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ABSTRACT

During April through August, 2000, a variety of fishing gears were used to capture adult, juvenile, larvae, and eggs of green sturgeon *Acipenser medirostris* and white sturgeon *Acipenser transmontanus* in the Rogue River, Oregon. We set 78 gill nets for an average 38 minutes and captured 38 individual green sturgeon (136-202 cm fork length) and eight white sturgeon (125-168 cm). Most adult sturgeons were tagged with spaghetti and passive integrated transponder (PIT) tags and 19 adult green sturgeon were radio tagged at capture. On 65 baited setlines fished overnight we captured only one white sturgeon (145 cm). No sturgeon were caught during eight hours of hook and line angling by staff. However, a volunteer angler captured 21 green sturgeon (154-205 cm) during September through early November. Fishing effort by staff (gill nets, setlines, and angling) occurred between river kilometers (RKM) 10 and 45; the effort was not uniform or random because river conditions only allowed gears to be fished effectively at several sites. The volunteer angler caught all green sturgeon between RKM 42 and 105. Beach seining conducted in an unrelated study captured 12 juvenile green sturgeon in 689 sets fished mid July through October at RKM 12.9.

No eggs or larvae of green or white sturgeon were collected during seven overnight sets of egg substrates or during 42 18-minute D-ring plankton net sets. These gears were difficult to fish with our small vessel in areas that seemed suitable for spawning.

Historic data from Columbia River commercial gillnetting and Rogue River beach seining are summarized in appendices. Data on morphological and meristic measurements collected from 50 green sturgeon captured in the 1999 Columbia River commercial gill net fishery are summarized as well.

INTRODUCTION

Relatively little is known about the biology and life history of green sturgeon *Acipenser medirostris* and there is widespread concern and uncertainty regarding its status. Green sturgeon are classified as a species of special concern by the U. S. Fish and Wildlife Service and California Department of Fish and Game (where the species was proposed for Class 1 "Threatened" listing) and as “rare” in Canada but have no special status in Washington or Oregon. The green sturgeon and Russian Sakahlin sturgeon *Acipenser mikadoi* (either a closely related species or a stock of green sturgeon) are the focus of a joint project by Russian and Oregon Department of Fish and Wildlife (ODFW) biologists due to their decline in abundance and spawning distribution.

The harvest of green sturgeon in Oregon has, until recently, been managed without the benefit of a comprehensive statewide investigation of population status. Most green sturgeon harvest occurs in the lower Columbia River, Oregon and Washington, and in Willapa Bay and Gray's Harbor, Washington. Sport harvest averaged less than 350 fish annually between 1985-1997 (San Francisco Bay to Gray's Harbor) while commercial and tribal harvests averaged almost 3,150 fish.

In 1999, the Oregon Department of Fish and Wildlife initiated a multi-year project to increase the understanding of green sturgeon population characteristics, distribution, and status in Oregon. The specific objectives of the project are to:

1. Summarize and analyze existing information on green sturgeon.

2. Describe characteristics of adult populations in the Columbia, Umpqua, and Rogue rivers.

3. Describe spawning and recruitment in the Umpqua and Rogue rivers.

This report serves to document current progress toward these objectives**.** Emphasis is placed upon field activities performed on the Rogue River during spring/summer 2000**.** Currently, the Rogue River is the only system in Oregon known to support green sturgeon spawning (Wang 1986; Moyle et al. 1995) based primarily on incidental capture of juveniles during salmonid monitoring studies. Progress toward Objective 1 is summarized as tabulated data, figures, and bibliographic references in Appendixes A-F.

METHODS

Rogue River 2000 Field Sampling

The Rogue River is located in southwest Oregon and flows 346 kilometers from its headwaters near Crater Lake to the Pacific Ocean at Gold Beach (Figure 1). Field sampling for adult and juvenile green and white sturgeon *Acipenser transmontanus* was conducted from early April through late July, 2000 in the lower 46 km of the Rogue River from Gold Beach to Agness.

Adult Sampling

Setlines:

During April – June 2000, we fished 65 setlines between the Kimball Bend at river kilometer (RKM) 12.9 and Copper Canyon (RKM 39.4) for an average of 25.28 h/set (Table 1, Figure 2). This gear is effective at capturing white sturgeon in the Lower Columbia River but has not been proven for green sturgeon. High flows in the early part of the season prohibited the use of gill nets, so setlines were our best option for capturing adult green sturgeon. Setlines consisted of 24 baited hooks along a 61-m mainline of 6-mm multi-strand nylon rope. Lines were marked with paint at 2.4-m intervals to aid in hook placement. To target adult fish, we used 12/0, 14/0, and 16/0 circle hooks attached to hook clips with either #42 or #72 braided ganion line (Rien et al. 1994). Hooks were baited with pieces of Pacific lamprey *Lampetra tridentata*, Pacific herring *Clupea harengus*, northern anchovy *Engraulis mordax*, eulachon *Thaleichthys pacificus*, sand shrimp *Callianassa californiensis*, or pickled squid *Loligo spp.* Setlines were weighted with 9-14 kg pyramid-style anchors at each end in addition to several 0.5-2.3 kg weights interspersed along the line. One end was attached to shore with a leader rope to facilitate in recovery and to ensure gear was not lost. Lines were generally fished overnight.

Large-Mesh Experimental Gillnets:

From May – August 2000, we deployed 78 gill nets between the Highway 101 bridge (RKM 1.7) and Agness (RKM 44.6; Figure 2). Nets were fished an average of 0.63 h/set (Table 1). Initially, we planned to restrict gill-net sampling to the months of March, April, and July to reduce potential handling of spring chinook *Oncorhyncus tschawytscha*. Unfortunately early season flows were too high for nets to be fished effectively. However, as it became apparent that setlines were ineffective at targeting green sturgeon we modified our sampling plan to allow the use of gill nets during the salmon run. All nets were 3.0-m deep. Nets were constructed using two types of webbing in several net lengths: 1) 30.5-cm stretch-measure web of braided nylon in 45.7-m and 91.4-m lengths, and 2) 23.5-cm stretched-measure of multi-strand monofilament in 30.4-m and 61.0-m lengths. We assumed that the 30.5-cm braided webbing would be too visible to fish effectively as static nets so this gear was generally drifted with river current. The 23.5 cm multi-strand nets were statically fished in suitable areas of deep, slow moving water for up to 7.5 h.

Angling:

Limited angling effort was made by ODFW staff in some reaches of the study area (RKM 11.9, 17.7, 33.1, and 35.6) in April and May, 2000, for a total of 7.46 angler hours. Additional effort was contributed by several volunteers who angled for sturgeon between RKM 24 and 104 during September and October 2000. The volunteer anglers were provided with sampling kits allowing them to measure, spaghetti tag, and collect genetic tissue samples from captured fish. Voluteer anglers recorded lateral scute counts to verify species identification.

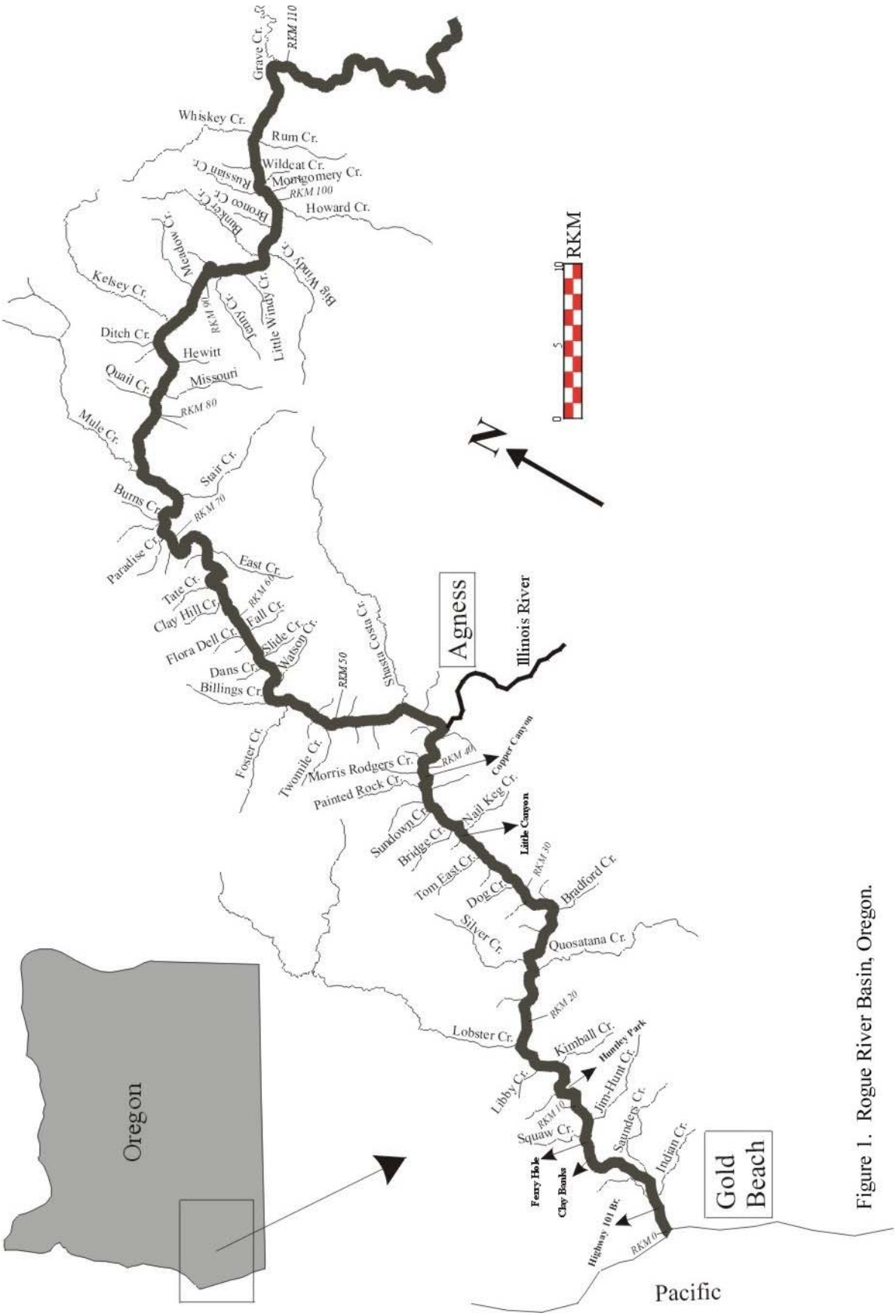

Figure 1. Rogue River Basin, Oregon.

Table 1. Effort (h) and catch by sampling week for several gears used to capture green and white sturgeon and their eggs, Rogue River, Oregon, 2000.

Gear		Effort (h)					Catch	
Week	N	Total	Mean	Min	Max	STD	Green Sturgeon	White Sturgeon
Angling								
April 3	2	2.30	2.30	2.30	2.30	--	0	0
April 10	2	2.06	2.06	2.06	2.06	--	0	0
April 24	4	3.10	1.55	1.50	1.60	0.07	0	0
	8	7.46	1.87	1.50	2.30	0.38	0	0
Setlines								
April 3	13	356.44	27.42	21.94	50.66	7.27	0	0
April 10	12	407.38	33.95	18.16	52.08	14.74	0	0
April 24	24	532.48	22.19	18.26	26.16	2.06	0	1
May 8	4	87.92	21.98	20.90	23.08	1.14	0	0
May 22	12	258.88	21.57	16.60	29.58	4.43	0	0
	65	1,643.10	25.28	16.60	52.08	8.61	0	1
Gill Nets								
May 8	20	14.14	0.71	0.08	1.44	0.39	0	2
May 22	5	5.28	1.06	0.66	1.50	0.30	3	1
June 5	14	11.82	0.84	0.38	2.50	0.53	6	2
June 19	10	5.08	0.51	0.46	0.54	0.02	5	2
July 3	9	4.36	0.48	0.08	0.72	0.20	12	1
July 17	8	4.56	0.57	0.48	0.98	0.17	18	0
July 31	12	3.60	0.30	0.14	0.50	0.13	1	0
	78	48.84	0.63	0.08	2.50	0.38	45[a]	8
D-Ring Egg and Larvae Nets								
April 3	1	0.26	0.26	0.26	0.26	--	0	0
April 24	2	1.54	0.77	0.62	0.92	0.21	0	0
June 5	19	4.75	0.25	0.02	0.26	0.05	0	0
June 19	13	3.64	0.28	0.24	0.50	0.07	0	0
July 3	7	2.59	0.37	0.26	0.52	0.14	0	0
	42	12.60	0.30	0.02	0.92	0.14	0	0
Egg Substrates								
April 3	2	58.30	29.15	23.08	35.22	8.58	0	0
April 10	2	38.64	19.32	18.26	20.38	1.50	0	0
July 3	2	119.66	59.83	46.66	73.00	18.63	0	0
July 17	1	47.26	47.26	47.26	47.26		0	0
	7	263.86	37.69	18.26	73.00	19.64	0	0

[a] Includes 38 individual fish. Five of these were recaptured once, and one was recaptured twice.

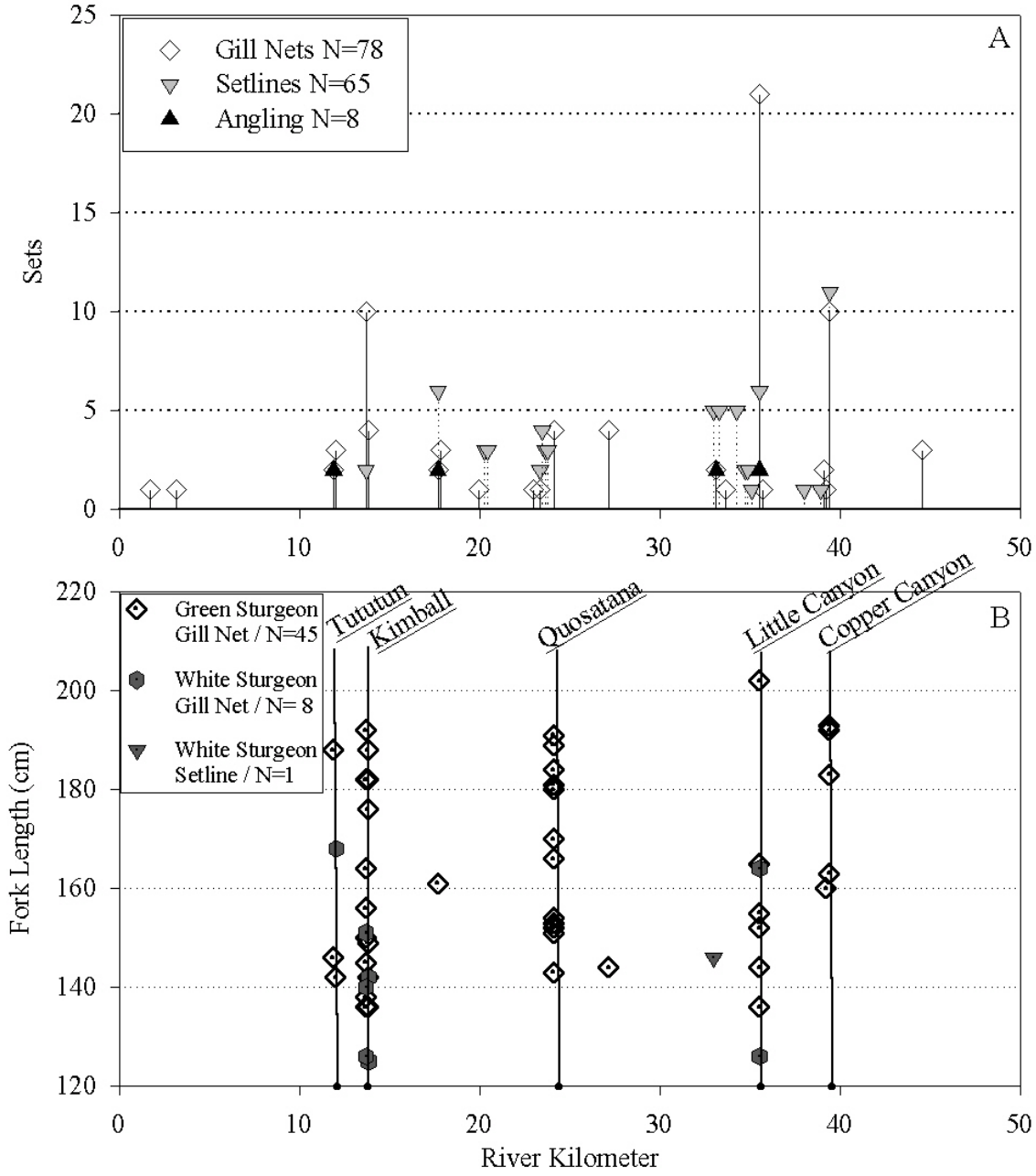

Figure 2. Effort by gear (A) and catch of green and white sturgeon (B) in the Rogue River, Oregon, 2000. Thirty-eight individual green sturgeon were caught. Five of these were recaptured once and one fish was recaptured twice.

Fish Processing:

We measured fork and total length (cm) of each sturgeon captured and examined all fish for tags and marks. Most sturgeons were tagged with both a passive integrated transponder (PIT) tag and an external spaghetti tag. The second left lateral scute was removed from each fish implanted with a PIT tag (Rien 1994). Pectoral fin ray sections were collected from most fish for age analyses. Tissue samples were also taken from the pectoral fins and stored in ethyl alcohol for subsequent genetic analyses.

We surgically examined 13 sturgeon >110-cm fork length following procedures outlined by Beamesderfer et al. (1989) to document sex and maturity. Gonad tissue samples were collected for histological confirmation of sex and measurement of egg diameters. Samples were fixed and stored in a 10% solution of buffered formalin.

Radio Telemetry

Some of the green sturgeon and white sturgeon captured in gill nets and setlines were outfitted with radio tags. Radio telemetry activities were performed in collaboration with Wildlife Conservation Society (WCS) staff. Radio tags from Advanced Telemetry Systems (ATS – supplied by WCS) and Lotek (supplied by ODFW) were used in this study. The majority of tags were internally implanted in the abdominal cavity following methods outlined in North et al. (1995). Some tags were applied externally, ventral to the dorsal fin following methods outlined by Kappenman et al. (1999) (Table 2). Wildlife Conservation Society personnel

performed the majority of radio tracking activity (see Erickson et al. 2001 for details). We also carried out some tracking but our effort was limited by time constraints imposed by other sampling activities.

Egg and Larval Sampling

Artificial substrates:

During April – July, 2001, we set out 7 substrates for an average of 37.69 h between RKM 15.9 and 38.9 (Table 1, Figure 2). Egg substrates are 0.70-m^2 frames of angle iron that encase a sheet of latex-coated animal hair filter material. This gear has been used successfully in the Columbia (McCabe 1990) and Sacramento (Schaffter 1997) rivers to collect white sturgeon eggs. On the assumption that the eggs of green sturgeon exhibit similar characteristics we fabricated several substrates according to specifications outlined by McCabe (1990). During April – July, 2000, we deployed seven substrates for a total of 263.83 h at sites immediately downstream of high velocity riffles (RKM 7.5 – 24.4) where green sturgeon were suspected to spawn as well as in locations occupied by previously radio-tagged sturgeon (Table 1, Figure 2). Substrates were attached to an anchor that was, in turn, attached to the shore via a weighted rope. Upon retrieval, we closely examined each substrate for the presence of eggs.

Table 2. Summary of green (GST) and white sturgeon (WST) outfitted with radio tags, Rogue River, 2000.

FISH INFORMATION					TAG INFORMATION			
Spp.	Fork Length	Total Length	Sex	Maturity	Tag Type	Application	Frequency	Code
GST	175	198	F	Developing	ATS	Internal	149.324	105
GST	182	190	F	Developing	ATS	Internal	149.354	105
GST	204	208	F	Spent?	ATS	Internal	149.324	195
GST	169	180	F	Developing	ATS	Internal	149.343	105
GST[a]	163	169	F	Ripe	ATS	Internal	149.393	105
GST	182	197	F	Developing	Lotek	Internal	149.460	167
GST	202	225	F	Ripe	ATS	Internal	149.393	195
GST	176	184	M	Ripe	Lotek	Internal	149.460	161
GST	136	154	M	Developing	ATS	Internal	149.343	195
GST[b]	165	177	M	Ripe	ATS	Internal	149.372	105
GST	188	205	M?	Unknown	Lotek	Internal	149.460	162
GST	160	176	U	Unknown	Lotek	External	149.460	165
GST	192	215	U	Unknown	Lotek	External	149.460	169
GST	192	207	U	Unknown	Lotek	External	149.460	168
GST	183	198	U	Unknown	ATS	External	149.384	195
GST	142	157	U	Unknown	Lotek	Internal	149.460	170
GST	144	158	U	Unknown	ATS	Internal	149.404	195
GST[c]	155	174	U	Unknown	ATS	Internal	149.384	195
GST	189	202	U	Unknown	ATS	Internal	149.372	105
WST	146	172	M	Developing	Lotek	Internal	149.460	163
WST	164	182	M	Immature	Lotek	Internal	149.460	166
WST	151	168	M	Unknown	Lotek	Internal	149.460	164
WST	141	158	M	Developed	ATS	Internal	149.384	105
WST	161	180	M	Developed	ATS	Internal	149.372	195

[a] Fish recaptured on 7/25 with out radio tag.

[b] Fish recovered dead on 7/4. Tag re-used.

[c] Fish reported dead on 7/4. Death unconfirmed. Tag recovered from river on 7/13 and subsequently re-used.

Plankton Nets:

During April – July, 2000, we used a D-shaped plankton net to capture sturgeon eggs and larvae in RKM 7.4 – 24.2. The net frame was 0.8 m wide at the base and 0.5-m deep. Netting was 7.9 mesh/cm marquisette. Lead weights were attached to the base of the frame to hold the net on the river bottom. A mechanical flow meter (General Oceanics) was suspended in the mouth of the net to estimate the volume of water sampled. We deployed the net 42 times from an anchored boat for short periods (average 0.5 h) immediately downstream of high velocity riffles where we believed green sturgeon could spawn or where larvae might be "funneled" and transported by the current. The duration of deployment was contingent upon sediment and debris load. Upon retrieval, the contents of the collection cup were emptied into a white plastic tray and were examined for eggs and larvae.

Other Activities

Pectoral fin spine samples from Columbia River commercial fisheries and Rogue River 2000 sampling were inventoried. We sectioned 30 samples for each 20-cm fork length interval for aging analysis (Table 3).

Rogue River water temperature and flow data obtained from U. S. Geologic Survey's web site is depicted in Appendix A. Data on 245 green sturgeon from which tissues have been collected is summarized in Appendix B. We compiled and summarized biological data on commercially-caught Columbia River green sturgeon collected by personnel from Oregon and Washington departments of fish and wildlfe while sampling at commercial processors from 1985 through 1999 (Appendix C).

We obtained historical data from ODFW seining activities on the Rogue River conducted during 1968 - 2000. Although salmonids were the target species of this sampling, adult and juvenile green sturgeon were caught incidentally. Over the period 21,632 seines were deployed between RKM 5.3 and RKM 50.7. Since 1976 the vast majority of sets are at Huntley Park (RKM 12.9) and since 1978 the effort has been standardized to about 15 sets/d, 3 d/wk, for 15 wk (July 15 – October 31). We summarized these incidental catches to obtain trend information (Appendix D).

We sampled 86 green sturgeon caught near Astoria in the August 1999 Columbia River commercial gillnet fishery. Thirty-six green sturgeon were sampled (length, weight, sex, maturity, and tissue for genetics) on 5 August in Astoria and the remaining 50 green surgeon were transported to Bonneville Hatchery for further sampling (morphometrics, meristics, sex, maturity, and tissue for genetics) on 6 August, 1999. Genetic tissue samples (1-2 cm barbel clips) were collected from all fish, labeled, and stored in ethyl alcohol. Replicate barbel samples were collected from the 50 fish sampled on 6 August and stored in a lysis buffer for DNA analyses by University of Idaho (Appendix E).

Table 3. Inventory of green sturgeon petoral-fin spines available for age determination.

Location (collection years)	Fork Length Interval (cm)							
	60-79	80-99	100-119	120-139	140-159	160-179	180-199	200-219
Columbia River [a] (1948 to 1953)	1	5	12	10	0	2	1	0
Columbia River [b] (1982-1991)	0	0	30	30	21	2	0	0
Columbia River [b] (1988-1991)	0	0	30	30	30	30	0	0
Rogue River (2000)	0	0	0	3	13	7	10	1
Total	1	5	72	73	64	41	11	1

[a] Fork lengths were estimated by converting total length data (inches) to total length (cm) and applying FL=TL/1.09.

[b] Fork lengths for 1982 and 1983 were estimated by converting total length (cm) data and applying FL= TL/1.09.

The digestive tracts from 46 of the fish examined at Bonneville Hatchery were frozen and later examined to determine food items. One digestive tract of a Rogue River green sturgeon was also examined. Stomach contents of Columbia River fish were algae (species unknown) and three pebbles. The Rogue River fish contained an exoskeleton of one crayfish (*Pacifasticus spp.*) and algae.

Finally we prepared an annotated bibliography of reference materials we have obtained or identified as potentially useful toward meeting project objectives (Appendix F).

RESULTS

Rogue River 2000 Field Sampling

Adult Sampling

We captured 38 individual green sturgeon (136-202 cm); all in gill nets (Figures 2 and 3).

One of these had previously been marked and tagged by WCS staff. We recaptured 6 of these fish once and one of them twice over the study period. All 37 unmarked green sturgeon were then tagged with PIT tags and spaghetti tags. We marked 35 of these fish by removing the second lateral scute anterior from the opercle. We chose not to remove a scute from two of the fish because they showed signs of stress. We collected 34 pectoral-spine samples for age determination, but again chose not to take samples from apparently stressed fish. Unlike white sturgeon, green sturgeon were prone to prolonged bleeding when scutes or fin spines were removed. We collected DNA tissue samples from 37 previously unmarked fish. Fourteen of the fish were radio-tagged for tracking by WCS staff.

A volunteer angler, Vernon Grieves, captured 21 green sturgeon (154-205 cm) from RKM 42 to 105. Identification was based on scute counts, photographs and conversations with Mr. Grieve. All fish he caught were tagged with a spaghetti tag and tissue sampled for later genetic assay.

We captured 9 individual white sturgeon (125-168 cm); one on a setline and eight in gill nets. One of these had a spaghetti tag at capture from another study. None of these were recaptured in the study period. We spaghetti-tagged eight white sturgeon and seven were injected with a PIT tag and marked by removing the second lateral scute anterior from the opercle. Three white sturgeon were radio-tagged for tracking by WCS staff. Seven DNA tissue samples and three pectoral spine samples were collected from white sturgeon.

We surgically examined 10 green sturgeon. Based on field examination, three fish were male (two were ripe), two were female (one was ripe), and five were of undetermined sex. We collected gonad tissue samples from eight fish for laboratory determination of sex and maturity. Three white sturgeon were surgically examined. All were male and none were ripe based on field examination.

Radio Telemetry

Short-term telemetry data indicates most fish have remained close to original capture locations with occasional limited movements (<3.2 km). One male white sturgeon tagged at RKM 35.2 appears to have left the system because it cannot be located by tracking efforts downstream of RKM 53.1. Another male white sturgeon tagged at RKM 11.6 apparently left the system but returned after a one-week absence. One male green sturgeon tagged at RKM 35.2 moved downstream 21.6 km to another high-use sturgeon hole. The ripe female green sturgeon tagged at RKM 17.4 moved upstream to approximately RKM 23.3 within 1 week of tagging.

Egg and Larval Sampling

We did not capture any eggs or larvae using D-ring plankton nets or with artificial substrates.

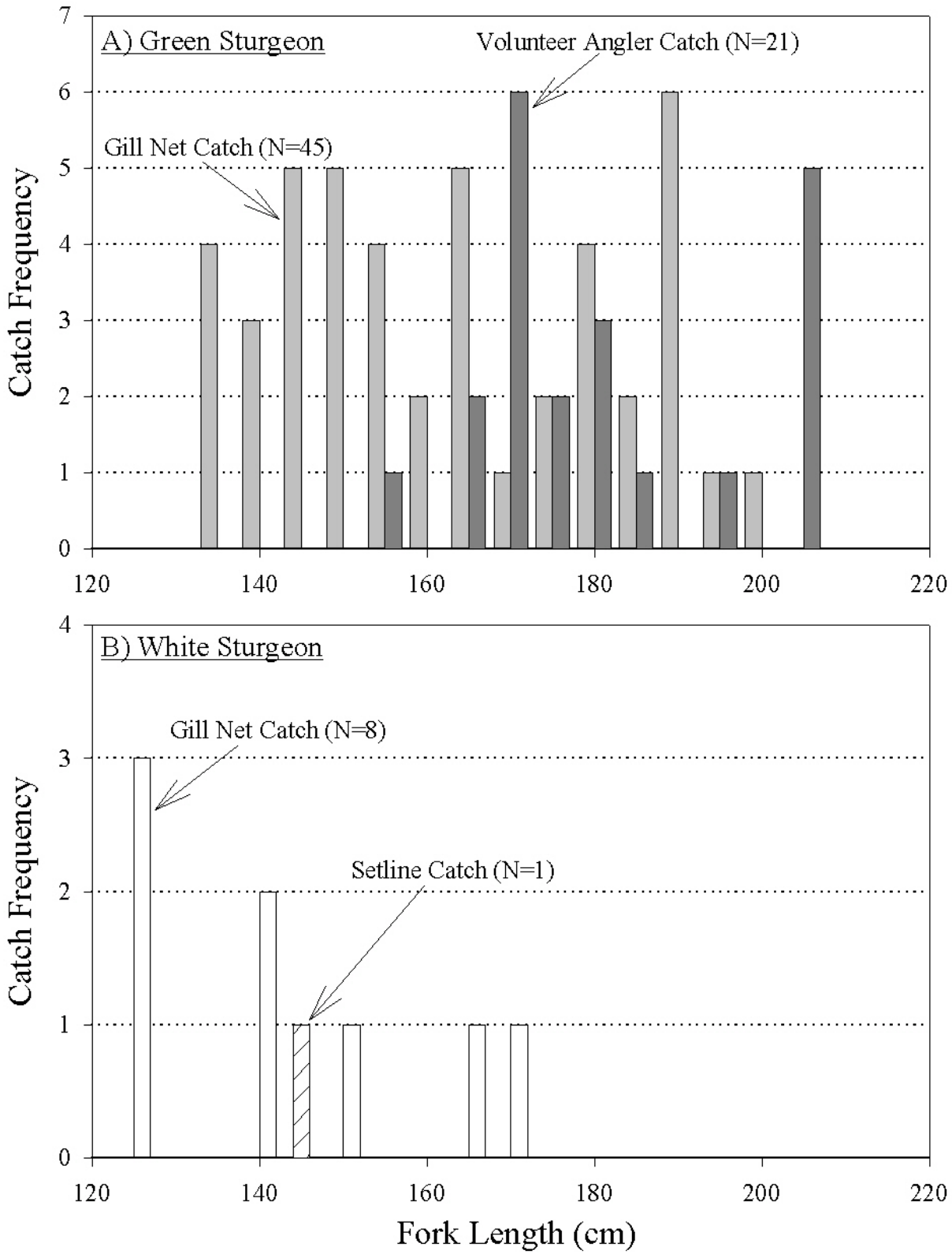

Figure 3. Length Frequency of green (A) and white sturgeons (B) by capture gear Rogue River, Oregon, 2000.

DISCUSSION

Adult white and green sturgeon were present in the Rogue River during this study period. Gill nets were the only gear that captured green sturgeon. Gill nets were fished May through July and catch rates were highest in July. This trend may reflect increased abundance of green sturgeon in July, but could also be influenced by our own increased experience with the river through the study period and increased effort in suitable sites. This trend is similar to information obtained from discussions with local anglers.

Our observations of sturgeon being caught by anglers, and conversations with experienced sturgeon fishing guides lead us to believe green sturgeon are a substantial component of a popular mixed species sturgeon fishery. One volunteer angler (Vernon Grieve) caught, marked, and tagged 21 green sturgeon for us. Yet, green sturgeon harvest in the Rogue River is rarely reported. This is probably because 1) most green sturgeon in the Rogue River are larger than slot limit for sport harvest (48-66 inches total length), 2) many anglers are unfamiliar with characteristics that distinguish white and green sturgeon, and 3) green sturgeon may be less vulnerable to capture on angling gear than white sturgeon.

We found angling and setlines to be unproductive gears for capturing green sturgeon in April and May. Angling was discontinued after only seven hours of effort and no green or white sturgeon catch in April. We simply felt this was a poor use of staff time. We fished 65 setlines in April and May and caught only one white sturgeon. Again we believed this was a poor use of staff time and decided to focus on gill nets as our primary gear to capture adult sturgeon.

Juvenile green sturgeon captured in beach seines over the last several decades are strong evidence that spawning occurs fairly regularly in the Rogue River (Appendix D). Yet, we were not able to document sturgeon spawning or spawning sites through collection of eggs or larvae. Generally, these gears were difficult to use on the Rogue River with our small vessels. We tried to deploy the gears in tailouts of chutes and rapids where we suspected green sturgeon would spawn – particularly areas downstream from radio-tagged ripe female green sturgeon. In these same areas the navigable channel is extremely narrow for the wide tour boats common in the lower Rogue. As such we were unable to safely deploy the artificial substrates in sites with high turbulent flows, and anchoring to deploy D-ring plankton nets was difficult or unsafe.

Autumn catches of large green sturgeon by volunteer anglers between RKM 68 and 105 lead us to speculate that green sturgeon may overwinter and spawn in these upstream reaches. This area of the Rogue is designated as “Wild and Scenic” and is characterized by large sets of rapids requiring highly skilled boat operators for navigation. Sampling this reach for eggs or juveniles is beyond our capabilities under our current scope of work.

Distributing gill net sets in a random or stratified fashion was not possible. As such catch data should be used cautiously in describing green sturgeon distribution. High catches or catch rates at specific sites are as much a factor of how effort had to be distributed as the distribution of fish. That said, we identified several sites that tended to be used by adult green sturgeon. As

increased river use and near-shore development is considered in the future, these areas may warrant special consideration to limit impacts on green sturgeon.

Plans for next year

Field sampling plans for 2001 will emphasize gillnetting at specific sites to index abundance of adult green sturgeon through the spring and summer. Gillnetting will also allow us to provide fresh marine fish for radio-tagging by WCS staff. We will continue sampling for eggs and larvae using artificial substrates and D-ring plankton nets at potential spawning sites that can be safely fished. Finally we will begin using a screw trap to fish for larvae in June and July. Screw traps have captured larvae effectively at specific sites on the Klamath and Trinity rivers. While we will again be forced to sample only the lower Rogue River, this is the only gear we are aware of that has effectively collected larval green sturgeon.

The 4th International Sturgeon Symposium is being held in Oshkosh, Wisconsin, July 8-12. We will present a poster entitled "Morphometric measurements and meristic count comparisons for North American and Asian forms of green sturgeon" (Appendix E) and make an oral presentation entitled "Green Sturgeon *Acipenser medirostris* Fisheries in the Eastern Pacific: Are Harvest Rates Sustainable?" which will synthesize current knowledge of population characteristics to describe potential production of green sturgeon and relate it to current Columbia River harvest.

ACKNOWLEDGEMENTS

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Doug DeHart, Steve King, and Dave Ward with ODFW's Fish Division supported efforts to investigate green sturgeon status and helped us with study design.

Kevleen Melcher, Tom Neill, and Patrick Frazier with ODFW's Columbia River Management section helped us secure historic data on Columbia River Fisheries. Jerry Grover (ODFW retired) Tom Satterthwaite (ODFW Grants Pass), Alan Smith (ODFW retired), and Russ Stauff helped us locate historic data for the Rogue River.

We are particularly indebted to Vernon Grieve, a fishing guide on the Rogue River, who tagged and collected data on 21 green sturgeon he caught in the Rogue's "Wild and Scenic" reach.

Dan Erickson, with WCS, worked as a full partner on this study. He helped us capture and tag fish, collect samples, and helped us locate potential spawning fish through radio telemetry.

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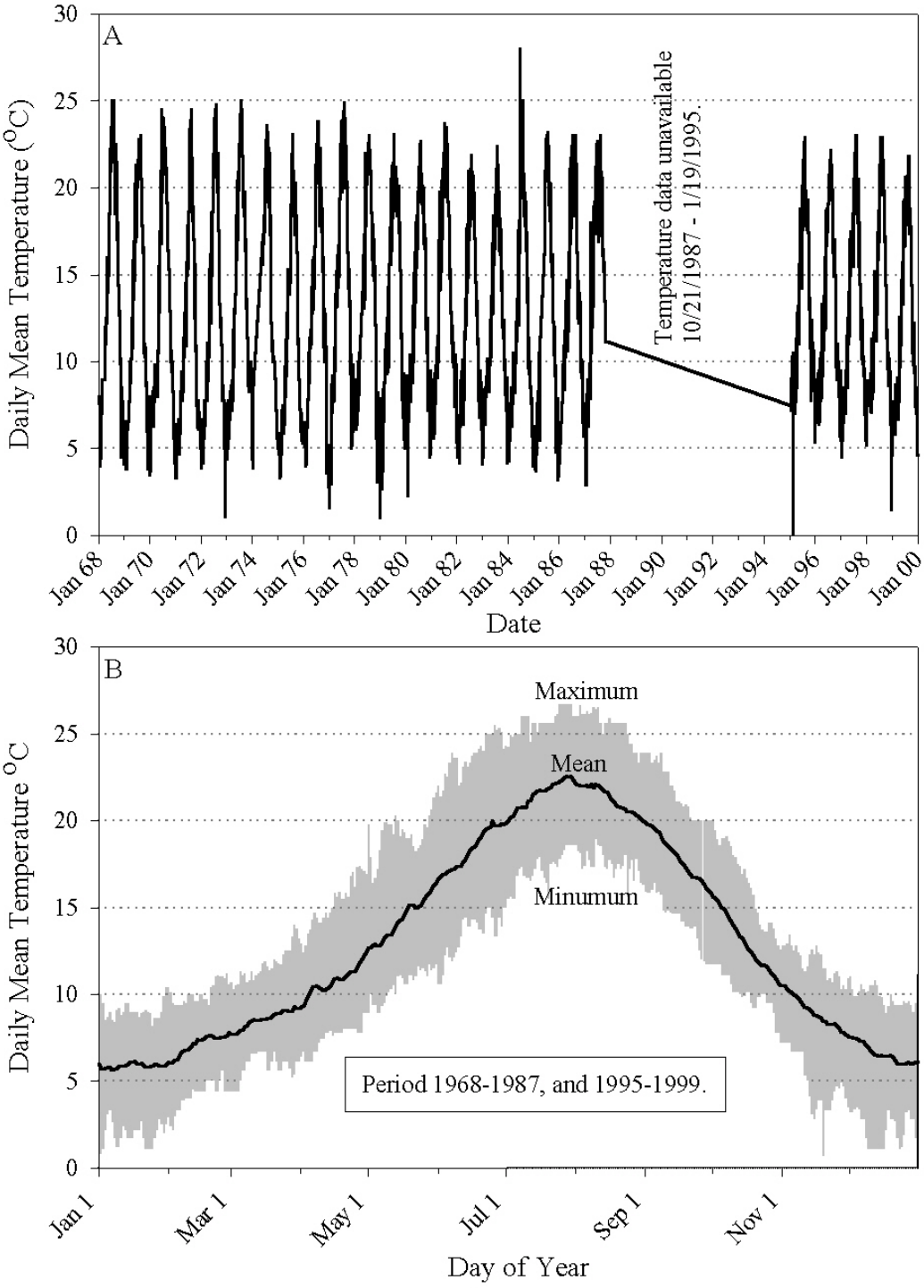
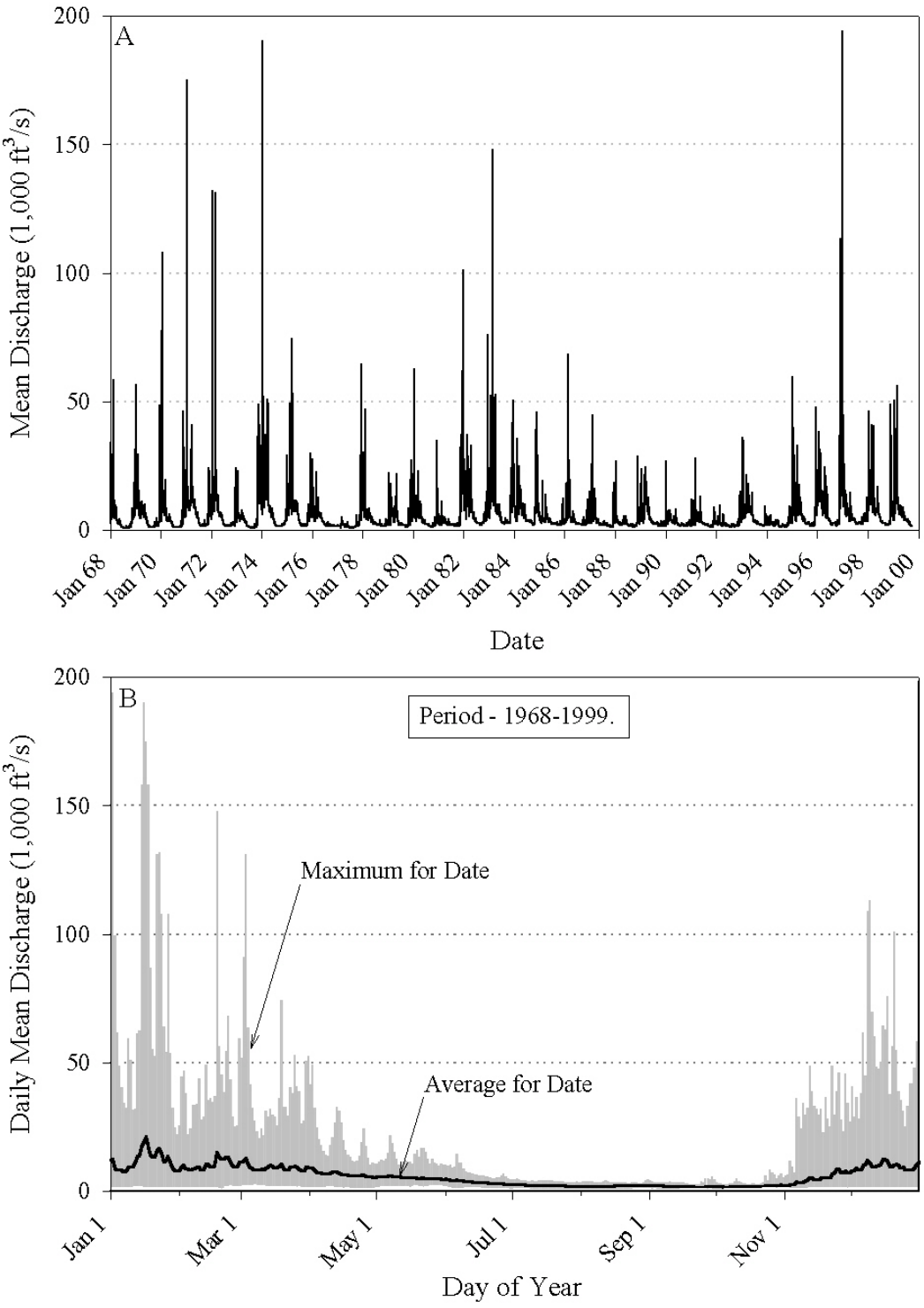
Appendix A.

Rogue River Water Temperature and Flow

Temperature and flow data for the Rogue River near Agness, Oregon, were obtained from the U. S. Geologic Survey (http://water.usgs.gov/usa/nwis/sw) and summarized in preparation for correlating river conditions with historic green sturgeon catch data.



Appendix Figure A-1. Rogue River water temperature near Agness, Oregon, 1968-1987, and 1995-1999. A) Mean by date. B) Average, minimum, and maximum by day of year.



Appendix Figure A-2. Rogue River discharge near Agness, Oregon, 1968-1999. A) Mean by date. B) Average and maximum daily means by day of year. Source: U. S. Geologic Survey (http://water.usgs.gov/usa/nwis/sw).

Appendix B.

Genetic Tissue Sample Disposition

Staff of ODFW's Columbia River Management section collected green sturgeon tissues as part of tagging efforts for green and white sturgeon in Oregon coastal estuaries. Tissues from green and white sturgeon were collected incidental to tagging efforts in the Rogue River from sites as far upstream as 105 km. Juvenile green sturgeon tissue samples were obtained from fish captured incidental to beach seine sampling conducted by ODFW's Gold Beach field office staff at Huntley Park on the Rogue River (12.9 km upstream from mouth). All were forwarded to Kathryn Kostow (ODFW) for genetic assay and archival (Appendix Table B-1).

Appendix Table B-1. Sumary of green and white sturgeon tissue samples collected by ODFW staff for genetic assay, February 2000 - February 2001.

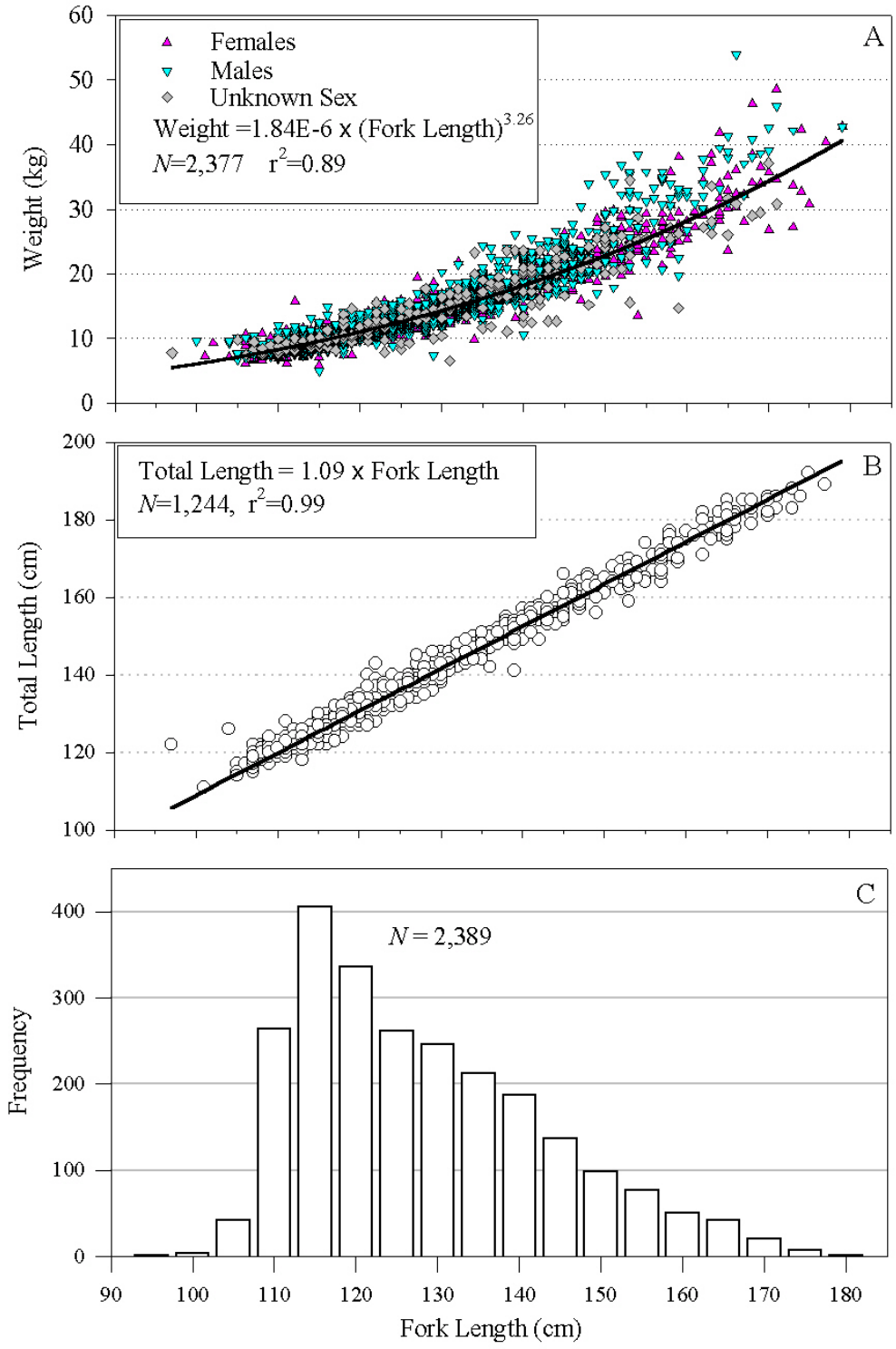
Year / Location	Green Sturgeon		Intermediate [a]	White Sturgeon
	Adult	Juvenile	Adult	Adult
2000				
Coos Bay, OR	1			
Pacific Ocean off Newport, OR	4			
Rogue River, OR	65	10		7
Tillamook Bay, OR	6			
Winchester Bay, OR	106			
Yaquina Bay, OR	11			
2001				
Coos Bay, OR	8			
Winchester Bay, OR	20			
Yaquina Bay, OR	5		1	
Total	226	10	1	7
Minimum Total Length (mm)	380	135	1,060	1,320
Maximum Total Length (mm)	2,250	330	1,060	1,800

a. This fish (most likely a green sturgeon) had morphological and meristic characteristics intermediate between white and green sturgeon.

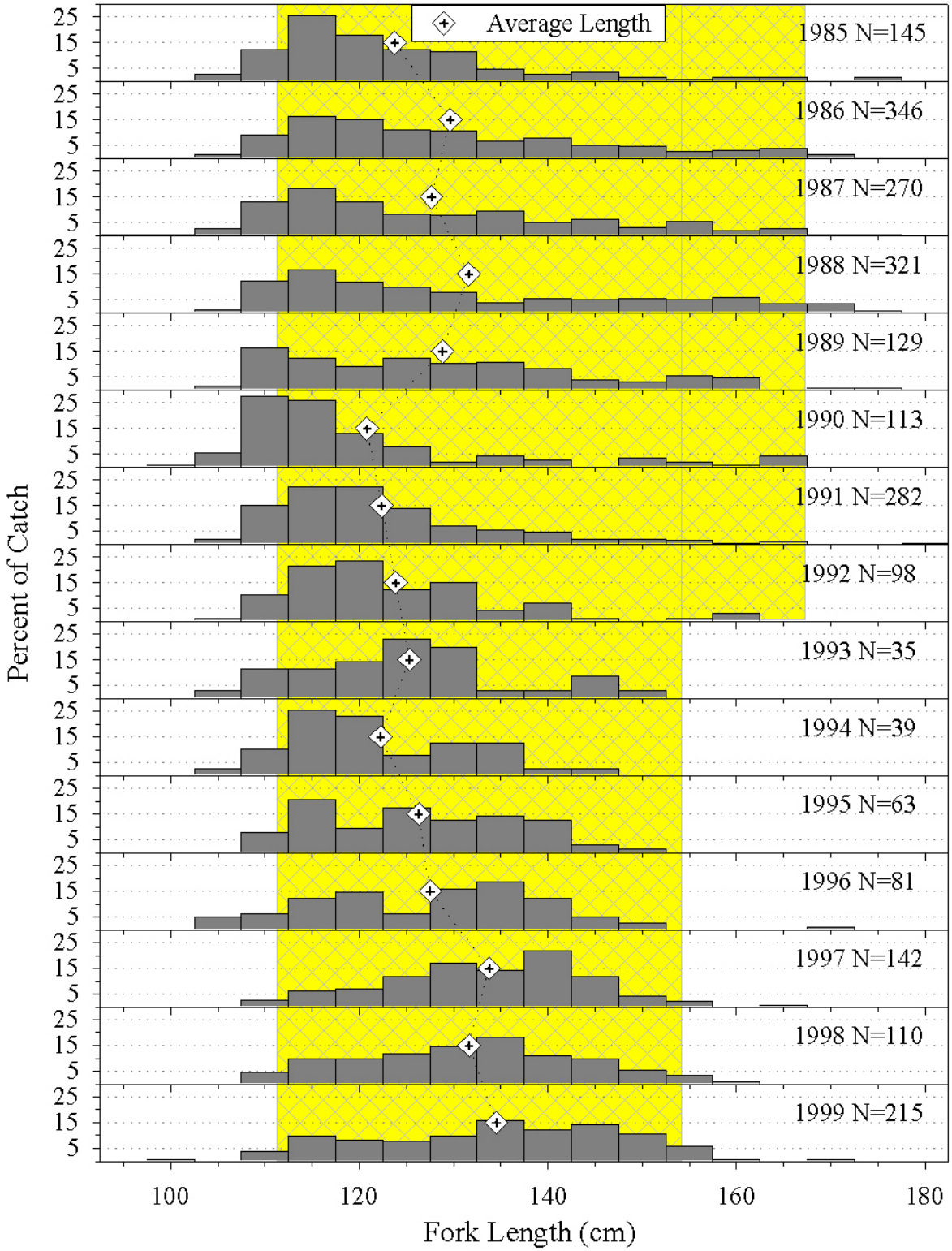
Appendix C.

Columbia River Harvest Data

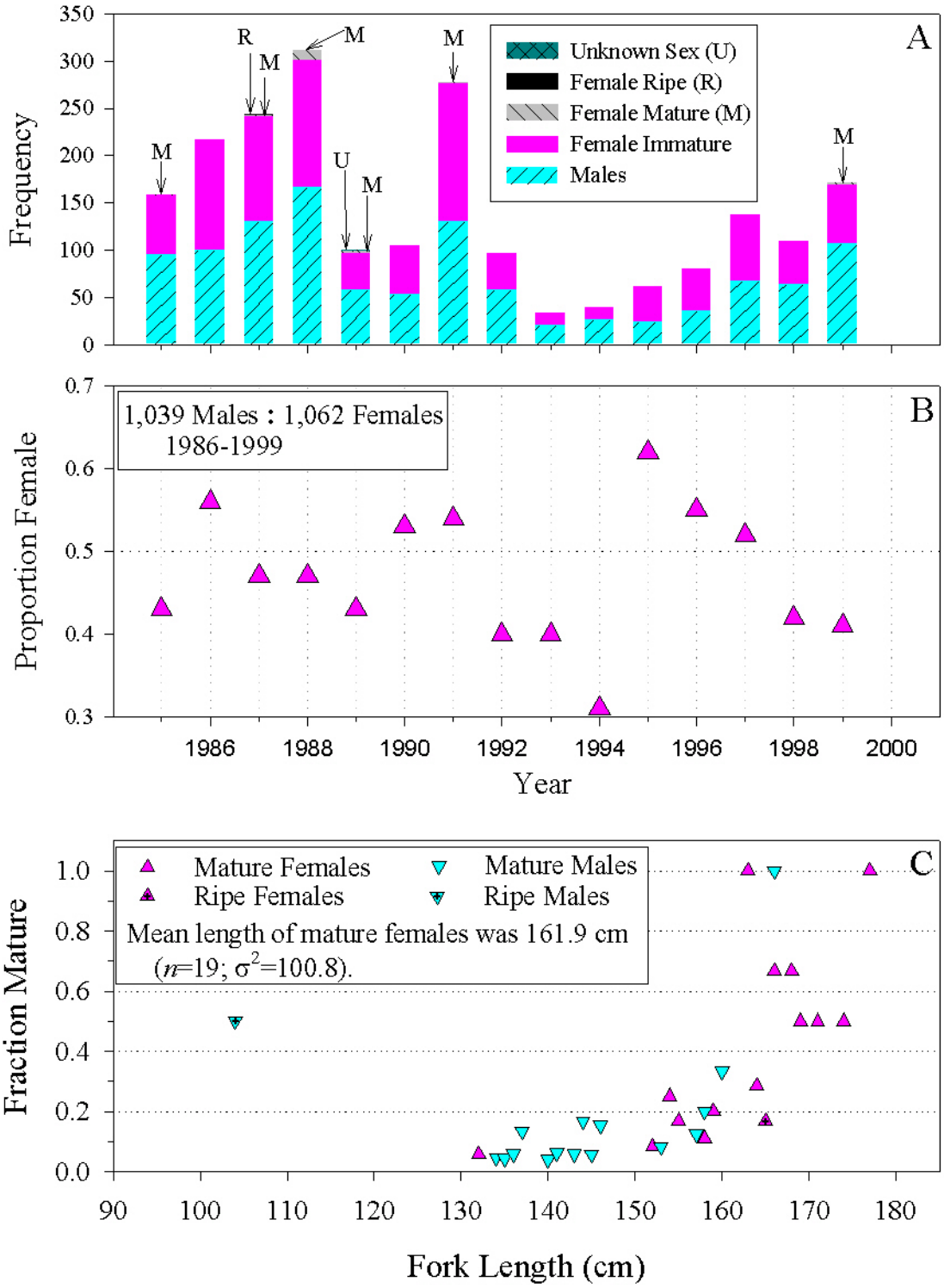
We compiled and summarized historic catch data collected by staff of ODFW's Columbia River Fish Management section from 1985-1999 in preparation for describing potential productivity of green sturgeon.



Appendix Figure C-1. Length and weight characteristics of green sturgeon sampled from Lower Columbia River commercial fisheries, 1985-1999: A) Fork length:weight relationship; B) Fork length:total length relationship; and C) Length frequency distribution of examined fish.



Appendix Figure C-2. Length frequency and mean length of green sturgeon sampled in Lower Columbia River commercial fisheries, 1985-1999. Legal slot limit, based on conversion from total length (FL = TL/1.09), is indicated by background shading.



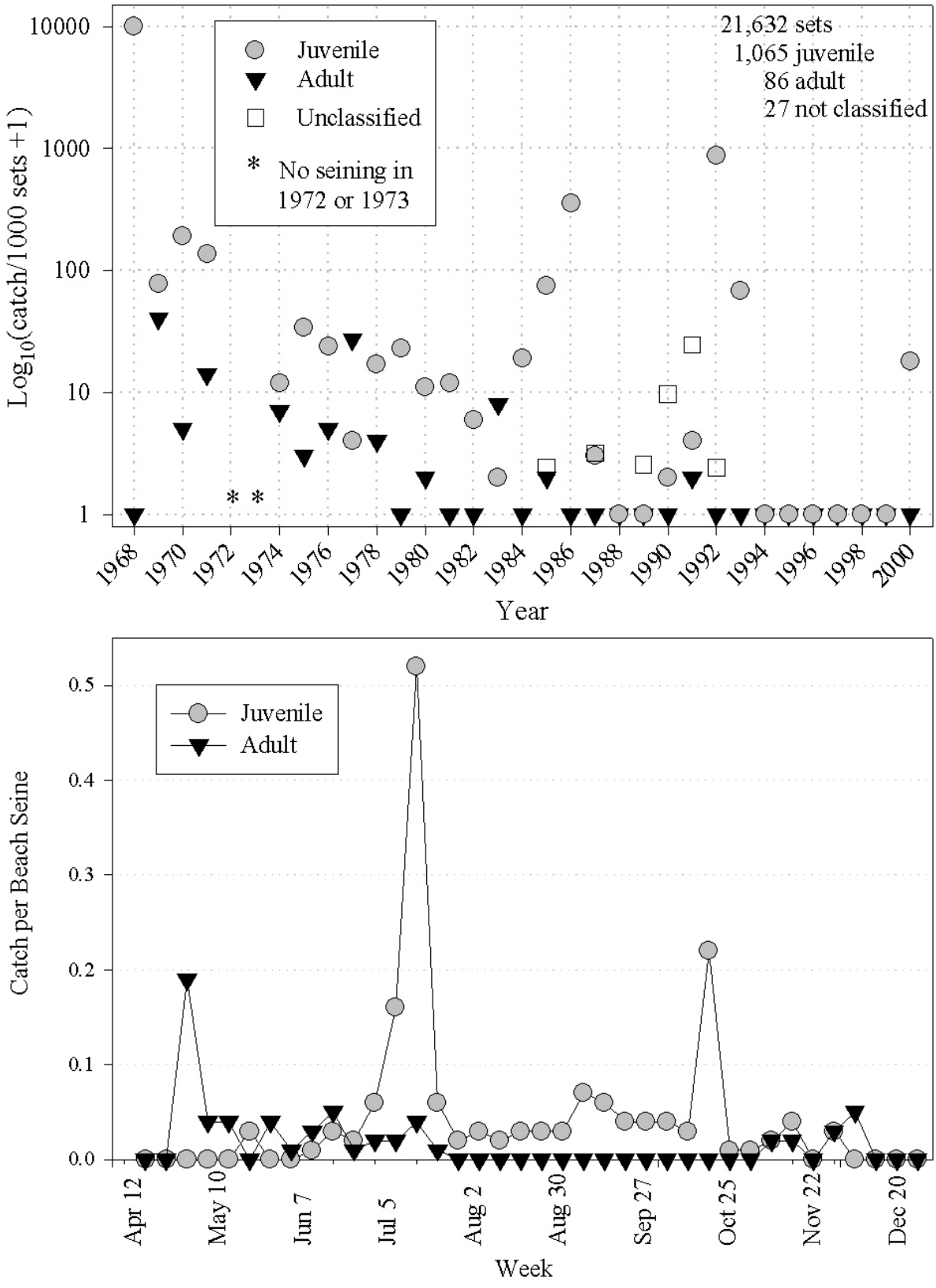
Appendix Figure C-3. Sex and maturity characterisics of green sturgeon harvested in Lower Columbia River commercial fisheries, 1985-1999: A) Sex of examined green sturgeon and maturity stage of females; B) Proportion of females in the examined harvest; and C) Maturity rate by fork length for males and females.

Appendix D.

Historic Rogue River Seine Data

Log books and original data sheets, 1968-1999, were examined to obtain incidental green sturgeon catch data from Rogue River beach seine sampling. This sampling is conducted to index salmonid abundance but sturgeon catches were typically recorded as notes on data sheets.

Seining for adult salmonids was conducted by ODFW's Fish Research (Grants Pass) and Gold Beach Field Office staff in 31 of the 33 years from 1968 through 2000. Juvenile green sturgeon were noted as bycatch in 23 of those years and adults were noted in 13 years. Adults were last noted in 1991 and since 1991 juvenile green sturgeon were reported in 1991, 1992, 1993 and 2000. It is possible that green sturgeon were captured but not recorded since they were not the focus of these efforts.



Appendix Figure D-1. Incidental green sturgeon catch during beach seining to monitor salmonid abundance, Rogue River, Oregon, 1968-2000. Data may include recaptured fish.

Appendix E.

Meristic and morphological characters for North American and Asian forms of green sturgeon *Acipencer medirostris* with reference to white sturgeon *Acipenser transmontanus*

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The green sturgeon *Acipenser medirostris* is widely distributed along the coast of North America, with known spawning populations in the Klamath, Sacramento, and Rogue rivers. It also spawns in the Tumnin River, Russian Federation (formerly USSR) but is otherwise uncommon in Asia. Whether North American and Asian populations are conspecific has been debated. Recent genetic analyses indicate these populations should likely be considered distinct species, although sample sizes have been small. As part of a cooperative study aimed at determining the systematics of sturgeons of the North Pacific, we collected genetic tissue samples and meristic and morphometric data from 50 green sturgeon harvested from the Columbia River, Oregon in August, 1999. Our meristic data expand published minimum or maximum values of variability for several characters including lateral scutes (22), ventral scutes (12), and gill rakers (26). Because we sampled significantly more fish than previous studies, our data also confirm absolute published ranges of several meristic characters of North American green sturgeon including dorsal scutes (7 minimum; 12 maximum), lateral scutes (22 minimum; 33 maximum), and gill rakers (15 minimum; 26 maximum). We found considerable overlap in meristic counts of Asian and North American populations of green sturgeon. Morphometric data showed considerable differences, especially measures related to the snout; it appears to be longer in green sturgeon from the Tumnin River. Specific detailed procedures for measuring sturgeon morphometric and meristic characters should be established to facilitate comparison of data.

Introduction

The green sturgeon *Acipenser medirostris* is a widely distributed, yet relatively uncommon anadromous species occurring along the Eastern Pacific coast of North America from Southern California to the Bering Sea (Miller and Lea 1972). Along the Western Pacific coast, this species has been reported from the Amur River south to the Sea of Japan (Soldatov 1915; Masuda et al. 1984). Current spawning populations are known only in the Sacramento, Klamath, and Rogue rivers of North America and in the Tumnin River, Russian Federation (formerly USSR). Targeted research has been virtually nonexistent until recently (Nakamoto et al. 1995; Erickson et al. this volume; Rien and North this volume; R. Shaffter, California Department of Fish and Game, personal communication), resulting in a weak understanding of the population status, biology and habitat needs of this species. Species classification has been equally confusing. At various times, Asian populations of the green or "Sakhalin" sturgeon have been classified as *A. mikadoi* (Hilgendorf 1892; Okada and Matsubara 1938; Matsubara 1955; Birstein 1993), *A. medirostris* (Berg 1948; Andriyashev and Panin 1953; Masuda et al. 1984; Artyukhin and Andronov 1990), and *A. medirostris mikadoi* (Lindberg and Legeza 1965). Recent genetic comparison of Asian and North American populations of green sturgeon provide evidence for

separate species classification; however sample sizes were small (Birstein 1993a; Blacklidge and Bidwell 1993; Van Eenennaam et al. 1999).

The main objective of this study was to collect large samples of genetic tissue and meristic and morphometric data as part of a cooperative investigation to determine the systematics of North Pacific sturgeons and further ongoing comparisons of Asian and North American populations of green sturgeon. The purpose of this report is to document the specific methods we used to collect morphometric and meristic characters of North American green sturgeon, and compare our results with data for other green sturgeon populations and for white sturgeon *Acipenser transmontanus*. Statistical analyses of data is beyond the scope of this report since comparable raw data for other studies was unavailable. Results of ongoing genetic analyses based on sampling described herein will be presented in the future.

Methods

Six meristic and 12 morphometric characters were measured from 50 green sturgeon (125-170 cm total length) harvested from the Columbia River estuary near Astoria, Oregon during a 4-5 August, 1999 commercial gillnet fishery. Fish were iced in plastic totes and transported to Bonneville Fish Hatchery near Cascade Locks, Oregon and refrigerated overnight prior to sampling on 6 August, 1999. Most counts and measurements were collected according to methods defined in Birstein et al. (1997b) and Scott and Crossman (1973). Some measurements were unclear, so actual measurements were subject to our interpretation and personal communication with Martin Hochleithner (Aqua Tech; Kitzbuhel, Austria). A detailed description of the counts and measurements collected are defined in Table 1.

Measurements of absolute (total) length (TL), head length (HL), snout length to eye (SL), post-orbital distance (PO), depth of head at eye (HD), maximum body depth (BD), and pectoral fin length (PL) were made to the nearest millimeter (except TL=cm) along the left lateral side. Snout length to barbels (SB), and distance from barbels to mouth (BM), were measured along the mid-ventral surface. Inter-orbital distance (IO), snout width at barbels (SWB), and snout width at mouth (SNW) were transverse measurements. Lateral scutes (LS), ventral scutes (VS), and gill rakers (GR) were enumerated from the left side of fish. Dorsal (DR) and anal (AR) fin ray counts included all individual rays from the longest anterior ray to the most posterior ray not associated with the posterior fin margin. This method resulted in counts significantly less than other published data that may represent total fin ray counts. Dorsal scute (DS) counts excluded small scutelets often observed in pairs immediately anterior to the dorsal fin. All measurements represent a straight line along the left side or midline of the fish. Most measurements were collected with calipers or dividers and a metric ruler except HD and BD were collected with two, inter-locked combination squares. English units and data were converted to metric equivalents.

Replicate barbel tissue samples were collected from all 50 fish and stored in ethyl alcohol and lysis buffer for future genetic analyses. Additional barbel tissue samples were collected from 36 green sturgeon and 10 white sturgeon sampled for length, weight, sex, and maturity only. Data described above was also collected from one additional green sturgeon (198 cm total length) collected on 27 July, 2000 at river kilometer 24.0 on the Rogue River, Oregon.

Results

Mean values of meristic and morphometric characters are summarized in Table 2. A comparison with references of other original data for green sturgeon and some common references for white sturgeon are provided in Table 3. Our meristic data expand published ranges of variability for several characters of this species including LS (22; minimum), VS (12; maximum), and GR (26; maximum). Because we sampled significantly more fish than previous studies, our data also confirm absolute published ranges of several meristic characters of North American green sturgeon including dorsal scutes (7 minimum; 12 maximum), lateral scutes (22 minimum; 33 maximum), and gill rakers (15 minimum; 26 maximum). Many additional references containing meristic data for green sturgeon could not be authenticated as being original data, rather than references to other work (Table 4). Inclusion of these references in addition to original studies referenced in Table 3 would increase the maximum range of LS to 36 (Masuda et al. 1984; Matsubara 1955); other ranges would not change. Considering the absolute of published ranges provided in Table 3, there appears to be little difference in meristic characters between Asian and North American populations of green sturgeon. There is also overlap in ranges of several meristic characters between green and white sturgeon, especially VS and AR. The only meristic count without overlap is LS, which is likely the most appropriate character to separate these two species. Additional characteristics that can be used to identify green and white sturgeon are provided in Table 5.

Comparative morphometric data indicate Asian green sturgeon have a longer, narrower head, with a significantly longer snout than the fish we examined (Table 6). Morphometric data for the single specimen collected from the Rogue River was similar to mean values for Columbia River fish.

The mean of SB/BM ratio for Columbia River green sturgeon was 0.74 indicating barbels were positioned closer to the snout than to the mouth; likely a result of measuring BM to the center of the mouth rather than to the anterior ridge around the mouth or to the lip. Our counts of DR and AR were low; again likely a result of the method we used and not due to actual differences between populations.

Discussion

Although it would be difficult to collect a large sample of morphometric measures from live fish, it is also important that dead specimens be in good condition so measurements are representative. We observed minor deformities in some fish as a result of being stored on ice in totes for 24 h. Measurements of head depth and maximum body depth of some specimens may be slightly biased because the ventral body wall seemed less firm than on live fish. To compensate for the effects of gravity, we applied moderate manual lateral compression as the measurement was taken. This method seemed reasonable but we recognize the potential for bias. Most other measurements and all meristic data were not likely effected.

Collection of morphometric data was an extremely tedious procedure but the importance of collecting a large sample was clearly evident. As more fish were examined, subtle differences in individuals became apparent, reaffirming the need to collect a representative sample. Meristic

characters were much easier to evaluate and seem advantageous because most counts can be collected from live fish. However, meristic data may not provide the detail necessary to discern differences between different populations of the same species.

The methods we used to count fin rays and measure barbel position (SB and BM) were probably not consistent with other studies. We had difficulty discerning the exact procedures that should be used to measure some characters because exact methods are seldom reported or are not available (Hubbs and Lagler 1958; Schreiber 1959). We attempted to duplicate measurements recorded by Artyukhin and Andronov (1990) but found many characters were subject to interpretation. The ratio for snout-to-barbel/barbel-to-mouth disagreed with keys that state this ratio should exceed 1.0 for green sturgeon and be <1.0 for white sturgeon. Had we measured to the anterior ridge around the mouth, the ratio would likely have shifted to ≥ 1.0. Our data related to barbel position and fin ray counts should not be used for comparative purposes unless exact collection methods are replicated. It is important for researchers to document the precise methods used to collect data. Specific, detailed procedures for measuring sturgeon morphometric and meristic characters should be established to facilitate comparison of data from different studies.

Because lateral scute count was the only mutually exclusive character between green and white sturgeon, it is a useful method for differentiating these two species that often co-exist. Many anglers and inexperienced researchers have difficulty identifying these species in the field.

Acknowledgments

Matthew Howell, Matt Hunter, Tom Neill, Tom Rien, and Dave Ward of Oregon Department of Fish and Wildlife (ODFW) assisted with collection of data. Scott Lusted of ODFW's Bonneville Fish Hatchery provided us with refrigerated storage and room to conduct our sampling.

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Table 1. Definitions of morphometric measurements and meristic counts collected from green sturgeon harvested in the Columbia River, Oregon, August 1999.

Absolute (total) length (TL): The linear distance (cm) from the anterior tip of the rostrum to the end of the upper lobe of the caudal fin in its natural position.

Head length (HL): The linear distance (nearest mm) from the anterior tip of the rostrum to the posterior margin of the operculum including the fleshy margin.

Snout length to eye (SL): The linear distance (nearest mm) from the anterior tip of the rostrum to the center of the eye.

Post-orbital distance (PO): The linear distance (nearest mm) from the posterior margin of the eye to the posterior margin of the operculum including the fleshy margin.

Inter-orbital distance (IO): The linear distance (nearest mm) between dorsal margins of the orbits.

Depth of head at eye (HD): With the fish placed in a natural, upright position on a flat surface, the maximum depth of the head (nearest mm) from the surface on a plane through both eyes.

Maximum body depth (BD): With the fish laying in a natural, upright position on a flat surface, the maximum depth of the body (nearest mm) from the surface to the most dorsal body-trunk point between scutes. Moderate manual lateral compression was applied as this measurement was taken to compensate for dorsal compression caused by the weight of the fish on the table.

Pectoral fin length (PL): The linear distance (nearest mm) from the anterior origin of the pectoral fin to the most distal margin.

Snout length to barbels (SB): The linear distance (nearest mm) from the anterior tip of the rostrum to anterior insertion of the center barbels.

Barbels to mouth (BM): The linear distance (nearest mm) from the posterior insertion of the center barbels to a transverse plane through the center of the closed mouth.

Snout width at barbells (SWB): The linear distance (nearest mm) through the widest point of the snout on a transverse plane through the barbel row.

Snout width at mouth (SWM): The linear distance (nearest mm) through the widest point of the snout on a transverse plane through the center of the mouth in a closed position.

Dorsal scutes (DS): The number of large, dorsal scutes between the head and the anterior insertion of the dorsal fin, excluding small, unhooked plates (scutelet) that occasionally occurred in pairs immediately anterior of the dorsal fin. The first anterior dorsal scute was counted if it was independent of the cranial plate structure.

Lateral scutes (LS): The number of left-side lateral scutes and scutelets beginning with the first anterior scute not connected to the pectoral girdle (cleithrum), posterior to the last lateral scutelet anterior to the point where the lateral line turns upward into the upper lobe of the caudal fin.

Ventral scutes (VS): The number of left-side ventral scutes anterior to the pelvic fin terminating under the pectoral fin. Scutelets were not observed.

Gill rakers (GR): The combined number of complete and rudimentary gill rakers on both limbs of the first gill arch (not the pseudobranch).

Dorsal fin rays (DR): The number of dorsal fin rays beginning with the longest anterior ray and counting posterior to the last complete ray excluding the ray associated with the posterior margin of the fin.

Anal fin rays (AR): Same criteria as dorsal fin ray count.

Table 2. Mean values, ranges, and standard deviations of 6 meristic and 12 morphometric characters collected from 50 Columbia River green sturgeon, August 1999.

Character	Mean	Range	STD
Total length (cm)	148	125-170	14.6
Dorsal scutes	9.4	7-12	1.1
Lateral scutes	28.5	22-33	2.8
Ventral scutes	9.2	7-12	1.1
Gill rakers	19.0	15-26	2.5
Dorsal fin rays[a]	28.5	12-36	3.4
Anal fin rays[a]	14.6	11-19	1.8
Head length (cm)	27.8	24.0-34.3	2.5
Snout to eye length (cm)	11.0	8.0-14.4	1.5
Inter-orbital distance (cm)	10.7	8.4-13.5	1.2
Post-orbital distance (cm)	16.6	12.8-20.0	1.8
Depth of head at eye (cm)	9.6	7.3-12.7	1.1
Maximum body depth (cm)	15.1	11.6-20.4	1.9
Pectoral fin length (cm)	18.8	13.5-24.0	2.4
Length of snout to barbels	5.3	3.1-7.2	0.8
Mouth to barbel distance	7.2	5.1-9.1	0.8
Snout width at barbels (cm)	8.9	6.8-11.4	1.1
Snout width at mouth (cm)	13.9	10.9-18.2	1.6

[a] Number of rays posterior to the longest ray (Scott and Crossman 1973).

Table 3. Summary of documented ranges for six meristic characters of Asian and North American (NA) populations of green sturgeon. Various white sturgeon references are included for comparison. Meristic characters are dorsal scutes (DS), lateral scutes (LS), ventral scutes (VS), dorsal rays (DR), anal rays (AR), and gill rakers (GR).

Source	Species (as noted by author(s)	Origin	DS	LS	VS	DR	AR	GR	N
			Green Sturgeon						
Artyukhin & Andronov 1990	*A. medirostris*	Asian	8-11	26-33	5-10	29-44	19-27	18-21	10[a]
Ayres 1854		NA	11-12	25-27	10-11	35	24		1[b]
Deng 2000	*A. medirostris*	NA	8-10	24-28	5-6	40-44	26-32		5[c]
Hilgendorf 1892		Asian	10	30-31		39-43			?[d]
Jordan & Snyder 1906		Asian	7-8	34	9	35-44	28-31		1[e]
Norris 1957	*A. medirostris*	NA	9	28	9	40-42	28-29		1[f]
ODFW (this report)	*A. medirostris*	NA	7-12	22-33	7-12	*12-36*	*11-19*	15-26	50[g]
ODFW (this report)	*A. medirostris.*	NA	9	25	8	37	25	25	1[h]
Schreiber 1959		NA		23-30		35-40	21-27	15-19	4[i]
Snyder 1908	*A. medirostris*	NA	11	27	9				1[j]
Ueno and Abe 1966	*A. medirostris*	Asian	10-11	28-34		35-39	26-27		2[k]
			Absolute ranges for green sturgeon						
Asia			7-11	26-34	5-10	29-44	19-31	18-21	13
North America			7-12	22-33	5-12	35-44	24-32	15-26	63
All			7-12	22-34	5-12	29-44	19-32	15-26	76
			White Sturgeon						
Hart 1973	A. transmontanus	NA	11-14	38-48	9-12	44-48	28-31		
Miller and Lea 1972	A. transmontanus	NA	11-14	38-48	9-12	44-48	28-31		
Schreiber 1959	A. transmontanus	NA		36-46		42-53	27-32	23-30	31[i]
Scott and Crossman 1973	A. transmontanus	NA	11-14	38-48	9-12	44-48	28-30	34-36	
			Absolute ranges for white sturgeon						
North America			11-14	36-48	9-12	42-53	27-32	23-36	

[a] Adults from Tumnin (Datta) River estuary, Russian Federation (formerly USSR)
[b] Juvenile from unknown location. Text refers to one specimen but states range for counts.
[c] Young-of-year progeny from adults collected in Klamath River, California, USA
[d] Life stage unknown from northern waters of Japan
[e] Preserved specimen from unknown location
[f] Juvenile from Point Vicente, Los Angeles County, California, USA
[g] Adults from Columbia River estuary, Oregon, USA
[h] Adult from Rogue River, Oregon, USA
[i] Young-of-year from Old, Sacramento, or Eel Rivers, California, USA
[j] Adult from Klamath River estuary, California, USA
[k] One juvenile from Konbumori and one from near the mouth of the Ishikari River, Japan
May not have been collected correctly

Table 4. Summary of ranges for six meristic characters of Asian and North American (NA) populations of green sturgeon. Includes references where origin of data could not be determined or authenticated. Meristic characters are dorsal scutes (DS), lateral scutes (LS), ventral scutes (VS), dorsal rays (DR), anal rays (AR), and gill rakers (GR).

Source	Species (as noted by author(s)	Origin	DS	LS	VS	DR	AR	GR	N
Bane & Bane 1971	*A. medirostris*		8-11	23-30	7-10				?
Berg 1911	*A. medirostris*	Asian	10	28-30	7-8	36-39	27-29		?
Berg 1948	*A. medirostris*	Asian	8-10	27-31	6-8	36-40	25-29	18-20	?
Bond 1973	*A. medirostris*			23-30		33-35			?
Bond & Beardsley 1978	*A. medirostris*			23-30					?
Carl et al. 1977	*A. medirostris*		8-11	23-30	5-10	33-35			?
Clemens & Wilby 1967	*A. medirostris*		8-11	23-30	7-10	33-36	22-28		?
Conte et al. 1988	*A. medirostris*			23-30					?
Dees 1961	*A. medirostris*			23-30					?
Dumeril 1870	*A. medirostris*	NA	10	28	10	36	18		?
Fry 1973	*A. medirostris*			23-31					?
Hart 1973	*A. medirostris*		7-11	22-30	6-10	33-36	22-28		?
In Linberg & Legeza 1965[a]		NA	10	25-26	10	40	27		?
In Linberg & Legeza 1965[a]		Asian	8-10	27-31		36-40	25-29		?
Kirsch & Fordice 1890	*A. medirostris*	NA	11	26-30	8	33	22		?
Masuda et al. 1984	*A. medirostris*		7-11	22-36	6-10	33-40	22-30		?
Matsubara 1955		Asian	7-10	34-36	8-9	35-40	25-30		?
Migdalski 1962	*A. medirostris*		8-11	23-30	7-10	33-36	22-28		?
Miller & Lea 1972	*A. medirostris*		8-11	23-30	7-10	33-42	22-29		?
Morrow 1980	*A. medirostris*		8-11	23-30	7-10	33-35		18-20	?
Moyle 1976	*A. medirostris*		8-11	23-30	7-10	33-36	22-28		?
Moyle et al. 1995	*A. medirostris*		8-11	23-30	7-10	33-36	22-28		?
Okada & Matsubara 1938	*A. mikadoi*	Asian	7-8	34	9	35-40	30		?
PSMFC 1996	*A. medirostris*		9-11	23-30	7-10				?
Schultz 1938	*A. medirostris*					33-35	22-28		?
Scott & Crossman 1973	*A. medirostris*		9-11	23-30	7-10	33-35	22-28	18-20	?
Snyder 1912		Asian	10	30-33	8-9				?
Vladykov & Greeley 1963	*A. medirostris*		8-11	23-31				18-20	?
Wang 1986	*A. medirostris*								?
Wydoski & Whitney 1979	*A. medirostris*			23-30					?

[a] In Russian

Table 5. Guidelines for field identification of green and white sturgeon in North America.

Characteristic	White Sturgeon	Green Sturgeon
Color	Gray	Olive green
Dorsal scutes	11-14	7-12 (usually sharp)
Lateral scutes[a]	36-48	22-33 (usually sharp)
Ventral scutes	9-12	5-12 (usually sharp)
Dorsal fin rays	42-53	35-44
Gill rakers	23-30	15-19
Barbels	Equidistant between mouth and tip of snout or closer to snout	Equidistant between mouth and tip of snout or closer to mouth
Longitudinal stripes	None	2 lateral from pectorals to pelvics; 1 on anterior ventral surface
Position of anus[a]	Posterior of anal fin insertion	Anterior to anal fin insertion
Scutes between anal fin and pelvic fin	2 rows of 4-8 scutes each	1-2 rows of 1-4 scutes each
Scutes between dorsal and caudal fin	Not present	May be present
Snout	Generally less pointed	Generally more pointed

[a] Most useful in field.

Table 6. Summary of 12 morphometric characters of Asian (Artyukhin and Andronov 1990) and North American (North et al. this report [b and c]) green sturgeon.

Character		Artyukhin and Andronov 1990[a]	North et al. this report[b]	North et al. this report[c]
Absolute (total) length (cm)	N	8	50	1
	range	148-180	125-170	198
	mean (+/-SE)	163 (4.0)	148 (2.1)	
Head length (cm)	N	8	50	1
	range		24.0-34.3	38.0
	mean (+/-SE)		27.8 (0.4)	
	% of TL	22.4-24.3	16.2-21.6	19.2
	mean (% of	23.3 (0.3)	18.8 (0.2)	
Snout length to eye (cm)	N	8	50	1
	range		8.0-14.4	15.1
	mean (+/-SE)		11.0 (0.2)	
	% of TL	10.0-12.0	5.0-9.9	7.6
	mean (% of	10.9 (0.2)	7.4 (0.2)	
Post-orbital distance (cm)	N	8	50	1
	range		12.8-20.0	21.2
	mean (+/-SE)		16.6 (0.3)	
	% of TL	10.9-12.1	10.2-12.3	10.7
	mean (% of	11.3 (0.1)	11.2 (0.1)	
Inter-orbital distance (cm)	N	7	50	1
	range		8.4-13.5	14.1
	mean (+/-SE)		10.7 (0.2)	
	% of HL	30.3-37.1	34.1-42.8	37.1
	mean (% of	34.1 (1.0)	38.5 (0.3)	
Depth of head at eye (cm)	N	7	50	1
	range		7.3-12.7	10.3
	mean (+/-SE)		9.6 (0.2)	
	% of TL	5.6-6.4	5.4-7.8	5.2
	mean (% of	6.0 (0.1)	6.5 (0.1)	
Greatest body depth (cm)	N	8	50	1
	range		11.6-20.4	20.3
	mean (+/-SE)		15.1 (0.3)	
	% of TL	11.9-16.9	9.2-13.0	10.2
	mean (% of	13.5 (0.5)	10.2 (0.1)	
Pectoral fin length (cm)	N	7	50	1
	range		13.5-24.0	20.3
	mean (+/-SE)		18.8 (0.3)	
	% of TL	11.5-13.5	10.7-15.4	10.2
	mean (% of	12.5 (0.2)	12.7 (0.1)	

Table 5 continued.

Length of snout to barbels (cm)	N	7	50	1
	range		3.1-7.2	8.4
	mean (+/-SE)		5.3 (0.1)	
	% of HL	26.2-30.7	12.4-24.8	22.1
	mean (% of	27.7 (0.8)	19.2 (0.4)	
Barbels to mouth (cm)	N	7	50	1
	range		5.1-9.1	6.3
	mean (+/-SE)		7.2 (0.1)	
	% of HL	17.8-21.3	21.3-29.3	16.6
	mean (% of	19.4 (0.5)	26.0 (0.3)	
Snout width at barbels (cm)	N	7	50	1
	range		6.8-11.4	10.6
	mean (+/-SE)		8.9 (0.2)	
	% of HL	28.7-35.1	27.2-36.6	27.9
	mean (% of	31.6 (1.0)	31.9 (0.3)	
Snout width at mouth (cm)	N	7	50	1
	range		10.9-18.2	13.5
	mean (+/-SE)		13.9 (0.2)	
	% of HL	35.7-45.4	43.7-59.6	35.5
	mean (% of	40.6 (1.5)	50.1 (0.4)	

[a] Tumnin (Datta) River green sturgeon (Asian) collected in 1986 and 1987.
[b] Columbia River green sturgeon (North American) collected in August
[c] Rogue River green sturgeon (North American) collected in July 2000.

Appendix F.

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We gathered 285 references dealing with green sturgeon, the Rogue River, or information generally applicable to our study.

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