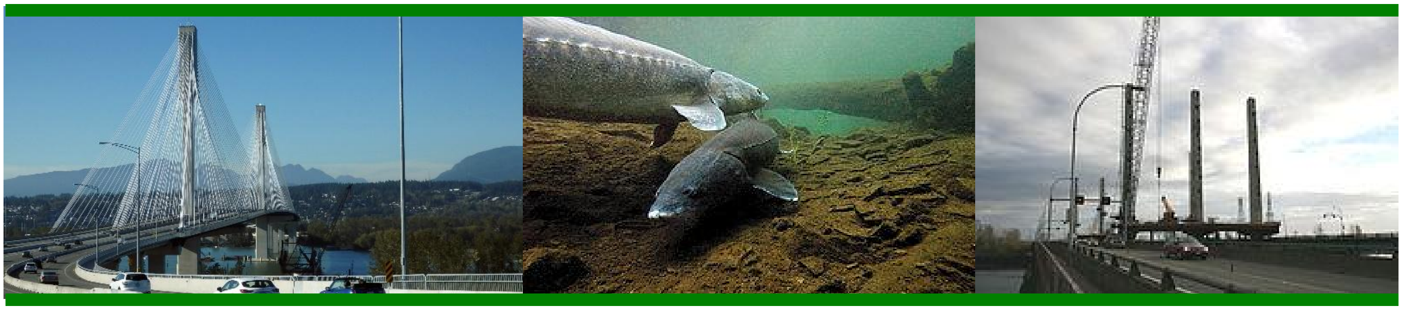
EA3094

White Sturgeon Interactions with Port Mann and Pitt River Bridges in the Kwikwetlem First Nation Territory

FINAL REPORT



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EXECUTIVE SUMMARY

In 2008, concerned by bridge construction activities underway in their traditional territory, the Kwikwetlem First Nation enlisted help from the Fraser River Sturgeon Conservation Society (FRSCS) and LGL Limited to begin a White Sturgeon (*Acipenser transmontanus*) acoustic tracking study. In all, 110 White Sturgeon of various sizes were acoustically tagged to determine the frequency and timing of movements past the Port Mann Bridge (being twinned across the Fraser River) and the Highway 7 Bridge (being twinned across the Pitt River). With acoustic-tagged sturgeon in the area, we took the opportunity and developed a broader tracking project, thus receivers were located not just near the bridge-crossings, but throughout the lower Fraser River and into adjacent marine areas. Acoustic tags were programmed to last for three years, and tracking spanned from 2008 to 2012.

Over the study period, there were 981 and 939 encounters between tagged sturgeon and the Port Mann and Highway 7 bridges, respectively, involving 84% and 88% of all tagged individuals. Bridge encounters occurred in all months, with busiest times in spring and autumn. Upstream and downstream passage events were about equally represented in the detection data, indicating movements back and forth through the construction areas; sturgeon had a greater tendency to move downstream in the spring (60.4-73.2% of events) and upstream in the autumn (58.7-63.5% of events). Adverse effects of construction could be minimized by limiting in-river construction activities to December to February, when sturgeon are least likely to be present in or migrating past these bridge sites. Since it is unlikely that construction schedules will be altered to accommodate sturgeon, measures should be taken to minimize disturbance (e.g., use sound and shockwave buffers around pile-driving and blasting locations).

This report presents the findings of the 2008-2012 White Sturgeon acoustic telemetry study in the lower Fraser River, with an emphasis on tracking data collected at the Port Mann and Highway 7 bridge locations. Results from the broader tracking project are reported in Robichaud et al. (2017).

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INTRODUCTION

White Sturgeon (*Acipenser transmontanus*) are endemic to the west coast of North America, with known spawning locations in the Sacramento, Columbia, and Fraser rivers (McPhail 2007). In Canada, White Sturgeon are of cultural and economic importance. The species has been important to aboriginals for generations (Nelson et al. 2013b), actively targeted by anglers (Inglis and Rosenau 1994), and at one time was commercially exploited (Semakula and Larkin 1968), although overfishing caused the fishery to crash at the turn of the last century (Echols and FRAP 1995; Ptolemy and Vennesland 2003). White Sturgeon are long-lived, late-maturing fish (Semakula and Larkin 1968), thus it is not surprising that populations have been slow to recover from the great declines caused by overfishing. In fact, White Sturgeon in the Fraser River downstream from Hells Gate (river kilometer 212) is assessed by the Committee on the Status of Endangered Wildlife in Canada as "Threatened" (COSEWIC 2012).

In the early 1990s, conservation concerns led many First Nations to voluntarily impose harvest restrictions on their own fisheries. In 1994, Fraser River recreational fishing regulations were modified to forbid anglers from retaining White Sturgeon (Echols and FRAP 1995). In 2000, White Sturgeon angling of all types was banned in the Nechako River watershed (RL&L 2000).

Anthropogenic impacts are not limited to fisheries. For example, pollutants have been recorded in tissues of Fraser River White Sturgeon at concentrations that could affect reproduction or other physiological functions (Kruse and Scarnecchia 2002). Also, underwater noise, such as that produced from pile driving during bridge or dock construction, has been shown to cause damage to sturgeon's internal organs, and could potentially change migratory behaviours enough to impact populations (Halvorsen et al. 2012). In fact, concerns regarding the potential impact of lower Fraser River bridge construction activities are what prompted the Kwikwetlem First Nation to enlist help from the Fraser River Sturgeon Conservation Society (FRSCS) and LGL Limited to initiate the multi-year acoustic telemetry study described here. Their main goal was to track movements of tagged White Sturgeon in the area of two bridges that were slated for twinning: by assessing the frequency and timing of sturgeon movements under the bridges, the possible impacts of the construction and demolition activities could be evaluated.

With acoustic-tagged sturgeon in the area, the study team took the opportunity and developed a broader tracking project, thus many analyses were performed using the dataset described herein. These include analyses of movement patterns, distribution, and travel speeds in the lower parts of the Fraser River (see details in Robichaud et al. 2017). This report focuses on the movements past the two bridge sites in the Kwikwetlem First Nation traditional territory.

METHODS

Study Area

The core study area included the lowermost 53 km of the mainstem Fraser River from the Strait of Georgia to Maple Ridge, and 21 km of the Pitt River from its confluence with the Fraser River (39 km from the Fraser River mouth) to Pitt Lake (Figure 1). These rivers are unregulated along their entire lengths, and are both tidally influenced within the core study area (Ashley 1980). Channel morphology and sediments in the Pitt River, described in Ashley (1980), retain characteristics of a pristine, unaltered system. By contrast, the lower Fraser River supports substantial shoreline industry, and has undergone significant physical modifications such as diking, dredging, and channel stabilization (McLaren and Ren 1995).

The focal area of this report is the part of the Fraser River near the Port Mann Bridge (35 km from the Fraser River mouth) and the Pitt River near the Highway 7 Bridge (4 km from the confluence of the Pitt and Fraser rivers).

Receivers and Transmitters

Telemetry equipment manufactured by Vemco (Bedford, NS, Canada) was selected for this study, so that our tags would be compatible with several other local and international receiver arrays (Figure 1). Telemetry detection repositories were maintained by Hydra (housing and sharing acoustic telemetry data, focused on arrays in Puget Sound) and POST ('Pacific Ocean Shelf Tracking'; housing and sharing data from arrays located within the Fraser River, the Strait of Georgia, Juan de Fuca Strait, and along the Pacific Shelf from California to Alaska), with whom we had data-sharing agreements.

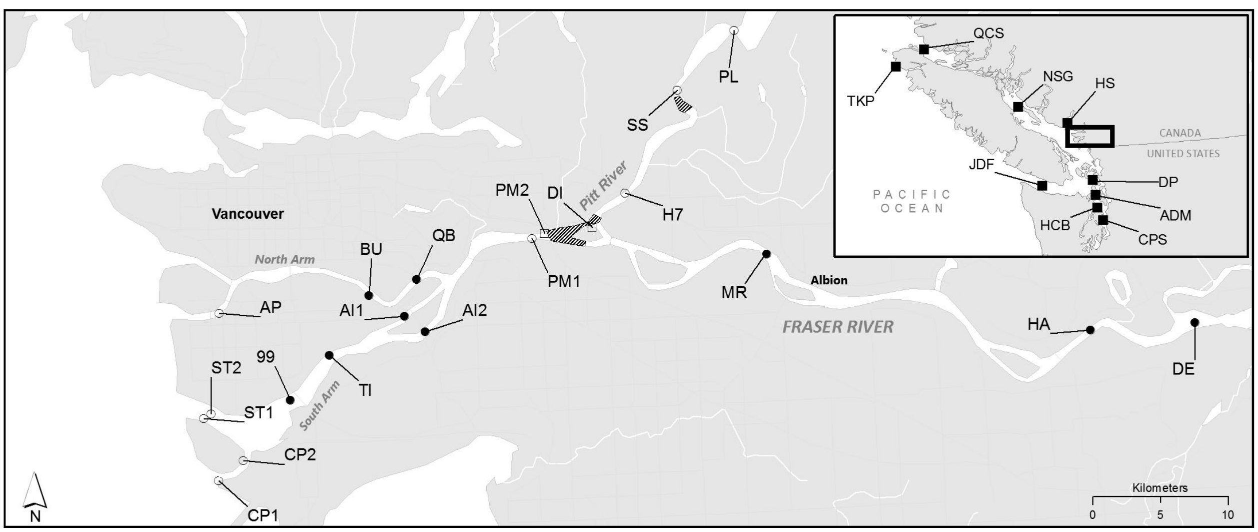

Figure 1. **Fixed-station receiver locations within the Fraser River (open: receivers deployed for this study; solid: receivers maintained by POST affiliates). Squares: receivers that were not in place for the full duration of the study period (the PM2 receiver was moved to DI). Hatched areas indicate tagging locations. Inset: the location of the lower Fraser River study area (box) and that of marine and estuarine receiver arrays maintained by POST and Hydra affiliates. Abbreviations: 99: Highway 99; ADM: Admiralty Inlet; AI: Annacis Island; AP: Airport; BU: Burnaby; CP: Canoe Pass; CPS: Central Puget Sound; DE: Dewdney; DI: Douglas Island; DP: Deception Pass; H7: Highway 7 Bridge; HA: Hatzic; HCB: Hood Canal Bridge; HS: Howe Sound; JDF: Juan de Fuca Strait; MR: Maple Ridge; NSG: Northern Strait of Georgia; PL: mouth of Pitt Lake; PM: Port Mann Bridge; QB: Queensborough Bridge; QCS: Queen Charlotte Strait; SS: Sturgeon Slough; ST: Steveston; TI: Tilbury Island; TKP: Topknot Point.**

Receivers used in this study (Vemco model VR2W) were deployed in 11 locations (Figure 1), although damage and loss meant that not all receivers were in place for the full duration of the study period. For the bridge detection work, receiver locations were selected to monitor movements in the Pitt River and near the Port Mann Bridge; while the broader study required placement of receivers near the mouth of the Fraser River (Figure 1). Locations were selected for ease of access and maximal detection efficiency, by selecting sites near boat launches in relatively constricted river reaches that were free of line-of-sight obstructions. Where channel-widths exceeded the expected detection range of the receivers (~ 500 m), a pair of receiver stations was deployed, with a station on each river bank. In the Pitt River, at the Port Mann Bridge, and in Canoe Pass, the pair of receivers, located on opposite banks, were intentionally staggered (one was ~ 500 m upstream from the other) in order to provide information about the directionality of White Sturgeon movements.

Receivers were mounted to a trolley, and the trolleys were threaded onto vertical tracks measuring 3.7 to 5.5 m (12 to 18 feet) in length. Vertical tracks were tied and lag-bolted to wooden pilings so that the bottom of the track would be submerged during all tidal and flow conditions; and the top of the track would remain above water during all but the highest waters. Steel cables were attached from the top of the track to the trolley to allow the receiver to be pulled up to the surface for downloading and battery replacement (without need of a SCUBA diver). The receiver-trolley assemblage was secured in place by threading a PVC tube through the track, drilling a hole through both the track and the PVC, and by fixing a padlock through the holes. Receivers were downloaded and maintained about three times per year. Once offloaded from the receiver, detection files were uploaded into the databases of two local telemetry data repositories (Hydra and POST).

Acoustic tags (Vemco model V16-4H, 68 × 16 mm, 25 g in air) transmitted a uniquely identifiable code at 69 kHz every six minutes. The tags were programmed to stop transmitting three years post-release. The tag model was selected for its power, battery life, and compatibility with local receiver arrays.

Capture and Tagging

Fishing guides and experienced volunteer anglers were coordinated to capture White Sturgeon in two locations (Figure 1). The first location was near the Port Mann Bridge, around Douglas Island, and in the mouth of the Pitt River (35-40 km from the Fraser River mouth). The second location was in the lower Pitt River ~13 km from the confluence with the Fraser River, at a location called "Sturgeon Slough." These locations were selected to ensure that there were acoustic-tagged individuals released upstream and downstream of both bridges of interest.

In order to control for seasonality, sampling occurred over three sessions (August 2008, October 2008, June 2009), and a total of 110 acoustic-tagged fish were released (Table 1).

White Sturgeon were captured using baited barbless hooks. All fish were measured (fork length, FL) to the nearest cm, and then scanned with a hand-held PIT tag reader for the presence of PIT tags. If a PIT tag was detected, the hexadecimal tag code was recorded; otherwise a new PIT tag was injected beneath the skin at a location just posterior to the bony head plate, left of the dorsal line, near the first dorsal scute (Nelson et al. 2013a).

Table 1. Distribution of tag allocations by location, tagging period, and White Sturgeon size category.

Tagging location	Size bin (FL, cm)	White Sturgeon Tagged			
		August 2008	October 2008	June 2009	Total
Pitt River					
	60 - 100	0	5	9	14
	100 - 140	1	17	10	28
	140 - 180	0	8	4	12
	> 180	0	4	0	4
	Subtotal	*1*	*34*	*23*	*58*
Port Mann Bridge					
	60 - 100	15	0	11	26
	100 - 140	11	0	7	18
	140 - 180	6	0	2	8
	> 180	0	0	0	0
	Subtotal	*32*	*0*	*20*	*52*
Grand Total		33	34	43	110

Fish selected for the application of acoustic tags were anesthetized in an MS222 bath (125 mg/L) until consciousness was lost. The animals were then placed in a surgical sling, ventral side up, with anesthetic flushed into the mouth and over the gills. A #21 rounded-edge scalpel was used to make a 5 cm incision at a location 20% between the midline and the ventral row of scutes along the belly, and 33% of the distance to the pectoral fin base from the anal pore. An otoscope was used to assist with sex determination. An acoustic tag was then inserted through the incision, which was then closed using multiple interrupted sutures. Suturing was performed using Ethicon PSII #0 monofilament with a CP-1 36 mm reverse cutting needle. Once half of the suturing was complete, the gills were flushed with fresh river-water, commencing the fish's recovery from sedation. Once suturing was completed, the fish was placed in the river and held at the surface until full consciousness was regained, and was released when the fish volitionally initiated escape behaviours.

Surgeries were performed by highly experienced individuals, and methods followed standard procedures (Parsley et al. 2008), adjusted in coordination with the International Centre for Sturgeon Studies (J. Morgan and G. Edmondson, Vancouver Island University, personal communication). To avoid the transmission of disease, all surgical equipment and tags were disinfected for 10 minutes and then rinsed in distilled water before coming into contact with a fish.

Mobile Tracking

In order to accurately determine fish positions, 20 mobile tracking surveys were performed over three winters (2009 - 2012). Details are provided elsewhere (Neufeld et al. 2010; Ghilarducci and Reeve 2012). Briefly, surveys were performed from a small boat, and lasted several hours per day. Surveys typically started in an upstream location, and the boat was allowed to drift downriver over the course of the day. In general, the goal was both to cover as large a proportion of the study area as possible, and to repeatedly sample key locations. During each tracking session, a unidirectional hydrophone was deployed over the side of the boat, pointed in the downstream direction. The hydrophone was wired to a Vemco VR100 receiver, which recorded (for each detection) the following: date, time, tag code, power of the signal, gain setting on the receiver, and GPS location of the boat.

Angler Recaptures

In addition to detections of acoustic tags recorded on study receivers, POST and Hydra arrays, and during mobile tracking surveys, we also recorded several recaptures of acoustic-tagged fish by anglers who scanned their catch for the presence of a PIT tag. Several thousand PIT-tagged sturgeon were sampled and released each year in the lower Fraser River as part of a mark-recapture population monitoring and assessment study conducted by the FRSCS (Nelson et al. 2013a). The date and location of all recaptures of acoustic-tagged fish were included in our detection database. Also, anglers are asked to inspect each fish that catch for abnormalities, so the state of the sutures or surgical scar was recorded upon recapture, when visible.

Data Processing

Detection data from all sources were assigned to a river kilometer (rkm, the distance of the detection from the Fraser River mouth), and were processed using custom database software, Telemetry Manager; this software facilitates data organization, record validation, and analysis via the systematic application of user-defined criteria. Temporal or spatial resolution, and noise filtering criteria, can be changed by the user at any time without altering the raw data (English et al. 2012). False records (e.g., those that resulted from electronic noise; single hits, and those that occurred in a sequence which was not possible) were flagged for exclusion, and the remaining records were compressed into a manageable database of sequential detections for each fish. Each record in the compressed database included the tag number, detection location (rkm), the number of sequential detections at that location, and the times of the first and last detection of the series. The compressed database was used for all subsequent analyses.

Bridge Encounters

Bridge encounter analyses made use of the detection data recorded on the receivers that were deployed at the Highway 7 and Port Mann bridges. Data from the receivers deployed upstream and downstream of the bridges were used to assess directionality of the passage movements. If a fish was detected at a bridge, an encounter event was scored, and the month of the detection was noted. For each encounter event, the sequence of the fish's detections was examined to determine whether or not the fish passed the bridge. If detections immediately before and after the encounter event were on the same side of the bridge, then passage could not be confirmed. If the before and after detections were on opposite sides of the bridge, passage was confirmed and the direction of passage was noted. In a minority of cases, the bridge encounter occurred at the end of a tag's three-year life, no subsequent detections were recorded, and no assessments could be made about passage.

In cases where detection efficiency was not 100% (and a fish passed a bridge without detection at the bridge-site receiver), bridge passage was inferred from detection histories that showed detections of fish on one side of the bridge followed by detections on the other side. In these instances, the month of the first post-passage detection was used as a proxy for the month of bridge passage.

RESULTS

Tagging

In all, 110 White Sturgeon were captured and acoustic-tagged over the three sessions, ranging from 62 to 203 cm FL (Table 1). The length distribution was skewed in favor of smaller fish (mean = 114.3; median = 107.7), where 78% measured less than 140 cm, and 3.6% measured > 180 cm FL. In total, 23% of the White Sturgeon tagged in the Pitt River were recaptures of fish that had previously been PIT-tagged in the Fraser River as part of the ongoing population assessment studies (Nelson et al. 2013a). In the area of the Port Mann Bridge, 32% of acoustic-tagged White Sturgeon already had PIT tags. The mark-rate difference between locations was not significant (i.e., a quasibinomial model including ‘location’ as a predictive factor did not have a significantly different fit from a model without: F = 1.2, df = 1, $P = 0.28$).

Sexing was done using an otoscope. The objects in the otoscope field of view appeared “smooth” for 69.1% of the tagged fish, and “grainy” for 29.1% (1.8% could not be examined). Although ripe adults should be simple to distinguish, immature or undeveloped gonads look more similar (Conte et al. 1988) and can be difficult to find within the body cavity using an otoscope. Given the relatively small size of the majority of fish tagged, and the large size at maturation (Conte et al. 1988; Hanson et al. 1992), it is unlikely that these otoscope data are indicative of sex.

Detections

At the end of the study, the POST and Hydra databases were queried to determine whether our tags had been detected at any of the shared receiver arrays. In addition, detection data from anglers with PIT tag scanners were queried for observations of our study fish. Overall, there were 0.86 million detections over the study period, and each of the 110 tagged fish was detected at least once (range: 2 to 65,016 detections per fish). None of the study fish were detected outside of the Fraser River, either on POST- or Hydra-associated arrays.

Anglers with PIT tag readers recorded 45 recaptures of acoustic-tagged White Sturgeon, including 31 unique individuals that were captured either one (n=19), two (n=10) or three (n=2) times since the date of surgical implantation. A few anglers that recaptured acoustic-tagged White Sturgeon observed and noted the surgical scar on the abdomen. Figure 2 shows that the frequency with which anglers reported surgical scarring declined over the first 10-12 months, after which the scarring apparently became unnoticeable (despite a total of 29 recapture events of acoustic-tagged fish occurring 12 months or more after surgery). The longest time between surgery and recapture, for which a surgical scar was noted, was 324 days (~10.5 months).

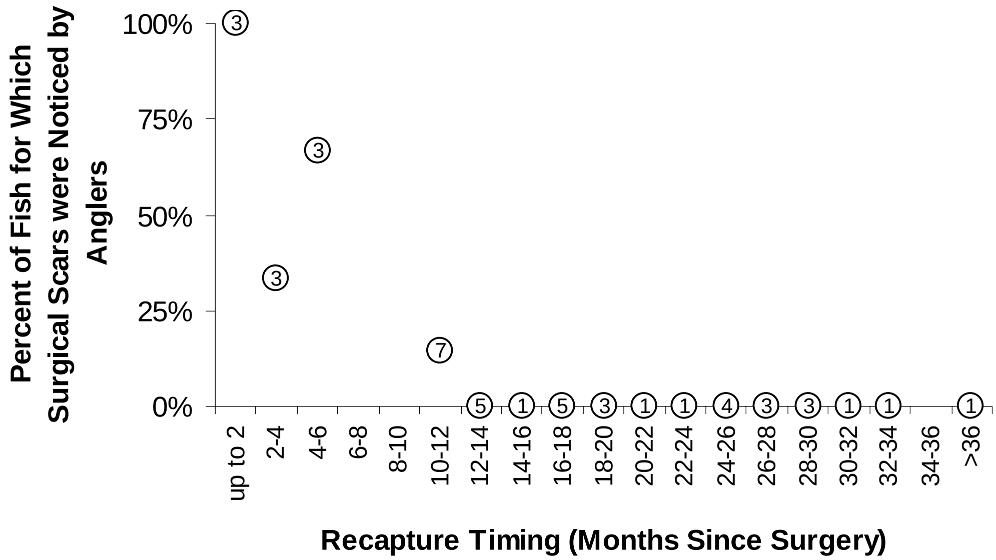

Figure 2. The percent of recaptured White Sturgeon for which surgical scars were reported by anglers, as a function of the number of months since surgery. Numbers inside circles show sample sizes for each 2-month timing bin.

Of the 110 tagged fish, 105 (95.5%) were detected moving among receiver sites and are assumed to have been behaving normally. Two tags appeared to have failed, as they were detected only for a short period (14 hours; 23 days) post-release. Three tags had detection histories suggesting mortality or tag-shedding, including two that were stationary throughout, and one that drifted slowly downstream over two months and never moved thereafter. These five tags were excluded from subsequent analysis.

Bridge Encounters

Of the 105 acoustic-tagged White Sturgeon, 92 (88%) encountered the receiver near the Highway 7 Bridge. Including repeat visits, there were 939 encounters at this bridge; of these 939 encounters, 481 (51.2%) were followed by detections on the other side of the bridge, indicating certain (dedicated) bridge crossing. These bridge-passage events were 47.4% (228) in the upstream direction and 52.6% (253) in the downstream direction. Of the 939 encounters, there were 446 (47.5%) cases in which the fish's next detection suggested that it turned back, thus bridge crossing could not be confirmed. The remaining 12 (1.3%) encounters occurred at the end of the tags' three-year life: the bridge encounter was the fish's last record, and no assessment could be made about passage. Detection efficiency of the receiver at the Highway 7 Bridge was 86.9%. Bridge encounters occurred in all months (Figure 3), but the busiest times were in late spring (14.4% in April, 10.5% in May) and in autumn (15.4% in September, 14.0% in October, 10.6% in November). At the Highway 7 Bridge, 73.2% of the April-May passage events were in the downstream direction, and 63.5% of those in September-November were in the upstream direction.

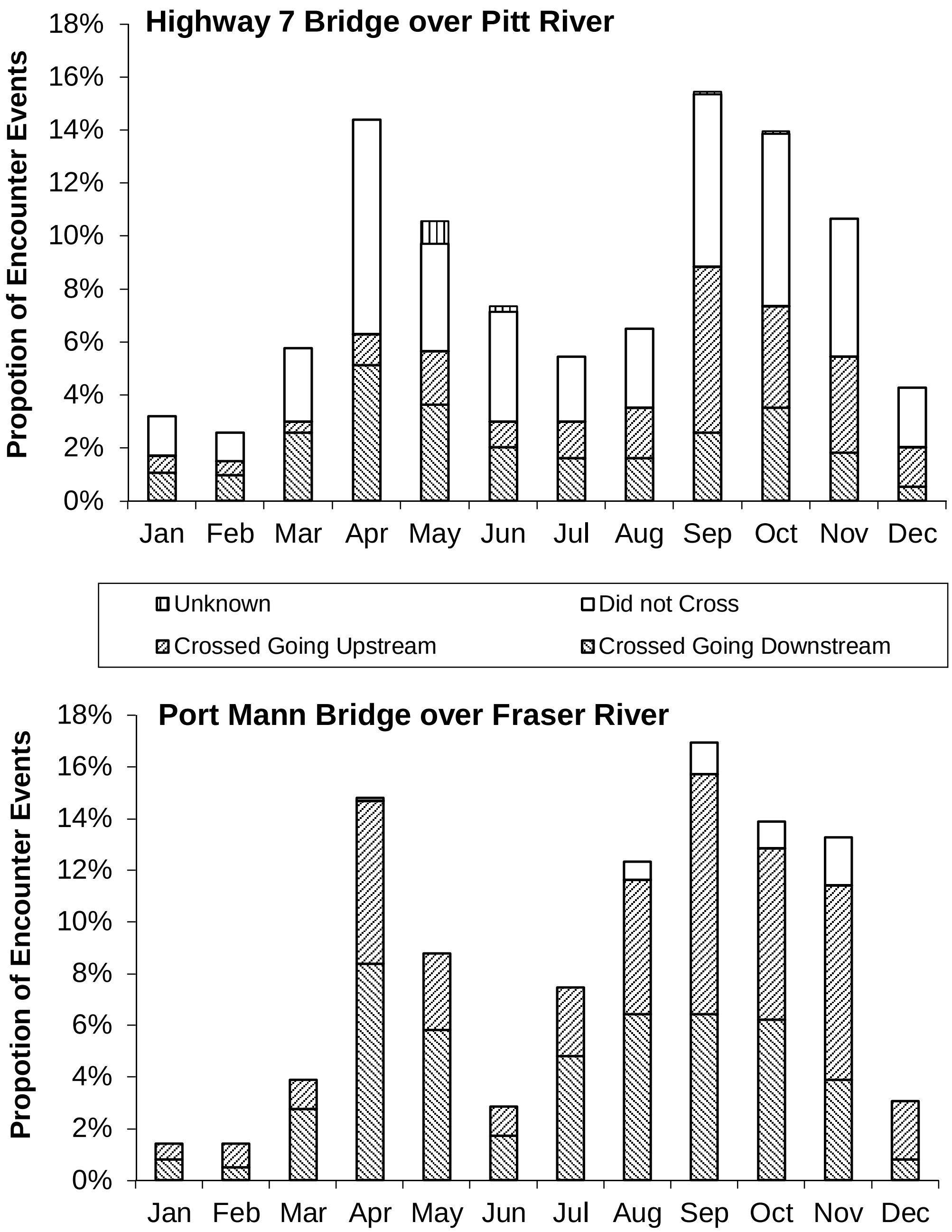

Figure 3. **Proportion of Highway 7 (n=939) and Port Mann (n=981) bridge encounter events that occurred by month, with events split into those that resulted in bridge passage (in upstream or downstream direction) or not ("Did not Cross"). "Unknown" is used when a fish's last detection at the end of the study was near a bridge.**

Of the 105 acoustic-tagged White Sturgeon, 89 (84%) were known to have been in the vicinity of the Port Mann Bridge. Including repeat visits, there were 981 encounters at this bridge. Of these 981 encounters, 933 (95.1%) were followed by detections on the other side of the bridge, indicating certain bridge passage. These bridge-passage events were 49.0% (457) moving upstream and 51.0% (476) moving downstream. Due to early and repeated loss and damage to the Port Mann Bridge receiver, the station was demobilized in late 2008 (it was moved to Douglas Island), and only 5.4% of the bridge-passage events from 2008-2012 were recorded by the receiver. Nearby receivers, located 2 km downstream and 4 km upstream, were used to assess timing of passage events. Bridge encounters occurred in all months (Figure 3), but the busiest times were in April (14.8%) and in autumn (56.4% of the encounters occur over four months: 12.3% in August, 16.9% in September, 13.9% in October, and 13.3% in November). At the Port Mann Bridge, 60.4% of the April-May passage events were in the downstream direction, and 58.7% of those in September-November were in the upstream direction.

DISCUSSION

Ideally, the assessment of the frequency and timing of White Sturgeon interactions with the two construction sites would have occurred before the construction activities began. That way, construction activities, especially those most likely to impact sturgeon (e.g., pile driving, see Halvorsen et al. 2012) could have been planned to coincide with periods when sturgeon are least likely to be present in the construction area. In this case, construction activities were already taking place while this study was underway. Nevertheless, the information developed over the course of this tracking study could potentially be useful for future construction projects.

In this study, sturgeon interacted with the bridge sites in all months, but there was notably more activity in the spring and autumn, when fish appeared to be moving downstream and upstream, respectively. This result parallels gillnet catch rates from the Albion Test Fishery, which peak in spring and autumn, and are interpreted as evidence for increased migratory activity (Nelson et al. 2017). This pattern is consistent with that from recaptures of PIT-tagged Lower Fraser River White Sturgeon (Nelson et al. 2013a), and for White Sturgeon in the Columbia River downstream of Bonneville Dam (DeVore and Grimes 1993). The timing of movements observed in this study are consistent with the availability of Eulachon (*Thaleichthys pacificus*) and Pacific salmon (*Oncorhynchus* spp.) in the lower Fraser River, both of which are known to be important food sources (Semakula and Larkin 1968; Echols and FRAP 1995; McAdam 1995) for White Sturgeon. Eulachon are most abundant in the lower Fraser and lower Pitt rivers from March to May, while salmon eggs and carcasses provide an abundant food source in these same locations from August to late November.

In this study, bridge encounters were least likely in winter (December to February) when sturgeon are relatively inactive and likely concentrated on overwintering grounds (e.g., Robichaud et al. 2017). Wintertime inactivity has been reported for White Sturgeon in the lower Fraser (Robichaud et al. 2017) and Kootenay (Apperson and Anders 1991) rivers, Lake Roosevelt (Brannon and Setter 1992), and the Columbia River in British Columbia (RL&L 1994), as well as for other sturgeons (Roussow 1957) and for many fishes in general (Crawshaw 1984). Given the multitude of other studies that corroborate the general movement patterns described in this report, we suggest that the results may be applicable as a starting point for discussions about the timing schedules of future bridge and other in-river construction projects.

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