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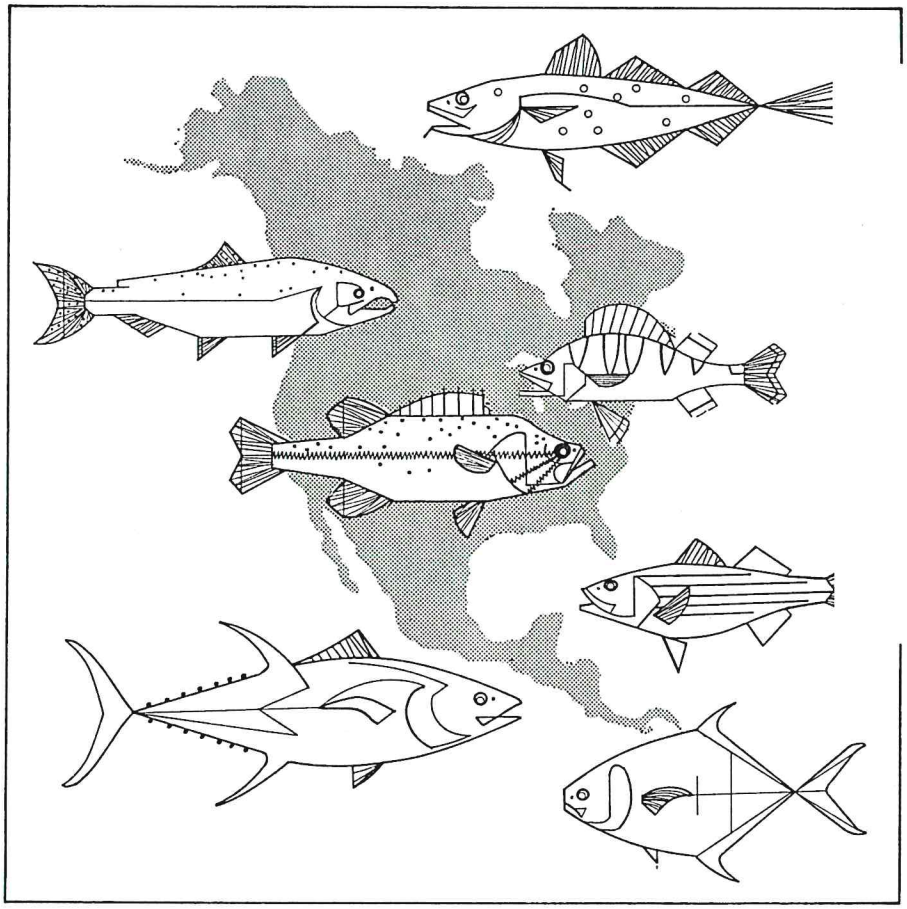

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NOTES

Occurrence of Grass Carp in the Lower Columbia and Snake Rivers

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Abstract.—Forty-nine adult grass carp *Ctenopharyngodon idella* were observed migrating upriver past lower Columbia and Snake river hydroelectric dams between August 1, 1996, and September 30, 1997, representing the first recorded sightings of this fish species in this system. From videotape records and visual counts, grass carp were estimated to range between 55 and 77 cm in total length (TL). One 7.7-kg, 86-cm individual captured in a gill net was identified as a sterile triploid. Although the source of these fish is unknown, their appearance in the Columbia and Snake rivers might have been related to extensive flooding that occurred in western Washington and Oregon in February 1996. The unintentional escape of grass carp into this large river system reemphasizes the need for the current requirement that all grass carp stocked in Pacific Northwest lakes be sterile triploids. It also suggests that increased attention to effective barrier construction and maintenance is important to prevent grass carp impacts in nontarget areas.

Grass carp *Ctenopharygodon idella* have been used extensively for aquatic macrophyte control in the United States since they were introduced from Asia in the early 1960s (Guillory and Gasaway 1978). Fertile, diploid grass carp were stocked in initial treatments, and because of the unknown potential impact to native fish and wildlife species, many states prohibited their use. However, in the 1980s, sterile triploid grass carp were developed (Leslie et al. 1987), and since then, the use of sterile grass carp has greatly expanded.

Grass carp have been stocked in Pacific Northwest lakes for almost two decades. Diploid grass carp were stocked illegally in many small ponds during the 1970s, and confiscated records of these stockings enabled state agencies to treat as many ponds as possible with the piscicide rotenone to remove these fish. Research was conducted in the 1980s on the efficacy of sterile triploid grass carp for aquatic plant control in the Pacific Northwest (Bonar 1990; Bonar et al. 1993; Pauley and Bonar 1996). Stocking sterile triploid grass carp was legalized in Idaho in 1988 (Idaho Fish and Game Commission, unpublished, 1988) and Washington in 1990 (Bonar 1994). Oregon has not allowed grass carp stocking except for one research site, Devils Lake near Lincoln City.

In 1996 and 1997, grass carp were identified migrating past several lower Columbia and Snake river dams, representing the first sightings of this species in the Columbia–Snake river system. The objectives of our study were to (1) report the first occurrence of these fish in this river system, (2) discuss sizes and locations of fish in the system, and (3) discuss potential implications of the escape of grass carp.

Methods

Fish passage at dams on the Columbia–Snake river system is recorded by both visual and video counts. Since the completion of fishway facilities at Bonneville Dam in 1938 (Clay 1995), fish counts have been conducted annually by the U.S. Army Corps of Engineers (USACE). In 1985, the Washington Department of Fish and Wildlife (WDFW) was contracted by USACE to monitor fish passage at Columbia and Snake river projects. At the time of this study, fish counting was conducted by WDFW personnel from Bonneville Dam to McNary Dam on the lower Columbia River and from Ice Harbor Dam to Lower Granite Dam on the Snake River (Figure 1).

Visual counts.—During 1996 and 1997, visual counts were made 16 h/d between 0400 and 2000 hours, Pacific Standard Time, April 1 through October 31 at Bonneville, The Dalles, John Day,

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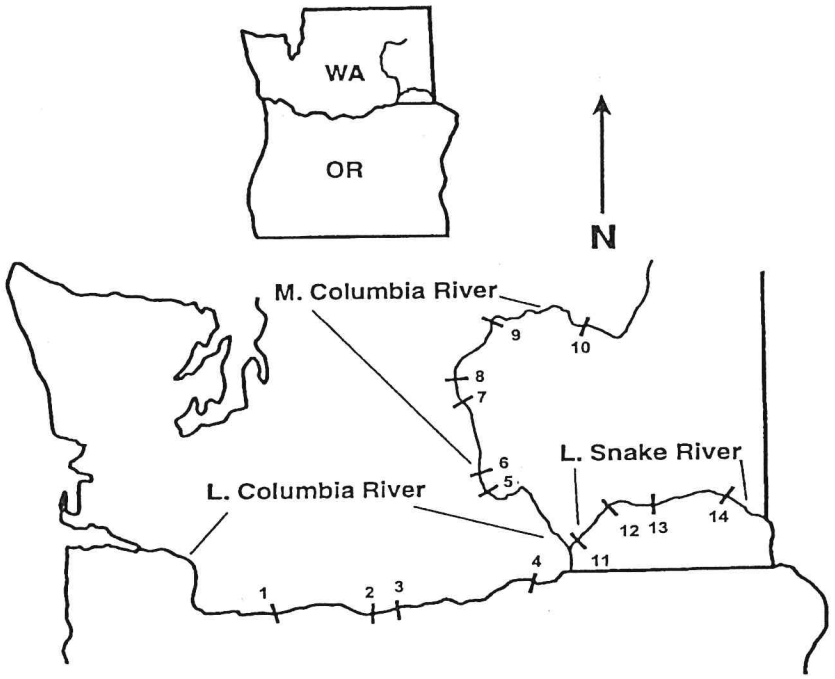

FIGURE 1.—Location of dams on the lower and middle Columbia River and lower Snake River, Washington (WA) and Oregon (OR). Lower (L.) and middle (M.) Columbia River dams are (1) Bonneville, (2) The Dalles, (3) John Day, (4) McNary, (5) Priest Rapids, (6) Wanapum, (7) Rock Island, (8) Rocky Reach, (9) Wells, and (10) Chief Joseph. Lower Snake River dams are (11) Ice Harbor, (12) Lower Monumental, (13) Little Goose, and (14) Lower Granite.

McNary, Ice Harbor, and Lower Granite dams. These counts were designed specifically to monitor migration of salmonids *Oncorhynchus* spp., but other species were recorded as well.

There were two fish count stations—one at each fish ladder—at each lower Columbia River dam and at Ice Harbor and Lower Monumental dams on the Snake River. At Little Goose and Lower Granite dams on the lower Snake River there was only one count station per dam. Technicians identified and counted individual fish moving upstream or downstream past a window.

Nylon lines divided the counting window into a grid, allowing size of fish migrating past the window to be ascertained, and the observed fish were categorized into one of several length-groups (e.g., 36, 46, 56, and 61 cm). A technician visually counted fish at all projects for the first 50 min of each hour for two shifts of 8 h (16 h/d). The visual counts were multiplied by 1.2 to estimate hourly passage.

Video monitoring.—At Bonneville, Ice Harbor, and Lower Granite dams, both visual and video monitoring of fish passage was conducted, whereas at Lower Monumental and Little Goose dams only video counts were obtained. Schedules for video counts were as follows: Bonneville Dam, year-round, 24 h/d; Ice Harbor Dam, November 1 to December 15, 24 h/d; Lower Granite Dam, March 1 to December 15, on a sampling schedule that varied from 8 to 24 h/d; and Little Goose Dam and Lower Monumental Dam, April 1 to October 31, 16 h/d. Panasonic[1] color video cameras (model WV-D5100) were used to record fish passage. The cameras, directed at the counting windows, had a field of view of about 1 × 1.5 m (from bottom of window to top). Each camera was attached to a Panasonic (model AG6720A) video recorder (48-h mode; 2.5 frames/s). Technicians changed tapes as needed. All videotapes were viewed with a Panasonic (model AG1960) VCR editor. Data from videotapes were analyzed similarly to visual counts except that video counts were conducted

[1] Mention of a product or trade name does not constitute endorsement.

TABLE 1.—Number of confirmed sightings of grass carp by fish counters at lower Columbia and Snake River dams, 1996 and 1997. Location numbers relate to Figure 1. No grass carp were sighted from December through June in either year.

Dam (map location)	Rkm[a]	1996					1997					Total
		Jul	Aug	Sep	Oct	Nov	Jul	Aug	Sep	Oct	Nov	
Bonneville (1)	232	0	2	6	4	0	1	1	7	0	0	21
The Dalles (2)	306	0	1	9	3	0	2	0	4	0	0	19
John Day (3)	346	0	0	0	1	0	0	0	0	0	0	1
McNary (4)	467	0	0	0	0	1	0	0	0	0	0	1
Priest Rapids (5) through Chief Joseph (10)		0	0	0	0	0	0	0	0	0	0	0
Ice Harbor (11)	534	0	0	2	1	0	0	0	0	0	0	3
Lower Monumental (12)	586	0	0	0	0	0	0	1	0	0	0	1
Little Goose (13)	630	0	0	0	2	0	0	0	0	0	0	2
Lower Granite (14)	691	0	0	0	1	0	0	0	0	0	0	1
Total		0	3	17	12	1	3	2	11	0	0	49

[a] Rkm = river kilometer (measured as distance from mouth of Columbia River).

for complete hourly periods with no adjustment to fish counting information.

Grass carp identification was confirmed by WDFW and Oregon Department of Fish and Wildlife (ODFW) fisheries biologists from two live fish caught by commercial gill-net fishers and from analysis of photographs made from individual frames from the videotapes. One of the grass carp captured was tested for ploidy on a Coulter model Elite Flow Cytometer.

Results and Discussion

Confirmed sightings of grass carp were made at Columbia and Snake River dams between August and November in 1996. At Bonneville Dam, an unconfirmed sighting of a grass carp was first reported by a fish counter on the Oregon shore in late April 1996. However, no confirmed sightings were made until August of that year (Table 1). In August, fish counters observed 20 fish thought to be grass carp at Bonneville Dam; however, only two could be verified. Similarly, 12 fish thought to be grass carp were observed at The Dalles Dam, and three were seen at John Day Dam during August. Only one of these could be verified at The Dalles, and none seen at John Day could be confirmed. Both videotapes and visual identifications by biologists familiar with grass carp taxonomy confirmed their presence during August. By September, all technicians were acquainted with the distinguishing characteristics of the grass carp, and the fish were observed from Bonneville Dam on the Columbia River to Lower Granite Dam on the Snake River (Table 1). No fish were observed at Priest Rapids Dam or any other dams upstream on the Columbia River (C. Carlson, Grant County Public Utility District, personal communication). The last grass carp recorded in 1996 was in November at McNary Dam. All grass carp were observed moving up river.

In 1997, 16 grass carp were observed moving upriver between July and September. Fifteen of these passed through lower Columbia River dams, whereas one was observed at Lower Monumental Dam on the Snake River. As in 1996, no grass carp were observed at Priest Rapids Dam or any other dams upstream from there on the Columbia River (C. Carlson, personal communication).

Grass carp adults observed at Bonneville Dam in 1996 ranged from 55 to 77 cm TL. Similarly, technicians on the Snake River observed grass carp between 55 and 71 cm TL. Total lengths were not measured at other dams; however, all reported grass carp were adults, and no juveniles were observed. In 1997, all grass carp observed at lower Columbia River dams ranged from 66 to 77 cm. The single individual observed at Lower Monumental Dam on the Snake River in 1997 was 66 cm.

Two grass carp specimens were recovered by the ODFW in 1996 above Bonneville Dam. One grass carp (2.6 kg) had been given to ODFW biologists in June by a commercial gill-net fisherman. The second (7.7 kg, 86 cm TL) was collected near Skamania Island above Bonneville Dam in September. A ploidy analysis, conducted by using flow cytometry, revealed that the Skamania Island specimen was a triploid.

The origin of the grass carp in the lower Columbia and Snake rivers is unknown. Regulations in both Idaho and Washington dictate that all imported grass carp must be triploids, and fish cannot

be stocked in systems with inlets or outlets unless they are screened. Most Washington waters stocked with grass carp are located around the Puget Sound and are less than 4 ha (Bonar et al. 1996), and Oregon does not allow the stocking of grass carp. However, fish have been stocked in ponds and lakes within the Columbia–Snake river drainage. The largest of these sites, Silver Lake, Washington (668 ha), was stocked with 83,000 triploid grass carp in 1992 (Scherer et al. 1995). Silver Lake drains into the Toutle River, which drains into the Cowlitz River and, in turn, into the Columbia River below Bonneville Dam (Figure 1). At the outlet of Silver Lake, there is a barrier to prevent grass carp from escaping into the Toutle River. In February 1996, significant flooding occurred in western Washington and Oregon along the Columbia River because of heavy rains. Water levels of Silver Lake and other water bodies in the Columbia River watershed rose, which could have allowed grass carp to escape to the river system.

The size range of grass carp captured in Silver Lake during an August 1996 electrofishing survey (60–77 cm TL; S. Bonar and J. Weinheimer, WDFW, unpublished data) was similar to that of grass carp seen in the lower Columbia River (56–76 cm TL). If grass carp escaped from site(s) downstream of Bonneville Dam in April 1996, they migrated more than 450 km in 2–7 months.

Diploid grass carp were stocked illegally in a few Washington and Oregon ponds in the Columbia River drainage during the 1970s and 1980s. Six grass carp, ranging from 9.5 to 16 kg, were bowhunted from the Tualatin and Yamhill rivers in Oregon, which drain into the Willamette River and ultimately into the Columbia. One of these, a 13-year-old, 12-kg specimen, was identified as a female diploid (K. Daily, ODFW, unpublished data). In 1988, WDFW biologists treated two ponds with rotenone in Kennewick, Washington, to remove illegally stocked grass carp of unknown ploidy. These ponds had unscreened outlets and were connected to the Columbia River (E. Anderson, WDFW, unpublished data). Given the size range of the fish seen at the fish ladders in the Columbia and Snake rivers, it is unlikely that they are from early diploid stockings. Diploids stocked in the 1970s would probably have been larger than the fish reported. Also, if the grass carp seen were offspring of diploid fish, their sizes would probably have been more variable, and juveniles would have been reported.

Management Implications

If the grass carp reported from the Columbia were sterile, it is unlikely that the few fish discovered would have significant impacts on the river system. The Columbia River is the 19th largest in the world, draining an area of 668,000 km^2 (Van der Leeden et al. 1990). Many of the reservoirs in the system have extensive aquatic plant coverage. Substantial grazing by a huge number of fish would be necessary to reduce the populations of these aquatic plants and cause significant impacts.

Reproducing grass carp populations have been reported to be established in river systems east of the continental divide (Conner et al. 1980; Courtenay et al. 1984; Brown and Coon 1991). Diploid grass carp were stocked extensively within many of these eastern watersheds. In contrast, few ponds were stocked with diploid grass carp in Washington and Oregon; when discovered, these illegal stockings of diploid grass carp were eliminated by state agencies. Diploid grass carp are able to reproduce successfully in large river systems containing a turbulent area with a volume of roughly 400 m^3/s for spawning, a current of 0.8 m/s or more to suspend the grass carp eggs and transport them downstream, and a suitable rearing area downstream, near the place of hatching, to protect the young from predators (Stanley et al. 1978). Presumably, portions of the Columbia–Snake river system would contain suitable spawning and rearing habitat for diploid grass carp.

Researchers have reported that the probability of successful reproduction of triploid grass carp, those currently permitted for stocking in Washington and Idaho, is virtually nonexistent. Allen et al. (1986) examined the products of male meiosis from triploid grass carp and estimated that the reproductive likelihood of competent sperm types from a triploid grass carp uniting with an egg from a *diploid* fish and producing a reproductively capable adult was 4×10^{-11} for every meiotic reduction of hexaploid spermatogonia under ideal conditions. Van Eenennaam et al. (1990) found that triploid grass carp semen was capable of fertilizing eggs obtained from diploid females. However, survival of diploid female × triploid male larvae from hatch to juvenile was lower than in diploid × diploid crosses by at least a factor of 560. They concluded that although triploid males potentially could participate in mating and spawning under natural conditions, they may be regarded as functionally sterile. A study that tested the suc-

cess for triploid × triploid crosses found that the very few offspring produced by triploid parents were grossly deformed and all died within 2 d posthatch (C. C. Starling, Florida Game and Fresh Water Fish Commission, unpublished, 1987).

The unintentional escape of grass carp into this large river system reemphasizes the need for the current requirement that only sterile, triploid grass carp be stocked into Pacific Northwest lakes. We recommend that all grass carp captured in the rivers be removed and not released back to the system and that the ploidy of these individuals be determined. Further monitoring of fish passage to detect juvenile grass carp would help determine if any reproduction is occurring due to presence of diploid individuals.

Increased vigilance is necessary to help reduce the number of triploid grass carp escaping into river systems. Construction of barriers to prevent triploid grass carp from migrating out of lakes is currently a requirement for stocking the fish in Washington and Idaho. Increased attention to effective barrier construction and maintenance is important to avoid impacts to aquatic macrophytes in nontarget areas and the loss of expensive grass carp from areas where aquatic plant control is desired. Moreover, further consideration should be given to the location and type of water bodies stocked with grass carp. In flood-prone lakes and ponds, plant control methods other than triploid grass carp should be carefully considered before using these fish.

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