Klamath River Green Sturgeon Acoustic Tagging and Biotelemetry Monitoring, 2009

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Yurok Tribal Fisheries Program technician Troy Fletcher Jr. displays a recently tagged green sturgeon on the Klamath River in 2009.

Introduction

The green sturgeon (*Acipenser medirotris*) is an anadromous Pacific Ocean sturgeon found in the coastal waters and rivers of western North America (Moyle 2002). Their distribution ranges from Ensenada, Mexico to the Bering Sea, Alaska (Scott and Crossman, 1973; Moyle, 2002). The only known spawning streams are the Rogue River in Oregon, and the Sacramento and Klamath Rivers in California. Recent genetic studies have identified two distinct population segments; one from the north and one from the south. Individuals belonging to the northern distinct population segment spawn in the Rogue and Klamath Rivers, while green sturgeon that spawn in the Sacramento River belong to the southern distinct population segment (Israel et al., 2004).

Green sturgeon life history, abundance, and distribution data is limited. Green sturgeon use freshwater primarily for spawning, and are mostly observed in saltwater and brackish estuaries of large coastal rivers (Scott and Crossman, 1973; Parks, 1978; Houston, 1988). However, stream residency has been documented during summer and fall for up to six months in the Klamath and Rogue Rivers (Benson et al., 2005; Erickson et al., 2002). Timing of emigration from the river was related to increased discharge, particularly the first freshets of the autumn and winter (Benson et al., 2005).

Green sturgeon populations in North America are considered vulnerable to endangered (Musick et al. 2000). Presumed spawning populations in the Eel, South Fork Trinity, and San Joaquin Rivers have been extirpated within the last 25 to 30 years (Moyle et al., 1995). Mature spawners in other populations are reduced, with mature females potentially numbering in the low hundreds (Musick et al., 2000; Moyle, 2002). Furthermore, anthropogenic activities can detrimentally affect green sturgeon populations, particularly dams and hydroelectric projects (Houston, 1988; Moyle et al., 1995; Erickson et al., 2002). Flows on the Sacramento, Rogue and Klamath Rivers are artificially manipulated and reduced, and while the full effects of flow manipulations on sturgeon are not known, they are sensitive to flow conditions for migrational cues (Benson et al., 2005; Erickson et al., 2002). Existing data is limited for this species, particularly regarding its abundance, distribution within its range, population dynamics, and ecological requirements. Until these parameters are identified and sufficiently understood, green sturgeon should be considered rare and a species of special concern, especially due to the extreme vulnerability of sturgeons globally (Houston, 1988; Birstein, 1993; Birstein et al., 1997; Musick et al., 2000; Moyle, 2002).

To the Yurok Tribe, green sturgeon are considered sacred and these large fish are an extremely valuable source of food. The Yurok people have lived along the banks of the Klamath River for millennia, subsisting on the Klamath's once abundant runs of anadromous fish. Water quality and water quantity issues have led to large scale declines in Klamath River anadromous fishes (NRC, 2002), and the status of green sturgeon populations are not known. The Yurok Tribe is concerned that declines in green sturgeon numbers may be eminent, and therefore initiated a long term study intended to gather as much information on these revered fish as possible.

From 2002 to 2005 the Yurok Tribal Fisheries Program (YTFP) captured and tagged 56 adult green sturgeon in the Klamath and Trinity Rivers. In 2002 and 2003 we used radio biotelemetry and focused our study on in-river movements and migrations of green sturgeon (see Benson et

al., 2005). Studies conducted in 2004 and 2005 also examined in-river movements, however, in these years we used acoustic biotelemetry which allowed us to also determine where green sturgeon go after emigrating from the Klamath River. Green sturgeon from all four study years were internally tagged with either radio or acoustic transmitters, or both. The acoustic transmitters used in 2004 and 2005 had a life expectancy of up to five years, so it is possible that some are still operational. Since 2002, the YTFP has deployed acoustic monitoring receivers throughout the lower Klamath, Trinity, and Salmon rivers in order to track the movements of any returning green sturgeon tagged in the Klamath River. This information will help researchers evaluate survival trends as well as spawning periodicity. Numerous green sturgeon have also been tagged at various locations in California, Oregon, and Washington, and our receivers will detect any of these fish if they enter the Klamath River. This data can assist researchers evaluate long distance migrational patterns. From 2006 to 2009, we also deployed a small receiver array (1-3 receivers) approximately one kilometer offshore from the mouth of the Klamath River in the Pacific Ocean. These receivers can inform us if any tagged green sturgeon are migrating through, or aggregating in the ocean near the Klamath River mouth.

Due to the five year lifespan of the acoustic tags previously used, most will be non-operational after 2010. In order to keep this valuable source of data, the YTFP decided to once again acoustically tag green sturgeon in the Klamath River. In the spring of 2009 we captured and tagged four adult green sturgeon with acoustic tags that have a ten year lifespan. We also deployed our acoustic in-river and oceanic receiver array to track the tagged individuals, as well as any others that may enter the Klamath River. This technical memorandum summarizes our findings from 2009.

Methods

Receiver Array

Beginning in April of 2009, we deployed an array of 10 acoustic receivers (Vemco Ltd. VR2 and VR2Ws) at sites downstream of river kilometer (rkm) 108 (Figure 1). The receivers were deployed at locations where river currents were slow and depths were greater than ten feet. The receivers were attached to a cable that was anchored to the river bottom and connected to the shore. Receivers were downloaded via laptop computer on a bi-monthly basis or opportunistically throughout the study period. We removed the receiver array from the river in December of 2009, with the exception of the Blue Creek (rkm 26) receiver which is deployed on a year round basis. We also deployed two sonic receivers in the Pacific Ocean approximately one kilometer offshore from the Klamath River's mouth in late September of 2008 (Figure 2). One of these receivers were downloaded on September 10, 2009, we were unable to locate the other.

Tagging

Fish were captured using a single stranded monofilament $7^{1/4}$in (stretched) mesh gill net. The net was 37 meshes deep (approx. 22 ft deep), 75 ft in length, and was set in a large eddy near Coon

Creek Falls (rkm 57) (Figure 1). One sturgeon was captured by tribal members at Weitchpec Bar (70) (Figure 1) and donated to the YTFP for tagging. Captured sturgeon were either tagged immediately, or held in black PVC culvert live wells overnight in the river. Each captured fish was weighed, had its fork length and total length measured, and had a mid-lateral scute count (both sides) recorded. We also collected a small DNA sample from the dorsal fin of each sturgeon. These samples were stored in micro-centrifuge tubes containing a solution of 95% ethanol.

An acoustic tag was surgically implanted into the abdominal cavity of each captured sturgeon. The sturgeon was prepared for surgery by placing it in a sling with a water filled hood attached to one end. This end was slanted downhill so that the fish's gills stayed in contact with fresh water at all times. An assistant monitored the breathing of each sturgeon during the surgery and filled the hood with fresh water as needed.

The incision and insertion process involved making a 2-3 in incision immediately to the right of the mid-line on the ventral side of the fish. The incision point was started approximately 4-5 in anterior from base of the pelvic fins. The exterior skin surface was pulled upward while making the insertion to protect the internal organs from accidental damage. When a clean incision was achieved, we checked for evidence of sex, and inserted the acoustic tag toward the posterior of the fish. The incision was closed using medical sutures and a standard surgical cross-stitch. Each incision took between 3-4 individual stitches to close. In general, the surgery lasted an average of 8-12 min, but never exceeded 15 min, and each fish was held after surgery for up to one half hour before being released.

The acoustic tags we used were produced by Vemco Ltd. They are model V-16-5H coded pinger transmitter, which is 16 mm in diameter, 92 mm long, and weighs 16 grams. This tag is designed to last a minimum of 3650 days.

Results

Four green sturgeon were captured and tagged in the Klamath River in 2009. One fish was tagged on May 14th; the other two were tagged on May 15th.

No green sturgeon that were tagged outside the Klamath River were detected by our in-river receiver array in 2009. Furthermore, no green sturgeon tagged in the Klamath River during previous studies migrated back into the Klamath River in 2009. The only sturgeon detected by our in-river receiver array in 2009 were the four fish tagged in the Klamath River in 2009.

The four tagged green sturgeon had an average length of 197.75 cm and an average weight of 51.5 kg (Table 1).

Fish 1 was tagged on May 14th at rkm 70 and was next detected at rkm 97 on May 21st through May 23rd. It was next detected at rkm 71 and then rkm 57 on May 27th. Fish 1 was then detected in the estuary at rkm 3 and rkm 1 on May 28th, before exiting the river on June 1st. Our last detection of fish one occurred on June 4th on our ocean array (Table 2).

Fish 2 was tagged on May 15th at Coon Creek (rkm 57) and on May 20th it was detected by both our estuary receivers (rkm 3 and 1). It was detected again on May 26th at rkm 57, and then at rkm 71 on May 28th. The next detection occurred on May 29th at rkm 79 and it was detected again at rkm 79 on June 9th. Fish 2 was detected again on June 10th at rkm 71 and our last detection occurred on June 11th at rkm 57 (Table 2).

Fish 3 was tagged on May 15th at Coon Creek (rkm 57) where it remained until May 17th. It was detected again on May 20th at rkm 70 and our last detection came on May 21st at rkm 79 (Table 2).

Fish 4 was tagged on May 15th at Coon Creek (rkm 57) where it remained until May 17th. The next detection occurred on May 19th at rkm 72 on the lower Trinity River. The next day, May 20th, fish 4 was detected back in the Klamath River at rkm 71. It was detected again on June 16th at rkm 79 where it remained until October 14th. The next detection came on November 23rd at rkm 71 where it held until November 28th. On December 17th our estuary receivers (rkm 3 and 1) detected fish 4 for the last time as it exited the Klamath River (Figure 2).

Our ocean receiver array was downloaded on September 10th, 2009. Due to foggy conditions, we could only locate one of the two receivers. The recovered ocean receiver detected 22 unique frequencies during the deployment period which was September 21st, 2008 until September 10th, 2009. Of the 22 detections, 12 were confirmed to be green sturgeon, 3 were found to be 7-gill sharks, and 7 were not identified (Table 3).

Klamath River discharge was recorded during the study by the USGS near the town of Klamath, CA (rkm 13, gauge # 11530500). The maximum discharge recorded was 17,500 cubic feet per second (cfs) on May 15th and the minimum was 2230 cfs recorded on September 28th (Figure 3). Klamath River temperature was recorded by the YTFP at Coon Creek Falls (rkm 57). The maximum temperature recorded during the study period was 25.8°C on July 28th and the minimum river temperature recorded was 5.2°C on December 16th (Figure 3).

Discussion

No tagged green sturgeon from previous studies in the Klamath River, or tagged sturgeon from areas outside of the Klamath River, were detected in 2009. No detection of previously tagged sturgeon has been occured in years past (McCovey, 2007), which may be due to the fact the most of the acoustic tags used in past Klamath River studies have expired batteries. The only tags that may still be operational were those used in the 2005 tagging study. In the 2005 study, only eight fish were tagged so it is not unexpected that none were detected.

Four green sturgeon were captured and tagged in mid May of 2009 as spring flows were decreasing. The run timing of fish ragged in 2009 is consistent with observations in preceding studies. The first green sturgeon tagged was captured at Weitchpec Bar (rkm 70) by a tribal fisherman and donated to the YTFP to be tagged due to its length being larger than the maximum retainable size limit (6'). After tagging, this sturgeon quickly migrated to the Dolans Bar area

(rkm 97), where it held for three days. This area is believed to hold green sturgeon spawning congregations in the spring, and we assume that this fish spawned at this time. It then made a rapid out-migration and left the Klamath River a week later.

The second sturgeon tagged was captured at Coon Creek Falls by YTFP personnel. This fish quickly migrated from Coon Creek to the estuary where it was detected five days later. It then traveled for six days, back upstream to Coon Creek Falls, where it was tagged. Such behavior is very uncommon and has not been observed in previous studies on the Klamath River. We believe that the fish retreated downriver due to tagging stress but resumed migration due to the overpowering need to spawn. The fish continued its up-stream migration and swam past our receiver at Aikens Hole (rkm 79) three days later. It remained upstream of this location for 11 days, most likely in the Red Cap Gorge, which is known to hold large congregations of green sturgeon. It was detected for the last time at rkm 57 two days later on June 11th. Due to the rapid nature of the sturgeon out-migration, and the moderate turbidity levels during this time, none of our receivers in the estuary detected this fish.

The third green sturgeon tagged was also captured at Coon Creek Falls. It rapidly migrated above our receiver at Aikens Hole (rkm 79) and was not detected again. We are unsure of the fate of this sturgeon, but believe it left the Klamath River sometime during the spring because no further detections were recorded in the summer or fall and high flows and turbidity in the spring can sometimes preclude detections. Once again, the moderate turbidity levels and rapid out-migration rates could be responsible for the lack of detections.

The fourth sturgeon tagged was captured at Coon Creek Falls by YTFP personnel, where it held for three days. Two days later, on May 19th it was detected two kilometers up Trinity River (rkm 72). After spending one day in the Trinity, it moved back down to the Klamath and then up to rkm 71. It is not uncommon for tagged sturgeon to enter the Trinity River and move back into the Klamath. We have observed this behavior in the past on several occasions (Benson et al., 2005). By June 16th fish 4 was at Aikens Hole (rkm 79) where it spent the next four months. This behavior is known as summer holding, and has been observed in approximately 75% of green sturgeon tagged in the Klamath River. After the summer holding period, fish 4 left Aikens Hole on October 14th. This movement coincided with the first significant increase in discharge of the fall, which is known to be an important migrational cue. As river discharge decreased back towards summer levels the sturgeon stopped its emigration and held at rkm 71 until November 28th. This fish exited the Klamath River on December 17th, when a drastic increase in discharge occurred.

Our ocean receiver array detected 22 unique frequencies from September 21st, 2008 to September 10th, 2009. Twelve of these detections were confirmed to be green sturgeon. Of those 12, nine were from the southern distinct population segment. They were tagged in the San Francisco Bay region, or the Sacramento River. Two of the green sturgeon detected were tagged in the Klamath River, and one was tagged in Willipa Bay. In previous years we have observed many green sturgeon migrating past, or congregating in, the oceanic estuary of the Klamath River. In years past, we found that the majority of these fish were tagged in the Sacramento River system (including the San Francisco Bay region). This was also true in 2008 and 2009. We believe that this observation is because that region is where the highest percentage of green

sturgeon have been tagged within the species' range. Our array also detected three seven gill sharks which were tagged in the San Francisco Bay in 2007. There were seven detected frequencies that have yet to be identified.

In 2010, the YTFP plans on acoustically tagging up to 20 green sturgeon in the Klamath River. We will also be installing our in-river and oceanic acoustic receiver arrays.

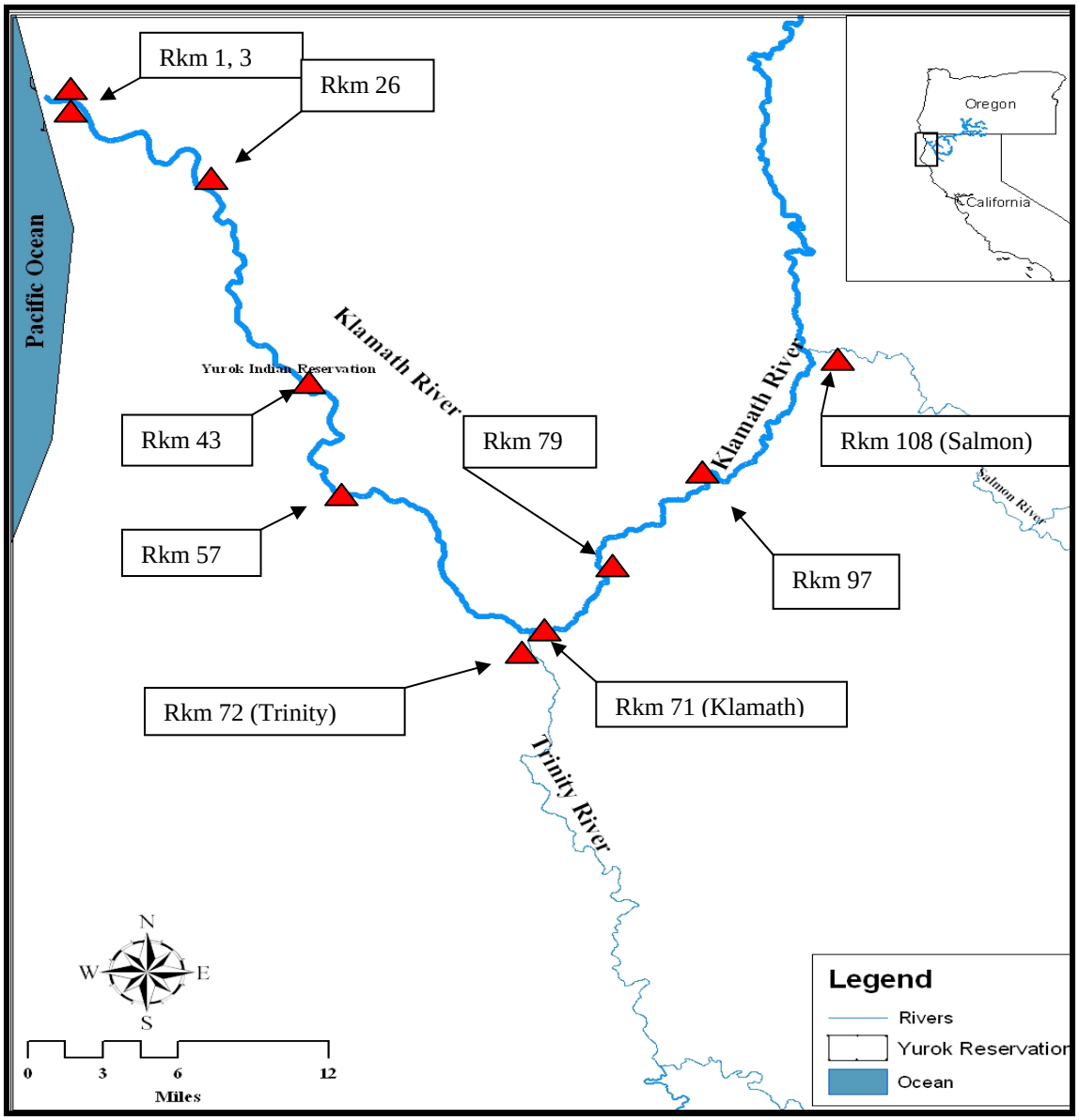

Figure 1: Map of the lower Klamath, Salmon, and Trinity Rivers showing sonic receiver locations during the green sturgeon acoustic tagging and biotelemetry monitoring project of 2009. Coon Creek (rkm 57) was also a capture and tagging location.

Figure 2: Satellite photo showing the mouth of the Klamath River and the adjacent Pacific Ocean. Triangles represent the locations of the two sonic receivers which were deployed on September 29th , 2008 and utilized during the 2009 green sturgeon sonic biotelemetry monitoring project. Photo from Google Earth 2008.

Table 1: Biological data from 2009 green sturgeon acoustic tagging project. Scute counts are from the right (R) and left (L) sides of the fish.

Number	Date Tagged	Tag Code	Sex	Length (cm)	Weight (kg)	Scute R	Scute L
1	5/14/2009	58687	Female	208	58.9	28	29
2	5/15/2009	58688	Male	173	36.2	28	25
3	5/15/2009	58689	Female	209	61.2	26	27
4	5/15/2009	58690	Female	201	49.8	25	24

Table 2: Results from the 2009 green sturgeon acoustic tagging and biotelemetry monitoring project. These four fish were tagged by the YTFP in 2009, no fish from previous years or other locations were detected. Two dates in the date of detection column indicates that the fish held in that area for the time span shown.

Fish ID	Location (rkm)	Date of Detection
1	Tagging (70)	5/14/2009
	97	5/21/2009-5/23/2009
	70	5/27/2009
	57	5/27/2009
	3	5/28/2009
	1	5/28/2009-6/1/2009
	ocean (-1)	6/4/2009
2	Tagging (57)	5/15/2009
	3	5/20/2009
	1	5/20/2009
	57	5/26/2009
	70	5/28/2009
	79	5/29/2009
	79	6/9/2009
	70	6/10/2009
	57	6/11/2009
3	Tagging (57)	5/15/2009
	57	5/15/2009-5/17/2009
	70	5/20/2009
	79	5/21/2009
4	Tagging (57)	5/15/2009
	57	5/15/2009-5/17/2009
	72 (Trinity)	5/19/2009-5/20/2009
	70 (Klamath)	5/20/2009
	79	6/16/2009-10/14/2009
	70	11/23/2009-11/28/2009
	3	12/17/2009
	1	12/17/2009

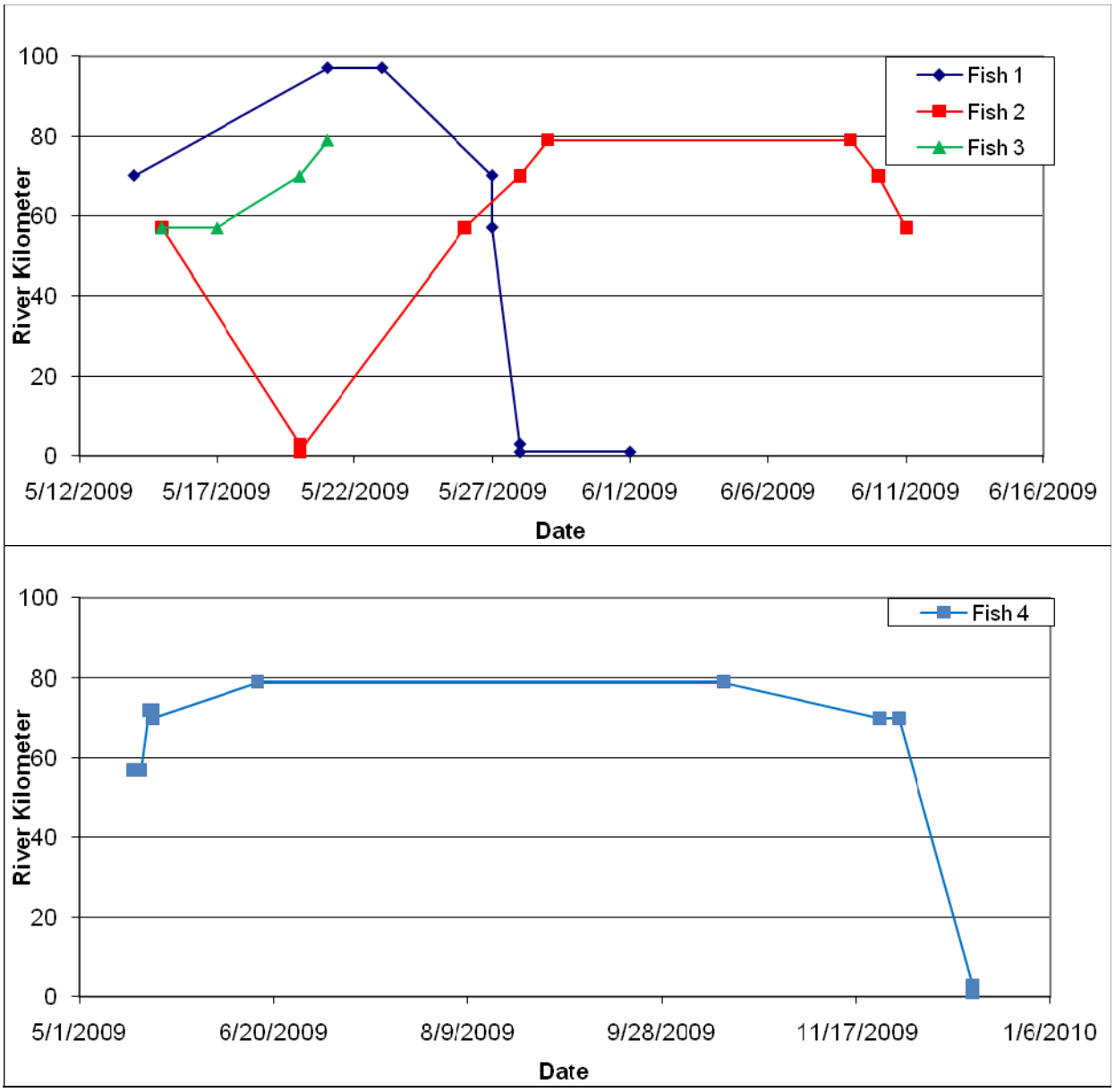

Figure 3: Movement history of the four tagged green sturgeon in the Klamath River during the 2009 green sturgeon acoustic tagging and biotelemetry monitoring project. Fishes 1, 2, and 3 were last detected in the spring of 2009 and fish 4 was last detected in December of 2009.

Table 3: Results from the 2009 green sturgeon acoustic tagging and biotelemetry monitoring project. Shown are all tagged fish detected by our ocean sonic receiver array. Multiple dates in the date of detection column indicates that the fish held in that area for the time span shown, or it was detected at different points in time. A hyphen indicates the fish held within range of the receiver for the two dates shown and a comma separates different dates of detection. Origin indicates the location the individual fish was captured and tagged and GS in the species column specifies that the tagged fish was green sturgeon.

Fish ID	Origin	Species	Date of Detection
907	San Pablo Bay	GS	10/4/08-10/5/08
16232	SF Bay	7gill shark	10/4/08, 2/1/09
912	San Pablo Bay	GS	10/12/2008
653	?	?	10/23/2008
539	Klamath	GS	11/5/08-11/17/08, 12/7/08
1138	Willipa Bay	GS	11/5/2008
52452	?	?	11/8/2008
52069	SF Bay	7gill shark	11/19/2008
625	?	?	12/14/2008
918	San Pablo Bay	GS	12/16/08, 12/29/08, 12/31/08-01/4/09, 2/20/09, 3/5/09
52454	?	?	12/19/2008
995	San Pablo Bay	GS	12/23/2008
618	?	?	1/13/09, 1/27/09, 1/30/09
5450	Sacramento River	GS	2/22/09, 4/16/09, 4/26/09,
2224	San Pablo Bay	GS	3/1/2009
58687	Klamath	GS	6/4/2009
2203	San Pablo Bay	GS	6/18/2009 *(Fish 1)
52439	?	?	7/31/09, 8/16/09, 8/18/09, 8/21/09
52451	?	?	8/18/09, 8/28/09, 9/2/09
52412	Sacramento River	GS	8/21/2009
16232	SF Bay	7gill shark	2/1/2009
918	San Pablo Bay	GS	12/31/08-1/4/09, 2/21/09, 3/5/09

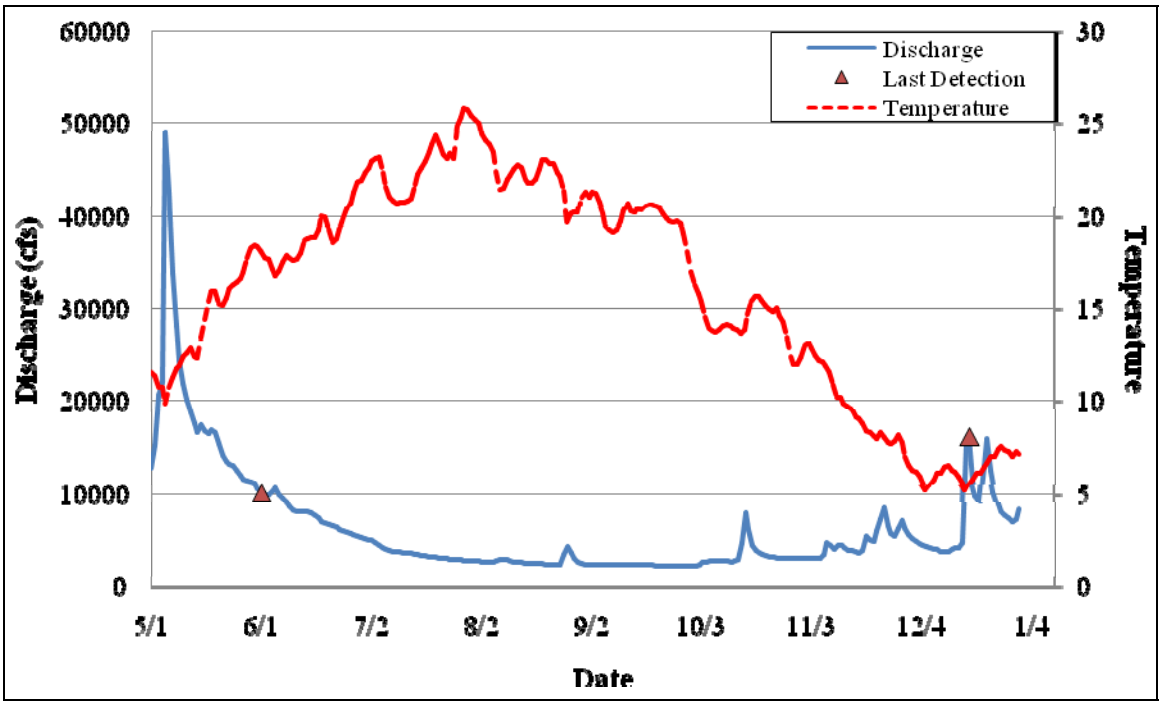

Figure 4: Klamath River discharge measured near Klamath, CA, along with Klamath River temperature during the green sturgeon acoustic tagging and biotelemetry monitoring project of 2009. Temperature was measured at Coon Creek (rkm 57) and discharge at Klamath Glen (rkm 13). Each point on the line represents the last time a sturgeon emigrating from the river was detected on our estuary receiver. The other two sturgeon were not detected by our estuary receiver, so we cannot be sure of their exact emigration date.

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