INFORMATION REPORTS

NUMBER 2009-01

FISH DIVISION
Oregon Department of Fish and Wildlife

Video Monitoring of Ocean Recreational Fishing Effort

VIDEO MONITORING OF OCEAN RECREATIONAL FISHING EFFORT

Robert T. Ames
Eric Schindler

Marine Resources Program
Oregon Department of Fish and Wildlife
Hatfield Marine Science Center
Newport, OR 97365
(541) 867-4741

2009

Final report for Grant 05-163, funded in part by the Restoration and Enhancement Program administered by the Oregon Department of Fish and Wildlife.

Table of Contents

Abstract

Ocean recreational fishing in the United States is monitored less rigorously than commercial fisheries. Video technology has been shown to be an effective tool for monitoring many commercial fisheries; it increases monitoring coverage, improves catch accounting, and can substantially reduce monitoring costs. This study investigated video monitoring as a tool to improve recreational fisheries effort estimates and reduce monitoring costs for management. Three cameras linked to a digital video recorder were used to monitor ocean recreational boats departing from Newport, Oregon. No statistical difference was found between the video method and the traditional sampler method for counting departing boats from dawn to 10:00 AM. However, a significant difference was found between the methods for estimating total daily boat effort. The traditional method of expanding sampler counts for unmonitored times underestimated daily boat effort in 89% of the cases relative to the 24 hour video monitoring census. These findings imply that the difference between effort estimation results was the expansion methodology. A cost-benefit projection showed video monitoring could provide significant savings. The annual cost to video monitor boat effort in one port was estimated to be 63% less than the traditional method. This study showed that video monitoring can increase the accuracy of the daily effort estimates and, at the same time, reduce program costs over the long term.

Introduction

Ocean recreational fishing in the United States is monitored less rigorously than commercial fisheries even though recreational anglers take more of some nearshore species (National Research Council 2006). In the past 20 years, recreational effort has increased by over 20%, rivaling commercial fisheries for many major fish stocks (Coleman et al. 2004). This has prompted federal and state governments to evaluate the methods used to collect recreational effort and catch information and to seek alternatives that provide more timely and accurate data.

Outside of the Pacific Northwest ocean recreational fishing effort is collected primarily by Coastal Household Telephone Surveys (CHTS) in the federal Marine Recreational Fisheries Statistics Survey program and in the majority of the state programs. This methodology which uses a random telephone calling protocol to contact coastal residents is criticized for not adequately including all private anglers in the sampling frame (National Research Council 2006). Anglers residing outside the coastal communities are typically excluded in the telephone survey. The sampling frame incorporates large numbers of non-fishing households, which makes the CHTS inefficient because only a small proportion of the population that participates in recreational fishing are contacted during each sampling period. Adjustment factors are derived from point intercept surveys of fishing anglers. These adjustments, which may account for as much as >50% in some strata of total fishing effort are based upon untested assumptions (Marine Recreational Information Program 2009). These assumptions are often inconsistent with the selection probability of the intercept survey sample design (ibid).

Recreational ocean survey programs, such as the programs in Washington, Oregon, and California utilize on-the-ground boat effort count methodologies to supplement, or as a substitute to, telephone surveys. On-the-ground boat counts provide advantages over the telephone surveys, including the ability to manage in-season since the data are collected in real-time. These effort counts are feasible only in areas with limited ocean access, where boats are forced through a narrow channel and are visible departing to or returning from the ocean. In Oregon, these on-the-ground counts are used exclusively, and provide daily estimates of ocean effort for ports where this methodology is employed. On-the-ground counts are conducted by samplers most typically from dawn to 10:00 AM. These morning counts capture the majority of the departing ocean effort because afternoon winds and sea-state conditions generally limit mid-day ocean departures. This methodology includes an expansion factor derived from intercept interviews of returning boats. The proportion of interviewed boats that report departing to the ocean before or after the sampler count periods are used to generate the expansion factor. These expansion factors are calculated weekly for each port and are applied back to the daily on-the-ground counts (Schindler et al. 2008). Generally, a single expansion factor for all days during the week is used, unless there is a significant difference in season types (e.g. Pacific halibut (*Hippoglossus stenolepsis*) opener, or coho salmon (*Oncorhynchus kisutch*) closure, etc.). If there is a change in season types then separate expansion factors are calculated because fishing behavior is directly related to season type. The expansions generally equate to 10% or less of the total effort for most weeks (ibid).

Video technology has been shown to be an effective tool to monitor many commercial fisheries. For example, video monitoring has been successfully implemented for catch accounting in the groundfish longline fishery off British Columbia, Canada and for compliance monitoring in the shore-based Pacific Whiting (*Merluccius productus*) trawl fishery off the Pacific coast (WA, OR, and CA) (Archipelago Marine Research Ltd. 2008 and National Marine Fisheries Service 2008). Video monitoring can increase monitoring coverage, improve catch accounting, as well as reduce monitoring costs (Ames et al. 2007, Ames et al. 2005, and McElderry et al. 2003). The use of this technology in recreational fisheries management for boat accounting could offer similar benefits.

Oregon Department of Fish and Wildlife (ODFW) evaluated video monitoring as a possible alternative to the traditional method, of using on-the-ground samplers, to count boats departing and returning from the ocean. The objective of this evaluation was to determine (1) whether video monitoring instead of on-the-ground samplers could be used to count boats, and (2) whether video monitoring could provide a net benefit over the traditional method.

Materials and Methods

The project was conducted in Newport, Oregon and utilized two digital video cameras, a thermal camera, and digital video recorders (DVR). One digital camera and a thermal camera were mounted on a tower adjacent to the Yaquina Bay jetty, latitude 44°36.832' N and longitude 124°04.020' W. These two cameras were designed to capture images of passing boats for the purpose of boat type identification. The thermal camera was used to aid in boat identification during times of low visibility, for example at night or when fog was present. A second digital camera with a telephoto lens was mounted on a tower 30 meters southwest of the other two cameras. This camera captured images of boats at the jetty mouth, departing to and returning from the ocean. All three cameras recorded simultaneously and continuously on a DVR, which was located at the study site.

A sampler stationed on the south jetty from dawn[1] to 10:00 AM identified boats as they traveled the jetty channel. Boats were counted by general category (e.g., recreational boats, commercial troll vessels, etc.) as they passed the camera towers. Boats that passed the camera towers, but did not enter the ocean were subtracted from the count. Three different samplers, operating at different periods, were used to count boats in this study. Total daily effort was derived from the sampler’s count multiplied by an expansion factor, which was based on the proportion of intercept interviews with reported departure times outside the sampler count period.

The recorded video was viewed post-event in the ODFW Newport office by a video analyst. The analyst identified and counted boats as seen from the video and in the same manner as the sampler. Boats that passed the tower cameras but did not enter the ocean, as seen from the second camera with a telephoto lens, were subtracted from the count. The analyst also counted recreational boats before dawn and after 10:00 AM and for the

[1] Samplers started counting boats at dawn, which was based on the timing of nautical twilight and was defined as either 5:00, 5:30, or 6:00 AM.

entire 24 hour day. Each 24 hour video count provided two counts of all recreational boats, those departing to the ocean (*out* count) and those returning from the ocean (*in* count). Recreational trips from Newport were assumed to be daily trips only[2]. The video analyst also recorded the time spent to view each 24 hour day in order to evaluate the potential cost of video counts relative to sampler counts. The view time was predicted to be significantly less than 24 hours because the analyst was able to fast forward the video when no boats were in the count area. Eight different video analysts, operating at different times, were used to count boats in this study.

Pairwise Comparisons

For each day, the counts of recreational boats entering the ocean as seen by the video analysts and on-the-ground samplers were paired. The count differences were compared (sampler count subtracted by the video count), and tested for statistical significance (i.e., the null hypothesis H_o was $\mu = 0$) using a randomization test. The randomization test was chosen over the parametric t-test because the data were highly skewed. Statistical significant level α of 0.05 was used. Bootstrapping was used to calculate the 95% confidence interval.

Four pairwise count differences were evaluated and outliers were investigated. The daily dawn to 10:00 AM comparison was evaluated to determine whether video counts provide the same accuracy as sampler counts. The second and third comparisons were to determine whether the 24 hour video *out* and *in* counts would provide the same accuracy as the expanded daily sampler counts. The second and third evaluations were valid only if the first comparison was shown to be statistically insignificant. The final comparison determined whether the video analyst's 24 hour *out* and *in* counts provided the same accuracy and to quantify any bias associated with the video monitoring method.

Cost Comparison

The average amount of time required to count boats from dawn to 10:00 AM, using both methods was compared. Also, the average time to monitor a 24 hour day using the video

---

[2] Boat interview data from Newport shows that >99% are daily trips.

method was compared to the average time required to make daily effort estimates using the traditional method. Finally, the annual cost of both methods to monitor five hours each day, seven days a week, in one port was projected. Time was converted to dollars based on ODFW's hourly cost to employ an Experimental Biologist Aid in 2008. The initial cost of the video monitoring equipment was US$20,000 and the equipment is expected to last a minimum of five years before replacement. Therefore, video monitoring program equipment costs are estimated at US$4,000 per year in addition to video processing costs.

Results

The study was conducted from July to September, 2007 with 41 and 38 paired sets conforming to the experimental protocols. During the study, the samplers recorded a total of 3,383 ocean recreational boats from dawn to 10:00 AM whereas the video analysts recorded 3365 boats (n = 41). The samplers' expanded counts totaled 3,532 ocean recreational boats while the video analysts' *out* and *in* counts totaled 4,011 and 4,034 respectfully (n = 38).

Pairwise Comparisons

The number of ocean recreational boats seen and recorded daily by the samplers and analysts between dawn to 10:00 AM were similar and consistent over the duration of the study. For most days the differences were small, three boats or less (Figure 1). However, differences greater than 10 boats were seen in 2 of the 41 comparisons. Dense fog that limited visibility was reported by both the samplers and video analysts on those two days. In contrast, the analysts' 24 hour *out* and *in* counts compared to the expanded samplers' counts showed large differences. The video counts estimated a higher daily boat effort in 89% of the cases relative to the expanded sampler counts (Figure 2).

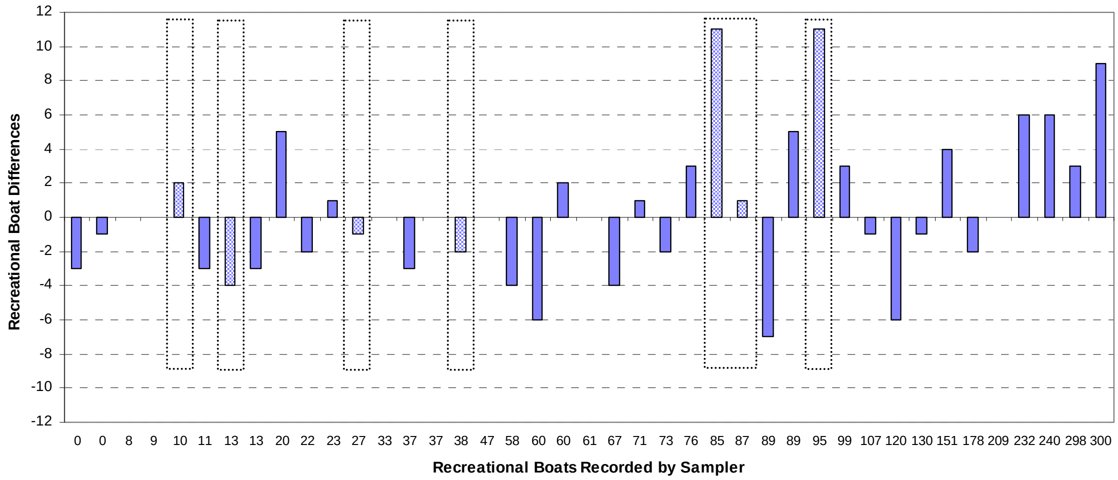

Figure 1. The video analysts' dawn to 10:00 AM counts compared to the samplers' counts (Samplers' count subtracted by analysts' count). Daily effort sorted from low to high. The enclosed textured bars are days when dense fog was encountered.

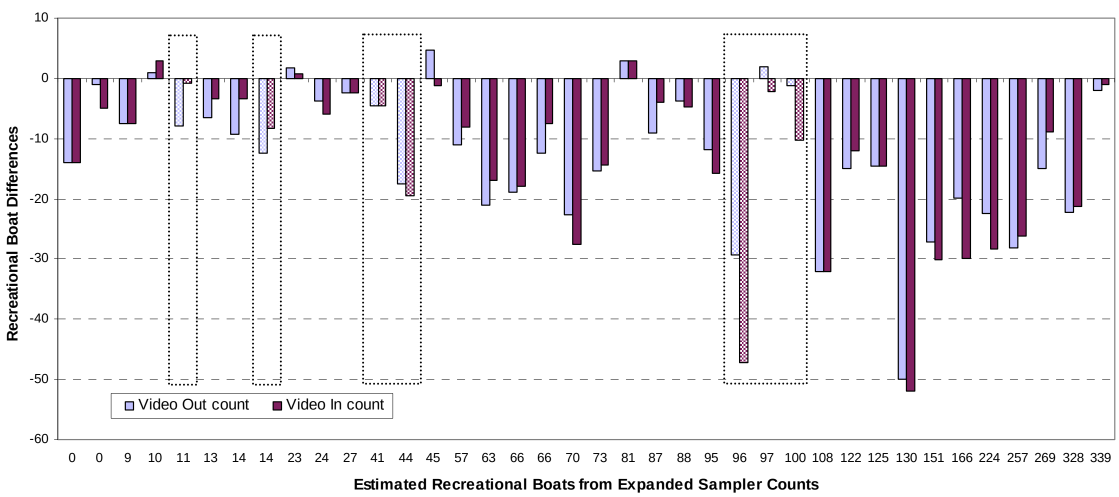

Figure 2. The video analysts' 24 hour *Out* and *In* counts compared to the samplers' expanded counts (samplers' expanded counts subtracted by analysts' 24 hour counts). Daily effort sorted from low to high. The enclosed textured bars are days when dense fog was encountered.

The dawn to 10:00 AM comparison showed a mean difference of 0.44 boats. The randomization test yielded a p-value of 0.49 with an associated bootstrapped 95% confidence interval of -0.79 to 1.74 (Figure 3). The analysts' *out* counts compared to the expanded samplers' counts were statistically different ($p < 0.001$) with a mean difference of -12.58 boats and a 95% confidence interval of -16.25 to -9.05 (Figure 3). Likewise the analysts' *in* counts compared to the expanded samplers' counts were significant ($p < 0.001$) with a mean difference of -13.18 boats and a 95% confidence interval of -17.47 to -9.16. Finally, the video analysts' 24 hour *out* and *in* count comparison produced a mean difference of 0.60 boats and a p-value of 0.44 with an associated 95% confidence interval of -0.87 to 2.24 (Figure 3).

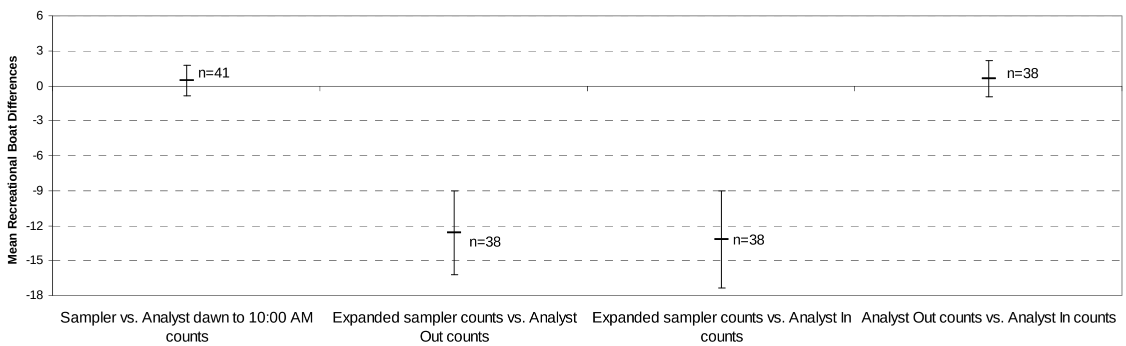

Figure 3. The mean recreational boat differences with bootstrapped 95% CI for each of the pairwise comparisons.

Cost Comparison

On average, the video analysts required about 55 minutes to monitor boat effort from dawn to 10:00 AM, while the on-the-ground samplers required 4 hours and 38 minutes. Swapping DVRs from the study site for processing in the office was estimated at 15 minutes per day, if daily analysis was required. Thus, total video analysis time, with DVR swap, would be 1 hour and 10 minutes. The time required for a 24 hour video census of boat effort was on average 4 hours and 13 minutes, and with DVR swap, 4 hours and 28 minutes. In contrast, the on-the-ground sampler counts, along with data processing, required on average 4 hours and 48 minutes for daily boat estimates. This comparison does not include the time required to collect and process interview data. Interview data are critical to generate daily expansions.

Projected annual cost to the program for five hours of monitoring each day, seven days week, in one port was US$12,300 using the video monitoring method compared to US$32,800 using the on-the-ground sampler count method. The video monitoring cost estimate included the prorated cost for the equipment over its estimated life of five years.

Discussion

Each monitoring method provides some advantages (Table 1). The samplers had the ability to examine more detailed information of passing boats using binoculars, which may have aided in differentiating similar boat types. While the analyst had the ability to stop the video and review passing boats when identifications were difficult. The video analyst also has the advantage of monitoring each 24 hour period without the use of expansion estimates; however it is cost prohibitive and inefficient to schedule samplers for 24 hour counts. Listing the advantages and disadvantages of each method are important because they help managers determine what method best fits their management objectives.

Pairwise Comparisons

The project answered important questions regarding the video system's reliability, precision, and efficacy. The video cameras and DVRs were reliable; there were no equipment failures during the study. The video analysts' and samplers' dawn to 10:00 AM effort counts were identical statistically. However, dense fog may have increased count differences and reduced precision on two occasions, as shown from the data (Figure 1). The video analysts noted that visibility was reduced considerably on those two days even when viewing the thermal imagery. This suggests that the thermal camera was only partially effective at mitigating fog conditions. Nevertheless, most of the differences found were more related to analyst and sampler sampling variability than to the video technology, as evident from the distribution of the count differences (Figure 1). The differences were equally distributed, the number of times the analyst over counted boats was approximately equal to the number of times the analyst under counted, relative to the sampler. In addition, half of the count differences were equal to or less than three boats (Figure 1). These results demonstrate that both the analysts' and samplers' abilities to identify recreational boats were the same, statistically and provided the same level of accuracy.

Table 1. Relative advantages and disadvantages of on-the-ground samplers compared to video-based monitoring of recreational boat effort.

Variable	Sampler	Video Analyst
Sampling	Portion of effort may be outside sampling frame	Includes total population with option to use different probability sampling methods
Data processing	Real-time	Occurs post-event. Provides the option of skipping days when bar was known to be closed
Safety	Isolated counting locations could potentially put samplers at risk to maltreatment by others	Video viewed in office
Sampling procedures	Relay effort in real-time to boat intercept samplers so they can adjust interview sampling to accommodate boat effort as needed	Boat intercept samplers would have no prior knowledge of effort
Boat type precision	Limited time for identification	Permanent record that can be examined repeatedly
Environment	Can adjust count location to improve visibility	Limited to fixed location
Boat type accuracy	The use of binoculars to examine details of vessel	Boat characteristics as viewed on the video with limited zoom capabilities
Cost of five hours of effort monitoring (i.e. boat counting)	5 hours and 10 minutes, including processing time	1 hour and 10 minutes, including daily DVR swap

Likewise, the comparisons between the video analyst's 24 hour daily, *out* and *in*, counts were identical statistically (Figure 3). Both video counts provided the same level of accuracy. The ability to obtain matching *out* and *in* counts, as experienced during this study, ensures that a certain level of accuracy is achieved using video monitoring. This study indicates that the use of video monitoring to obtain effort information is a viable and reliable alternative to the traditional, on-the-ground counting methodology.

In contrast, the video analysts' 24 hour daily *out* and *in* counts were both significantly different from the samplers' expanded daily counts (Figure 2). This suggests that either the video counts after 10:00 AM were biased or expansions used during this study were insufficient to accurately account for boats departing outside the count period. The latter is the most likely cause of the count differences. Recall, expansion factors are derived from interviews of returning boats; the ratio of boats that report departing outside the count period. These interviews are pooled for each port separately and one expansion factor is calculated for all days within that week or season type. These expansions are then applied back to the daily counts. The count differences experienced during this study may be related to (1) the use of weekly or season type expansions instead of daily expansions, (2) incorrect interviewing procedures and reporting, and (3) sampler work schedules.

Pooling interviews to calculate one expansion factor for the week or season type may have not adequately accounted for the differences between days; days with more interviews would influence the expansion factor more then days with few interviews. High variability between days as seen during this study suggests that this could have contributed to the underestimates; however, it was probably not the root cause.

Boats that reported leaving at dawn or just after and boats that report leaving at 10:00 AM or just before are assumed to have been counted by the sampler, but may have been missed entirely because the anglers may have reported the time they left the dock instead of when they left the bay and entered the ocean. If the departure question was asked improperly and the vessel operators reported the time they left the dock, about two miles up stream from the study site, instead of when they entered the ocean then those boats may have been excluded from the effort. Likewise, if the vessel operators incorrectly reported their departure times then those boats also may have been excluded from the effort. For example, if the vessel operator reports departing the bay at 5:00 AM, but actually departs at 4:55 then that boat would be absent from the sampler's count. Incorrect interviewing procedures and reporting by vessel operators may have resulted in expansions that underestimated the ratio of boats leaving outside of the count period. The degree to which these factors impacted the overall boat totals during this study is unclear. Nevertheless, requiring the samplers to ask a standardized departure question that is explicit should increase data quality and the accuracy of effort estimates.

Finally, sampler schedules may influence the accuracy of the expansion factor. When effort is expected to be low, managers allocate a lower number of samplers and fix their schedules around peak boat return times to maximize the number of interviews. Thus, the expansion factors used may have echoed the scheduling patterns by the program, and not the true proportion of boats departing outside the count periods. Modifying samplers' schedules so interviews are conducted throughout the fishing day should provide expansion factors that are more representative, since boats leaving outside the dawn to 10:00 AM count periods would be interviewed.

Delineating factors that could cause expansion errors should be the focus of future studies. This was an observational study with a narrow spatial and temporal scope, so inferences should be limited to this study only. The degree to which factors such as interview styles and sampler schedules affect total estimates of effort should be investigated. If these factors are found to be highly influential to the effort estimates, then standardizing the interview departure question and modifying samplers' schedules to include all boat return times (as best as possible) should be done to prevent future biases.

Cost Comparison

Video monitoring provides almost unlimited options in terms of video sampling, which could significantly reduce the viewing time and cost. Different sampling schemes (e.g., stratified, cluster, etc.) could be compared in terms of cost and precision. For example, a two-stage cluster design with a simple inflation estimator could be used instead of a 24 hour census to reduce video monitoring costs; where the primary sampling unit (psu) is hour and the secondary sampling unit (ssu) is minute. For each day, a random selection of psu and then ssu could be taken for video analysis and the population and variance totals could be compared with other sampling schemes and the census total (if known). If boat counts were needed for 12 hours per day instead of 24 hours, the analyst would be capable of viewing seven days of video in less than 16 hours, or two working days. Moreover, the video is viewed post event, which might allow analysts to skip days when ocean access was closed to recreational boats due to weather or sea conditions. This could provide significant savings by reducing the video view time required by the analyst. Currently samplers' schedules are fixed beforehand and when ocean access closes due to weather the samplers are typically instructed to continue the count because ocean assess may reopen. Furthermore, a sampling design that uses recorded video could incorporate quality assurances and controls. For example, a second video analyst could be used to randomly choose days and times for a second viewing, and on days when the primary analysts' *out* and *in* counts showed significant differences. This process would aid in validating the effort counts at a relatively small cost. If a video census is deemed unnecessary or too expensive, then comparisons of different video sampling schemes would aid in the development of an efficient sample design.

Conclusion

Our test shows that a video monitoring program could increase the accuracy of the effort estimates and at the same time reduce costs over the long term. These cost savings could be transferred to additional interviews and biological sampling, or alternatively, used to reduce program costs during periods of funding shortfalls. Further development of this technology by incorporating online networking capabilities could provide more timely effort estimations. As well, including other technologies such as hydrophones for boat detection and identification in dense fog could increase the accuracy of the effort estimates.

Acknowledgments

We are grateful for the support of ODFW and the Marine Resources Program, specifically: Bill Herber, Ted Calavan, Scott Malvitch, and Robert Anderson. As well, we would like to thank the samplers and the video analysts that participated in this project, Jessica Moll, Kevin Kemper, Don Bodenmiller, Linda Zumbrunnen, Gwyn Wooley-Scott, Alyssa Gibson, Clifford Owens, Ryan Easton, and Mary Conser. Also, we would like to acknowledge Bright Wright, Bruce Leaman, David Sampson, Robert Hannah, and David Fox for their insight and advice. Finally, we would like to thank the ODFW Restoration and Enhancement board for their financial contribution to this project.

References

Ames R. T., Leaman B. M., Ames K. L. 2007. Evaluation of Video Technology for Monitoring of Multispecies Longline Catches. North American Journal of Fisheries Management 27:955-964

Ames, R. T., G. H. Williams, and S. M. Fitzgerald. 2005. Using digital video monitoring systems in fisheries: Application for monitoring compliance of seabird avoidance devices and seabird mortality in Pacific halibut longline fisheries. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-AFSC-152: page 93. Available: http:// www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-152.pdf. (December 2008).

Archipelago Marine Research Ltd. 2008. Electronic Monitoring: Project Summary BC Groundfish Longline Fisheries. Available: http://www.archipelago.ca/highlight.aspx?ID=9EEE0F65-6A30-4B0C-AA11-573F1D7F8022 (December 2008).

Coleman F.C., Figueria, W.F., Ueland, J.S., and Crowder, L.B. 2004. The impact of United States recreational fisheries on marine fish populations. Science 305: 1958-1960.

Marine Recreational Information Program. 2009. Washington Dual-Frame Telephone Survey Project Plan (Available from NOAA Fisheries Services, Office of Science and Technology, 1315 East-West Highway Silver Spring, MD 20910).

McElderry, H., J. Schrader, and J. Illingworth. 2003. The efficacy of video-based electronic monitoring for the halibut longline fishery. Canadian Science Advisory Secretariat: Research document 2003/042. Available: http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2003/RES2003_042_E.pdf. (December 2008).

National Marine Fisheries Service. 2007. 2007 Shore-based Hake Fishery: At-sea Electronic Monitoring Program. Available: http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Whiting- Management/2007/upload /Summary_hake_2007_EM_project.pdf (December 2008).

National Research Council 2006. Review of Recreational Fisheries Survey Methods. National Academies Press, Washington DC.

Schindler E., Flanders P., Bodenmiller D., and Wright B. 2008. Sampling Design of the Oregon Department of Fish and Wildlife's Ocean Recreational Boat Survey. Oregon Department of Fish and Wildlife. Available: http://www.dfw.state.or.us /MRP/salmon/ORBS%20Backgrounder/ORBSDesign.htm (December 2008).

OREGON
Fish & Wildlife

3406 Cherry Ave. NE
Salem, Oregon 97303