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SHAD ATLAS INSIDE!

■ THE SHAD FOUNDATION'S ■

SHAD JOURNAL

A call for an international shad conference
One of Earth's great biological invasions
Elementary school students speak up for American shad

VOLUME 2, NUMBER 1, FEBRUARY 1997

COURTESY OF THE SMITHSONIAN INSTITUTION, NMNH, DIVISION OF FISHES

A 116-YEAR-OLD AMERICAN SHAD SPECIMEN that ichthyologist David Starr Jordan collected in the Columbia River in 1880. To learn how this East Coast native made its way to the Columbia, please turn to page 4.

President's Note:

To reach out to the world's shad community, the Shad Foundation has established a World Wide Web (WWW) homepage which contains many links to shad-related organizations, and descriptions of various shad species descriptions and their natal river basins. Although rudimentary, it presents a framework to aid those interested in shad worldwide to communicate with each other. In the future, we will develop a "forum" page to allow interactive public discussion of issues related to shad and their ecosystems. Please introduce your friends and colleagues to the Foundation by directing them to this new WWW site at the address given above.

In this second issue of the Shad Journal, Dr. Karin Limburg calls for a World Shad Conference, proposing that we convene in 1998 or 1999 to evaluate the global status of shads. Four students at Westbrook Elementary School describe their adventures in returning shad to their traditional spawning grounds in the Potomac River. And an oceanographer and fisheries biologist examine how shad took the Pacific coast by storm starting in 1871.

-R. Hinrichsen

INSIDE

A World Shad Conference Proposal

A proposal to convene an international meeting to assess the status of alosines worldwide

by Karin E. Limburg

Shads (Clupeidae: subfamily Alosinae) constitute a cosmopolitan group of fishes that exploit a wide range of habitats worldwide. Many of the 30+ species in this subfamily currently support or have historically supported important commercial fisheries.

Now, in the late 20th century, as the mounting pressures of human population growth and pollution continue to impinge on natural ecosystems, many of these alosine species are experiencing serious declines. Some are locally extinct in large areas of their historic range and are threatened in the remainder. The triumvirate assaults of habitat loss or degradation, pollution, and overharvesting could eventually result in global extinction of many species.

This is a proposal to convene an international meeting to assess the status of alosines worldwide. The purpose would be four-fold: (1) to bring up to date the systematics of the group, including new information on phylogenies and distribution of species; (2) to describe the status (population estimates, life history characteristics, exploitation, habitat and pollution status) of individual species; (3) to synthesize global trends in shad populations; and (4) to develop recommendations for management strategies.

This format is based upon a highly successful conference held in 1994 at the American Museum of Natural History in New York City to assess the global status of sturgeons. Dr. John R. Waldman of the Hudson River Foundation, a key organizer of the 1994 sturgeon conference, is interested in the proposed shad conference as a complement to the sturgeon conference. But we must first determine what interest a shad conference holds for the global scientific community.

As the mounting pressures of human population growth and pollution continue to impinge on natural ecosystems, many alosine species are experiencing serious declines.

Is there sufficient interest among the researchers and managers involved with alosines to warrant such a conference? That is why we are placing this proposal in front of the Shad Journal's readership—we wish to find out.

If the interest is there, then we will identify a venue and means to underwrite the meeting. We plan to schedule the meeting for 1998 or 1999. We will publish the proceedings, most likely as a special issue of a refereed scientific journal. We will also construct a World Wide Web home page for the conference which will contain abstracts, papers and data that authors make available, and a directory of shad researchers worldwide.

Please send your opinions and proposed shad topics before May 1, 1997 to the author, Karin E. Limburg, whose postal and e-mail addresses are listed below, or to John R. Waldman, Hudson River Foundation, 40 West 20th Street, 9th Floor, New York, NY 10011, U.S.A. We welcome interest in joining planning/steering committees.

The Author

KARIN E. LIMBURG is a fisheries ecologist with interests in life history theory and whole-ecosystem influences on fish population dynamics. Her dissertation (1994, Cornell University) concerned the ecological constraints on juvenile American shad migration from natal rivers. She continues studies on American shad migration and also works on other estuarine fish questions. For further information, contact the author at the Department of Systems Ecology, University of Stockholm, S-106 91 Stockholm, Sweden, or via e-mail at Karin_L@system.ecology.su.se.

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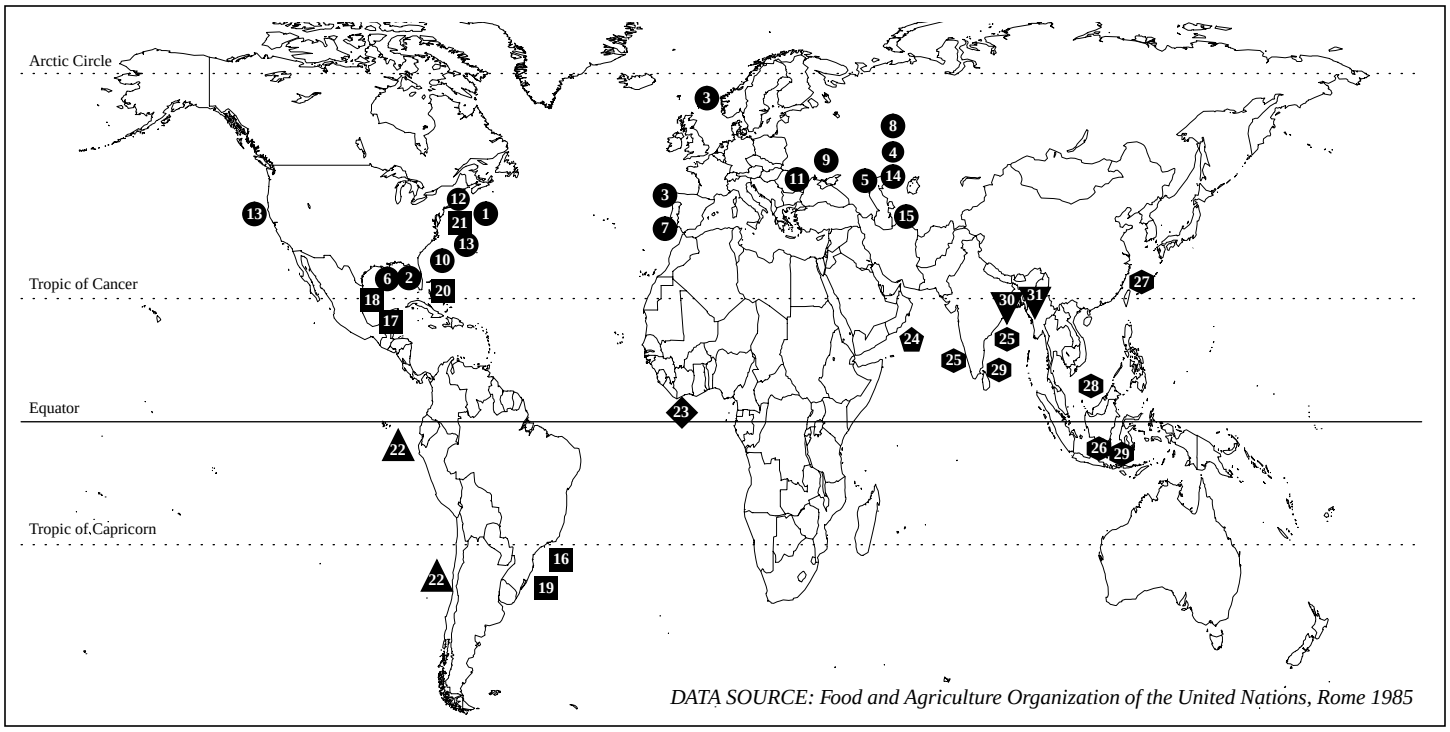
The Shad Foundation is a Washington State non-profit corporation that was established in 1996 to promote a greater understanding of shad for the purpose of restoration where depleted, or their wise recreational or commercial use where abundant.

Trustees: Richard A. Hinrichsen, *University of Washington, Seattle, Washington;* Curtis Ebbesmeyer, *Evans-Hamilton, Inc., Seattle, Washington*; Richard St. Pierre, *U.S. Fish and Wildlife Service, Harrisburg, Pennsylvania.*

Submissions. The editors welcome submission of articles on any aspect of shad. The Journal publishes letters, commentaries, histories, scientific articles, interviews, reviews, and philosophical and methodological items related to shad the world over. (See instructions on back cover.)



THE WORLD DISTRIBUTION OF SHADS. Each number shows an approximate species location. Species of the same genus are given the same geometric figure, e.g., ● represents the genus *Alosa*. A map key is given below.

Common Species Name	*Scientific Name*	*Approximate Geographical Distribution*
1 Blueback shad	*Alosa aestivalis* (Mitchill, 1814)	N. America (Atlantic coasts from Cape Breton, Nova Scotia south to St. John's R., Florida).
2 Alabama shad	*Alosa alabamae* (Jordan & Evermann, 1896)	Gulf of Mexico from Mississippi delta east to Choctawatchee R.; also Iowa, Arkansas to W. Virginia rivers.
3 Allis shad	*Alosa alosa* (Linnaeus, 1758)	European coasts from Bergen, Norway to northern Mauritania, also western Mediterranean. Not in Baltic Sea.
4 Caspian marine shad	*Alosa brashnikovi* (Borodin, 1904)	Caspian Sea, mainly in south.
5 Caspian shad	*Alosa caspia* (Eichwald, 1838)	Caspian Sea, Black Sea, Sea of Azov.
6 Skipjack shad	*Alosa chrysochloris* (Rafinesque, 1820)	Gulf of Mexico (from Corpus Christi, Texas east to Pensacola, Florida). In Mississippi and Ohio Rivers.
7 Twaite shad	*Alosa fallax* (Lacepède, 1803)	European coasts from south Iceland coast, British Islands, Baltic, to Morocco; whole of Mediterranean Sea.
8 Caspian anadromous shad	*Alosa kessleri* (Grimm, 1887)	Caspian Sea (in the sea and along both shores of central and northern parts; south and southeast in winter).
9 Black Sea shad	*Alosa maeotica* (Grimm, 1901)	Black Sea and Sea of Azov.
10 Hickory shad	*Alosa mediocris* (Mitchill, 1814)	N. America. Atlantic coasts from Maine to the St. John's R., Florida.
11 Pontic shad	*Alosa pontica* (Eichwald, 1838)	Black Sea and Sea of Azov (also in Don, Danube and other rivers).
12 Alewife	*Alosa pseudoharengus* (Wilson, 1811)	N. America. Atlantic coasts from Gulf of St. Lawrence to N. Carolina; in streams and rivers. Great Lakes.
13 American shad	*Alosa sapidissima* (Wilson, 1811)	N. America. Spawning from St. John to St. John's R. on E. Coast, Columbia to Sacramento R. on W. Coast.
14 Saposhnikovi shad	*Alosa saposhnikovi* (Grimm, 1887)	Caspian Sea, including lower parts of Volga R.; more common in north.
15 Agrakhan shad	*Alosa sphaerocephala* (Berg, 1913)	Caspian Sea (more common in northern and central parts).
16 Brazilian menhaden	*Brevoortia aurea* (Spix & Agassiz, 1829)	E. coast of South America from Brazil to Argentina.
17 Finescale menhaden	*Brevoortia gunteri* (Hildebrand, 1948)	Gulf of Mexico. Chandeleur Sound, Louisiana, to Gulf of Campeche, Mexico.
18 Gulf menhaden	*Brevoortia patronus* (Goode, 1878)	Gulf of Mexico. Florida Bay, Gulf of Campeche, Mexico.
19 Argentine menhaden	*Brevoortia pectinata* (Jenyns, 1842)	E. coast of South America. Brazil, Uruguay, and Argentina.
20 Yellowfin menhaden	*Brevoortia smithi* (Hildebrand, 1941)	Atlantic coasts (Beaufort N. Carolina to Indian R., Florida). Gulf of Mexico (Biscayne Bay eastward).
21 Atlantic menhaden	*Brevoortia tyrannus* (Latrobe, 1802)	Atlantic coasts (Nova Scotia south to Indian R., Florida).
22 Pacific menhaden	*Ethmidium maculatum* (Valenciennes, 1847)	W. coast of S. America. Gulf of Guayaquil south to Talcahuano.
23 Bonga shad	*Ethmalosa fimbriata* (Bowdich, 1825)	Eastern central Atlantic (Dakhla, western Sahara, to Lobito, Angola). Dwarf population in Lake Nokoué, Benin.
24 Kelee shad	*Hilsa Kelee* (Cuvier, 1829)	Indo-West Pacific. From Gulf of Oman, south to Durban and Madagascar. Bay of Bengal to Papua New Guinea.
25 Hilsa shad	*Tenualosa ilisha* (Hamilton-Buchanan, 1822)	Northern Indian Ocean from the Persian Gulf eastward to Burma; also in rivers.
26 Longtail shad	*Tenualosa macrura* (Bleeker, 1852)	Malaysia and Indonesia (Java Sea and Sarawak, also effluent rivers.)
27 Reeves shad	*Tenualosa reevesii* (Richardson, 1846)	China. From about 30 degrees N. latitude southward into South China Sea. Spawns in Yangtze River.
28 Laotian shad	*Tenualosa thibaudeaui* (Durand, 1940)	Mekong R. system. Mool R., Thailand; Luang Prabang, Vientiane, Pakse, Hatsalao, Tha Ngon and Tha Bo, Laos.
29 Toli shad	*Tenualosa toli* (Valenciennes, 1847)	India (eastern and western coasts, also rivers) to Java Sea and South China Sea.
30 Indian river shad	*Gadusia chapra* (Hamilton-Buchanan, 1822)	Rivers of India and Bangladesh affluent to the Bay of Bengal.
31 Burmese river shad	*Gadusia variegata* (Day, 1869)	Rivers of Burma (chiefly the Irrawaddy; perhaps others).

Oceanography of The Pacific Shad Invasion

Seth Green's bold experiment, transporting shad via the transcontinental railroad to the U.S. West Coast in 1871, fostered one of earth's great biological invasions

by Curtis Ebbesmeyer and Richard Hinrichsen

"*…instead of migrating up the coast from south to north in the spring and back again in the fall, they simply spend their oceanic life in the seas quite adjacent to the rivers where born, and return to them in the proper season.*"

So wrote the great biologist Spencer Fullerton Baird on April 6, 1871, to explain the ocean habits and spawning runs of American shad. His reasoning, built upon Occam's Razor (the simplest explanation is best), was flawless, but there was one problem—his conclusions were wrong. They were proven so not by a scientist, but by a sports enthusiast and pioneer fish culturist from Albany, New York, named Seth Green.

For eons American shad (*Alosa sapidissima*) migrated at sea only along the east coast of North America. That changed irreversibly in June 1871 when Seth Green transported thousands of shad fingerlings to the Sacramento River, California, from his hatchery on New York's Hudson River via the then-recently completed transcontinental railroad. Green planted the shad at the request of the California Fisheries Commission. (Other fish culturists, starting with Livingston Stone in 1873, would eventually also make this transcontinental journey with shad fry, but under the auspices of the U.S. Fish Commission.)

None realized that concurrently with the shad planting the oceanographic conditions along the Pacific coast became ideal for shad's coastal ocean migrations. In part because of this environment, North America's largest American shad run, totaling about 5 million annually, now occurs on the Columbia, which is the largest river by volume flowing into the Pacific Ocean from North America. Here we consider how temperature anomalies and ocean currents may have fostered one of earth's great, but poorly understood, biological invasions.

Shad Surprise

At the time Green conducted his bold experiment, eminent scientists did not suspect shad's invasion potential. Before distant shad colonization became evident, Spencer F. Baird, the first U.S. Fish Commissioner, put forward his simple, yet flawed, theory of the shad's ocean habits.

By the 1880s the establishment of shad in the Columbia River 600 miles north of Sacramento became apparent to salmon fishermen who caught the shad in their nets and threw them onto shore to rot and to scientists who received reports of shad specimens sent to the National Museum in Washington, D.C.

Shad's rapid invasion northward, at a rate of 100-200 kilometers per year, gave Baird pause, prompting him to seek more a robust explanation for shad's behavior—one that considered both ocean temperatures and currents.

In 1887 Baird wrote:

> "The cause is probably to be sought in the genial influences of the Japan current, which brings the warmth of equatorial Asia to temper the extremes of the Arctic climate on the southern shore of the Alaskan Peninsula, and thence sweeping to the south, carries tropical heat to the latitude of San Francisco. Repelled on the one hand by the low temperature of the great rivers and fringe of the coastal waters, and solicited on the other by the equable and higher temperature of the Japan current, the shad have become true nomads, and have broken the bounds of the hydrographic area [San Francisco Bay] to which we had supposed they would be restricted. Following the track of the Asiatic current, and finding more congenial temperatures as they progress, it is not unreasonable to expect that some colonies will eventually reach the coast of Asia and establish themselves in its great rivers."

Baird's theory combined shad's sensitivity to water temperature with the meager knowledge of sea currents oceanographers possessed in the late 1800s. Though crude, his theory represents perhaps the first application of fisheries oceanography, now—more than a century later—a burgeoning discipline.

COURTESY OF THE SMITHSONIAN INSTITUTION

SPENCER BAIRD, director of the Smithsonian Institution and the first U.S. Fish Commissioner, once believed that American shad underwent no long-range oceanic migrations. He was proven wrong by Seth Green's bold experiment.

Seth Green's Bold Experiment

Seth Green's account of his journey to California, published in the *Report of the New York Fish Commissioners, 1872*

COURTESY OF THE SMITHSONIAN INSTITUTION, NMNH, DIVISION OF FISHES

SETH GREEN, the father of fish culture in America, successfully transported 10,000 shad fry from his hatching establishment on the Hudson River to the Sacramento River in 1871.

The most interesting experiment [of mine] was the transportation of the [shad] fry to California. This was undertaken at the expense of the [fish] commissioners of California, but with the permission of the New York [Fish] Commissioners. The attempt was apparently hopeless, and nothing but failure was predicted, but it turned out to be a success…

On the 19th day of June, 1871, I started at 6 a.m. from my hatching establishment ten miles below Albany, on the Hudson River, with twelve thousand young shad in four eight-gallon milk-cans. They had been hatched the night before at the establishment under charge of the New York [Fish] Commissioners. I arrived at Rochester at 10 p.m., and changed the water, substituting that from the Genesee River, without injury to the fish. I arrived at Cleveland at 7:45 the next morning; put two hundred shad in Lake Erie, and changed the water again. The fish were then fresh and lively, without any signs of sickness. I again changed the water at Toledo, and when I arrived at Chicago at 7 p.m. the fish were still in good order. Here I first tried the water from the city water-works, but found there was too much oil in it; so I went to the lake. Having tasted the water and found that it would answer, I put two hundred fish in Lake Michigan, and June 21 started with cans newly filled, at 10:45 a.m., for California. I carried an extra can of water, for before me was a long stretch of almost arid land; still I was fortunate enough to find some places between Chicago and Omaha where I could get a few pails of water and make a partial change. The fish were still in good order when we arrived at Omaha; but there I could not find any water in which they would live five minutes. The way I tested the water was by filling a tumbler and putting a few fish in it; it was easy to tell at once, by the behavior of the fry, whether the water agreed with them or not. I did not get a full change until I reached Laramie River. From Omaha I did not find any good water for four hundred miles, and the only way I kept my charges alive was by drawing the water out of the cans into pails, and pouring it from one pail into another until purified; this process being assisted by my getting a little ice-water from the car-tanks.

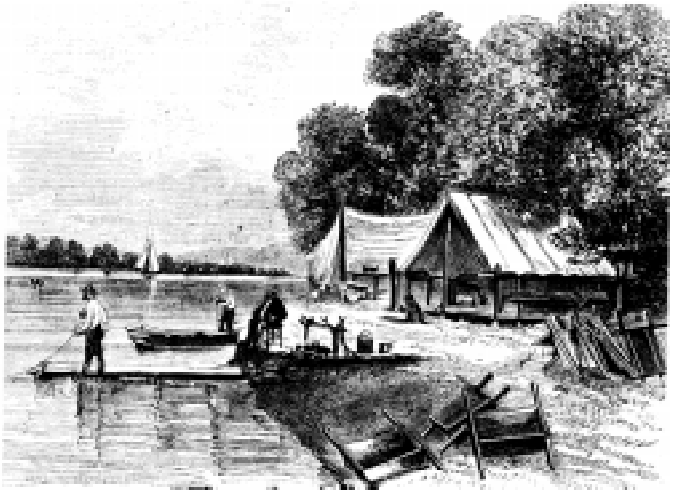
June 22.—Bad water all day, with the thermometer 100 degrees Fahrenheit [38 degrees Celsius] in the shade from 9 a.m. to 4 p.m. I used ice-water the entire day, a very little at a time, and had hard work to keep the temperature of the water below 82 degrees Fahrenheit [28 degrees Celsius]. I began to feel blue, and doubtful of the result. The fish suffered considerably, but the weather began to be cold toward night, and I got the temperature of the water down to 75 degrees Fahrenheit [24 degrees Celsius] at 9 p.m., the fish recovering a little.

June 23.—I arrived at Laramie River at 5 p.m. and got a good change of water; fish doing well, and I began once more to feel hopeful and encouraged. We had a frost that night, and next morning at 7, I changed water at Green River, where it was in proper condition. At 2 p.m. I got another change from a stream in which there were trout, and again at Ogden, where I put two hundred fish in the river.

June 25.—The water was changed at the Humboldt River; the water was good and continued good all the rest of the way.

June 26.—I arrived at Sacramento and took the fish up the river two hundred and seventy-five miles from Sacramento, in company with Messrs. Redding and Smith, the California fishery commissioners. In their presence I deposited the fish in the Sacramento River the same night at 10 p.m.; there was about ten thousand in good order.

On the sixth and seventh days out they began to be very busy looking for food. Whenever I changed the water they would clean up all the food there was in it in five minutes. They did not suffer for food as long as the sack [yolk sac] lasted on their bellies; that is about five days; then they needed sustenance. If I could get a change of water often enough from running streams I could carry them a long way, as nearly all streams are filled with small insects. With this view I examined the water of the Sacramento where I put them in, and found plenty of food for the young fry. I then went down to the Pacific Ocean and found that there were plenty of sand-fleas, which are the principal food of the old shad in the Atlantic. And now I can only say that if they do not have shad in the Pacific Ocean there will be but one cause, the roily water, caused by washing the mountains down for gold. However, I think the fish will get through all right.



UNIVERSITY OF WASHINGTON SPECIAL COLLECTIONS

HARPER'S WEEKLY April 27, 1872

THE HATCHING ESTABLISHMENT on the Hudson River where Seth Green hatched the 10,000 American shad fry which he planted in the Sacramento River.

Today few scientists are aware of the North American shad invasion, and thus far no theory has been advanced beyond Baird's. Here we revisit Baird's interpretation in light of recent reconstructions of late 19th-century oceanographic conditions in the Pacific Ocean.

El Niño and George Davidson's Current

William C. Leggett's pioneering studies demonstrated that the shad migrated along the U.S. east coast in waters with temperatures between 13-18 degrees Celsius just prior to spawning. Because Green planted east coast American shad, we hypothesized a similar temperature preference along America's west coast. However, as the table below demonstrates, for much of the year surface waters at the mouth of San Francisco Bay, through which the shad must pass as they swim into the Pacific Ocean, are typically colder than pre-spawning adult shad prefer. We therefore sought a mechanism by which coastal temperatures would rise into the shad's range, explaining the explosive invasion from San Francisco Bay. The candidate? El Niño.

Since World War II, numerous oceanographic studies have produced a comprehensive understanding of El Niño events. Roughly, it consists of a sequence of physical processes stretching across the Pacific Ocean, which results in increased temperatures along North America's west coast. During an event's beginning phase, zonal winds along the equator increase in strength, driving warm waters eastward thereby piling them against the west coast of South America. Then, some of the warm water is deflected northward. El Niños vary greatly in duration, some persisting for several years. They also vary in strength.

"…it is not unreasonable to expect that some colonies will eventually reach the coast of Asia and establish themselves in its great rivers."

During very strong El Niños the warm water penetrates north to the Gulf of Alaska, but during normal events no further than San Francisco. Studies of coastal fauna suggest that El Niños have occurred frequently. Strong ones have occurred about once every decade over the past 500 years.

When Baird contemplated the shad invasion, the surface waters off the U.S. west coast were often abnormally warm because an unusual number of El Niños occurred during the 30-year period 1864-1894. During these El Niño events, tongues of water possibly as warm as 16 degrees Celsius pushed northward along the coast, sometimes as far as Cape Flattery, Washington, as during the El Niño of 1982-83. In the strong El Niño of 1957-58, water 3 degrees Celsius warmer than normal was found in a layer 100 meters deep off Washington State.

Although Green could not have anticipated it when he planted his shad fry in 1871, six to seven years later, when his shad would be mature, a strong El Niño pushed northward, creating ideal conditions for a shad invasion of the Pacific coast.

To reconstruct the temperatures that maturing shad may have encountered along the Pacific Coast, we added 3 degrees Celsius to monthly average surface water temperatures recorded at the southern (Golden Gate, California) and northern (Neah Bay, Washington) ends of the Davidson Current [See table at left].

The reconstructed sea surface temperatures indicate that the nearshore waters off the coast of Washington State might have warmed to above the maturing shad's lowest preferred temperature (13 degrees Celsius) between the Golden Gate and Cape Flattery during May through October, 1877-1878. If so, this would have opened the way for pre-spawning adults to migrate to the Columbia River to spawn. Indeed, by 1880, ichthyologist David Starr Jordan confirmed that shad had invaded the Columbia; he sent two specimens collected at Astoria, Oregon to the Smithsonian Institution as proof [Specimen numbers 25524 and 27322, Smithsonian Institution, NMNH, Division of Fishes].

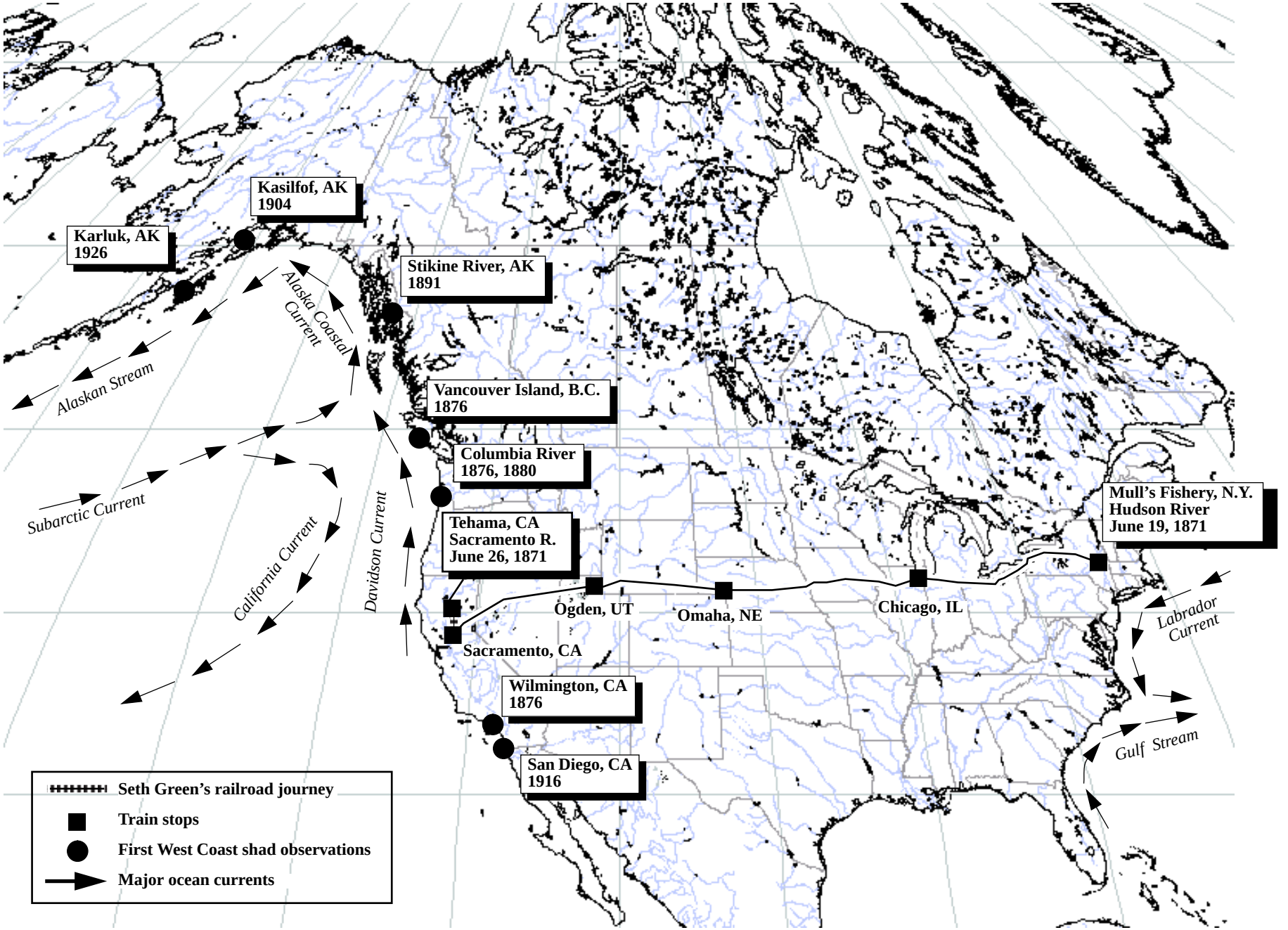
While Baird formulated his theory of why shad invaded the West Coast, George Davidson of the U.S. Coast and Geodetic Survey first identified the coastal current flowing from San Francisco northward to Vancouver Island, Canada. It was a transient river at sea, 50 miles [81 kilometers] wide, developing each October and vanishing in April of the following year. The current is named in Davidson's honor because, by alerting sea captains to its existence, he saved countless lives at sea.

When Green's shad migrated to sea through San Francisco's Golden Gate during the fall of 1871 (as they are now known to do), they essentially entered a swift cur-

A STRONG EL NIÑO would raise water temperatures off the U. S. west coast into the shad's preferred range. Tabled here are mean and estimated El Niño temperatures at San Francisco, California (37°48'N. Latitude; 51 years of measurements), and at Neah Bay, Washington (48°22'N. Latitude; 37 years of measurements). The El Niño temperatures were estimated by adding 3 degrees Celsius to the monthly average. Temperatures in bold lie in American shad's preferred temperature range (13-18 degrees Celsius).

Month	*San Francisco Temperature (degrees Celsius)*		*Neah Bay Temperature (degrees Celsius)*	
	Mean	*With El Niño*	*Mean*	*With El Niño*
January	10.4	**13.4**	7.3	10.3
February	10.9	**13.9**	7.4	10.4
March	11.6	**14.6**	7.9	10.9
April	12.4	**15.4**	9.1	12.1
May	**13.1**	**16.1**	10.6	**13.6**
June	**13.9**	**16.9**	11.6	**14.6**
July	**14.7**	**17.7**	11.8	**14.8**
August	**15.2**	**18.2**	11.6	**14.6**
September	**15.5**	**18.5**	11.3	**14.3**
October	**14.8**	**17.8**	10.6	**13.6**
November	**13.0**	**16.0**	9.4	12.4
December	11.2	**14.0**	8.2	11.2

The Shad Express — An Invasion Aided by Humans, Trains, and Ocean Currents



rent winding its way along the west coast of North America. Within the Davidson Current the young shad fry would be pushed along at a rate of 1-2 miles [1.6-3.2 kilometers] per hour northward.

The Davidson Current has apparently aided plant migrations up the Pacific coast. The "sea rocket," *Cakile edentula*, a plant indigenous to the Atlantic coast of North America, first arrived on the Berkeley shore of San Francisco Bay in 1882. By 1891 it was commonly found around the Bay and outside the Golden Gate, 36 kilometers south to Half Moon Bay. It spread northward at a rate of 65 kilometers per year, reaching Oregon by 1901, Washington by 1907, British Columbia by 1909, and Kodiak Island off Alaska by 1931. Amazingly, this rate is similar to the northward invasion rate of shad—about 100 kilometers per year.

Invasion Routes to Asia

That shad have survived and thrived for a century despite the comings and goings of El Niños, suggests that they have repeatedly found their preferred spawning temperatures along the West Coast shoreline. We cannot disagree with Baird in that some shad may even have reached Asia. American shad apparently have been observed near the Kamchatka Peninsula, but temperatures there would be beyond their preferred spawning temperature range. To find more congenial spawning temperatures, they would be forced southward along the west Pacific or they would return to the warm waters of their birth.

For shad to cross the Pacific, they might take two routes: (1) in tropical latitudes, swimming with the North Equatorial Current (NEC); or (2) following the system of coastal currents (CC) flowing counter-clockwise around the North Pacific Ocean.

The California Current sweeps southward off the shelf of Oregon and California and continues on as the NEC, crossing the south side of the great gyre to the Philippines. An object drifting in this current would typically cross the Pacific in three years. However, if taking this route, shad could not sustain themselves in the open ocean's nutrient-poor waters.

If shad followed the more nutrient-rich coastal route, drifting northward in the Davidson current, they could continue across the Pacific in a clockwise direction, connecting with the Alaska Coastal Current along Canada and Alaska and with the Alaskan Stream along the Alaskan Peninsula. They would eventually reach Kamchatka where American shad have indeed been observed.

Thus to reach Asia as Baird suggested, only an indirect route—northward to Alaska, to Kamchatka and southward to China—appears feasible because of food limitations. Conceivably, migrating from off the Kamchatka Peninsula south toward China, shad may have invaded numerous Asiatic rivers.

Questions Remain

From this brief consideration of the North American shad invasion we are left with many questions which can only be answered with substantial research.

At the top of our list of questions are:

(1) If shad are truly a transpacific species and Asian populations have spawned since the last ice age, why were shad absent from the west coast of North America prior to 1871? Since American shad appear to have swum from North America to Asia, why did they not invade the Americas from Asia long before Green arrived?

(2) Did shad planted in West Coast rivers, after crossing the North Pacific, spawn in Asia? Careful identifications of shad in Asian rivers may reveal great surprises.

We challenge our scientific readership to begin the international research and dialog to help answer these fundamental questions.

GEORGE DAVIDSON, a pioneer West Coast scientist of the late 19th century and a member of the National Academy of Sciences, discovered an inshore eddy current which may have propelled shad fry northward from the Golden Gate, helping them take by storm the Pacific Coast of North America.

The Authors

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The authors thank Lisa Palmer of the Smithsonian Institution, Division of Fishes, Washington, D.C., for locating the shad specimen collected in the Columbia River and C. Marie Hall of the Rochester Museum and Science Center Library, Rochester, New York, for her help in researching Seth Green's transcontinental railroad journey.

Further Reading

A footnoted manuscript is available on request by sending $5.00 (U.S.) to the Shad Foundation, P.O. Box 21748, Seattle, WA 98111-3748.

THE MIGRATIONS OF THE SHAD. William C. Leggett in *Scientific American*, Vol. 228, No. 3, pages 92-98; March 1973.

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One Night with Shad

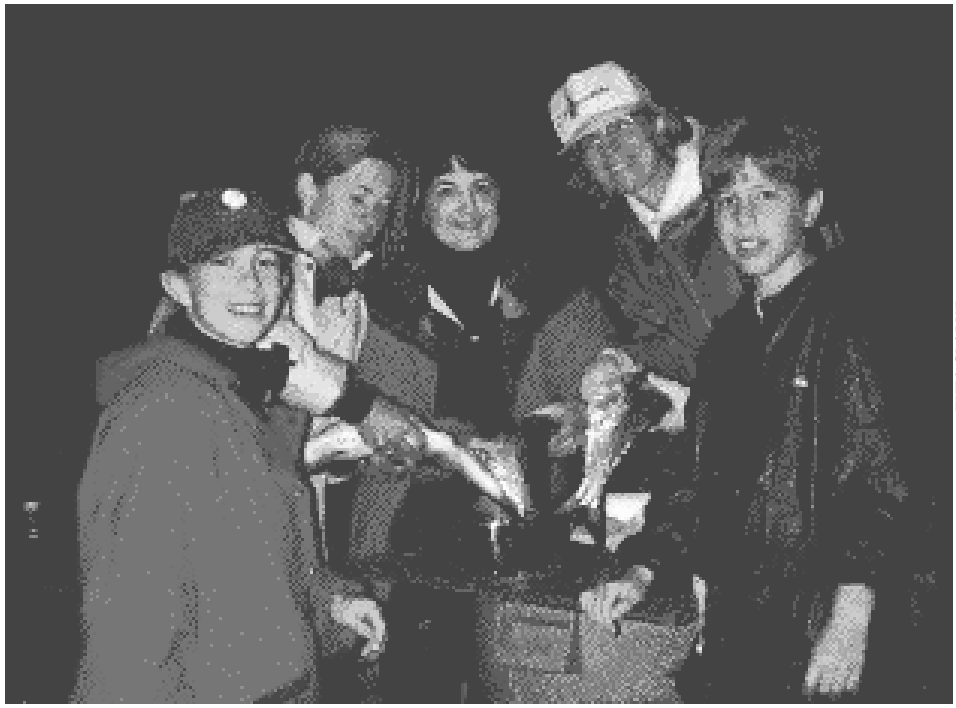
A night of shad research spawns a great adventure

by Nick Richman and Karna Sandler

Our great shad adventure began after school on Wednesday, May 1, 1996. Nick Richman, Karna Sandler, Thea Clarke, Karen Degerberg, and Sandi Geddes drove to an area of the Potomac River near Mount Vernon. We met Sandy Burk from the Department of Environmental Protection (DEP) and Jim Cummins from the Potomac River Interstate Commission. We were at the home of Mr. Harley, a commercial waterman, who had many stories about fishing on the Potomac.

We boarded two boats, a flat-bottomed work boat and a Key West, then motored about four miles to our fishing spot. We were fishing for American shad. We put out two 500 foot-long gill nets. It was hard work casting the nets; they were tangled, and arranging the weights on them required quick hands.

Our job was complicated when the battery on our workboat died. We were marooned with only some shovels to use as paddles. The Key West came to our rescue and had to tow us for the remainder of our adventure. We pulled our gill nets in and one by one American shad could be seen in the net. We released each fish from the net and threw them into large containers filled with water. We threw back many fish that were not American shad (striped bass and hickory shad). We also threw back some American shad that were not ready with eggs and some females that we did not need.



THEA CLARKE

SPAWNING SHAD ON THE POTOMAC, the crew squeeze eggs and sperm into a bucket. From left to right are author Karna Sandler, Sandy Burk, Sandi Geddes, Karen Degerberg, and author Nick Richman.

We Spawn the Shad

Back on a small, sandy beach, we set up a shad lab. We ran our fingers along the females' abdomens and squeezed out their eggs into a bowl. Then we held the male shad so that its abdomen was facing down and squeezed the sperm into the same bowl. Jim Cummins stirred it together with his hands. It looked like applesauce. He added water to it to activate the sperm. He let it sit for five minutes, and then he put it in a container in the river. The container let the river water through, but didn't let the eggs out.

We let it sit there for an hour. In the meantime, we measured and weighed the fish we had caught and recorded the data. To pass the time, we tried to guess how much each shad weighed.

A Windstorm Whips Up Waves

Finally, we packed up the boats and started back to the dock. Little did we know how long the trip back would be and how big the waves would be! Because we were being towed and it was so windy, it took us more than one hour to get back! It seemed like forever!! Those of us who sat in the front of the boat (the kids, of course) got soaked and soon retreated to the back.

When we eventually got back, Jim Cummins packed the eggs in plastic bags, added oxygen, and packed them in Styrofoam containers. The eggs had grown to the size of pearls and filled nine liter containers. They looked like translucent orange marbles. Mr. Cummins estimated that we had fertilized 400,000 eggs. He took them all to a fish hatchery that night. By the time we started home, it was almost midnight. Even though it was a late night, it was a great adventure!

The Authors

NICK RICHMAN, 11, attended Westbrook Elementary for six years, and is now attending Anslem Abbey School, Washington, D.C. His favorite pastimes include model rocket launching, reading and making paper airplanes. He can be reached at Krich876@AOL.com.

KARNA SANDLER is now in the sixth grade, attending Westland Middle School. She enjoys tennis, basketball, sailing, softball, and ice skating, and attends summer camp in Maine.

The Shad Project

Students strive to restore shad in the Potomac using a full shad system

by Michael Robinson and Trevor W. Swett

The Aqua Eagles Stream Team has become involved in the shad restoration project. We will raise and release American shad into the Potomac River. We have received a full shad system from the Chesapeake Bay Foundation. A full shad system is a very complicated aquarium for raising shad. It consists of many assorted pumps, filters, valves, and tubes attached to two tanks. The top tank is where the shad will live. The bottom cleans the upper tank. This happens when bacteria, housed in the lower tank, flow into the upper tank. Fortunately, these bacteria are not germs. They're good bacteria that help clean the upper tank.

Right now, the full shad system is running, but we have not gotten the shad yet. Before we put shad in the system, we have to run tests to see if the tank is working properly. Shad are extremely sensitive creatures. If you so much as touch them with a net in their aquarium, they will die. We are testing for ammonia, nitrite, nitrate, and pH levels in the water. Temperature also makes a difference. We may have to move the aquarium to a new area if the spot we have selected is too warm for the shad.

Shad have been called poor man's salmon because of their scrumptious roe and delicious meat. They used to be so common that people thought they could just pick them out of the water.

Shad Perils

Over-fishing and dams have taken their toll on the shad. Since 1963 the shad population has declined 94 percent in Maryland and 82 percent in Virginia.

If we do our part, the shad will once again be abundant in the Potomac.

To help you understand how dams and overfishing are endangering the shad, we'll tell you a bit about the shad's lifecycle. After the shad are born in the Potomac River, they migrate to the Atlantic Ocean. There they stay for three to five years. Then they return to their spawning grounds to lay their eggs. Unfortunately, blockages like dams sometimes stop them from getting there. This is a major problem; if the shad die before they spawn, soon there will be no more shad. Also, shad refuse to spawn unless there is a large population of shad around them. This means that overfishing can destroy the shad population too. Our shad will be marked with a chemical so that they can be identified later.

Recently, people have been making hatcheries to try to reintroduce shad to the Potomac. But there are not enough of these facilities. This is where we come in.

We are the only elementary school in Maryland that is a part of this pilot program. A middle school and a high school are also involved. A few of our members helped release shad last year.

A Tribute To the Project

As a tribute to the shad project we planted five shadbushes next to our stream. Shadbushes were given their name because they bloom at the same time the shad migrate. [Shadbush, or serviceberry, is the common name for about 25 species of shrubs or small trees, genus *Amelanchier*, belonging to the rose family, *Rosaceae*.]

We cannot save the shad alone. We need your help. If we do our part, the shad will once again be abundant in the Potomac.

Westbrook Elementary's Aquaculture Project

Westbrook was chosen to be part of a pilot aquaculture project to raise shad larvae in the school and release them as part of an extensive shad restoration project in the Potomac River. We are the only elementary school that was part of this adventure!

The Chesapeake Bay Foundation, the Montgomery and Prince George's County Stream Teams, and the Harrison Lake Hatchery were project sponsors.

Several members of Westbrook's Stream Team wrote a mini-grant to the Chesapeake Bay Trust to request funding for the large aquarium system that was required. Students helped to set up our "full shad system" on April 11, 1996. Shad were raised and released May 1996. Aqua Eagle Stream Team representatives collected shad data with local watermen on the Potomac River after sunset on April 26, 1996.

We just found out that we will be able to participate in the Shad Release Program again this year. Westbrook Stream Team will host the kick-off and education forum on shad on Saturday, April 19, 1997.

-Sandi Geddes, Westbrook Elementary teacher, Bethesda, Maryland

For further information see the Westbrook Elementary School homepage at http://www.mcps.k12.md.us/schools/westbrookes/shadstory.html.

The Authors

MICHAEL ROBINSON is a sixth grader at Pyle Middle School in Bethesda, Maryland. While at Westbrook Elementary School, he was actively involved in the Stream Team and the Shad Release Program. His family is a member of the Sierra and the Potomac Appalachian Trail clubs. He can be reached at Sjrobins@erols.com.

TREVOR W. SWETT, 11, also a former Westbrook Elementary student now attends Saint Albans School in Washington, D.C. He wants to be a writer or a scientist.

Shad Bites

Shads Make a Splash in Iceland

Two scientists won high honors in late September 1996 for their research on alosines (members of the shad family) which they presented at the 84th Annual Science Conference of the International Council for the Exploration of the Sea (ICES) in Reykjavik, Iceland. Scientists around the world gathered at the conference to present papers and posters in 20 theme sessions and attend committee meetings, mostly concerning North Atlantic fishery issues. Few papers dealt with the alosines, but two of these gained conference honors. Overall best paper was awarded to Delphine Martin of Cemagref at Bordeaux, France for "Global model of the dynamics and ecology of the population of allis shad (*Alosa alosa*) in the Gironde-Garonne-Dordogne watershed." In the Anadromous/Catadromous theme session, Richard St. Pierre of the U.S. Fish and Wildlife Service in Harrisburg, Pennsylvania was awarded best paper for his presentation on American shad (*A. sapidissima*), "A recipe for success: Anadromous fish restoration in the Susquehanna River."

For further information contact Richard St. Pierre at R5FFA_SRC@mail.fws.gov or Delphine Martin at Martin@Bordeaux.Cemagref.fr. ❐

First Rappahannock ShadFest

The Chesapeake Bay Foundation and the Friends of the Rappahannock will sponsor their first ShadFest on April 19, 1997 in Fredericksburg, Virginia. This outdoor family event of food and fun will be centered around the theme of restoring fish

(continued on back cover)

NEW CHARTER MEMBERS OF THE SHAD FOUNDATION

The Shad Foundation welcomes its new individual and corporate members and invites you to become a charter member*.

Jim Norris, Port Townsend, Washington, USA
Mizanur Rahman, Bergen, Norway
Michael Dadswell, Wolfville, Nova Scotia, Canada
Judith D. Shardo, Mobile, Alabama, USA
U.S.G.S. Research and Development Laboratory, Wellsboro, Pennsylvania, USA
Upper Delaware Council, Inc., Narrowsburg, New York, USA
Melissa Grader, Turners Falls, Massachusetts, USA
Matthew J. O'Donnell, Turners Falls, Massachusetts, USA
Clemon W. Fay, Indian Island, Maine, USA
Christian S. Hinrichsen, Seattle, Washington, USA
Boyd Pfeiffer, Phoenix, Maryland, USA
Greg Garman, Richmond, Virginia, USA
Pennsylvania Fish and Boat Commission, State College, Pennsylvania, USA
Jill Leonard, Turners Falls, Massachusetts, USA
Phillip Bettoli, Cookeville, Tennessee, USA
Lenox Dick, Vancouver, Washington, USA
Richard St. Pierre, Harrisburg, Pennsylvania, USA
Connecticut Department of Fisheries Division, Old Lyme, Connecticut, USA
Connecticut River Coordinator, Sunderland, Massachusetts
Karin E. Limburg, Stockholm, Sweden
Newsdata Corp., Seattle, Washington, USA
Jorgen Skjeveland, Annapolis, Maryland, USA
Charles Paulsen, Lake Oswego, Oregon, USA

Charter membership is open through 1997

2/97

JOIN THE SHAD FOUNDATION by subscribing to the Shad Journal for $15

Your annual subscription of $15 includes an annual membership in the Foundation and four issues of the Shad Journal

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AFFILIATION(S) *(examples: Hudson River Foundation, Delaware River Shad Fishermen's Association, etc.)*

SHAD(S) OF INTEREST

INTEREST(S) IN SHAD *(examples: biology, sports fishing, commercial fishing, history, etc.)*

Make your check or money order for $15 U.S. payable to THE SHAD FOUNDATION, P.O. Box 21748, Seattle, WA 98111-3748 USA

Bites *(continued)*

passage on the Rappahannock River. Over 100 miles of shad and herring spawning habitat are blocked by the Embrey Dam. A bucket brigade "fish-lift" will be conducted if weather and the shad run cooperate. The festivities will include a traditional Virginia shad planking (roasting shad on fruitwood boards over an open fire).

For further information contact the Friends of the Rappahannock at 540-373-3448. ❒

Shad Fishing Tournament Offers Large Prizes

The 15th Annual Forks of the Delaware Shad Fishing Tournament will be held April 25-May 3, 1997 on the Delaware River near Easton, Pennsylvania. Grand prizes are $1,500 for 1st place, $1,000 for 2nd, and $850 for 3rd place, decreasing by $100 for subsequent places to $150 for 10th place. There are also prizes given daily and for the Women's Challenge. Participants can enjoy a fishing seminar and tackle swap, a kid's casting contest, a 4.5-mile shad run, and a shad cook out. Last year's first-place winner was John W. O'Hara of Quakertown, Pennsylvania, who landed a 7.03-pound, 25 5/8-inch-long shad. For conservation, the organizers discourage fishing in the vicinity of the newly constructed shad ladders and in the entire Lehigh River.

For further information, contact the tournament headquarters by phone at (610) 250-7136, or by mail at P.O. Box 907, Easton, Pennsylvania, 18044-0907. ❒

New Book on Shad Fishing

A new book out on shad sports fishing, "*Experience the World of Shad Fishing*," by Lenox Dick has landed on the shelves and is piquing the interest of Northwest fishers. Dick's book contains information on history, biology, fishing equipment, stream fishing, bank fishing, boats and anchoring for shad, where to catch shad in the U.S. and a chapter on boning shad. The book treats in detail sports fishing for American shad in the Northwest. It is available for $7.95 (U.S.) through Frank Amato Publications, P.O. Box 82112, Portland, Oregon. (503) 653-8108.

Submissions

ALL contributions must be DOUBLE-SPACED. Submissions via e-mail or on disk (Mac or DOS) are strongly encouraged. If e-mailing the contribution, you may need to split it up and send it as several messages. No message should exceed 1.7 megabytes. Scanned photographs should be e-mailed individually. Direct your contributions to Richard Hinrichsen, Editor-In-Chief, The Shad Journal, P.O. Box 21748, Seattle, WA 98111-3748 or to the e-mail address: hinrich@cqs.washington.edu.

Letters to the Editor and Articles. The Journal publishes letters, commentaries, histories, scientific articles, interviews, reviews, and philosophical and methodological items related to shad the world over. There are no page limits but authors are asked to edit their submissions for clarity and precision. Previously published items from other sources can be republished in the Journal if the contributor obtains permission of the author and the copyright holder, and clearly identifies the original publication. Articles translated into English sare also welcome.

Please do not include footnotes or references in the text. Choose 4-5 of the most relevant references for inclusion at the end of the article. References may include a World Wide Web address. Write a short description of the site and its location followed by its address (URL). Write a brief biographical statement which includes your interest in shad, and current work. Please include your e-mail address, fax number, phone number, and postal address.

News Briefings (Shad Bites). Submit brief news articles on developments relating to shad in your area. For upcoming meetings, submit a brief description, including title, a short paragraph on objectives and content, dates, location, registration requirements, and the meeting contact person's name, street address, and phone/FAX/e-mail address.

Obituaries. The Foundation will honor the memory of members and friends through obituaries. The obituary should describe the person's history (date and place of birth, professional address and title) and his/her involvement with shad.

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