Use of an Artificial Substrate to Capture Eulachon (*Thaleichthys pacificus*) Eggs in the Lower Columbia River

Marc D. Romano, Matthew D. Howell[1], and Thomas A. Rien

Oregon Department of Fish and Wildlife

17330 Southeast Evelyn Street

Clackamas, Oregon 97015

[1]Washington Department of Fish and Wildlife

2108 Grand Boulevard

Vancouver, Washington 98661

Abstract

Artificial substrates were used to collect eulachon *Thaleichthys pacificus* eggs in the lower Columbia River. Using this method, we collected eulachon eggs from river kilometer 56 to river kilometer mile 117. Catch per unit effort varied with sampling time and location. In areas that eggs were collected the bottom composition varied, yet was dominated by medium to fine sand. We conclude that in 2001 eulachon spawned over a wide range of the mainstem of the lower Columbia River. Further, we believe that artificial substrates can be a useful tool to assist in identifying eulachon spawning timing and location.

Introduction

The eulachon *Thaleichthys pacificus* is an anadromous fish that spawns in the lower reaches of 30 to 40 coastal rivers and streams from the Klamath River drainage in California, to the Bering Sea, Alaska. Most of these rivers and streams experience a pronounced spring runoff, or freshet (DFO 1999). The Columbia River supports one of the world's largest spawning populations of the species (DFO 1999), and is the site of an important commercial and recreational eulachon fishery. Commercial landings of eulachon have been highly variable. In 1948 and again in 1951 the commercial catch of eulachon in the Columbia River exceeded 450,000 kg, yet in 1992 and again in 1994 the commercial catch fell below 450 kg. A sharp decline in commercial landings occurred in 1990 and continued through 1999. It is unclear how much of the decline is due to a decrease in the number of spawning eulachon or a result of in-season adjustments to harvest regulations. However, the 2001 commercial eulachon fishery exceeded 79,400 kg and was considered to be quite strong (WDFW and ODFW 2001).

Little is known about the spawning distribution of eulachon in the mainstem lower Columbia River. Spawning generally begins in January or February and is completed by late April. Spawning adults however, have been observed in the river as early as December. Active spawning has been observed in tributaries of the Lower Columbia River, including the Cowlitz River, the Kalama River, the Lewis River, and the Sandy River (Smith and Saalfeld 1955). Eulachon eggs have been caught in plankton nets in the lower Columbia River but exact spawning locations have proved difficult to locate. Smith and Saalfeld (1955) identified two locations in the mainstem Columbia River as eulachon spawning locations (one upriver of the mouth of the Kalama River at river kilometer (RK) 117 and the other near RK 82). These findings were based on the presence of spent and partially spent fish in commercial catches from these areas.

Depending on her size, a female eulachon can produce from 17,000 to 60,000 eggs (Hart and McHugh 1944, Smith and Saalfeld 1955). Eulachon eggs are small, with an average diameter between 0.8 and 1.0 mm. Eulachon eggs contain a double membrane, the outer of which ruptures shortly after fertilization and remains attached to the egg by a single point, forming a short stalk or peduncle. The free edges of the outer membrane are highly adhesive and capable of sticking to substrate material (Hart and McHugh 1944). Smith and Saalfeld (1955) reported that eulachon spawn primarily over substrates of fine pea-sized gravel.

The lower Columbia River is routinely dredged to maintain a shipping channel minimum depth of 12.2 m and minimum width of 182 m. The U. S. Army Corps of Engineers (USACE) has proposed an increase in dredging operations to deepen the existing channel and accommodate larger vessels (USACE 1999). To assess potential impacts of channel deepening operations on eulachon, USACE contracted with the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW) to characterize the eulachon spawning run and larval emigration from the lower Columbia River. The objectives of the present study were to locate and characterize eulachon spawning sites within the proposed channel-deepening area.

If eggs are captured on an artificial substrate then it is reasonable to assume that adult fish are spawning in the immediate vicinity. Prior to this study, artificial substrates had not been used to catch eulachon eggs. Artificial substrates have been used to collect white sturgeon *Acipenser transmontanus* eggs in the Columbia River (McCabe and Beckman 1990, Parsley et al. 1993, McCabe and Tracy 1994) and rainbow (American) smelt *Osmerus mordax* eggs in Maine (Rothschild 1961). This method has proven to be a useful tool in identifying spawning locations of both species. We based our artificial substrates on the design of McCabe and Beckman (1990). Similar to eulachon eggs, white sturgeon eggs are demersal and highly adhesive. Eulachon eggs however are much smaller than sturgeon eggs and prior to this study it was not clear whether this would affect the results.

Methods

Study Area

Our study was conducted in the lower Columbia River, from RK 48.3 to RK 136.8 (near the mouth of the Lewis River; Figure 1). Several points throughout this area are being considered as potential channel deepening, or in-river disposal sites for the USACE channel deepening project (USACE 1999).

Artificial substrate construction

The artificial substrates used in this study were constructed following the methods outlined by McCabe and Beckman (1990), with the exception of the substrate material available for eggs to adhere. The frame was constructed from a 76 cm x 91 cm angle-iron outer-frame with strips of flat iron bar to provide support. Three strips of iron bar were welded into place on one side of the frame and three more were secured with nuts and bolts on the other side. Two 76 cm x 91 cm pieces of commercially available, low nap indoor-outdoor carpet material, placed back to back, were used as an egg adhesion surface. The carpet was secured in the frame by the two sets of flat iron bar. Securing the iron bar on one side of the frame with nuts and bolts facilitated easy removal of the carpet pieces. McCabe and Beckman (1990) utilized latex-coated animal hair material as an egg adhesion surface. Carpet material with a 2-4 mm nap depth was chosen as the egg adhesion surface for our study due to concerns that the depth of animal hair would make it difficult to find the smaller eulachon eggs.

Two different types of anchors were used to secure the substrates in place on the river bottom. A three fluke anchor constructed of steel bars (13 mm diameter), PVC pipe (8 cm diameter) and concrete, similar to those employed by McCabe and Beckman (1990) was used on several of the substrates. Other substrates were secured with a 20 lbs. pyramid shaped lead weight. Buoy lines were connected to all substrates to mark the location of placement. The length of the line used depended on the depth and velocity of the water. The set location of each substrate was recorded from a Global Positioning System (GPS) unit on board the deploy vessel. Upon retrieval the location of the substrate was once again taken from the onboard GPS unit to determine if the substrate had moved from its original placement location. No substrates were found to have moved significantly from their original locations.

Sampling methods

Sampling in the lower Columbia River using artificial substrates commenced on 26 February and lasted until 30 March 2001. We sampled from RK 48.3 to RK136.8, with at least two artificial substrates placed every 1.6 RK (except that only one substrate was placed between RK 59.6 and RK 61.2). We did not attempt to standardize or stratify substrate placement among depths or habitat types. Depths of sampling ranged from 0.9 to 12.8 m and distance from the riverbank ranged from 4.5 m to greater than 91.4 m. Sampling at greater depths was problematic because the substrates tended to get covered in silt when placed in deeper water. Generally, substrates placed deeper, and further from the riverbank tended to silt in the most, whereas substrates placed close to the riverbank in shallow water tended to silt in the least. This may be due to increased river velocity in deeper water, farther from the riverbank.

Our sampling effort was broken into three rounds. The first sampling round was conducted from 26 February – 28 February. Sampling in this round was limited to river kilometers 80.5 – 83.7, and only 7 substrates were set. In order to test artificial substrates as a viable means of catching eulachon eggs, substrates were initially placed in locations that were believed to be eulachon spawning locations (Smith and Saalfeld 1955). The second sampling round was conducted from 8 March – 14 March, and a total of 17 substrates were deployed. These were placed over a wider range of the river, from RK 86.9 – RK 109.4. During the final round of sampling, a more systematic approach was employed. Previously, substrates had been placed in areas believed to be possible eulachon spawning sites. For the final round, which lasted from 19-20 March substrates were set from RK 48.3 – RK 136.8, in an attempt to characterize spawning distribution over a larger area. At least two substrates were set every 1.6 km (except that only one substrate was placed between RK 59.6 and RK 61.2).

All substrates were left in the water for At least 18 h, to ensure that sampling occurred throughout an entire tide cycle and during both day and night. Most substrates were left out <24 h; however we were unable to retrieve one substrate on the first attempt and had to return at a lower tide. The particular substrate fished for 40 h. Additionally, two substrates were lost due to unknown causes.

The composition of bottom material at sites where eggs were caught was sampled using a Ponar grab sampler. Bottom samples collected in the field were brought back to the lab for analysis. In the lab, samples were dried and then passed through a series of sieves to determine particle size. The particle size of bottom material was classified using a modified Wentworth classification (Orth 1983). Some locations consisted of bottom material with a particle size that was too large to sample with the Ponar device. These locations were directly adjacent to rip rap riverbanks. They are listed as "large particles associated with rip rap" in the summary of bottom material. We do not know whether these sites are actually riprap or a naturally occurring, large particle substrate. Additionally, we were unable to sample the bottom material at three sites. One site (mouth of the Kalama River) had a river velocity that was too strong to sample with the Ponar device. Two other sites (mouth of Abernathy Creek) were dry due to a decrease in the river level when we returned to sample the bottom material.

Results

During the first sampling round, only seven substrates were placed. One of these substrates successfully caught eggs, for a success rate of 14.3%. The substrates fished for a total of 71.2 h (effort), and three eggs were caught, resulting in a catch per unit effort (CPUE) of 0.04 eggs/h for the sampling round. The average set depth was 7.0 m, and the average number of eggs caught per set was 0.43.

Among 17 substrates set during the second round of sampling, nine caught eggs, yielding a success rate of 52.9%. Effort totaled 449.3 h during this period for a CPUE of 0.17 eggs/h. This sampling period seemed to coincide with the peak of eulachon spawning activity (based on sport and commercial harvest activity). The average set depth was 4.7 m, and the average catch was 1.88 eggs/set.

For the final sampling round a total of 123 substrates were set and 13 sets caught eggs for a success rate of 10.6%. Effort totaled 2,691 h during this period for a CPUE of 0.02 eggs/h. The average set depth was 7.4 m, and the average catch was 0.36 eggs/set.

For the entire study 147 substrates were set, 23 of which successfully caught eulachon eggs for an overall catch success rate of 15.6%. A total of 122 eggs were caught for an average of 0.84 eggs/substrate. Egg catches on a single set ranged from zero to 27. The river bottom composition of sites where eggs were caught was varied, yet was dominated by medium to fine sand substrates (Table 1).

Discussion

Although we believe this is the first time artificial substrates have been used to collect eulachon eggs, they have been used to collect eggs of the rainbow (American) smelt (Rothschild 1961). Like eulachon, rainbow smelt are broadcast spawners, laying highly adhesive eggs that readily become attached to stream substrates. Rothschild (1961) used 3.1 x 12.7 cm strips of heavy canvas as an egg-depositional surface, attached to a glazed black ceramic tile (11.4 x 11.4 cm). Since 1988 artificial substrates have been used in the Columbia River to collect white sturgeon eggs (McCabe and Beckman 1990, Parsley et al. 1993, McCabe and Tracy 1994). Although the design employed by Rothschild (1961) was effective at catching smelt eggs, we chose to follow the design of McCabe and Beckman (1990) because it had been successfully used in the higher flows of the Columbia River.

We caught eulachon eggs over a larger area of the river (RK 56.3 to RK 117.5) than previously described to be spawning habitat (Smtih and Saalfield 1955). The area that we caught the highest concentration of eggs (between RK 90.1 and RK 98.2; Figure 1 and 2) has not previously been documented as a spawning location. This however, does not present a complete picture of eulachon spawning distribution in the river. The strength of the eulachon spawning run in the lower Columbia River varies throughout the course of a single season. CPUE may vary temporally depending on when the peak of spawning activity occurs. River kilometers sampled nearer to the peak of spawning activity (both spatially and temporally) may have greater CPUE. Daily CPUE ranged from 0 eggs/h of effort to 0.20 eggs/h of effort (Figure 3). The greatest daily CPUE occurred on 9 March (0.20 eggs/h of effort) and 13 March (0.16 eggs/h of effort). Sampling days that occurred before 9 March and after 13 March averaged less than 0.08 eggs/h of effort. This result must be interpreted cautiously because a single day of sampling was limited to a small area of the river. On any given day only a small section of the study area was sampled (most days approximately 9.7 river kilometers were covered). Thus observed temporal differences in CPUE may be influenced by daily spatial differences in sampling.

Although the catch was variable among sample times and sample locations, this study has shown that eulachon eggs can be caught using an artificial substrate. The presence of viable eggs is an indicator that spawning is occurring in the vicinity. Within our study area we caught the greatest number of eggs between RK 90.1 and RK 98.2 (Germany Creek to Barlow Point), and to a lesser extent RK 107.8 through RK 111.0 (mouth of the Cowlitz River to Cottonwood Island). We have also shown that spawning occurs at many points throughout our study area, from RK 56.3 (Price Island) to RK 117.5 (mouth of the Kalama River).

Dredging associated with channel deepening is unlikely to directly impact eulachon spawning areas. We were unable to sample using substrates within areas designated for channel deepening due to the dynamic nature of the bottom in these areas. In 2000 we attempted to fish several frames in areas proposed for deepening and the frames were quickly buried in sand, which made them ineffective and difficult to retrieve. This sort of substrate movement is typical in the sand wave environment found on the bottom of all the riverine areas proposed for channel deepening. Sand waves in this reach are generally large, with heights of 1.8-3.7 m and lengths up to 150-m (personal communication with Karl Eriksen, Portland District, USACE). Given the dynamic nature of channel substrates, we believe these areas do not provide stable surfaces that would allow an adhesive egg to incubate for 30 d. We considered that eggs incubating in near-shore areas in the proximity of dredging activities might be affected if these activities alter flow patterns or increase sedimentation. However, hydraulic models completed by USACE indicate dredging will not alter the river's flow patterns. The USACE also expects the average annual bedload transport in the main river channel to remain within the existing range of 75,000-300,000 m^3/yr (USACE 1999). While more intensive sampling using egg substrates over multiple years would allow us to better identify and characterize long-term eulachon spawning sites and relative levels of use among areas, we do not believe this information is needed to assess impacts of channel-deepening activities that have been proposed. To reduce unforeseen impacts on eulachon eggs, channel-deepening operations could be scheduled to avoid areas in which we caught the greatest number of eulachon eggs during the typical peak spawning period.

Acknowledgements

We thank Peter Barber, Brad Cady, Jody Gabriel, Robin Mills, Francesca Saenz, and Steve West for assistance in field collection of the data. John DeVore (WDFW), Nancy Uusitalo (WDFW), and David Ward (ODFW) helped with initial study conception, design, and analysis of data. Brad James (WDFW) reviewed a draft of this manuscript. Kim Larson (USACE) provided assistance as project manager. This work was funded by the U. S. Army Corps of Engineers (contract W66QKZ 10745277).

References

DFO. 1990. Eulachon. DFO Science Stock Status Report. Department of Fisheries and Oceans, Canada.

Hart, J. L., and J. L. McHugh. 1944. The smelts (Osmeridae) of British Columbia. Bulletin of the Fisheries Research Board of Canada 64:1–27.

McCabe, G. T., Jr., and L. G. Beckman. 1990. Use of an artificial substrate to capture eggs of the white sturgeon. California Fish and Game 76:248–250.

McCabe, G. T., Jr., and C. A. Tracy. 1994. Spawning and early life history of white sturgeon, *Acipenser transmontanus*, in the lower Columbia River. Fishery Bulletin 92:760–772.

Orth, D. J. 1983. Aquatic Habitat Measurements. Pages 61-84 *in*: L. A. Nielsen and D. L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland.

Parsley, M. J., L. G. Beckman, and G. T. McCabe, Jr. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122:217 – 227.

Rothschild, B. J. 1961. Production and survival of eggs of the American Smelt, *Osmerus mordax* (Mitchill), in Maine. Transactions of the American Fisheries Society 90:42-48.

Smith, W. E., and R. W. Saalfeld. 1955. Studies on Columbia River smelt *Thaleichthys pacificus* (Richardson). Fisheries Research Papers 1(3): 2-23, Washington Department of Fisheries, Olympia, Washington.

USACE. 1999. Integrated Feasibility Report for Channel Improvements and Environmental Impact Statement. U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

WDFW and ODFW. 2001. Washington and Oregon Eulachon Management Plan. Washington Department of Fish and Wildlife, Olympia, WA.

Table 1. Summary of artificial substrate data for sites where eggs were caught. Bottom composition data based on a modified Wentworth classification.

River kilometer	Date	Depth (m)	Eggs	CPUE (eggs/h)	Bottom composition
56.3	3/29	11.6	3	0.14	large particles associated w/ rip rap
57.9	3/29	9.4	5	0.24	medium to fine sand
74.0	3/26	8.5	1	0.05	coarse to medium sand with pebbles
77.2	3/26	9.4	1	0.05	mixed cobble and pebbles
78.9	3/26	9.1	1	0.05	medium to fine sand
80.5	3/25	4.6	1	0.05	coarse to medium sand
82.1	2/27	12.8	3	0.13	pebble
86.9	3/8	1.8	1	0.03	no sample taken
86.9	3/8	1.8	3	0.10	no sample taken
90.1	3/8	3.0	18	0.62	cobble and pebble mix
90.1	3/8	7.6	2	0.07	medium to fine sand
91.7	3/19	9.8	11	0.49	medium to fine sand
93.3	3/19	7.3	3	0.13	medium to fine sand
93.3	3/8	4.6	2	0.07	large particles associated w/ rip rap
95.0	3/19	8.5	2	0.09	medium to fine sand
96.6	3/8	4.0	14	0.51	medium to fine sand
98.2	3/12	0.9	3	0.13	medium to fine sand
98.2	3/12	12.8	27	1.20	medium to fine sand
99.8	3/21	4.0	1	0.04	medium to fine sand
107.8	3/23	5.5	4	0.15	medium to fine sand
109.4	3/8	2.7	5	0.19	medium to fine sand
111.0	3/23	8.2	10	0.37	medium to fine sand
117.5	3/20	9.8	1	0.05	no sample taken

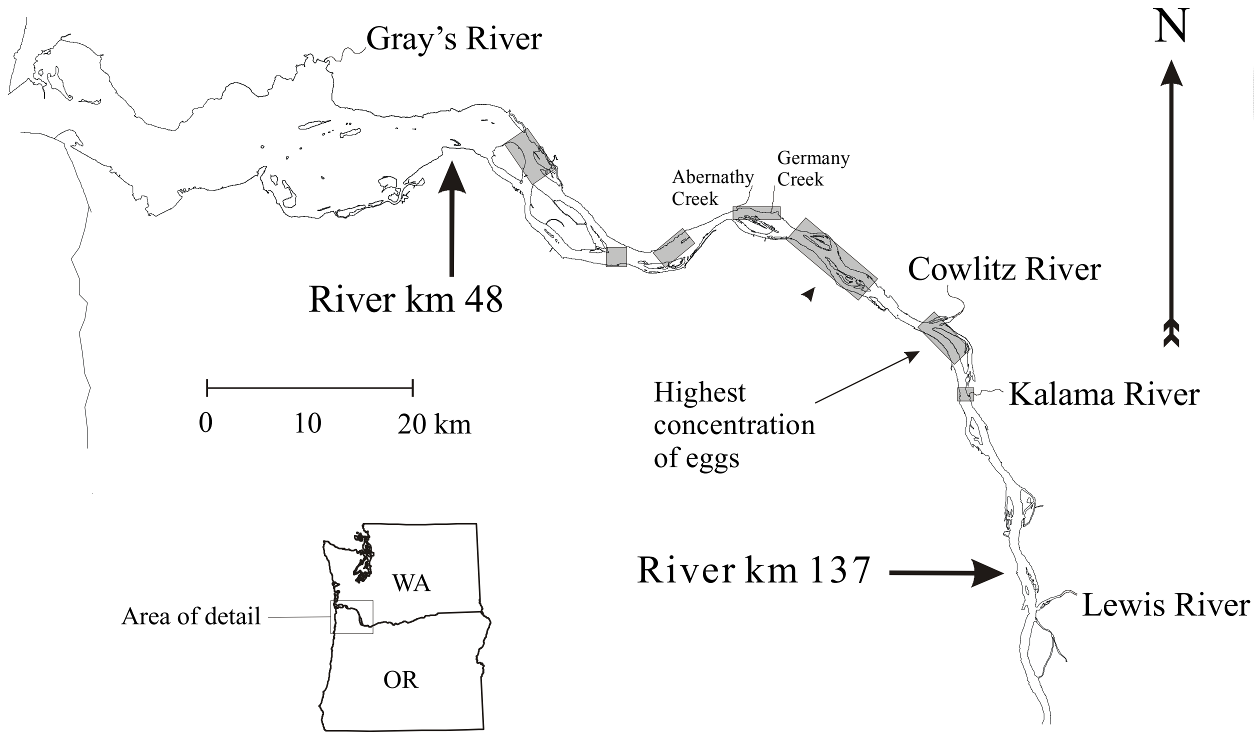

Figure 1. Artificial-substrate smpling was conducted from RK 48 – 137 in the Columbia River. Shaded areas indicate sampling sites where eulachon eggs were successfully captured 27 February – 29 March 2001.

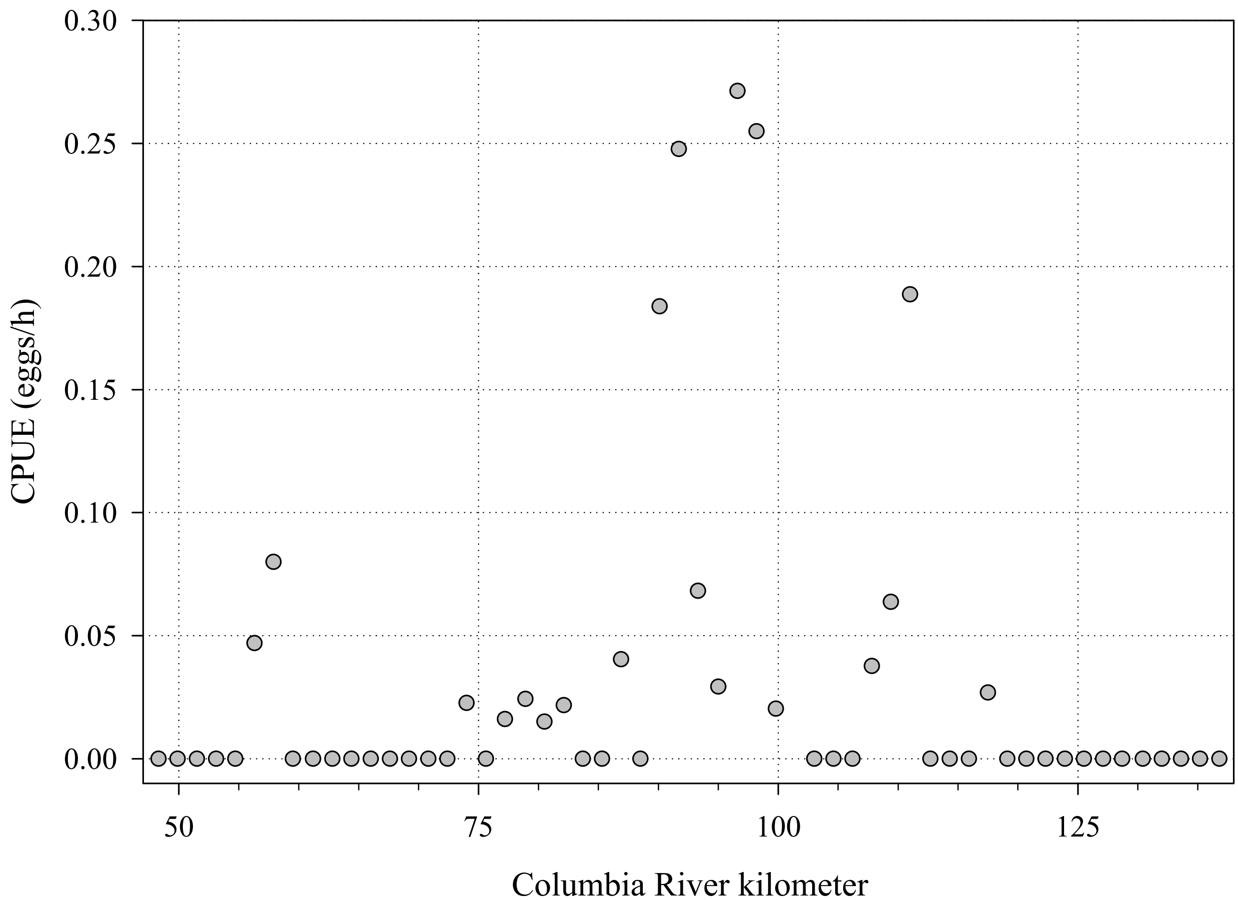

Figure 2. Egg catch/h for each river 1.6 kilometers sampled. Sampling was conducted between river kilometers 48 and 137.

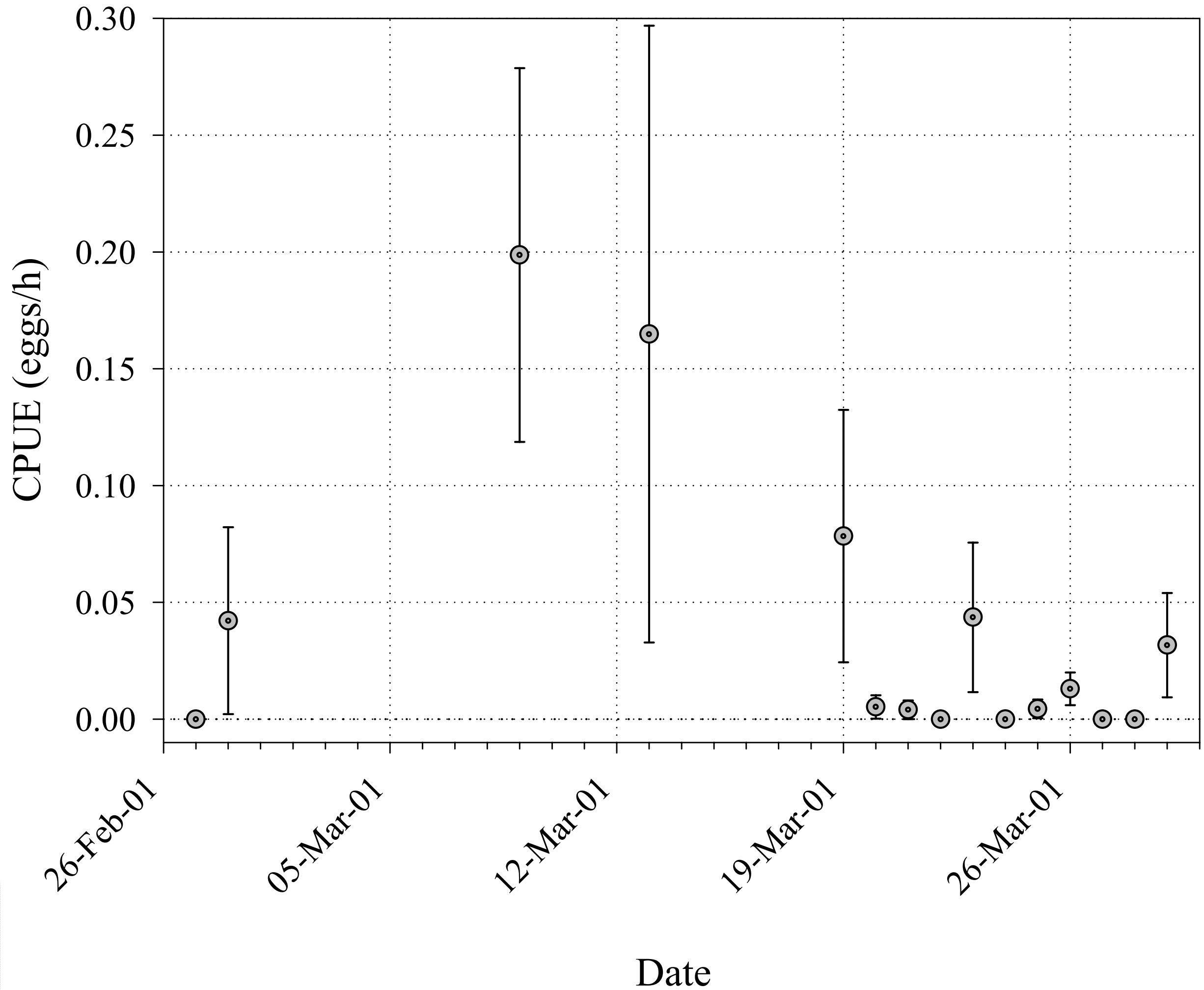

Figure 3. Egg catch/h listed by date each artificial substrate was retrieved. No substrate frames were examined 1-8, 10-12, or 14-18 March 2001. Error bars represent one standard error.