0.0	73	15.00	55.56	70	2.20	7.33

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27	SUISB	01/31/86	SCOTER	M	A	1270.0	71	26.00	89.66	71	5.30	18.28
31	SUISB	01/31/86	SCOTER	F	A	1180.0	72	24.00	85.71	71	4.40	15.17
22	SUISB	01/31/86	SCOTER	M	A	0.0	69	35.00	112.90	70	3.70	12.33
30	SUISB	01/31/86	SCOTER	F	A	1200.0	72	20.00	71.43	72	4.00	14.29
29	SUISB	01/31/86	SCOTER	F	J	1010.0	72	22.00	78.57	72	4.50	16.07
122	SUISM	02/13/86	AMCOOT	M	U	640.0	76	0.65	2.71	75	0.39	1.56
121	SUISM	02/13/86	AMCOOT	M	U	580.0	74	0.57	2.19	71	0.34	1.17
120	SUISM	02/13/86	AMCOOT	M	U	600.0	75	0.94	3.76	73	0.43	1.59
119	SUISM	02/13/86	AMCOOT	M	U	600.0	75	0.56	2.24	72	0.23	0.82
118	SUISM	02/13/86	AMCOOT	M	U	620.0	76	0.56	2.33	74	0.53	2.04
123	SUISM	02/13/86	AMCOOT	F	U	520.0	76	0.73	3.04	74	0.54	2.08
128	SUISM	02/13/86	AMCOOT	M	U	700.0	74	0.83	3.19	73	0.48	1.78
499	SUISM	07/11/86	AMCOOT	F	A	460.0	72	1.70	6.07	72	0.78	2.79
454	SUISM	06/17/86	AMCOOT	F	U	380.0	76	0.78	3.25	74	0.34	1.31
452	SUISM	06/16/86	AMCOOT	M	U	580.0	74	0.98	3.77	72	0.53	1.89
498	SUISM	07/02/86	AMCOOT	F	A	480.0	73	1.20	4.44	72	0.69	2.46
125	SUISM	02/13/86	AMCOOT	M	U	580.0	75	0.61	2.44	72	0.34	1.21
126	SUISM	02/13/86	AMCOOT	M	U	650.0	75	0.42	1.68	76	0.24	1.00
453	SUISM	06/17/86	AMCOOT	F	U	400.0	67	1.60	4.85	71	0.53	1.83
500	SUISM	07/02/86	AMCOOT	M	A	580.0	72	1.30	4.64	71	0.78	2.69
124	SUISM	02/13/86	AMCOOT	M	U	750.0	73	0.68	2.52	73	0.46	1.70
497	SUISM	06/23/86	AMCOOT	F	A	540.0	75	1.10	4.40	72	0.50	1.79
451	SUISM	06/16/86	AMCOOT	M	U	640.0	72	0.92	3.29	71	0.56	1.93
127	SUISM	02/13/86	AMCOOT	M	U	600.0	74	0.53	2.04	74	0.31	1.19
466	SUISM	06/17/86	BNSTLT	F	J	100.0	0	1.20	0	0	0.00	0.00
214	SUISM	03/07/86	BNSTLT	M	U	170.0	0	1.50	0	0	0.00	0.00
215	SUISM	03/07/86	BNSTLT	F	U	180.0	0	1.60	0	0	0.00	0.00
219	SUISM	03/07/86	BNSTLT	M	U	200.0	0	2.40	0	0	0.00	0.00

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216	SUISM	03/07/86	BNSTLT	M	U	185.0	0	2.60	0	0	0.00	0.00
465	SUISM	06/17/86	BNSTLT	U	J	100.0	0	1.10	0	0	0.00	0.00
463	SUISM	06/17/86	BNSTLT	F	A	160.0	0	1.50	0	0	0.00	0.00
217	SUISM	03/07/86	BNSTLT	M	U	205.0	0	3.80	0	0	0.00	0.00
461	SUISM	06/17/86	BNSTLT	F	A	160.0	0	1.90	0	0	0.00	0.00
460	SUISM	06/17/86	BNSTLT	F	A	150.0	70	1.80	6.00	0	0.00	0.00
462	SUISM	06/17/86	BNSTLT	M	A	140.0	73	1.70	6.30	0	0.00	0.00
458	SUISM	06/17/86	BNSTLT	F	A	140.0	0	1.60	0	0	0.00	0.00
457	SUISM	06/17/86	BNSTLT	M	A	150.0	0	2.70	0	0	0.00	0.00
459	SUISM	06/17/86	BNSTLT	M	A	160.0	0	1.90	0	0	0.00	0.00
464	SUISM	06/17/86	BNSTLT	U	J	100.0	0	1.30	0	0	0.00	0.00
213	SUISM	03/07/86	BNSTLT	M	U	175.0	0	1.60	0	0	0.00	0.00
212	SUISM	03/07/86	BNSTLT	F	U	195.0	0	2.00	0	0	0.00	0.00
211	SUISM	03/07/86	BNSTLT	F	U	190.0	0	2.10	0	0	0.00	0.00
210	SUISM	03/07/86	BNSTLT	F	U	185.0	0	1.20	0	0	0.00	0.00
218	SUISM	03/07/86	BNSTLT	M	U	200.0	0	1.10	0	0	0.00	0.00
209	SUISM	03/07/86	MALLRD	M	A	1200.0	75	1.60	6.40	0	0.00	0.00
208	SUISM	03/07/86	MALLRD	M	A	1220.0	70	0.89	2.97	71	0.17	0.59
489	SUISM	06/18/86	MALLRD	M	A	1340.0	66	0.78	2.29	70	0.49	1.63
205	SUISM	03/07/86	MALLRD	M	A	1160.0	73	0.88	3.26	72	0.16	0.57
204	SUISM	03/07/86	MALLRD	M	A	1120.0	75	1.60	6.40	70	0.49	1.63
117	SUISM	02/13/86	MALLRD	M	A	1200.0	73	0.96	3.56	71	0.35	1.21
495	SUISM	06/19/86	MALLRD	M	A	980.0	72	1.60	5.71	74	0.52	2.00
496	SUISM	06/19/86	MALLRD	M	A	1160.0	72	0.65	2.32	70	0.34	1.13
116	SUISM	02/13/86	MALLRD	M	J	1250.0	71	1.20	4.14	71	0.30	1.03
115	SUISM	02/13/86	MALLRD	M	A	1450.0	74	1.20	4.62	71	0.40	1.38
455	SUISM	06/17/86	MALLRD	M	A	1260.0	70	1.20	4.00	71	0.38	1.31
456	SUISM	06/17/86	MALLRD	M	A	1400.0	75	0.80	3.20	73	0.36	1.33

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492	SUISM	06/18/86	MALLRD	M	A	1380.0	64	0.54	1.50	71	0.35	1.21
494	SUISM	06/19/86	MALLRD	M	A	890.0	70	0.33	1.10	71	0.25	0.86
493	SUISM	06/19/86	MALLRD	M	A	820.0	77	0.44	1.91	78	0.29	1.32
207	SUISM	03/07/86	MALLRD	M	A	1180.0	74	1.30	5.00	72	0.28	1.00
490	SUISM	06/18/86	MALLRD	M	A	1100.0	68	2.30	7.19	70	0.76	2.53
206	SUISM	03/07/86	MALLRD	M	A	1160.0	74	1.30	5.00	73	0.22	0.81
491	SUISM	06/18/86	MALLRD	M	A	1360.0	63	0.48	1.30	70	0.28	0.93
203	SUISM	03/07/86	MALLRD	M	A	1100.0	73	1.20	4.44	72	0.34	1.21
251	TLDDS	03/24/86	AMCOOT	F	U	490.0	75	1.10	4.40	72	0.42	1.50
256	TLDDS	03/24/86	AMCOOT	F	U	420.0	76	3.30	13.75	75	2.10	8.40
253	TLDDS	03/24/86	AMCOOT	M	U	600.0	73	2.60	9.63	79	1.20	5.71
252	TLDDS	03/24/86	AMCOOT	F	U	540.0	77	1.50	6.52	75	1.20	4.80
277	TLDDS	03/25/86	AMCOOT	F	U	520.0	74	4.50	17.31	73	1.50	5.56
250	TLDDS	03/24/86	AMCOOT	M	U	680.0	74	8.30	31.92	74	5.80	22.31
248	TLDDS	03/24/86	AMCOOT	M	U	710.0	75	4.20	16.80	72	2.90	10.36
392	TLDDS	05/28/86	AMCOOT	M	U	640.0	70	11.00	36.67	73	4.70	17.41
391	TLDDS	05/28/86	AMCOOT	F	U	440.0	73	5.40	20.00	74	1.60	6.15
390	TLDDS	05/28/86	AMCOOT	M	U	680.0	74	3.60	13.85	72	1.10	3.93
255	TLDDS	03/24/86	AMCOOT	F	U	500.0	0	3.30	0	75	1.60	6.40
249	TLDDS	03/24/86	AMCOOT	M	U	570.0	74	3.20	12.31	73	1.20	4.44
370	TLDDS	05/28/86	AVOCET	M	U	310.0	70	12.00	40.00	0	0.00	0.00
379	TLDDS	05/28/86	AVOCET	F	U	305.0	0	17.00	0	0	0.00	0.00
272	TLDDS	03/25/86	AVOCET	M	U	310.0	69	6.30	20.32	0	0.00	0.00
377	TLDDS	05/28/86	AVOCET	M	U	320.0	69	12.00	38.71	0	0.00	0.00
271	TLDDS	03/25/86	AVOCET	M	U	365.0	72	3.40	12.14	0	0.00	0.00
375	TLDDS	05/28/86	AVOCET	M	U	305.0	74	12.00	46.15	0	0.00	0.00
269	TLDDS	03/25/86	AVOCET	F	U	360.0	70	3.60	12.00	0	0.00	0.00
373	TLDDS	05/28/86	AVOCET	M	U	310.0	70	6.40	21.33	0	0.00	0.00

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SAMPLE NUMBER	LOCA-TION	DATE OF SAMPLE COLLECTION	SPECIES	SEX	AGE	BIRD WEIGHT	LIVER, PCT. MOIST.	LIVER, SE.ppm wet wt.	LIVER, SE.ppm dry wt.	FLESH, PCT. MOIST.	FLESH, SE.ppm wet wt.	FLESH, SE.ppm dry wt.
268	TLDDS	03/25/86	AVOCET	F	U	365.0	68	9.10	28.44	0	0.00	0.00
371	TLDDS	05/28/86	AVOCET	M	U	320.0	71	16.00	55.17	0	0.00	0.00
376	TLDDS	05/28/86	AVOCET	M	U	330.0	70	8.00	26.67	0	0.00	0.00
374	TLDDS	05/28/86	AVOCET	M	U	315.0	72	9.40	33.57	0	0.00	0.00
372	TLDDS	05/28/86	AVOCET	F	U	320.0	73	9.90	36.67	0	0.00	0.00
378	TLDDS	05/28/86	AVOCET	F	U	230.0	71	6.50	22.41	0	0.00	0.00
267	TLDDS	03/25/86	AVOCET	F	U	345.0	69	5.60	18.06	0	0.00	0.00
266	TLDDS	03/25/86	AVOCET	F	U	315.0	68	9.20	28.75	0	0.00	0.00
265	TLDDS	03/24/86	AVOCET	F	U	315.0	70	4.90	16.33	0	0.00	0.00
264	TLDDS	03/24/86	AVOCET	M	U	310.0	68	12.00	37.50	0	0.00	0.00
263	TLDDS	03/24/86	AVOCET	M	U	330.0	71	1.90	6.55	0	0.00	0.00
270	TLDDS	03/25/86	AVOCET	F	U	290.0	69	3.10	10.00	0	0.00	0.00
380	TLDDS	05/28/86	CNTEAL	M	U	410.0	70	4.40	14.67	74	0.99	3.81
381	TLDDS	05/28/86	CNTEAL	M	U	335.0	73	2.10	7.78	74	0.58	2.23
257	TLDDS	03/24/86	CNTEAL	M	U	340.0	72	11.00	39.29	70	2.80	9.33
258	TLDDS	03/24/86	CNTEAL	M	U	385.0	72	3.30	11.79	72	1.10	3.93
259	TLDDS	03/24/86	CNTEAL	M	U	395.0	71	2.40	8.28	73	0.85	3.15
260	TLDDS	03/24/86	CNTEAL	M	U	440.0	74	3.50	13.46	73	1.50	5.56
261	TLDDS	03/24/86	CNTEAL	F	U	325.0	70	2.30	7.67	73	0.59	2.19
262	TLDDS	03/24/86	CNTEAL	F	U	390.0	72	7.30	26.07	72	0.97	3.46
273	TLDDS	03/25/86	CNTEAL	M	U	415.0	73	8.80	32.59	72	2.40	8.57
274	TLDDS	03/25/86	CNTEAL	M	U	380.0	68	4.50	14.06	0	0.00	0.00
275	TLDDS	03/25/86	CNTEAL	F	U	380.0	71	4.50	15.52	71	1.00	3.45
389	TLDDS	05/28/86	CNTEAL	F	U	315.0	71	5.70	19.66	74	1.30	5.00
387	TLDDS	05/28/86	CNTEAL	M	U	365.0	70	9.30	31.00	73	2.10	7.78
386	TLDDS	05/28/86	CNTEAL	M	U	445.0	71	6.20	21.38	71	0.93	3.21
385	TLDDS	05/28/86	CNTEAL	M	U	365.0	70	6.10	20.33	74	1.60	6.15
384	TLDDS	05/28/86	CNTEAL	M	U	360.0	0	4.80		73	1.20	4.44

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SAMPLE NUMBER	LOCATION	DATE OF SAMPLE COLLECTION	SPECIES	SEX	AGE	BIRD WEIGHT	LIVER, PCT. MOIST.	LIVER, SE.ppm wet wt.	LIVER, SE.ppm dry wt.	FLESH, PCT. MOIST.	FLESH, SE.ppm wet wt.	FLESH, SE.ppm dry wt.
383	TLDDS	05/28/86	CNTEAL	M	U	375.0	72	3.00	10.71	73	0.50	1.85
382	TLDDS	05/28/86	CNTEAL	M	U	405.0	71	4.70	16.21	73	1.70	6.30
276	TLDDS	03/25/86	CNTEAL	F	U	355.0	72	9.20	32.86	73	2.00	7.41
388	TLDDS	05/28/86	CNTEAL	M	U	375.0	69	7.80	25.16	74	2.50	9.62
287	TWISS	03/25/86	AVOCET	F	U	290.0	0	6.00	0	0	0.00	0.00
286	TWISS	03/25/86	AVOCET	F	U	290.0	71	6.90	23.79	0	0.00	0.00
285	TWISS	03/25/86	AVOCET	M	U	325.0	70	2.00	6.67	0	0.00	0.00
284	TWISS	03/25/86	AVOCET	F	U	290.0	72	5.10	18.21	0	0.00	0.00
283	TWISS	03/25/86	AVOCET	M	U	310.0	68	6.60	20.63	0	0.00	0.00
282	TWISS	03/25/86	AVOCET	F	U	305.0	72	3.80	13.57	0	0.00	0.00
280	TWISS	03/25/86	AVOCET	F	U	295.0	68	17.00	53.13	0	0.00	0.00
279	TWISS	03/25/86	AVOCET	M	U	340.0	72	2.70	9.64	0	0.00	0.00
278	TWISS	03/25/86	AVOCET	F	U	330.0	71	5.80	20.00	0	0.00	0.00
412	TWISS	05/29/86	AVOCET	M	U	300.0	0	9.70	0	0	0.00	0.00
413	TWISS	05/29/86	AVOCET	M	U	295.0	0	8.50	0	0	0.00	0.00
414	TWISS	05/29/86	AVOCET	M	U	320.0	72	8.30	29.64	0	0.00	0.00
415	TWISS	05/29/86	AVOCET	M	U	300.0	0	9.40	0	0	0.00	0.00
416	TWISS	05/29/86	AVOCET	M	U	290.0	72	5.50	19.64	0	0.00	0.00
417	TWISS	05/29/86	AVOCET	M	U	300.0	68	26.00	81.25	0	0.00	0.00
418	TWISS	05/29/86	AVOCET	F	U	275.0	70	11.00	36.67	0	0.00	0.00
419	TWISS	05/29/86	AVOCET	F	U	325.0	73	12.00	44.44	0	0.00	0.00
420	TWISS	05/29/86	AVOCET	M	U	300.0	0	15.00	0	0	0.00	0.00
421	TWISS	05/29/86	AVOCET	F	U	315.0	69	8.90	28.71	0	0.00	0.00
281	TWISS	03/25/86	AVOCET	M	U	300.0	69	2.90	9.35	0	0.00	0.00
433	TWISS	05/30/86	BNSTLT	F	U	150.0	0	12.00	0	0	0.00	0.00
432	TWISS	05/30/86	BNSTLT	M	U	180.0	71	11.00	37.93	0	0.00	0.00
438	TWISS	05/30/86	BNSTLT	F	U	170.0	0	14.00	0	0	0.00	0.00
431	TWISS	05/30/86	BNSTLT	F	U	165.0	69	26.00	83.87	0	0.00	0.00

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SAMPLE NUMBER	LOCA-TION	DATE OF SAMPLE COLLECTION	SPECIES	SEX	AGE	BIRD WEIGHT	LIVER, PCT. MOIST.	LIVER, SE.ppm wet wt.	LIVER, SE.ppm dry wt.	FLESH, PCT. MOIST.	FLESH, SE.ppm wet wt.	FLESH, SE.ppm dry wt.
436	TWISS	05/30/86	BNSTLT	M	U	155.0	0	14.00	0	0	0.00	0.00
434	TWISS	05/30/86	BNSTLT	F	U	155.0	0	7.50	0	0	0.00	0.00
294	TWISS	03/25/86	BNSTLT	M	U	185.0	73	15.00	55.56	0	0.00	0.00
437	TWISS	05/30/86	BNSTLT	M	U	155.0	0	4.60	0	0	0.00	0.00
435	TWISS	05/30/86	BNSTLT	M	U	155.0	0	21.00	0	0	0.00	0.00
430	TWISS	05/30/86	BNSTLT	M	U	180.0	0	23.00	0	0	0.00	0.00
439	TWISS	05/30/86	BNSTLT	M	U	160.0	0	9.80	0	0	0.00	0.00
314	TWISS	03/27/86	CNTEAL	M	U	370.0	70	4.80	16.00	0	0.00	0.00
313	TWISS	03/27/86	CNTEAL	F	U	375.0	0	4.30	0	71	0.59	2.03
312	TWISS	03/27/86	CNTEAL	F	U	370.0	72	4.10	14.64	72	0.54	1.93
315	TWISS	03/27/86	CNTEAL	M	U	355.0	69	2.60	8.39	72	0.64	2.29
293	TWISS	03/25/86	CNTEAL	F	U	320.0	72	3.90	13.93	73	0.76	2.81
292	TWISS	03/25/86	CNTEAL	M	U	370.0	70	11.00	36.67	74	2.10	8.08
291	TWISS	03/25/86	CNTEAL	M	U	355.0	72	4.50	16.07	73	1.20	4.44
290	TWISS	03/25/86	CNTEAL	M	U	425.0	84	6.50	40.62	0	0.00	0.00
289	TWISS	03/25/86	CNTEAL	M	U	385.0	70	3.70	12.33	72	0.53	1.89
288	TWISS	03/25/86	CNTEAL	M	U	355.0	72	3.20	11.43	72	1.00	3.57

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SELENIUM VERIFICATION STUDY
MAY 1987

DATE OF SAMPLE COLLECTION	LOCATION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L [1/]	PCT. MOISTURE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES CARPPP									
* LOCATION BBRES									
06/11/86	BBRES	CARPPP	6	348	711.0	F	81	0.51	2.68
06/11/86	BBRES	CARPPP	6	367	767.4	F	80	0.68	3.40
* LOCATION COACH									
05/21/86	COACH	CARPPP	1	500	2442.9	F	76	2.80	11.67
05/21/86	COACH	CARPPP	1	420	1115.1	F	81	2.00	10.53
05/21/86	COACH	CARPPP	1	440	1897.2	F	78	4.20	19.09
05/21/86	COACH	CARPPP	1	580	3015.0	F	77	3.70	16.09
05/21/86	COACH	CARPPP	1	380	965.5	F	79	2.00	9.52
05/21/86	COACH	CARPPP	1	390	937.2	F	79	2.40	11.43
* LOCATION PVODR									
04/14/86	PVODR	CARPPP	1	375	882.5	F	80	1.20	6.00
04/14/86	PVODR	CARPPP	1	360	696.6	F	79	0.64	3.05
04/14/86	PVODR	CARPPP	1	400	1120.6	F	80	0.82	4.10
04/14/86	PVODR	CARPPP	1	400	1207.6	F	83	0.58	3.41
* LOCATION RESDR									
04/15/86	RESDR	CARPPP	1	310	616.2	F	80	0.45	2.25
04/15/86	RESDR	CARPPP	1	270	379.2	F	79	0.33	1.57
04/15/86	RESDR	CARPPP	1	260	334.5	F	81	0.34	1.79
04/15/86	RESDR	CARPPP	1	270	399.1	F	80	0.34	1.70
04/15/86	RESDR	CARPPP	1	275	389.0	F	80	0.44	2.20
04/15/86	RESDR	CARPPP	1	270	394.3	F	80	0.44	2.20
04/15/86	RESDR	CARPPP	1	430	1454.8	F	79	0.40	1.90
* LOCATION STNYA									
05/13/86	STNYA	CARPPP	6	378	881.0	F	79	0.39	1.86
04/29/86	STNYA	CARPPP	6	388	886.1	F	80	0.46	2.30
* LOCATION STNYB									
05/14/86	STNYB	CARPPP	6	448	1619.4	F	79	0.50	2.38
05/14/86	STNYB	CARPPP	6	448	1619.4	F	78	0.48	2.18
* LOCATION WWRIV									
05/20/86	WWRIV	CARPPP	1	320	883.1	F	80	1.10	5.50
05/20/86	WWRIV	CARPPP	1	350	1136.6	F	79	1.30	6.19
05/20/86	WWRIV	CARPPP	1	440	1529.8	F	81	1.10	5.79
05/20/86	WWRIV	CARPPP	1	350	1005.6	F	80	1.10	5.50
05/20/86	WWRIV	CARPPP	1	320	574.2	F	81	1.10	5.79
05/20/86	WWRIV	CARPPP	1	460	1897.5	F	79	1.30	6.19

1/ Tissue type: W = whole, F = flesh, muscle, soft tissue, L = liver.

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SELENIUM VERIFICATION STUDY
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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES CHNCAT									
* LOCATION BBRES									
06/11/86	BBRES	CHNCAT	6	317	383.7	F	80	0.27	1.35
06/11/86	BBRES	CHNCAT	6	328	451.8	F	79	0.26	1.24
* LOCATION CMP13									
08/06/86	CMP13	CHNCAT	1	190	78.7	F	80	0.81	4.05
08/06/86	CMP13	CHNCAT	1	245	154.2	F	80	0.57	2.85
08/06/86	CMP13	CHNCAT	1	225	123.9	F	79	0.70	3.33
08/06/86	CMP13	CHNCAT	1	210	96.0	F	81	0.90	4.74
08/06/86	CMP13	CHNCAT	4	218	113.2	F	80	0.78	3.90
* LOCATION COACH									
05/21/86	COACH	CHNCAT	1	240	151.0	F	80	1.00	5.00
05/21/86	COACH	CHNCAT	3	202	87.4	F	81	0.81	4.26
05/21/86	COACH	CHNCAT	1	250	154.3	F	84	1.20	7.50
05/21/86	COACH	CHNCAT	1	295	254.0	F	81	0.10	0.53
05/21/86	COACH	CHNCAT	1	290	309.1	F	81	0.34	1.79
05/21/86	COACH	CHNCAT	1	250	189.5	F	79	1.10	5.24
* LOCATION MUDSL									
08/07/86	MUDSL	CHNCAT	1	220	118.7	F	81	0.42	2.21
08/07/86	MUDSL	CHNCAT	4	220	118.2	F	80	0.52	2.60
08/07/86	MUDSL	CHNCAT	1	230	134.6	F	81	0.58	3.05
08/07/86	MUDSL	CHNCAT	1	210	114.9	F	82	0.42	2.33
08/07/86	MUDSL	CHNCAT	1	220	104.8	F	80	0.56	2.80
* LOCATION SALTS									
08/07/86	SALTS	CHNCAT	1	200	81.5	F	80	0.30	1.50
08/07/86	SALTS	CHNCAT	1	500	1848.0	F	80	0.18	0.90
08/07/86	SALTS	CHNCAT	1	450	1084.6	F	80	0.17	0.85
08/07/86	SALTS	CHNCAT	3	222	119.9	F	81	0.34	1.79
08/07/86	SALTS	CHNCAT	1	260	180.5	F	81	0.36	1.89
08/07/86	SALTS	CHNCAT	1	205	97.8	F	81	0.30	1.58
* LOCATION SJRMR									
08/06/86	SJRMR	CHNCAT	1	210	186.9	F	79	0.28	1.33
08/06/86	SJRMR	CHNCAT	1	190	188.4	F	82	0.21	1.17
08/06/86	SJRMR	CHNCAT	1	190	187.2	F	80	0.22	1.10
08/06/86	SJRMR	CHNCAT	1	210	192.2	F	78	0.25	1.14
08/06/86	SJRMR	CHNCAT	4	200	99.8	F	79	0.25	1.19
* LOCATION STNYA									
04/29/86	STNYA	CHNCAT	4	339	480.5	F	79	0.31	1.48
04/29/86	STNYA	CHNCAT	4	340	471.4	F	76	0.31	1.29

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DATE OF SAMPLE COLLECTION	LOCATION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOISTURE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
* LOCATION STNYB									
05/14/86	STNYB	CHNCAT	5	171	76.0	F	79	0.20	0.95
05/14/86	STNYB	CHNCAT	5	170	69.0	F	78	0.18	0.82
* LOCATION WWRIV									
05/20/86	WWRIV	CHNCAT	1	380	800.1	F	75	0.75	3.00
05/20/86	WWRIV	CHNCAT	1	340	453.5	F	80	0.52	2.60
05/20/86	WWRIV	CHNCAT	1	420	887.8	F	78	0.54	2.45
05/20/86	WWRIV	CHNCAT	6	196	94.3	F	80	0.52	2.60
** SPECIES CORVNA									
* LOCATION SALTN									
05/19/86	SALTN	CORVNA	1	530	1740.3	F	78	3.00	13.64
05/19/86	SALTN	CORVNA	1	540	1554.2	F	75	3.00	12.00
05/19/86	SALTN	CORVNA	1	530	1497.6	F	77	3.00	13.04
05/19/86	SALTN	CORVNA	1	530	1436.2	F	77	3.10	13.48
05/19/86	SALTN	CORVNA	1	520	1409.9	F	77	3.40	14.78
05/19/86	SALTN	CORVNA	1	500	1215.4	F	76	2.90	12.08
05/19/86	SALTN	CORVNA	1	490	1145.5	F	76	3.10	12.92
05/19/86	SALTN	CORVNA	1	670	3177.9	F	74	3.60	13.85
05/19/86	SALTN	CORVNA	1	480	1230.2	F	77	3.30	14.35
05/19/86	SALTN	CORVNA	1	460	938.4	F	77	2.80	12.17
05/19/86	SALTN	CORVNA	1	500	1197.2	F	78	2.90	13.18
** SPECIES CROAKR									
* LOCATION SALTN									
05/19/86	SALTN	CROAKR	1	250	183.3	F	80	3.10	15.50
05/19/86	SALTN	CROAKR	1	210	134.7	F	80	4.50	22.50
05/19/86	SALTN	CROAKR	1	240	171.6	F	79	3.70	17.62
05/19/86	SALTN	CROAKR	1	240	156.3	F	78	4.10	18.64
05/19/86	SALTN	CROAKR	1	235	162.3	F	79	4.10	19.52
05/19/86	SALTN	CROAKR	1	220	136.6	F	80	4.50	22.50
05/19/86	SALTN	CROAKR	1	310	357.5	F	80	3.80	19.00
05/19/86	SALTN	CROAKR	1	280	268.1	F	81	3.60	18.95
05/19/86	SALTN	CROAKR	1	210	157.8	F	78	3.60	16.36
** SPECIES ENGSOL									
* LOCATION CNSFB									
01/08/86	CNSFB	ENGSOL	6	134	0.0	F	81	0.52	2.74
05/01/86	CNSFB	ENGSOL	7	133	20.4	F	82	0.44	2.44
01/08/86	CNSFB	ENGSOL	6	137	0.0	F	81	0.41	2.16
05/29/86	CNSFB	ENGSOL	7	141	22.0	F	84	0.44	2.75

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DATE OF SAMPLE COLLECTION	LOCA- TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST- URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
* LOCATION HMBLT									
06/10/86	HMBLT	ENGSOL	8	128	21.4	F	80	0.36	1.80
02/04/86	HMBLT	ENGSOL	14	116	0.0	F	82	0.27	1.50
06/10/86	HMBLT	ENGSOL	8	125	19.9	F	80	0.41	2.05
* LOCATION SNPBB									
01/07/86	SNPBB	ENGSOL	8	146	28.8	F	84	0.47	2.94
01/07/86	SNPBB	ENGSOL	9	142	29.0	F	82	0.58	3.22
05/06/86	SNPBB	ENGSOL	6	98	8.2	F	79	0.58	2.76
05/06/86	SNPBB	ENGSOL	6	96	7.1	F	79	0.69	3.29
* LOCATION SOSFB									
01/08/86	SOSFB	ENGSOL	6	126	16.8	F	80	0.51	2.55
05/01/86	SOSFB	ENGSOL	6	112	13.9	F	80	0.42	2.10
05/01/86	SOSFB	ENGSOL	6	112	13.5	F	82	0.41	2.28
01/08/86	SOSFB	ENGSOL	6	120	14.1	F	80	0.51	2.55
** SPECIES GAMBSA									
* LOCATION TLDDS									
05/28/86	TLDDS	GAMBSA	36	26	0.2	W	78	3.60	16.36
05/28/86	TLDDS	GAMBSA	36	26	0.2	W	77	4.20	18.26
** SPECIES HERRNG									
* LOCATION CNSFB									
05/01/86	CNSFB	HERRNG	6	89	7.4	W	78	0.62	2.82
05/01/86	CNSFB	HERRNG	6	91	8.2	W	80	0.68	3.40
01/10/86	CNSFB	HERRNG	15	77	4.8	W	81	0.69	3.63
01/10/86	CNSFB	HERRNG	15	76	4.6	W	81	0.70	3.68
02/19/86	CNSFB	HERRNG	6	197	98.4	F	72	0.39	1.39
02/19/86	CNSFB	HERRNG	6	196	97.3	F	75	0.39	1.56
* LOCATION HMBLT									
06/12/86	HMBLT	HERRNG	1	200	80.7	W	71	1.30	4.48
02/03/86	HMBLT	HERRNG	6	198	109.4	F	76	0.41	1.71
02/03/86	HMBLT	HERRNG	6	206	120.4	F	74	0.40	1.54
* LOCATION SNPBB									
05/06/86	SNPBB	HERRNG	40	58	1.2	W	82	0.67	3.72
02/04/86	SNPBB	HERRNG	1	200	61.0	W	74	0.52	2.00
05/06/86	SNPBB	HERRNG	29	58	1.1	W	82	0.63	3.50
* LOCATION SOSFB									
02/05/86	SOSFB	HERRNG	4	174	61.7	F	74	0.35	1.35

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DATE OF SAMPLE COLLECTION	LOCA- TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST- URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
05/01/86	SOSFB	HERRNG	50	45	0.0	W	83	0.57	3.35
05/01/86	SOSFB	HERRNG	50	45	0.0	W	83	0.58	3.41
02/05/86	SOSFB	HERRNG	4	172	68.1	F	77	0.32	1.39
* LOCATION SUISB									
05/08/86	SUISB	HERRNG	8	58	1.8	W	80	0.53	2.65
** SPECIES LFSMLT									
* LOCATION CNSFB									
05/06/86	CNSFB	LFSMLT	9	99	9.6	W	69	0.24	0.77
01/10/86	CNSFB	LFSMLT	9	100	8.2	W	81	0.31	1.63
01/08/86	CNSFB	LFSMLT	18	75	3.5	W	81	0.32	1.68
05/06/86	CNSFB	LFSMLT	9	95	9.0	W	69	0.26	0.84
* LOCATION HMBLT									
02/04/86	HMBLT	LFSMLT	9	94	6.6	W	81	0.24	1.26
02/04/86	HMBLT	LFSMLT	9	94	6.7	W	80	0.22	1.10
* LOCATION SNPBB									
05/06/86	SNPBB	LFSMLT	6	87	6.9	W	71	0.33	1.14
01/07/86	SNPBB	LFSMLT	14	64	2.3	W	86	0.32	2.29
01/13/86	SNPBB	LFSMLT	17	69	2.6	W	82	0.34	1.89
05/06/86	SNPBB	LFSMLT	6	89	6.0	W	70	0.34	1.13
* LOCATION SOSFB									
01/09/86	SOSFB	LFSMLT	11	63	1.8	W	82	0.36	2.00
01/08/86	SOSFB	LFSMLT	14	63	2.1	W	85	0.27	1.80
05/01/86	SOSFB	LFSMLT	8	91	6.6	W	73	0.27	1.00
05/01/86	SOSFB	LFSMLT	8	91	7.2	W	71	0.23	0.79
* LOCATION SUISB									
01/13/86	SUISB	LFSMLT	15	80	4.8	W	82	0.26	1.44
01/06/86	SUISB	LFSMLT	18	77	3.9	W	81	0.36	1.89
05/07/86	SUISB	LFSMLT	9	93	8.0	W	72	0.34	1.21
05/07/86	SUISB	LFSMLT	9	93	8.6	W	70	0.34	1.13
** SPECIES LMBASS									
* LOCATION BBRES									
06/11/86	BBRES	LMBASS	5	240	183.7	F	82	0.57	3.17
06/11/86	BBRES	LMBASS	5	244	197.1	F	81	0.59	3.11
* LOCATION PVODR									
04/14/86	PVODR	LMBASS	1	280	403.4	F	79	0.81	3.86
04/14/86	PVODR	LMBASS	1	370	971.1	F	80	0.97	4.85

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
04/14/86	PVODR	LMBASS	1	380	1038.5	F	80	1.10	5.50
04/14/86	PVODR	LMBASS	1	330	611.0	F	78	0.73	3.32
04/14/86	PVODR	LMBASS	1	300	451.1	F	80	0.89	4.45
** SPECIES NANCHV									
* LOCATION CNSFB									
05/07/86	CNSFB	NANCHV	6	107	11.8	W	77	0.47	2.04
01/08/86	CNSFB	NANCHV	11	62	1.6	W	77	0.62	2.70
05/07/86	CNSFB	NANCHV	6	107	12.0	W	76	0.46	1.92
* LOCATION SNPBB									
05/06/86	SNPBB	NANCHV	7	92	7.0	W	75	0.56	2.24
05/06/86	SNPBB	NANCHV	7	98	8.8	W	75	0.52	2.08
* LOCATION SOSFB									
01/08/86	SOSFB	NANCHV	8	82	4.1	W	77	0.56	2.43
01/08/86	SOSFB	NANCHV	8	85	4.5	W	78	0.60	2.73
05/01/86	SOSFB	NANCHV	7	96	7.8	W	79	0.48	2.29
05/01/86	SOSFB	NANCHV	7	99	8.1	W	77	0.45	1.96
* LOCATION SUISB									
06/02/86	SUISB	NANCHV	9	89	7.2	W	76	0.50	2.08
06/02/86	SUISB	NANCHV	9	91	8.1	W	77	0.47	2.04
** SPECIES SFLNDR									
* LOCATION CNSFB									
01/08/86	CNSFB	SFLNDR	1	460	1528.0	F	77	0.34	1.48
05/01/86	CNSFB	SFLNDR	1	415	970.6	F	80	0.40	2.00
01/10/86	CNSFB	SFLNDR	1	378	660.3	F	80	0.25	1.25
05/01/86	CNSFB	SFLNDR	1	420	0.0	F	82	0.33	1.83
05/29/86	CNSFB	SFLNDR	1	445	1023.6	F	83	0.40	2.35
05/01/86	CNSFB	SFLNDR	1	475	1434.6	F	80	0.48	2.40
01/10/86	CNSFB	SFLNDR	1	380	805.1	F	78	0.39	1.77
* LOCATION HMBLT									
06/11/86	HMBLT	SFLNDR	1	290	326.2	F	79	0.19	0.90
* LOCATION SNPBB									
05/06/86	SNPBB	SFLNDR	3	323	392.3	F	82	0.88	4.89
05/06/86	SNPBB	SFLNDR	1	550	2013.1	F	81	0.58	3.05
01/06/86	SNPBB	SFLNDR	1	426	0.0	F	81	0.70	3.68
01/06/86	SNPBB	SFLNDR	3	213	120.6	F	81	0.82	4.32

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
* LOCATION SOSFB									
06/30/86	SOSFB	SFLNDR	1	455	1198.5	F	79	0.44	2.10
* LOCATION SUISB									
01/06/86	SUISB	SFLNDR	5	179	77.9	F	79	1.20	5.71
05/08/86	SUISB	SFLNDR	4	210	75.2	F	80	1.20	6.00
01/06/86	SUISB	SFLNDR	5	177	73.7	F	79	1.00	4.76
** SPECIES SPSNDB									
* LOCATION CNSFB									
01/10/86	CNSFB	SPSNDB	9	96	8.6	W	79	0.47	2.24
05/28/86	CNSFB	SPSNDB	10	90	7.7	W	80	0.45	2.25
01/10/86	CNSFB	SPSNDB	9	92	7.7	W	79	0.46	2.19
05/28/86	CNSFB	SPSNDB	10	89	7.1	W	80	0.47	2.35
* LOCATION HMBLT									
02/04/86	HMBLT	SPSNDB	5	110	14.7	W	78	0.29	1.32
02/04/86	HMBLT	SPSNDB	5	102	10.5	W	79	0.31	1.48
06/10/86	HMBLT	SPSNDB	10	81	5.9	W	79	0.42	2.00
06/10/86	HMBLT	SPSNDB	10	81	6.1	W	79	0.36	1.71
* LOCATION SNPBB									
05/29/86	SNPBB	SPSNDB	14	64	2.4	W	80	0.35	1.75
05/29/86	SNPBB	SPSNDB	14	63	2.2	W	79	0.38	1.81
* LOCATION SOSFB									
05/27/86	SOSFB	SPSNDB	10	69	3.8	W	80	0.43	2.15
05/27/86	SOSFB	SPSNDB	10	70	4.0	W	80	0.41	2.05
** SPECIES STGSCU									
* LOCATION CNSFB									
02/05/86	CNSFB	STGSCU	5	143	45.2	F	82	0.34	1.89
02/05/86	CNSFB	STGSCU	5	134	35.0	F	81	0.43	2.26
* LOCATION HMBLT									
02/04/86	HMBLT	STGSCU	6	145	0.0	F	84	0.24	1.50
02/04/86	HMBLT	STGSCU	6	141	0.0	F	86	0.25	1.79
06/10/86	HMBLT	STGSCU	9	130	25.0	F	82	0.28	1.56
06/10/86	HMBLT	STGSCU	9	126	21.9	F	81	0.28	1.47
* LOCATION SNPBB									
05/06/86	SNPBB	STGSCU	6	161	54.6	F	81	0.47	2.47
05/06/86	SNPBB	STGSCU	6	154	50.5	F	82	0.47	2.61
01/13/86	SNPBB	STGSCU	6	134	0.0	F	83	0.42	2.47

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
01/13/86	SNPBB	STGSCU	8	134	0.0	F	82	0.46	2.56
* LOCATION SOSFB									
05/01/86	SOSFB	STGSCU	5	139	35.3	F	82	0.56	3.11
05/01/86	SOSFB	STGSCU	5	165	60.7	F	83	0.49	2.88
05/01/86	SOSFB	STGSCU	5	160	57.0	F	82	0.45	2.50
05/01/86	SOSFB	STGSCU	5	143	40.8	F	.	0.36	
01/10/86	SOSFB	STGSCU	6	155	0.0	F	81	0.39	2.05
01/10/86	SOSFB	STGSCU	6	150	0.0	F	81	0.40	2.11
* LOCATION SUISB									
05/07/86	SUISB	STGSCU	6	108	14.2	F	82	0.45	2.50
05/07/86	SUISB	STGSCU	6	107	14.4	F	81	0.40	2.11
01/13/86	SUISB	STGSCU	6	143	38.0	F	83	0.44	2.59
01/13/86	SUISB	STGSCU	6	140	39.0	F	82	0.53	2.94
** SPECIES TILPIA									
* LOCATION SALTN									
05/19/86	SALTN	TILPIA	1	190	159.9	F	79	2.80	13.33
05/19/86	SALTN	TILPIA	1	240	329.0	F	78	3.90	17.73
05/19/86	SALTN	TILPIA	1	205	181.4	F	77	3.30	14.35
05/19/86	SALTN	TILPIA	1	230	286.1	F	78	3.50	15.91
05/19/86	SALTN	TILPIA	1	200	215.4	F	76	3.40	14.17
05/19/86	SALTN	TILPIA	1	200	179.4	F	78	3.10	14.09
05/19/86	SALTN	TILPIA	1	220	229.9	F	78	4.00	18.18
05/19/86	SALTN	TILPIA	1	185	143.6	F	81	3.40	17.89
05/19/86	SALTN	TILPIA	1	225	263.6	F	79	3.30	15.71
05/19/86	SALTN	TILPIA	1	300	510.8	F	77	3.40	14.78
05/19/86	SALTN	TILPIA	1	190	161.7	F	79	3.40	16.19
05/19/86	SALTN	TILPIA	1	220	236.9	F	77	3.70	16.09
05/19/86	SALTN	TILPIA	1	320	690.4	F	79	3.30	15.71
05/19/86	SALTN	TILPIA	1	215	201.5	F	78	4.20	19.09
05/19/86	SALTN	TILPIA	1	200	164.9	F	77	4.50	19.57
** SPECIES WHTCAT									
* LOCATION SALTS									
08/05/86	SALTS	WHTCAT	1	220	137.5	F	83	0.17	1.00
08/05/86	SALTS	WHTCAT	1	180	71.1	F	82	0.17	0.94
08/05/86	SALTS	WHTCAT	1	165	60.0	F	82	0.20	1.11
08/05/86	SALTS	WHTCAT	1	160	46.5	F	83	0.21	1.24
08/05/86	SALTS	WHTCAT	1	185	83.1	F	82	0.21	1.17
08/05/86	SALTS	WHTCAT	1	175	74.3	F	82	0.25	1.39
08/05/86	SALTS	WHTCAT	6	181	78.8	F	81	0.22	1.16

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* LOCATION SJRMR									
08/05/86	SJRMR	WHTCAT	6	188	99.0	F	82	0.29	1.61
08/05/86	SJRMR	WHTCAT	1	185	81.4	F	81	0.28	1.47
08/05/86	SJRMR	WHTCAT	1	170	82.1	F	81	0.34	1.79
08/05/86	SJRMR	WHTCAT	1	190	97.5	F	81	0.20	1.05
08/05/86	SJRMR	WHTCAT	1	205	112.1	F	82	0.31	1.72
08/05/86	SJRMR	WHTCAT	1	200	131.7	F	82	0.28	1.56
08/05/86	SJRMR	WHTCAT	1	180	88.3	F	80	0.33	1.65
** SPECIES WSTRGN									
* LOCATION SNPBB									
03/17/86	SNPBB	WSTRGN	1	1118	0.0	F	78	1.60	7.27
03/09/86	SNPBB	WSTRGN	1	1016	0.0	F	79	1.10	5.24
05/24/86	SNPBB	WSTRGN	1	1245	0.0	F	78	1.10	5.00
04/06/86	SNPBB	WSTRGN	1	1359	0.0	F	75	2.00	8.00
03/09/86	SNPBB	WSTRGN	1	1207	0.0	F	74	4.00	15.38
03/17/86	SNPBB	WSTRGN	1	1060	0.0	F	79	2.00	9.52
03/17/86	SNPBB	WSTRGN	1	1067	0.0	F	68	1.30	4.06
04/04/86	SNPBB	WSTRGN	1	1067	0.0	F	76	1.70	7.08
04/04/86	SNPBB	WSTRGN	1	1118	0.0	F	77	1.60	6.96
04/05/86	SNPBB	WSTRGN	1	1359	0.0	F	77	2.20	9.57
** SPECIES WSUCKR									
* LOCATION BBRES									
06/11/86	BBRES	WSUCKR	6	307	353.1	F	78	0.51	2.32
06/11/86	BBRES	WSUCKR	6	275	255.0	F	80	0.51	2.55
** SPECIES YFGOBY									
* LOCATION SNPBB									
02/04/86	SNPBB	YFGOBY	5	171	27.1	W	81	0.48	2.53
05/06/86	SNPBB	YFGOBY	9	82	5.1	W	77	0.47	2.04
05/06/86	SNPBB	YFGOBY	9	80	4.8	W	79	0.46	2.19
* LOCATION SUISB									
05/08/86	SUISB	YFGOBY	3	124	9.4	W	83	0.47	2.76
05/08/86	SUISB	YFGOBY	18	49	1.0	W	83	0.35	2.06
02/03/86	SUISB	YFGOBY	4	150	19.4	W	81	0.46	2.42
02/03/86	SUISB	YFGOBY	4	154	20.6	W	81	0.47	2.47

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DATE OF SAMPLE COLLECTION	LOCA- TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST- URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES CHNCAT									
* LOCATION BBRES									
06/11/86	BBRES	CHNCAT	6	317	383.7	L	81	1.60	8.42
06/11/86	BBRES	CHNCAT	6	328	451.8	L	83	1.50	8.82
* LOCATION CMP13									
08/06/86	CMP13	CHNCAT	4	218	113.2	L	85	2.40	16.00
* LOCATION COACH									
05/21/86	COACH	CHNCAT	9	240	162.1	L	83	2.00	11.76
* LOCATION MUDSL									
08/07/86	MUDSL	CHNCAT	4	220	118.2	L	81	2.60	13.68
* LOCATION SALTS									
08/07/86	SALTS	CHNCAT	3	222	119.9	L	84	1.80	11.25
08/07/86	SALTS	CHNCAT	1	600	1848.0	L	84	1.40	8.75
08/07/86	SALTS	CHNCAT	1	450	1084.6	L	82	1.50	8.33
* LOCATION SJRMR									
08/06/86	SJRMR	CHNCAT	4	200	99.8	L	82	1.90	10.56
* LOCATION STNYA									
04/29/86	STNYA	CHNCAT	4	339	480.5	L	82	1.70	9.44
04/29/86	STNYA	CHNCAT	4	340	471.4	L	81	1.80	9.47
* LOCATION STNYB									
05/14/86	STNYB	CHNCAT	5	171	76.0	L	80	1.90	9.50
05/14/86	STNYB	CHNCAT	5	170	69.0	L		2.10	
* LOCATION WWRIV									
05/20/86	WWRIV	CHNCAT	6	196	94.3	L	82	2.00	11.11
05/20/86	WWRIV	CHNCAT	1	340	453.5	L	80	2.60	13.00
05/20/86	WWRIV	CHNCAT	1	380	800.1	L	79	3.80	18.10
05/20/86	WWRIV	CHNCAT	1	420	887.8	L	80	2.50	12.50
** SPECIES CORVNA									
* LOCATION SALTN									
05/19/86	SALTN	CORVNA	1	530	1740.3	L	50	1.80	3.60
05/19/86	SALTN	CORVNA	1	480	1230.2	L	51	2.00	4.08
05/19/86	SALTN	CORVNA	1	530	1436.2	L	57	2.20	5.12
05/19/86	SALTN	CORVNA	1	530	1497.6	L	59	2.20	5.37
05/19/86	SALTN	CORVNA	1	540	1554.2	L	43	2.30	4.04
05/19/86	SALTN	CORVNA	1	530	1522.2	L	42	1.60	2.76

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DATE OF SAMPLE COLLECTION	LOCA- TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST- URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
05/19/86	SALTN	CORVNA	1	490	1145.5	L	54	1.90	4.13
05/19/86	SALTN	CORVNA	1	500	1215.4	L	50	2.20	4.40
05/19/86	SALTN	CORVNA	1	670	3177.9	L	48	2.50	4.81
05/19/86	SALTN	CORVNA	1	520	1409.9	L	46	2.00	3.70
05/19/86	SALTN	CORVNA	1	500	1197.2	L	49	2.50	4.90
05/19/86	SALTN	CORVNA	1	460	938.4	L	67	5.00	15.15
** SPECIES CROAKR									
* LOCATION SALTN									
05/19/86	SALTN	CROAKR	1	210	157.8	L		5.10	.00
05/19/86	SALTN	CROAKR	1	240	156.3	L		4.10	.00
05/19/86	SALTN	CROAKR	1	220	136.6	L		5.50	.00
05/19/86	SALTN	CROAKR	1	310	357.5	L		3.90	.00
05/19/86	SALTN	CROAKR	1	280	268.1	L		4.40	.00
05/19/86	SALTN	CROAKR	1	235	162.3	L		5.70	.00
05/19/86	SALTN	CROAKR	1	240	171.6	L		4.00	.00
05/19/86	SALTN	CROAKR	1	210	134.7	L		5.00	.00
05/19/86	SALTN	CROAKR	1	250	183.3	L		3.90	.00
** SPECIES ENGSOL									
* LOCATION CNSFB									
05/29/86	CNSFB	ENGSOL	7	141	22.0	L		1.50	.00
05/01/86	CNSFB	ENGSOL	7	133	20.4	L		1.70	.00
* LOCATION HMBLT									
02/04/86	HMBLT	ENGSOL	6	127	0.0	L		0.00	.00
06/10/86	HMBLT	ENGSOL	8	125	19.9	L		2.10	.00
* LOCATION SOSFB									
05/01/86	SOSFB	ENGSOL	6	112	13.9	L		1.50	.00
05/01/86	SOSFB	ENGSOL	6	112	13.5	L		1.60	.00
** SPECIES LMBASS									
* LOCATION BBRES									
06/11/86	BBRES	LMBASS	5	240	183.7	L		1.70	.00
06/11/86	BBRES	LMBASS	5	244	197.1	L	80	1.30	6.50
* LOCATION PVODR									
04/14/86	PVODR	LMBASS	1	300	451.1	L	80	1.50	7.50
04/14/86	PVODR	LMBASS	1	330	611.0	L	78	2.00	9.09
04/14/86	PVODR	LMBASS	1	280	403.4	L	80	1.20	6.00
04/14/86	PVODR	LMBASS	1	380	1038.5	L	78	1.90	8.64
04/14/86	PVODR	LMBASS	1	370	971.1	L	80	1.60	8.00

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES SFLNDR									
* LOCATION CNSFB									
01/10/86	CNSFB	SFLNDR	1	378	660.3	L	68	1.10	3.44
05/01/86	CNSFB	SFLNDR	1	415	970.6	L	77	1.50	6.52
05/29/86	CNSFB	SFLNDR	1	445	1023.6	L	77	2.50	10.87
01/10/86	CNSFB	SFLNDR	1	380	805.1	L	70	1.80	6.00
05/01/86	CNSFB	SFLNDR	1	475	1434.6	L	72	1.70	6.07
01/08/86	CNSFB	SFLNDR	1	460	1528.0	L	68	1.60	5.00
* LOCATION HMBLT									
06/11/86	HMBLT	SFLNDR	1	290	326.2	L		0.97	00
* LOCATION SNPBB									
05/06/86	SNPBB	SFLNDR	1	550	2013.1	L	74	2.10	8.08
01/06/86	SNPBB	SFLNDR	1	426	9999.9	L	72	1.60	5.71
05/06/86	SNPBB	SFLNDR	3	323	392.3	L	79	2.20	10.48
01/06/86	SNPBB	SFLNDR	3	213	120.6	L		1.90	.00
* LOCATION SOSFB									
06/30/86	SOSFB	SFLNDR	1	455	1198.5	L	68	1.70	5.31
* LOCATION SUISB									
01/06/86	SUISB	SFLNDR	5	177	73.7	L		2.80	.00
01/06/86	SUISB	SFLNDR	5	179	77.9	L		3.40	.00
05/08/86	SUISB	SFLNDR	4	210	75.2	L		2.70	.00
** SPECIES STGSCU									
* LOCATION CNSFB									
02/05/86	CNSFB	STGSCU	5	134	35.0	L	77	1.20	5.22
02/05/86	CNSFB	STGSCU	5	143	45.2	L	77	1.20	5.22
* LOCATION HMBLT									
02/04/86	HMBLT	STGSCU	6	141	0.0	L	75	1.10	4.40
02/04/86	HMBLT	STGSCU	6	145	0.0	L		0.00	.00
06/10/86	HMBLT	STGSCU	9	130	25.0	L		0.89	.00
06/10/86	HMBLT	STGSCU	9	126	21.9	L		1.10	.00
* LOCATION SNPBB									
05/06/86	SNPBB	STGSCU	6	154	50.5	L		1.80	.00
05/06/86	SNPBB	STGSCU	6	161	54.6	L	78	1.70	7.73
01/13/86	SNPBB	STGSCU	6	134	0.0	L	75	1.70	6.80
01/13/86	SNPBB	STGSCU	8	134	0.0	L	74	1.50	5.77

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DATE OF SAMPLE COLLECTION	LOCATION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOISTURE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
* LOCATION SOSFB									
05/01/86	SOSFB	STGSCU	5	160	57.0	L		1.60	.00
05/01/86	SOSFB	STGSCU	5	165	60.7	L		1.60	.00
05/01/86	SOSFB	STGSCU	5	143	40.8	L		1.20	.00
01/10/86	SOSFB	STGSCU	6	155	0.0	L	72	1.20	4.29
05/01/86	SOSFB	STGSCU	5	139	35.3	L		1.30	.00
01/10/86	SOSFB	STGSCU	6	150	0.0	L	76	1.20	5.00
* LOCATION SUISB									
01/13/86	SUISB	STGSCU	6	143	38.0	L	79	1.60	7.62
05/07/86	SUISB	STGSCU	6	108	14.2	L		1.60	.00
01/13/86	SUISB	STGSCU	6	140	39.0	L	80	1.60	8.00
05/07/86	SUISB	STGSCU	6	107	14.4	L		1.40	.00
** SPECIES TILPIA									
* LOCATION SALTN									
05/19/86	SALTN	TILPIA	5	253	382.0	L	76	8.30	34.58
05/19/86	SALTN	TILPIA	4	207	0.0	L	75	7.30	29.20
05/19/86	SALTN	TILPIA	4	226	274.0	L	79	4.70	22.38
05/19/86	SALTN	TILPIA	4	214	208.3	L	75	6.80	27.20
** SPECIES WHTCAT									
* LOCATION SALTS									
08/05/86	SALTS	WHTCAT	6	181	78.8	L	83	1.50	8.82
* LOCATION SJRMR									
08/05/86	SJRMR	WHTCAT	6	188	99.0	L	82	2.50	13.89
** SPECIES WSTRGN									
* LOCATION SNPBB									
03/09/86	SNPBB	WSTRGN	1	1016	0.0	L	63	1.20	3.24
03/17/86	SNPBB	WSTRGN	1	1060	0.0	L	64	2.30	6.39
03/09/86	SNPBB	WSTRGN	1	1207	0.0	L	67	3.10	9.39
05/24/86	SNPBB	WSTRGN	1	1245	0.0	L	64	2.30	6.39
03/17/86	SNPBB	WSTRGN	1	1067	0.0	L	73	2.40	8.89
04/04/86	SNPBB	WSTRGN	1	1067	0.0	L	69	3.70	11.94
04/04/86	SNPBB	WSTRGN	1	1118	0.0	L	74	2.70	10.38
04/05/86	SNPBB	WSTRGN	1	1359	0.0	L	74	2.60	10.00
04/06/86	SNPBB	WSTRGN	1	1359	0.0	L	70	3.70	12.33
03/17/86	SNPBB	WSTRGN	1	1118	0.0	L	70	3.90	13.00

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES SSCLAM									
* LOCATION HMBLT									
02/03/86	HMBLT	SSCLAM	9	55	0.0	F	89	0.28	2.55
02/03/86	HMBLT	SSCLAM	9	55	0.0	F	88	0.28	2.33
* LOCATION SOSFB									
04/03/86	SOSFB	SSCLAM	33	24	0.0	F	91	0.36	4.00
* LOCATION CNSFB									
04/04/86	CNSFB	SSCLAM	9	68	0.0	F	88	0.35	2.92
04/04/86	CNSFB	SSCLAM	9	64	0.0	F	87	0.38	2.92
* LOCATION SNPBB									
04/04/86	SNPBB	SSCLAM	25	52	0.0	F	90	0.42	4.20
04/04/86	SNPBB	SSCLAM	18	51	0.0	F	90	0.25	2.50
* LOCATION HMBLT									
06/09/86	HMBLT	SSCLAM	11	56	0.0	F	88	0.23	1.92
06/09/86	HMBLT	SSCLAM	11	54	0.0	F	89	0.22	2.00
* LOCATION SOSFB									
06/23/86	SOSFB	SSCLAM	12	60	0.0	F	89	0.50	4.55
06/23/86	SOSFB	SSCLAM	12	63	0.0	F	90	0.40	4.00
* LOCATION CNSFB									
06/24/86	CNSFB	SSCLAM	8	68	0.0	F	86	0.35	2.50
06/24/86	CNSFB	SSCLAM	8	69	0.0	F	87	0.34	2.62
* LOCATION SNPBB									
06/25/86	SNPBB	SSCLAM	9	51	0.0	F	86	0.32	2.29
06/25/86	SNPBB	SSCLAM	9	51	0.0	F	87	0.27	2.08

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES SHRIMP									
* LOCATION SUISB									
01/06/86	SUISB	SHRIMP	16	82	0.0	W	78	0.68	3.09
01/06/86	SUISB	SHRIMP	16	80	0.0	W	78	0.66	3.00
* LOCATION SNPBB									
01/06/86	SNPBB	SHRIMP	14	82	4.1	W	77	0.52	2.26
01/06/86	SNPBB	SHRIMP	14	82	4.3	W	78	0.53	2.41
* LOCATION SOSFB									
01/09/86	SOSFB	SHRIMP	28	65	2.0	W	78	0.47	2.14
01/09/86	SOSFB	SHRIMP	28	64	1.9	W	78	0.46	2.09
* LOCATION CNSFB									
01/10/86	CNSFB	SHRIMP	18	76	3.2	W	79	0.52	2.48
01/10/86	CNSFB	SHRIMP	18	73	3.0	W	79	0.50	2.38
* LOCATION HMBLT									
02/04/86	HMBLT	SHRIMP	17	65	2.5	W	77	0.37	1.61
02/04/86	HMBLT	SHRIMP	17	63	2.4	W	78	0.36	1.64
* LOCATION SNPBB									
05/06/86	SNPBB	SHRIMP	12	83	4.5	W	78	0.52	2.36
05/06/86	SNPBB	SHRIMP	12	84	4.5	W	78	0.52	2.36
* LOCATION SUISB									
05/30/86	SUISB	SHRIMP	36	47	0.7	W	80	0.35	1.75
05/30/86	SUISB	SHRIMP	36	48	0.7	W	80	0.38	1.90
* LOCATION HMBLT									
06/10/86	HMBLT	SHRIMP	25	57	1.6	W	78	0.34	1.55
06/10/86	HMBLT	SHRIMP	25	57	1.4	W	79	0.33	1.57
* LOCATION SOSFB									
06/30/86	SOSFB	SHRIMP	36	62	1.7	W	78	0.45	2.05
06/30/86	SOSFB	SHRIMP	36	62	1.6	W	79	0.42	2.00

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DATE OF SAMPLE COLLECTION	LOCA- TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST- URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES DNCRAB									
* LOCATION CNSFB									
01/08/86	CNSFB	DNCRAB	3	100	0.0	F	89	0.74	6.73
01/08/86	CNSFB	DNCRAB	3	102	0.0	F	87	0.96	7.38
05/22/86	CNSFB	DNCRAB	6	105	0.0	F	80	0.96	4.80
05/22/86	CNSFB	DNCRAB	6	102	0.0	F	91	1.10	12.22
* LOCATION HMBLT									
02/03/86	HMBLT	DNCRAB	3	87	0.0	F	87	0.59	4.54
02/03/86	HMBLT	DNCRAB	5	90	0.0	F	84	0.67	4.19
06/11/86	HMBLT	DNCRAB	6	86	0.0	F	88	0.68	5.67
06/11/86	HMBLT	DNCRAB	6	84	0.0	F	85	0.72	4.80
* LOCATION SNPBB									
01/07/86	SNPBB	DNCRAB	4	97	0.0	F	81	2.00	10.53
01/07/86	SNPBB	DNCRAB	4	100	0.0	F	79	1.80	8.57
05/27/86	SNPBB	DNCRAB	6	93	0.0	F	83	1.10	6.47
05/27/86	SNPBB	DNCRAB	6	92	0.0	F	80	1.20	6.00
* LOCATION SOSFB									
01/28/86	SOSFB	DNCRAB	6	95	0.0	F	76	1.40	5.83
05/21/86	SOSFB	DNCRAB	5	69	0.0	F	86	0.62	4.43
* LOCATION SUISB									
01/06/86	SUISB	DNCRAB	5	98	0.0	F	86	1.70	12.14
01/06/86	SUISB	DNCRAB	5	98	0.0	F	90	1.80	18.00

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SELENIUM ppm wet wt.	SELENIUM ppm dry wt.
** SPECIES BOATMN									
* LOCATION TLDDS									
05/28/86	TLDDS	BOATMN	99	4	0.0	W	86	1.60	11.43
05/28/86	TLDDS	BOATMN	99	7	0.0	W	83	3.00	17.65
05/28/86	TLDDS	BOATMN	99	7	0.0	W	83	3.20	18.82
05/28/86	TLDDS	BOATMN	99	4	0.0	W	83	1.60	9.41
* LOCATION TWISS									
05/30/86	TWISS	BOATMN	99	4	0.0	W	85	2.00	13.33
05/30/86	TWISS	BOATMN	99	4	0.0	W	84	2.20	13.75
05/30/86	TWISS	BOATMN	99	4	0.0	W	88	2.60	21.67
05/30/86	TWISS	BOATMN	99	4	0.0	W	88	2.70	22.50

White et al. 1987. Selenium Verification Study, 1987. A report to the State Water Resources Control Board. California Dept. of Fish and Game.

SUPPLEMENT TO APPENDIX F

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DATE OF SAMPLE COLLECTION	LOCA-TION	SPECIES	NUMBER IN SAMPLE	SIZE mm	WEIGHT g	W F L	PCT. MOIST-URE	SE ppm wet wt.	SE ppm dry wt.
** SPECIES STBASS									
* LOCATION ANTCH									
04/15/86	ANTCH	STBASS	1	630	2754.0	F	0	0.40	0.00
04/22/86	ANTCH	STBASS	1	780	6180.0	F	0	0.32	0.00
04/28/86	ANTCH	STBASS	1	740	5467.0	F	0	0.27	0.00
04/28/86	ANTCH	STBASS	1	680	3914.0	F	0	0.32	0.00
05/22/86	ANTCH	STBASS	1	570	2697.0	F	0	0.26	0.00
* LOCATION CLKBG									
04/11/86	CLKBG	STBASS	1	700	3929.0	F	0	0.39	0.00
04/16/86	CLKBG	STBASS	1	580	2483.0	F	0	0.34	0.00
04/16/86	CLKBG	STBASS	1	640	3598.0	F	0	0.37	0.00
04/29/86	CLKBG	STBASS	1	800	6386.0	F	0	0.41	0.00
05/20/86	CLKBG	STBASS	1	870	9909.0	F	0	0.29	0.00
* LOCATION ANTCH									
04/15/86	ANTCH	STBASS	1	630	2754.0	L	76	1.80	7.50
04/22/86	ANTCH	STBASS	1	780	6180.0	L	75	1.70	6.80
04/28/86	ANTCH	STBASS	1	740	5467.0	L	74	1.60	6.15
04/28/86	ANTCH	STBASS	1	680	3914.0	L	74	0.94	3.62
05/22/86	ANTCH	STBASS	1	570	2697.0	L	73	1.10	4.07
* LOCATION CLKBG									
04/11/86	CLKBG	STBASS	1	700	3929.0	L	75	1.90	7.60
04/16/86	CLKBG	STBASS	1	580	2483.0	L	72	1.70	6.07
04/16/86	CLKBG	STBASS	1	640	3598.0	L	67	1.40	4.24
04/29/86	CLKBG	STBASS	1	800	6386.0	L	71	1.60	5.52
05/20/86	CLKBG	STBASS	1	870	9909.0	L	70	1.00	3.33

APPENDIX G. Selenium Concentrations in Tissue Samples Analyzed by Hydride Generation AA and either Graphite Furnace AA at WPCL and/or Neutron Activation at the University of Missouri in ug/g Wet Weight (PPM). Zeros indicate analyses not conducted.

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
F	1	W	0.36	0.31	0.33
F	1	W	0.26	0.27	0.32
F	4	F	0.58	0.00	0.63
F	4	F	0.47	0.00	0.48
F	5	W	0.32	0.00	0.29
F	5	W	0.34	0.00	0.38
F	6	W	0.32	0.00	0.32
F	6	W	0.31	0.33	0.32
F	8	F	0.41	0.31	0.40
F	8	F	0.52	0.38	0.49
F	10	W	0.27	0.24	0.24
F	10	W	0.36	0.30	0.32
F	13	W	0.70	0.00	0.68
F	13	W	0.69	0.00	0.73
F	14	W	0.46	0.00	0.55
F	14	W	0.47	0.00	0.49
F	16	F	0.39	0.00	0.37
F	16	L	1.20	0.98	1.40
F	16	F	0.40	0.32	0.42
F	16	L	1.20	0.89	1.20
F	17	F	0.46	0.33	0.43
F	17	L	1.50	1.10	1.60
F	17	F	0.42	0.31	0.41
F	17	L	1.70	0.00	1.60
F	20	F	0.27	0.18	0.26
F	21	W	0.29	0.21	0.26
F	21	W	0.31	0.25	0.27
F	22	F	0.25	0.00	0.16
F	22	L	1.10	0.00	1.10
F	22	F	0.24	0.15	0.20
F	23	W	0.24	0.18	0.22
F	23	W	0.22	0.21	0.20
F	31	F	1.20	1.50	0.00
F	36	L	2.00	2.10	0.00
F	53	L	1.80	0.00	1.50
F	82	F	3.40	3.40	0.00
F	82	L	2.00	2.40	0.00
F	83	L	2.50	3.20	0.00
F	87	L	2.30	0.00	2.20
F	88	F	3.00	2.90	0.00
F	88	L	2.20	2.60	0.00
F	89	F	3.10	3.30	0.00
F	89	L	2.20	0.00	2.20
F	90	F	3.30	3.60	0.00
F	91	F	3.00	2.90	0.00
F	93	F	2.90	2.90	0.00
F	105	F	3.40	3.70	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
F	106	F	3.90	4.50	0.00
F	107	F	3.30	3.70	0.00
F	108	F	3.50	3.40	0.00
F	111	F	3.30	3.30	3.30
F	112	F	4.00	3.90	0.00
F	114	F	4.50	4.40	0.00
F	115	F	3.70	3.90	0.00
F	117	F	1.10	0.98	0.00
F	118	F	1.10	0.00	1.10
F	119	F	1.10	1.20	0.00
F	120	F	1.30	1.40	0.00
F	121	F	1.30	1.40	0.00
F	122	L	3.80	4.20	0.00
F	123	L	2.60	0.00	2.30
F	124	L	2.50	0.00	2.20
F	125	L	2.00	0.00	1.80
F	131	F	2.40	2.40	0.00
F	132	F	2.00	2.10	0.00
F	133	F	4.20	4.10	0.00
F	135	F	3.70	3.50	0.00
F	146	F	3.40	3.50	0.00
F	147	F	2.80	3.10	0.00
F	148	F	3.30	3.40	0.00
F	149	F	3.40	3.30	3.40
F	156	F	4.00	0.00	3.70
F	156	L	3.10	0.00	2.80
F	158	L	3.90	0.00	3.90
F	160	L	2.40	0.00	2.40
F	161	L	3.70	0.00	3.50
F	163	F	2.20	0.00	2.10
F	164	F	2.00	0.00	2.00
F	164	L	3.70	0.00	3.30
F	180	L	1.10	1.00	0.00
F	180	L	0.89	0.83	0.00
F	190	F	0.57	0.00	0.54
F	190	L	1.30	1.20	0.00
F	191	F	0.68	0.00	0.72
F	192	F	0.27	0.00	0.27
F	192	L	1.60	0.00	1.60
F	192	L	1.50	0.00	1.30
F	227	L	1.40	1.40	0.00
F	228	L	1.50	1.30	0.00
F	301	F	0.34	0.31	0.00
F	302	F	0.22	0.35	0.00
F	303	F	0.29	0.30	0.00
F	315	L	7.30	8.40	0.00
F	316	L	8.30	8.70	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
F	317	L	2.00	1.90	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
I	1	F	1.70	0.00	1.80
I	1	F	1.80	1.40	1.80
I	2	W	0.68	0.59	0.62
I	2	W	0.66	0.51	0.56
I	3	F	1.80	1.80	2.40
I	3	F	2.00	0.00	2.00
I	5	W	0.53	0.00	0.53
I	5	W	0.52	0.63	0.56
I	6	F	0.96	1.10	1.10
I	6	F	0.74	0.00	0.78
I	7	W	0.47	0.00	0.45
I	7	W	0.46	0.52	0.45
I	8	W	0.52	0.49	0.48
I	8	W	0.50	0.40	0.47
I	9	F	1.40	0.00	1.40
I	10	F	0.28	0.00	0.31
I	11	F	0.67	0.60	0.64
I	11	F	0.59	0.58	0.49
I	12	W	0.36	0.30	0.32
I	12	W	0.37	0.31	0.32
I	17	F	0.38	0.00	0.34
I	18	F	0.36	0.00	0.46
I	22	W	1.60	1.80	0.00
I	24	W	2.70	3.60	0.00
I	24	W	2.60	3.40	0.00
I	27	F	1.20	1.00	0.00
I	27	F	1.10	1.00	0.00
I	28	F	0.36	0.00	0.36
I	31	F	0.72	0.00	0.74

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	1	F	0.26	0.00	0.25
B	1	L	0.82	1.20	0.94
B	2	F	0.30	0.25	0.32
B	2	L	0.72	0.80	0.34
B	3	F	0.19	0.00	0.17
B	3	L	0.90	0.96	0.84
B	4	F	0.33	0.25	0.28
B	5	F	0.37	0.28	0.34
B	5	L	0.99	1.00	0.97
B	6	L	2.20	2.20	2.30
B	7	F	0.27	0.22	0.30
B	7	L	0.62	0.66	0.53
B	8	F	0.48	0.31	0.48
B	8	L	0.93	0.95	0.57
B	9	F	0.34	0.31	0.39
B	9	L	1.50	1.50	1.20
B	10	F	0.16	0.15	0.20
B	10	L	0.60	0.61	0.54
B	11	F	0.63	0.00	0.55
B	11	L	0.71	0.98	0.82
B	16	F	0.41	0.35	0.34
B	17	F	0.49	0.39	0.48
B	18	F	0.49	0.40	0.46
B	19	F	0.55	0.46	0.52
B	21	F	0.46	0.39	0.45
B	21	L	1.30	1.50	1.50
B	22	F	3.70	4.60	0.00
B	22	L	35.00	35.00	31.00
B	23	F	2.20	2.50	0.00
B	23	L	15.00	17.00	14.00
B	24	F	1.60	1.60	1.40
B	24	L	10.00	10.00	0.00
B	25	F	2.00	1.70	0.00
B	25	L	15.00	17.00	0.00
B	26	F	3.80	3.70	0.00
B	26	L	30.00	36.00	31.00
B	27	F	5.30	4.80	5.10
B	27	L	26.00	27.00	25.00
B	28	F	4.50	5.20	0.00
B	28	L	28.00	25.00	32.00
B	29	F	4.50	4.40	0.00
B	29	L	22.00	27.00	0.00
B	30	F	4.00	3.40	3.70
B	30	L	20.00	25.00	21.00
B	31	F	4.40	4.60	4.30
B	31	L	24.00	28.00	26.00
B	32	F	2.40	1.80	2.20

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	32	L	7.60	7.20	7.00
B	33	F	1.80	2.00	0.00
B	33	L	6.60	6.40	5.90
B	34	F	4.00	3.40	4.00
B	34	L	8.80	10.00	9.80
B	35	F	2.70	2.30	2.80
B	35	L	8.70	8.80	8.10
B	36	F	4.80	4.50	4.90
B	36	L	19.00	17.00	19.00
B	37	F	1.90	1.60	1.90
B	37	L	6.00	6.40	6.00
B	38	F	0.87	0.67	0.82
B	38	L	3.60	3.50	3.50
B	39	F	1.80	1.70	1.90
B	39	L	8.10	8.50	7.80
B	40	F	1.50	1.20	1.50
B	40	L	7.60	7.40	6.90
B	41	F	1.20	1.30	0.00
B	41	L	4.50	4.70	4.10
B	42	L	1.40	1.60	0.00
B	43	L	1.90	1.90	0.00
B	44	L	1.40	1.50	0.00
B	45	L	1.40	1.50	0.00
B	47	L	1.40	1.60	0.00
B	48	L	1.10	1.10	0.00
B	49	L	2.20	2.20	0.00
B	50	L	2.00	2.00	0.00
B	51	L	2.10	2.20	0.00
B	52	L	1.70	1.80	0.00
B	53	L	2.60	2.70	0.00
B	54	L	2.60	3.30	0.00
B	55	F	0.73	0.72	0.00
B	55	L	1.70	1.90	0.00
B	56	F	1.60	2.00	0.00
B	56	L	4.20	4.10	0.00
B	58	F	0.67	0.54	0.00
B	58	L	3.60	3.70	3.20
B	59	F	0.89	0.00	0.85
B	59	L	2.50	2.80	2.50
B	60	F	0.71	0.77	0.00
B	60	L	3.00	4.10	2.80
B	61	F	0.70	0.00	0.68
B	61	L	3.00	3.20	2.80
B	62	F	0.98	0.00	0.93
B	62	L	2.90	2.90	2.80
B	63	F	0.55	0.50	0.46
B	63	L	2.40	2.40	2.30

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	64	F	0.99	0.86	0.89
B	64	L	2.70	2.70	2.50
B	65	L	5.60	5.20	5.10
B	66	L	2.40	2.30	2.30
B	67	F	0.94	0.00	0.85
B	67	L	3.20	3.70	0.00
B	68	L	5.80	5.40	5.10
B	69	L	7.20	7.40	0.00
B	70	L	7.40	7.70	0.00
B	72	L	8.70	9.50	0.00
B	73	L	5.90	6.50	0.00
B	74	L	7.20	7.90	0.00
B	75	L	4.60	5.10	0.00
B	77	L	7.90	8.40	0.00
B	78	F	0.65	0.00	0.63
B	78	L	1.60	0.00	1.60
B	79	F	1.30	1.50	0.00
B	79	L	3.20	3.10	2.90
B	80	L	2.70	2.90	0.00
B	81	F	1.70	1.80	0.00
B	81	L	4.40	4.70	0.00
B	82	L	2.40	2.80	0.00
B	83	F	2.50	0.00	2.40
B	83	L	4.90	5.00	4.60
B	84	F	1.80	0.00	2.00
B	84	L	13.00	13.00	12.00
B	85	F	2.10	2.00	2.30
B	85	L	9.40	9.40	9.20
B	86	F	2.10	2.20	2.10
B	86	L	12.00	0.00	11.00
B	87	F	2.80	3.10	2.90
B	87	L	17.00	17.00	16.00
B	88	F	1.80	1.80	1.90
B	88	L	7.40	7.40	7.30
B	89	F	1.70	1.70	1.70
B	89	L	11.00	11.00	11.00
B	90	F	1.40	1.50	1.50
B	90	L	9.50	9.50	9.20
B	91	F	2.00	2.10	2.10
B	91	L	7.20	6.80	7.40
B	92	L	7.40	7.00	6.70
B	93	F	1.00	1.00	1.10
B	93	L	6.90	6.60	6.80
B	94	F	2.10	2.30	2.10
B	95	L	5.00	4.80	0.00
B	96	L	4.10	4.30	0.00
B	97	L	4.50	4.50	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	98	L	4.30	4.40	0.00
B	99	F	4.30	0.00	4.10
B	99	L	18.00	0.00	16.00
B	100	F	2.60	0.00	2.60
B	100	L	22.00	19.00	21.00
B	101	F	2.40	0.00	2.40
B	101	L	15.00	12.00	14.00
B	102	F	2.80	0.00	2.50
B	103	F	1.40	1.60	0.00
B	103	L	9.00	7.70	8.20
B	104	F	2.10	1.80	2.00
B	104	L	11.00	9.80	10.00
B	105	F	1.60	1.80	0.00
B	105	L	7.50	7.60	7.90
B	106	F	1.60	1.60	0.00
B	107	F	2.40	1.90	2.20
B	107	L	9.00	7.00	8.40
B	108	L	6.80	5.50	6.10
B	109	F	2.70	3.20	0.00
B	109	L	5.10	0.00	4.70
B	110	F	2.80	3.30	0.00
B	110	L	4.80	4.80	0.00
B	111	L	5.60	5.80	0.00
B	112	L	5.30	5.10	0.00
B	113	L	4.40	4.30	0.00
B	114	L	4.90	4.70	0.00
B	115	L	1.20	0.00	1.20
B	116	L	1.20	1.30	1.10
B	117	L	0.96	0.00	0.86
B	118	L	0.56	0.00	0.51
B	119	F	0.23	0.34	0.33
B	119	L	0.56	0.00	0.55
B	121	L	0.57	0.00	0.49
B	122	F	0.39	0.44	0.00
B	123	F	0.54	0.00	0.49
B	123	L	0.73	0.00	0.68
B	124	F	0.46	0.00	0.37
B	124	L	0.68	0.00	0.64
B	126	F	0.24	0.21	0.21
B	126	L	0.42	0.43	0.37
B	128	F	0.48	0.00	0.40
B	128	L	0.83	0.00	0.76
B	137	L	10.00	9.40	0.00
B	138	L	2.70	2.70	0.00
B	139	L	5.10	6.10	0.00
B	140	F	2.30	1.90	0.00
B	142	L	6.70	7.20	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	144	L	18.00	16.00	16.00
B	145	L	7.80	8.10	0.00
B	146	F	0.93	0.00	0.99
B	146	L	3.00	0.00	2.90
B	147	F	1.20	1.40	0.00
B	147	L	3.40	3.60	0.00
B	148	F	0.71	0.74	0.00
B	148	L	2.00	2.30	0.00
B	149	F	2.00	2.00	0.00
B	149	L	5.60	5.40	5.30
B	150	F	1.50	0.00	1.60
B	150	L	3.00	0.00	2.90
B	151	L	1.50	1.60	0.00
B	152	F	1.30	1.50	0.00
B	152	L	2.60	2.80	0.00
B	153	F	1.20	1.30	0.00
B	154	F	1.70	2.10	0.00
B	154	L	4.20	4.30	0.00
B	155	F	0.93	0.00	0.94
B	155	L	2.80	0.00	2.70
B	156	F	1.10	1.20	0.00
B	157	F	1.40	1.40	0.00
B	158	L	7.90	8.30	0.00
B	161	L	8.60	9.00	0.00
B	162	L	15.00	13.00	15.00
B	163	F	0.88	0.00	0.81
B	163	L	1.00	0.00	1.10
B	164	F	0.84	0.00	0.92
B	165	F	1.30	1.10	0.00
B	165	L	1.70	2.00	1.70
B	166	L	1.20	0.00	1.30
B	167	L	1.20	1.40	0.00
B	168	L	1.10	1.20	0.00
B	169	F	0.98	0.00	0.89
B	169	L	1.20	1.20	1.20
B	170	F	0.73	0.00	0.91
B	171	F	1.50	1.50	0.00
B	171	L	1.60	1.60	1.50
B	172	F	0.79	0.00	0.84
B	175	L	2.50	2.50	0.00
B	176	L	1.20	1.30	0.00
B	177	L	3.20	3.00	0.00
B	179	L	1.20	1.50	0.00
B	180	L	1.50	0.00	1.40
B	181	L	2.90	0.00	2.60
B	182	L	1.80	1.90	0.00
B	183	L	3.40	0.00	3.10

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	184	L	2.70	0.00	2.60
B	186	L	1.70	2.00	0.00
B	187	L	1.80	2.20	0.00
B	189	L	1.70	0.00	1.50
B	190	F	1.60	1.60	0.00
B	190	L	14.00	0.00	15.00
B	191	F	1.60	1.70	0.00
B	191	L	18.00	0.00	16.00
B	192	F	1.60	1.60	0.00
B	192	L	12.00	0.00	12.00
B	193	F	1.80	1.50	1.80
B	193	L	17.00	13.00	16.00
B	194	F	1.50	1.50	0.00
B	194	L	13.00	0.00	12.00
B	195	L	17.00	0.00	15.00
B	196	F	2.00	0.00	1.80
B	196	L	13.00	0.00	13.00
B	197	F	1.90	2.00	0.00
B	197	L	14.00	0.00	13.00
B	198	F	1.40	1.30	0.00
B	198	L	16.00	0.00	14.00
B	199	L	16.00	0.00	15.00
B	200	L	4.20	4.40	0.00
B	201	L	5.50	5.80	0.00
B	202	L	5.60	6.20	0.00
B	203	F	0.34	0.00	0.27
B	203	L	1.20	0.00	1.10
B	204	L	1.60	0.00	1.30
B	205	L	0.88	0.00	0.88
B	206	F	0.22	0.00	0.27
B	206	L	1.30	0.00	1.20
B	207	F	0.28	0.00	0.24
B	207	L	1.30	0.00	1.10
B	208	L	0.89	0.00	0.83
B	209	L	1.60	0.00	1.50
B	210	L	1.20	1.40	0.00
B	211	L	2.10	1.90	0.00
B	212	L	2.00	2.00	0.00
B	213	L	1.60	2.00	0.00
B	214	L	1.50	1.40	0.00
B	215	L	1.60	2.00	0.00
B	216	L	2.60	2.80	0.00
B	217	L	3.80	4.30	0.00
B	218	L	1.10	1.30	0.00
B	219	L	2.40	2.50	0.00
B	220	L	9.20	11.00	0.00
B	222	L	2.10	2.30	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	224	L	2.40	2.50	0.00
B	226	L	4.70	5.10	0.00
B	227	L	1.80	2.00	0.00
B	228	L	1.80	2.10	0.00
B	229	L	2.20	2.20	0.00
B	230	L	1.90	2.10	0.00
B	231	L	2.90	2.70	0.00
B	232	L	2.50	2.60	0.00
B	233	L	2.60	2.80	0.00
B	234	L	3.10	3.30	0.00
B	235	L	1.50	1.70	0.00
B	236	L	0.89	0.95	0.00
B	237	L	3.30	3.90	0.00
B	238	L	3.80	4.10	0.00
B	242	L	3.00	3.30	0.00
B	244	L	2.60	3.10	0.00
B	245	L	1.40	1.50	0.00
B	247	L	2.20	2.60	0.00
B	248	F	2.90	3.20	0.00
B	248	L	4.20	4.40	0.00
B	249	F	1.20	1.20	0.00
B	249	L	3.20	3.40	0.00
B	250	L	8.30	8.40	0.00
B	251	F	0.42	0.00	0.40
B	253	L	2.60	2.90	0.00
B	257	F	2.80	2.40	0.00
B	261	L	2.30	2.60	0.00
B	262	F	0.97	0.00	0.92
B	264	L	12.00	12.00	0.00
B	265	L	4.90	5.50	0.00
B	266	L	9.20	8.60	0.00
B	267	L	5.60	6.00	0.00
B	268	L	9.10	11.00	0.00
B	269	L	3.60	3.60	0.00
B	270	L	3.10	3.30	0.00
B	271	L	3.40	3.90	0.00
B	272	L	6.30	7.30	0.00
B	273	F	2.40	2.30	0.00
B	273	L	8.80	9.20	0.00
B	274	L	4.50	5.10	0.00
B	275	L	4.50	5.50	0.00
B	276	F	2.00	1.80	0.00
B	276	L	9.20	9.40	0.00
B	277	L	4.50	4.60	0.00
B	278	L	5.80	6.40	0.00
B	279	L	2.70	2.50	0.00
B	281	L	2.90	3.60	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	282	L	3.80	4.00	0.00
B	284	L	5.10	5.50	0.00
B	286	L	6.90	7.10	0.00
B	287	L	6.00	6.80	0.00
B	289	L	3.70	4.10	0.00
B	290	L	6.50	6.20	0.00
B	291	L	4.50	4.70	0.00
B	292	L	11.00	11.00	0.00
B	293	L	3.90	4.00	0.00
B	295	L	5.10	5.50	0.00
B	297	L	2.60	2.90	0.00
B	298	L	2.90	3.00	0.00
B	299	L	6.30	6.60	0.00
B	301	F	0.38	0.00	0.34
B	302	L	3.40	3.80	0.00
B	303	F	0.45	0.63	0.00
B	303	L	3.30	2.90	0.00
B	306	L	2.20	2.10	0.00
B	307	L	3.70	4.00	0.00
B	308	L	2.40	2.60	0.00
B	309	L	3.30	3.20	0.00
B	313	L	4.30	4.80	0.00
B	314	L	4.80	4.90	0.00
B	316	L	0.92	0.83	0.00
B	319	F	0.58	0.00	0.56
B	322	F	0.77	0.00	0.73
B	322	L	1.70	1.70	1.50
B	323	L	1.80	2.10	0.00
B	324	L	1.30	1.20	0.00
B	325	F	0.71	0.85	0.00
B	325	L	1.20	1.20	0.00
B	326	F	2.60	2.80	0.00
B	326	L	2.20	2.30	0.00
B	327	L	1.60	1.90	0.00
B	329	L	1.40	1.30	0.00
B	330	L	0.86	1.10	0.00
B	331	L	1.20	1.20	0.00
B	332	L	7.10	7.20	0.00
B	333	F	1.10	1.20	0.00
B	333	L	3.40	3.70	0.00
B	334	L	4.60	4.90	0.00
B	335	L	4.60	4.30	0.00
B	336	L	3.80	3.80	0.00
B	337	L	3.70	3.60	0.00
B	338	L	4.00	4.00	0.00
B	339	F	1.60	1.80	0.00
B	339	L	5.70	6.20	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	340	F	1.50	1.60	0.00
B	340	L	6.40	6.00	0.00
B	341	F	1.20	0.00	1.30
B	341	L	4.80	4.60	4.50
B	342	F	1.30	1.50	0.00
B	342	L	7.00	7.10	0.00
B	343	L	3.90	3.40	0.00
B	344	F	1.60	1.80	0.00
B	344	L	4.00	4.20	0.00
B	345	L	4.60	4.00	0.00
B	346	L	5.50	4.80	0.00
B	347	F	1.60	1.60	0.00
B	347	L	4.50	4.00	0.00
B	348	F	1.30	1.40	0.00
B	348	L	3.40	3.00	0.00
B	349	L	6.80	7.60	0.00
B	350	L	11.00	12.00	0.00
B	351	L	8.60	9.00	0.00
B	352	L	10.00	11.00	0.00
B	353	L	13.00	15.00	0.00
B	354	L	7.80	8.10	0.00
B	355	L	9.60	9.60	0.00
B	356	L	9.40	12.00	0.00
B	357	L	5.20	5.80	0.00
B	358	L	9.40	8.20	0.00
B	359	L	5.30	5.30	0.00
B	360	L	5.40	5.60	0.00
B	361	L	4.70	5.30	0.00
B	362	L	6.20	5.80	0.00
B	363	L	3.30	3.40	0.00
B	364	L	2.20	2.40	0.00
B	365	L	4.80	4.60	0.00
B	366	L	1.70	1.80	0.00
B	367	L	2.70	2.70	0.00
B	368	L	2.80	2.80	0.00
B	370	L	12.00	12.00	0.00
B	371	L	16.00	16.00	0.00
B	372	L	9.90	9.90	0.00
B	373	L	6.40	5.80	0.00
B	374	L	9.40	9.10	0.00
B	375	L	12.00	11.00	0.00
B	376	L	8.00	8.90	0.00
B	377	L	12.00	9.90	0.00
B	378	L	6.50	6.60	0.00
B	379	L	17.00	16.00	0.00
B	380	L	4.40	4.50	0.00
B	381	F	0.58	0.63	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	381	L	2.10	2.10	0.00
B	382	F	1.70	1.70	0.00
B	382	L	4.70	4.90	0.00
B	383	F	0.50	0.50	0.00
B	383	L	3.00	3.00	0.00
B	384	L	4.80	5.30	0.00
B	385	L	6.10	6.70	0.00
B	386	F	0.93	1.00	0.00
B	386	L	6.20	6.50	0.00
B	387	F	2.10	2.10	0.00
B	387	L	9.30	8.60	0.00
B	388	L	7.80	8.00	0.00
B	389	L	5.70	5.50	0.00
B	390	L	3.60	3.30	0.00
B	391	L	5.40	5.20	0.00
B	392	L	11.00	12.00	0.00
B	393	L	2.80	2.50	0.00
B	394	L	6.10	5.80	0.00
B	395	L	3.40	3.00	0.00
B	396	L	3.30	3.10	0.00
B	397	L	3.70	3.20	0.00
B	398	L	2.80	3.40	0.00
B	399	L	2.20	2.00	0.00
B	400	L	3.50	3.90	0.00
B	401	L	4.30	4.20	0.00
B	402	L	2.80	3.20	0.00
B	403	F	0.71	0.70	0.00
B	403	L	1.60	1.90	0.00
B	404	L	7.80	8.10	0.00
B	405	L	3.50	3.50	0.00
B	406	F	1.00	1.00	0.00
B	406	L	7.40	7.20	0.00
B	407	L	2.50	2.50	0.00
B	408	L	2.80	2.80	0.00
B	409	L	4.90	4.70	0.00
B	410	L	2.00	2.00	0.00
B	411	F	2.00	2.20	0.00
B	412	L	9.70	12.00	0.00
B	413	L	8.50	9.10	0.00
B	414	L	8.30	8.10	0.00
B	416	L	5.50	5.60	0.00
B	417	L	26.00	29.00	0.00
B	418	L	11.00	10.00	0.00
B	419	L	12.00	11.00	0.00
B	420	L	15.00	18.00	0.00
B	421	L	8.90	10.00	0.00
B	422	L	3.80	3.70	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	423	L	2.70	2.80	0.00
B	424	L	3.20	3.00	0.00
B	425	L	2.50	2.60	0.00
B	426	L	3.20	3.10	0.00
B	427	L	3.20	3.10	0.00
B	428	L	1.30	1.10	0.00
B	429	L	1.80	1.80	0.00
B	430	L	23.00	23.00	0.00
B	431	L	26.00	23.00	0.00
B	432	L	11.00	9.50	0.00
B	433	L	12.00	10.00	0.00
B	434	L	7.50	8.10	0.00
B	435	L	21.00	22.00	0.00
B	436	L	14.00	15.00	0.00
B	437	L	4.60	4.20	0.00
B	438	L	14.00	12.00	0.00
B	439	L	9.80	10.00	0.00
B	440	L	4.70	4.20	0.00
B	441	L	3.60	3.40	0.00
B	442	L	4.20	4.20	0.00
B	443	L	3.10	3.00	0.00
B	444	L	3.40	3.20	0.00
B	445	L	3.30	3.30	0.00
B	446	L	4.30	4.30	0.00
B	448	L	3.70	3.30	0.00
B	449	L	2.80	2.60	0.00
B	451	F	0.56	0.54	0.00
B	451	L	0.92	0.95	0.00
B	452	L	0.98	0.97	0.00
B	453	L	1.60	1.90	0.00
B	454	L	0.78	0.83	0.00
B	455	L	1.20	1.00	0.00
B	456	L	0.80	0.80	0.00
B	457	L	2.70	2.80	0.00
B	458	L	1.60	1.60	0.00
B	459	L	1.90	2.00	0.00
B	460	L	1.80	1.80	0.00
B	461	L	1.90	1.90	0.00
B	462	L	1.70	1.60	0.00
B	463	L	1.50	1.40	0.00
B	464	L	1.30	1.30	0.00
B	465	L	1.10	0.96	0.00
B	466	L	1.20	1.20	0.00
B	467	L	0.62	0.49	0.00
B	469	L	0.99	1.10	0.00
B	470	L	0.65	0.57	0.00
B	471	L	0.43	0.38	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	473	L	0.35	0.33	0.00
B	474	L	0.57	0.57	0.00
B	475	L	0.83	0.77	0.00
B	476	F	0.46	0.00	0.39
B	478	F	0.42	0.00	0.39
B	479	L	1.00	1.20	0.00
B	480	L	1.40	1.30	0.00
B	482	L	2.10	2.10	0.00
B	483	F	0.61	0.00	0.55
B	486	L	1.50	1.30	1.30
B	487	L	0.47	0.49	0.00
B	488	L	0.40	0.44	0.00
B	489	L	0.78	0.76	0.00
B	490	L	2.30	2.00	0.00
B	491	L	0.48	0.54	0.00
B	492	L	0.54	0.60	0.00
B	493	L	0.44	0.39	0.00
B	494	L	0.33	0.24	0.00
B	495	L	1.60	1.60	0.00
B	497	L	1.10	1.30	0.00
B	498	L	1.20	1.20	0.00
B	499	L	1.70	1.40	0.00
B	500	L	1.30	1.50	0.00
B	503	L	2.00	2.00	0.00
B	504	L	2.10	2.20	0.00
B	505	L	2.80	2.70	0.00
B	506	L	2.10	2.20	0.00
B	507	L	1.80	1.90	0.00
B	508	L	2.10	1.80	0.00
B	509	L	4.00	4.20	0.00
B	510	L	1.50	1.30	0.00
B	511	L	1.20	1.20	0.00
B	512	L	1.10	1.10	0.00
B	513	L	1.30	1.50	0.00
B	514	L	1.70	1.70	0.00
B	515	L	1.20	1.40	0.00
B	516	L	1.60	1.50	0.00
B	517	L	1.20	1.30	0.00
B	518	L	1.30	1.40	0.00
B	519	L	2.00	2.10	0.00
B	520	L	1.40	1.50	0.00
B	521	L	1.40	1.40	0.00
B	522	L	1.80	1.80	0.00
B	523	L	3.80	3.40	0.00
B	524	L	3.00	2.70	0.00
B	525	L	2.30	2.40	0.00
B	526	L	3.00	2.70	0.00

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ANIMAL TYPE	SAMPLE NUMBER	TISSUE TYPE	SEHGAAWPCL PPM WET WT.	SEGFAAWPCL PPM WET WT.	SENAAUMRR PPM WET WT.
B	527	L	2.90	3.30	0.00
B	528	L	2.80	3.30	0.00
B	529	L	2.10	2.20	0.00
B	530	L	2.60	2.90	0.00
B	531	L	2.10	2.20	0.00
B	532	L	1.90	2.30	0.00
B	533	L	1.90	2.00	0.00
B	534	L	1.80	1.90	0.00
B	535	L	2.20	2.60	0.00
B	536	L	2.00	2.40	0.00
B	538	L	3.50	3.00	0.00
B	539	L	4.10	3.50	0.00
B	540	L	2.20	2.40	0.00
B	541	L	2.50	2.40	0.00
B	542	L	2.40	2.20	0.00
B	543	L	3.00	3.10	0.00
B	544	L	1.80	1.80	0.00
B	545	L	1.90	2.00	0.00
B	546	L	2.50	2.80	0.00
B	547	L	3.10	3.20	0.00
B	548	L	3.80	3.50	0.00
B	549	L	2.70	2.60	0.00
B	550	L	1.70	1.80	0.00
B	551	L	1.30	1.10	0.00
B	552	L	1.80	1.60	0.00
B	553	L	4.60	5.50	0.00
B	555	L	5.10	5.70	0.00
B	556	L	3.40	3.70	0.00
B	557	L	4.20	4.50	0.00
B	558	L	5.70	6.10	0.00
B	559	L	9.70	9.20	0.00
B	560	L	4.40	4.50	0.00
B	562	L	5.60	6.40	0.00

APPENDIX H. TRACE ELEMENT CONCENTRATIONS (ug/L) IN WATER SAMPLES ANALYZED BY THE DEPT. OF WATER RESOURCES BRYTE LABORATORY.

SAMPLE NUMBER	REP NO.	LOCATION	DATE	SE 1/	AG	AS 2/	CD	CR	CU	MN	MO	PB	ZN
0		blank	02/21/86	0	-10 3/	0	-5	-10	-10	-10	-5	-5	-10
1		SALTN	02/26/86	8	-10	30	0	-10	-10	33	15	-5	17
21	A	PVODR	04/14/86	0	-10	2	-5	-10	-10	276	26	-5	-10
21	B	PVODR	04/14/86	1	-10	2	-5	-10	-10	296	18	-5	-10
22	A	PVODR	04/14/86	2	-10	3	-5	-10	-10	-10	6	-5	-10
23	A	PVODR	04/14/86	1	-10	2	-5	-10	-10	280	18	-5	-10
24	A	MITCH	04/14/86	1	-10	2	-5	-10	-10	232	22	-5	-10
25	A	RESDR	04/15/86	0	-10	3	-5	-10	-10	552	7	-5	18
26	A	RESDR	04/15/86	0	-10	2	-5	-10	-10	508	12	-5	12
27	B	SALTN	04/16/86	2	-10	22	-5	12	-10	228	7	-5	30
27	A	SALTN	04/16/86	2	-10	22	-5	12	-10	276	15	-5	22
28	A	WWRIV	04/17/86	3	-10	5	-5	11	-10	200	46	-5	32
29	A	WWRIV	04/17/86	3	-10	4	-5	-10	13	107	40	-5	13
30	A	WWRIV	04/17/86	3	-10	4	-5	-10	-10	114	42	-5	12
30	B	WWRIV	04/17/86	3	-10	4	-5	10	-10	145	33	-5	16
31	A	WWRIV	04/17/86	4	-10	8	-5	-10	-10	98	49	-5	19
32	A	WWRIV	04/17/86	3	-10	4	-5	-10	-10	130	40	-5	21
33	A	WWRIV	04/17/86	3	-10	4	-5	10	-10	122	32	-5	14
34	A	WWRIV	04/17/86	2	-10	3	-5	10	-10	138	36	-5	25

1/ total Se in water after: Presser, T.S. and I. Barnes. Water Resources Investigations Report, 84-4122, US Geological Survey, May, 1984.

2/ total As in water after: Standard Methods for the Examination of Water and Waste Water, 16th Edition, p 165, Method 303E, 1985.

All other trace elements after: Methods for Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory. EPA-600/4-79-020. Method 4.1.3. 1983.

3/ minus (-) sign indicates concentration < the detection limit which is the number following.

APPENDIX I. SELENIUM CONCENTRATIONS IN WATER SAMPLES ANALYZED IN DUPLICATE USING A DRY-ASH TECHNIQUE WITH HGAA AT WPCL AND NEUTRON ACTIVATION (NAA) RESULTS FOR COMPARISON, ug/L (PPB).1/

SAMPLE NUMBER	WPCL-1 PPB Se	WPCL-2 PPB Se	NAA PPB Se
22	1.9	2.0	1.6
23	0.8	0.9	1.5
24	0.8	0.9	1.3
25	0.2	0.1	<0.5
26	0.6	0.7	<0.5
28	4.5	4.7	4.0
29	4.5	4.5	4.4
31	7.1	7.1	6.1
32	4.3	4.4	2.6
33	4.3	4.1	3.0
35	1.1	0.8	<0.5
36	0.7	1.0	<0.5
48	2.6	2.6	<0.5
49	2.4	2.2	2.5
50	26.0	27.5	31.4
51	14.5	14.5	14.1
52	0.8	0.5	<0.5
53	3.3	3.2	2.3
54	122.0	118.0	110.1
55	108.0	109.0	101.0
56	0.5	0.5	<0.5

1/ see Analytical Techniques for Selenium in Water, p. 27.