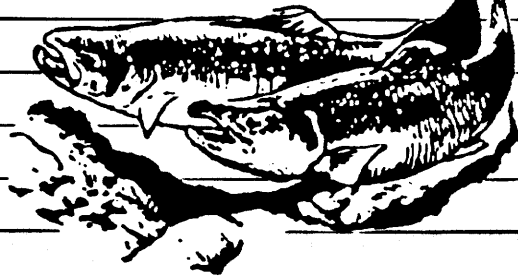


Research



Information bulletin

**U.S. DEPARTMENT OF THE INTERIOR
NATIONAL BIOLOGICAL SERVICE**

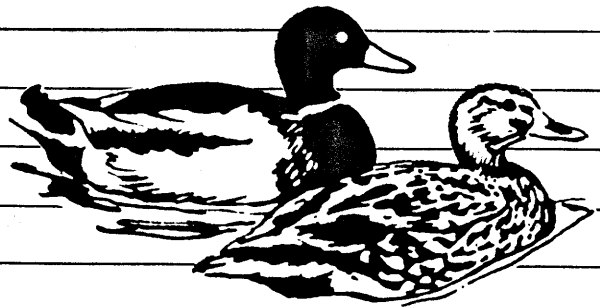
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Diving Ducks in the Great Lakes Switch Diets

Since zebra mussels (*Dreissena polymorpha*) invaded the Great Lakes in the late 1980's, there has been speculation about which waterfowl species in North America eat zebra mussels and the proportion of zebra mussels in the diets of waterfowl. In Europe, tufted ducks (*Aythya fuligula*), common pochards (*A. ferina*), and coots (*Fulica atra*) were reported to eat large quantities of zebra mussels. Waterfowl may make a significant contribution to the development of integrated pest management of zebra mussels in the United States.

Waterfowl Collected on Lakes St. Clair and Erie

We collected feeding waterfowl during winter and spring 1992 and again between fall and spring 1992–1993. We concentrated on collecting lesser scaup (*A. affinis*), common goldeneye (*Bucephala clangula*), bufflehead (*B. albeola*), redhead (*A. americana*) and canvasback (*A. valisineria*) because many of these diving duck species have traditionally eaten mollusks and are present in the habitats where zebra mussels are now abundant. We collected diving ducks at as many different locations (12–13) as possible in areas with the major waterfowl concentrations in the U.S. portion of the two lakes (Figure). Waterfowl were dissected in the field, and only waterfowl with food in their

esophagi or proventriculi (upper gastrointestinal [GI] tract) were used in the analysis.

Diving Ducks Are Eating Zebra Mussels

Diving ducks in Lake Erie and Lake St. Clair consume zebra mussels, although the magnitude of the shift from other foods to zebra mussels varies by species (Table 1). Of the ducks that we collected, 94% of the lesser scaup, 83% of the common goldeneye, 78% of the redhead, and 60% of the bufflehead had eaten zebra mussels. In contrast, only 1 of 11 canvasback (9%) had eaten zebra mussels.

Zebra mussels were the main prey in the diet of lesser scaup and common goldeneye (Table 2). Less than 25% of redheads, buffleheads, and canvasbacks had fed exclusively on zebra mussels. Redheads seemed to have ingested zebra mussels incidentally while foraging on aboveground portions of pondweed (*Potamogeton* sp.); small zebra mussels were attached to the stems of vegetation in the redhead's upper GI tract. Two redheads, however, had eaten exclusively zebra mussels. Some bufflehead (47%) had eaten zebra mussels and other food, and some (40%) had eaten only other foods such as amphipods, isopods, and caddisflies. Most canvasbacks had consumed only wildcelery (*Vallisneria americana*) winterbuds. One

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Table 1. Frequency of occurrence^a of zebra mussels (*Dreissena polymorpha*) in the upper gastrointestinal tracts of diving ducks in Lake Erie and Lake St. Clair during fall and spring 1992–93.

Species	<i>n</i> ^b	Percentage of ducks with zebra mussels
Lesser scaup	33	94
Common goldeneye	6	83
Redhead	9	78
Bufflehead	15	60
Canvasback	11	9

^a Number of ducks by species that ate zebra mussels divided by total number of ducks by species.

^b Number of ducks by species with food in the upper GI tract.

Table 2. Frequency of occurrence^a of zebra mussels (*Dreissena polymorpha*) and other foods in upper gastrointestinal tracts of diving ducks in Lake Erie and Lake St. Clair during fall and spring 1992–93.

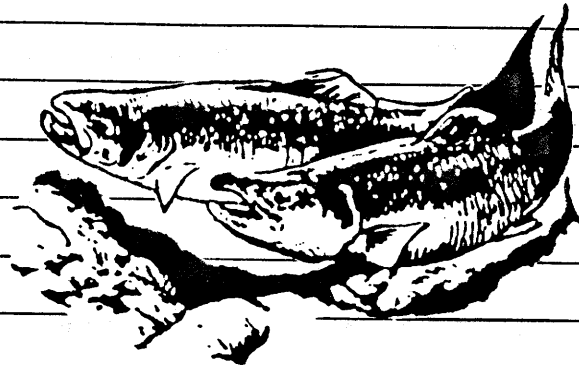
Species	Percentage of ducks with		
	Only zebra mussels	Zebra mussels and other foods	Only other foods
Lesser scaup	73	21	6
Common goldeneye	67	17	17
Redhead	22	78	0
Bufflehead	13	47	40
Canvasback	9	0	91

^a Number of ducks by species with food in each of the categories divided by the total number of ducks, by species.

Table 3. Frequency of occurrence^a of zebra mussels (*Dreissena polymorpha*) and other foods in upper gastrointestinal tracts of lesser scaup (*Aythya affinis*) during fall and spring 1992–93.

Location	Percentage of ducks with		
	Only zebra mussels	Zebra mussels and other foods	Only other foods
Lake Erie	82	14	4
Lake St. Clair	0	80	20

^a Number of ducks by lake and by species with food in each of the categories divided by the total number of ducks, by lake and species.



In Lake DeSmet, Wyoming, Fish are Rare in the Diet of the Eagle Lake Strain of Rainbow Trout

Rainbow trout (*Oncorhynchus mykiss*) native to Eagle Lake, Lassen County, California, prey heavily on minnows in summer and consequently grow to trophy sizes. Eagle Lake rainbow trout are being reared as a unique hatchery strain and have been introduced to many lakes and reservoirs because they are believed to be more piscivorous than other strains of rainbow trout.

We assessed the extent of fish consumption by rainbow trout from Eagle Lake in Lake DeSmet, Wyoming, where a substantial assemblage of forage fishes was present. The fish assemblage includes rainbow trout from Eagle Lake, brown trout (*Salmo trutta*), yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*), black crappies (*Pomoxis nigromaculatus*), common carp (*Cyprinus carpio*), white suckers (*Catostomus commersoni*), longnose suckers (*C. catostomus*), and emerald shiners (*Notropis atherinoides*). Also present, but in lower numbers, are mountain suckers (*Pantosteus platyrinchus*), creek chubs (*Semotilus atromaculatus*), and fathead minnows (*Pimephales promelas*). Abundant forage fishes are primarily emerald shiners and young-of-the-year yellow perch. Emerald shiners were introduced to provide forage for the rainbow trout from Eagle Lake in 1984.

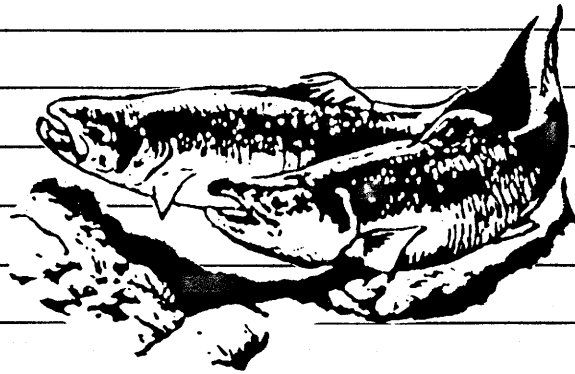
The stomach contents of 200 rainbow trout collected during 1991 were assessed. Cladocerans composed the greatest number of food items, whereas insects composed the greatest biomass (Table). The abundance of cladocerans, insects, and other invertebrates in the stomachs did not vary with length of the fish. Fish were in only 1.5% of the stomachs but accounted for 14% of the total biomass of food items in the stomachs. Four fish were found (two young-of-the-year yellow perch and two unidentified fish). There was no indication of greater fish consumption with increasing length of rainbow trout.

The abundance of cladocerans, insects, and other invertebrates in the stomachs varied over the year (Table). Cladocerans were the only food items during January and February, whereas insects were found in March and April. Insects became increasingly important diet items during summer. Fish were in stomachs only in fall.

The diet of Eagle Lake rainbow trout in Lake DeSmet was similar to diets of rainbow trout from other lakes and reservoirs. In most lentic systems, zooplankton and insects are often the predominant prey items of rainbow trout.

In spite of an abundance of forage fishes, the Eagle Lake strain of rainbow trout did not consume

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Colder Water 15 Days After Fertilization Enhanced Survival of Cutthroat Trout

Published studies have indicated that prolonged incubation at low water temperatures lowers the survival of salmonid species. We investigated the effect of fertilizing eggs and maintaining embryos at optimum temperatures for various durations before cooling. Our objectives were to determine whether the survival of cutthroat trout (*Oncorhynchus clarki*) embryos fertilized at 7°C differed when we reduced temperatures to 3 or 5°C at 2 h, 15 d, 25 d, or 35 d after fertilization and to compare these results with the survival of embryos incubated at 7°C throughout development.

Sexually mature adult fish were spawned with the dry method. Water-hardened eggs were incubated in lots of 100 with four replicates of each treatment. Embryos incubated at 7°C were acclimated to lower temperatures at 1°C/h.

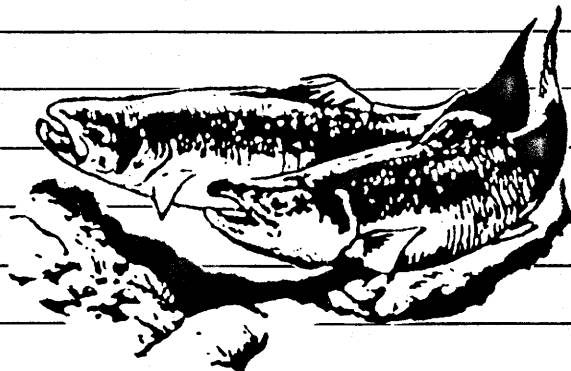
The mean survival to hatching and to the swim-up stages differed significantly among embryos incubated at 3, 5, and 7°C (Table). Survival of embryos was lowest at 3°C 2 h after fertilization. Survival was highest for embryos chilled to 3°C after incubation at 7°C for 15 d.

A reduction in survival with increased time to hatching was associated with declining incubation temperatures when cooling occurred 2 h after fertilization. This was similar to other experiments. However, survival was high when the embryos were cooled 15 d after fertilization and close to the eyed stage of development. Cooling cutthroat trout embryos to 3°C after 15 d extended the mean time to hatching by 31 d beyond that observed at 7°C and also enhanced survival by 15%. Delaying temperature reductions for several days beyond fertilization may provide substantial benefits to hatchery managers.

For further information contact:

Wayne A. Hubert
Wyoming Cooperative Fish and Wildlife
Research Unit
University of Wyoming
Box 3166, University Station
Laramie, WY 82071
(307) 766-5415

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Midwest Floodwaters Provide Habitat for Grass Carp To Spawn

The unprecedented flooding in the Midwest caused billions of dollars in damages to the economy. Fish and wildlife were affected by displacement and by alterations in their habitats. Although fish and wildlife might be killed and their habitats destroyed, floods create new habitats and return other habitats to an earlier successional stage. Most species are temporarily harmed, but some will benefit in the long run. The flood has expanded habitat for one non-native species, the grass carp (*Ctenopharyngodon idella*), which will likely spread into new areas.

High Water Triggers Grass Carp Spawning

High water with increased current and turbidity elicits grass carp migration to spawning sites and stimulates mating behavior. Spawning habitat exists only in large rivers, and spawning requires temperatures above 18°C. Only summer floods provide the combination of warm temperatures and high waters ideal for spawning. In previous years, spawning in the United States occurred only in the lower Missouri and Mississippi rivers and a river in Texas. With flooding, many more waterways are transformed into large rivers and provide spawning habitat. Grass carp now present in the Mississippi system should have had ample opportunity to spawn in a number of tributaries.

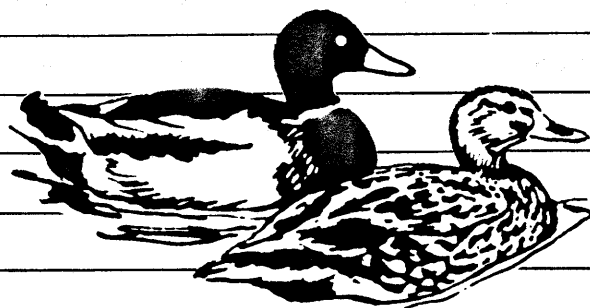
Conditions Are Ideal for Egg Incubation

Grass carp eggs are semipelagic and require currents to keep the eggs suspended for a 20- to 30-h incubation period. Current speed must be 0.6 to 1.5 m/s. The duration of incubation depends on temperature—faster hatching occurs at temperatures above 25°C. The river length needed for incubation depends on the combination of current speed and temperature. At typical flood conditions in the Midwest, 50 to 80 km of free-flowing water is needed. Eggs tolerate high turbidity.

Floods Opened Way to Nursery Habitat

Lack of access to backwater nursery habitat limited grass carp in the Mississippi system in normal years because rivers were confined to their main channels. After hatching, larval grass carp must find their way out of the river channel into backwaters. With levees bursting and river water spilling into the floodplains, the larvae are transported into habitat well-suited for survival and growth. The flood of 1993 created millions of hectares of nursery, fulfilling the habitat requirement of submerged terrestrial vegetation. Planktonic food, such as rotifers, should multiply rapidly, whereas fish predators of grass carp larvae

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A Diet of Wild Celery Is Better Than Baltic Clams for Wintering Canvasbacks

The Baltic clam (*Macoma balthica*) is the dominant food of canvasbacks (*Aythya valisineria*) on the Chesapeake Bay; however, when compared with a diet of wild celery tubers (*Vallisneria americana*), we found clams to be a poor diet for canvasbacks for regaining body mass following a period of fasting. This finding could explain why the Chesapeake Bay population of canvasbacks declined at the same time submerged aquatic plants were decimated in the Bay.

The diet of canvasbacks wintering on Chesapeake Bay has changed in response to a decline in water quality and loss of submerged aquatic vegetation. Formerly dominated by plant foods, especially wild celery, canvasback diets now contain more than 90% Baltic clams. The consequences of this dietary change on the ability of canvasbacks to survive periods of food deprivation and severe winter weather are unknown. We studied the influence of diets of Baltic clams, wild celery, and whole corn (*Zea mays*) on rate of recovery of body mass by captive canvasbacks in a series of fasting and feeding trials.

Clam and Tuber Diets Contrasted

We conducted six trials, three per winter, in 1990 and 1991. Trials were conducted in identical pens designed for complete control of food available to the ducks. Two males and two females, randomly selected from the captive ducks, were placed in each

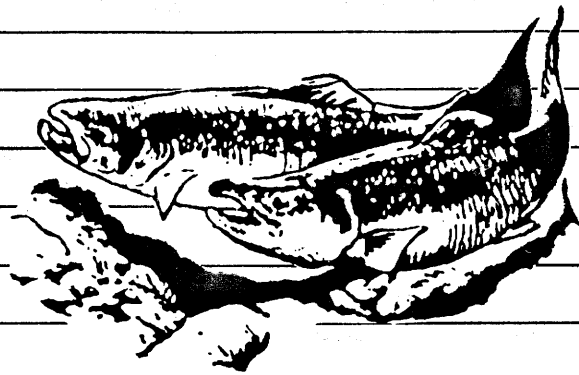
of the eight pens. Each pen was randomly assigned a control (nutritionally balanced commercial duck feed), wild celery, Baltic clam, or whole corn diet (two pens each diet). We selected wild celery and Baltic clams because they represent the traditional and current foods dominating the diets of wintering canvasbacks, and corn because of its widespread availability and use by canvasbacks. Each trial consisted of three parts: (1) fasting (body mass loss), (2) feeding (body mass gain), and (3) maintenance (body mass stable). Foods were fed ad libitum three or four times each day during the feeding part of trials. Ducks were weighed at 2–3 day intervals during fasting and recovery periods.

Body Mass Recovery Better on Wild Celery

During fasting, canvasbacks were not allowed to lose more than 20% of their body mass—45–50% is thought to be a lethal level. Mean loss of body mass was 26 g/bird per day. The rate of body mass loss was greatest during the first 2 days of fasting; the loss of body mass decreased by one-third during the following 4 days as the birds adjusted to food deprivation.

Recovery of body mass differed among diets in 1990 ($P = 0.003$) and 1991 ($P = 0.0111$), and among 2–3-day periods in 1990 ($P = 0.0001$) and 1991 ($P = 0.0001$) within trials. Ducks fed the control diet gained 42 g/bird per day body mass whereas birds fed treatment diets gained less—32 g/bird per day on

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Juvenile Spotted Seatrout Use Different Habitat Zones of a Shallow Nearshore Seagrass Meadow

Spotted seatrout (*Cynoscion nebulosus*) utilize seagrass habitat during all stages of their life cycle, but seagrasses are considered an especially important habitat for juvenile seatrout. The role of seagrass ecosystems as nursery habitat for spotted seatrout is believed to be related to the provision of abundant food and cover associated with the submerged vegetation. We examined the abundance and distribution of juvenile spotted seatrout in adjacent habitat zones of a nearshore seagrass meadow at Cedar Keys National Wildlife Refuge, Florida, during a 6-week period from 5 August to 20 September 1992.

Seagrass Habitat Zones Sampled for Young Spotted Seatrout

Moving seaward from the shoreline, the zonation of the nearshore margin of the seagrass meadow consists of a fringing sand zone (sand), a *Halodule wrightii* (hal) zone, and a *Thalassia testudinum* (thal) zone. Because of the large width of the *Thalassia* zone, two different bands of this zone were examined, a shallow band directly adjacent to *Halodule* (thal 1), and a deeper band further from shore (thal 2).

The habitat zones exist along an intertidal exposure gradient. The frequency and duration of tidal exposure increases moving shoreward. Average depth increases moving seaward from about 40 cm in the sand, to 54–55 cm in the *Halodule* and

first *Thalassia*, and to 65 cm in the second *Thalassia*. Mean water temperatures (30–33° C) increase moving shoreward, as does the variation in water temperature. Salinity averaged 25 ppt during the study period.

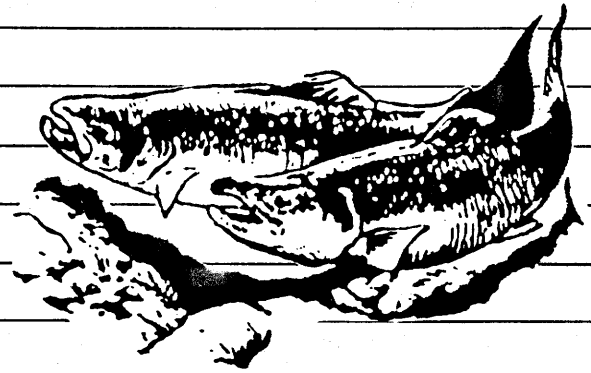
The density of the seagrass shoots is greatest in the *Halodule* (3000 shoots/m²), intermediate in the *Thalassia* (800–900 shoots/m²), and nonexistent in the sand zone which is only vegetated ephemerally. Though shoot density is greatest in the *Halodule*, seagrass biomass density is greatest in the *Thalassia*. This is because of the much wider and more robust blades of *Thalassia* as compared with the narrow-bladed *Halodule*. Canopy height is greatest in the *Thalassia* zone (19–21 cm), and decreases moving shoreward to *Halodule* (15 cm) and the sand zone (0 cm).

Juvenile spotted seatrout were sampled at random locations both among and within habitat zones and bands by using a bag seine (15 m long, 6 mm-mesh wings, 3 mm-mesh bag). Nets were pulled parallel to the shoreline in each zone over an area of 200 m², after which the ends were encircled and pursed.

Juvenile Spotted Seatrout Found Only in Vegetated Habitat Zones

No juvenile spotted seatrout were captured in the fringing sand zone. Comparison of the abundance of juvenile seatrout in the vegetated zones indicated

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Isolation of *Aeromonas salmonicida* from Paddlefishes

Paddlefish, *Polyodon spathula*, are endemic to river systems of the Mississippi River basin. The species was once abundant throughout the basin, but during the last century its range and population diminished. Paddlefish populations have been adversely affected by anthropogenic alterations that destroy or prevent access to spawning sites, by exploitation, and by pollution. Recently, the culture of paddlefish has become important for the enhancement of wild populations and for meeting the commercial demand for roe (caviar) and meat. Fingerlings raised in hatcheries can be overcrowded and sometimes suffer from poor water quality and from disease.

Diseases of Paddlefish

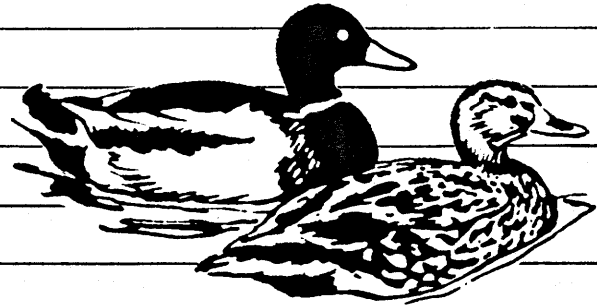
Most published literature on diseases of paddlefish is about parasitic infestations. A parasitic coelenterate, *Polypodium hydriforme*, and a microsporidian, *Pleistophora* sp., have been reported in paddlefish eggs. Nematodes, *Thynnascaris dollfusi*, *Contracaecum spiculigerum*, *Cammallnus* sp., and *Hysterothylacium dollfusi*, commonly infest the intestinal tracts of paddlefish. The most commonly reported pathology consists of scars (some of which are healed) from attempts by anglers to snag a fish or from propellers of power boats and bent rostrums from colliding with dam structures. Bacterial and viral infections of paddlefish have not

been previously reported, but as culture of paddlefish becomes more common, bacterial problems are likely to increase.

Isolation of *Aeromonas salmonicida*

Aeromonas salmonicida, the causative agent of furunculosis in fish, was isolated during a period of acute mortality in paddlefish fingerlings (12–13 cm) reared in spring and summer 1992 at the Spring River State Fish Hatchery, Arkansas. The Spring River, which is the main water supply for the hatchery, flooded several times during April, May, and June. Water turbidity increased during these flood stages. By June, fungal growth was on the rostrums of fish and was attributed to overcrowding. The fish were separated to reduce stocking densities and were treated with formalin. Although the fungus was controlled, mortality of the fish continued to rise. On 12 June 1992, two fish were necropsied and cultured for bacteria. *Aeromonas salmonicida* was presumptively identified from kidney samples. The bacterial isolates and additional dead paddlefish were shipped to the National Fisheries Research Center in Leetown, West Virginia, for confirmation. Gill tissues, kidneys, spleens, and livers were sampled from four fish and plated onto Coomassie Brilliant Blue agar. *Aeromonas salmonicida* was isolated from gill tissue or from the kidneys of three of

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Harvest of Blue-winged Teal in the Neotropics

The harvest of blue-winged teal (*Anas discors*) in Mexico, the Caribbean, and Central and South America (i.e., the Neotropics) has traditionally been considered low, partly based on the low number of blue-winged teal band recoveries from that region. The harvest of blue-winged teal in the Neotropics could be estimated from band recovery rates, but reporting rates are not known.

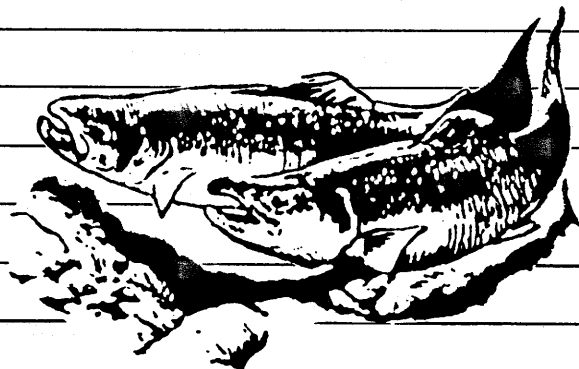
After the breeding season, most blue-winged teal migrate as far as northern South America. Censuses in the southern United States and in Mexico in winter do not account for a large proportion of the total blue-winged teal population. The winter waterfowl survey by the U.S. Fish and Wildlife Service in 1960 revealed that wetlands on the Caribbean lowlands of Colombia and Venezuela in northern South America are among the most important blue-winged teal wintering areas. Our studies of waterfowl in the Ciénaga Grande de Santa Marta, Colombia, revealed that the Ciénaga Grande is an important blue-winged teal wintering and stopover area.

Subsistence hunting of blue-winged teal is common in the Ciénaga Grande. Blue-winged teal are either shot or captured at night from dugout canoes equipped with small oil lamps. Canoe operators use casting nets similar to those used for fishing. A good catch on a calm, moonless night varies between 20 and 60 or more. Canoe operators typically keep some birds for their families and sell the rest to their village neighbors. Sport hunting in the Ciénaga Grande is often practiced by city hunters from other parts of the country or from abroad.

Blue-winged teal are hunted throughout the entire Neotropical region. In fact, blue-winged teal bands have been recovered from at least 20 different countries in the Neotropics. No attempts have been made to evaluate the band reporting rates in the Neotropics; however, many Neotropical biologists believe that only a very small proportion of the bands are reported. In a preliminary study of waterfowl use of the Ciénaga Grande region in 1979–80, we collected 103 blue-winged teal bands from local fishermen and hunters in the primitive villages around the wetland. These bands, kept as souvenirs and never reported by the hunters, represented 5.5% of the total number of recovered bands in Colombia until 1980 or 2.9% of all recovered bands in South America. Hunters in the Ciénaga Grande were not familiar with the bird-banding programs, did not understand the message on the band, and in most instances had limited access to post offices. Low blue-winged teal band reporting rates from the Ciénaga Grande region are possibly typical of the Neotropical region.

Band reporting rates in the Neotropics possibly vary among countries and among the regions of each country. City hunters, who may have been exposed to banding as a technique for the study of bird migration, are more likely to report bands than hunters from remote areas. For example, in Colombia, a greater number of blue-winged teal bands have been reported from wetlands near large cities such as Bogotá, Cali, and Barranquilla than from wetlands in the more remote eastern savannas or llanos, where blue-winged teal also winter.

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Juvenile Spotted Seatrout Find Abundant Foods at Cedar Keys, Florida

Information on the status of the spotted seatrout (*Cynoscion nebulosus*) and their foods in the Northeast Gulf of Mexico will assist with the maintenance of the fishery in the rapidly developing area near Cedar Keys, Florida. Populations of the spotted seatrout are essential to commercial and recreational fishing in the northeast Gulf of Mexico. Spotted seatrout remain throughout their lives in the general vicinity where spawned and are among the first fish species to suffer when local habitats are disturbed. Past studies of the seatrout in the vicinity of Cedar Keys in the 1940's and elsewhere in the 1970's are a basis for comparison with the present study.

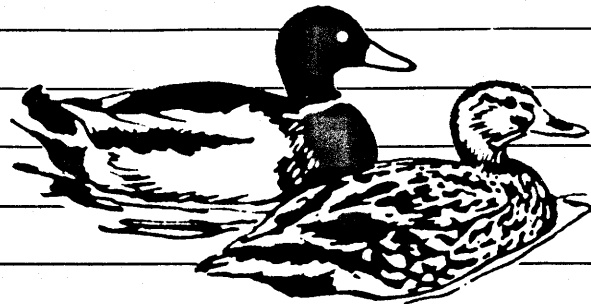
From September 1992 to September 1993 we collected spotted seatrout and their foods from four different habitat zones in a 1.5-km band of seagrass beds along the south shore of Seahorse Key, one of four small islands that compose the Cedar Keys National Wildlife Refuge, Florida. The shoreline sand zone (I), partially exposed during low tide, is followed progressively by a 25-m band of shoal grass *Halodule wrightii* (zone II) at 0.5-m average depth. We sampled the broad 75-to-400-m band of turtle grass (*Thalassia testudinum*) at two depths: at 1 m (zone III) and at 1.5 m (zone IV). Beyond these beds at 2-m average depth is manatee grass (*Syringodium filiforme*) mixed with turtle grass and other seagrasses.

Sampling of fish and their epibenthic and hyperbenthic invertebrate foods was done monthly

in each zone at randomly selected points along 30 transects that are perpendicular to shore and spaced 30 m apart. Spotted seatrout were collected with a 15-m long bag seine, and invertebrates were collected with a sled trawl (18-cm × 53-cm aperture) with a conical net (0.6-mm mesh net). The trawl was winched at 0.3-m/s for 10 m parallel to shore. The water at Seahorse Key is usually clear and well mixed, and the range of annual water temperatures was 11 to 34°C at pH of about 8, dissolved oxygen of about 7–8 mg/L, and total salinities between 17 ppt in winter–spring and 31 ppt in summer.

Diverse and abundant foods were available to the spotted seatrout in late summer, fall, and early summer. Foods were less abundant in winter (January–February) probably because of seasonal die-back of grasses, less habitat, and lower temperatures and salinities. During March and May 1993, diversities averaged about 30 taxa per sample, and densities averaged 2,650 organisms per sample. Key crustacean foods of the seatrout usually exceeded 50% of the total number of organisms in the seagrasses. These were mysids (*Hippolyte zostericola* and *Tozeuma carolinense*), tanaid (*Hargeria rapax*), cumaceans (*Oxyurostylis smithi* and *Almyracuma* sp.), and decapods (grass shrimp [*Palaemonetes* cf. *intermedius*] and pink shrimp (*Penaeus duorarum*)).

Research Information Bulletins (RIBs) are internal National Biological Survey documents whose purpose is to provide information on research activities. Because RIBs are not subject to peer review, they may not be cited. Use of trade names does not imply U.S. Government endorsement of commercial products.



Electrified Fences Reduced Predation on Least Tern and Snowy Plover Eggs and Chicks

High rates of predation on eggs and chicks can severely reduce reproduction in ground-nesting waterfowl and shorebirds. Wildlife managers have used electrified fences for more than 50 years to protect breeding waterfowl from predators. We evaluated the usefulness of electrified fences for decreasing predation by mammals on eggs and chicks of the endangered least tern (*Sterna antillarum*) and the listing candidate snowy plover (*Charadrius alexandrinus*) and for establishing new nesting colonies by these species.

Study Sites and Methods

The study was conducted on the salt flat of the Salt Plains National Wildlife Refuge, Oklahoma. In 1991, an electrified fence was constructed around a 16-ha (400 × 400 m) area. An area that had not been used by nesting least terns in previous years was selected to preclude adverse effects on an established nesting colony and to determine the efficacy of an electrified fence for establishing a new nesting colony. One solar-powered unit (Gallagher B-150 energizers, 12-V DC, with deep cycle 12-V batteries; Gallagher Power Fence, Inc., San Antonio, Texas) was used to provide power for the fence. The fence consisted of five wires spaced at 14, 28, 42, 62, and 86 cm from the ground. Soil from the salt flat was used to make 15 ridges (about 10 m long × 0.5 m wide × 0.2 m high) to serve as nesting platforms

inside the fence and to attract adult terns and plovers during the breeding season (May–July).

In 1992, electrified fences were constructed around two 3.75-ha areas (250 × 150 m) about 3.0 km east of the 16-ha site. The power for these fences was also provided by solar units. However, unlike the 16-ha site, the two smaller sites had been used by nesting terns and plovers during the year before the fences were constructed.

Nests inside and outside the enclosures were checked every 3 days, and daily mortality of the eggs and chicks and nesting success were estimated with the Mayfield Method. We compared the daily mortality inside the fences with daily mortality outside the fences.

Mortality Reduced in Fenced Areas

At the 16-ha site, the daily mortality of eggs and chicks of least terns was significantly higher outside than inside the fence in 1991 ($t = 2.56$, $P = 0.012$) and in 1992 ($t = 1.93$, $P = 0.037$; Table 1), and the daily mortality of eggs and chicks of snowy plovers was the same inside and outside the fence in 1991 ($t = 0.92$, $P = 0.190$) and in 1992 ($t = 1.44$, $P = 0.083$; Table 1). The least terns and the snowy plovers established a nesting colony in this site. The number of least tern nests rose from 3 in 1991 to 10 in 1992, and the number of snowy plover nests rose from 2 in 1991 to 13 in 1992 (Table 1).

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Table 1. Daily mortality rates of eggs and chicks and nesting success of least terns and snowy plovers inside and outside a 16-ha area enclosed by an electrified fence in the Salt Plains National Wildlife Refuge, Oklahoma, 1991 and 1992.

Variables	1991		1992	
	Inside	Outside	Inside	Outside
Least terns				
n^a	3	11	10	7
Nesting success (%)	81.0	7.8	50.5	7.1
Daily mortality rate	0.010	0.114 ^b	0.032	0.119 ^b
Standard error	0.015	0.038	0.016	0.042
Snowy plovers				
n^a	2	9	13	9
Nesting success (%)	77.8	48.7	55.1	22.8
Daily mortality rate	0.010	0.028	0.024	0.057
Standard error	0.014	0.014	0.010	0.021

^a Number of nests.

^b Rate was greater ($P < 0.05$) outside than inside the fence.

Table 2. Daily mortality rates of eggs and chicks and nesting success of least terns and snowy plovers inside and outside two (combined) 3.5-ha areas enclosed by electrified fences in the Salt Plains National Wildlife Refuge, Oklahoma, 1992.

Variables	Least terns		Snowy plovers	
	Inside	Outside	Inside	Outside
n^a	4	2	7	14
Nesting success (%)	64.9	24.7	56.3	17.2
Daily mortality rate	0.020	0.065	0.023	0.068 ^b
Standard error	0.020	0.044	0.016	0.021

^a Number of nests.

^b Rate was greater ($P < 0.05$) outside than inside the fence.

U.S. DEPARTMENT OF THE INTERIOR NATIONAL BIOLOGICAL SURVEY

PRODUCT ANNOUNCEMENT FEBRUARY 1994

The following publications were authored by Research and Development personnel, U.S. Fish and Wildlife Service, and received by the Publications Management Officer, Office of Information Transfer during the past six months.

Generally, these product announcements are scheduled for distribution bimonthly. Because of budget constraints, this schedule was discontinued in September 1993.

The process for distribution has been inclusion with the *Research Information Bulletin* (RIB) mailing. The RIB mailing is monthly. The product announcement is bimonthly.

For many of you, this will be your first product announcement containing series and nonseries publications. The data for this listing is provided by authors using the *Bibliographic and Cost Data Form*. This form is required for each nonseries manuscript now published by any author of the National Biological Survey.

If you have questions, contact Tom Cortese, the Publications Management Officer at (303) 226-9401 x216.

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ALCFWRU

U.S. National Biological Survey
Alabama Cooperative Fish and Wildlife Research Unit
331 Funchess Hall
Auburn University
Auburn, AL 36849

ARCFWRU

U.S. National Biological Survey
Arkansas Cooperative Fish and Wildlife Research Unit
Zoology Department SE 632
University of Arkansas—Fayetteville
Fayetteville, AR 72701

ARCUS-Fairbanks

U.S. National Biological Survey
Arctic Research Consortium of the United States (ARCUS)
P.O. Box 80684
Fairbanks, AK 99708

CRUC-Washington D.C.

U.S. National Biological Survey
Cooperative Fish and Wildlife Research Units Center
1849 C. Street, N.W.
Mail Stop 725—ARLSQ
Washington, DC 20240

GACFWRU

U.S. National Biological Survey
Georgia Cooperative Fish and Wildlife Research Unit
School of Forest Resources
University of Georgia
Athens, GA 30602

HICFRU

U.S. National Biological Survey
Hawaii Cooperative Fishery Research Unit
2538 The Mall
University of Hawaii
Honolulu, HI 96822

Hawaii Research Group
P.O. Box 44
Hawaii National Park, HI 96718

PWRC-Palmer

U.S. National Biological Survey
Patuxent Wildlife Research Center—Palmer
Puerto Rico Research Group
Rd. 191, KM 4.5
P.O. Box N
Palmer, PR 00721

PWRC-Patuxent

U.S. National Biological Survey
Patuxent Wildlife Research Center
Laurel, MD 20708

SCCFWRU

U.S. National Biological Survey
South Carolina Cooperative Fish and Wildlife Research Unit
Department of Aquaculture, Fisheries and Wildlife
GO 8 Lehotsky Hall
Clemson University
Clemson, SC 29634-0362

SDCFWRU

U.S. National Biological Survey
South Dakota Cooperative Fish and Wildlife Research Unit
Department of Wildlife and Fishery Sciences
South Dakota State University
Brookings, SD 57007-1696

TNCFRU

U.S. National Biological Survey
Tennessee Cooperative Fishery Research Unit
Box 5114, Biology Department
Tennessee Technological University
Cookeville, TN 38505

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Information bulletin

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL BIOLOGICAL SURVEY

NO. 11
DATE 1994

Culture of Zebra Mussels in Five Water Sources

The life cycle of the zebra mussel (*Dreissena polymorpha*) has been extensively studied to control and lessen the harm of this nuisance species to the environment and aquatic organisms. Research in the laboratory requires methods that maintain the organism in a healthy state. Because mussels are confined to water, the quality of the water, nutrients, and food organisms determine the mussels' condition. The characteristics of the water source determine the availability of metabolic elements that are essential for growth and survival of mussels. We evaluated five different water sources as potential culture waters for zebra mussels by monitoring crucial water characteristics and mussel survival.

Culture Methods and Water Quality Characteristics

Culture water was obtained from one site on the Mississippi River, two sites on the Black River (Black River-A and Black River-B), the well-water supply of the National Fisheries Research Center-LaCrosse laboratory, and a standardized reconstituted test water supply. Water of the Black River was sampled at two locations because of differences in water characteristics from the mixing of Mississippi River water with Black River water at the Black River-B site. Twenty zebra mussels (4–8 mm shell length) were placed in each of five 38-L aquariums with 20 L of aerated culture water at room temperature ($20^{\circ}\text{C} \pm 1^{\circ}\text{C}$) and were fed equal portions of a daily diet of live multi-species

algae (*Chlorella* and *Ankistrodesmus*) and dried chlorella. The water sources were tested in triplicate. Dissolved oxygen, pH, and temperature were monitored daily. Twice weekly a half volume of water was siphoned from each aquarium and replaced with fresh culture water to maintain water quality. Before replacement, culture waters were poured through a 5- μm bag filter to remove microorganisms and particulate matter. Before and after each replacement, water quality characteristics of pH, dissolved oxygen, hardness, alkalinity, conductivity, and ammonia were monitored. Mussels were assessed for survival and growth after 68 days of culture. Each live mussel was measured with a computer-assisted Optical Pattern Recognition System.

Water Sources Had Distinctive Characteristics

Personnel of the National Fisheries Research Center—LaCrosse had monitored the water sources for this study since the early 1970's. A substantial historical data base revealed that the water sources have distinctive characteristics. In our study, the Mississippi River water had a higher mean hardness value (226 ppm; mg/L CaCO_3) than the Black River-B (172 ppm), well water (146 ppm), Black River-A (80 ppm), and reconstituted water (51 ppm). Alkalinity and conductivity evidenced the same trends. Dawson (U.S. Fish and Wildlife, personal communication) reported that calcium levels were highest in the Mississippi River (22.5 ppm) and in

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Research



Information bulletin

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL BIOLOGICAL SURVEY

NO. 12
DATE 1994

Improved Cryogenic Coring Device for Sampling Wetland Soils

Cryogenic soil-coring methods (i.e., freezing the soil in situ with liquid nitrogen) have been used to collect shallow (≤ 50 cm) cores of loose, unconsolidated wetland sediments and offer several advantages over conventional soil-coring techniques. Freezing the soil eliminates compaction, dewatering, and loss of flocculent material at the water-sediment interface. Hence, cryogenic coring is suitable for sampling both shallow water bottoms and emergent marsh soils, although it has been primarily used for the latter. Because soil compaction is avoided, small diameter cores (3–5 cm) can be taken with minimal disruption to the marsh surface. The frozen soil core allows an investigator to immediately determine core quality, to measure soil profiles, and to subsample for further analysis. Processing the core in the field allows the collection of a complete and timely data set. Traditional core collection methods require inspection in the laboratory to determine these values.

We have used cryogenic coring in coastal Louisiana since 1986 to collect marsh soil cores for estimating vertical accretion from artificial soil marker horizons (e.g., feldspar [visible horizon] and stable isotopes [invisible horizon]) and soil bulk density. The cryogenic apparatus provides many advantages for determining soil bulk density because (1) the soil pore spaces are preserved as ice, (2) flocculent material is captured in ice, (3) compaction is insignificant, (4) microstratigraphy is preserved, and (5) surface area disruption is reduced.

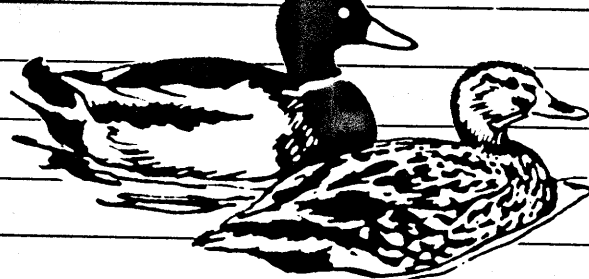
How Cryogenic Coring Works

Cryogenic coring uses liquid nitrogen to freeze the marsh substrate. The coring apparatus has three basic components: (1) a dewar to transport the liquid nitrogen to the field, (2) a coring device—a narrow copper tube referred to as a bullet, and (3) a system for efficiently delivering the liquid nitrogen from the dewar to the coring device (e.g., tygon tubing or a flexible stainless steel hose with welded connections). To collect a core, a 1 cm-diameter copper tube (bullet) is inserted in the marsh substrate to a desired depth and liquid nitrogen is pumped through it. The marsh freezes, beginning at the copper tube and moving outward, and the final core diameter is determined by how long the liquid nitrogen is pumped through the bullet. The bullet is pulled from the marsh substrate, resulting in "marsh-on-a-stick" or a "marsh-cicle." The depth of a visible marker horizon can be easily determined in the field from this frozen core. A conventional core tube can also be used to core through the frozen marsh before the bullet is extracted if a core of known volume is needed (e.g., to determine soil bulk density).

Early Designs of the Apparatus

Designing an efficient coring apparatus requires balancing portability and efficient delivery of the liquid nitrogen. Pressure is required to deliver the

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Freshwater-Intermediate Marsh Plant Responds to Increased Water Depth

Vegetation patterns in wetland habitats are influenced by biological (e.g., competition, herbivory) and physical (e.g., water flooding depth) factors. Increased water depth depletes soil oxygen that in turn affects plant metabolism and growth. Whereas some freshwater emergent, herbaceous marsh plants temporarily increase growth in response to increased flooding, others reduce or cease growth.

Consequences of Stress From Flooding

Wetland plants that survive and adjust to flooding may have reduced vigor and, consequently, lowered productivity. They may become more susceptible to additional stressors such as increased salinity, resulting in increased population mortality. In Louisiana, where more than 40% of the coastal wetlands of the contiguous United States are located, wetland loss is a major resource management issue. Based on wetland-loss rates through the 1970's, projected annual rates in Louisiana in the 1980's were 100 km²/year to 130 km²/year. Analyses of aerial photographs, however, indicated that the actual annual loss was 66 km²/year between 1983 and 1990. Inland marsh fragmentation and loss, as opposed to shoreline erosion, is considered the main cause of large-scale and widespread habitat change in Louisiana.

Study of a Common Marsh Plant

Sagittaria lancifolia is a common perennial in coastal Louisiana marshes and composes about 15%

of vegetation cover in fresh (< 0.5 ppt) and 7% in intermediate (0.5 to 5.0 ppt) marsh types. We studied the effects of flooding on *S. lancifolia* by manipulating water depths in a marsh in the Barataria Unit of the Jean Lafitte National Historical Park in Louisiana. Sods were dug from the marsh and replaced at lower elevations of 7.5 and 15.0 cm in relation to the surrounding marsh surface. We monitored plant growth during two summers and compared it with the growth of plants that were dug up and replaced at their original elevations (disturbed control plants). We also monitored environmental physical parameters, namely, soil redox potential, salinity, and concentrations of soil interstitial water sulfide and nutrients. Differences were considered significant when $P \leq 0.05$.

Plants Alter Growth Form

The growth form but not the standing crop (aboveground dried biomass) of plants exposed to increased flooding (decreased elevation) was affected. Maximum and mean stem heights ($n = 18$) were significantly greater in the 15-cm treatment plants than in disturbed control plants. These differences were established early in the first growing season and were apparent at first measurement in the following year (Fig. 1). Analyses of tissue elemental concentrations indicated that the 15-cm treatment plants had significantly lower concentrations of Cu, Fe, Na, and Zn in the leaves.

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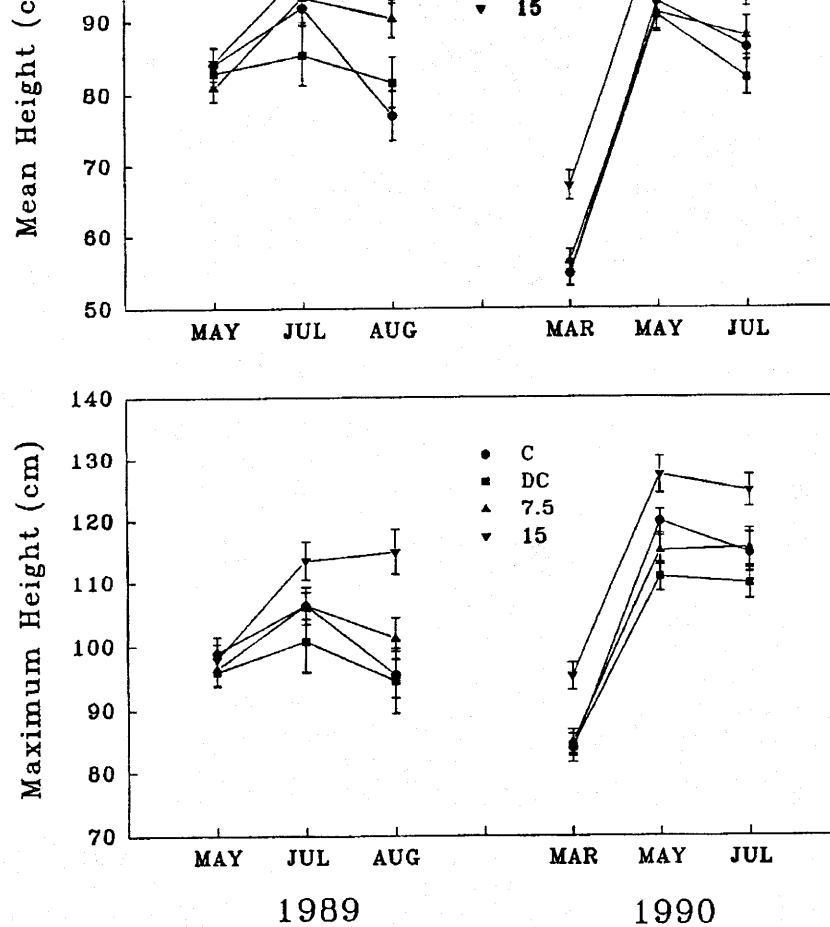


Fig. 1. Mean and maximum stem heights of *Sagittaria lancifolia* in a marsh in the Jean Lafitte National Historical Park, Louisiana, during the 1989 and 1990 growing seasons. Treatment symbols: C = control, DC = disturbed control, 7.5 = elevation decreased 7.5 cm, 15 = elevation decreased 15.0 cm.

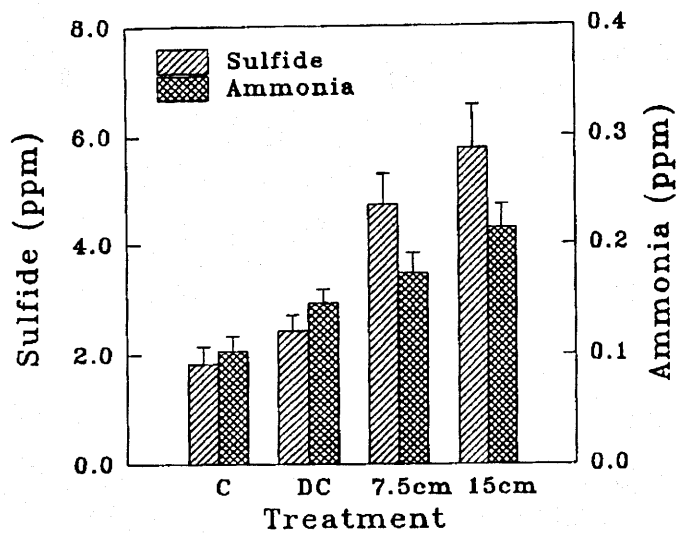


Fig. 2. Posttreatment mean concentrations of interstitial water sulfide and ammonia-nitrogen concentrations in a marsh in the Jean Lafitte National Historical Park, Louisiana. Treatment symbols as in Fig 1.

Selenium May Harm Razorback Suckers in the Green River, Utah

The razorback sucker, *Xyrauchen texanus*, is a federally listed endangered species that inhabits the Colorado River basin. Studies of the fish in the Green River of Utah between 1979 and 1986 revealed low numbers of adults, little growth, and no apparent recruitment. The decline of the species throughout the Colorado River system has been attributed to dams, habitat destruction, degraded water quality, and interactions with non-native fishes. Despite the presence of irrigated agriculture in the Green River drainage, little attention has been given to the effects of contaminants from irrigation. A detailed investigation of the middle Green River by the Department of the Interior revealed elevated concentrations of selenium in water, sediments, and biota and raised concerns about adverse effects on the endangered razorback sucker.

In spring 1992, a study of the middle Green River near Jensen, Utah, was conducted in cooperation with the Colorado River Fishery Project (CRFP). To determine selenium concentrations, biologists of CRFP collected samples of eggs from three female and milt from five male razorback suckers that were captured in the middle Green River. A 0.5-mm diameter muscle plug was removed from the back of each adult and analyzed for selenium.

Eggs and Muscle Plugs Had Elevated Selenium

Selenium in the eggs of three razorback suckers from the Green River were 3.7 to 10.6 ppm (Table). One sample of eggs collected from a razorback sucker

in the Green River in 1991 had 28 ppm selenium. By comparison, eggs of razorback suckers from the Dexter National Fish Hatchery, New Mexico, had 2.8 ppm (dry weight) selenium, which is similar to concentrations in other fish species (2.0–3.1 ppm) from other uncontaminated locations in the United States. Increased edema and lordosis have been reported in fathead minnow larvae hatched from fish with 24 ppm selenium in their ovaries and reduced survival of bluegill larvae hatched from fish with 18 ppm selenium in their ovaries.

Selenium concentrations in milt of five razorback suckers from the Green River were <1.1 to 6.7 ppm. These concentrations are similar to about 2.0–3.8 ppm selenium in milt of fish species from uncontaminated sites in the United States.

Muscle plugs from razorback suckers contained 4.4 to 32 ppm selenium in females and 3.6 to 26 ppm in males. These concentrations highly correlated with selenium in eggs ($r = 0.99$) and in milt ($r = 0.87$). This relation may allow future prediction of selenium concentrations in gonads based on concentrations in muscle tissue. Findings from concurrent research strongly suggest that muscle plugs from the anterior, middle, and posterior areas of the back of adult razorback suckers have similar selenium concentrations.

Selenium May Be Harming Endangered Fishes

The above-normal selenium concentrations in eggs may harm the reproductive success of razorback

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Fluoride Affects Aluminum Toxicity in Atlantic Salmon

The addition of small amounts of fluoride to test solutions reduced mortality and gill damage and improved growth of young Atlantic salmon (*Salmo salar*) exposed to aluminum in acidic water; greater amounts of fluoride either had no effect or increased the toxicity of test solutions. Recovery of Atlantic salmon in the northeastern United States depends in part on suitable water quality in streams that juveniles use. Northeastern waters have been harmed by acid precipitation, and aluminum has been identified as the primary cause of harm to fish. Aluminum forms complexes with naturally occurring organic acids and hydroxide, fluoride, and sulfate ions. Fluoride-aluminum complexes are the dominant inorganic aluminum compounds in surface waters, yet their influence on Atlantic salmon has not been assessed or considered in the management of suitable water qualities in streams that are essential to the recovery of the Atlantic salmon.

We conducted short-term acute and 30-day chronic exposure studies to determine the influence of fluoride addition on the toxicity of aluminum to young Atlantic salmon at pH levels of 5.5 and 6.5. Tests were conducted in water the quality of which simulated that of waters in the northeastern United States. In short-term tests, the endpoints of survival, growth, and histopathological changes in gill tissue were examined under a series of aluminum concentrations at the two pH levels and four fluoride concentrations (0, 50, 250, 500 ppb). In

long-term tests, the endpoints were examined at two pH levels with either 0 or 200 ppm aluminum and with either 0, 100, or 200 ppb fluoride concentrations.

Fluoride-Aluminum Complexes Reduced Survival and Growth

At low pH (5.5), high fluoride (500 ppb) increased the toxicity of aluminum (96-h LC50, 478 ppb), but at near-neutral pH (6.5), low fluoride (50 ppb) decreased aluminum toxicity (96-h LC50, 1,134 ppb). Aluminum toxicity was not affected at pH 5.5 by low fluoride additions (50 or 250 ppb) or at pH 6.5 by high fluoride additions (250 or 500 ppb). In general, young Atlantic salmon were 6 times more sensitive to aluminum than brook trout (*Salvelinus fontinalis*) tested by other investigators.

Survival of Atlantic salmon after 30 days exposure was 2 to 6 times lower in all pH 5.5 treatments—with or without fluoride—than at pH 6.5. Moreover, fish length and weight was reduced in all fluoride-aluminum treatments at pH 5.5 but only in the 0 ppb fluoride-200 ppb aluminum treatment at pH 6.5. Growth in fish length during early life stages is important to later survival because smaller fish have lesser swimming abilities (stamina, speed) than larger fish of the same age. Thus, smaller than normal Atlantic salmon have lesser survival skills for capturing food and avoiding predators.

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Algae Removal by Zebra Mussels in Western Lake Erie

The zebra mussel (*Dreissena polymorpha*) was first observed in Lake Erie in 1988. The mussels quickly established high-density colonies on the reefs within the lake. Water clarity progressively increased from 1988 through 1990, concomitant with a decrease in chlorophyll levels. Using a bioenergetics model, I estimated that zebra mussels consume more than 25% of the primary production in western Lake Erie.

Bioenergetics Models Give Consumption Estimates

A bioenergetics model is an accounting of the energy intake and use by an animal. In the model, growth of an animal is equal to consumption minus the sum of respiration and waste losses. Zebra mussels remove phytoplankton through their inhalant siphons. Appropriately-sized particles are actually consumed, whereas larger particles accumulate as pseudofeces and are ejected through the inhalant siphon.

I developed a bioenergetics model that was verified with observations on growth of zebra mussels from western Lake Erie. The model explained growth of an average zebra mussel.

Next, the model was applied to the zebra mussel population in western Lake Erie. Total removal of phytoplankton was estimated for April through October 1990 as a function of the average zebra mussel density on the hard-bottom areas of western Lake Erie. A density of 50,000 mussels/m² is considered typical of the hard-bottom areas of the

western basin. At a density of 50,000 individuals/m², the zebra mussel population of western Lake Erie would have removed 6.4 million tonnes (6.4 megatonnes) of phytoplankton from the water column during the 1990 growing season. Of the phytoplankton removed, 5.0 megatonnes were actually consumed and 1.4 megatonnes were ejected in pseudofeces.

Zebra Mussels Remove Over One-fourth of the Primary Production

Phytoplankton are primary producers—they use sunlight to synthesize organic matter from carbon dioxide. The net primary production of an ecosystem is the amount of organic matter synthesized by the primary producers that is available for consumption by higher trophic levels.

Net primary production in western Lake Erie from April through October 1990 was estimated at 24.8 megatonnes. Therefore, according to the bioenergetics model application, zebra mussels removed 26% of the available food for higher trophic levels in the western Lake Erie ecosystem.

Bioenergetics Models Can Give Ecosystem Perspectives

The walleye (*Stizostedion vitreum*) is a piscivorous fish, and its population supports valuable recreational and commercial fisheries in western Lake Erie. In a previous study, a bioenergetics model was applied to the walleye

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Furunculosis Diagnosed in Mississippi River Fishes

In late summer 1993, many bowfin (*Amia calva*) and bigmouth buffalo (*Ictiobus cyprinellus*) from a fish farm on the Mississippi River died from an infectious disease. The bacterium *Aeromonas salmonicida* isolated from these fish confirmed a diagnosis of furunculosis. Furunculosis is a serious disease of bony fishes and can cause severe mortality—often approaching 100% within infected populations. The bacterium commonly produces hemorrhage of the fins, body surface, and viscera. Skin lesions initially appear as small, white areas that progress into furuncles that ultimately open to form deep necrotic ulcers in the musculature. The bacterium is a primary pathogen and the presence of two or three cells can initiate infection and cause rapid development of furunculosis in susceptible fish. This report adds bowfin and bigmouth buffalo to the list of susceptible hosts.

Biology of Diseased Fish

Bowfin range from the St. Lawrence River–Lake Champlain drainage of Quebec and Vermont across southern Ontario to the Mississippi drainage of Minnesota. Fish average 457–610 mm long and 0.75–1.12 kg. Adults (3–5 years old) spawn in spring. Bowfin are voracious, piscivorous predators that also eat crayfish and frogs. Regional common names include bowfin, dogfish, and mudfish.

Bigmouth buffalo are restricted in range to central North America. These fish average 254–457 mm long, and adults spawn in spring. This fish, with its terminal mouth and general body shape, is easily confused with carp. Bigmouth buffalo coexist in similar environments with other predaceous fish such as the bullhead, burbot, perch, pike, and walleye. Adults are probably free of predators. Regional common names include bigmouth buffalo, redmouth buffalo, buffalo, and buffalofish.

Predators for Retail Sale

Feral fish were captured in fyke nets by a commercial fishing operation between Mississippi River mile markers 679 and 648 and transported to earthen holding ponds on the Mississippi River at the junction of northeast Iowa, southeast Minnesota, and west-central Wisconsin. Fish were held for sale as predator fish to eliminate crowding or stunting conditions in fish ponds and small lakes. Crowding in earthen ponds was believed to be the predisposing stress that induced disease. After many died, fish with severe hemorrhaging of skin and mouth were brought to the Fish Disease Control Center (La Crosse, Wisconsin) where they were diagnosed with furunculosis. The etiologic agent was isolated and identified as *Aeromonas salmonicida*.

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Significance of Avian Pox for Reintroduction Programs

Avian pox, a disease caused by infection with avipoxvirus, appears as both cutaneous pox and wet pox. Cutaneous pox, the form generally reported in wild birds, is recognized by crusty growths that appear on unfeathered skin on the feet, legs, and around the edges of the eyes and mouth. Large lesions on the face and feet may interfere with a bird's vision and its abilities to fly and to perch. Death is usually because of starvation (through the inability to obtain food), predation, or bacterial infection of pox lesions. Conversely, pox lesions may also regress with little or no ill effect. Wet pox, a less common diphtheritic form, occurs in the mucous membranes of upper digestive and respiratory tracts and usually requires treatment. Avian pox is generally transmitted by direct contact of broken skin between birds, aerosols, mechanical transfer by insects, or contact with contaminated surfaces of branches, feeders, and cages. The virus is resistant to environmental factors and can persist on contaminated surfaces for many months.

Avian Pox Rarely Found in Wild Waterfowl

Avian pox is rarely diagnosed in wild waterfowl, although experimental studies show they can be infected. Avian pox was first confirmed in wild waterfowl in the United States in a free-ranging mute swan (*Cygnus olor*) in New York. It was subsequently reported in one green-winged teal (*Anas carolinensis*) in Alaska, two mallards (*Anas*

platyrhynchos) in Georgia, one Canada goose (*Branta canadensis*) in Ontario, two Canada geese in Tennessee and Georgia, and two common goldeneye (*Bucephala clangula*) in Canada.

Reintroduced Trumpeter Swans Develop Avian Pox

In 1989 and 1991, outbreaks of avian pox occurred in Wisconsin among reintroduced trumpeter swans (*Cygnus buccinator*). Avian pox was confirmed in September 1989 by the National Wildlife Health Research Center (NWHR) in a trumpeter swan at Crex Meadows Wildlife Management Area (WMA) and in another trumpeter swan at Mead WMA in September 1991. Other reintroduced swans at each site were suspected of having avian pox. The swan reintroduction program was initiated in 1989 at the Crex Meadows WMA and was moved to Mead WMA in summer 1991 to expand the release area in Wisconsin.

After the 1989 outbreak of avian pox in the reintroduced trumpeter swans, the NWHR requested that Wisconsin field biologists submit any waterfowl suspected of having pox lesions for laboratory confirmation. Wisconsin biologists stated that pox-like lesions have been seen for years on wild waterfowl during banding operations. Avian pox was confirmed by virus isolation or histology in nine waterfowl collected in Wisconsin between 1989 and 1992; seven were from the two swan reintroduction

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Commercial Fry Feed Improves Growth of Cultured Lamprey Larvae

Larval sea lampreys (*Petromyzon marinus*) are collected from the wild and held for toxicity tests before lampricide applications to streams, development of supplemental control methods, medical research, and other reasons. These animals must be healthy to ensure valid test results. In a 13-month study, supplemental feeding with BioKyowa A-250 fry feed (BioKyowa, Inc., Chesterfield, Missouri) improved the growth and survival of captive populations of sea lamprey larvae.

Yeast Is Still the Primary Feed for Lamprey Larvae

Historically, larval sea lampreys have been fed a slurry of bakers' yeast either once or twice a week. We conducted a study from 23 July 1992 to 1 September 1993 to determine the most suitable feeding schedule and the utility of supplemental feeding with a commercially available fry feed. We did not consider the fry feed to be a suitable replacement for the yeast because of its high cost (about \$100 for 500 g).

Twenty groups of 50 sea lamprey larvae were anesthetized, measured, weighed, and placed in aquariums at a density of about 400 animals/m². The larvae were allowed to burrow into clean beach sand about 75 mm deep and were supplied with aerated Lake Huron water at ambient temperature (range, 1 to 21°C).

Larvae in 10 aquariums were fed twice a week; larvae in the remaining 10 aquariums were fed only once a week. All larvae were fed a slurry of bakers' yeast and water at a rate of 0.27 g of yeast per animal. Animals in five tanks on each feeding schedule were also given the fry feed at a rate of 0.03 g per animal. During feeding, the water to the aerated aquariums was shut off for about 16 h.

Any dead larvae on the surface of the substrate were removed daily, measured, and recorded. About every 2 months, the larvae were anesthetized and reweighed. To maintain the proper population density, dead and missing animals were replaced with larvae marked by latex injection. Marked larvae were not included in growth calculations. Corrections were made for all dead and missing larvae to more accurately calculate changes in mean weight in each aquarium.

Feeding Twice a Week Was More Effective

Over the course of the study, larval weight gains were consistently greater, weight losses were consistently less (a mean weight loss was recorded for all groups between 22 October and 15 December 1992), and total deaths was less for those fed twice a week (Table). Within a feeding schedule, mean weight gains were always greater and losses always less in those aquariums in which the diet was supplemented with the fry feed—many of these

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Fish Antisera Does Not Neutralize Bacterial Chondroitinase

Commercial and recreational fishes such as salmon, trout, catfish, bass, and baitfish are all susceptible to columnaris disease, caused by the bacterium *Cytophaga columnaris* (a.k.a. *Flexibacter columnaris*). Infection typically occurs during warm weather when water temperatures are elevated, but epizootics have occurred among Pacific salmon when water temperatures were slightly above freezing. Infection spreads rapidly causing acute mortality and symptomatically appears as a body and tail rot. Fins commonly erode trailing strings of yellowish material (i.e., bacterial masses) that remain attached to the fish. Many of the details related to this progressive pathology are yet unknown, but investigators speculate that degradative bacterial enzymes are involved. One such enzyme, chondroitin AC lyase or chondroitinase breaks down chondroitin sulfates (ChSO_4) composing intracellular matrices and cartilage. Strong activity occurs in vitro and the enzyme may, wholly or in part, be responsible for cartilage degradation resulting in fin rot. Conclusive evidence, however, does not exist to state that chondroitinase is a virulence factor of columnaris disease.

Rapid Method Used To Study Chondroitinase

Prerequisite to studying the kinetics and possible role of chondroitinase in the pathogenesis of columnaris disease, a rapid assay was developed

that yields quantitative data (i.e., $\mu\text{g ChSO}_4$ degraded/mL/h) in less than 3 h. The assay consists of incubating ChSO_4 (1 part), a standardized concentration of *C. columnaris* cells (1.5 parts), and a low nutrient basal medium (7.5 parts) at room temperature for 2.5 h. At 30-min intervals the concentration of ChSO_4 that has not been degraded is determined by addition of an acidic albumin solution. The optical density of the reaction vessel is determined and compared to a standard curve. This assay has proven valuable for evaluating chondroitinase activity among individual isolates of *C. columnaris* and correlating enzyme kinetics to in vivo pathogenicity. Reaction kinetics of the enzyme vary among bacterial isolates, and preliminary data suggests that isolates with high degradative rates are more virulent in fish.

Antibody Effect on Enzyme Secretion

The presence of antibody produced against a specific bacterial pathogen can be detected in fish serum by an agglutination assay. Serial dilutions of serum (containing antibody) are reacted with a standardized, fixed bacterial suspension (antigen). If antibody against the bacteria is present, then a binding reaction results in the formation of an antibody-antigen matrix that agglutinates or precipitates and is visualized within a reaction vessel. Some bacteria, such as *C. columnaris*, form self-aggregates, and agglutination of cells can

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Erratum

In Research Information Bulletin Number 90 (1993), the figures were inadvertently omitted. Please replace the original report with the reprint provided here.

Cholinesterase Activity Useful in Detecting Freshwater Mussel Exposure to Organophosphate and Carbamate Pesticides

Determination of cholinesterase (ChE) activity is a well accepted method for diagnosing vertebrate exposure to organophosphate and carbamate pesticides. Cholinesterase activity that is inhibited by about 20% is considered indicative of exposure to ChE inhibitors. Brain ChE activity that is inhibited by 50% or more in dead animals is considered diagnostic of lethal anti-ChE poisoning. Responses and assessment tools for aquatic invertebrates exposed to ChE-inhibiting pesticides are not as well developed. In 1990, we investigated a die-off of freshwater mussels in central North Carolina. Using unperfected but repeatable techniques, we determined that cholinesterase activity in selected tissues was significantly inhibited at and downstream from the kill site compared to a reference site upstream. The inhibition of ChE activity in the mussels from the die-off site and the presence of nearby agricultural lands suggested that ChE-inhibiting pesticides may have caused the die-off. This led us to develop methods and criteria for evaluating exposure of freshwater mussels to these pesticides.

Adductor Muscle Is Tissue of Choice for ChE Assay

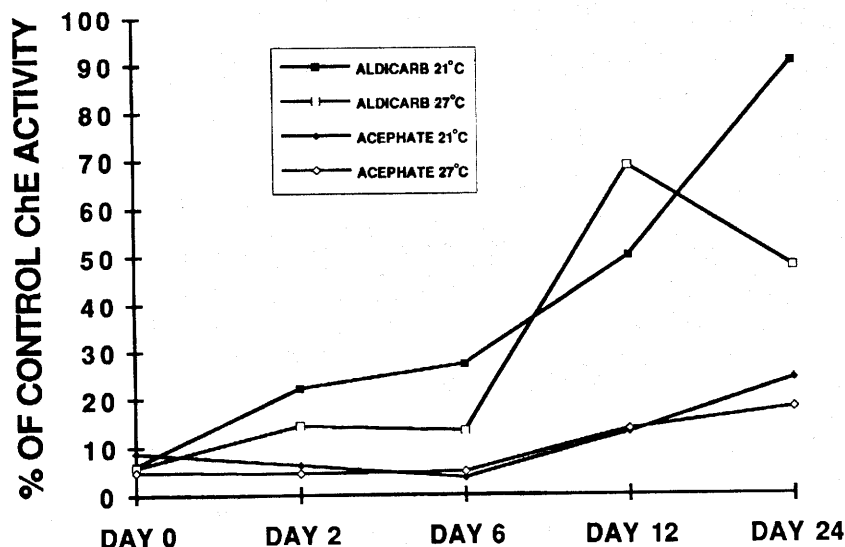
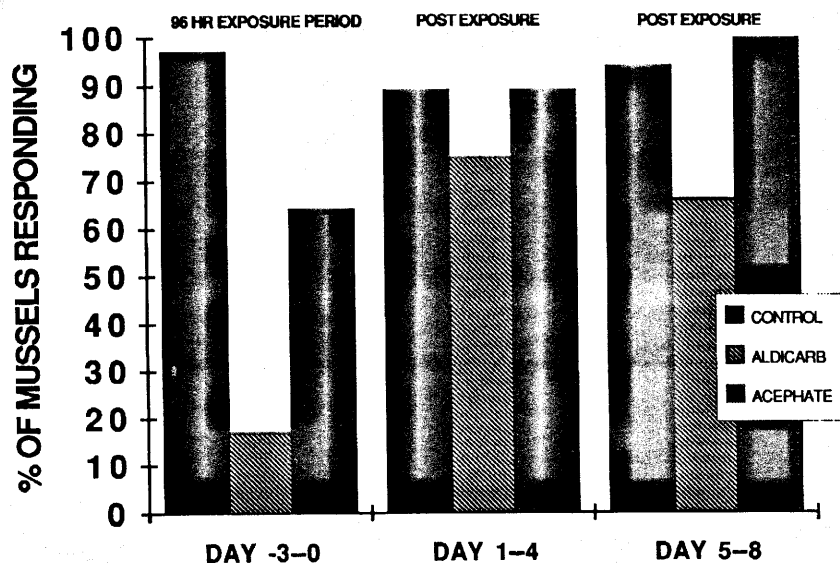
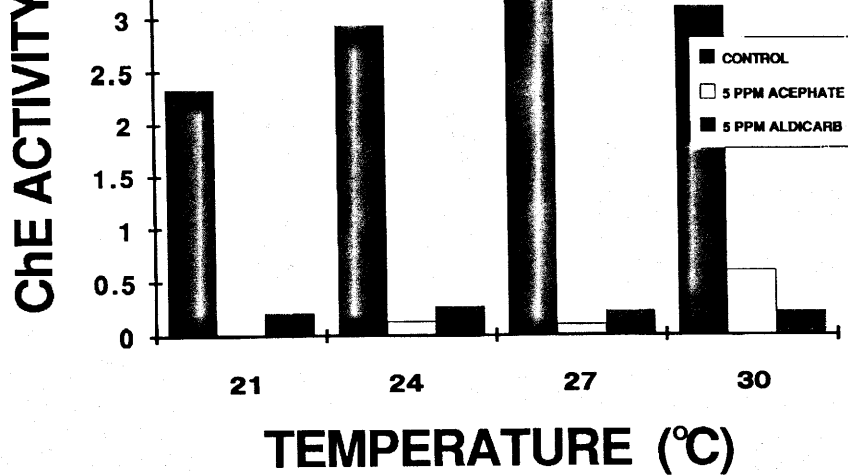
Nervous tissue and plasma, tissues normally used in vertebrate assessments of ChE activity, could not

be easily obtained from mussels. We found that the mantle of the eastern elliptio (*Elliptio complanata*) had inconsequential ChE activity, whereas the adductor muscle had low but consistently detectable levels. The adductor muscle was easily identified and dissected and became our tissue of choice for ChE assays. Adductor muscle was placed in Tris buffer at a ratio of 1:10 and homogenized with a biohomogenizer (BioSpec Products). Other types of homogenizers did not work well with the fibrous muscle tissue. We centrifuged the homogenate, then extracted the sample for ChE assay from the clear layer between the pellet at the bottom and the frothy layer at the surface. To compensate for the low ChE activity in our samples, we used 200 μ L of homogenate. This represented a 10-fold increase in the amount of homogenate normally used for vertebrate plasma and brain. These were the only modifications made to the standard colorimetric ChE assay as described by Hill and Fleming (1982).

ChE Activity Responds in Dose-related Manner

We exposed *E. complanata* to graded doses of aldicarb and acephate in a 96-h static test at 22° C. No mortality occurred at any concentrations, including the maximum concentrations of 320 ppm of acephate and aldicarb. Cholinesterase activity

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Hydrogen Peroxide Controls Fungal Infections on Trout Eggs

Malachite green, once the preferred fungicide for fishery use, is no longer permitted for treatment of fish or fish eggs for control of fungus—the Food and Drug Administration has restricted the use of malachite green on food fish. Formalin is an effective fungicide, but fishery managers are concerned about safety to the user and effluents in the environment. Other antifungal agents, therefore, are needed to maintain healthy fish and eggs in fish culture systems.

Hydrogen peroxide is active against a wide variety of organisms—bacteria, yeasts, fungi, viruses, and spores. Federal agencies list this chemical as Generally Recognized As Safe when used as a bleaching agent in manufacturing or feeding practices or as an antimicrobial agent in cheese production or drinking water treatment. Furthermore, hydrogen peroxide has been used as an antiseptic and a treatment for skin parasites, protozoans, and monogenetic trematodes on fish and is proposed as a treatment for sea lice on salmon. We designed experiments to evaluate the effectiveness of hydrogen peroxide for control of fungal infections on eggs of rainbow trout (*Oncorhynchus mykiss*).

In Vivo Procedures

Green eggs of rainbow trout were placed in Heath incubation trays and maintained in well water with a flow rate of 1 L/min. Groups of 500 eggs were

confined within 15-cm diameter acrylic rings that were fastened to the screen of each incubation tray. Eggs were inoculated with fungus (*Saprolegnia parasitica*) actively growing on hemp seeds suspended by tea balls in the upper tray of each duplicated treatment. Infection of eggs generally occurred within 7 days. The infection rate of about 10% in each tray was obtained by exchanging infected eggs between trays. Eggs infected at the 0 and 10% level were then exposed to hydrogen peroxide for 15, 30, or 60 min every other day for 2 weeks. Treatments ceased when the eggs began to hatch. A positive control group was inoculated with fungus but not treated with hydrogen peroxide. A negative control group was not inoculated with fungus nor treated with hydrogen peroxide.

Efficacy of Hydrogen Peroxide

Artificial infection of eggs was successful—infection rates increased substantially in the positive control and the hatch rate for those eggs was only 2.1% (Table). Hydrogen peroxide treatments of 500 ppm controlled fungal infections on eggs not infected (0% infection) at exposures of 15, 30, and 60 min; hatch rates were significantly higher than for control groups. This treatment concentration was effective for control of fungus at the 10% infection rate only in the 60-min exposure. The 1,000-ppm treatments, however, were effective for control of fungus and increasing the hatch rate at

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Study in a Mesocosm Reveals Discrepancy Between the Relative Abundance of Zooplankton in Fish Guts and in the Environment

Lake whitefish (*Coregonus clupeaformis*) larvae selectively feed on larger members of the zooplankton community. We were able to accurately document food preferences and selection by the larvae in relation to the prey community because we conducted our study in a mesocosm, which is an enclosure of an ecosystem larger than 1 m³.

Food habits of fishes have long been determined by examination of gut contents. Comparison of gut contents with the relative or actual abundance of food items in the surrounding environment can be revealing about the species-specific degree of food-type preference. Sampling bias often limits the utility of comparisons of gut and environment because not all species of prey organisms are equally vulnerable to sampling gear. Therefore, data on the occurrence of types of food organisms in gut samples are often used as an indicator of what a fish prefers to eat.

Mesocosm Permits Controlled In Situ Sampling

We placed a mesocosm in a small, mesotrophic lake in southeastern Michigan to investigate the food preferences of larval lake whitefish. Each of four floating net-cages (2-m³, 0.8 mm mesh) was stocked

with 500 newly hatched larval fish. Zooplankton from the surrounding waters could pass into and out of the cages. We sampled the fish and zooplankton weekly for 8 weeks from 5 April to 24 May 1989. Two replicate samples were taken from each of the four cages with lake whitefish (fish cages) and from four cages without fish (control cages).

Gut Contents Indicate Feeding Is Not Random

Analysis of gut contents revealed little change in the mean length of zooplankton that were eaten (Fig. 1). Lake whitefish routinely ate prey larger than the average-sized prey in the cages. They preyed mostly on cyclopoid copepods (primarily *Cyclops* species), the only prey group that was significantly selected at levels higher than neutrality (Strauss' electivity index). Small prey such as copepod nauplii were negatively selected, and larger prey such as large cladocerans (primarily *Daphnia*, *Eurycerus*, and *Simocephalus*) and calanoids (primarily *Skistodiaptomus*) were neutrally selected in proportion to the low abundance in the fish cages.

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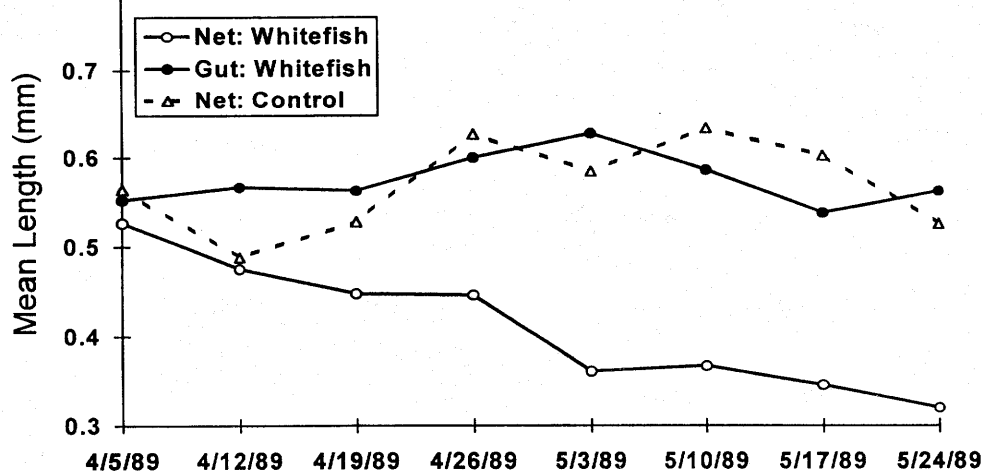


Figure 1. Mean length of zooplankton in samples from net-cages with lake whitefish (*Coregonus clupeaformis*), net-cages without lake whitefish, and lake whitefish guts, 5 April–24 May 1989.

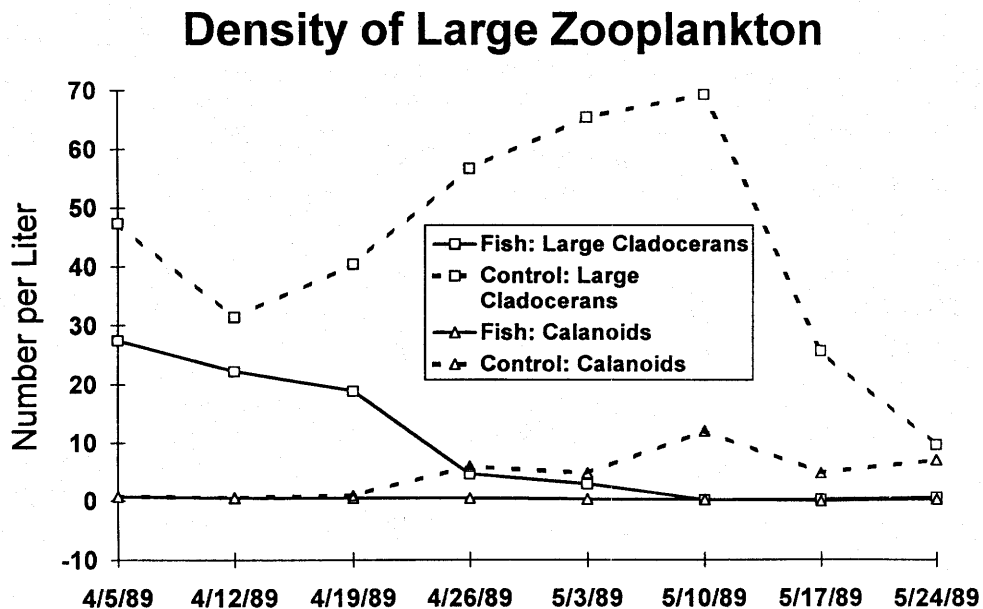


Figure 2. Density of large cladoceran (primarily *Daphnia*, *Eurycerus*, and *Simocephalus*) and calanoid copepods (primarily *Skistodiaptomus*) in net-cages with lake whitefish (*Coregonus clupeaformis*) and in net-cages without lake whitefish, 5 April–24 May 1989.

Improper Formation of Composite Samples Jeopardizes Data Interpretation

Our purpose is to alert researchers to potential problems in forming a suitable composite sample and in analyzing the data correctly. One of the practices associated with environmental studies is the combining of samples into a composite that is analyzed to obtain a single average measure. For example, five samples of sediment or five fish are combined (homogenized), and a single analytical measurement of contaminant load is obtained from the composite. The formation of a composite may be justified when the cost of analysis is high in relation to the cost of collecting individual samples. Composite samples may be essential when the analytical technique requires more material than a single sample or individual specimen can provide. We investigated the properties of composite samples using computer simulations based on actual contaminant concentrations measured from individual fish.

Size Variation Among Fish Contributes to the Bias of Incorrectly Formed Composite Samples

Whole fish are often combined in a large mixer or homogenizer when forming a composite sample for fish contaminant analysis. This procedure, which we call the Batch Method, leads to biased estimates of contaminant concentration because larger fish contribute proportionally more mass to the

composite. Although fish of the same age class are sometimes used to form the composite, size variation within an age class may be significant. The correct procedure, the Individual Method, is to homogenize each fish separately, obtain an equal-sized subsample from each homogenate, and combine the subsamples to form the composite.

Simulations With Striped Bass Data Illustrate the Bias

To demonstrate the effects of the two procedures to form a composite, we worked with observations on individual contaminant concentrations in 195 striped bass (*Morone saxatilis*) between 55 and 116 cm long. Contaminant concentrations in these fish ranged between 0.1 and 40.7 ppm; the mean contaminant concentration was 3.57 and the variance was 24.10 (Fig. 1). We then produced computer-generated composites by combining groups of five fish randomly selected (with replacement) from the original sample; we simulated the formation of 10,000 composites following the well-described bootstrap procedure.

The Individual Method Yields Unbiased Estimates

Concentration of each composite sample was estimated in two ways, corresponding to the two procedures described previously. The Individual

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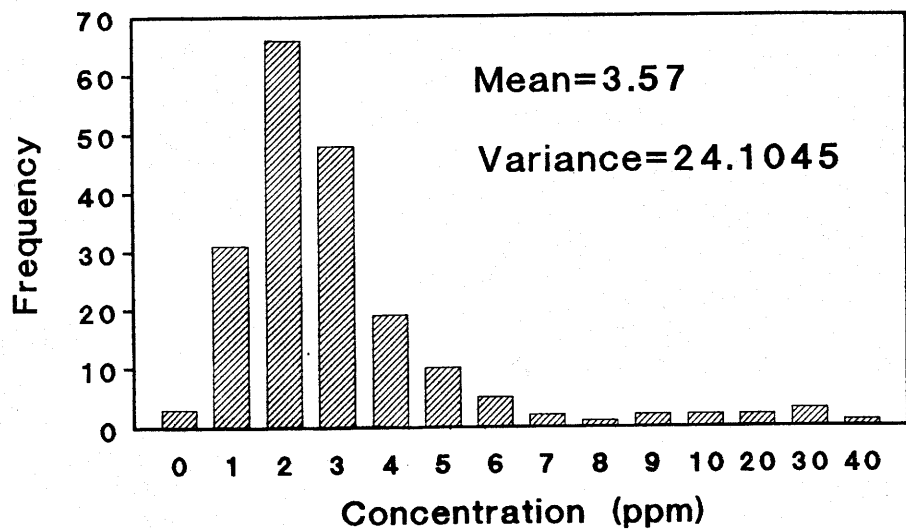


Fig. 1. Contaminant concentrations in striped bass (*Morone saxatilis*).

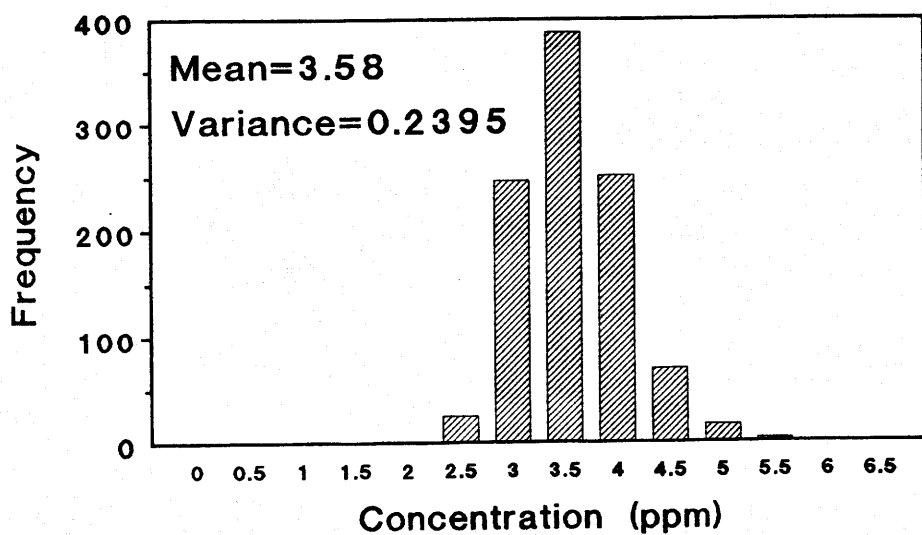


Fig. 2. Mean concentration for 1,000 simulated 20-composite tests.

How Many Fish Should Be Used in a Composite Sample?

In this bulletin, we provide guidelines for determining sample sizes necessary to work with composite samples. The need to form composite samples is sometimes associated with the high cost of analytical measurements, as in the analysis of contaminant concentrations in fish tissue. In these situations, researchers form composite samples to obtain a relatively low-cost estimate of the average measure of contaminant concentration. One of the following questions invariably arises:

1. If we want to obtain reliable estimates of the mean and variance, and we can analyze only X samples, how many fish should we collect to form those X composites? or
2. If we collect Y individual fish, how many composites should be formed, and how many fish should be combined to form each composite sample?

To answer these questions, we used a simulation approach and examined the tradeoffs in precision of the estimates of mean and variance. Our base population consisted of 195 striped bass (*Morone saxatilis*) for which we knew individual contaminant concentrations. We simulated the formation of composite samples using bootstrap sampling, a common technique for statistical analyses.

Form Composite Samples in the Correct Manner

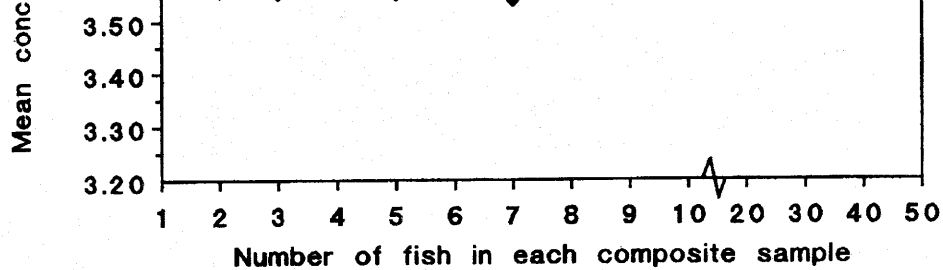
In a previous bulletin (RIB No. 23), we demonstrated the correct technique of forming composite samples: each fish is homogenized and equal-sized subsamples from each homogenate are combined to form a single composite sample. The contaminant concentration in the composite estimates the average of the concentrations in the individual fish.

For this study, we used the bootstrap technique to randomly sample fish from the base population and calculated contaminant concentrations for each simulated composite sample. We varied either the number of fish collected while holding the number of composites fixed, or we varied the number of composites while holding the number of fish collected constant. We repeated each combination 1,000 times. We then examined the mean contaminant concentration and the variance of the variance, a measure of the relative precision of the variance. The true mean was estimated directly from the base population and was helpful in interpreting our results.

Collect More Fish With a Fixed Number of Samples

In the first example, we attempted to answer the question, If an investigator can process only

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concentration vs. number of fish per composite.

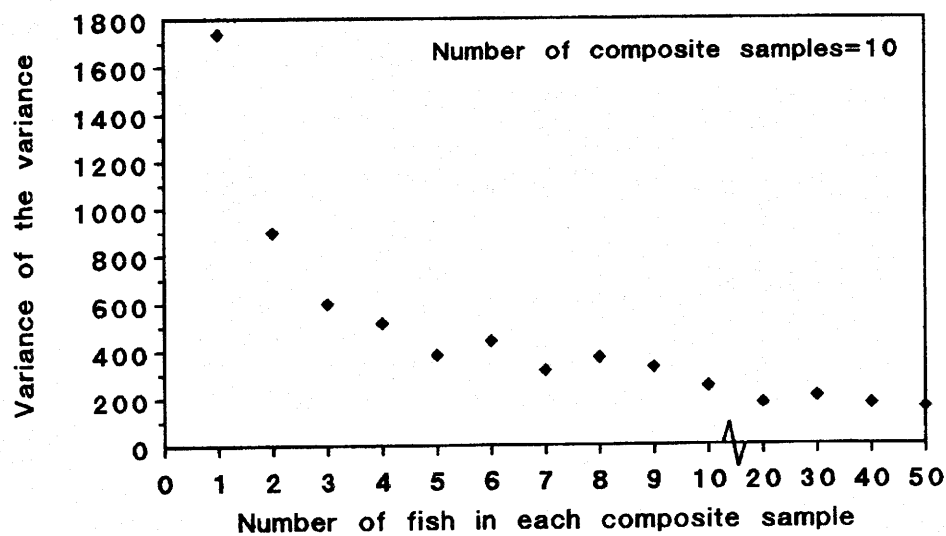


Fig. 1b. Precision of the variance vs. number of fish per composite.

Low Selenium in Waterfowl Wintering at Kern National Wildlife Refuge

Excessive levels of selenium (Se) have been linked to impaired reproduction and embryotoxicity in breeding waterbirds. Little is known, however, about Se accumulation in wintering waterfowl. I examined Se concentrations in northern pintails (*Anas acuta*) northern shovelers (*A. clypeata*), green-winged teals (*A. crecca*), and ruddy ducks (*Oxyura jamaicensis*) wintering in the southern San Joaquin Valley, California, to determine if freshwater wetlands reduce dietary Se exposure among wintering waterfowl. The wetlands included more than 2,800 ha of Se contaminated evaporation ponds (Figure); Kern National Wildlife Refuge (NWR), an uncontaminated freshwater area of about 1,200 ha; and small areas of private hunting clubs and flooded agricultural fields. Freshwater habitat provides both seeds (carbohydrate) and aquatic invertebrates (protein), whereas hypersaline evaporation ponds produce few seeds but many aquatic invertebrates.

I hypothesized that Se concentrations in waterfowl would reflect their mobility, foraging strategies, and habitat quality and availability. Northern pintails, northern shovelers and green-winged teals are highly mobile during the winter, whereas ruddy ducks are generally less mobile. Northern pintails and green-winged teals tend to forage principally on plant matter and should have lower concentrations of Se than northern shovelers and ruddy ducks that consume a high proportion of animal matter. Likewise, highly

mobile species moving among all habitats (northern shovelers) should have lower Se concentrations than species with lower mobility (ruddy ducks) given similar foraging strategies.

Seasonal and Sex Differences in Selenium Concentrations Were Apparent in Breast but not Liver Tissue

I obtained breast and liver tissue samples of the four waterfowl species for Se analysis from birds taken by hunters during the 1988–89 hunting season on Kern NWR and from the same species shot on nearby evaporation ponds. After converting Se wet weight values to dry weights, I used the common log of each value to calculate geometric means for making comparisons of Se concentrations in tissues among species and between habitats. Separate ANOVAs were done for breast and liver tissue using a general linear models approach to assess the effects of species, sex, season, and habitat on mean Se concentrations. Significant main effects and interactions were followed up with Fisher's Protected LSD test and linear contrasts among the means to isolate specific differences. The results of the ANOVAs and subsequent analysis indicated significant differences among species within each habitat, and differences between habitats within each species (Table).

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as a source of uncontaminated aquatic invertebrates. The area of freshwater habitats and their duration of flooding should be increased by delivering water in August and retaining it longer into spring, providing uncontaminated habitat in critical late summer and late winter periods. Freshwater habitats should be managed to increase aquatic invertebrate production and provide sources of invertebrates other than

For further information contact:

Douglas A. Barnum
Northern Prairie Wildlife Research Center
Wildlife Research Field Station
6924 Tremont Road
Dixon, CA 95620
(805) 725-1958

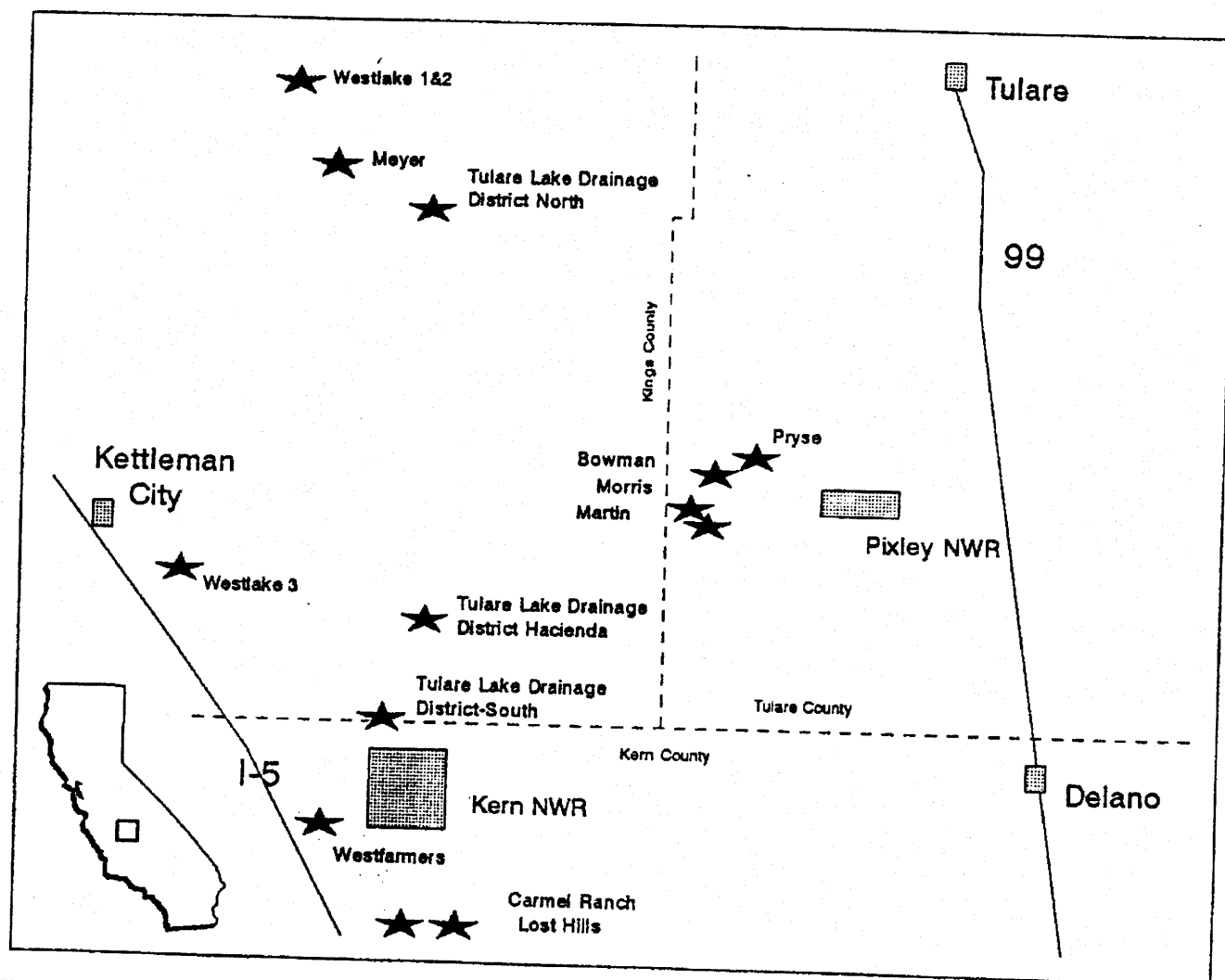


Figure. Kern National Wildlife Refuge and surrounding evaporation ponds.

Development of Techniques to Propagate Rare Fishes in Virginia

The spotfin chub (*Cyprinella monacha*), slender chub (*Erimystax cahni*), and yellowfin madtom (*Noturus flavipinnis*) are on the federal list of threatened fishes in Virginia. Although recovery plans for these species recommend captive propagation, recent population surveys indicate that all three are too rare to be used experimentally for developing captive breeding techniques. Consequently, we used common congeneric species as surrogates to develop protocols for propagation of the rare fishes. Surrogates were carefully selected to help ensure that their spawning requirements and behaviors were similar to those of the target species. The whitetail shiner (*Cyprinella galactura*) was selected as the surrogate species for the spotfin chub, the streamline chub (*Erimystax dissimilis*) and blotched chub (*E. insignis*) were selected as surrogates for the slender chub, and the margined madtom (*Noturus insignis*) was selected as the surrogate for the yellowfin madtom. We investigated methods to promote gonadal maturation, induce spawning, and rear larvae of these fishes.

Slender Chub Surrogates

Efforts to rear the streamline chub and blotched chub were abandoned relatively early because these species are extremely sensitive to electrofishing (mortality of collected fish is typically more than 50%) and are difficult to maintain for long periods in

the laboratory. Thus, attempts to propagate the slender chub and other chubs in captivity should not be undertaken until these problems are resolved.

Spotfin Chub Surrogate

Six species of *Cyprinella* have readily spawned in tanks under simulated natural conditions; however, several other species, including the whitetail shiner, spawn infrequently or not at all under these conditions. Methods for rearing larval *Cyprinella* have not been evaluated. We induced spawning of whitetail shiner females by injecting them with human chorionic gonadotropin (HCG) and carp pituitary extract (CPE) at mean dosages of 1,688 I.U./kg and 20 mg/kg, respectively (14 of 45 females spawned), or with luteinizing hormone-releasing hormone analogue (LHRHa) and domperidone at mean dosages of 363 µg/kg and 36 mg/kg, respectively (21 of 86 females spawned). Most females spawned within 30 h of the first injection. Captive whitetail shiners developed mature gonads under a variety of temperature and photoperiod conditions. Spawning condition was maintained for more than 2 years when they were held at constant warm temperature (≈24°C) and long photoperiod (16 h light). Stripped ova were effectively wet-spawned, and larvae hatched in 8 days at 25°C. Dry spawning is not suggested because the eggs are too adhesive. We obtained a mean hatch rate of 55%, but lack of swimbladder

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Water Sampling Technique Detects Bacterium That Causes Columnaris Disease in Fish

Columnaris disease, caused by *Cytophaga (Flexibacter) columnaris*, affects salmonids and most warmwater fishes throughout the world. Infected fish often have extensive gill necrosis, and columnar aggregates ("haystacks") of bacteria are revealed by microscopic examination of the gills. Necrotic lesions are common along outer margins of fins and over the dermis. This bacterium is isolated on specialized media, and other microbes can overgrow the pathogen. The disease is controlled by administration of oral antibiotics or bath treatments of potassium permanganate. Both treatments have several disadvantages: (1) sensitivity of this bacterium to antibiotics is difficult to assess, (2) potassium permanganate can exacerbate existing lesions, and (3) to date, neither treatment is legal. In fact, no drugs or chemicals are legally available to treat food fish for columnaris disease.

At present, the best method of controlling columnaris disease in fish culture facilities is prevention. Although data concerning transmission and epidemiology of the disease are limited, *C. columnaris* can exist in water for as long as 32 days. Detection of the organism in water samples would alert hatchery personnel to make informed management decisions.

Water Filtration Method

The water filtration method is similar to the procedure used to detect *Aeromonas salmonicida*. Briefly, the assay is conducted as follows:

1. Prepare Tryptone-Yeast-Gelatin (TYG) agar plates by adding 2 g tryptone, 0.5 g yeast extract, 2 g gelatin and 15 g agar to 1 L of distilled water. Autoclave and dispense into sterile petri dishes.
2. Collect and pass water through a Millipore filter apparatus using a presterilized 0.45 μm filter. The water sample may be diluted before filtering if necessary for accurate bacterial counts.
3. Blot the filter (grid-side down) onto TYG agar for approximately 5 min. Remove and discard the filter.
4. Incubate TYG plates for at least 96 h at room temperature. Calculate the number of colony-forming units (cfu)/mL of water for each sample. Transfer yellow-rhizoid colonies to Tryptone-Yeast Extract-Salts (TYES) broth for further identification. TYES broth is 4 g tryptone, 0.4 g yeast extract, 0.5 g $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ and 0.5 g $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ in 1 L distilled water.

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Lower Returns of Walleyes From Trawling Than From Other Methods

Recapture of tagged walleyes (*Stizostedion vitreum*) that were caught initially in trawls was lower than recapture of walleyes initially caught by electroshocking, fyke nets, and trap nets in the Lake Winnebago, Wisconsin, system. Various studies of animal populations involve capture, marking, and release of animals for subsequent recapture. Investigators often use the most convenient or efficient method to catch animals for marking. However, if that method harms the animals, subsequent recaptures may be reduced. Comparison of returns of the marked individuals from different initial methods of capture may indicate that some capture methods reduce the recapture rate.

Walleyes Caught for Tagging by Four Methods

The Lake Winnebago system in west-central Wisconsin comprises four lakes totaling 66,850 ha and two large inflowing rivers, the Wolf and the Fox. The Wisconsin Department of Natural Resources caught and tagged walleyes in the system: 5,089 by boomshocking (220 V, DC, 1–2 amps) in 1986–91, 548 by fyke nets and trap nets in 1986–88, and 736 by trawling in 1988 (Table). The

10-m bottom trawl with a 6.7-m head rope, main bag mesh of 32 mm, and cod end mesh of 4 mm was towed for 5-min intervals in depths of 4.5–6 m.

Walleyes were tagged below the posterior end of the first dorsal fin with consecutively numbered anchor tags. Voluntary tag returns by anglers were grouped into intervals of the first year and the first 2 years after tagging (Table).

Lower Returns for Walleyes Initially Caught by Trawling

Angler returns for walleyes caught in the trawl were significantly lower ($P < 0.01$) than for fish caught by the other methods (Table). Anglers returned less than 3% of the tags from walleyes originally captured by the trawl in the first year after tagging and returned about 4% through the second year. Return rates for walleyes tagged from electroshocking, fyke nets, and trap nets were about 6 to 7% for the first year and 7 to 9% through the second year. Returns did not differ among the fish captured by boomshocker, fyke net, and trap net.

Walleyes released from trawls had a lower survival rate than those released from electrofishing, fyke nets, and trap nets. Percent returns from trawling were 43% (first year) to 48%

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Information bulletin

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL BIOLOGICAL SURVEYNO. 29
DATE 1994

Endangered Fish in the Green River of Utah are Adversely Affected by Inorganic Contaminants in Irrigation Water

Concentrations of boron, selenium, and zinc in Ashley Creek, a tributary of the Green River in Utah, are waterborne hazards to Colorado squawfish (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus*), and bonytail (*Gila elegans*). The middle Green River provides important remnant habitat to which these three endangered species are sensitive.

The middle Green River is the site of a Department of the Interior (DOI) National Irrigation Water Quality Program investigation concerning the possible adverse effects of selenium on biota. The DOI study identified elevated concentrations of boron, selenium, and zinc in water, bottom sediments, and biological tissue (fish, aquatic invertebrates, and plants) in the Ashley Creek-Stewart Lake area of the middle Green River. No direct relation to possible effects on endangered fish was established, however.

Young-of-the-year Colorado squawfish and razorback sucker use shallow embayments for nursery habitats. The embayments are at and below the mouth of Ashley Creek and the Stewart Lake outlet. Irrigation return flows are concentrated in these areas. Although little is known about habitat use by young bonytail, they probably use similar nursery habitat. This study was conducted to evaluate the hazard of inorganic contaminants to these species in irrigation water.

Toxicity Tests Were Conducted

The first step was to determine contaminant concentrations that cause adverse effects. Three life stages (swim-up, 1-g, and 2-g fry) of Colorado squawfish, razorback sucker, and bonytail were tested. Fish were obtained as eggs from Dexter National Fish Hatchery, New Mexico; wild fish were not used in tests. Tests were conducted in water that simulated conditions in the middle Green River near Jensen, Utah (197 ppm hardness, 107 ppm alkalinity, 46 ppm calcium, 49 ppm sodium, 23 ppm chloride, 159 ppm sulfate). Fish were exposed for 4 days to either boron, lithium, selenate, selenite, uranium, vanadium, or zinc. Results of these toxicity tests were used to calculate a standard measure of toxicity, the 96-h LC50, which is the concentration of a toxicant that kills 50% of the test organisms in a 96-h exposure period.

Sensitivity Was Similar Among Species

The overall order of toxicity to all species and life stages combined, from most toxic to least toxic, was as follows (" $>$ " denotes significant difference at $P = 0.05$): vanadium = zinc $>$ selenite $>$ lithium = uranium $>$ selenate $>$ boron (Table 1). Sensitivity to the seven inorganic contaminants did not significantly differ among the three species.

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Table 1. Acute toxicity (96-h LC50, ppm) of seven inorganic contaminants to early life stages of Colorado squawfish, razorback sucker, and bonytail tested in reconstituted middle Green River basin water at 25°C.

Species life stage	Vanadium	Zinc	Selenite	Lithium	Uranium	Selenate	Boron
Colorado squawfish							
Swim-up fry	7.8 ^a	1.7 ^a	14 ^a	17 ^a	46 ^a	66 ^a	279 ^a
0.4–1.1g juvenile	3.8 ^b	4.3 ^a	36 ^b	28 ^b	46 ^a	286 ^b	>100
1.7g juvenile	4.3 ^b	12 ^b	32 ^b	41 ^c	46 ^a	331 ^b	527 ^b
Razorback sucker							
Swim-up fry	8.8 ^a	4.1 ^a	15 ^a	25 ^a	46 ^a	48 ^a	233 ^a
0.9g juvenile	4.0 ^b	6.5 ^b	8.9 ^b	53 ^b	46 ^a	36 ^{ab}	279 ^a
2.0g juvenile	3.0 ^c	16 ^c	16 ^a	186 ^c	46 ^a	25 ^b	>100
Bonytail							
Swim-up fry	5.3 ^a	4.8 ^a	19 ^a	22 ^a	46 ^a	55 ^a	280 ^a
1.1g juvenile	2.2 ^b	5.8 ^a	17 ^a	62 ^b	46 ^a	246 ^b	>100
2.6g juvenile	5.1 ^a	23 ^b	15 ^a	65 ^b	46 ^a	217 ^b	552 ^b
Geometric mean	4.6	6.6	18	42	46	97	337

^{a,b,c}Letters in common for each species and inorganic contaminant are not significantly different ($P = 0.05$).

Table 2. Maximum inorganic concentrations (ppm) in three waters sampled as part of the DOI reconnaissance investigation of the middle Green River in 1986-87.

Inorganic contaminants	Irrigation project drains	Ashley Creek (Green River tributary)	Green River
Boron	1.2	0.63	0.080
Selenium	0.14	0.073	0.003
Uranium	0.073	0.033	—
Zinc	0.040	0.020	0.010
Vanadium	0.005	0.002	—

Table 3. Margin of uncertainty ratios (BEC ÷ EEC) using the 96-h LC50 for the most sensitive species and life stage as the biological effect concentration (BEC), and the maximum inorganic concentrations reported in the DOI reconnaissance investigation of the middle Green River as the expected environmental concentration (EEC).

Inorganic contaminants	Ashley Creek (Green River tributary)	Green River
Zinc	85	170
Selenite	122	2,967
Selenate	342	8,333
Boron	370	2,912
Vanadium	1,100	—
Uranium	1,394	—

Common Salt Is Fungicidal on Trout Eggs

Malachite green, the preferred fungicide for fishery use, is no longer legal for control of fungus on fish or fish eggs. Formalin is an effective fungicide, but fishery managers are concerned about safety to the user and effects of effluent in the environment. Other antifungal agents are needed to maintain healthy fish and eggs in fish culture systems.

Salt (sodium chloride) has been widely used by the aquaculture industry as a therapeutic agent and to reduce stress to fish. Some fish farmers use salt for routine management purposes without proper knowledge of how it functions. Salt is commonly used to prevent and treat bacterial diseases, eliminate external parasites, reduce stress conditions during fish transport, and reduce toxicity of ammonia and nitrate nitrogen in fish ponds. Some reports in the literature suggest that use of seawater is effective for control of the common fungus *Saprolegnia* sp. on eggs of salmon. Others suggest that mixtures of sodium chloride and calcium chloride will control fungus on incubating eggs. We designed experiments to evaluate the effectiveness of sodium chloride for control of fungal infections on incubating eggs of rainbow trout (*Oncorhynchus mykiss*).

In Vivo Procedures

Green eggs of rainbow trout were placed in Heath incubation trays and maintained in well water with a flow rate of 1 L/min. Groups of 500 eggs were confined within 15-cm diameter acrylic

rings fastened to the screen of each incubation tray. Eggs were inoculated with fungus (*Saprolegnia parasitica*) actively growing on hemp seeds suspended by tea balls in the upper tray of each duplicated treatment. Infection of eggs generally occurred within 7 days. The infection rate of about 10% in each duplicate series of trays was obtained by exchanging infected eggs between the trays. Eggs infected at the 0 and 10% level were then exposed to salt solutions for 15, 30, or 60 min every other day for 2 weeks. Treatments ceased when the eggs began to hatch. A positive control group was inoculated with fungus, but not treated with salt; a negative control group was not inoculated with fungus nor treated with salt.

Efficacy of Common Salt

The hatch rate for control groups of eggs was only 12% for those infected with fungus and 28% for those that were not infected, suggesting that the infection procedure was successful. These eggs were tested during August when trout eggs are generally smaller in size and lower in fertility. The 1.5% salt treatment was ineffective for control of fungus on infected eggs, but the hatch rate of uninfected eggs improved slightly. The 3% salt treatment was highly effective for controlling infection in the uninfected eggs; hatch rates were 65% in 15-min exposures, 66% in 30-min exposures, and 72% in 60-min exposures. These hatch rates were considerably higher than the uninfected control group (28%), confirming the therapeutic

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Decrease in Prevalence of Bacterial Kidney Disease in Columbia and Snake River Chinook Salmon Hatcheries, 1988–1992

Bacterial kidney disease (BKD) is the most serious health problem presently affecting wild and cultured salmonids in the Pacific northwest. The history of BKD and reports on the effects of hatchery rearing conditions suggest that anthropogenic activities, such as the addition of unpasteurized fish flesh and viscera to fish food and the unavoidably stressful conditions in the aquaculture environment have exacerbated all fish diseases.

The goal of this study was to describe the epidemiology of BKD in spring chinook salmon (*Oncorhynchus tshawytscha*) in Columbia River basin hatcheries and during seaward migration. To achieve this goal, we defined two objectives: to determine if there were changes in prevalence or severity of BKD in spring chinook salmon before release from hatcheries and during seaward migration, and (if changes were detected) to determine if the changes were related to differences in hatchery practices or river environment.

BKD Monitoring: Eight Hatcheries, Three Dams, Five Years

Spleens and anterior kidneys were sampled from 60 to 100 chinook salmon just before release at four hatcheries in each of the Columbia River and Snake River basins during 1988–92. Freeze-branded fish from the same groups were collected as they

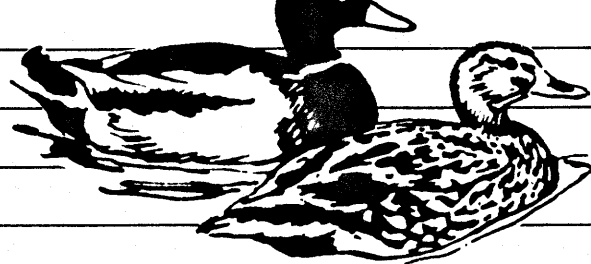
migrated past Lower Granite, Rock Island, and McNary dams. Presence of BKD was determined by enzyme-linked immunosorbant assay (ELISA) and severity was based on the mean ELISA optical density of those samples that were positive for BKD.

In 1993, a four-page questionnaire was sent to each hatchery manager. We requested information about such aspects as the annual number of adult returns and spawners, hatchery practices such as the use of therapeutic agents, and water quality. Environmental data for the river systems was obtained from available publications.

Prevalence of BKD Decreased in Hatchery Fish

From 1988 to 1992, the prevalence of BKD decreased in six of the eight hatcheries (Fig. 1). The severity of infection in the BKD-positive fish in the hatcheries was not related to prevalence and did not change during the study (data not shown). All of the hatcheries showing improvement reported that they used various combinations of (1) culling eggs from severely infected females, (2) segregating progeny according to the severity of BKD in parents, or (3) reducing loading density in juvenile rearing ponds. We are concerned that culling eggs may remove genetic components from the populations that allow a severely infected adult to survive and reproduce.

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Information bulletin

U.S. DEPARTMENT OF THE INTERIOR
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The Snapping Turtle: An Important Component of North American Wetlands

The snapping turtle (*Chelydra serpentina*) ranges from southern Canada to tropical Ecuador and is an important inhabitant of many aquatic habitats, especially in North America. It is native to the eastern two-thirds of the United States and has been introduced to a few sites in some western states. The snapping turtle has broad ecological tolerances and inhabits an array of aquatic habitats from small streams and ponds to large rivers, lakes, and reservoirs. The snapping turtle has a diverse diet—individuals are known to eat a variety of live and dead plant and animal material including many small vertebrates. Waterfowl and game fish are an infrequent component of their diet. Because snapping turtles are an integral component of the biodiversity of North American wetlands, it is necessary to consider them in the management of most freshwater aquatic systems.

As part of a study to evaluate components of the *Chelydra* HSI Model, we examined habitat use and activity of snapping turtles on the floodplain of the Patuxent River at the Patuxent Wildlife Research Center, Laurel, Maryland. We used both live trapping and radiotelemetry to monitor turtle activity and movements.

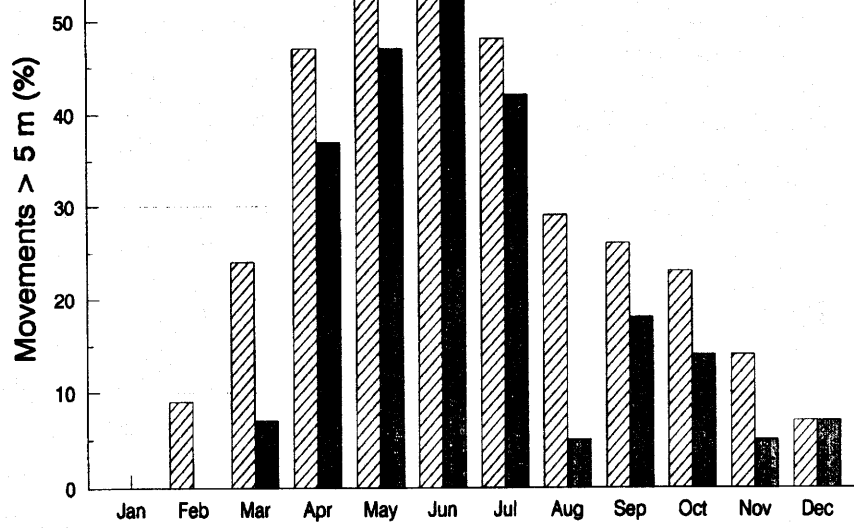
Adult snapping turtles on our study area are most active in late spring and early summer and become much less active in late summer. They are most common in shallow water (<1 m deep) habitats that have soft organic substrates, abundant woody

structure (branches and logs), and aquatic vegetation (Table).

In fall most of the telemetered turtles move to different habitats for overwintering. These new sites generally are shallow (≤ 20 cm) aquatic habitats in woodlands, particularly swampy areas near the inflow of a pond; seeps in the forest; and small oxbows along the Patuxent River. Several turtles overwinter in sites with saturated substrates but little or no surface water. One of the most conspicuous components of nearly all overwintering sites is the presence of some kind of woody structure. Turtles dig under trunks and roots of toppled trees, beneath root masses of living trees and bushes, and into log and branch jams in the river, and use natural cavities and beaver (*Castor canadensis*) burrows.

Some turtles become inactive during parts of July, August, and September (Figure) and occupy habitats more similar to those used for overwintering than those used during periods of high activity in spring. For example, one individual burrowed into mud in a woodland seep on 15 August and remained buried until mid-October when a heavy rain inundated the area. During this period, the water table receded and the soil became much drier. Following the rain, the turtle burrowed beneath the root mass of a small tree in about 25 cm of water. This new site was about 20 m from the previous late summer retreat. The animal did not leave the second site until the end of March the following year. Several other

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activity of 14 male (1,039 relocations) and 6 female (592 relocations) snapping turtles (*Chelydra serpentina*) tracked with radio transmitters between April 1989 and December 1992. An individual was recorded as having moved if its new location was more than 5 m from its previous location. Time between relocations ranged from a minimum of 10 hours during the active season to a maximum of about 1 month in midwinter.

A Simple and Inexpensive System for Elevating Mist Nets

The mist net is useful to field ornithologists. While mist nets are used to capture a wide variety of birds, problems exist in placing nets in some locations. The midstory or canopy dwellers are a continuing challenge. Several designs have been proposed for placement of mist nets high above the ground. Most require expensive pulleys, net frames, and other devices. We have developed a simple, cost-efficient net scheme design to elevate nets that is easy to assemble and operate.

Design

Poles and rigging are the keys to our design. For each pole, we join 3.05-m sections of galvanized electrical conduit. Conduit is lightweight, fairly rigid, and easily carried. We use 1.9-cm tubing, but 1.3-cm tubing will work. Standard compression coupling fittings are used to join the sections and duct tape is used to wrap the fittings to smooth the edges. We believe joining three or four sections, sufficiently guyed, may be possible, but we have only used two sections (6.1 m) thus far. An eyebolt (we use 0.64×6.35 cm) is fixed to the top of each pole; we drill the hole for the eyebolt about 5 cm from the top. To steady the poles, we tie guy strings to the top of

each pole and attach them at ground level to nearby trees or shrubs.

We use nylon string running in a continuous loop—like that used to raise a flag on a flag pole—to raise and lower the nets. Five loops, about 10 cm in diameter, are tied in the string at intervals corresponding to the distances between the net shelves, about 55 cm. These loops are placed around the pole and allowed to slide along the pole as the net is raised and lowered (Figure). The five loops keep the continuous loop tight against the pole and provide the proper distance for tying the net loops at the end of each trammel. We think that heavy, 100- to 150-pound test monofilament fishing line may be used.

Placing Nets in the Field

We place the five loops in the lowest position and plant the first pole in the ground. A net loop at the end of each trammel is then attached to each of the five loops in the continuous string and the net is stretched to its full length and proper level of tautness in the direction of the second pole. The loops on the continuous string are lowered on the second pole, the pole is planted, and the net loops are attached. Guide strings are then stretched

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A Microvideo Camera for Inspecting Nests

Study of breeding birds often requires periodic monitoring of nests. Biologists have used pole-mounted mirrors to examine the contents of overhead noncavity or cupped nests. A mirror attached to the end of a pole is raised above the nest where the image reflected in the mirror reveals the contents of the nest. As the distance to the mirror increases, however, the reflected image becomes more difficult to discern; for higher nests this becomes an obvious problem. Dense vegetative cover associated with some nests can make mirrors impractical. We use microvideo cameras for nest monitoring in our studies of birds nesting in bottomland hardwood forests. These small, lightweight, rugged units are efficient for inspecting nests.

Design of Microvideo Camera

We attach a microvideo camera to a fiberglass pole extendible to 13.6 m (Crain Ent. model number MR-STD-13.6). The video image is transmitted to a portable hand-held monitor at ground level. Both camera and monitor are powered by a small rechargeable 7.2-V battery (typically found in hobby shops). We mount the camera to a 20-cm length of 1.25-cm diameter flexible copper tubing with two

large rubber bands and attach the tubing to the end of the pole with hose clamps so that approximately half of its length extends beyond the pole. The flexible tubing allows the camera to be easily turned in any direction.

The camera is a SuperCircuits model PC-3 (7 cm [H] × 4.6 cm [W] × 2.3 cm [D] and weighs 37.5 g). The camera has a minimum focal length of 15.25 cm (but may be adjusted to shorter lengths), a horizontal resolution of 240 lines, and is operable under light conditions between 2 and 100,000 lux. The PC-3 is black and white, but more expensive color models are available. The monitor is an LCD Citizen M329 Mark II. The screen size is 57.1 × 42.6 mm with 94,608 pixels. It is 80 mm (H) × 91 mm (W) × 27.1 mm (D) and weighs approximately 130 g. Both monitor and camera are wired with plug-in connections that hook to the battery source. We use a Tandy 7.2-V, 1200-mAh rechargeable Ni-Cad battery pack (Tandy cat. no. 23-230A) that provides over 1 h of use. It is compact (13 cm [L] × 5 cm [W] × 2 cm [D]), lightweight (315 g), and easily carried in the field. A slightly larger 8.6-V battery will power the system for about 3.5 h.

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Mucus as a Source for Reliable Isolation of *Aeromonas salmonicida* from Asymptomatic Fish

Aeromonas salmonicida, the cause of furunculosis, is a major pathogen of salmonid fishes. The bacterium is usually diagnosed in kidney samples of systemically infected fish by either serodiagnostic assay or bacteriological culture. Fish that survive epizootics of furunculosis generally become latent carriers of *A. salmonicida* and serve as a reservoir of infection for other fish. Still, it is often difficult to recover the bacterium from the kidneys of suspect carriers. Recently, we recovered the organism from mucus of asymptomatic Atlantic salmon (*Salmo salar*). The dilution count procedure used to detect the pathogen in mucus allowed for easy separation of individual colonies and subsequent recovery of *A. salmonicida*. Such observation could provide an effective nonlethal alternative to sampling regimens presently recommended for the detection of this pathogen. This study was conducted to further substantiate that mucus is a valid site for the nonlethal isolation of *A. salmonicida*.

Lake Trout Samples Processed to Detect Latent Infection

Juvenile lake trout (*Salvelinus namaycush*) were sampled ($n = 100$ fish per group) at quarterly intervals within their first year of life. Two groups were sampled from each of three state fish hatcheries at Bath, Caledonia, and Rome (New York), which have a continuing history of enzootic furunculosis. Another two groups of lake trout were also sampled

at the Caledonia hatchery. Paired mucus and kidney samples were processed for *A. salmonicida* by dilution drop counts on Coomassie Brilliant Blue agar. Inoculated plates were incubated up to 72 h at ambient temperature until colonies were visible. Bacteria were quantified in dilutions containing 10–30 colonies. Individual colonies were subcultured and identified by standard microbiological procedures.

Mucus Was a Reliable Source for Recovering the Pathogen

Our data indicated that mucus was indeed a viable site for the detection and isolation of *A. salmonicida* in carrier fish. Although *A. salmonicida* was not detected in any population at every quarterly inspection, each population tested positive at some time during the year of study. A total of 26 groups of lake trout was studied during this investigation. Five groups had *A. salmonicida* in both mucus and kidney samples, but the pathogen was further detected in another 10 groups from mucus samples, alone. No group tested positive for *A. salmonicida* in kidney samples that was not already positive by assay of mucus.

Regular Monitoring Program Enhanced Detection

These data further suggested that single-point inspections of either mucus or kidney samples may produce erroneous results. Monitoring of mucus

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Media Composition Has Little Effect on Growth of Two Fish Pathogens, *Cytophaga columnaris* and *Cytophaga psychrophila*

Cytophaga columnaris (= *Flexibacter columnaris*) and *Cytophaga psychrophila* are two yellow-pigmenting species of bacteria often associated with disease in fish. This study compared growth of both pathogens in media used by fish health biologists to culture yellow-pigmenting bacteria. All bacteria used in this study (ten isolates per species) were originally obtained from diseased fish. *Cytophaga columnaris* causes Columnaris disease and induces pathology in both warmwater and coldwater fishes. *Cytophaga psychrophila* causes cold-water disease and this condition is principally a problem for salmonid fishes. Both bacteria require isolation on plating media with reduced agar and nutrient concentrations, but growth is limited. We did this study to see if growth could be increased to improve diagnostic methods.

Bacterial Cultivation

Bacteria were originally inoculated onto *Cytophaga* agar for 24 h to provide initial inocula for further study. *Cytophaga columnaris* was incubated at 20°C and *C. psychrophila* was incubated at 15°C throughout the study. After incubation, growth was washed from the agar with sterile, phosphate-buffered saline (pH = 7.2) and each bacterial suspension was standardized with phosphate buffer to a 60% transmittance (525 nm) using a

Spectronic-20 colorimeter. Aliquots (0.1 mL) of standardized suspensions were used to inoculate 5.0 mL of each broth medium described in Table 1. Cultures were incubated for 48 h and were quantified on an agar-based form of the respective medium in which they were incubated by dilution drop counts.

Bacterial Growth Was Not Influenced by Medium Composition

Our results indicated that growth of either *C. columnaris* or *C. psychrophila* was not selectively enhanced by culture in the seven media that were tested (Table 2). Although bacterial concentrations for *C. psychrophila* were somewhat higher in Medium A (Table 2), differences in the culture of either pathogen may simply reflect the individual preference of a given diagnostician rather than specific nutritional effects on the bacteria.

For further information contact:

Rocco C. Cipriano or Jeffrey D. Teska
National Fish Health Research Laboratory
Box 700
Kearneysville, WV 25430
(304) 725-8462

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Skin Reflectance as a Nonlethal Measure of Smoltification for Juvenile Salmonids

The change from an undeveloped, dark-colored parr to a developed, silvery smolt is caused by the deposition of guanine crystals in the skin and is one of the most obvious physical changes associated with smoltification. Estimates of the level of smoltification using measures of silvering, including skin guanine concentrations and visual classifications, have been used. However, assessing skin guanine concentration requires sacrificing the fish, and although visual assessment of silvering is nonlethal, it is subject to bias between observers and differences in light.

I developed a system of measuring skin reflectance to quantify the silvering of juvenile salmonids without harming the fish. Skin reflectance is a measure of the amount of light reflecting from the surface of the fish. The objectives were to determine if skin reflectance changes during the period of smoltification and to examine correlations between skin reflectance and other measures of smoltification including gill ATPase activity and skin guanine concentration.

Video and Computer-based System to Measure Silvering

The photo reflectance video analysis system was designed to illuminate a fish with diffuse, consistent light, record an image of the fish, and calculate skin reflectance. Diffuse light, from photo bulbs and an opaque plexiglass box, reflects from the surface of the

fish and is recorded by using a high-resolution video camera and a video camera recorder (VCR). An IBM-compatible computer retrieves the image from the VCR and calculates skin reflectance as the amount of light reflected from a section of skin based on a grey scale calibrated from 0 to 10. Skin reflectance, gill ATPase activity, and skin guanine were measured on freeze-branded juvenile steelhead (*Oncorhynchus mykiss*) and chinook salmon (*O. tshawytscha*) sampled from hatcheries (prerelease) and dams (migrants) along the Snake and Columbia rivers.

Skin Reflectance Correlated With Other Measures of Smoltification

Skin reflectance increased during smoltification in migrating juvenile salmonids as shown by significantly higher mean skin reflectance in 11 of 13 freeze-branded groups of steelhead, spring chinook salmon, and fall chinook salmon recaptured as migrants when compared to samples collected before release (Fig. 1, representative steelhead data shown). Skin reflectance of marked groups of juvenile salmonids collected in 1991 and 1992 were correlated significantly with gill ATPase activity and skin guanine (Fig. 2, representative steelhead data shown), with correlation coefficients (r) for mean values between 0.56 and 0.98 for all three species.

I have shown that migrating salmonids recaptured at downstream sites had significantly

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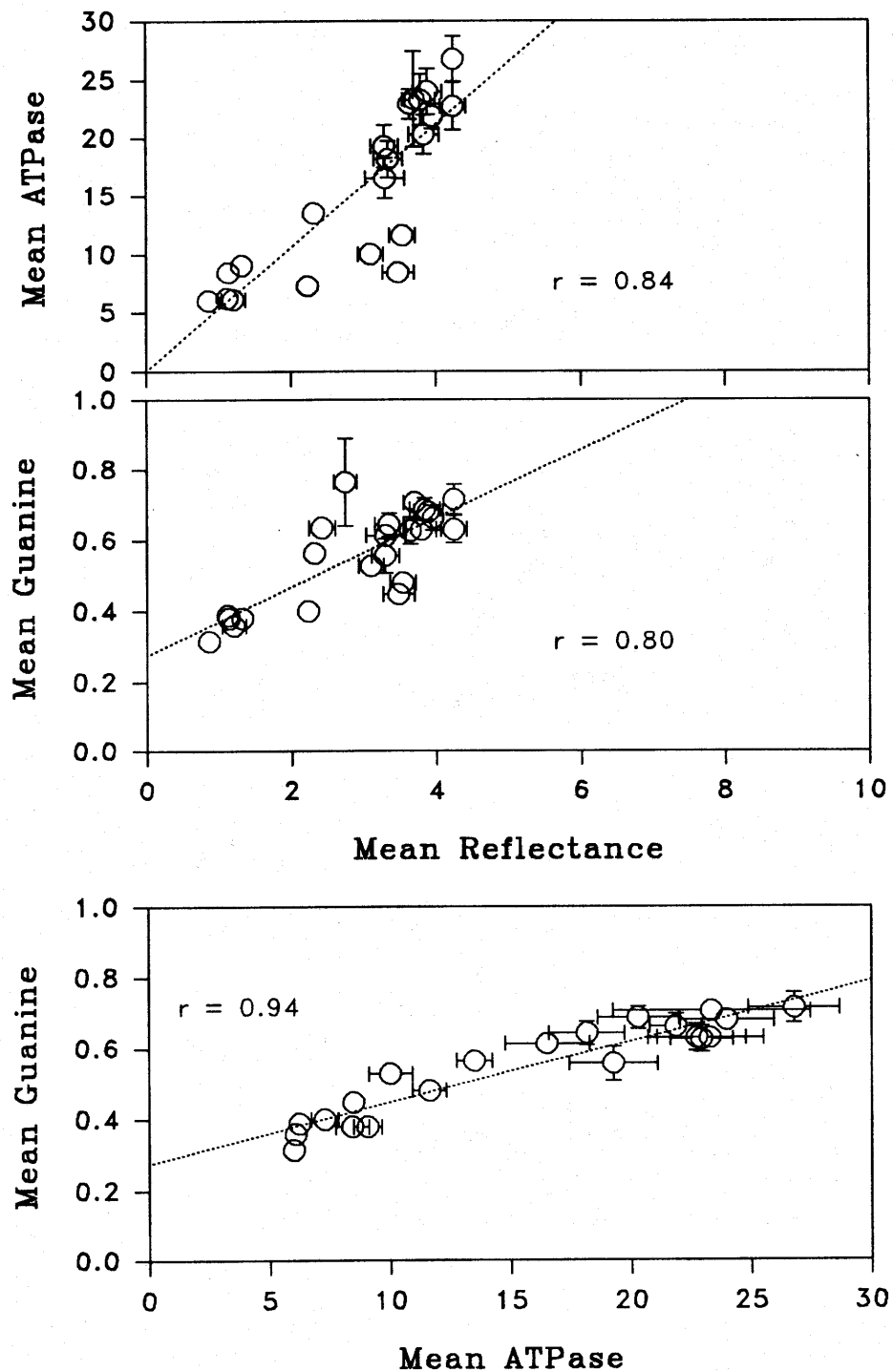


Fig. 2. Correlations between mean ($\pm$ SE) skin reflectance, gill ATPase activity ($\mu\text{moles P}_i \cdot \text{mg prot}^{-1} \cdot \text{hr}^{-1}$), and skin guanine ($\text{mg guanine}/\text{cm}^2$ skin) from juvenile steelhead sampled in 1992. Correlation coefficients (r) are significant ($P \leq 0.05$).

Improved Device for Extracting Sediment Pore Water

The feasibility of conducting toxicity tests with sediment pore water has been demonstrated, and the porewater approach has been used successfully in marine and estuarine sediment quality assessment studies. Initially, we designed and used an extraction device made of Teflon, which has been described previously (RIB No. 89-107). Our experience with this Teflon pressurized extraction device has led to the development of a similar but improved device.

Improved Porewater Extractor Composed of a Modified PVC Compression Coupling

The Teflon extractors are expensive (~\$500 per unit); the setup is somewhat awkward to use, cumbersome to load, unload, and reload sediment; and the system requires two persons to operate. The improved extractor (Fig. 1) is constructed from a polyvinyl chloride (PVC) compression coupling for 10 cm i.d. PVC pipe. These commercially available couplings (Lascotite) consist of a cylinder (25 cm high and 13 cm in diameter) with threaded ends and threaded open compression nuts. The coupling is fitted with end plates cut from 8 mm thick PVC sheeting and are held in place by threaded end nuts. The gaskets provided with the coupling are discarded and silicon O-rings are used to seal the top and bottom connections. Like the original Teflon extractor, the bottom end plate (Fig. 1) has several interconnected concentric grooves to

facilitate flow of the pore water to the central exit port. An 8- μ m polyester filter is placed between the bottom end plate and the silicon O-ring. Before a sediment sample is loaded, the bottom end nut is tightened in place by using the stationary bottom wrench (Fig. 1) and a standard strap wrench. After the sediment is loaded, the top end plate (fitted with a pressure relief safety valve and a quick-disconnect fitting for attaching the compressed air line) within the top compression coupling nut is attached. To tighten the top coupling nut, the strap wrench and the coupling nut wrench (Fig. 1) are used. Once the extractor is loaded and sealed, a high-pressure hose is attached to the quick-disconnect fitting on the top end plate, and the extractor is pressurized with air from a SCUBA tank, as was done with the original Teflon extractor system. Pressure is controlled with a first-stage regulator on the tank, an intermediate governor regulator, and second-stage regulators attached to a manifold that services multiple extractors (Fig. 2). The governor regulator is set (usually at 40 psi) to control the maximum pressure allowed at the second-stage regulators. During the extraction process, pressure at the second-stage regulators is gradually increased from ~10 psi to 35–40 psi. Simple wooden stands can be constructed to accommodate several extractors simultaneously. The stands support the extractor units and provide a space below each to place a porewater sample collecting jar or bottle.

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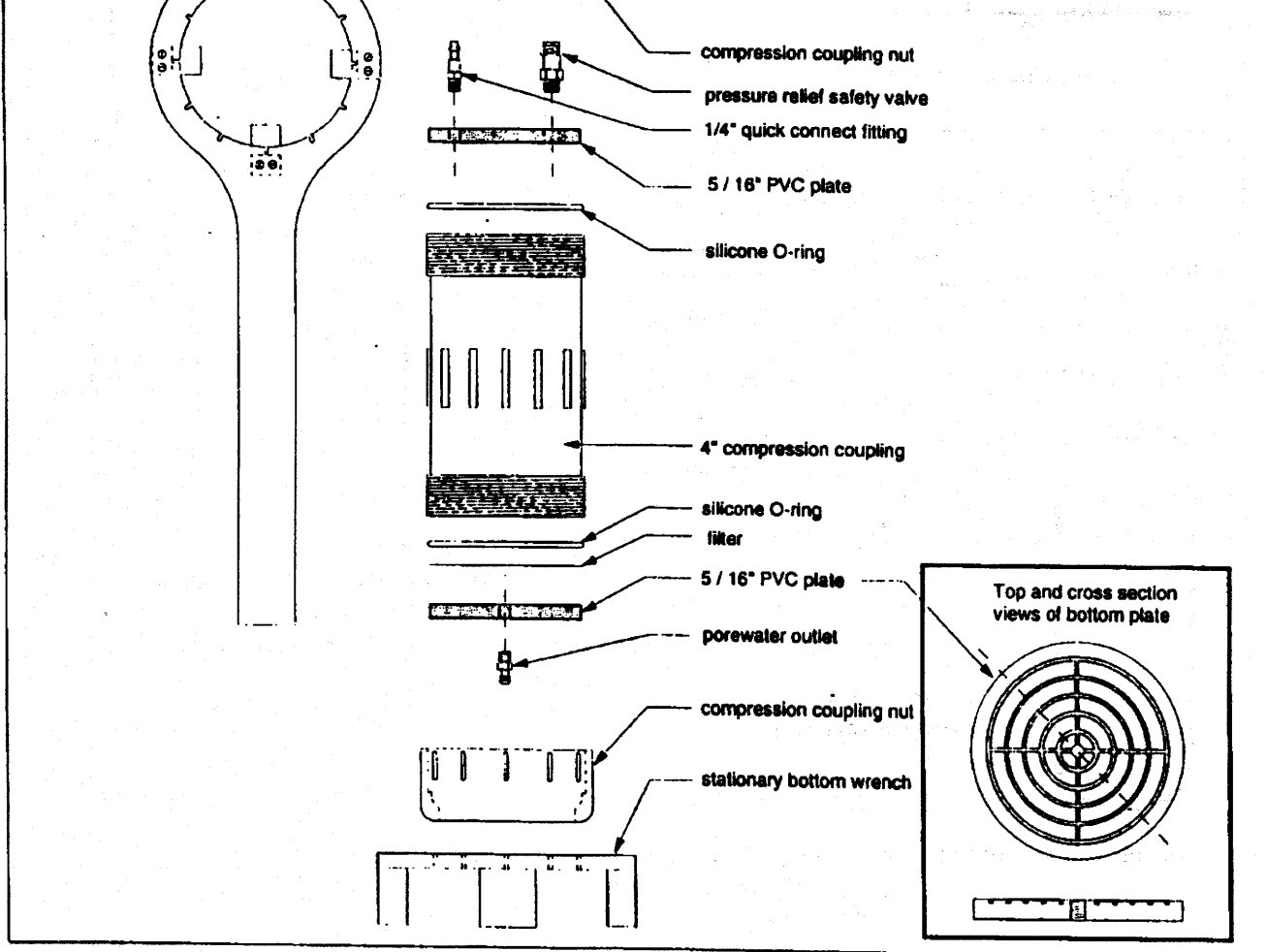


Fig. 1. Sediment porewater extraction device.

Chlorophyll-*a* Related to Bird Use in Freshwater Wetlands

About 80% of the continental population of redheads (*Aythya americana*) winters along the Gulf coast of southern Texas and northern Tamaulipas. While in southern Texas, redheads rely upon freshwater wetlands for dietary fresh water. Fresh water is used to compensate for the salt redheads ingest while feeding on seagrass rhizomes in the frequently hypersaline (up to 60–70 ppt) Laguna Madre. Only a few freshwater wetlands are available to serve the approximately 300,000–600,000 wintering redheads in southern Texas. During drought many of these wetlands go dry, and those that remain are extremely important to redheads. One pond (Pond A) in southern Texas has experienced overcrowding by more than 10,000 birds during past winters of dry years. To find out if large concentrations of redheads significantly affect this wetland, we investigated the effect of heavy bird use on water quality.

Water Samples Analyzed for Chlorophyll-*a*

We obtained water samples for 2 years at 6–8 week intervals from two freshwater wetlands, one receiving heavy bird use (Pond A), and the other receiving light bird use (Pond B). The number of birds on each wetland was estimated within 1–2 days of each water sampling trip. To estimate phytoplankton density, water samples were analyzed for chlorophyll-*a* by passing water samples through a glass fiber filter (1.2- μ m pore size),

extracting the pigments from the filter, and then determining chlorophyll-*a* concentration using a spectrophotometer.

Redheads Influenced Chlorophyll-*a* Levels

Our findings indicate that birds can significantly influence the phytoplankton density of a wetland. We found that during periods of heavy bird use, Pond A had high levels of chlorophyll-*a* (Fig. 1), whereas Pond B, receiving light bird use, did not experience elevated levels of chlorophyll-*a* (Figure 2). From early December 1990 to early January 1991, bird use was heavy at Pond A. During this period, redheads made up about 90% of all birds present on Pond A. In February 1991, bird use of Pond A declined sharply and remained low for the rest of the study. This drop in bird use coincided with the onset of 2.5 years of unusually frequent rainfall. This prolonged increase in rainfall lowered the salinity of the Laguna Madre to below 30 ppt, apparently alleviating the redheads' need for freshwater wetlands. Only when redheads were present on Pond A in large numbers were chlorophyll-*a* levels unusually high. This suggests that the redheads enriched the water by means of their feces, triggering the growth and proliferation of phytoplankton.

Because most of our research was conducted during a period of unusually high rainfall, the effect of prolonged heavy bird use on the water quality of

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Diagnostic Findings in Aleutian Canada Geese

Dead Geese Found in California

From 1976 through 1991, 102 Aleutian Canada geese (*Branta canadensis leucopareia*) found dead on wintering areas and migratory routes in California were sent to the National Wildlife Health Research Center for necropsy examination. Carcasses collected in 1987-91 accounted for 90% of the deaths. Most (82) of the birds were found in the upper San Joaquin Valley, but nine came from near Crescent City, five each from the Sacramento Valley and Salton Sea, and one from Humboldt Bay.

Avian Cholera, Shooting, and Lead Poisoning were Largest Causes of Deaths

Avian cholera, an infectious bacterial disease caused by *Pasteurella multocida*, accounted for 64 of the deaths (Figure). Although Aleutian Canada geese are at risk to avian cholera throughout their migratory and winter range, all 64 carcasses were found in the upper San Joaquin Valley. Geese died of avian cholera from late December through February, and nearly half (30) of the deaths occurred during a single outbreak of this disease in the winter of 1990-91. Shooting resulted in the deaths of 14 Aleutian Canada geese--8 from the upper San Joaquin valley, 4 from Salton Sea, and 2 from the Sacramento Valley. Ten of the 14 had

recent fatal gunshot wounds, and the other four died of peritonitis caused by shooting. Lead poisoning in Aleutian Canada geese was first diagnosed in 1987 and was the primary cause of death for eight geese. Lead poisoning was a concurrent diagnosis in two of the birds that died of avian cholera. These carcasses had lesions consistent with lead poisoning, elevated liver lead concentrations (8-63 ppm wet weight), and lead shot pellets were found in the gizzard contents of 8 of the 10 birds. Nine of the carcasses were found in the upper San Joaquin Valley and one near Crescent City. Five additional geese had elevated liver lead concentrations (2 ppm wet weight), indicating probable recent exposure to metallic lead.

Other Diagnostic Findings

Five Aleutian Canada geese died of traumatic injuries caused by impact and predation, three drowned, three were emaciated (no cause could be determined), and one died of salmonellosis caused by an intestinal infection with *Salmonella typhimurium*. A kidney deformity was found in one bird, one died of a mixed bacterial infection, and no cause of death could be determined for two birds. One was scavenged with traumatic injuries and the

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Bacterial Kidney Disease: Bacterial Isolate Virulence Determined in Brook Trout

Bacterial kidney disease (BKD) causes death in hatchery reared and wild populations of salmonid fishes. The causal bacterium, *Renibacterium salmoninarum*, is difficult to culture. Treatment of BKD is complex because *R. salmoninarum* is transmitted through intra-ovum infection, as well as by fish-to-fish contact. The bacterium can survive within the cell, which allows the pathogen to evade the host's cellular immune response. Presently, the most significant geographical foci of BKD in North America are the Pacific Northwest and the Great Lakes. The most severe disease occurs primarily among migrating salmon. Biologists use a combination of antimicrobial therapy and brood stock management—including egg culling and pair mating—to control BKD.

LD50 Values Were Determined for *R. salmoninarum*

Recent advances in the success of isolation and growth of *R. salmoninarum* have provided answers to questions about the biology of the disease. It was evaluated in this study if differences in virulence of *R. salmoninarum* isolates could be related to origin

of the host. Isolates were collected during 1991–92—most were taken from clinically infected adults returning to spawn. Isolates from five hosts were included in the study: coho (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) from Little Manistee Weir, Michigan; chinook salmon from Kewanee, Wisconsin; chinook salmon from Strawberry Creek, Wisconsin; and coho and chinook salmon from the Pacific Northwest. Five isolates (three from the Michigan coho) were chosen from each origin, and LD50 values were determined by intraperitoneal (ip) injection into groups of the OWHI strain of brook trout (*Salvelinus fontinalis*). Each isolate was grown for about 14 days and examined for purity; 10-fold dilutions were prepared; and 0.1 mL of each dilution was injected into each fish (15 fish/group). Control fish were injected with KDM2+metabolite medium (culture medium) and peptone-saline (diluent). The number of bacteria injected (cfu/mL) for each isolate was determined by performing a viable, drop plate count technique and culturing on KDM2+metabolite agar medium. After challenge, each group of fish was observed for 70 days. During this time, deaths were recorded and individual fish that died were

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Bacterial Gill Disease: Selected Environmental Stressors Thought to Predispose Salmonids to the Disease

Bacterial gill disease (BGD) is a problem among juvenile fishes in many trout hatcheries. High mortality occurs within a few days after onset of the disease. Although a causative organism, *Flavobacterium branchiophila*, has been described, in vitro culture is difficult. The bacterium is omnipresent, and reservoirs of infection include the hatchery water supply and presence of carrier fish. Deaths result when masses of bacteria colonize the gill surface and impede gas exchange. The fish suffocate.

Fish culturists having experience with BGD note an association of the disease with overcrowding and overfeeding. Other related adverse conditions may include decreased dissolved oxygen, increased ammonia levels, accumulation of metabolic waste products, and an accumulation of suspended particulate matter that irritates the gills. Although BGD occasionally occurs in fishes maintained at optimal culture conditions, epizootics occur more frequently in situations where stressful conditions exist. Turbidity was selected as a stressor because BGD epizootics have often occurred at this laboratory within a few days after heavy rainfall that produced turbid water for 6–18 h.

Three Environmental Factors Were Used in an Attempt to Induce BGD

Experiments were conducted to determine if loading density, overfeeding, and turbidity

predispose fingerling (10–15 cm) brook trout (*Salvelinus fontinalis*) to BGD. A multifactorial experiment was designed to test each factor at three different levels, singularly and in combination. Replication was done in triplicate using 81 experimental groups. Optimum (control) levels were based on parameters accepted by hatchery personnel to maximize healthy conditions for rearing trout.

Conditions tested were loading density at 1.6 kg (3.52 lb) fish/ft³ of water (optimum), and 1.5 and 2.5 times optimum; feeding rate at 0.92% body weight fed (optimum), and 1.5 and 2.0 times optimum; and challenges with mud (turbidity) at zero times per week (optimum), and 1 and 2 times per week. Fish were maintained in 16.5 L tanks with 12.5°C spring water at a flow of 1 L/min. Tanks were cleaned only when the outlet was blocked—metabolic waste and particulate matter were allowed to accumulate. Groups were weighed and the rate of feeding was adjusted twice per month.

Sediment was collected near the source of this laboratory's spring water supply. Sediment was filtered through a 0.6 mm sieve (U.S. standard sieve series No. 30) and autoclaved. The material was added to achieve 100 ppm turbidity. At 100 ppm turbidity, tanks remained visibly turbid for several hours after application. Uneaten food and excrement added to the turbidity. Because the filtered particulate matter was autoclaved, the challenge created only a physical irritation of the gill

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Duck Nest Success Higher in Areas Occupied by Coyotes Than in Areas Occupied by Red Foxes

Mammalian predation on duck eggs in nests has been identified as a principal cause of low recruitment rates among dabbling ducks in the Prairie Pothole Region (PPR). The red fox (*Vulpes vulpes*) is responsible for significant losses of nests. Coyotes (*Canis latrans*) also depredate duck nests, but are believed to be less harmful to duck production than are red foxes. Both coyotes and red foxes are territorial and, in sympatric populations, coyotes tend to exclude red foxes through interference competition. In the United States portion of the PPR, coyote populations are expanding to the detriment of fox populations. Changes in distribution and abundance of coyotes affect the potential magnitude of red fox predation on eggs in nests. If ducks benefit by coyotes suppressing the depredations by red foxes, there exists the possibility of using management of coyotes as a biological method for increasing success of duck nests.

We Compared Nest Success on Areas Coyotes Occupied and Areas Red Foxes Occupied

During 1990–92 we tested the hypothesis that the presence of coyotes rather than foxes would result in higher duck nest success in uplands of waterfowl

production areas and national wildlife refuges in North Dakota and South Dakota. We worked in different localities each year so that findings would be representative of a large region. Study areas were selected randomly each year from a pool of ≥30 candidate study areas. The principal canid species of each study area was determined primarily from observations of tracks during two systematic surveys. To select study areas, a track survey of randomly ordered candidate areas was conducted in April–early May. We selected for study the first five to seven areas occupied exclusively or predominantly by coyotes and the first five to seven areas occupied exclusively or predominantly by red foxes. A second survey conducted in late May–June confirmed or changed canid status of areas. Information from incidental observation of canid tracks on study areas and sighting of canids on or near study areas also was used in final determination of the canid status of each study area.

Duck nests were located during three systematic searches of uplands on each study area at 3-week intervals from early May through June. We found nests by using a chain towed between two vehicles to flush hens from nests. Nests were visited at 7- to 10-day intervals until the fate of each nest was determined.

Daily survival rates (DSRs) of nests were calculated by the Mayfield method, and DSRs were

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made at 24 h. Deaths were recorded and surviving fish were placed in a separate tank. Each fish was used only once.

Salinity Tolerance Increases With Age of Fish

Five-day-old sturgeon tolerated salinities of 18 ppt for 1 h. Survival for 24 h in salinities as great as 9 ppt was 100%—no survival was observed from 12 ppt through 30 ppt. Sturgeon 55 days old were unable to tolerate salinities above 12 ppt for 24 h. Survival of sturgeon was 100% in salinities as great as 9 ppt, and 80% at a salinity of 12 ppt. Salinities in the Suwannee River estuary have varied from 0 to 30 ppt throughout the year. Few or no young sturgeon (less than 2 months old) would survive longer than 2 months

exposed to varying osmotic conditions until they are older, larger, and better able to cope with changes in salinity. As we learn more about how gradual changes in salinity affect survival of young fish, as well as how acute changes affect larger fish, the closer we will be to fully understanding the marine segment of Gulf sturgeon life history.

For further information contact

Ann M. Foster, C. Frank Jordan,
or James P. Clugston
Southeastern Biological Science Center
7920 N.W. 71st Street
Gainesville, Florida 32606
(904)378-8181

measuring O_2 production by plants over 3 h at 20°C and about 58 $\mu\text{mol}/\text{m}^2$ per s of photosynthetically active radiation from full-spectrum fluorescent lighting.

Herbicide	Range of conc. Tested	<i>N</i>	IC50	95% Confidence interval	Slope	<i>R</i> ²
Acifluorfen	1.0–10		> 10			
Alachlor	1.0–10					
Atrazine	0.03–2.0	30	0.29	0.020–0.042	–50.97	0.81
Cyanazine	0.005–3.125	25	0.032	0.021–0.048	–42.91	0.88
Glyphosate	1–10		> 10			
Linuron	0.02–1.95	36	0.07	0.043–0.112	–59.14	0.64
Paraquat	0.008–8.0	36	0.24	0.13–0.42	–36.04	0.68
Metolachlor	1.0–10		> 10			
Metribuzin	0.004–0.013	30	0.008	0.005–0.013	–41.25	0.86
Simazine	0.03–2.68	25	0.164	0.082–0.327	–88.80	0.58
2,4-D	1.0–10		> 10			

gentle aeration served as the test chambers. Small sago pondweed plants were planted into an artificial growth medium contained in 2-ounce glass jars and placed into test chambers. Seven days later, after plants were rooted in the growth media, herbicides were added to each test chamber. The test was static (i.e., herbicides were added to each test chamber without renewal or removal). We used eight replications of each experimental group and compared biomass of dosed and control groups at the end of a 4-week test.

Atrazine, Paraquat, and Linuron Reduce Growth at $\leq 1,000$ ppb

We tested six herbicides commonly used in the Chesapeake Bay watershed (Fig. 1). Stock herbicide solutions were prepared from technical grade materials (purities $\geq 90\%$) made by dissolving herbicides in water or in acetone and then water (acetone then evaporated). Stock solutions were then added to the artificial fresh water to achieve a dilution series. Atrazine, paraquat, and linuron reduced biomass production at concentrations $\leq 1,000$ ppb.

Photosynthesis and Respiration Determined

We determined net oxygen production and respiration of plants placed in BOD bottles with herbicides added. Tests were run at 20–22°C under lights with $58 \mu\text{mol}/\text{m}^2$ per s of PAR. We tested twelve herbicides, including those used in the biomass production experiments, and determined the concentrations inhibiting photosynthesis by 50% (Table). Herbicides tested did not have a significant effect on dark respiration.

Photosynthesis Results Complement Biomass Results

For photosynthesis-inhibiting herbicides, dose responses for photosynthesis and biomass production were closely related for atrazine, linuron, and paraquat (Fig. 2). Our data suggest that IC₅₀ values can serve as predictors of growth

effects for herbicides inhibiting the photosynthesis. It is still not certain, however, that inhibition of photosynthesis is a consistent predictor of either absolute or relative effects of photosynthesis-inhibiting herbicides on biomass.

Several Factors Important in Assessing Herbicide Effects

Our work is intended to indicate the relative phytotoxicity of herbicides to sago pondweed as a representative rooted, submersed aquatic macrophyte. Herbicide concentrations inhibiting photosynthesis and biomass production under our standardized test conditions should not be interpreted as biological effect levels in field situations. Rather, the data should be useful as one component in evaluating the potential environmental hazard of herbicides reaching aquatic systems. Other factors to be included in models of environmental hazards include herbicide application rates and timing, herbicide persistence and translocation characteristics, and environmental variables (such as temperature, light, predation pressure, and water hardness).

For further information contact

W. James Fleming
North Carolina Cooperative Fish and
Wildlife Research Unit
Box 7617, NCSU
Raleigh, NC 27695
(919)515-2631

Jeffery J. Momot
Olympia Field Office
Olympia, Washington 98502
(206)753-9440

or

M. Steven Ailstock
Anne Arundel Community College
Arnold, Maryland 21012
(410)541-2230

PCDFs were differentiated well according to class and structure. As expected, nonplanar PCBs were not well predicted by these equations.

Enzyme induction and binding affinity data need to be collected to generate analogous predictive equations for a range of fish and wildlife species. Software already exists that will compute contaminant LSER values and predict acute contaminant toxicities for representative aquatic species (RIB 89-28).

LSER Equations Estimate Induction Potentials and Dioxin-like Activity

We generated three predictive equations that allow estimation of two types of enzyme induction activity and a measure of dioxin-like binding for a contaminant. LSER predicted relative binding affinities for many halogenated aromatic compounds related to PCDDs, PCDFs, and PCBs and their metabolites by using only molecular structures.

Compounds That Bind to Proteins May Cause Tumors in Fish

The binding affinity model using LSER is novel, indicating the likelihood of fitting a dioxin-like contaminant into the A_h receptor site on a

protein. This protein then transports the contaminant into the nucleus, where DNA-contaminant interaction and subsequent carcinogenesis in fish can occur.

Compounds That Induce Enzyme Activity Linked to Chronic Conditions Such as Impaired Reproduction

Predicted induction activity for nonplanar PCBs suggested mechanisms other than the model for planar halogenated aromatics developed here. Most of the tested PCBs were ortho-substituted or nonplanar compounds, which are toxic to fish and wildlife and are more often associated with toxic effects such as neurological damage or impaired reproduction.

For further information contact

James P. Hickey, or
Dora R. Passino-Reader
Great Lakes Science Center
1451 Green Road
Ann Arbor, Michigan 48105
(313)994-3331, ext. 233 or 229

Fig. 1. Percent of sample plots in kg/ha class intervals (midpoint given on X axis) in conventionally harvested (1985-86 pooled) and stripped (1993) rice fields in the Sacramento Valley, California.

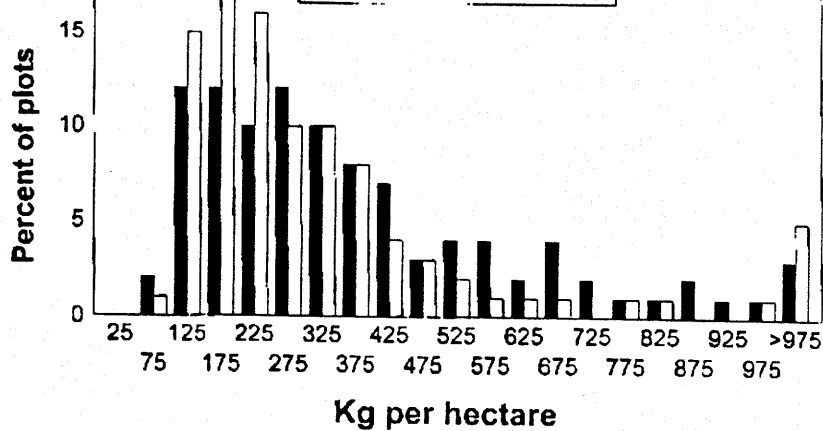
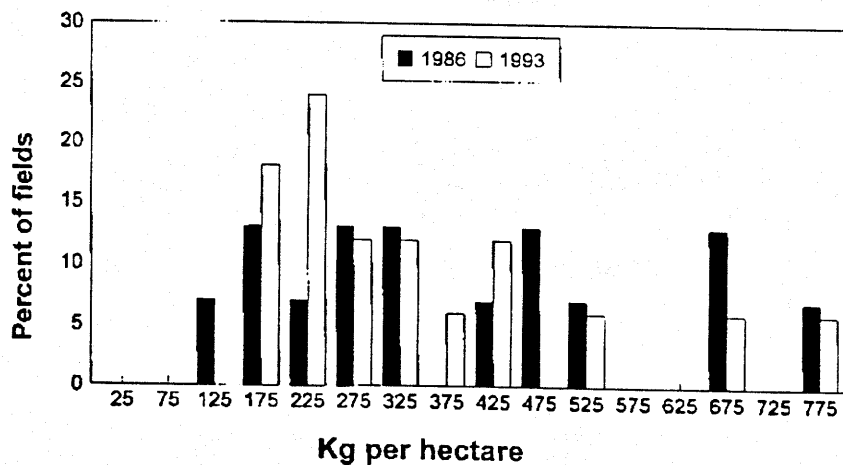


Fig. 2. Percent of sample fields in kg/ha class intervals (midpoint given on X axis) in conventionally harvested (1986) and stripped (1993) rice fields in the Sacramento Valley, California.



processing. Threshing components separate the seeds from the panicles, the seeds are retained, and straw is carried through and out the back to fall on the ground. Individual seeds in this straw and seeds still attached to incompletely processed seed heads become waste rice available for feeding waterfowl. Additional waste rice results from shatter as the machine passes through the fields and impacts adjacent rice plants.

A harvester with a stripper header attached operates at speeds up to 12.8 kph (normal range, 3.2 to 6.4 kph). The cutter-bar header is replaced with a stripper header that consists of a rotor with hundreds of stripping teeth attached. The rotor revolves at 300–1,000 rpm and strips the seeds from the seed heads and sweeps them into the harvester for storage until off-loaded. Thus, the machine does not process cut straw, markedly increasing harvest rates. Seed is still lost out the back of the machine, some seed is retained by panicles after stripping, and shatter still occurs.

Sampling Techniques Repeated From 1985 to 1986

In fall 1985, we sampled two plots in each of 111 conventionally cut fields. We sampled eight plots in each of 15 fields in 1986, reducing time and personnel requirements while retaining similar precision. In fall 1993, we repeated methodology from 1986, and sampled eight plots in each of 17 stripped fields. Selection of fields was not random because the number of strippers in use was limited, but each of the 17 fields was harvested with a different stripper by a different harvester operator. All strippers were identical (Shelbourne-Reynolds Engineering Limited, England) but were mounted on a variety of brands and models of harvesters. We placed 0.3×5.5 -m plots randomly within fields and oriented them perpendicular to the direction of harvester travel, as in 1985–86. We collected samples with wet-dry vacuums powered by portable generators. Samples were threshed, cleaned, hand-separated, and the seeds dried and weighed.

In 1985, we obtained estimates from 22 of the plots on the amount of rice remaining on the ground versus that in the straw on top of the stubble. We multiplied these percentages by total loss to obtain kg/ha of rice in the straw and on the ground. We obtained similar estimates (rice retained on seed heads after stripping) for all plots ($n = 136$) in 1993. We calculated field estimates for rice losses in 1986 to compare with 1993 data,

but we did not do so for 1985 because two plots per field (in 1985) is not sufficient to derive accurate or precise field estimates.

Unable to sample conventionally harvested fields as controls in 1993, we compared 1993 results with our 1985–86 data and similar data from the Rice Objective Yield Survey through 1989 (U.S. Department of Agriculture [USDA], program terminated 1989). The USDA data were not significantly different from ours for 1985–86 ($P > 0.05$) and are reliable measures of conventional harvest loss. Contacts with agricultural interests and rice growers convinced us that no important changes to conventional harvest had been made since 1989 that would have measurably altered the amount of harvest losses. In spite of this assurance, the lack of a true control measurement for 1993 requires prudent interpretation of results.

Stripper Harvest Seems to Be More Efficient

The total amount of rice left after stripper harvest averaged 344 kg/ha (Table) compared with the pooled mean of 388 kg/ha for conventionally harvested fields in 1985 and 1986. Comparative USDA means were 375, 394, 368, 627, and 468 kg/ha for 1985 through 1989, respectively. Thus, conventional harvest losses (rice available for waterfowl) increased at least through 1989. Harvest losses may have been higher still in 1993 because average yield was 9,320 kg/ha in 1993 compared with 7,885–8,750 kg/ha from 1985 to 1989 (California Agricultural Statistics Service), and losses tend to correlate with yield. For example, yields are up to 50% less in the Southeast than in California and harvest losses have ranged from only 140 to 225 kg/ha. Therefore, use of 1985–89 values to compare with stripper results seems reasonable.

The 344 kg/ha in stripped fields was not statistically different ($t = 1.42$, $df = 475$, $P > 0.05$) from the 388 kg/ha found in 1985–86. An average of about 290 kg/ha was left on the ground with both harvest techniques, but the stripper left less seed in the straw (52 kg/ha or 15% of total) than did the conventional harvester (97 kg/ha or 25% of total; $t = 2.18$, $df = 156$, $P < 0.05$; Table). Thus, the stripper left about half as much rice within the straw as did conventional harvest; variation around the larger ground average masked this difference when comparing overall means.

older than 28 days, NDV antibody titer ranged from 1:80 to 1:2,560 in birds with neurologic signs. Because approximately 10 days are required to produce detectable antibody, NDV infection probably occurred after the chicks were 18 days old.

Relatively High NDV Antibody Titer Is an Indicator of Current Infection

Newcastle disease virus, neurologic signs, and relatively high NDV antibody titer were commonly associated in the same chick. All (34/34) of the sick but only 7.7% (7/91) of the healthy double-crested cormorant chicks had antibody to NDV virus. NDV was isolated from the tissues of 29% (10/34) of the sick double-crested cormorant chicks with antibody.

The high frequency at which NDV was isolated from the cloacae suggests the possibility of fecal shedding of the virus. NDV was isolated from 54% (7/13) of cloacal swabs from sick chicks. NDV was isolated from the cloacal swabs of only 2.3% (2/84) of healthy cormorants without antibody to NDV and was not isolated from any (0/7) of the cloacal swabs of the healthy cormorants with antibody to NDV.

Cormorant Sera

If exposure to NDV occurred during the die-off (summer 1992), low titer may represent waning antibody. Antibody imparted to the embryo (maternal) may be even lower by the time the eggs are laid. Sufficient work has not been done to determine whether this type of antibody is protective against NDV infection. Of the 105 juvenile and adult cormorants sampled in February and April 1993, 48% (51) had NDV antibody. The antibody level was generally low: 41% (21/51) had a titer of 1:10, 39% (20/51) had a titer of 1:20, 18% (9/51) had a titer of 1:40, and 2% (1/51) had a titer of 1:80.

For further information contact:

Douglas E. Docherty, Diana R. Goldberg,
Ronald M. Windingstad, or Linda C. Glaser
National Wildlife Health Center
6006 Schroeder Road
Madison, WI 53711
(608) 271-4640

Concentrations of Malachite Green

Adult fish reared from eggs treated with malachite green during incubation should contain virtually no residues. Malachite green residue

William H. Gingerich
National Fisheries Research Center
P.O. Box 818
La Crosse, WI 54601
(608) 783-6451

Hurricane

Hurricane effect on the growth of individual trees was evident during the tree ring dating process. Suppressed growth patterns were noted in cores collected from all but two control sites. In particular, there were rings missing for years immediately following hurricane Camille. Several innovative approaches were used to determine whether the timing of a hurricane was coincident with changes in growth pattern. These detection methods included repeated measure analysis of growth rates before and after the hurricane, differences in within-tree stemwood distribution, and growth departures from expected biological growth. All site collections demonstrated some growth sensitivity to one or more hurricanes with one or more of the above analytical approaches.

Repeated measure analysis of prehurricane and posthurricane growth proved to be effective where the growth response among all trees within a site was consistently positive or negative. Some sites had tree cohorts that responded with growth suppression or release depending on the tree's age and stature that tended to average out the response of either group. Ratios of stemwood distribution that describe the pattern of growth allocation within a tree dramatically illustrated the effect of hurricanes in years immediately following major storms for all sites and collections. These results show that trees require 3-7 years to recover some balance in growth allocation after injury by a hurricane. Departures from expected growth trends were coincident with several hurricanes, most notably Hurricane Camille. Unlike the repeated measure analysis, this approach is sensitive to identifying suppressed and released ring series concomitant with the year of a hurricane.

Hurricane Windspeed Critical to Spatial Effect

In all cases, the higher the windspeed, the more severe the effect was on tree growth and development. Based on wind profiles generated with the hurricane simulation model, minimum sustained windspeeds as low as 42 mps were sufficient to alter growth pattern and stand structure. As a rule, there was a direct correlation between the degree and evidence of storm effect with distance from the

and to growth response at critical windspeeds.

Trees blew over in accordance with the wind direction. Additional evidence from forest plot data demonstrates that windthrow azimuths of downed logs were nonrandom and that they correlated with hurricane wind vectors. Furthermore, age classes of trees within a site more often coincided with the dates of past hurricanes indicating seedling reestablishment following disturbance.

Research and Management Implications

We offer a means to detect the historic pattern and effect of hurricanes on the growth and development of coastal forests. We developed new analytical approaches to use tree rings to build chronologies of past hurricanes beyond the existing meteorological records and to determine the spatial significance and intensity of such storms. The combination of forest inventory and growth data allows the construction of empirical equations describing the relation between hurricane abiotics and forest susceptibility and damage. The combination also offers the ability to construct statistical probabilities of hurricane frequency and intensity along stretches of the gulf coast. These empirical results are being used in computer simulation models to predict potential effects expected under global warming of increased hurricane activity on our coastal ecosystems.

For more information contact:

Thomas W. Doyle
National Wetlands Research Center
700 Cajundome Boulevard
Lafayette, LA 70506
(318) 266-8500

or

Lance E. Gorham
Johnson Controls World Services
National Wetlands Research Center
700 Cajundome Boulevard
Lafayette, LA 70506
(318) 266-8500



Utility of Model for Managers

Model results suggest the following:

1. Species tolerance limits to salt, flooding, and wave action provide a reliable estimate of suitable species and potential establishment success for the plants in arid regions in western North America.
2. The following list of regional plants and environmental factors is an example of a model application for an impoundment that may be permanently flooded at Bear River Migratory Bird Refuge. Only those species with no X marks in the columns would be expected to be abundant in the area. This simple model can provide resource managers with the ability to predict the range of probable habitat types that can be created or maintained under managed conditions.
3. The presence of viable seeds is the overriding predictor of plant establishment; the absence of such seeds suggests that a lag should be expected in plant establishment. Predictive model accuracy is enhanced by adequate seed bank data, and seed banks may be investigated by direct investigation of soil contents or by greenhouse germination testing of soils before wetland management.

thereby reduce the establishment potential of most wetland plants. In areas of high wind, a series of smaller impoundments may perform better than a single large impoundment.

5. This model is only successful if it aids insight, brings biological facts into associations with a wetland manager's intuition, or helps guide decisions through the maze of unknowns usually encountered in the planning process for wetland management. The models will provide a logical, repeatable procedure for considering a range of options and may aid decision making when other supporting evidence is unobtainable. Model performance may be greatly improved by tailoring it to specific situations and fine-tuning it on individual sites over time.

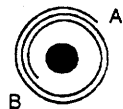
For further information or copies of the plant growth tolerance information cross-referenced with literature citations, contact:

A. Lee Foote or Thomas W. Doyle
National Wetlands Research Center
700 Cajundome Boulevard
Lafayette, LA 70506
(318) 266-8667

Table. Growing conditions.

Plant species	Salinity tolerance	Wave tolerance	Flooding tolerance	Prediction
<i>Typha</i> sp.	X			absent
<i>Polygonum</i> sp.	X			absent
<i>Scirpus olneyi</i>				present
<i>Scirpus robustus</i>				present
<i>Potamogeton pectinatus</i>		X		absent
<i>Salicornia europea</i>			X	absent
<i>Distichlis spicata</i>				present
<i>Tamarix</i> sp.			X	absent

needle-nosed pliers (modified for banding with small-diameter tips) for 10 min. Be sure the band has a 4–5-mm total gap between the inside of the band and the parrot's leg.



6. Put a very small steel hose clamp around the band, making sure glue is not on the outer surface, and allow the glue to set for another hour while the parrot rests in a darkened cage. Remove the clamp.

Bands Evaluated for 24 Months

I attached 18 bands to 17 *Amazona* parrots (one parrot was banded on both legs) during the last

although the glue was no longer present. I have documented many cases of swellings, infections, and problems with standard butt-end and lock-on FWS bands on parakeets and parrots but have not seen any problems with the plastic legs bands on the 17 marked parrots. More than 500 sightings of these parrots have been made during the last 2 years.

For further information contact

J. Michael Meyers
Patuxent Environmental Science Center
Puerto Rico Research Group
P.O. Box N
Palmer, PR 00721-0501
(809) 888-2930

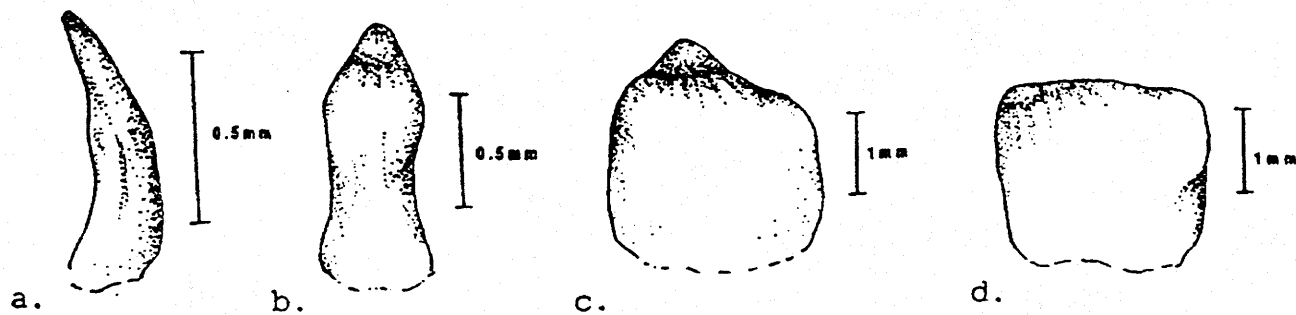


Fig. 1. Types of teeth of freshwater drum: *a*, cardiform; *b*, villiform; *c*, molariform; and *d*, molariform with flattened cusp.

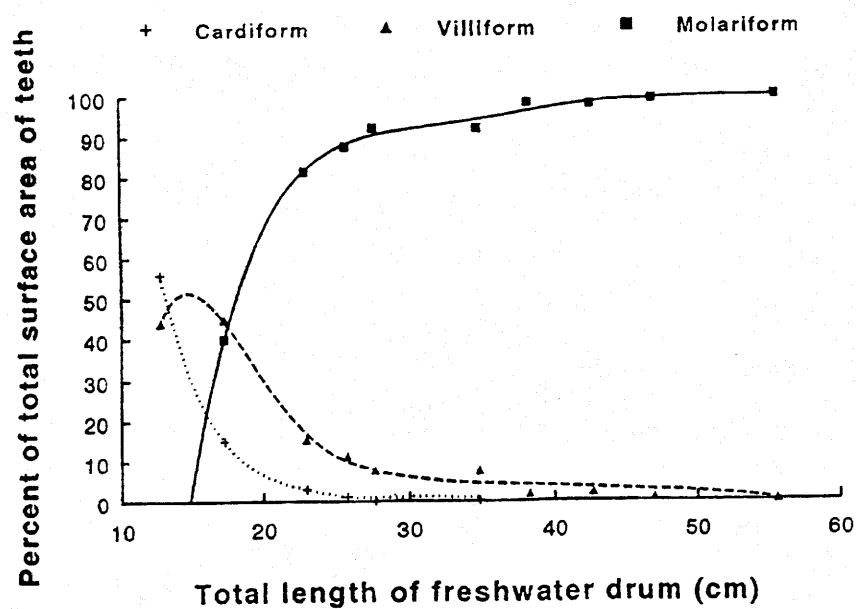


Fig. 2. Pharyngeal tooth composition of freshwater drum.

immunoassays with whole cell lysates. The homology observed in molecular structure and antigenic nature indicate that *C. psychrophila* is a potential candidate for vaccine development.

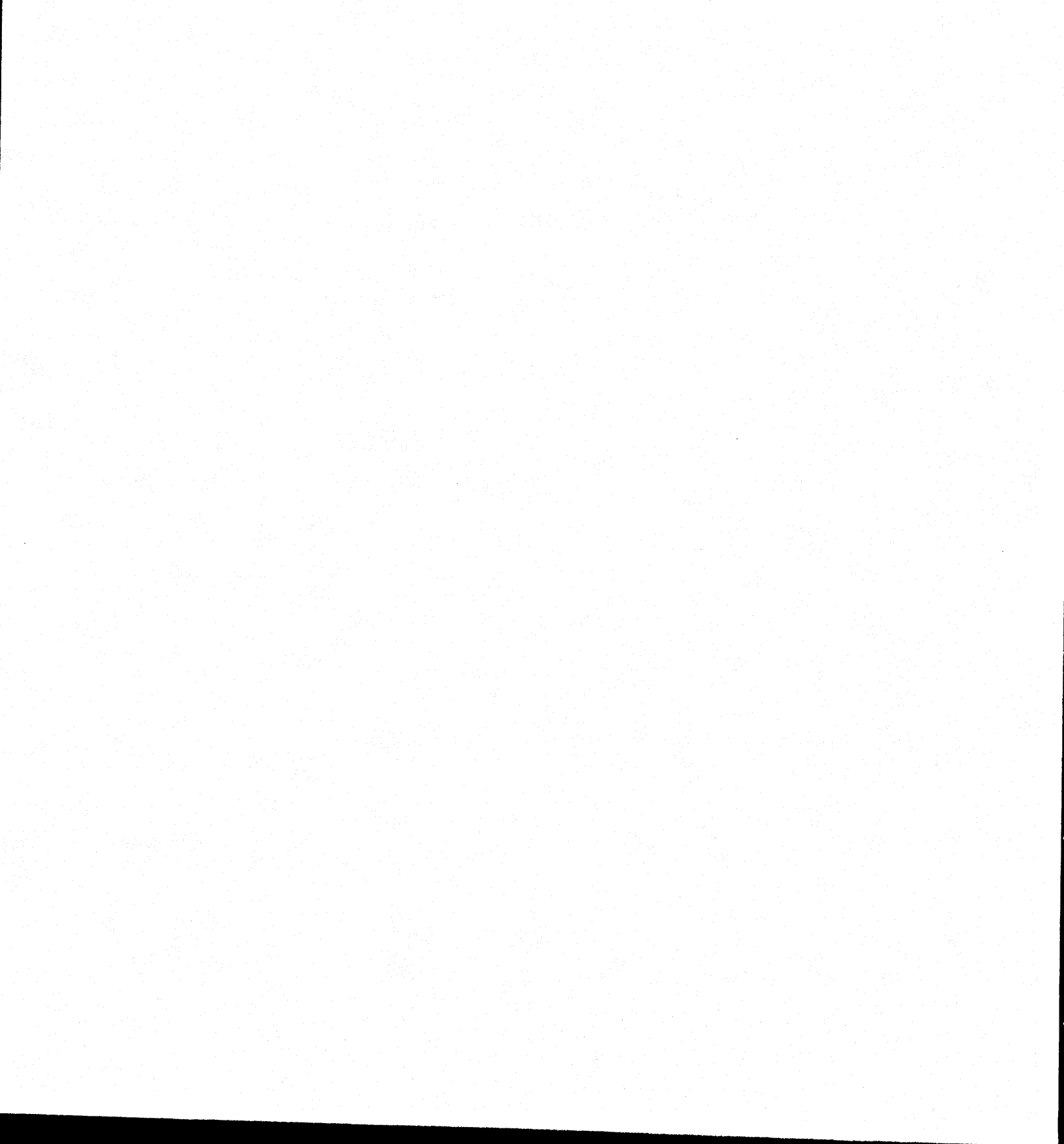
Genotypic Analysis Suggests Close Relationship Between *C. psychrophila*, *Flavobacterium odoratum*, and *Flexibacter flexilis*

Polymerase chain reactions are often used to study rDNA variation in eubacteria. Amplification products of the 16S-23S spacer region are often conserved between strains of bacteria but are highly variable between species. All isolates phenotypically identified as *C. psychrophila* produced a single rDNA spacer amplification product of about 240 BP

strain-to-strain uniformity observed using phenotypic and serotypic techniques, the *C. psychrophila* isolates elaborated varied ribotypes. Thus, ribotyping may offer selective advantages to further study epidemiological differences associated with the etiological agents causing epizootics of cold-water disease.

For further information contact:

Rocco C. Cipriano and W. Bane Schill
National Fish Health Research Laboratory
Box 700
Kearneysville, WV 25430
(304) 725-8461



Research



Information bulletin

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL BIOLOGICAL SURVEY

Number 64
1994

Exposure of Wild Waterfowl to *Mycoplasma anatis*

Mycoplasmas have been associated with clinical respiratory disease and decreased productivity in domestic fowl. During field studies on the health status and causes of death in ducks, we isolated *Mycoplasma anatis* from wild hens and ducklings. In subsequent laboratory studies, we determined that *M. anatis* decreases the pipping and hatching success of game-farm mallard eggs (RIB 1992, No. 6). *Mycoplasma anatis* also seemed to have an effect on the growth of ducklings inoculated before hatch (RIB 1992, No. 72). The prevalence of mycoplasma infections and their effect on wild waterfowl populations, however, has received limited investigation. We determined previous exposure to *M. anatis* in several species of wild ducks at five study sites in the Central and Mississippi flyways as an indication of its prevalence and distribution.

Measurement of Exposure to *Mycoplasma anatis*

We developed a standard, enzyme-linked immunosorbent assay (ELISA) and used serum antibody titers (measured as percent response

compared to standard positive and negative controls) to indicate previous exposure of wild ducks to *M. anatis*. Antisera to *M. anatis* was prepared by hyperimmunization of New Zealand white rabbits with a reference strain culture of the organism. This culture was also used as the antigen in our ELISA test. The ELISA test was standardized to determine positive or negative exposure to *M. anatis* by sampling two groups of domestic Pekin ducks with known mycoplasma infection status. One flock (39 birds sampled) had no previous exposure to *M. anatis*, and the other flock (63 birds sampled) was presently infected. Serum samples were obtained from both groups of ducks, as well as tissue samples (trachea, lung, and reproductive organs) to confirm the status of *M. anatis* infection.

Samples From Wild Ducks

We obtained serum samples from breeding mallards (*Anas platyrhynchos*) and canvasbacks (*Aythya valisineria*) in the Central flyway, and from wintering mallards and American black ducks (*Anas rubripes*) in the Mississippi flyway (Figure). Breeding mallards were captured near Kulm,

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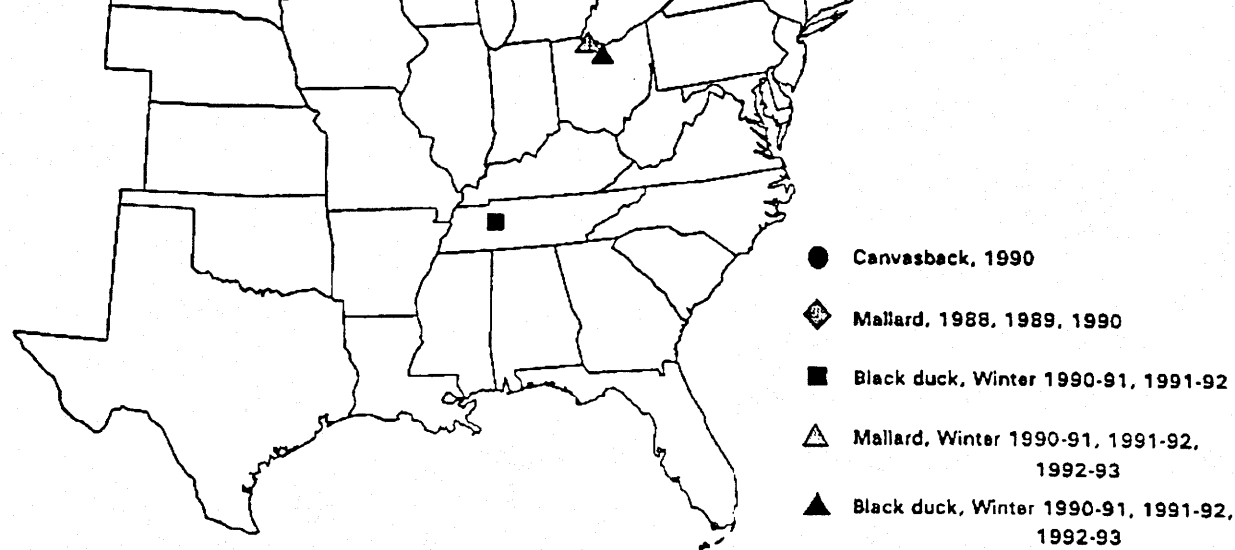


Figure. Study sites in North Dakota, Minnesota, Tennessee, and Ohio where serum samples were obtained to determine the prevalence of exposure to *Mycoplasma anatis*.

Table 1. Prevalence of *Mycoplasma anatis* exposure in breeding adult hen mallards (*Anas platyrhynchos*) and canvasbacks (*Aythya valisineria*) from the Central flyway.

Location	Species	Year	Prevalence ^a
Minnesota	Mallard	1988	11/16 (69)
Minnesota	Mallard	1989	5/6 (83)
Minnesota	Mallard	1990	16/19 (84)
N. Dakota	Mallard	1988	1/1 (100)
N. Dakota	Mallard	1989	13/18 (72)
N. Dakota	Mallard	1990	10/12 (83)
Minnesota	Canvasback	1990	0/19 (0)

^a Prevalence: Number positive/Number sampled (%).

Modeling Effects of Flow Alteration on Riparian Vegetation

One approach for predicting the effects of a proposed flow alteration in western riparian vegetation employs a relation between riparian vegetation and hydroperiod. Changes in distribution of vegetation are estimated by determining how a new flow regime would alter the hydroperiod or the time inundated. We recently developed and applied this approach to the herbaceous riparian communities in the Black Canyon of the Gunnison National Monument, Colorado.

Plant Distribution Related to Hydroperiod Gradient

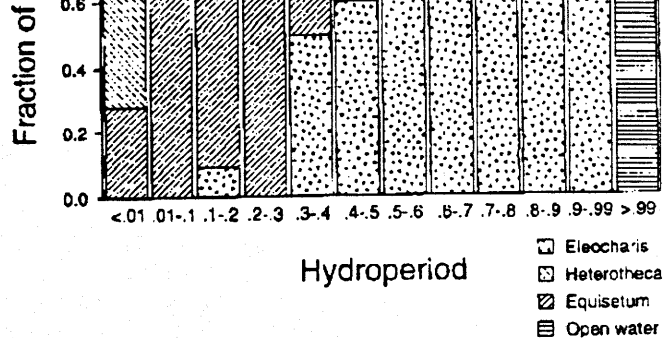
Our method begins with the definition of vegetative cover types, based on the existing vegetation. We used the TWINSpan classification program to identify cover types on 133 randomly located 1- × 2-m plots. The 83 plant species were organized into three vegetated cover types, named after a dominant species, and an open water type lacking emergent vegetation.

After surveying the elevation of each plot, we used the HEC-2 step-backwater hydraulic model, in combination with linear interpolation between hydraulic cross-sections, to determine the discharge necessary to inundate each plot. The hydrologic record, as represented by a flow duration curve, allowed us to calculate the hydroperiod or the fraction of time that each plot had been inundated. The resulting positions of cover types along a hydroperiod gradient are shown in Fig. 1.

Changes From Alternative Instream Flows Simulated

A change in river management results in a new flow duration curve, which can be used to redistribute the cover types among the plots. For each hydroperiod class, we calculated the proportion of plots in each cover type (Fig. 1). We then used these proportions as probabilities to estimate the future cover type of a plot from its future hydroperiod.

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along hydroperiod gradient duration.
Vegetated cover types are named by one of their dominant plants.

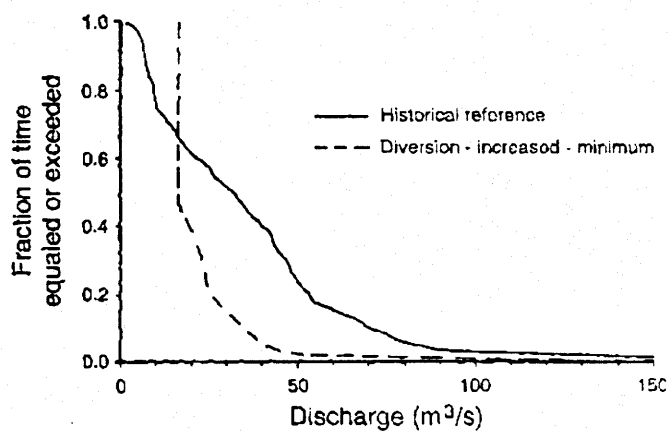


Fig. 2. Flow duration curves for the 17-year historical reference condition and a hydrologic alternative of diversion with increased minimum flow.

Table. Percent of bar area occupied by each cover type simulated under a diversion and increased minimum flow alternative compared to the reference conditions at the time of sampling.

Hydrologic alternative	Cover types			
	Open water	Eleocharis	Equisetum	Heterotheca
Reference	0	37	53	10
Diversion-increased-minimum	13	6	46	35



Rapid Collection of Water Discharge, Depths, and Velocities Along Transects

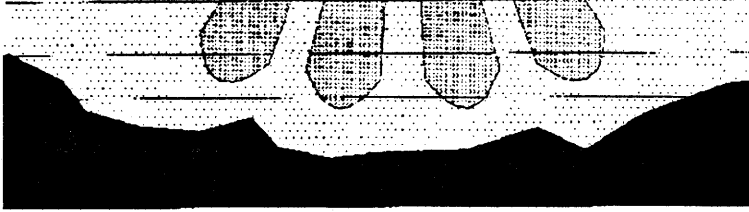
Reducing the time required and the difficulty of collecting data on river depths, velocities, and discharge for input into the Physical Habitat Simulation (PHABSIM) system would encourage instream flow studies on larger rivers. The PHABSIM is used to predict the spatial and temporal distribution of water depths and velocities under different flows for the purpose of evaluating the effects of flow on aquatic habitat. The PHABSIM is a library of computer programs used to simulate the hydraulic condition of streams that can then be used to simulate habitat. The data required for the hydraulic simulations include measurements of water elevation, depths, and velocities along transects across a stream and perpendicular to the streamflow. These data are usually obtained by wading or by using boats maneuvered along the transect line and held in place while the measurements are taken. The process is time-consuming and usually represents the most expensive component of instream-flow

studies. The logistics of collecting the data on wide, deep rivers seem daunting. As a result, instream-flow studies on larger rivers have been avoided.

A recent innovation in sonar technology enables the collection of extremely detailed water velocity information from a moving boat. An Acoustic Doppler Current Profiler (ADCP) uses the Doppler effect (the apparent change in the frequency of a wave resulting from relative motion of the source and the receiver) to measure the motion, direction, and depth of water from the echoes of a sonic pulse. The ADCP transmits pulses from four transducers (Figure) and transforms the echoes into water velocities segregated into user-defined "depth cells." The result is a profile of velocity and depth measurements at a single vertical along the transect. Verticals can be measured as frequently as every 6 to 8 s; the number of verticals obtained for each transect then becomes a function of boat

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Pomer.



Diet Affects Body Composition of Chinook Salmon

Hatchery-reared salmonids often contain proportionally greater amounts of body lipid (storage fat) and proportionally lesser amounts of body protein (muscle) and ash (bone) than do their wild counterparts of equal size. The effect of body composition on postrelease survival and subsequent return of mature adults is presently unknown. High lipid deposits may benefit the fish by providing reserve energy during adaptation to the wild, or may hinder the fish by delaying transformation and downstream migration. Compositional differences between hatchery and wild fish may be attributed to various factors, including altered environment, feeding rate, level of exercise, or diet. Diets presently fed to chinook salmon (*Oncorhynchus tshawytscha*) fingerlings are formulated to produce maximum growth, and they contain higher levels of lipid in proportion to protein than would be found in natural prey. Our objective was to determine what relation exists between dietary protein level and body composition in cultured chinook salmon.

Feeding Trial Conducted

A feeding trial was conducted using juvenile spring chinook salmon averaging 1.4 g each. Seven diets were formulated using purified ingredients (casein, gelatin, dextrin, corn oil, cod liver oil, cellulose, vitamins, minerals) containing protein levels ranging from 30 to 60% of the dry diet. Total calories (metabolizable energy) were held equal among all treatments. Each diet was fed for 14 weeks to three replicate groups of 167 fish held in 140-L fiberglass tanks.

Carcass Composition Affected

Dietary protein level had no effect on fish survival, efficiency of feed conversion, or percent apparent protein retention. However, the protein efficiency ratio declined as dietary protein increased. Total weight gain increased progressively (linear response) with added increments of dietary protein. This was reflected by an increase in the percentage of carcass protein

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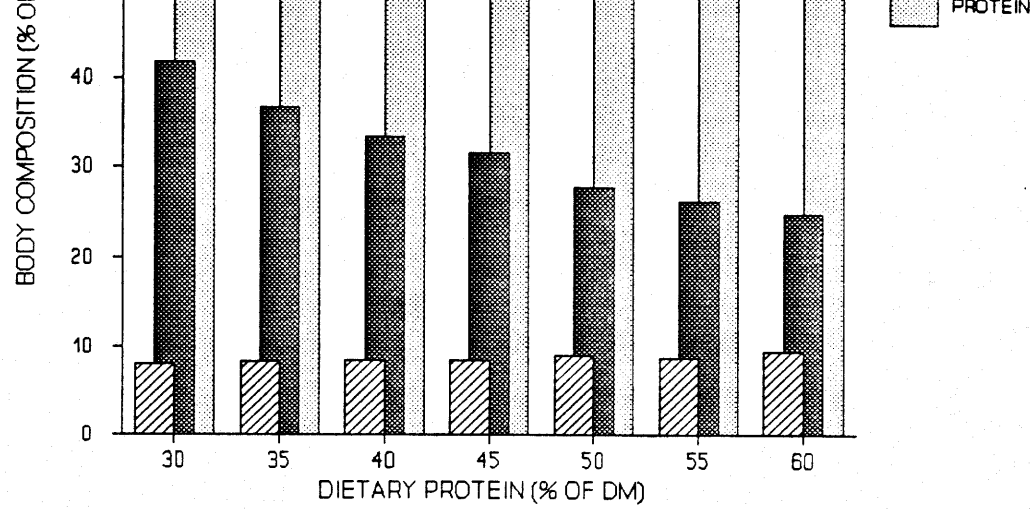


Fig. 1. Body composition of spring chinook salmon (*Oncorhynchus tshawytscha*) as affected by dietary protein content. Data are expressed as a percentage of dry carcass weight after a 14-week feeding trial.

Bacteria Give False-Positive Results Using BKD Diagnostic Tests

The National Broodstock Program (NBP) was established in 1970 to provide disease-free trout eggs to the National Fish Hatchery system of the U.S. Fish and Wildlife Service (USFWS). The Erwin National Fish Hatchery (NFH) plays a key role in the NBP, supplying 15 million rainbow trout eggs from six genetic strains annually. The Erwin NFH (Erwin, Tennessee) operates under the USFWS Fish Disease Control Policy that includes annual inspections by fish health biologists. On 5 November 1993, ovarian fluid samples from adult brood rainbow trout (*Oncorhynchus mykiss*; lot #RBT-ARD-91-ENN) were collected for routine disease monitoring.

Ovarian Fluid Tested for Viruses and Bacteria

Ovarian fluid samples from 150 fish were combined into pools of five (30 total pools). Each pooled sample was evaluated for viruses by cell culture and for the presence of the bacterium *Renibacterium salmoninarum*, the cause of

bacterial kidney disease (BKD), by a direct fluorescent antibody technique (DFAT) using polyvalent anti-*R. salmoninarum* sera. Observation of the DFAT slides revealed the presence of fluorescing cells, many not consistent with *R. salmoninarum* morphology. Identical results were obtained using three different sources of polyvalent antisera, each prepared using whole-cell antigens (Kirkegaard & Perry Laboratories, Gaithersburg, Maryland; National Fish Health Research Laboratory, Leetown, West Virginia; and Micrologix International, Victoria, British Columbia).

Bacteria Yield Positive Results in Serologic Tests

Cross-reacting bacteria present in the ovarian fluid were quantitated by a membrane-filtration fluorescent antibody technique (MF-FAT) by using Kirkegaard & Perry antiserum (Table). Each of the four ovarian fluid samples were also evaluated by a second serologically based test—an enzyme-

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Remote Communication With Cellular Telephone Modem Link

Cellular telephones provide a valuable wireless communication link that may be enhanced for electronic data transmission with the addition of a cellular interface. Although many researchers have access to cellular telephones and use them for voice communication, they may not be utilizing the technology to maximum potential. Cellular telephones can be used to electronically transmit data within or among cellular service areas.

Cellular Interface Provides Modem Link

The cellular interface is compatible with any hardware that contains a standard RJ-11 jack, including computer modems, telemetry receivers with modems, fax machines, data loggers, and answering machines. We installed an interface (Audiovox Corporation, model STI-85B, Hauppauge, New York 11788) on a cellular telephone (Audiovox Corporation, model Trans 410A, Hauppauge, New York 11788). The RJ-45 cable from the handset cradle on the cellular telephone was removed from the transceiver unit

jack and inserted into the interface; a second RJ-45 cable from the interface was coupled on the transceiver unit jack. A desired RJ-11 hardware device was connected to the interface with a RJ-11 cable (Figure). The system retains the ability to receive and send calls like any other cellular telephone. Only a simple programming modification is required to activate the cellular telephone to automatically answer incoming calls.

The device is 24 mm high $\times$ 54 mm wide $\times$ 93 mm deep, weighs 59 g, and operates at temperatures of -30 to $+60^{\circ}\text{C}$. The current drain of the telephone with the interface is approximately 2 mA/h standby and 15 mA/h while in use, with 3 W (50 ohms) of RF power output. This allows 4 h of operation or 8 h of standby power using the standard battery pack (2 A h) in conserve power mode. We connected a cigarette lighter adapter to a 100-A h, 12-V deep-cycle marine battery to obtain a 2-week noninterrupted power supply.

Proper hardware configuration and cellular telephone antenna selection ensures high quality data transmission and are crucial to the success of

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Breeding Waterbird Use of Louisiana Rice Fields in Relation to Planting Practices

Rice (*Oryza sativa*) is cultivated throughout the southeastern United States and in California. Between 1987 and 1993, 0.95–1.24 million ha of rice were planted annually nationwide. Rice fields are managed wetlands and as such represent habitats with high potential value to wildlife, especially waterbirds. Whereas the importance of rice fields for wintering waterfowl is widely recognized, use of this habitat by nesting waterbirds such as king rails (*Rallus elegans*), common moorhens (*Gallinula chloropus*), purple gallinules (*Porphyryla martinica*), least bitterns (*Ixobrychus exilis*), fulvous whistling ducks (*Dendrocygna bicolor*), and mottled ducks (*Anas fulvigula*) has not been adequately studied. Because enforcement of the Clean Water Act will eventually prohibit discharge of silt-laden water and require farmers practicing "water seeding" (seed planted in water) to hold water on fields for at least 15 days before discharge, "dry seeding" (seed spread or drilled in fields before flooding) of rice will probably become more common in

southwestern Louisiana. We undertook this study to estimate densities of waterbirds nesting in rice fields in southwestern Louisiana and compare densities of waterbirds nesting in water-seeded and dry-seeded fields.

Densities of Waterbird Nests in Rice Fields Were Estimated

This study was conducted in Acadia, Evangeline, and Vermillion Parishes in southwestern Louisiana. We selected 14 dry-seeded fields that were about 16.2 ha, had planting dates spanning the entire planting season, and were representative of the varieties of rice grown in southwestern Louisiana. Water-seeded plots were chosen from nearby fields planted with the same variety of rice and on the same schedule as companion dry-seeded plots. Plots were surveyed completely for waterbird nests after rice had headed. Surveys consisted of two persons walking through the rice spaced about 20 m apart

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Management and Research Implications

Densities of waterbird nests were not affected by planting practices during the year of study, but there was some suggestion that hatching success of fulvous whistling ducks was greater in water-seeded than in dry-seeded rice fields (15.9 vs. 8.8%). Further study is required to clarify the effects of planting practices on nesting success of waterbirds and survival of young in rice fields. Moreover, because rice fields also receive extensive use by waterbirds during other times of the year, a more comprehensive assessment is needed to understand how water versus dry planting practices influence waterbird use of rice fields throughout the year. For example, rice fields are heavily used by spring-migrating shorebirds after fields, flooded in preparation for planting, have been leveled with a blade. Dry-planted rice fields are not flooded in spring and therefore are unavailable to migrating shorebirds. Furthermore, flooding of rice fields in winter to control weeds, a practice commonly followed by farmers that plant in water, provides habitat for wintering waterbirds. Patterns of

of rice fields throughout rice-growing areas. Such information is essential for the development of management options for rice cultivation that maximize benefits to both producers and waterbirds.

For further information contact

William L. Hohman or Joseph L. Moore
Southern Science Center
700 Cajundome Boulevard
Lafayette, Louisiana 70506
(318)266-8662

or

Richard A. Coon
U.S. Fish and Wildlife Service
Region 4—Division of Wildlife and Habitat
Management
1875 Century Boulevard
Atlanta, Georgia 30345
(404)679-7193

Telemetry Study Identifies Movement Patterns and Migration Routes of Northern Pintails Instrumented in Louisiana

Declines of the northern pintail (*Anas acuta*) breeding population have increased interest in pintail biology. Habitat availability and use by northern pintails are of particular interest as factors that may have contributed to their decline. Northern pintails are believed to be highly nomadic, with frequent long-distance movements to utilize ephemeral habitats. Our study was begun to identify movement patterns and environmental factors influencing movements of northern pintails wintering in Louisiana, which can then assist with the identification of areas needed for refuge acquisition and the timing of management practices. Providing high-quality habitat is an important aspect of northern pintail management in Louisiana.

Backpack Radio Transmitters Are Used

Northern pintails were captured with bait traps and rocket nets at Catahoula Lake,

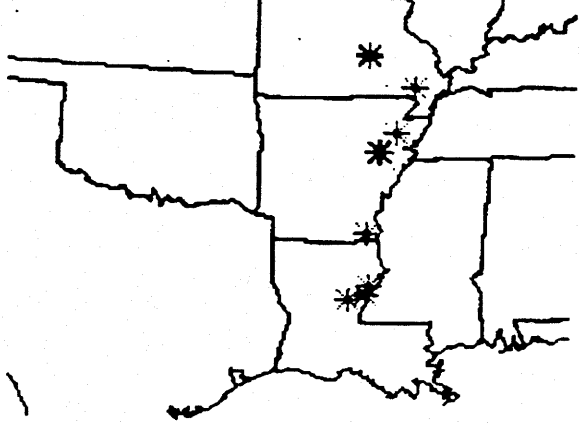
Louisiana, in late October and early November 1992. Fifty after-hatch-year and 39 hatch-year females were instrumented with backpack radio transmitter packages featuring a mortality sensor and a 180-day expected lifespan. Instrumented females were located weekly from aircraft. Flights covered Louisiana, eastern Arkansas, western Mississippi, and western Texas. In March 1993, flights extended into southern Missouri and western Tennessee, with one flight over Missouri, Illinois, Iowa, South Dakota, and Nebraska. At an altitude of 1,220 to 1,980 m, signal reception was as far as 64 km.

Hunting Is the Most Important Cause of Mortality

Ten (20%) after-hatch-year and 6 (16%) hatch-year females died during the monitoring period. Of these, 12 females were known to have been killed by hunters. Four additional females were found dead during the waterfowl season, but a cause of death could not be determined.

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instrumented northern pintails (*Anas acuta*) located during migration in late March 1993.



A Radio Transmitter Collar for Parrots

A new transmitter attachment design and collar were used to radio-track parrots for 36–52 weeks. The system provides protection from chewing of the transmitter, batteries, collar, and base of the whip antenna.

Parrots Difficult to Radio-mark

The powerful jaw muscles and large bills of *Amazona* sp. enable them to destroy bands and other radio devices. Few investigators have successfully attached radio transmitters to parrots. I designed a collar and case that foils destruction by the birds.

Developing the Transmitter and Collar

The testing of two transmitters with collars similar to designs used on parrots in other studies provided clues for designing a virtually indestructible collar, antenna, and transmitter attachment. One transmitter design, previously used on fledgling parrots, failed on adults because of a weak connecting mechanism and poor design

of collar and antenna. Parrots chewed through soldered collars that were a combination of brass bands and stainless steel wire (59 kg-test), through connecting mechanisms composed of six double loops and knots of nylon string covered with epoxy, and through the soldered connection of the antenna base. All wires and brass bands were covered with heat-shrink plastic tubing, which was also destroyed.

Another transmitter was attached to a sturdy brass band for the collar. No damage occurred to the collar or its connecting mechanism (nut and bolt), but the transmitter and antenna were heavily damaged by parrots chewing through the epoxy resin and removing transmitter components including batteries, wires, and in one case the entire transmitter. This collar damaged feathers on the parrots' necks.

The transmitter developed in this study was encased in a brass cylinder (Figure). A brass tube (2.3 mm in diameter) was silver-soldered longitudinally to the cylinder to attach the collar (59 kg-test stainless steel wire). The collar and antenna wires were covered with black,

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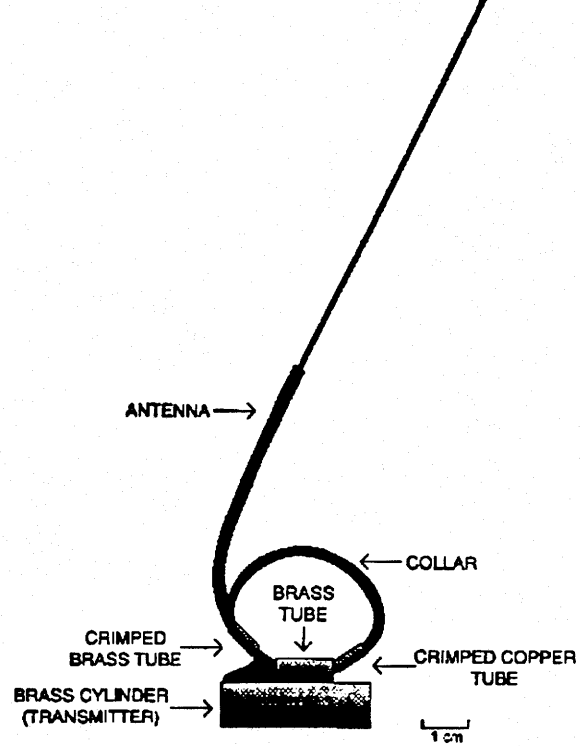


Figure. Radio transmitter design and attachment.

Proventricular Infection by a Nematode in the Endangered Laysan Duck

The endangered Laysan duck (*Anas laysanensis*) is found only on Laysan Island, part of the Northwest Hawaiian Islands National Wildlife Refuge. Laysan Island, about 1,450 km from Hawaii, encompasses about 365 ha and has a large, shallow brine lake in the center. Depending on ocean influx and rainfall, the lake area varies from 40 ha to more than 81 ha.

The ducks are generally found near the lake feeding on brine flies on the lake edge, larvae of various native moths in surrounding vegetation, and brine shrimp within the lake. Although the lake is mostly saline, ducks congregate near several freshwater seeps along the edge of the lake. Laysan duck populations have fluctuated from 50 to 450 individuals depending on the time of year censuses are taken.

Laysan Duck Die-off

In October 1993, 27 adult Laysan ducks were found weak or dead around the lake. The water level of the lake was unusually low due to an ongoing drought, and the brine fly population was believed to be lower than normal.

Thirteen ducks were necropsied and blood was collected from 10 ducks. Necropsy revealed severe emaciation, a thickened proventricular wall with excess mucus and a rough mucosa, and variably sized nodules along the proventricular and intestinal walls. Clinical pathology results from blood samples revealed a response compatible with that found in severe emaciation and parasitic infection.

Marked hyperplasia of the proventricular mucosa was seen on microscopic examination of tissues sampled from all 13 Laysan ducks necropsied. The architecture of proventricular submucosal glands was severely distorted with marked dilation and atrophy of the glandular epithelium. Cross-sections of numerous nematodes migrating through the wall of the proventriculus were observed. The nodules associated with the small intestine were filled with debris and bacteria. Their origin remains undetermined, and tuberculosis was ruled out as the cause.

Parasitologic examination of three gastrointestinal tracts revealed numerous (more than 100 in each bird) slender nematodes 5.0 mm

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Research



Information bulletin

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL BIOLOGICAL SURVEY

Number 74
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Intestinal Morphology Differs Between Gulf Coast Redhead Populations

Several studies have shown that diet quality and quantity can affect the size of a bird's digestive organs, and that organ size may be affected by osmoregulatory demands associated with reduced availability of fresh water. As part of a larger study on redheads (*Aythya americana*) wintering in Louisiana and Texas, we investigated the visceral morphology of two redhead populations for two consecutive winters. Our objective was to determine if the size of intestines varied by location, year, or time of year.

Study Areas

The Chandeleur Islands are a 65-km long chain of barrier islands located about 40 km off the Louisiana coast in the Gulf of Mexico; the islands serve as wintering habitat for about 20,000 redheads. The Laguna Madre of Texas is a hypersaline lagoon system about 180 km long and is separated from the Gulf of Mexico along its

eastern side by Padre Island. Ponds along the mainland are available for use by redheads as a source of fresh water for drinking. About 300,000 redheads winter in the Laguna Madre area annually. The Louisiana and Texas study sites are vegetated with seagrasses and have salinities of 17–30 ppt and 40–65 ppt, respectively.

Processing of Specimens

We collected redheads at the Chandeleur Islands ($n = 150$) during the winter of 1988–89 (year 1), and at the Laguna Madre ($n = 551$) during 1988–89 (year 1) and 1989–90 (year 2). Birds were cooled on ice within 5 h of collection, and frozen in the laboratory within 1–4 days. After the field season, carcasses were dissected and intestines were measured and weighed ingesta-free. For statistical analysis, time of year was treated as a continuous variable, whereas sex, age, location, and year were treated as discrete

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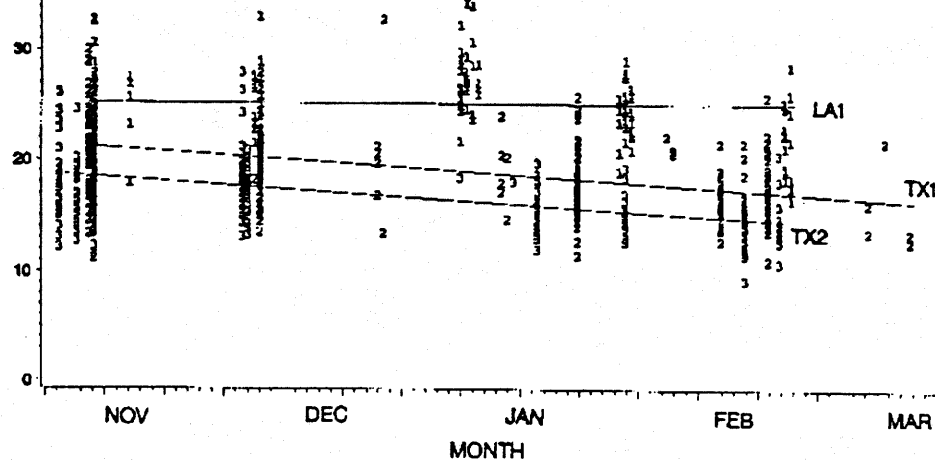


Figure. Intestine mass over winter (November–March) by state and collection year for redheads (*Aythya americana*) collected at the Chandeleur Islands, Louisiana, and the Laguna Madre, Texas. LA1 = regression line for birds collected in Louisiana during collection year 1 (1988–89); TX1 = regression line for birds collected in Texas during collection year 1 (1988–89); TX2 = regression line for birds collected in Texas during collection year 2 (1989–90). Individual observations: 1 = LA1; 2 = TX1; 3 = TX2. Slope of regression line was significant ($P = 0.0001$) for TX1 and TX2. Significant difference between means: LA1 > TX1 ($P = 0.0001$), TX1 > TX2 ($P = 0.0004$).

Low Incidence of Pairing and Courtship Behavior in Redheads Wintering in Louisiana

Redheads (*Aythya americana*) have been observed to be one of the earliest species of the genus *Aythya* to initiate courtship and pair bonds in Texas (35–60% of the females observed were paired before departure from the wintering grounds). We conducted behavioral studies of a separate population of redheads, wintering in Louisiana, to document their courtship activity and pair formation chronology during winter 1988–89. Our study area was Chandeleur Sound, adjacent to the Chandeleur Island chain about 40 km off Louisiana's Gulf of Mexico coast. About 20,000 redheads winter there each year.

Behavioral Data Collected

We collected data from observation blinds established at four locations on the Chandeleur Islands. Behavioral, flock, and environmental data were collected during 6 half-day (dawn to noon or

noon to dusk) observation periods between days 8 and 17 of each month, November 1988 through March 1989. We used spotting scopes and recorded the sex and presence or absence of courtship behavior for each bird observed during 2-minute scans conducted at 15-minute intervals. Courtship data were expressed as a percentage of total birds scanned. Between scans, we observed individual females for a minimum of 1 minute each and recorded whether or not they were paired (a paired female was one accompanied by a single male that followed, led, or courted the female and whose movements were in synchrony with hers). Pairing was expressed as a percentage of the total number of females that we observed between scans. Both variables (percent courtship and percent paired females) were rank-transformed for data analysis, and differences were tested among months using analysis of variance.

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Suckers Spawned From Captive Broodstock

The sucker family (Catostomidae) includes a wide variety of species, some of which are threatened and endangered. Other suckers have extensive ranges and are often common inhabitants in freshwater ecosystems. Some are important as a bait species for sport fisheries throughout the year. Only a few of these species have been artificially spawned. We are attempting to develop sucker culture methods that use captive broodstock, a technique that has not been utilized for most sucker species. This technique can be used to culture suckers for restoration of depleted wild stocks or for baitfish production.

Wild Spawning of White Suckers

For years, the white sucker (*Catostomus commersoni*) has been cultured throughout the north-central and northeastern states as bait or as feeder minnows for hatchery-raised gamefish. Captive broodstock have not been maintained because of their abundance during natural spawning runs. Broodstock are obtained from the wild, typically below small dams where the mature

fish concentrate during spawning runs. At that time the broodstock are manually spawned at the side of the stream or at a hatchery and then released. The eggs are then hatched and the fry are raised in ponds.

Baitfish farmers in most southern states do not culture suckers because they have little opportunity to obtain sucker broodstock because of the paucity of small dams on streams. In addition, suckers have not been a traditional bait species in the South.

Baitfish farmers in the South have recently expressed the desire for a fish species that grows to approximately 17.8 cm (7 inches) within one growing season so that it could be sold to anglers seeking large predatory fish such as walleyes (*Stizostedion vitreum*), striped bass (*Morone saxatilis*), or southern largemouth bass (*Micropterus salmoides*). To be economically viable the species should also have a large potential market at smaller sizes and have a wide geographical range so that it would not be considered an exotic fish in states where it was marketed.

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The Fisher: Old-growth Specialist Or Northern-forest Generalist?

In 1990, environmentalists petitioned the U.S. Fish and Wildlife Service to list the Pacific fisher (*Martes pennanti pacifica*) as endangered in California, Oregon, and Washington. The petition argued that fishers require old-growth forests, and the amount of old-growth had been reduced to the extent that the Pacific fisher was approaching extinction. The Service denied the petition, in part because the rangewide data on the habitats used by fishers were contradictory.

Do Fishers Require Old-growth Forests?

Personnel of the Maine Cooperative Fish and Wildlife Research Unit, with support from the Maine Department of Inland Fisheries and Wildlife (MDIFW), conducted the largest telemetry study of habitat use by fishers ($n = 76$) to date. This study concluded that in south-central Maine optimum fisher habitat was a diversity of second-growth forest types—including a variety of upland and wetland forests—that were intermixed.

In contrast with our findings that fishers in south-central Maine are forest generalists, researchers in other areas have characterized fisher habitat, especially winter habitat, as predominantly mature (i.e., Great Lakes Region) to climax (i.e., Pacific Northwest) coniferous forests, with some biologists considering the fisher an old-growth specialist.

If fishers require older, closed-canopy forests, present trends in forest management toward shorter rotations to harvest are counter to the needs of the species. To conserve a species unique to North America, and to resolve a conflict with forest harvest schedules across the species' extensive range, the critical question is as follows: Do fishers in the Northeast merely use different habitat than in the Northwest or are other factors at play?

Snow as a Habitat Component

Literature on the ecology of fishers suggests that deep snow is stressful to the species and

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Burn Data Base: A Prescribed and Wildfire Tracking Program

Fire is an important management tool for many parks and refuges under the auspices of the Department of Interior. Prescribed burning is a common practice for controlling habitat succession and risk of wildfire. A cooperative research study between the National Wetlands Research Center, Louisiana State University, and the St. Marks National Wildlife Refuge has resulted in a fire research and management tool in the form of an interactive data base and query system. This system is being used to track the fire history of St. Marks NWR and to facilitate fire research and management.

Fire Management Plan and Application

St. Marks National Wildlife Refuge is divided into three separate geographic land units; each unit is further divided into management compartments usually defined by roads and property boundaries. Each management

compartment contains one or more burn blocks. Presently, there are 178 designated burn blocks, most of which are burned on a 3-year rotation. Fire management includes maintaining three separate burning seasons—winter (October–March), spring (April–June), and summer (July and August). The difficulty of tracking such a complex and aggressive fire program has warranted the development of a specialized computer program and data base for recording prescribed and wildfire activity and for assisting fire scheduling and planning.

Burn Data Base Development

The burn data base is a menu-driven program designed for easy data entry, acquisition, and query specific to fire management goals and objectives. The program is written in dBase 3 and 4 and C as a self-contained program that can run with or without the parent software. The program centralizes the records of three management units,

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Sonic Distance Device Improves Field Sampling Efficiency and Accuracy

Stem mapping is the process of recording plant location relative to a fixed origin on a defined coordinate system. Approaches to stem mapping differ in their level of precision depending on the equipment used. A study was conducted to determine the utility and accuracy of sonic distance devices for stem mapping forest research plots.

Two basic approaches commonly used to map forest stands are triangulation and polar sampling. Triangulation requires measured distances from two fixed points, whereas polar sampling involves the measure of a compass reading (azimuth) and distance from a single fixed point. Both methods require at least one distance measurement. The type and condition of equipment used can affect the quality of measurement. Cloth measuring tapes, for example, may stretch with time and abuse. Today, manufacturers offer a wide range of metal and fiberglass measuring tapes that remain stable and durable.

How a measurement is accomplished may be more important than what type or brand of instrument used. In a forest setting, there are always other trees that stand in the line of measurement requiring some compensation of measurement for the inevitable bend in the tape. The time-consuming tasks of unwrapping and rethreading the tape with each measurement is also a factor in achieving a straight line for accuracy.

In recent years, a wide array of electronic distance devices have become available. A sonic distance device was tested for accuracy and dependability for stem mapping a bottomland hardwood forest in coastal Louisiana.

Electronic Distance Devices

Electronic distance devices meet the public's need for wireless, tapeless distance-measuring capability. Realtors, construction crews, and survey teams are already using this technology in order to speed the process and improve the

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function of these devices. The field application
may also preclude the use of a sonic device if the
distances involved are more than 50 m. For

700 Cajundome Boulevard
Lafayette, Louisiana 70506
(318)266-8500

Intensive Seasonal Predator Removal Had Little Effect on Duck Nest Success in Waterfowl Production Areas

Nest success of dabbling ducks in Waterfowl Production Areas (WPA's) in North Dakota, South Dakota, and Minnesota is usually less than the 15-20% needed to maintain duck populations. Predation by mammals, especially red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), badgers (*Taxidea taxus*), and Franklin's ground squirrels (*Spermophilus franklinii*) causes most nest failures. Managers seek ways to reduce depredations of eggs in duck nests in WPA's.

We Evaluated the Use of Seasonal Predator Removal

During 1987-90, we worked with U.S. Fish and Wildlife Service (FWS) wetland management districts in western Minnesota and eastern North Dakota to remove predators from WPA's. Data were obtained from 12 pairs of removal (predators removed) and control (no predators removed)

WPA's. Nine pairs (seven in Minnesota and two in North Dakota) were studied for 1 year and three pairs (one in Minnesota and two in North Dakota) were studied for 2 years. Study area pairs had similar habitat characteristics, and the predator removal treatment was randomly assigned to one WPA of each pair. The WPA's ranged from 61 to 301 ha. We treated each study area year (one WPA for 1 year) as an independent datum. Study constraints stipulated that (1) predators would be removed seasonally from within WPA's only, (2) removal methods would include only those approved for widespread use by FWS managers, and (3) removal schemes would be suitable for adoption by FWS managers.

Predator removal was conducted by experienced trappers. Trapping with live traps, quick-kill body-gripping traps, and padded foothold traps were the primary removal methods. Snares were used in two areas, and a few predators were shot or dug from dens. Some

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(North Dakota) or less than (North Dakota) species in abundance than in North Dakota], abundance of duck nests in many of our areas was low. We found <25 nests per area in half the areas. These factors, along with immigration of predators into the areas and presence of predators that evaded capture, overpowered our efforts to substantially increase duck nest success.

Constraints placed on our trappers limited their effectiveness, especially (1) restricting the removal of predators to WPA's only, (2) restricting the choice of removal methods, (3) tending traps daily, and (4) requiring inflexible 8-h workdays that began and ended at headquarters. However, for legal, social, and humane reasons, these types of constraints are

or predators removed or amount of area treated over the thoroughness of removal effort are likely to be ineffective.

For further information contact

Alan B. Sargeant, Marsha A. Sovada, or
Terry L. Shaffer
Northern Prairie Science Center
8711 37th Street Southeast
Jamestown, North Dakota 58401
(701)252-5363