Alaska Research Associates, Inc.

LGL Alaska Research Associates, Inc.
2000 W International Airport Road Suite C1
Anchorage, Alaska 99502 USA
Tel: (907) 562-3339 Fax: (907) 562-7223

To: Nate Johnson and Monty Worthington, Ocean Renewable Power Company
From: Justin Priest and Matt Nemeth, LGL Alaska Research Associates, Inc.

Re: Data Analysis for Monitoring of the RivGen® in the Kvichak River, 2015

Date: November 11, 2015

This memo summarizes the preliminary data analyses from fish and wildlife monitoring at the RivGen® Power System, a submerged hydrokinetic device operated by the Ocean Renewable Power Company (ORPC) in the Kvichak River in July and August 2015. Monitoring was performed by LGL Alaska Research Associates, Inc., in accordance with the 2015 Monitoring Plan developed in March 2015 and Alaska Department of Fish and Game (ADF&G) Fish Habitat Permit FH 15-II-0038. Data presented here are preliminary and may change after final QA/QC. Interim results and figures were also presented in monthly progress reports at the end of July and August.

Fish movements at the RivGen® device were described using video footage collected from five underwater cameras mounted to the pontoons of the power system. Video footage was collected 24 hours/day July 19–25 and again August 19–27, 2015; review was done by watching the first 10 minutes of a selected hour from each of the four primary cameras (the fifth camera was a backup). Spatially, the camera field of view captured the port side of the RivGen® device, including upstream and downstream views of the port side turbine (only). In accordance with the Monitoring Plan, footage was reviewed to achieve partial temporal coverage during different categories of turbine operating status and daytime/nighttime conditions (Figure 1). At night, two underwater lights lit the viewing area. In addition, bird and marine mammal surveys were conducted for 15 minutes each morning of monitoring. Methods and the overall approach were similar to those described for the demonstration study conducted at the same site in 2014.

Blocks of video footage from portions of 238 different hours were reviewed inseason in 2015. There were 359 events with fish, composed of approximately 1,202 individual fish from at least six species. The majority of fish observations were of solitary fish; the largest school was approximately 100 fish. Species composition varied from July to August and also from day to night. In particular, salmon smolt were almost exclusively seen at night, and were more prevalent in July than August. Several instances of fish moving through the RivGen® turbine were noted and reported inseason as part of the Adaptive Management Plan. We did not detect any obvious physical injuries to fish, and saw no altered behavior by wildlife near the RivGen® device. Cameras, lights, and power system components all operated reliably. All video footage has been archived.

Preliminary results are presented in more detail below, organized by each Objective from the 2015 Monitoring Plan. Where appropriate, data are also presented in Tables and Figures below.

Data analyses listed by 2015 monitoring objective:

1) Summary of monitoring effort.
   a) Video review effort, by RivGen® device status and time group.
      (1) Table 1. Review effort by RivGen® device status and month.
      (2) Figure 1. Daily schedule of RivGen® device operations and data review effort.

2) Presence and timing of fish and wildlife at the RivGen® device (Objective 1 from Monitoring Plan).
   a) Fish monitoring observations.
      (1) Table 2. Number of fish observation events and number of fish, by month, day/night status, and RivGen® device operating status.
      (2) Table 3. Species and number of fish observed, by month and day/night status.
      (3) Table 4. Fish per reviewed hour block, by species, month, and day/night status.
      (4) Figure 2. Hourly summary of review effort, raw observations, and observations standardized by review effort for fish.
   b) Wildlife monitoring observations.
      (1) Table 5. Bird and wildlife observations by species group.

3) Characterize fish movements past the RivGen® device (Objective 2).
   a) Basic movement type.
      (1) Table 6. Movement classification/direction by species, day/night, and RivGen® status.
   b) Movements in relation to the RivGen® device.
      (1) Table A (to be determined): Movement of fish under, over, or through the turbine area.
      (2) Evidence of passage delay: We saw no obvious evidence of passage delay. Adult salmon were clearly able to move around the device, both going upstream (mostly in the daytime), or downstream (mostly at night). Adult salmon also showed general milling behavior that did not appear to be repeated attempts to move past the device. Finally, juvenile salmon were seen transiting past the device, usually travelling downstream. Juvenile salmon sometimes held downstream of the turbine briefly.

4) Describe the behavioral response of fish or wildlife contacting the RivGen® device (Objective 3).
   a) Table B (to be determined): Number of fish showing obvious attraction to, avoidance of, or sheltering at the RivGen® device in 2015, by species and day/night status.

b) Evidence of avoidance or attraction by fish: We saw no obvious evidence of attraction to the RivGen® device. Any such attraction would likely have only been detected as fish markedly altering course to move directly towards the RivGen® device; we saw no instances of this. We did see instances of avoidance by fish moving downstream, which sometimes altered course to move either over or under the turbine. Avoidance by upstream-moving fish (i.e., fish that avoided the RivGen® device altogether by moving away from it before coming into camera view) would not be easily detectable because the fish would have already altered their course before being able to be observed.

c) Evidence of avoidance or attraction by wildlife: There was no evidence of attraction or avoidance by wildlife during the study; all animals observed showed no behavioral changes near the RivGen® device. No marine mammals were observed in 2015.

5) Describe any acute effects from contact with the RivGen® device (Objective 4).

a) Evidence of disorientation, injury, or mortality: Acute effects of fish moving through the RivGen® device, including any potential adverse effects were documented and reported in four Adaptive Management Reports delivered within 48 hours of the incident. We saw no obvious indication of moribund or inert behavior that might indicate injury or mortality. We did see some potential disorientation by juvenile salmon moving downstream. In these events, schools of fish dispersed as they approached the RivGen® device from upstream; afterwards, downstream of the RivGen® device, these fish milled or moved around abruptly in the eddy behind the turbines, before resuming downstream movement.

Table 1. Summary of the review effort during all RivGen® device operational statuses, 2015. "Partial" hours were when turbines only operated during part of an hour block. "Spinning Whole Hour (Stbd turbine only)" hours were operations when only the starboard turbine was operational.

	July		August		Total	
Device Status	Not Reviewed	Reviewed	Not Reviewed	Reviewed	Not Reviewed	Reviewed
Day						
Not Spinning	26	39	25	11	51	50
Partial	1	16		4	1	20
Spinning Whole Hour		44		69	0	113
Spinning Whole Hour (Stbd turbine only)				17	0	17
Day Subtotal	*27*	*99*	*25*	*101*	*52*	*200*
Night						
Not Spinning	32	6	24	3	56	9
Partial		3			0	3
Spinning Whole Hour		1	20	18	20	19
Spinning Whole Hour (Stbd turbine only)			2	7	2	7
Night Subtotal	*32*	*10*	*46*	*28*	*78*	*38*
Total	59	109	71	129	130	238

Table 2. Summary of the total number of fish events and individuals during all device statuses, 2015. A "Fish Event" is defined as an observation of at least one fish during subsampling review. "Spinning Whole Hour (Stbd turbine only)" was when only the starboard turbine was operational.

	July			August			Total	
Device Status	# Fish Events	Total Fish Seen		# Fish Events	Total Fish Seen		# Fish Events	Total Fish Seen
Day								
Not Spinning	17	26		2	3		19	29
Partial	16	39		1	1		17	40
Spinning Whole Hour	57	196		19	19		76	215
Spinning Whole Hour (Stbd turbine only)				10	10		10	10
Day Subtotal	*90*	*261*		*32*	*33*		*122*	*294*
Night								
Not Spinning	150	736		5	5		155	741
Partial	16	75					16	75
Spinning Whole Hour	4	15		49	64		53	79
Spinning Whole Hour (Stbd turbine only)				13	13		13	13
Night Subtotal	*170*	*826*		*67*	*82*		*237*	*908*
Total	260	1,087	0	99	115	0	359	1,202

Table 3. Total number of fish by species during day/night and month, 2015.

	July		August			
Species	Day	Night	Day	Night	Total	Total %
Chum salmon (adult)			14	12	26	2.2%
Coho salmon (adult)			5	2	7	0.6%
Pink salmon (adult)				2	2	0.2%
Sockeye salmon (adult)	259	51	1	1	312	26.0%
Unidentified adult salmon			9	8	17	1.4%
Unidentified juvenile salmonid		773	1	52	826	68.7%
Rainbow trout			1		1	0.1%
Lamprey spp.	1		1	1	3	0.2%
Unknown species	1	2	1	4	8	0.7%
Total	261	826	33	82	1,202	100.0%

Table 4. Number of fish detected per reviewed hour block by species, 2015. Data are standardized to 10-minute review blocks.

	July		August		
Species	Day	Night	Day	Night	Total
Chum salmon (adult)	-	-	0.1	0.4	0.1
Coho salmon (adult)	-	-	0.0	0.1	0.0
Pink salmon (adult)	-	-	0.0	0.1	0.0
Sockeye salmon (adult)	2.6	5.1	0.0	0.0	1.3
Unidentified adult salmon	-	-	0.1	0.3	0.1
Unidentified juvenile salmon	0.0	77.3	0.0	1.9	3.5
Rainbow trout	-	-	0.0	0.0	0.0
Lamprey spp.	0.0	0.0	0.0	0.0	0.0
Unidentified species	0.0	0.2	0.0	0.1	0.0
Total	2.6	82.6	0.3	2.9	5.1

Table 5. Summary of bird and wildlife observations near the RivGen® device, 2015. Data are standardized to the 15-minute sampling periods.

Taxonomic Group	Sightings	Number of individuals sighted	Number of individuals within 15 m of device	Number of individuals per sample period
Passerines	34	41	4	2.7
Bald Eagles	6	7	0	0.5
Other Raptors	1	1	0	0.1
Waterfowl and Loons	8	11	0	0.7
Gulls, Jaegers, and Terns	53	133	0	8.9
Corvids	3	3	0	0.2
Shorebirds	10	12	0	0.8
Terrestrial mammals	0	0	0	0
Marine mammals	0	0	0	0

Table 6. The number of fish events classified by movement type for each species, 2015. Proportions are per subtotaled day and night.

Movement Type	Chum salmon (adult)	Coho salmon (adult)	Pink salmon (adult)	Sockeye salmon (adult)	Unidentified adult salmon	Unidentified juvenile salmon	Rainbow trout	Lamprey spp.	Unidentified species	Total	Subtotal %
Day											
Milling	5	3		33	5				1	47	38.5%
Travel down	4			8	4	1		2	1	20	16.4%
Travel up	2	1		33			1			37	30.3%
Travel, other	2	1		12						15	12.3%
Undetermined				3						3	2.5%
Day Subtotal	*13*	*5*	*0*	*89*	*9*	*1*	*1*	*2*	*2*	*122*	*100.0%*
Night											
Milling	2	1	2	6	2	20			1	34	14.3%
Travel down	9	1		30	6	142		1	4	193	81.4%
Travel up				3		2				5	2.1%
Travel, other						1				1	0.4%
Undetermined				2		2				4	1.7%
Night Subtotal	*11*	*2*	*2*	*41*	*8*	*167*	*0*	*1*	*5*	*237*	*100.0%*
Total	24	7	2	130	17	168	1	3	7	359	100.0%

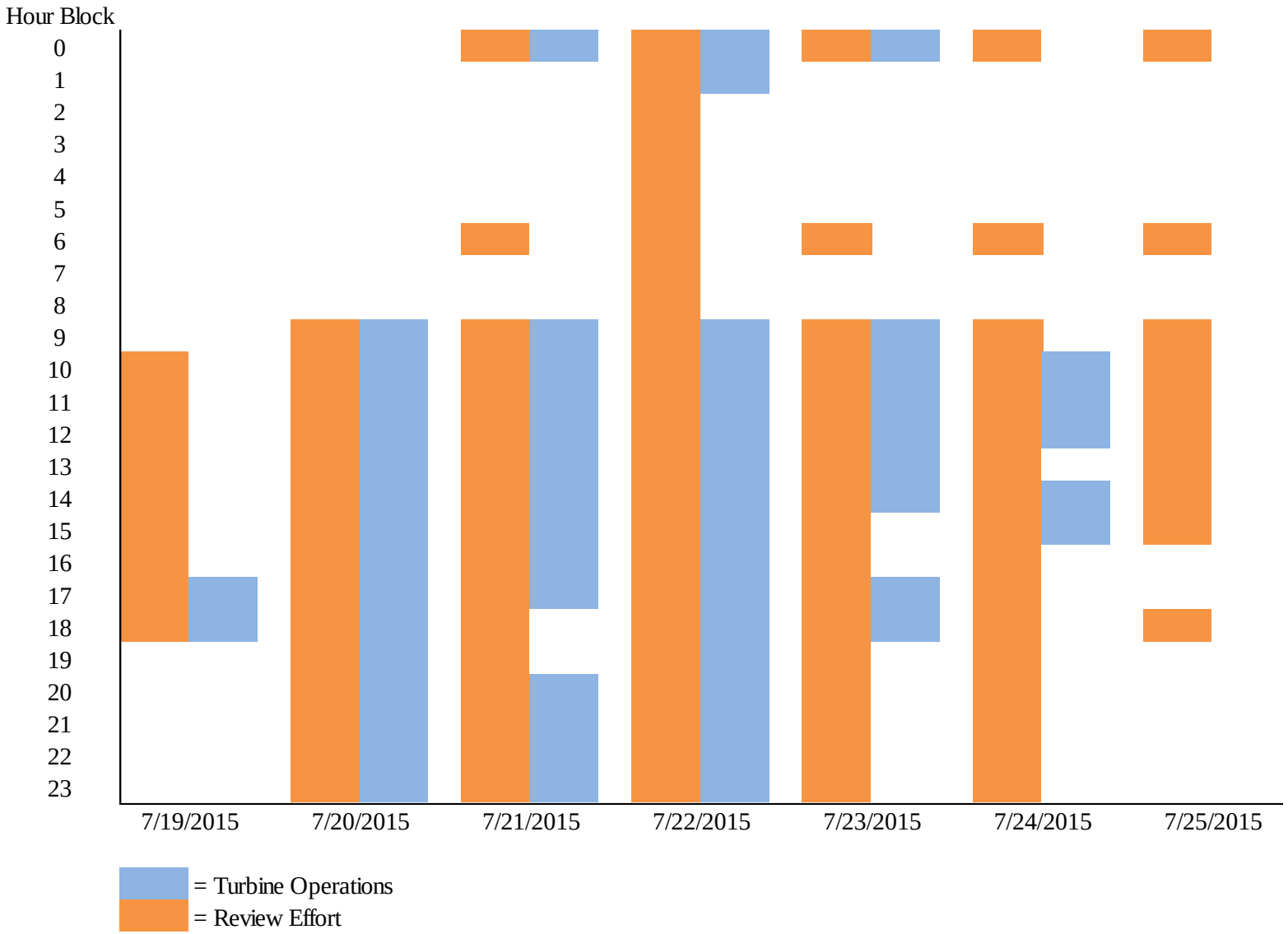

Figure 1A. Summary of turbine operations and review effort of the video system, July 2015. "Half" hours were operations when only one of the two turbine sides was operational.

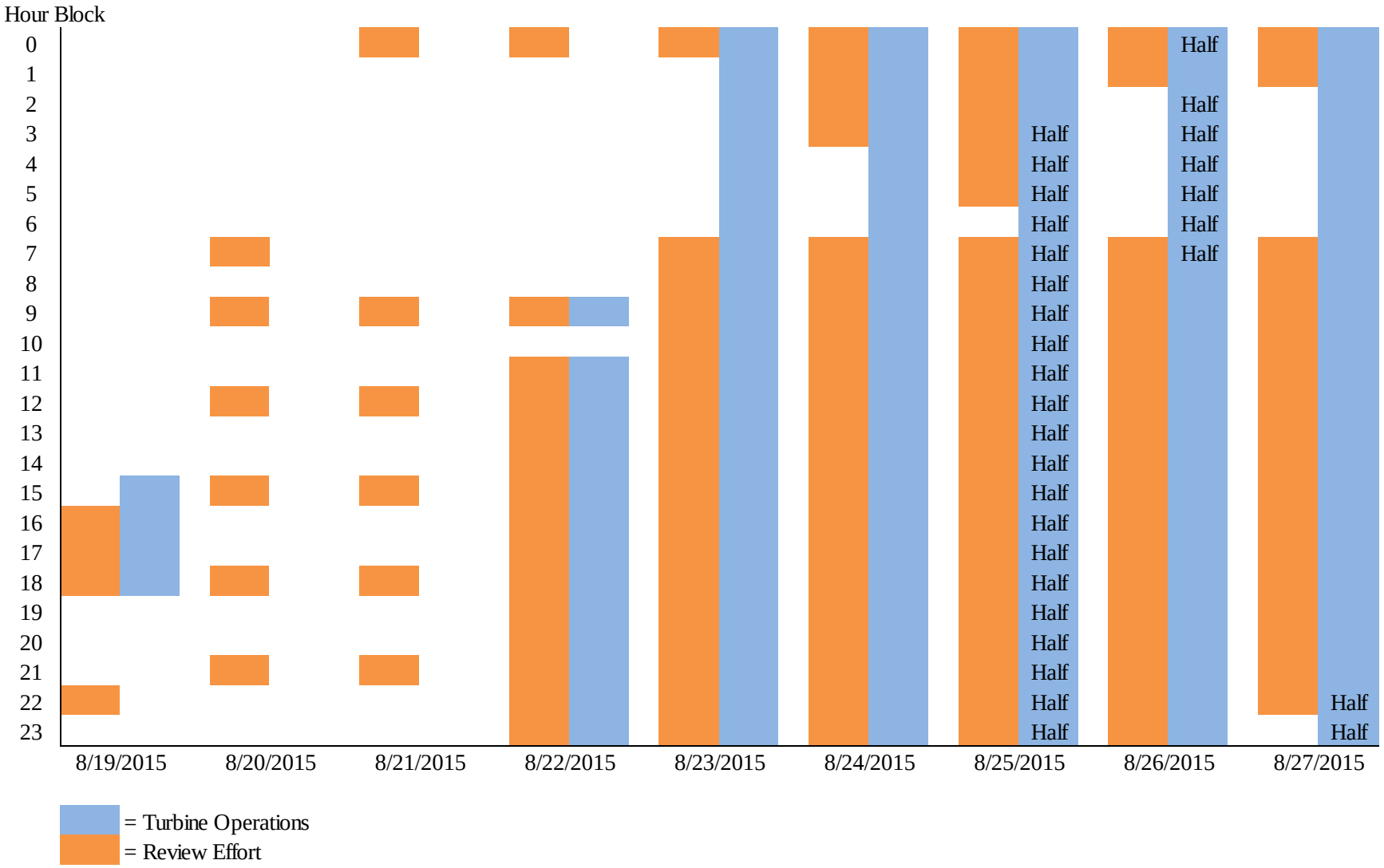

Figure 1B. Summary of turbine operations and review effort of the video system, August 2015. "Half" hours were operations when only the starboard turbine was operational.

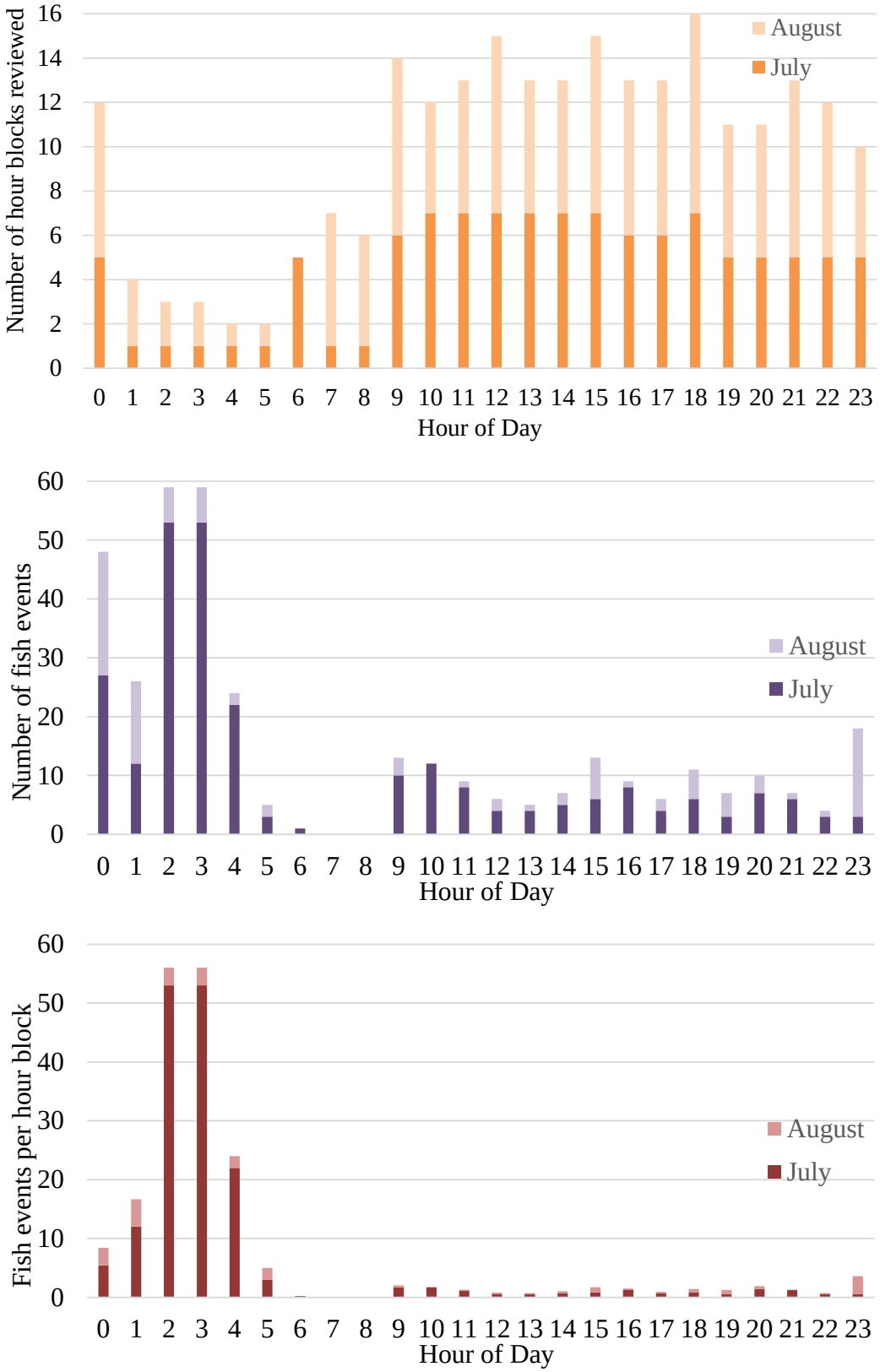

Figure 2A, 2B, 2C. Review effort by hour of day, number of fish events by hour of day, and fish events per hour, by hour of day.