MARINE RECREATIONAL INFORMATION PROGRAM

FY 2017 Final Report:

A Video Monitoring System to Evaluate Ocean Recreational Fishing Effort in Astoria, Oregon

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Background

Recreational fisheries harvest represents a substantial and increasing proportion of the total fisheries harvest in the United States (Coleman et al. 2004; Ihde et al. 2011). Therefore, effective fisheries management strategies designed to maintain sustainable populations of recreationally important species rely on accurate catch and effort data from the recreational sector.

Unlike commercial fisheries harvest and effort data which is generally available via catch accounting systems such as fish tickets, logbooks, and observer programs, recreational catch and effort data is usually obtained from surveys of the recreational fishing population. Survey programs tasked with estimating recreational catch and effort may use a variety of methods to sample the angling population including on-site (access point, roving, aerial) and off-site (mail, telephone, web-based, door-to-door, logbooks, harvest cards) designs (Pollock et al. 1994; Jones and Pollock 2012). A main objective of the Marine Recreational Information Program (MRIP) is to promote continued improvements to these survey techniques in order to increase the quality and accuracy of the recreational fisheries data collected and used in the assessment and management of fish stocks (National Academies of Sciences 2017).

Historically the Oregon Department of Fish and Wildlife's (ODFW) Ocean Recreational Boat Survey (ORBS) had used partial day live bar crossing counts by staff to count recreational craft entering the ocean in all major ports. These counts originally were conducted from dawn until 13:00, and eventually the count periods were reduced to dawn until 10:15 in most ports. A proportional effort expansion for trips outside of the count period, which was based on the ratio of sampled trips which entered the ocean outside of the count period, was applied. Since 2009, ORBS has implemented a video boat count methodology in most ports to estimate ocean recreational fishing effort. In these locations, samplers view recorded video of vessel activity, as opposed to traditional physical effort estimation methods such as bar crossing counts or counts of boat trailers plus vacant moorage slips. Video-based boat counts have resulted in increasing the accuracy of daily effort counts and improving the flexibility and efficacy of sampling procedures (Ames and Schindler, 2009). To date, video boat counting of recreational effort has been adopted and implemented in the following Oregon ports: Garibaldi, Depoe Bay, Newport, Winchester Bay, Charleston, Bandon, Gold Beach, and Brookings.

Remote time-lapse photography and video-based monitoring has proven to be an effective tool for collecting recreational fishing effort information (Ames and Schindler 2009; Greenberg and Godin 2015; van Poorten et al. 2015; Hartill et al. 2016; Keller et al. 2016; Powers and Anson 2016; Wood et al 2016). The potential benefits of video monitoring to estimate recreational effort are multifold. Video monitoring can increase the spatial and temporal coverage of fishing activity by removing the limitations of having a sampler physically present for vessel counts. Recordings of vessel activity can be conducted continuously and cameras can be placed at multiple access points. This degree of coverage normally cannot be duplicated with live counts by field staff without prohibitive operating costs or increased safety concerns (such as working in isolated locations during pre-dawn hours). Eliminating the constraint of having field personnel conduct live effort counts also increases overall survey efficiency and sampling coverage by reducing the work hours spent on boat counting duties, and allocating more hours to collecting data through angler intercept interviews.

Additionally, because recorded video can be reviewed multiple times and stored for further analysis, increased precision of effort data may result. Video monitoring has generally proven to be a cost effective alternative to a live effort count. Although the initial costs of a video system may be expensive, the cost of having survey staff conduct equivalent counts over the same locations and time periods typically exceeds the initial video equipment costs over the long term. Furthermore, because recorded fishing effort can be reviewed at an increased playback speed, the cost per unit of time spent collecting the data is substantially lower when compared to a live count.

In this study, a new type of video monitoring system was developed and implemented in the Astoria area to estimate ocean recreational fishing effort originating from Oregon access points in the Columbia River. The lower Columbia River Estuary poses a significant challenge to estimating ocean recreational fishing effort. Because both Oregon and Washington vessels enter the ocean at the mouth of the Columbia River, a standard bar crossing count approach cannot effectively be used to estimate ocean recreational fishing effort originating from Oregon access points. ODFW currently employs an on-site boat counting approach in which vessels are tallied as they cross a North/South line extending from the Hammond Boat Basin to the Washington shore. However, this method has the potential to bias the Oregon-based recreational effort estimate due to the inclusion of some Washington boats in the count and from errors in counting due to poor visibility across the Columbia River. Additionally, Oregon-based ocean recreational effort originates almost entirely from three main access points in the lower Columbia River Estuary: the Hammond marina/boat ramp, the Warrenton marina/boat ramp and the Astoria West End mooring basin. These sites are geographically separated to such an extent that daily on-site boat counts would be required to quantify the effort associated with each port across all relevant strata. Assigning samplers to conduct these counts would be extremely inefficient from a survey design standpoint and would lead to decreased sampling coverage and unreliable estimates.

Therefore, the Astoria area represents a potential candidate for a video monitoring system to improve recreational effort data collection and estimation. Additionally, video monitoring of each access point would provide information on the relative contribution of each access point to the overall recreational effort in both the ocean and estuary from the Astoria area. This information will guide survey design in order to achieve proportional allocation of sampling coverage and appropriate weighting techniques.

Currently, ORBS boat counting systems at other locations consist of cameras aimed at a single access point or bar crossing in each port. This allows port samplers to either view recorded activity at the recording site or retrieve recordings via USB or swappable hard drive for review at an another station in port. This procedure of retrieving and reviewing recorded video of vessel activity would be inefficient in the Astoria area because of the substantial distance between the multiple access points. To address this limitation, this study evaluated the use of a video boat counting methodology using web-based camera technology to monitor and estimate recreational ocean boat effort originating from three Oregon access points in the Astoria area. The objectives of this study are to 1) evaluate our current boat count methodology for the Astoria area by comparing ocean recreational effort estimates generated by concurrent on-site live boat counts and video-based boat counts, 2) quantify the relative proportion of ocean and total recreational effort originating from each of the major access points in the lower Columbia estuary, and 3) evaluate this technology for potential future application in other locations.

Methods

Video monitoring system

Recreational boat effort in the Astoria area was recorded via a web-based monitoring system consisting of IP (Internet Protocol) cameras located at three recreational access points in the lower Columbia River Estuary (Figure 1) and a viewing station in the ODFW Astoria office (2001 Marine Drive Room 120, Astoria, OR 97103). Video IQ HD iCVR cameras and associated hardware were installed on existing infrastructure at each location. Internet connectivity was established at each location to upload recorded video to a storage device for review at the ODFW Astoria office. Camera locations at each access point were selected that provided relatively short range observations of choke points that access the Columbia River and were downstream of recreational moorage slips and boat ramps. The Hammond camera system (Figure 2) was installed on an existing utility pole approximately 150 m from the harbor entrance. A second camera was installed on this utility pole that was directed across the Columbia River. However, this video review method was abandoned due to difficulties identifying vessels at long distances on the Columbia River. The Warrenton camera (Figure 3) was affixed to a pole on a City of Warrenton commercial dock downstream of the Warrenton marina/boat ramp on the Skipanon River. The camera was directed toward the north bank of the Skipanon River approximately 200 m away. Because of the location of the camera at Warrenton, internet connectivity could not be delivered directly to the camera site. Instead, internet was installed in a nearby City of Warrenton facility and a wireless bridge was used to connect to the cameras via Wi-Fi. The West End camera system (Figure 4) was installed on the Port of Astoria Administrative Office (10 Pier 1 Building, Suite 308, Astoria, Oregon 97103) and directed toward the entrance to the West Mooring Basin approximately 160 m away. Continuous video at each access point was recorded 24 hours per day and stored on each cameras' internal recorders as well as an external storage device at the Astoria ODFW office. Recorded video was reviewed using Genetec Omnicast (www.genetec.com) and Avigilon View (www.avigilon.com) software.

Figure 1. Map of the Astoria area with locations of web cameras at the Hammond marina, Warrenton marina and West End mooring basin.

Figure 2. A) Map of the Hammond marina/boat ramp with location of camera station and point of view of camera. B) Hammond camera location on utility pole.

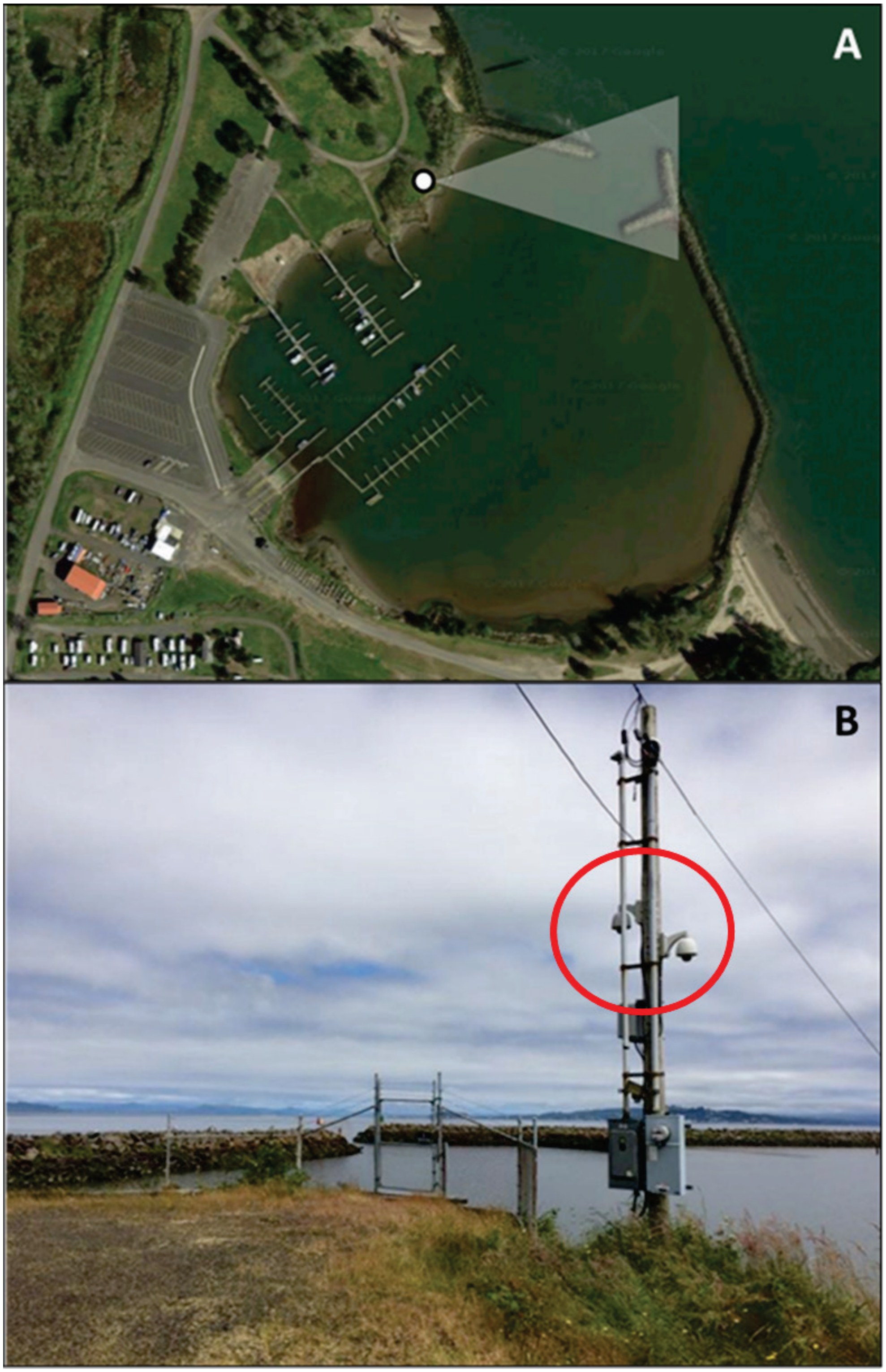


Figure 3. A) Map of the Warrenton marina/boat ramp with location of camera station and point of view of camera. B) Warrenton camera location on utility pole. Boats moored downstream of camera location are commercial vessels.

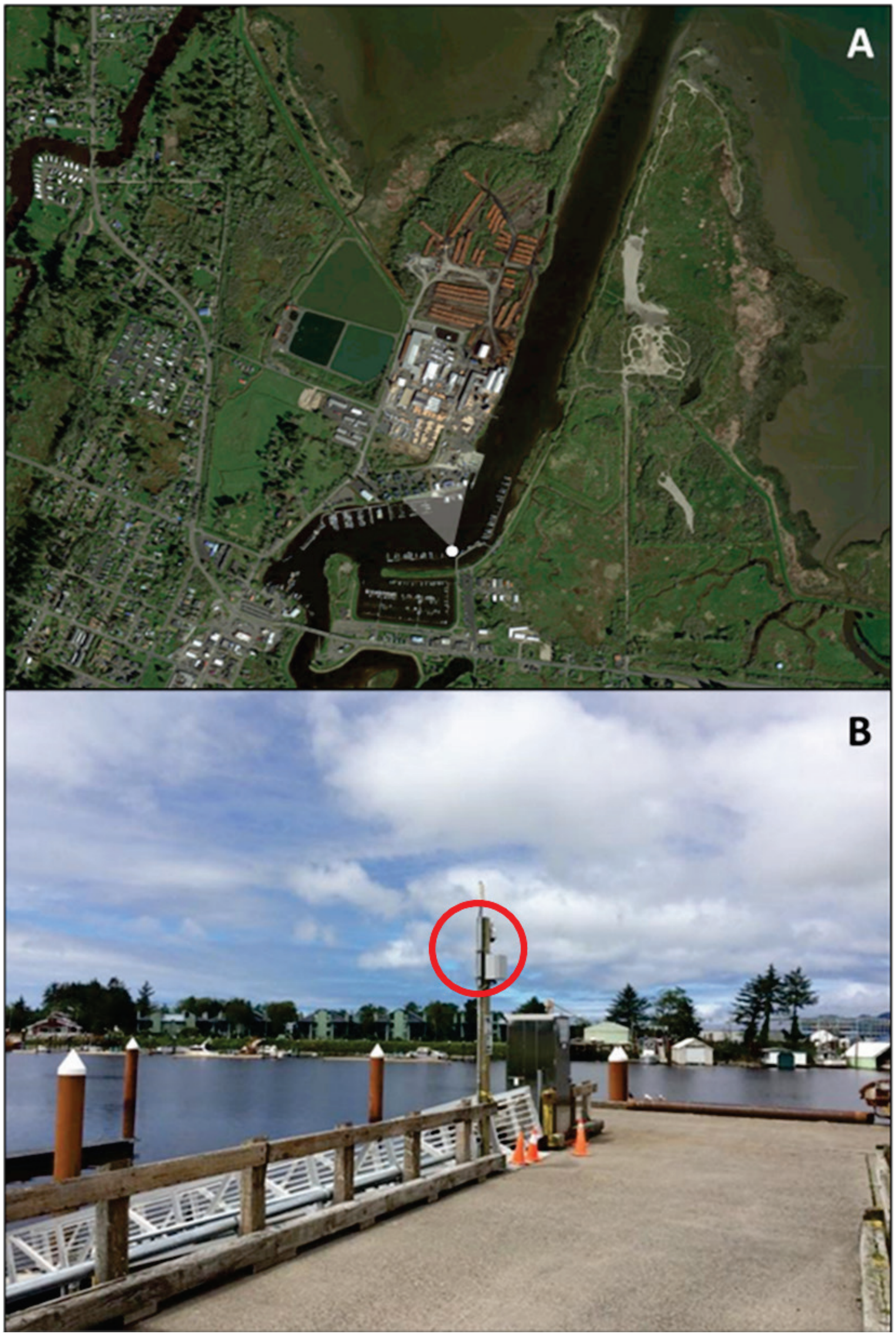
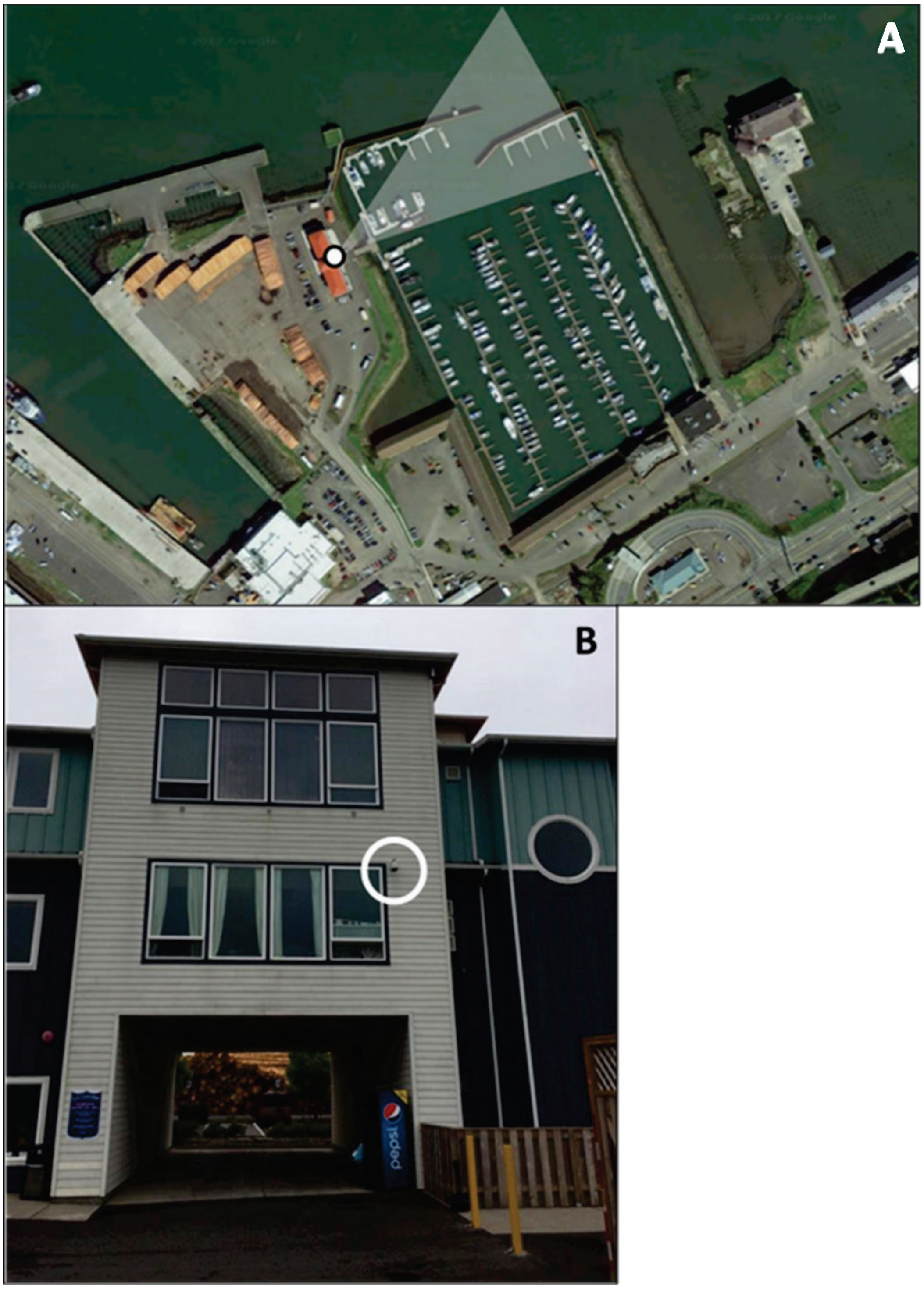


Figure 4. A) Map of the Astoria West End mooring basin with location of camera station and point of view of camera. B) West End camera location on Port of Astoria facility.



Live Private Boat Count Protocol

The daily live boat count was conducted by a sampler stationed at the parking area near Seafarer's Park in Hammond, OR (46.206181, -123.951627). The boat count began at least 30 minutes before sunrise and continued until 10:15 each day. Private recreational boats were counted as they crossed a north/south line drawn from the Hammond Boat Basin to the Washington shore. Counts of both out (heading downriver) and in (heading upriver) were recorded and aggregated within 30 minute intervals. This exit count was later adjusted by ORBS staff based on the proportion of intercept interviews with reported departure times outside of the count period, the proportion of boat trips with activity both inside the estuary and the ocean, and a final adjustment to estimate the number of ocean recreational boat trips based on the proportion of ocean to estuary private boat trips interviewed (Schindler et al. 2015).

Video-based Private Vessel Count Protocol

Daily recorded video for each access point was reviewed post-event by a sampler at the viewing station in the Astoria ODFW office[1]. Vessel counts covered the interval between 04:15 and 20:15 for each day of recorded video. Private recreational boats were counted as they crossed the marina breakwaters in Hammond and West End, or as they crossed downstream of the view of the camera in Warrenton. Both out and in counts were recorded and aggregated within 30 minute intervals. Exit counts were adjusted during data processing by ORBS staff based on the proportion of intercept interviews with reported departure times outside of the count period, the proportion of boat trips with activity both inside the estuary and the ocean, and a final adjustment to estimate the number of ocean recreational boat trips based on the proportion of ocean to estuary trips interviewed (Schindler et al. 2015).

Angler Intercept Sampling and Estimation Description

Sampling was conducted from May 2, 2016 through September 29, 2016. Beginning May 2, 2016, four Marine Resources Program (MRP) Ocean Sampling Project port samplers were deployed to assignments in the Astoria area. On June 19, 2016, a fifth sampler was trained and assigned to duties in Astoria.

Samplers were each assigned to work five days per statistical week (Mon – Sun). Weekend days were assigned an inclusion probability of 1.0 and thus, were always assigned to all sampling personnel. Daily sampling assignments were assigned randomly without replacement within time strata (Table 1) from six combinations of access point – time period work shifts (Table 2). Access points consisted of Hammond, Warrenton, or West End, and time periods were generally defined as Early (07:00 – 15:00) or Late (12:00 – 20:00). Generally, two samplers per day were assigned to conduct a live vessel count and a video-based count, respectively. To maintain sufficient levels of intercept sampling, certain days were not assigned a live count. Daily live counts were absent on four of thirty days in May and June, respectively. Live counts were conducted every day from July through September. Coinciding with the opening of the Columbia River Buoy 10 Estuary Salmon Fishery, beginning August 1, sampling in the Astoria area was supplemented by ODFW Columbia River Management (CRM) personnel. At the

[1] The viewing station in the Astoria office was operational on August 1, 2016. Videos recorded prior to August 1 were reviewed by Newport staff post-season.

request of CRM, in order to account for anticipated higher volumes of angler effort at the Hammond access point during the Buoy 10 salmon fishery, a greater proportion of sampler assignments were shifted to Hammond. In addition to sampling at Hammond, Warrenton, and Astoria West End; CRM samplers were also assigned to the Astoria East End basin and John Day boat ramp, located farther upstream.

Estimates of effort were stratified to statistical weeks or to time strata within statistical weeks based on "relevant ocean fishing seasons" (Table 1). Sampling protocols were conducted as described in Schindler et al. 2015. Effort for days in which live counts were not conducted in May (n =4) and June (n = 4) was estimated as the mean of observed effort within the same stratum. Effort estimates generated from the live count method incorporated pooled interview data from all access points to produce an effort estimate for the entire Astoria area per temporal stratum. Conversely, using the video-based method, effort estimates were generated for each access point using effort and interview data collected from each access point, respectively. For the video-based estimation procedures, in instances when no interview data were available from an access point for a specific time stratum, interview data from available access points were pooled to generate an estimate (Table 3).

Missing Data Imputation of Video-based Counts

Video-based effort data was missing during some time periods due to video malfunction or sampler protocol errors. In order to generate complete effort estimates, these missing values were imputed using the process described by van Poorten (2015). Ratios of observed outgoing video effort between the three access points were calculated across all time periods. To fill in missing data gaps for a particular access point, the respective ratios were multiplied by the observed effort at each of the other two access points and the average of those estimates was used to predict the effort for the missing time period. If video data was missing for two access points during the same time period, the missing data was estimated using only the ratio from the single available access point.

Occasionally, video effort data was only partially missing from a half-hour time period due to video malfunction. In these instances, count data that was observed during the half-hour period was simply expanded by the proportion of the half-hour time period that was missing.

Total ocean effort estimate comparison between live and video-based methods

To evaluate the estimated ocean boat trips generated from the live count and the video-based method, a paired t-test was conducted to compare the estimated ocean trips generated from each method at each time stratum of the sampling season (Table 1). A Shapiro-Wilk normality test on the paired differences of estimated ocean boat effort between the two methods indicated the differences were not normally distributed ($p < 0.001$) and right-skewed. A square root transformation of the data was performed and the Shapiro-Wilk normality test on the transformed differences indicated normality assumptions were satisfied ($p = 0.2672$).

Differences between the two methods were also assessed with a Bland-Altman plot. A Bland-Altman plot is a technique for graphically analyzing the difference between two methods designed to measure the same parameter, in this case estimated ocean boat trips, by plotting the differences (y-axis) against the average (x-axis) of the two methods.

Table 1. Temporal strata, dates, and ocean fishing seasons used for catch and effort estimates.

Strata[2]	Dates	Relevant Open Ocean Fishing Seasons
19W	5/2 – 5/4	
19D	5/5 – 5/8	All-Depth Halibut
20W	5/9 – 5/11	
20D	5/12 – 5/15	All-Depth Halibut
21W	5/16 – 5/18	
21D	5/19 – 5/22	All-Depth Halibut
22W	5/23 – 5/25	
22D	5/26 – 5/29	All-Depth Halibut
23W	5/30 – 6/1; 6/4 – 6/5	
23D	6/2 – 6/3	All-Depth Halibut
24W	6/6 – 6/12	
25W	6/13 – 6/19	
26W	6/20 – 6/26	
27W	6/27 – 6/30	
27D	7/1 – 7/3	Ocean Chinook Salmon and Selective Coho Salmon
28W	7/4 – 7/10	Ocean Chinook Salmon and Selective Coho Salmon
29W	7/11 – 7/17	Ocean Chinook Salmon and Selective Coho Salmon
30W	7/18 – 7/24	Ocean Chinook Salmon and Selective Coho Salmon
31W	7/25 – 7/31	Ocean Chinook Salmon and Selective Coho Salmon
32W	8/1 – 8/7	Ocean Chinook Salmon and Selective Coho Salmon
33W	8/8 – 8/14	Ocean Chinook Salmon and Selective Coho Salmon
34W	8/15 – 8/21	Ocean Chinook Salmon and Selective Coho Salmon
35W	8/22 – 8/27	Ocean Chinook Salmon and Selective Coho Salmon
35D	8/28	
36W	8/29 – 9/4	
37W	9/5 – 9/11	
38W	9/12 – 9/18	
39W	9/19 – 9/25	
40W	9/26 – 10/2	

[2] Strata correspond to the number of the statistical week and the stratification type. Statistical weeks listed with a "W" and a "D" represent weeks in which a stratification was employed as a result of a change in fishing seasons within the statistical week.

Table 2. Access Point – Time Period sampling assignments

Access Point – Time Period Assignments
Hammond – Early
Hammond – Late
Warrenton – Early
Warrenton – Late
West End – Early
West End – Late

Table 3. Access points and time strata with no interviews recorded.

Access Point	Strata
Warrenton	19D
Warrenton	20D
Warrenton	21D
Warrenton	21W
Warrenton	22W
Warrenton	23D
West End	19W
West End	21D
West End	23D

Results and Discussion

Video-based Private Vessel Counts

During the study, video analysts recorded 11,409 and 11,801 departing and returning vessels at the Hammond basin (3.4% difference). Warrenton basin departing and returning video counts totaled 6,937 and 6,748, respectively (2.8% difference). West End departing and returning video counts totaled 7,017 and 7,020, respectively (0.01% difference). Observed differences between departing and returning totals are slightly higher, yet comparable to numbers observed in a similar study conducted in Newport in 2007 by Ames and Schindler (2009). In the Newport study, the overall percent difference between *out* and *in* counts was 0.57%; however, it should be noted that the 2009 study conducted counts of recorded vessel activity over a 24 hour period, which may account for some of the discrepancy in the current study.

Visibility problems and video malfunctions

For the study period of May 2, 2016 through September 29, 2016 there were a total of 4,832 half-hour intervals (151 days · 32 half-hour intervals) of potential video per access point. Video malfunction resulted in the loss of video during 193 (4%), 18 (0.4%), and 6 (0.1%) half-hour viewing intervals at Hammond, Warrenton, and West End, respectively. When necessary, these video gaps were filled using the procedure described previously. Of the remaining video, video analysts noted limited visibility due to fog or boat lights during 21 (0.5%), 49 (1%), and 3 (0.1%) half-hour intervals at Hammond, Warrenton, and West End, respectively. In comparison, samplers conducting live counts made note of fog influencing the counts on 16 out of 151 days (10.6%).

Sampling statistics

Port samplers conducted interviews for 3,326; 1,212; and 1,100 returning boat trips at Hammond, Warrenton, and West End, out of an estimated 12,521; 7,473; and 7,375 boat trips, respectively. Season-wide sampling rates at Hammond, Warrenton, and West End were 26.5%, 16.2%, and 14.9%. The ORBS attempts to obtain at least a minimum sample rate goal of 20% per port and time stratum. Out of 29 time strata, Hammond failed to meet this objective in four temporal strata; however, sampling rates at Warrenton and West End dropped below the 20% threshold in 26 and 19 strata, respectively (Table 4).

The access point-specific sampling rates observed as a result of this study have identified a potential deficiency in our sampling design and source of bias in our estimation methodology for the Astoria area. In many temporal strata, especially for Warrenton and West End, sampling rates fell below the minimum objective and may not have been adequate to produce reliable estimates. Reasons for the low sampling fraction have yet to be identified, but various causes may be responsible. In 2016, four of the five samplers in the Astoria area were new to the Ocean Sampling Project and relative inexperience may have led to inefficient sampling performance. Discussions with samplers did indicate that the layout of the West End mooring basin made it challenging to track returning vessels to the correct moorage slip and missed interviews may have occurred. Similarly, at Warrenton, samplers observed recreational effort departing from the marina located on the north bank of the Skipanon River. Typically, samplers assigned to Warrenton will be positioned at the boat ramp located on the south side of the Skipanon River. From this position, samplers would be unable to intercept boats returning both to the Skipanon boat ramp and the Port of Warrenton marina.

Our project will continue to assess techniques to improve our sampling protocols and sampler allocation methods to resolve issues identified by this study. Additionally, the continued use of the video-based technology will allow our project to assess sampling performance in-season in order to identify and more adaptively resolve issues in a more immediate timeframe.

Table 4. Intercept interviews, estimated total boat trips and sampling rates for Astoria-area access points in 2016.[3]

	Hammond			Warrenton			West End		
Strata	Interviews	Estimated Total Boat Trips	% Sampled	Interviews	Estimated Total Boat Trips	% Sampled	Interviews	Estimated Total Boat Trips	% Sampled
19D	4	11	36.4%	**0**	**12**	**0.0%**	8	9	88.9%
19W	1	7	14.3%	1	1	100.0%	**0**	**15**	**0.0%**
20D	19	37	51.4%	**0**	**24**	**0.0%**	5	21	23.8%
20W	8	14	57.1%	1	6	16.7%	3	15	20.0%
21D	1	7	14.3%	**0**	**3**	**0.0%**	**0**	**12**	**0.0%**
21W	5	9	55.6%	**0**	**4**	**0.0%**	4	11	36.4%
22D	5	30	16.7%	1	16	6.3%	2	25	8.0%
22W	1	5	20.0%	**0**	**11**	**0.0%**	2	10	20.0%
23D	4	11	36.4%	**0**	**6**	**0.0%**	**0**	**9**	**0.0%**
23W	10	43	23.3%	3	20	15.0%	7	67	10.4%
24W	6	22	27.3%	1	13	7.7%	2	51	3.9%
25W	31	69	44.9%	4	37	10.8%	1	45	2.2%
26W	16	41	39.0%	7	31	22.6%	13	76	17.1%
27D	52	101	51.5%	4	37	10.8%	18	55	32.7%
27W	3	15	20.0%	2	12	16.7%	1	33	3.0%
28W	29	81	35.8%	4	46	8.7%	12	105	11.4%
29W	59	161	36.6%	6	65	9.2%	19	126	15.1%
30W	107	236	45.3%	3	79	3.8%	17	146	11.6%
31W	50	170	29.4%	9	126	7.1%	53	189	28.0%
32W	434	1,123	38.6%	140	597	23.5%	172	615	28.0%
33W	539	2,190	24.6%	276	1,407	19.6%	161	1,140	14.1%
34W	534	2,539	21.0%	280	1,587	17.6%	225	1,525	14.8%
35D	124	278	44.6%	50	176	28.4%	42	176	23.9%
35W	343	2,950	11.6%	190	1,880	10.1%	130	1,613	8.1%
36W	440	1,316	33.4%	148	742	19.9%	90	741	12.1%
37W	247	600	41.2%	61	314	19.4%	79	363	21.8%
38W	94	219	42.9%	15	120	12.5%	21	112	18.8%
39W	90	149	60.4%	4	56	7.1%	11	43	25.6%
40W	70	87	80.5%	2	45	4.4%	2	27	7.4%
Total	3,326	12,521	26.5%	1,212	7,473	16.2%	1,100	7,375	14.9%

[3] Values in bold indicate strata in which no interviews were recorded for a given access point. Total boat trip estimates were produced based on available interview data pooled from access points in the same time stratum.

Live and video-based ocean effort estimate comparison

Total ocean effort estimated using the live count for the study period totaled 1,548 ocean boat trips compared to the 2,059 ocean boat trips estimated by the video-based method (Table 5, Figure 5). A paired t-test on the transformed data indicated a significant difference in the estimated ocean effort produced by the live count and the video based methods ($t = 2.968$, $p = 0.006$). The Bland-Altman plot (Figure 6) indicated relatively good agreement between the two methods at low levels of estimated ocean effort (< 50 boat trips); however, a positive trend in the difference between the video-based method and the live count was observed as effort increased, with the video-based method generating consistently higher estimates.

The reasons for the differences observed in ocean effort between the two vessel count methodologies are not evident; however, several possible factors may be responsible. In general, the video-boat count method consistently produced higher estimates of ocean effort. The video-based ocean effort estimate exceeded the live count estimate in 19 of 29 temporal strata, with the largest differences observed during periods of the highest effort. Samplers have noted that live counts on the Columbia River may be subject to errors because of difficulties in keeping track of vessels as they navigate downstream. This is especially true during the lower Columbia River Buoy 10 fishery when a large amount of boat traffic steadily moves back and forth in front of the live count location. Additionally, early morning departures under poor light conditions, limited visibility due to fog, and distinguishing small vessels at long distances across the Columbia River have been identified as possible sources of error when conducting the live count.

As mentioned, because the live count period ends at 10:15, interview data is used to expand private boat counts for departures that occurred outside of the live count window. Interviews of anglers are used to obtain the ratio of boats that report departing outside the count period. The resulting expansion factor is applied to the count data to obtain a total estimate of departures. It is possible that expansion factors derived from interviews did not accurately scale live boat counts to estimated total departures. Significant differences between video analysts' 24 hour counts and expansions of counts ending at 10:00am were also observed in Ames and Schindler (2009). In the present study, early and late sampler time shifts were assigned to cover the entire sampling day to prevent unrepresentative sampling and potentially biased expansion factors; however, low sampling rates observed at some sites and temporal strata may have been a factor.

The ORBS project will continue to evaluate sampling designs and strategies to maintain sufficient and representative sampling in the Astoria area. The continued use of the video-based methodology will reduce errors associated with the poor visibility and other vessel counting problems associated with the live counting method. Additionally, the extended viewing period made possible as a result of the recorded video may reduce potential errors associated with biased expansion factors.

Table 5. Estimated ocean boat trips generated by the live count and video-based methodologies for the Astoria area in 2016.

Strata	Live Count	Video-based Count
19W	0	0
19D	20	9
20W	3	13
20D	46	63
21W	6	9
21D	0	0
22W	5	9
22D	19	34
23W	19	36
23D	14	26
24W	4	7
25W	28	43
26W	15	23
27W	0	0
27D	85	116
28W	48	106
29W	157	177
30W	250	359
31W	43	28
32W	155	253
33W	214	205
34W	206	310
35W	116	162
35D	18	7
36W	25	25
37W	15	16
38W	27	14
39W	6	7
40W	4	2
Total	1,548	2,059

Figure 5. Estimated ocean boat trips per temporal stratum generated from the live count and video-based methodologies.

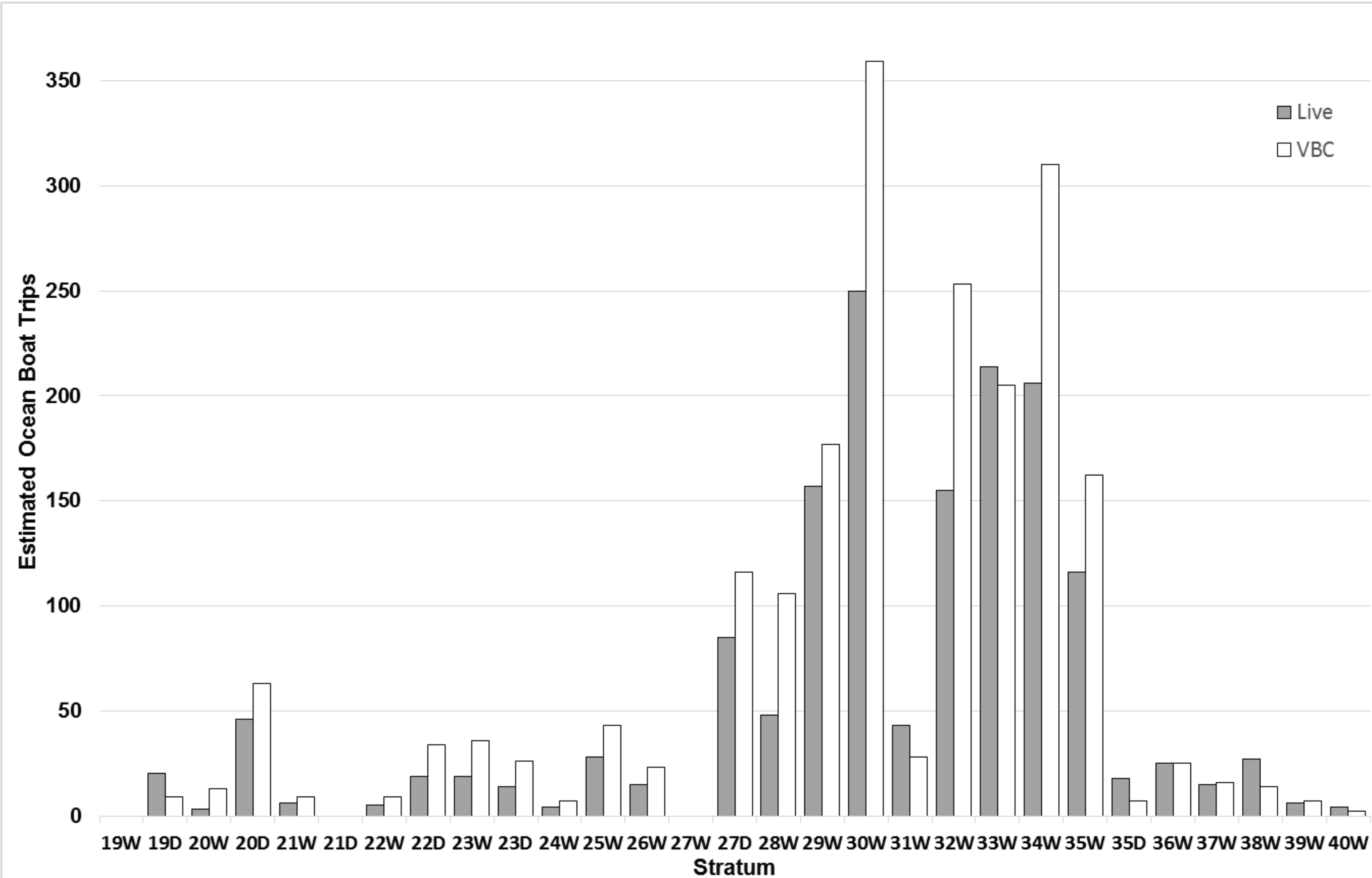
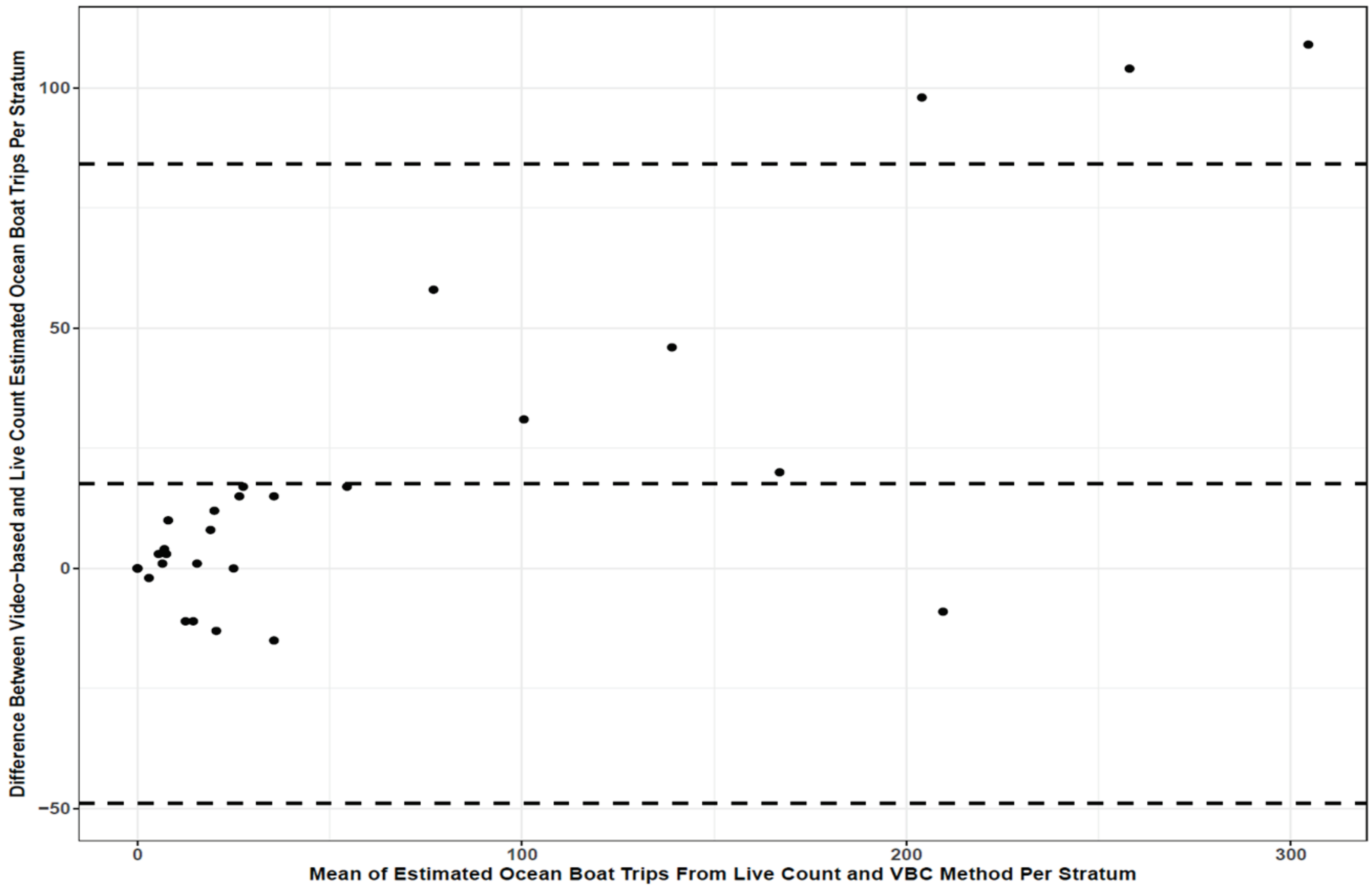


Figure 6. Bland-Altman plot of the mean of estimated ocean boat trips vs. the difference between the ocean boat trips estimated with video-based and the live count methodology. Middle hashed line represents the mean difference. Upper and lower hashed lines represent ± 1.96 *S.D* (95% limits of agreement).



Within Access Point Ocean Proportion Comparison

If the proportion of ocean recreational trips originating from each access point is consistently different or variable between locations, and intercept data is not properly weighted or stratified to account for differences between the locations, resulting ocean recreational estimates may be biased. Additionally, differences in the relative proportion of ocean to estuary trips may vary by fishing season. Understanding potential differences between the access points and how these differences vary may help to guide sampling design and estimation procedures.

Lower than anticipated sampling rates, sample sizes (total interviews) and the absence of interview data from some access points during specific time strata precluded defensible statistical analysis and hypothesis testing of potential differences in access point-specific ocean effort proportions between locations. However, available interview data was assessed visually to identify general trends in the relative proportion of ocean interviews at each access point during relevant fishing seasons in 2016.

Throughout 2016, a number of fishing seasons occurred in the ocean and estuary that may have influenced angler activity in the Columbia River area. Openings and closures of these fisheries influenced total effort and likely influenced the relative proportion of ocean effort. To account for the potential influences of fishing season, relative ocean effort proportions were assessed in relation to these time periods.

Time strata included in this assessment could be characterized by five primary fishing season types in the Astoria area: Groundfish (GF), All-Depth Halibut (ADH), Estuary Salmon (ES), Ocean Salmon (OS), and Buoy 10 (B10). These seasons overlapped temporally into six main classifications that were used as levels of fishing season in the evaluation: GF, ADH/GF, GF/ES, OS/GF/ES, OS/B10/GF, and B10/GF (Table 6). The ‘Groundfish (GF)’ season is generally an ocean fishery targeting bottomfish species such as lingcod, rockfish, greenlings, and others. Fishing for groundfish was open in the ocean throughout the time period of the study, and thus was open during other primary fishing seasons described below. The All-Depth Halibut fishery is a popular ocean recreational fishery that allows retention of Pacific halibut at any depth, but restricts retention of most other groundfish species if a Pacific halibut is retained. The ‘Estuary Salmon (ES)’ fishery was open for summer Chinook, summer steelhead, and sockeye salmon upstream of the Astoria-Megler Bridge from June 16-July 31. The ‘Ocean Salmon (OS)’ fishery in 2016 was open to Chinook salmon and fin-clipped coho salmon in the ocean from July 1 through August 27. The ‘Buoy 10 (B10)’ fishery is a popular estuary fishery in the lower Columbia River targeting Chinook and coho salmon. The Buoy 10 fishery opened on August 1 and ran through the remainder of the study period.

Although, total sample sizes were low in many cases in 2016 (Table 7), general trends in the proportion of ocean effort from each access point could be observed. Generally, the Hammond marina displayed a higher proportion of ocean effort; however, this appeared to vary by fishing season (Figure 7). With the opening of the lower Columbia River Buoy 10 salmon season, the high volume of estuary trips substantially reduced the proportion of ocean effort observed for all access points and made differences between locations negligible.

Prior to the implementation of the video-based effort counting methodology in Astoria, intercept data from each access point could not be appropriately weighted because a corresponding estimate of effort was not available from each location. Therefore, interview data collected from all access points were pooled to produce a total ocean effort estimate for the entire Astoria area. If differences in relative ocean effort existed between the access points, disproportionate sampling between locations may have led to biased estimates in the past.

Based on observed differences between access points, this assessment suggests that generating individual ocean effort estimates for each access point using the respective intercept interviews and video-based exit counts from each location may be a more appropriate method than pooling interviews. However, as mentioned previously, because of missing interview data from certain access points, some temporal strata including many of the All-Depth Halibut strata were unavailable for comparison. Results of the evaluation may have differed if more information had been available from these time periods. Additionally, sampling rates observed for many access points and strata were much lower than anticipated. This reduced sampling fraction likely contributed to the variability observed in the results. Continued use of the video system and subsequent improvement to our angler intercept sampling is suggested in order to provide further assessment of relative effort proportions and other fishery characteristics between access points in the Astoria area.

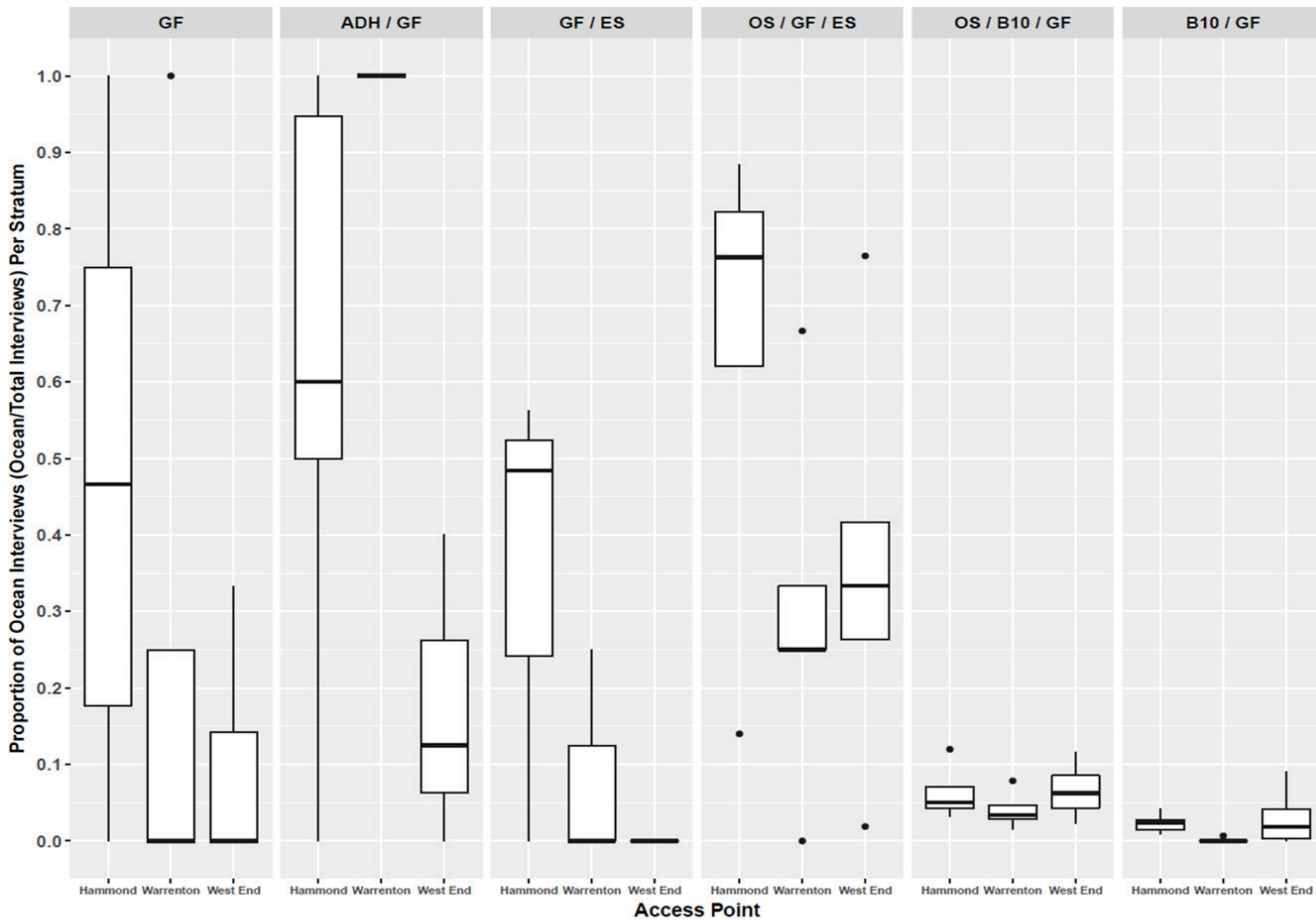
Table 6. Temporal strata, dates and levels of fishing season used to compare access point-specific proportion of ocean effort. GF - Groundfish, ADH – All-depth halibut, ES – Estuary salmon, OS - Ocean salmon, B10 - Buoy 10.

Strata	Dates	Fishing Seasons
19W	5/2 – 5/4	GF
19D	5/5 – 5/8	ADH / GF
20W	5/9 – 5/11	GF
20D	5/12 – 5/15	ADH / GF
21W	5/16 – 5/18	GF
21D	5/19 – 5/22	ADH / GF
22W	5/23 – 5/25	GF
22D	5/26 – 5/29	ADH / GF
23W	5/30 – 6/1; 6/4 – 6/5	GF
23D	6/2 – 6/3	ADH / GF
24W	6/6 – 6/12	GF
25W	6/13 – 6/19	GF / ES
26W	6/20 – 6/26	GF / ES
27W	6/27 – 6/30	GF / ES
27D	7/1 – 7/3	OS / GF / ES
28W	7/4 – 7/10	OS / GF / ES
29W	7/11 – 7/17	OS / GF / ES
30W	7/18 – 7/24	OS / GF / ES
31W	7/25 – 7/31	OS / GF / ES
32W	8/1 – 8/7	OS / B10 / GF
33W	8/8 – 8/14	OS / B10 / GF
34W	8/15 – 8/21	OS / B10 / GF
35W	8/22 – 8/27	OS / B10 / GF
35D	8/28	B10 / GF
36W	8/29 – 9/4	B10 / GF
37W	9/5 – 9/11	B10 / GF
38W	9/12 – 9/18	B10 / GF
39W	9/19 – 9/25	B10 / GF
40W	9/26 – 10/2	B10 / GF

Table 7. Number of ocean interviews, total interviews and percent ocean interviews for Astoria-area access points in 2016 per temporal stratum with relevant fishing seasons.

		Hammond			Warrenton			West End		
Strata	Fishery	Ocean Interviews	Total Interviews	% Ocean	Ocean Interviews	Total Interviews	% Ocean	Ocean Interviews	Total Interviews	% Ocean
19W	GF	0	1	0.0%	0	1	0.0%	0	0	-
19D	ADH / GF	2	4	50.0%	0	0	-	1	8	12.5%
20W	GF	1	8	12.5%	1	1	100.0%	1	3	33.3%
20D	ADH / GF	18	19	94.7%	0	0	-	2	5	40.0%
21W	GF	4	5	80.0%	0	0	-	0	4	0.0%
21D	ADH / GF	0	1	0.0%	0	0	-	0	0	-
22W	GF	1	1	100.0%	0	0	-	0	2	0.0%
22D	ADH / GF	3	5	60.0%	1	1	100.0%	0	2	0.0%
23W	GF	6	10	60.0%	0	3	0.0%	1	7	14.3%
23D	ADH / GF	4	4	100.0%	0	0	-	0	0	-
24W	GF	2	6	33.3%	0	1	0.0%	0	2	0.0%
25W	GF / ES	15	31	48.4%	1	4	25.0%	0	1	0.0%
26W	GF / ES	9	16	56.3%	0	7	0.0%	0	13	0.0%
27W	GF / ES	0	3	0.0%	0	2	0.0%	0	1	0.0%
27D	OS / GF / ES	46	52	88.5%	1	4	25.0%	6	18	33.3%
28W	OS / GF / ES	18	29	62.1%	1	4	25.0%	5	12	41.7%
29W	OS / GF / ES	45	59	76.3%	2	6	33.3%	5	19	26.3%
30W	OS / GF / ES	88	107	82.2%	2	3	66.7%	13	17	76.5%
31W	OS / GF / ES	7	50	14.0%	0	9	0.0%	1	53	1.9%
32W	OS / B10 / GF	52	434	12.0%	11	140	7.9%	20	172	11.6%
33W	OS / B10 / GF	25	539	4.6%	9	276	3.3%	8	161	5.0%
34W	OS / B10 / GF	29	534	5.4%	10	280	3.6%	17	225	7.6%
35W	OS / B10 / GF	11	343	3.2%	3	190	1.6%	3	130	2.3%
35D	B10 / GF	3	124	2.4%	0	50	0.0%	0	42	0.0%
36W	B10 / GF	4	440	0.9%	1	148	0.7%	1	90	1.1%
37W	B10 / GF	3	247	1.2%	0	61	0.0%	2	79	2.5%
38W	B10 / GF	4	94	4.3%	0	15	0.0%	1	21	4.8%
39W	B10 / GF	2	90	2.2%	0	4	0.0%	1	11	9.1%
40W	B10 / GF	2	70	2.9%	0	2	0.0%	0	2	0.0%

Figure 7. Proportion of ocean boat effort per temporal stratum from each access point and fishing season in 2016.



Relative Contribution of Effort from Access Points

The relative contribution of estimated ocean boat trips appeared to differ between access points in 2016 (Table 8; Figure 8). In general, Hammond marina contributed substantially more estimated ocean boats trips (56.4%) in 2016 than did West End (26.7%) and Warrenton (16.9%). This pattern of the relative ocean effort between the three access points had been previously assumed, but had not been assessed empirically. Because of the relative proximity of the Hammond marina to the ocean and the accessibility and size of its boat ramp and parking lot, a large volume of effort launches from this access point. The West End mooring basin lacks a boat ramp and consists of only dock slips. Relatively larger private vessels tend to moor at this location and may explain the increased relative ocean effort compared to the Warrenton marina, which has a smaller boat ramp and moorage area.

Estimated total boat trips (ocean and estuary combined) also differed between access points in 2016 (Figure 9, Table 9). The Hammond marina contributed the largest proportion to estimated total effort (45.8%), while Warrenton and West End contributed similar proportions, 27.3% and 26.9%, respectively. Total boat trip estimates remained relatively constant throughout 2016 until the opening of the Columbia River Buoy 10 salmon season on August 1st (Stratum 32W), which resulted in greatly increased effort at all three access points. Total effort began to steadily decline after the closure of North of Cape Falcon ocean salmon seasons on August 27th (35W).

Reliable estimates of effort and catch depend on a sufficient level of intercept sampling at each access point in the Astoria area. The implementation of the video-based methodology provided quantification of the amount and relative proportions of effort from each access point in the Astoria area in 2016. The video system also allowed our project to identify general patterns in private recreational effort in relation to changes in fishing seasons. Continued video monitoring will occur in 2017 to further evaluate these trends. This information will be beneficial in guiding effective temporal and spatial allocation of sampling assignments to maintain adequate sample sizes for the intercept survey and monitor in-season sampling performance.

Additionally, having access point-specific estimates of effort allows for appropriate stratification and weighting of intercept interview data in the estimation procedure. As mentioned, prior to 2016, effort estimates for each access point were unavailable, so intercept interview data were aggregated from all locations and applied to the total effort estimate from the live count methodology. If effort and angling characteristics differed between access points, accurate estimates generated from the live count method relied on proportionally representative sampling occurring at each location. Based on observations in 2016, it does not appear that the sampling proportions were well matched to the estimated proportion of total effort from each access point (Figure 10). Hammond was consistently sampled at a higher proportion, and was generally overrepresented compared to Warrenton and West End. Without proper stratification, this mismatch in representation could produce biased overall estimates. Using the video-based methodology, individual estimates of effort for each access point can now be determined, and stratification of intercept data to each respective location achieved. This will eliminate the need for strict correspondence between relative sampling and effort proportions at each access point and produce more accurate estimates for the Astoria area.

Figure 8. Estimated ocean boat trips per stratum and access point in 2016. Strata in which no interviews occurred for a given access point have been excluded. Date on the x-axis represents the start date of the respective stratum.

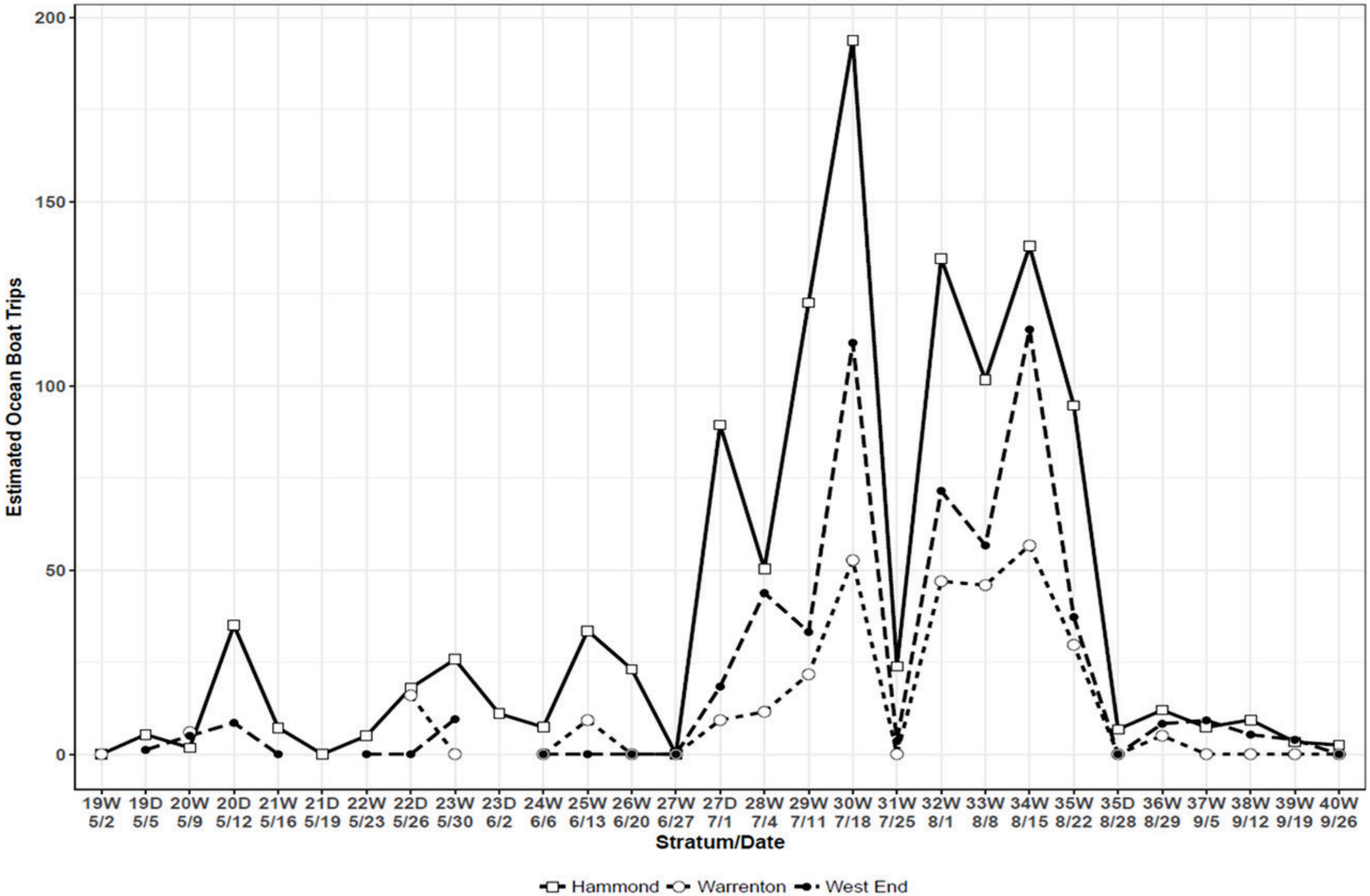


Table 8. Estimated total ocean boat trips by access point and percentage contribution per temporal stratum.[4]

Strata	Hammond		Warrenton		West End	
19W	0	-	0	-	**0**	**-**
19D	5	55.6%	**3**	**33.3%**	1	11.1%
20W	2	15.4%	6	46.2%	5	38.5%
20D	35	55.6%	**20**	**31.7%**	8	12.7%
21W	7	77.8%	**2**	**22.2%**	0	0.0%
21D	0	-	**0**	**-**	**0**	**-**
22W	5	55.6%	**4**	**44.4%**	0	0.0%
22D	18	52.9%	16	47.1%	0	0.0%
23W	26	72.2%	0	0.0%	10	27.8%
23D	11	42.3%	**6**	**23.1%**	**9**	**34.6%**
24W	7	100.0%	0	0.0%	0	0.0%
25W	34	79.1%	9	20.9%	0	0.0%
26W	23	100.0%	0	0.0%	0	0.0%
27W	0	-	0	-	0	-
27D	89	76.7%	9	7.8%	18	15.5%
28W	50	47.2%	12	11.3%	44	41.5%
29W	122	68.9%	22	12.4%	33	18.6%
30W	194	54.0%	53	14.8%	112	31.2%
31W	24	85.7%	0	0.0%	4	14.3%
32W	135	53.4%	47	18.6%	71	28.1%
33W	102	49.8%	46	22.4%	57	27.8%
34W	138	44.5%	57	18.4%	115	37.1%
35W	95	58.6%	30	18.5%	37	22.8%
35D	7	100.0%	0	0.0%	0	0.0%
36W	12	48.0%	5	20.0%	8	32.0%
37W	7	43.8%	0	0.0%	9	56.3%
38W	9	64.3%	0	0.0%	5	35.7%
39W	3	42.9%	0	0.0%	4	57.1%
40W	2	100.0%	0	0.0%	0	0.0%
Total	1162	56.4%	347	16.9%	550	26.7%

[4] Values in bold indicate strata in which no interviews were recorded for a given access point. Ocean boat trip estimates were produced based on available interview data pooled from access points in the same time stratum.

Figure 9. Estimated total boat trips (ocean and estuary) per stratum and access point in 2016. Date on the x-axis represents the start date of the respective stratum.

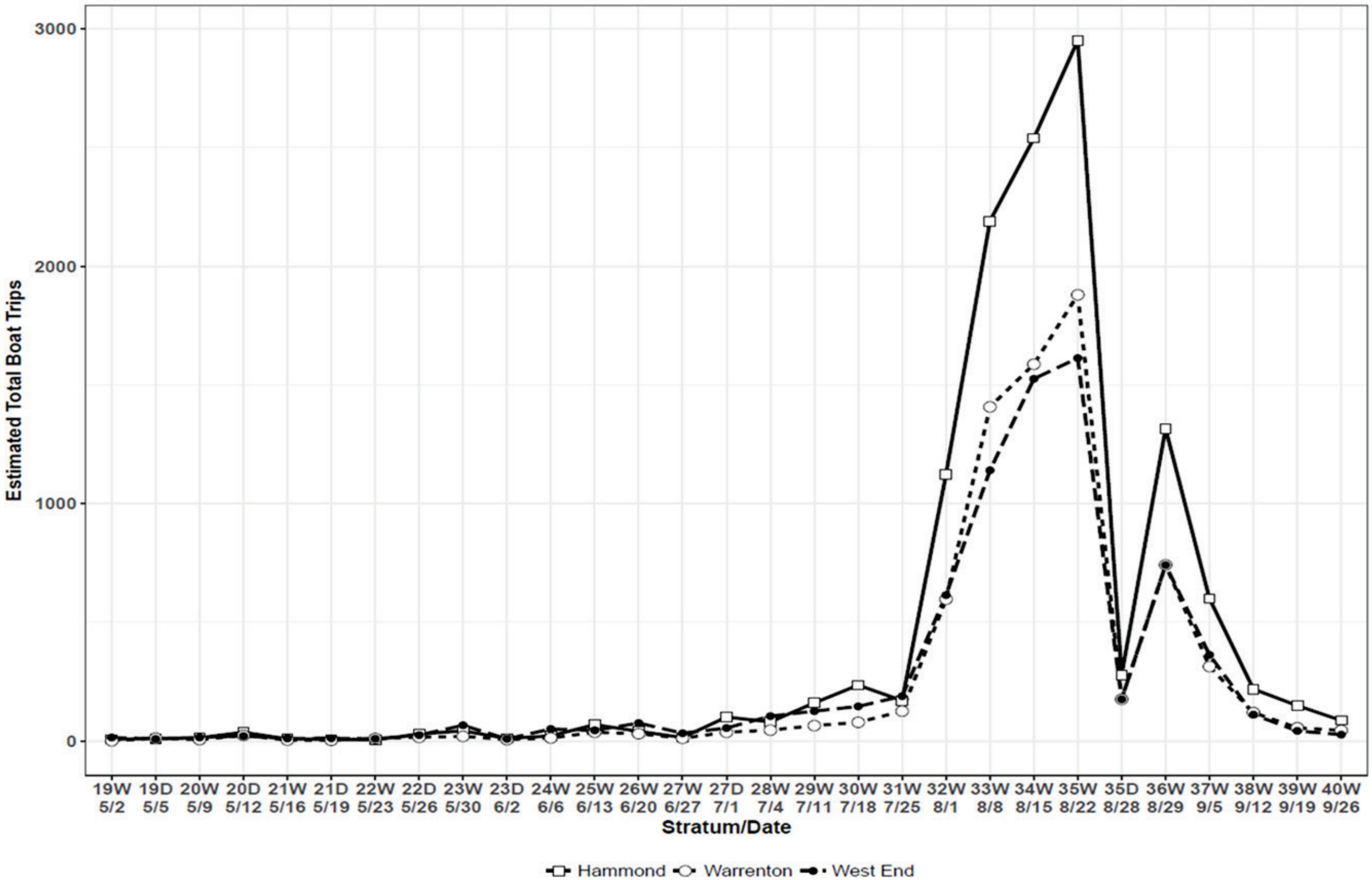
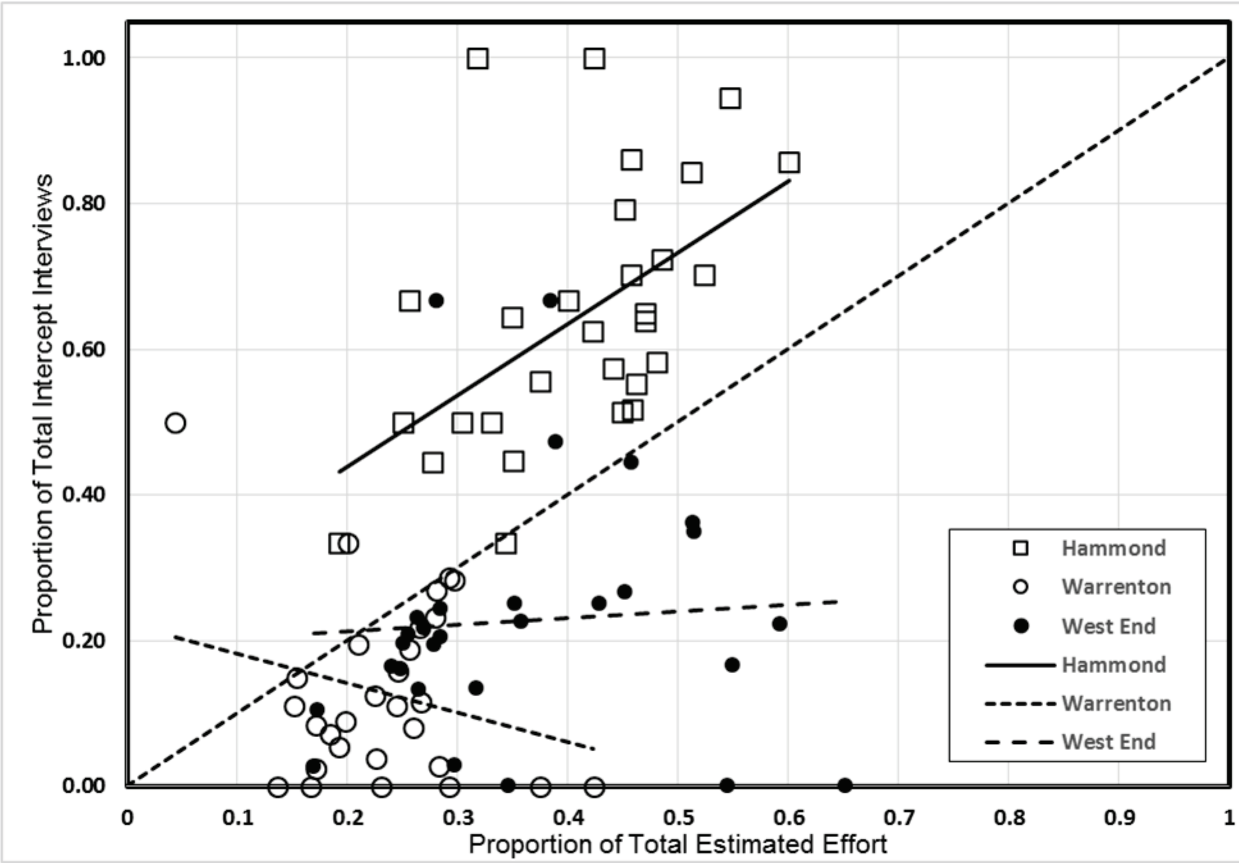


Table 9. Estimated total boat trips (ocean and estuary) by access point and percentage contribution per temporal stratum.[5]

Strata	Hammond		Warrenton		West End	
19W	7	30.4%	1	4.3%	**15**	**65.2%**
19D	10	32.3%	**12**	**37.5%**	9	28.1%
20W	14	40.0%	6	17.1%	15	42.9%
20D	37	45.1%	**24**	**29.3%**	21	25.6%
21W	9	37.5%	**4**	**16.7%**	11	45.8%
21D	7	31.8%	**3**	**13.6%**	**12**	**54.5%**
22W	5	19.2%	**11**	**42.3%**	10	38.5%
22D	30	42.3%	16	22.5%	25	35.2%
23W	43	33.1%	20	15.4%	67	51.5%
23D	11	42.3%	**6**	**23.1%**	**9**	**34.6%**
24W	22	25.6%	13	15.1%	51	59.3%
25W	70	46.1%	37	24.5%	45	29.8%
26W	41	27.7%	31	20.9%	76	51.4%
27W	15	25.0%	12	20.0%	33	55.0%
27D	101	52.3%	37	19.2%	55	28.5%
28W	81	34.9%	46	19.8%	105	45.3%
29W	160	45.6%	65	18.5%	126	35.8%
30W	236	51.2%	79	17.1%	146	31.7%
31W	171	35.2%	126	26.0%	189	39.0%
32W	1,124	48.1%	597	25.6%	614	26.3%
33W	2,190	46.2%	1,407	29.7%	1,141	24.1%
34W	2,539	44.9%	1,587	28.1%	1,525	27.0%
35W	2,951	45.8%	1,880	29.2%	1,612	25.0%
35D	278	44.1%	176	27.9%	176	27.9%
36W	1,316	47.0%	742	26.5%	741	26.5%
37W	599	46.9%	314	24.6%	363	28.4%
38W	219	48.6%	120	26.6%	111	24.7%
39W	149	60.1%	56	22.6%	43	17.3%
40W	86	54.4%	45	28.3%	27	17.0%
Total	12,521	45.8%	7,473	(27.3%)	7,375	26.9%

[5] Values in bold indicate strata in which no interviews were recorded for a given access point. Total boat trip estimates were produced based on available interview data pooled from access points in the same time stratum.

Figure 10. Relationship between the proportion of total estimated effort and the proportion of total intercept interviews from each access point per temporal stratum in 2016. Dashed line running through origin represents 1:1 relationship.



Conclusions and Future Work

To explore improving effort estimation procedures in the Astoria area, ORBS implemented a new type of video-based methodology which utilized a web-based video recording system to monitor private recreational effort in the three primary Oregon boat access points in the lower Columbia River. This study provided a proof of concept that a remote, web-based video system could be successfully installed using multiple access points, and this method has potential for similar application in other recreational survey locations. The video system proved to be a reliable vessel counting tool that experienced only minor, temporary disruptions due to video malfunction and visibility issues throughout the study. Moving forward, we anticipate these interruptions to become even less frequent as technical issues are resolved.

Results of the study indicated significant differences between our traditional live count approach and the video-based methodology. Potential factors causing discrepancies between the two methods were only assumed; however, we feel the video-based system can provide more complete accounting of vessels departing and returning to access points. The video system may lower vessel counting errors and improve effort estimation by reducing visibility issues associated with weather and long viewing distances, increasing the time frame of the daily count period to capture a greater proportion of departing vessels, and reducing vessel identification errors by allowing unlimited reviews of the recorded video.

Additionally, the video-based system provided a quantitative evaluation and comparison of the amount of recreational effort for each Astoria area access point. Prior to the study, this information had only been assumed anecdotally. Understanding patterns and trends in access point-specific effort will further improve our estimation methodology by providing information on sample size requirements for each access point and improving proportional allocation schemes to produce sufficient levels of sampling for the Astoria area. Additionally, intercept interviews can now be appropriately stratified to the respective location to minimize bias associated with unrepresentative sampling between access points. Comparisons between observed effort and sampling fractions in 2016 identified periods and locations where sampling objectives were not met and may have been insufficient to generate reliable estimates. These observations of site-specific sampling rates were previously not available prior to the video boat counting system. Continued monitoring with the video system will allow for further evaluation of the sampling design and provide a means to more adaptively identify and resolve problems with our sampling methodology. Further assessment will also include more analyses on potential differences in angler characteristics between access points to guide future catch estimation procedures.

Intercept interviews from East End mooring basin and the John Day boat ramp suggest that only minor amounts of ocean boat effort originate from these access points located farther upstream. In 2016, the CRM program observed only 6 ocean interviews out of 1,072 (0.6%) for East End and 2 ocean interviews out of 149 (1.3%) from John Day. These interviews were not included in the estimation procedure for the video-based method in this study. However, to improve estimates of estuary effort and catch, CRM has recently installed similar video systems to monitor vessel effort from these locations. Results of this work are not available at the time of this writing, but the addition of these two cameras will provide near complete coverage of the ocean-going recreational effort for the Oregon side of the Columbia River. Continued coordination with CRM personnel will continue to account for this effort in the future.

This study provides support for the continued use of the web-based video recording system to estimate recreational fishing effort in the Astoria area. This method represents a reliable and effective tool to monitor recreational boat activity and improve our effort estimation methodology. This technology may also be beneficial in other locations as well. A major advantage of a multi-camera web-based system is that multiple locations can be monitored remotely without a sampler having to physically retrieve recordings or conduct on-site effort surveys. In recreational fishing ports with multiple access points, a web-based system may be employed to provide a continuous record of recreational activity with recordings uploaded to a centralized location for viewing. To continue to improve our catch and effort estimation procedures coast-wide, the Ocean Recreational Boat Survey will continue to explore potential locations that may be a candidate for this type of system.

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