Washington MRIP Consultant's Review Sampling Ocean Fisheries in "Shoulder" Months

FY 2013 Proposal

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1. Overview

1.1. Sponsor
Russell Porter

1.2. Focus Group
Survey Design and Evaluation

1.3. Background
Comprehensive and sound management of recreational finfish fisheries in Washington State requires information on catch, effort, and stock-specific fishery impacts necessary to meet established conservation and allocation mandates. These data are federally required to open and manage recreational fisheries, especially considering the need to limit and monitor impacts to threatened species. For the Washington ocean Marine Catch Areas (Areas 1-4), these critical fishery information needs are met through the Washington Department of Fish and Wildlife (WDFW) Ocean Sampling Program (OSP). To generate estimates of marine fish catch and effort in ocean Marine Catch Areas (for the “private boat” and “charter boat” modes), WDFW employs a procedure based on data collected by an access point intercept survey. The OSP survey is designed to provide both total effort and catch per unit effort (CPUE). These data are used to generate estimates of total catch and effort by Marine Catch Area, month, and fishing mode which are provided to the Recreational Fishery Information Network (RecFIN , www.recfin.org). Currently, ocean fishery sampling occurs in all major ocean access ports during “peak” effort months, May through September. Access sites that showed effort during March, April and/or October were sampled in recent years at a lower rate but continuous state and federal funding reductions have forced OSP to use all available funding to cover peak effort months. It is clear from previous sampling and from the 2011-2012 Washington coastal winter sampling MRIP project that March, April, October, and November have the potential to be significant contributors to total ocean groundfish catch. We hope to assess this contribution by fully sampling these time periods for a third consecutive year to determine whether a “correction factor” will be appropriate when funding for these time periods is unavailable. This proposal funds sampling of these months in all major Washington ocean access ports and addresses undercoverage issues identified by the 2010 MRIP Consultant Review of the Washington Ocean Sampling Program.

1.4. Project Description
The proposed project implements one of the recommended actions resulting from the MRIP’s 2010 review of the WDFW OSP. During that review, the MRIP consultants (experts in sampling design, statistics, and estimation methods) recommended specific actions that OSP could implement to improve total ocean catch estimation. The major category of improvement recommended by the MRIP consultants was to address under-coverage issues. Two proposals to address the temporal sampling portion of this recommendation have been funded previously by MRIP. Beginning in October, 2011 and continuing through April, 2013, these projects allowed full sampling of all major Washington coastal access sites during all months typically not sampled or sampled at a very low rate. This includes October through April. Data collected during the 2011-2012 MRIP winter sampling project indicates that March and April contribute significant groundfish catch in most major coastal Washington ports, with October and November contributing to total catch in most ports as well. The months of December through February have thus far proved to have minor or no effort or catch in all coastal ports; this assessment will continue through April, 2013. The intent of this project is to address the coverage recommendations that came out of the MRIP review of OSP. The OSP has been sampling the “shoulder months” (March, April, and October) for several years in Westport and Neah Bay at a lower rate. However, it is fairly certain that shoulder month sampling will be impossible beginning in October, 2013 without new sources of funding. The State was granted an exemption from the National Angler Registry on the merits of our sampling programs and we hope to hold the structure of the OSP intact. However, if that is impossible, we hope to determine whether using a “correction factor” to estimate catch and effort from non-sampled timeframes is appropriate.Catch and effort during shoulder months are lower than in the peak months but are significant in some areas. With such tight harvest margins on species like yelloweye and canary rockfish, catch estimates in those shoulder months could make the difference in a decision to close a fishery early. Catch and effort during shoulder months is variable and weather-dependent, and ratio adjustments based on averages may or may not be precise enough to use in a closure decision that would have major economic consequences.This proposed project requests funds to continue full sampling of “shoulder months” – March, April, October, and November in all coastal ports as detailed below. Work on this project would begin October 1, 2013, and cease on April 30, 2014, with a final report completed by September 30, 2014. This will be the final season of a 3-year assessment; if we conclude that ratio adjustments based on averages are not precise enough to use in a closure decision, we will pursue additional stable funding to sample this time period.

1.5. Public Description

1.6. Objectives
The objective of this project is to collect recreational fishing catch and effort data in all major ocean access ports during the months adjacent to the normally-sampled time frame that have demonstrated significant catch or effort during the last two sampling projects. This includes March, April, October, and November in Neah Bay, La Push, Westport, and Ilwaco. This project would commence on October 1, 2013 and conclude on April 30, 2014.

1.7. References
Evaluation of Washington ocean recreational catch and effort from minor ocean access sites near the Washington coast.
Consultant's Report: Preliminary Review of Washington's Ocean Sampling Program (OSP)

2. Methodology

2.1. Methodology
Sampling design would be identical to that currently used by the OSP during “peak” months (complete documentation is available on the RecFIN website, http://www.recfin.org/documents/wa-osp-methods102008-0). Each port would be assigned one sampler during the months of March, April, October, and November, and staff may be stationed either in the port or in the Montesano office. Sampling would be coordinated by permanent staff in the WDFW Region 6 office in Montesano, WA; these staff would pick up data from samplers bi-monthly, and estimates of recreational effort and catch would be generated and provided to the RecFIN database monthly by the last day of the following month.

2.2. Region
Pacific

2.3. Geographic Coverage
Washington's major ocean access points, Neah Bay, La Push, Westport, and Ilwaco, WA

2.4. Temporal Coverage
September 2013 - September 2014 (sampling during October - April)

2.5. Frequency
See sampling methodology

2.6. Unit of Analysis
Vessel based survey (private and charter vessels)

2.7. Collection Mode
Intercept survey

3. Communication

3.1. Internal Communication
Internal communication will consist of a bi-monthly email report distributed to the project team during the sampling period detailing number of boats sampled by general activity (fishing or non-fishing) and anglers encountered, and whether or not fish were observed. The internal project team will also receive a copy of the catch estimates provided externally as well as the final report (described below).

3.2. External Communication
Monthly reporting to the MRIP Operations Team will occur through the MRIP online reporting system reporting activity on the project and sampling results as described above. In addition, catch estimates will be provided monthly to the Pacific States Marine Fisheries Commission for incorporation into the RecFIN database; these estimates will be provided within 30 days of the end of each month (eg. by November 30, 2013, for October 2013). A final report on the project will be submitted to the Operations Team by September 30, 2014.

4. Assumptions/Constraints

4.1. New Data Collection
N

4.2. Is funding needed for this project?

4.3. Funding Vehicle
RecFIN

4.4. Data Resources

No data is required from NOAA. All data will be collected by OSP.

4.5. Other Resources

Additional samplers will be needed to be hired and trained. More time from existing staff will also be required for sampler supervision, data entry, error checking, data analysis, catch estimation, and report writing.

4.6. Regulations

No regulatory changes are required.

4.7. Other

We are assuming funding will be available in time to hire, train, and begin sampling in October, 2013.

5. Final Deliverables

5.1. Additional Reports

Estimates of monthly catch and effort will be generated and provided to the RecFIN database.

5.2. New Data Set(s)

Existing database will be used

5.3. New System(s)

None

6. Project Leadership

6.1. Project Leader and Members

First Name	Last Name	Title	Role	Organization	Email	Phone 1	Phone 2
Scott	Barbour	Fish and Wildlife Biologist 2	Team Member	WDFW	scott.barbour@dfw.wa.gov		
Wendy	Beeghley	Fish & Wildlife Biologist 4	Team Leader	Washington Dept of Fish and Wildlife	wendy.beeghley@dfw.wa.gov	3602491215	
Erica	Speidel	Scientific Technician	Team Member	WDFW	erica.speidel@dfw.wa.gov		

7. Project Estimates

7.1. Project Schedule

Task #	Schedule Description	Prerequisite	Schedule Start Date	Schedule Finish Date	Milestone
2	Sample major ocean access points	1	10/01/2013	11/30/2013	
3	Hire and train Spring sampling staff		02/01/2014	02/28/2014	
1	Hire and train Fall sampling staff		09/01/2013	09/30/2013	

Task #	Schedule Description	Prerequisite	Schedule Start Date	Schedule Finish Date	Milestone
4	Sample major ocean access points	3	03/01/2014	04/30/2014	Y
5	Analysis and Final Report	2, 4	09/01/2014	09/30/2014	Y

7.2. Cost Estimates

Cost Name	Cost Description	Cost Amount	Date Needed
Sampling staff	16 staff months sampling time (average $3,135/month salary + $1,400/month benefits)	$72560.00	07/01/2013
Project duties for existing perm. staff (hiring, training, supervision, catch estimates, data management)	4 staff months Scientific Technician 4	$20200.00	07/01/2013
Data analysis and report writing	.5 month of data analysis from staff biometrician or consultant for analysis and final report writin	$5000.00	04/01/2014
Goods&Services	Supplies and materials for sampling, field office space rental, personnel fees	$3400.00	07/01/2013
Travel	Travel to ports from Montesano and by samplers within ports	$1775.00	07/01/2013
Indirect	Agency indirect (current 28.36% assumed for contract period)	$29192.37	07/01/2013
TOTAL COST		$132127.37	

8. Risk

8.1. Project Risk

Risk Description	Risk Impact	Risk Probability	Risk Mitigation Approach
Change in state or federal regulations that prohibit ocean fishing during the time period covered in this proposed project.	An assessment of effort and catch during the project period relative to the normally-sampled timeframe would be impossible if the fishery was closed.	Low	There is no way to mitigate this risk; sampling would be unnecesary if fishery was closed.
Weather that prevents sampler from accessing survey site	Scheduled sampled days may be unsampled if bad weather (snow, windstorms, landslides) prevent access to sampling sites	Low	We will pre-schedule alternative sampling days within each spatial/temporal stratum should scheduled primary sampling days be missed.

9. Supporting Documents

"WDFW Oocean Sampling Program Methods", page 1

Washington State Department of Fish and Wildlife Ocean Sampling Program Overview

Updated October, 2008

Introduction

The Washington Department of Fish and Wildlife's Ocean Sampling Program (OSP) estimates total ocean recreational effort and catch by boat type (charter and private), port, catch area, and trip type (primary target species). Boat trip sampling is conducted randomly to generate estimates of catch for most ocean-caught species: salmon, rockfish and other groundfish, halibut, albacore, sharks, and cods. Estimates of released fish are also generated using angler interviews.

The ocean fisheries have been sampled by the Washington Department of Fish and Wildlife since the early 1960's. Creel data is used exclusively in the ocean areas to estimate Washington recreational catch and effort.

Sampling Methods

Field samplers are stationed in all major coastal access sites: Ilwaco, Chinook, Cape Disappointment State Park, Westport, La Push, and Neah Bay. Westport and Neah Bay are monitored from March through October; all other ports are monitored from May through September.

The OSP mainly uses a two-stage design for each port, with days constituting the primary sampling units (PSU) and boats within each sampled day as the secondary sampling units (SSU). Selection of days follows simple random procedures. Although sampling of boats is approximately systematic (e.g., every k*th* boat), the selection procedure is not exact and this stage is treated as simple random for estimation purposes. Each port is sampled a minimum of 4 to 5 days per week and days are stratified by weekend and weekday. Typically, all weekend days and holidays are sampled and the remaining available sampling effort within a port is randomly assigned to the weekdays. Daily estimates are expanded over days within strata to produce weekly, monthly and annual estimates. Variations on this theme are employed when sampling the land-based fishery at the Columbia River North jetty; here, weekdays and weekend days are not distinguished.

Effort is measured in units of boat-trips and angler-trips, and on sampled days, is measured throughout the entire period of boat activity, i.e., from the time when the first boat leaves a port until the last boat returns. On a given sampling day, the total number of boats that left a port is counted. During periods of high effort, effort is measured through an exit count, where all boats exiting a port are counted throughout daylight hours. In Westport, this method includes boats exiting from Ocean Shores and all Grays Harbor launching sites. In Neah Bay, this method includes boats launching from the Snow Creek resort.

During periods of low effort, effort is measured through an entrance count: a count of all boats entering that marina. During an entrance count, boats that exited from Ocean Shores and other Grays Harbor launching sites are excluded from the Westport effort count; in Neah Bay, entrance counts include boats exiting from the Snow Creek resort.

The catch per boat is sampled through intercept surveys. Returning boats are systematically sampled at a minimum target rate of 20% within each boat type (charter and private). Every *k*th boat to enter the harbor is included in the sample regardless of size, mooring location, trip type, etc. The size of the sample (leading to the calculation of *m*) depends on the projected effort and the number of available samplers. Overall, the sampling rate in each port in a year averages over 50% for charter boats and over 40% for private boats.

Through year 2000, data collected from each sampled boat trip include target species, area fished, number of anglers, landed catch by species, released salmon by species, and other biological data. Beginning in 2001, data collected include released yellow eye and canary rockfish. Beginning in 2002, releases of all marine fish by species were enumerated in the samples, and beginning in 2003, depth at which the majority of rockfish in the catch were hooked was added.

Catch and Effort Estimation

The OSP generates preliminary estimates of catch and effort in-season to meet the demands of ocean fishery management. Catch estimates for quota fisheries (currently salmon and halibut) are generated weekly; catch estimates for all other species are generated monthly and provided to the RecFin database by the end of the following month. Final post-season catch and effort estimates for all species are generated by February 1 each year; these post-season estimates replace any existing in-season estimates.

OSP Estimated Stratum Totals (Primary Stage)

Combined (total) catch estimates are typically stratified by weekend/holiday and weekday. In some strata, every day is sampled. In those strata the combined estimates are simply sums of the daily catches. In other strata, where some days are not sampled, the average catch per day over all sampled days is multiplied by the number of days in the stratum to estimate the total catch.

Let:

a = the marine catch area,

i = trip type,

t = Weekend/holiday or Weekday stratum,

N_t = the number of days in stratum t,

T_t = collection of all days in stratum t,

n_t = the number of days sampled in stratum t, (rather than the number of boats sampled as above),

S_t = collection of sampled days in stratum t (when S=T, n=N),

Y_{taik} = estimated catch (or effort) on day k for stratum t in area a from trip type i,

C_{tai} = catch for stratum t in area a from trip type i,

Then

$$\hat{C}_{tai} = N_t \frac{\sum_{k \in S_t} \hat{Y}_{taik}}{n_t}$$

with estimated variance (Thompson 1992, p. 129):

$$\hat{V}\left(\hat{C}_{tai}\right) = \frac{N_t(N_t - n_t)}{n_t} \frac{\sum_{k \in S_t} \left(\hat{Y}_{taik} - \hat{\bar{Y}}_{tai}\right)^2}{n_t - 1} + \frac{N_t}{n_t} \sum_{k \in S_t} \hat{V}\left(\hat{Y}_{taik}\right)$$

where

$$\hat{\bar{Y}}_{tai} = \frac{\sum_{k \in S_t} \hat{Y}_{taik}}{n_t}.$$

For strata with all days sampled, $n_t = N_t$, and the catch and variance estimators reduce to:

$$\hat{C}_{tai} = \sum_{k \in T_t} \hat{Y}_{taik}$$

and

$$\hat{V}\left(\hat{C}_{tai}\right) = \sum_{k \in T_t} \hat{V}\left(\hat{Y}_{taik}\right).$$

OSP Daily Catch and Effort Estimation (Secondary Stage)

Both catch and effort are post-stratified by trip-type and area fished. Effort in terms of boat-trips is simply the sample number of boats for each trip-type and area expanded by the appropriate boat-type (charter or private) exit/entrance count. Effort in terms of angler-trips is calculated as the mean number of anglers per boat (indexed by trip-type and area) expanded by the counted total population of boats.

The total catch for a given species on a sampled day is the product of the population of boats and the estimated catch per boat, again post-stratified by trip-type and area fished. Key assumptions in the current estimation procedures are that:

1) All boats exiting/entering a port are included in the exit/entrance count
2) Exit/entrance counts are made without error
3) The approximate systematic sample of boats can be treated as a simple random sample
4) Anglers answer questions accurately and do not conceal fish

In the following discussion, subscripts referring to port and boat-type are suppressed. Let:

M_t = total exit or entrance count for a given port on day *t* (assumed known without error),

m_t = total boats sampled on day *t*,

m_{tai} = number of boats sampled of trip type *i* fishing in area *a* on day *t*,

a_{taij} = number of anglers on the *j*th boat from trip type *i* fishing in area *a* on day *t*,

y_{taij} = number of species specific fish caught on the *j*th boat from trip type *i* in area *a* on day *t*, and

Y_{tai} = total catch of specific species caught from trip type *i* in area *a* on day *t*.

The estimate of the number of boat-trips of trip-type *i* and area *a* follows the procedure outlined in Lai et. al. (1991) where the proportion of boats in each category is estimated by:

$$\hat{p}_{tai} = \frac{m_{tai}}{m_t}$$

with estimated variance (Cochran 1977, p. 52):

$$V(\hat{p}_{tai}) = \frac{\hat{p}_{tai} \cdot (1 - \hat{p}_{tai})}{(m_t - 1)} \cdot (\frac{M_t - m_t}{M_t})$$

The estimated total boat-trips is then obtained by:

$$\hat{M}_{tai} = M_t \cdot \hat{p}_{tai}$$

with estimated variance:

$$\hat{V}(\hat{M}_{tai}) = M^2{}_t \cdot \hat{V}(\hat{p}_{tai})$$

Effort expressed in terms of angler-trips is the product of the average anglers per boat-trip times the total number of boat-trips. The mean number of anglers per boat-trip (for trip-type *i* and fishing area *a*) is estimated as:

$$\hat{\hat{a}}_{tai} = \frac{\sum_j a_{taij}}{m_t}$$

with variance:

$$\hat{V}(\hat{\hat{a}}_{tai}) = \frac{\sum_j (a_{taij} - \hat{\hat{a}}_{tai})^2}{m_t(m_t - 1)} \cdot \left(\frac{M_t - m_t}{M_t}\right)$$

Thus the estimated total number of angler-trips is:

$$\hat{a}_{tai} = M_t \cdot \hat{\hat{a}}_{tai}$$

with variance:

$$\hat{V}(\hat{a}_{tai}) = M^2{}_t \cdot \hat{V}(\hat{\hat{a}}_{tai})$$

The catch (or number released) for a specific species on sampled day *t* in area *a* from trip type *i* is similarly estimated by:

$$\hat{Y}_{tai} = \frac{\sum_j y_{taij}}{m_t} M_t$$

with estimated variance:

$$\hat{V}(\hat{Y}_{tai}) = \frac{\sum_j (y_{taij} - \hat{\hat{y}}_{tai})^2}{m_t(m_t - 1)} M_t (M_t - m_t)$$

This estimate and it's variance differs somewhat from that described in Lai et al. (1991) since the total count, M_t (assumed to be a known quantity), is used to expand the estimated CPUE (calculated over all sampled boats) rather than the estimated boat-trips by trip-type and area fished.

Staff and Training

Approximately 24 field samplers are employed each season to collect catch and effort data. Two full time biologists coordinate sampling activities, one full time technician generates in-season groundfish catch estimates, and one data entry operator enters collected data electronically. In addition, 3 onboard observers collect encounter, mark status, and other information from salmon fishing vessels participating in mark-selective fisheries.

Each season, new samplers are provided a general sampling manual and a sampling supplement specific to the port to which they are assigned. One or more days of office training is provided, followed by two or more days of intense field training. Field training and performance feedback continue throughout the season.

Budget and Data Collection Statistics

The OSP utilizes a budget of over $600,000 annually. This funding consists of both Federal and State sources. Some funds are specifically dedicated to certain data collection aspects while other funds are more general.

Since 1990, the OSP has conducted between 16,000 and 28,000 boat interviews per season coastwide. In 2007, for instance, 79,640 angler interviews were completed, and 4,814 chinook (54% of total estimated catch) and 41,013 coho (49% of total estimated catch) were examined and scanned for CWTs. Approximately 12,300 albacore, 140,000 black rockfish, 10,900 halibut, and 13,400 lingcod were examined and speciated.

Literature Cited

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Lai, H-L., R.Moore, and J. Tagart. 1991. Methodologies for estimating catch and effort statistics of ocean sport fishery off the Washington Coast with users guide for the program 'OSFP.FOR'. Prog. Report No. 289. Wash. Dept. of Fisheries, Olympia, WA. 35 pp.

Thompson, S.K. 1992. Sampling. John Wiley. 343 pp.

Consultant's Report: Preliminary Review of Washington's Ocean Sampling Program (OSP)

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December 6, 2010

1 Introduction

During the two-day meeting in Montesano, Washington, on November 8–9, 2010, we met with Washington Department of Fish and Wildlife (WDFW) staff to discuss WDFW's Ocean Sampling Program. In this document, we will provide our initial reaction to the design and estimation procedures we learned about during the meeting.

We begin by briefly summarizing our overall reaction to OSP: it is a well-designed and executed program. The geography of the Washington coast offers distinct advantages, including a very small number of sites from which boat launches are practical. There is also limited shore and private access, so the spatial allocation of sampling effort is relatively straightforward. Anglers' required compliance with WDFW sampling efforts is another attractive feature of the program.

The program has a large and thorough sampling effort, with fine spatial and temporal stratification. The geography of sites makes it possible to obtain high-quality measures of effort, via exit counts for high-pressure sites, or

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entrance counts for low-pressure sites. OSP appears to have careful design in all of its aspects, and rigorous randomization. There is also a clear and clean match between the sampling design and the estimation methods, including appropriately weighted estimates and variance estimation procedures that properly take into account the stratified, two-stage survey design. The methodology is nearly assumption-free, given its rigorous basis in probability sampling. Nevertheless, the presentation that was shown to us explicitly listed the small number of assumptions that do appear in the methodology (e.g., assuming that systematic sampling can be treated as simple random sampling). The consultants had very favorable reactions to all of these characteristics of OSP.

In the remainder of this report, we outline our recommendations for possible extensions or improvements to OSP, as well as a few suggestions for further study.

2 Preliminary Findings and Recommendations

2.1 Domain Estimation

In what follows, a "domain" is any subpopulation of interest for producing estimates, such as trip type (e.g., salmon, halibut, groundfish, other). A domain may or may not be a "stratum", which is a subpopulation that is identifiable prior to sampling. Strata are sampled independently, with a sample size that is allocated in advance. This sample size can be treated as known (except for nonresponse issues). A "post-stratum," on the other hand, does not have a pre-allocated sample size. It is typically not identiable *a priori*, so the sample size in a post-stratum is an unpredictable random quantity. A post-stratum does, however, have a known population size, obtained outside the survey.

These distinctions are important when it comes to obtaining proper variance estimates for domain and population estimates. For domains that are not strata, estimates of domain means have a nonlinear (ratio) form, due to the random sample size in the denominator. Standard survey software can account for such nonlinearity if strata and domains are clearly identified. In the case of post-stratification, additional precision can be obtained from the known population information. We return to this point below.

2.2 Sample Size and Undercoverage Issues

For all of the major ports in the main season, OSP has a major sampling effort, dedicated to checking 20% of the landed salmon catch for coded wire tags. The data that we saw indicated that the 20% target is exceeded by a good margin. This suggests that it should be possible to reallocate some of the sampling effort to gain more information in shoulder-season months, to employ more on-board observers, and to devote more attention to known "undercoverage" issues. Undercoverage occurs when some parts of the population under study have zero probability of selection into the sample: e.g., shore mode fishing, minor ports like Tokeland and Nahcotta, or winter months. This leads to the possibility of bias in estimation of some target parameters if the "uncovered" part of the population differs from the "covered", sampled part of the population. For an "uncovered" part of the population, there is by definition no possibility of information obtained in a sample, so only extrapolation from the covered part of the population is possible.

Even if the uncovered part of the population is similar to the covered part *now*, bias due to undercoverage can arise over time in a dynamic population. For example, while boats may almost never go out from some ports in winter *now*, this may change as anglers obtain better gear (e.g., GPS). Anglers may begin using different gear; e.g., fishing from non-standard watercraft, like kayaks and jet skis. Or anglers may target different species in the future. An example is the targeting of tuna by recreational anglers, particularly on overnight trips.

It was clear to us that WDFW staff have been continually thinking of the dynamics of this target population, and we encourage them to continue to do so. It is also clear that OSP must stop somewhere in order to define the target population. Still, we encourage them to think broadly in defining the target population and, whenever possible, to move in the direction of a full probability sample of the target population by reallocating resources beyond those needed to achieve sufficient precision for the large ports in the main season. This could be done with a relatively small reallocation of the full sampling effort.

For the specific example of overnight tuna trips, it appears that estimates may be off substantially, because up to 50% of the trips are not recorded. Estimates might be greatly improved by reallocating sampling effort to some combination of night sampling and charter logbook data collection (either a census or a sample from a list frame of charters). This may be possible since these trips are all leaving from one location, Westport. More generally, undercoverage issues might be addressed through some combination of reallocated sampling efforts and collection of suitable auxiliary data.

2.3 Auxiliary Data

There may be opportunities to include auxiliary information into the estimation procedures, to gain precision at almost no additional cost. For example, weather, bar conditions, ocean conditions, and (where relevant) river conditions may have some explanatory power for effort and catch, particularly in the off-season when other information may be difficult and costly to obtain. Note that even if regression relationships are imperfect, auxiliary data may be very useful in producing more efficient estimators using "model-assisted estimation." Like direct survey estimates, model-assisted estimators are design-unbiased or nearly so, and allow for consistent variance estimation and proper confidence interval construction (even if the regression model is imperfect). If the regression model has reasonable explanatory power, the model-assisted estimator has smaller variance and narrower confidence intervals than the direct estimator that ignores auxiliary data.

To make things concrete, fix attention on one particular port and a given time period such as a month, and consider collecting data using the current stratified two-stage sample, but additionally recording (on the basis of weather and ocean conditions) whether the sampled day is a "good" or a "bad" fishing day. Denote the number of good sampled days at that port as d_{good} and the number of bad sampled days as d_{bad}. Next, let D_{good} denote the total number of good days (sampled or unsampled) and D_{bad} the total number of bad days for the time period, obtained by looking at external sources of information such as weather records. (If fishing was completely impossible on some days due to weather, then $D_{\text{good}} + D_{\text{bad}} < D =$ total number of days in the period.) Finally, let $\hat{C}_{\text{good}}$ denote the estimated total catch on good days at the port, and $\hat{C}_{\text{bad}}$ denote the estimated total catch on bad days. We assume that the catch on days that are not part of D_{good} and D_{bad} is zero, and for simplicity also assume that the days are sampled with equal probability. Then the post-stratified estimator of total catch at that port and over that time period is

$$\hat{C} = D_{\text{good}} \frac{\hat{C}_{\text{good}}}{d_{\text{good}}} + D_{\text{bad}} \frac{\hat{C}_{\text{bad}}}{d_{\text{bad}}}.$$

This estimator is essentially unbiased whether or not catch on good days differs from catch on bad days. If the catch does differ, then the post-stratified estimator will have smaller variance than the estimator that ignores good versus bad. The same principles apply in more complicated situations, as long as the selection probabilities of the sampled days are known, and existing survey software can compute these estimators as well as their estimated variances.

2.4 Finer Stratification and Collapsed Strata Variance Estimation

One specific issue that arose in OSP was with both a primary and secondary launch site, like Neah Bay and Snow Creek in Area 4. Such sites can be divided into two strata, with different sampling rates within each. If the sampling rate drops to the level of a single site-day within stratum, then unbiased variance estimation is not possible. In this case, a standard approach is to create "collapsed strata" for the purposes of variance estimation. This simply means combining similar strata until there are at least two site-days per stratum, then treating the combined strata as if they were real strata. It can be shown that this leads to a slight overestimation of the variance, so the approximation is conservative. The greater the similarity of the combined strata, the smaller the overestimation. So, for example, if Snow Creek was sampled one day per week for each of 12 weeks, it might be sensible to combine adjacent weeks into six collapsed strata, with two days per collapsed stratum.

Collapsed strata can be used in existing statistical software for complex surveys, including the `survey` package in R or `proc surveymeans` in SAS, among others. In either case, a data set would be constructed exactly as if the collapsed strata were real strata. That is, the data would include the following elements:

- collapsed stratum identifiers

- primary sampling unit identifier: site-day (for proper two-stage variance estimation)
- sampling weight
- sampling fractions within strata (taking advantage of finite population corrections)
- response variables

2.5 Digital Data Recording

OSP has had the distinct advantage of a dedicated, long-term staff, including data entry specialists who transfer handwritten survey instruments to digital format. We recommend that OSP explore electronic data capture in the field, known as Computer-Assisted Personal Interviewing (CAPI). Electronic data capture speeds up data entry and editing, and can improve data quality because edits can be built into the survey instrument, allowing real-time corrections in the field. Further, both the basic data and various kinds of metadata (like information about the data collection process) can be recorded. Electronic data capture and transfer could also makes the OSP less reliant on hard-to-replace staff, like the data entry specialist with 30 years of experience. Building the expertise of staff into the design of a CAPI instrument and its edits would yield a well-documented and tranferable methodology. Finally, we note that electronic data capture devices are becoming increasingly powerful, robust, and inexpensive. We list some recent references on CAPI methodology below, and there is a large body of knowledge on this topic available within the survey community:

- Gravleel, C.C. 2002. Mobile Computer-Assisted Personal Interviewing with Handheld Computers: The Entryware System 3.0. *Field Methods*, 14(3): 322-336.
- Couper, M. 2005. Technology Trends in Survey Data Collection. *Social Science Computer Review*, 23(4): 486-501.
- Ice, G. 2004. Technological Advances in Observational Data Collection: The Advantages and Limitations of Computer-Assisted Data Collection. *Field Methods*, 16(3): 352-375.

3 Conclusion

The WDFW has done an excellent job of designing and conducting OSP, as noted at the beginning of this report. It is close to a "textbook" example of an applied probability sample. The discussion in this document contains a few suggestions for improvements, some of which would require further investigation. In particular, the possible reallocation of sample or the use of charter logbook data to address undercoverage issues (§2.2), the use of auxiliary data to increase the precision of estimators (§2.3) and the switch to CAPI would all require further study in order to determine how to best implement them.

MARINE RECREATIONAL INFORMATION PROGRAM

Addressing Recommendations from the MRIP Sponsored Review of Monitoring of Washington's Ocean Sampling Program: Evaluation of recreational catch and effort during off peak months on Washington's coast

Washington Department of Fish and Wildlife

February 6, 2015

INTRODUCTION

Comprehensive and sound management of recreational finfish fisheries in Washington State requires information on catch, effort, and stock-specific fishery impacts necessary to meet established conservation and allocation mandates. These data are federally required to open and manage recreational fisheries, especially considering the need to limit and monitor impacts to threatened species. For the Washington ocean Marine Catch Areas (Areas 1-4), these critical fishery information needs are met through the Washington Department of Fish and Wildlife (WDFW) Ocean Sampling Program (OSP).

To generate estimates of marine fish catch and effort in ocean Marine Catch Areas (for the "private boat" and "charter boat" modes), WDFW employs a procedure based on data collected by an access point intercept survey. The OSP survey is designed to provide both total effort and catch per unit effort (CPUE). These data are used to generate estimates of total catch and effort by Marine Catch Area, month, and fishing mode which are provided to the Recreational Fishery Information Network (RecFIN, www.recfin.org).

Currently, ocean fishery sampling occurs in all major ocean access ports during "peak" effort months, May through September. Some access sites are also sampled at a lower rate during March, April, and/or October. Effort and catch are assumed to be insignificant during all non-sampled temporal/spatial combinations. This assumption had been tested only once, in a limited study in 2002, with inconclusive results. This is the final year of a three-year proposal to test this assumption, with this final year focusing on the higher-effort "shoulder" months – March, April, October, and November.

The objective of this project was to test the assumption that ocean fishing effort and catch are indeed insignificant during the months between September and May. This was a recommendation resulting from the Marine Recreational Information Program's (MRIP) recent review of the WDFW OSP. Based on the findings of the initial stages of the project, work on this project was conducted in two segments October 1, 2013 thru November 30, 2013 and March

1, 2014 thru April 30, 2014. In comparison, prior related work (Stage 1) began October 1, 2011 and ceased on April 30, 2012 while Stage 2 began October 1, 2012 and ceased on April 30, 2013.

METHODS

Methods were identical to those used in the initial stages of this project. One field sampler was stationed in each major Washington coastal access site: Ilwaco, Westport, La Push, and Neah Bay; the small ports of Chinook (near Ilwaco) and Snow Creek (near Neah Bay; access to this site is closed during winter months) were not sampled. One Scientific Technician and one Biologist worked to coordinate sampling, collect data, and generate monthly estimates of catch and effort. One Biometrician analyzed the resulting catch data, comparing "shoulder" months to normally sampled months.

In each port, most weekend days were sampled, and sampled weekdays were assigned using a random number generator to total 40 hours per week. Each port was sampled 3 to 5 days per week and days were stratified by weekend and weekday.

The OSP mainly uses a two-stage design for each port, with days constituting the primary sampling units (PSU) and boats within each sampled day as the secondary sampling units (SSU). Selection of days follows simple random procedures. Although sampling of boats is approximately systematic (e.g., every k*th* boat), the selection procedure is not exact and this stage is treated as simple random for estimation purposes. Daily estimates are expanded over days within strata to produce weekly, monthly and annual estimates.

Effort is measured in units of boat-trips and angler-trips, and on sampled days, is measured throughout the entire period of boat activity, i.e., from the time when the first boat leaves a port until the last boat returns. On a given sampling day, the total number of boats that left a port is counted. Boat effort was measured during this project through an <u>entrance count:</u> a count of all boats entering that marina.

The catch per boat is sampled through intercept surveys. Returning boats are systematically sampled at a minimum target rate of 20% within each boat type (charter and private). Every *k*th boat to enter the harbor is included in the sample regardless of size, mooring location, trip type, etc. The size of the sample (leading to the calculation of *m*) depends on the projected effort and the number of available samplers. Overall, the sampling rate during normally sampled timeframes in each port in a year averages over 50% for charter boats and over 40% for private boats. For this project, the sampling goal was 100% of the vessels entering the port on each sampled day, which should result in an overall sampling rate of approximately 60% in each port for the season.

Data collected from each sampled boat trip include target species, area fished, number of anglers, landed catch by species, released salmon by species, releases of all marine fish by species, depth at which the majority of rockfish in the catch were hooked, and other biological data.

Catch and Effort Estimation

The OSP generates preliminary estimates of catch and effort in-season to meet the demands of ocean fishery management. Catch estimates for quota fisheries (currently salmon and halibut) are generated weekly; catch estimates for all other species are generated monthly and provided to the RecFin database by the end of the following month. Final post-season catch and effort estimates for all species are generated by February 1 each year; these post-season estimates replace any existing in-season estimates. For this project, final estimates of effort and catch were generated monthly and provided to the RecFin database by the end of the following month

OSP Estimated Stratum Totals (Primary Stage)

Combined (total) catch estimates are typically stratified by weekend/holiday and weekday. In some strata, every day is sampled. In those strata the combined estimates are simply sums of the daily catches. In other strata, where some days are not sampled, the average catch per day over all sampled days is multiplied by the number of days in the stratum to estimate the total catch.

Let:

a = the marine catch area,

i = trip type,

t = Weekend/holiday or Weekday stratum,

N_t = the number of days in stratum t,

T_t = collection of all days in stratum t,

n_t = the number of days sampled in stratum t, (rather than the number of boats sampled as above),

S_t = collection of sampled days in stratum t (when S=T, n=N),

Y_{taik} = estimated catch (or effort) on day k for stratum t in area a from trip type i,

C_{tai} = catch for stratum t in area a from trip type i,

Then

$$\hat{C}_{tai} = N_t \frac{\sum_{k \in S_t} \hat{Y}_{taik}}{n_t}$$

with estimated variance (Thompson 1992, p. 129):

$$\hat{V}\left(\hat{C}_{tai}\right) = \frac{N_t (N_t - n_t)}{n_t} \frac{\sum_{k \in S_t} \left(\hat{Y}_{taik} - \hat{\bar{Y}}_{tai}\right)^2}{n_t - 1} + \frac{N_t}{n_t} \sum_{k \in S_t} \hat{V}\left(\hat{Y}_{taik}\right)$$

where

$$\hat{\bar{Y}}_{tai} = \frac{\sum_{k \in S_t} \hat{Y}_{taik}}{n_t} .$$

For strata with all days sampled, $n_t = N_t$, and the catch and variance estimators reduce to:

$$\hat{C}_{tai} = \sum_{k \in T_t} \hat{Y}_{taik}$$

and

$$\hat{V}\left(\hat{C}_{tai}\right) = \sum_{k \in T_t} \hat{V}\left(\hat{Y}_{taik}\right).$$

OSP Daily Catch and Effort Estimation (Secondary Stage)

Both catch and effort are post-stratified by trip-type and area fished. Effort in terms of boat-trips is simply the sample number of boats for each trip-type and area expanded by the appropriate boat-type (charter or private) exit/entrance count. Effort in terms of angler-trips is calculated as the mean number of anglers per boat (indexed by trip-type and area) expanded by the counted total population of boats.

The total catch for a given species on a sampled day is the product of the population of boats and the estimated catch per boat, again post-stratified by trip-type and area fished. Key assumptions in the current estimation procedures are that:

1) All boats exiting/entering a port are included in the exit/entrance count
2) Exit/entrance counts are made without error
3) The approximate systematic sample of boats can be treated as a simple random sample
4) Anglers answer questions accurately and do not conceal fish

In the following discussion, subscripts referring to port and boat-type are suppressed. Let:

M_t = total exit or entrance count for a given port on day *t* (assumed known without error),

m_t = total boats sampled on day *t*,

m_{tai} = number of boats sampled of trip type *i* fishing in area *a* on day *t*,

a_{taij} = number of anglers on the *j*th boat from trip type *i* fishing in area *a* on day *t*,

y_{taij} = number of species specific fish caught on the *j*th boat from trip type *i* in area *a* on day *t*, and

Y_{tai} = total catch of specific species caught from trip type *i* in area *a* on day *t*.

The estimate of the number of boat-trips of trip-type *i* and area *a* follows the procedure outlined in Lai et. al. (1991) where the proportion of boats in each category is estimated by:

$$\hat{p}_{tai} = \frac{m_{tai}}{m_t}$$

with estimated variance (Cochran 1977, p. 52):

$$V(\hat{p}_{tai}) = \frac{\hat{p}_{tai} \cdot (1 - \hat{p}_{tai})}{(m_t - 1)} \cdot (\frac{M_t - m_t}{M_t})$$

The estimated total boat-trips is then obtained by:

$$\hat{M}_{tai} = M_t \cdot \hat{p}_{tai}$$

with estimated variance:

$$\hat{V}(\hat{M}_{tai}) = M^2{}_t \cdot \hat{V}(\hat{p}_{tai})$$

Effort expressed in terms of angler-trips is the product of the average anglers per boat-trip times the total number of boat-trips. The mean number of anglers per boat-trip (for trip-type *i* and fishing area *a*) is estimated as:

$$\hat{\hat{a}}_{tai} = \frac{\sum_j a_{taij}}{m_t}$$

with variance:

$$\hat{V}(\hat{\hat{a}}_{tai}) = \frac{\sum_j (a_{taij} - \hat{\hat{a}}_{tai})^2}{m_t (m_t - 1)} \cdot (\frac{M_t - m_t}{M_t})$$

Thus the estimated total number of angler-trips is:

$$\hat{a}_{tai} = M_t \cdot \hat{\hat{a}}_{tai}$$

with variance:

$$\hat{V}(\hat{a}_{tai}) = M^2{}_t \cdot \hat{V}(\hat{\hat{a}}_{tai})$$

The catch (or number released) for a specific species on sampled day *t* in area *a* from trip type *i* is similarly estimated by:

$$\hat{Y}_{tai} = \frac{\sum_j y_{taij}}{m_t} M_t$$

with estimated variance:

$$\hat{V}\left(\hat{Y}_{tai}\right) = \frac{\sum_j \left(y_{taij} - \hat{\bar{y}}_{tai}\right)^2}{m_t\left(m_t - 1\right)} M_t\left(M_t - m_t\right)$$

This estimate and its variance differs somewhat from that described in Lai et al. (1991) since the total count, M_t (assumed to be a known quantity), is used to expand the estimated CPUE (calculated over all sampled boats) rather than the estimated boat-trips by trip-type and area fished.

RESULTS

In the first report (Stage 1) on this project, March and April in some areas were included as “normally sampled months” in our calculations since some areas have been sampled at a reduced rate during these time periods. After discussion, we felt it more appropriate not to include these as “normally sampled months”, but rather as winter months since (1) sample rates and the number of days sampled during these months has been at rates well below normal, and (2) funding for sampling these months is not dedicated or secure. In addition, halibut and tuna catches were removed from the analysis and preliminary estimates were replaced with finalized estimates for the 2011-2012 and 2012-2013 seasons. Consequently, the analyses for the 2011-12 and 2012-2013 seasons have been modified.

“Winter” months in this analysis are defined as the months of October through April. Catch in the months of December, 2013, and January and February, 2014 is assumed to be zero. “Normally sampled” months are defined as the months of May through September.

Creel sampling of months not currently fully covered by the ocean sampling program (October – April) during the first two years of the project demonstrated that there is a small harvest of marine finfish during this time period in Ilwaco and La Push, and a more significant harvest in Westport and Neah Bay. Creel sampling of “shoulder” winter months during the 2013-14 season supported the determination that Westport and Neah Bay experience a significant harvest of marine finfish, and La Push experiences a small harvest. Ilwaco demonstrated a more significant harvest during the “shoulder” winter months of the 2013-2014 season than in previous years. During the 2013-14 season, the winter catch ranged from 3.5% of yearly total catch in the north coast of Washington state (La Push) to 15.1% in the south coast (Ilwaco). During the 2012-13 season, the winter catch ranged from 7.7% of total yearly catch in the south coast (Ilwaco) to 18.6% of the total in the central coast (Westport) (Table 2), while 2011-12 winter catches ranged from 4.5% in Ilwaco to 15.7% in Westport (Table 3).

Table 4 shows the percent of canary and yelloweye rockfish encounters occurring in winter versus normally-sampled months for each coastal port. Canary and yelloweye are federally-listed threatened rockfish species that are intensively managed following federal rebuilding plans. These two rockfish species currently limit the Washington ocean groundfish fisheries, so precision in estimating impacts on these species is a high priority to fishery managers.

La Push consistently showed the highest rates of canary and yelloweye encounters along the coast during winter months. Westport also demonstrated significant canary and yelloweye encounters during winter months. There was little consistency year-to-year in canary and yelloweye rockfish encounter rates in any port except Neah Bay.

Table 5 shows the catch contribution by month for each port for the three seasons sampled. In all ports, April was the biggest contributor to winter months catch, followed by March in most ports.

The marine fish catch by species during normally sampled and winter months is shown for each port in Appendix 1. Only port/species combinations that indicate winter months catch exceeded 10% of the total harvest are included.

Catch estimates derived from sampling only the May – September time period are underestimated in all ports. The following section examines the effect of the bias on the total uncertainty of catch estimates and considers a correction based on the results of the sampling effort.

Table 1. 2013-2014 Groundfish catch estimates and associated standard errors from each major port for the months normally sampled by WDFW's Ocean Sampling Program, for the additional winter months funded by this project, total harvest for the year, and the percentage of the catch from the winter months.

	Normally-Sampled Months		Winter Months		TOTAL CATCH		
PORT	**Catch** $\hat{C}_{OSP}$	**Standard Error** $S\hat{E}(\hat{C}_{OSP})$	**Catch** $\hat{C}_{W}$	**Standard Error** $S\hat{E}(\hat{C}_{W})$	**Catch**	**Standard Error**	**Percent Catch from Winter months**
Ilwaco	14,289	813	2,537	390	16,826	902	15.1%
Westport	179,892	5,796	29,420	2,673	209,312	6,382	14.1%
La Push	41,147	1,611	1,481	133	42,628	1,616	3.5%
Neah Bay	94,094	4,667	10,381	1,321	104,475	4,851	9.9%
Catch regardless of target trip type							

Table 2. 2012-2013 Groundfish catch estimates and associated standard errors from each major port for the months normally sampled by WDFW's Ocean Sampling Program, for the additional winter months funded by the previous MRIP sampling project, total harvest for the year, and the percentage of the catch from the winter months.

PORT	Normally-Sampled Months		Winter Months		TOTAL CATCH		Percent Catch from Winter months
	Catch $\hat{C}_{OSP}$	Standard Error $S\hat{E}(\hat{C}_{OSP})$	Catch $\hat{C}_W$	Standard Error $S\hat{E}(\hat{C}_W)$	Catch	Standard Error	
Ilwaco	12,899	635	1,074	149	13,973	652	7.7%
Westport	156,247	5,288	35,599	1,841	191,846	5,599	18.6%
La Push	36,044	1,504	3,096	346	39,140	1,543	7.9%
Neah Bay	80,308	2,743	9,326	630	89,633	2,814	10.4%
Catch regardless of target trip type							

Table 3. 2011-2012 Groundfish catch estimates and associated standard errors from each major port for the months normally sampled by WDFW's Ocean Sampling Program, for the additional winter months funded by the previous MRIP sampling project, total harvest for the year, and the percentage of the catch from the winter months.

PORT	Normally-Sampled Months		Winter Months		TOTAL CATCH		Percent Catch from Winter months
	Catch $\hat{C}_{OSP}$	Standard Error $S\hat{E}(\hat{C}_{OSP})$	Catch $\hat{C}_W$	Standard Error $S\hat{E}(\hat{C}_W)$	Catch	Standard Error	
Ilwaco	15,250	631	721	73	15,970	635	4.5%
Westport	165,813	3,933	30,990	1,779	196,803	4,316	15.7%
La Push	36,480	1,682	2,427	111	38,907	1,686	6.2%
Neah Bay	59,594	1,568	8,172	837	67,766	1,777	12.1%
Catch regardless of target trip type							

Table 4. Percent of total canary rockfish and yelloweye rockfish encounters (retained and released) by time period for each WA coastal port during the 2011-12, 2012-13, and 2013-14 sampling seasons.

	2011-2012		2012-2013		2013-2014	
PORT/ SPECIES	Winter months	Normally-sampled months	Winter months	Normally-sampled months	Winter months	Normally-sampled months
Ilwaco						
CANARY	**0%**	**100%**	**0%**	**100%**	**13%**	**87%**
YELLOWEYE	**2%**	**98%**	**0%**	**100%**	**7%**	**93%**
Westport						
CANARY	**16%**	**84%**	**24%**	**76%**	**8%**	**92%**
YELLOWEYE	**7%**	**93%**	**20%**	**80%**	**5%**	**95%**
La Push						
CANARY	**17%**	**83%**	**50%**	**50%**	**26%**	**74%**
YELLOWEYE	**14%**	**86%**	**34%**	**66%**	**13%**	**87%**
Neah Bay						
CANARY	**5%**	**95%**	**6%**	**94%**	**5%**	**95%**
YELLOWEYE	**2%**	**98%**	**4%**	**96%**	**2%**	**98%**

Table 5. Catch contribution by month for each WA coastal port during the 2011-12, 2012-13, and 2013-14 sampling seasons.

	ILWACO			WESTPORT			LA PUSH			NEAH BAY		
MONTH	2013-14	2012-13	2011-12	2013-14	2012-13	2011-12	2013-14	2012-13	2011-12	2013-14	2012-13	2011-12
January	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
February	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
March	2.9%	2.8%	0.1%	2.3%	7.8%	2.1%	0.5%	2.8%	1.3%	0.1%	0.1%	0.2%
April	8.7%	4.2%	2.3%	10.6%	9.6%	12.6%	1.6%	5.1%	4.7%	9.3%	10.3%	11.4%
May	18.9%	15.2%	9.0%	19.0%	19.2%	19.0%	39.0%	40.2%	31.0%	40.9%	41.3%	33.5%
June	23.8%	33.0%	16.3%	17.5%	20.9%	16.9%	9.8%	12.1%	18.7%	10.2%	14.4%	14.0%
July	19.3%	21.2%	28.9%	21.2%	16.1%	20.1%	15.3%	12.4%	22.8%	18.0%	15.1%	20.0%
August	15.7%	16.3%	25.6%	19.5%	20.2%	20.2%	26.8%	24.9%	17.8%	16.2%	16.4%	16.0%
September	7.2%	6.5%	15.7%	8.7%	5.0%	8.1%	5.6%	2.4%	3.5%	4.8%	2.4%	4.5%
October	3.5%	0.6%	1.7%	1.2%	1.1%	1.0%	1.4%	0.0%	0.3%	0.4%	0.0%	0.4%
November	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
December	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Bias correction for unsampled months

One metric used to evaluate estimators is through comparing the mean squared error (MSE) which takes into account both bias and variance, expressed mathematically as

$$MSE(\hat{C}) = Bias^2(\hat{C}) + Variance(\hat{C})$$

Often the most desirable estimator is one with the smallest MSE. However, a zero bias does not always equate to a smaller MSE. At times, additional sampling to reduce or eliminate bias can increase the variance of an estimator, particularly if additional parameters are required to obtain an unbiased estimate of the target quantity. Alternatively, the cost of additional sampling may not decrease an MSE sufficiently to justify the use of additional resources.

If the total, unbiased catch in a year is the sum of the current OSP estimate plus the catch from winter months, then

$$Bias(\hat{C}) = \hat{C}_{OSP} - (\hat{C}_W + \hat{C}_{OSP}),$$
$$Bias(\hat{C}) = -\hat{C}_W$$

where $\hat{C}_{OSP}$ = catch as estimated by the current OSP program,
$\hat{C}_W$ = catch from the winter months, or months currently not sampled,
$\hat{C}$ = the total catch for the year.
Total catch is underestimated by the amount of harvest in winter months.

Under the assumption that winter harvest is small or non-existent and $\hat{C}_{OSP}$ is used for total harvest, the MSE is

$$MSE(\hat{C}) = (\hat{C}_w)^2 + Variance(\hat{C}_{OSP}). \quad \text{Eq. 1}$$

The MSE of total harvest calculated by sampling all months is

$$MSE(\hat{C}) = Variance(\hat{C}_{OSP} + \hat{C}_w),$$
$$MSE(\hat{C}) = Variance(\hat{C}_{OSP}) + Variance(\hat{C}_w) \quad \text{Eq. 2}$$

because the bias is zero and all months are sampled independently. The MSE of $\hat{C}_{OSP}$ is larger than total harvest, $\hat{C}$, across all ports based on 2011-2012 sampling (Table 2), although the difference decreases with $\hat{C}_W$.

Current OSP catch estimates can be corrected for negative bias using a the following bias correction,

$$\hat{C}_{corr} = \frac{\hat{C}_{OSP}}{BiasCorr} \quad \text{Eq. 3}$$

where $BiasCorr = \dfrac{\hat{C}_{OSP}}{\hat{C}_{OSP} + \hat{C}_W}$. The corrected catch estimate $\hat{C}_{corr}$ is unbiased to the first term of a Taylor series expansion,

$$E\left(\hat{C}_{corr}\right) \doteq \frac{E\left(\hat{C}_{OSP}\right)}{\frac{E\left(\hat{C}_{OSP}\right)}{E\left(\hat{C}_{OSP}+\hat{C}_{W}\right)}},$$

$$E\left(\hat{C}_{corr}\right) \doteq E\left(C_{OSP}+C_{W}\right)$$

$$E\left(\hat{C}_{corr}\right) \doteq C$$

The variance of the bias corrected estimate, $\hat{C}_{corr}$, is as follows,

$$Var\left(\hat{C}_{corr}\right) \doteq \hat{C}_{corr}^{2}\left(\frac{Var\left(\hat{C}_{OSP}\right)}{\hat{C}_{OSP}^{2}}+\frac{Var\left(BiasCorr\right)}{BiasCorr^{2}}\right) \qquad \text{Eq. 4}$$

where $Var\left(BiasCorr\right)$ is a function of the $\hat{C}_{OSP}$, $\hat{C}_{W}$, and their associated variances,

$$Var\left(BiasCorr\right) \doteq \left(\frac{\hat{C}_{W}}{\hat{C}_{OSP}+\hat{C}_{W}}\right)^{2}\left(\frac{Var\left(\hat{C}_{OSP}\right)}{\hat{C}_{OSP}^{2}}+\frac{Var\left(\hat{C}_{W}\right)}{\left(\hat{C}_{OSP}+\hat{C}_{W}\right)^{2}}\right) \qquad \text{Eq. 5}$$

Note that Eq. 3 is derived under the assumption that a bias correction would be independently estimated. Table 2 provides a comparison of the MSE’s for current OSP estimates (Eq. 1), total catch, $\hat{C}$ (Eq. 2), and corrected catch, $\hat{C}_{corr}$ (Eq. 3). Because $\hat{C}_{corr}$ is unbiased, the MSE is equal to the variance.

Table 5. 2013-2014 mean squared error among different estimates of groundfish catch.

	Mean Square Error		
Port	**Current OSP catch estimate**	**Total Catch Winter Included**	**Corrected catch estimate**
Ilwaco	7,148,707	813,670	950,276
Westport	903,919,899	40,736,903	46,839,257
La Push	5,034,038	2,613,621	2,798,531
Neah Bay	132,589,016	23,562,769	27,142,965

Table 6. 2012-2013 mean squared error among different estimates of groundfish catch.

	Mean Square Error		
Port	**Current OSP catch estimate**	**Total Catch Winter Included**	**Corrected catch estimate**
Ilwaco	77,563,118	76,432,067	86,853,065
Westport	1,285,886,757	22,034,750	33,166,183
La Push	12,507,257	3,042,252	3,565,161
Neah Bay	89,426,498	2,855,156	3,860,571

Table 7. 2011-2012 mean squared error among different estimates of groundfish catch.

	Mean Square Error		
Port	**Current OSP catch estimate**	**Total Catch Winter Included**	**Corrected catch estimate**
Ilwaco	1,156,573	642,346	703,071
Westport	23,752,177	19,368,689	19,854,154
La Push	3,714,371	3,288,801	3,403,412
Neah Bay	15,801,230	15,720,879	15,832,764

With the exception of Ilwaco in 2012-2013, estimates of total groundfish catch based on sampling in all months have the lowest MSE, followed by the corrected catch estimates () for all years. Differences among MSEs decrease as the bias decreases. The MSE of the corrected estimates is between that of $MSE\left(\hat{C}_{OSP}\right)$ and $MSE\left(\hat{C}\right)$, but closer to $MSE\left(\hat{C}\right)$.

We noted some consistency in the percentage of total catch attributable to the winter months for Westport, La Push and Neah Bay, suggesting that a bias correction could be used for these ports for the total. We verified this by calculating the coefficient of variation (CV) of the percentage of total catch observed during winter months over the 3 years of this study for Neah Bay and Westport (Table 8). In La Push, the CV for the catch in typically unsampled months was higher at 38% however the percentage across all years was less than 10%. The percentage of catch in winter months doubled in Ilwaco each year of the study. Subsequently we cannot recommend a bias correction for Ilwaco at this time.

Current OSP catch estimates for Neah Bay, La Push and Westport can be corrected for negative bias by Eq. 2 using the values in Table 8. We estimated the bias corrections as follows,

$$\overline{BiasCorr} = \frac{\hat{\hat{C}}_{OSP}}{\hat{\hat{C}}_{OSP}+\hat{\hat{C}}_{W}},$$

where $\hat{\hat{C}}_{OSP}$ = the average catch from the regularly sampled months for the three years of the study calculated as $\hat{\hat{C}}_{OSP} = \frac{\sum_{i=1}^{3}\hat{C}_{OSP,i}}{n}$, and

$\hat{\hat{C}}_{W}$ = the average catch from the winter sampled months for the three years of the study calculated as $\hat{\hat{C}}_{W} = \frac{\sum_{i=1}^{3}\hat{C}_{W,i}}{n}$,

The associated variance of $\overline{BiasCorr}$ is calculated as in Eq. 5, with the appropriate substitutions as follows,

$$Var\left(\overline{BiasCorr}\right) \doteq \left(\frac{\hat{\hat{C}}_W}{\hat{\hat{C}}_{OSP} + \hat{\hat{C}}_W}\right)^2 \left(\frac{Var\left(\hat{\hat{C}}_{OSP}\right)}{\hat{\hat{C}}_{OSP}^2} + \frac{Var\left(\hat{\hat{C}}_W\right)}{\left(\hat{\hat{C}}_{OSP} + \hat{\hat{C}}_W\right)^2}\right).$$

Although there was less consistency in percentage of winter catch for individual species across years for total catch, the bias correction could be still be used as a conservative measure to account for harvest of species of concern. Table 8 shows proposed bias corrections that could be used to account for catch during unsampled months.

Table 8. The proposed bias correction ($\overline{BiasCorr}$) to account for unsampled winter months for the four ports that were part of this study.

Port	CV (% catch winter months)	Bias Correction ($\overline{BiasCorr}$)	SE ($\overline{BiasCorr}$)	PSE ($\overline{BiasCorr}$)
Ilwaco	60%	None		
Westport	14%	16.1%	1.3%	7.9%
La Push	38%	5.8%	0.3%	5.3%
Neah Bay	10%	10.6%	0.7%	6.2%

DISCUSSION

This three-year study was designed to test the assumption that ocean fishing effort and catch are insignificant during the months between September and May, which are typically either not sampled or sampled at very low rates. The two seasons of sampling year-round and one year of sampling “shoulder” months in Washington coastal ports demonstrated that both Westport and Neah Bay experience significant (comprising 10% or greater of the total annual groundfish harvest) early spring groundfish harvest. March and April in Westport and April in Neah Bay proved important contributors to total groundfish catch. Early-season catch in La Push comprised less than 10% of the total annual catch in each year of the study, but contributed significant canary and yelloweye rockfish impacts in March and April. The early spring groundfish harvest in Ilwaco was significant in the final study year only and was inconsistent seasonally.

One of the objectives of this study was to determine whether a catch bias correction would be feasible to apply to months that are typically not sampled or are sampled at a low rate in the Washington ocean recreational fisheries. Based on the three years of data collected, a bias correction appears feasible in Westport, La Push, and Neah Bay. However, fishery managers have concerns about the precision of groundfish bias corrected catch estimates particularly for canary and yelloweye rockfish, given the rebuilding status and restrictive catch constraints on these species and the economic and social impacts of in-season regulation changes or closures. Although a catch bias correction is least feasible in Ilwaco, that area contributes the smallest overall groundfish catch, and specifically, fewer impacts on canary and yelloweye than any other ocean area.

Based on the results of this study, we have prioritized how available sampling funding might be used for ocean recreational sampling in future years. Taking into consideration the potential for catch bias correction, the desired catch estimation precision for intensive fishery impact management, the contribution (in numbers of fish) that each area makes to total Washington ocean recreational groundfish catch, and the economic and social impacts of in-season regulation modifications, we recommend that sampling resources be prioritized as follows:

1. Maintain resources to sample core months (May – September).
2. Sample in March and April in Westport and April in Neah Bay and La Push.
3. Sample March in La Push.
4. Sample April in Ilwaco.
5. Sample March in Neah Bay.
6. Sample October in all ports.
7. Sample other winter months as funding allows.

Appendix 1

Ocean marine fish recreational catch by species that exceeded 10% harvest[1/] in the winter months during the 2013-2014 season.

Port Sampled	Species Name	TOTAL CATCHES (NUMBERS OF FISH)			
		Normally-Sampled Months	Winter Months	Percent landed in normally-sampled months	Percent landed in winter months
Ilwaco	BLACKROCK	11,170	1,861	86%	14%
Ilwaco	BLUEROCK	1	11	11%	89%
Ilwaco	CABEZON	113	18	86%	14%
Ilwaco	CANARY (released)	37	5	87%	13%
Ilwaco	CHINA	7	2	79%	21%
Ilwaco	KELPGREENLING	262	46	85%	15%
Ilwaco	LINGCOD	1,031	415	71%	29%
Ilwaco	MISCELLANEOUS	361	154	70%	30%
Ilwaco	QUILLBACK	46	19	71%	29%
Ilwaco	TIGER	10	2	85%	15%
La Push	BLUEROCK	144	23	86%	14%
La Push	CANARY (released)	91	35	72%	28%
La Push	MISCELLANEOUS	48	12	79%	21%
La Push	QUILLBACK	30	15	67%	33%
La Push	VERMILLION	1	4	27%	73%
La Push	YELLOWEYE (released)	304	45	87%	13%
La Push	YELLOWTAIL	138	85	62%	38%
Neah Bay	LINGCOD	12,341	1,946	86%	14%
Neah Bay	MISCELLANEOUS	258	91	74%	26%
Neah Bay	PERCH	12	8	60%	40%
Neah Bay	YELLOWTAIL	1,294	392	77%	23%
Westport	BLACKROCK	128,969	25,070	84%	16%
Westport	BLUEROCK	37	40	48%	52%
Westport	LINGCOD	16,125	3,507	82%	18%
Westport	TIGER	3	1	75%	25%

[1/] Analysis of harvest includes released canary and yelloweye rockfish.

Ocean marine fish recreational catch by species that exceeded 10% harvest[1/] in the winter months during the 2012-2013 season.

Port Sampled	Species Name	TOTAL CATCHES (NUMBERS OF FISH)			
		Normally-Sampled Months	Winter Months	Percent landed in normally-sampled months	Percent landed in winter months
Ilwaco	CABEZON	101	33	75%	25%
Ilwaco	KELPGREENLING	344	56	86%	14%
Ilwaco	LINGCOD	1,025	218	82%	18%
La Push	BLUEROCK	63	8	88%	12%
La Push	BOCACCIO	15	2	88%	12%
La Push	CANARY (released)	68	67	50%	50%
La Push	LINGCOD	4,180	766	85%	15%
La Push	MISCELLANEOUS	40	20	66%	34%
La Push	QUILLBACK	21	6	77%	23%
La Push	TIGER	6	1	85%	15%
La Push	YELLOWEYE (released)	146	76	66%	34%
La Push	YELLOWTAIL	75	128	37%	63%
Neah Bay	CABEZON	1,464	256	85%	15%
Neah Bay	LINGCOD	12,117	2,515	83%	17%
Neah Bay	MISCELLANEOUS	195	98	67%	33%
Neah Bay	YELLOWTAIL	1,720	347	83%	17%
Westport	BLACKROCK	124,103	28,227	81%	19%
Westport	BLUEROCK	56	26	68%	32%
Westport	CABEZON	175	45	80%	20%
Westport	CANARY (retained)	-	2	0%	100%
Westport	CANARY (released)	288	91	76%	24%
Westport	COPPER	16	3	85%	15%
Westport	KELPGREENLING	272	206	57%	43%
Westport	LINGCOD	11,824	5,849	67%	33%
Westport	PERCH	11	3	79%	21%
Westport	QUILLBACK	209	77	73%	27%
Westport	TIGER	13	2	86%	14%
Westport	YELLOWEYE (released)	277	69	80%	20%

[1/] Analysis of harvest includes released canary and yelloweye rockfish.

Ocean marine fish recreational catch by species that exceeded 10% harvest[1/] in the winter months during the 2011-2012 season.

Port Sampled	Species Name	TOTAL CATCHES (NUMBERS OF FISH)			
		Normally-Sampled Months	Winter Months	Percent landed in normally-sampled months	Percent landed in winter months
Ilwaco	BLUEROCK	47	10	82%	18%
Ilwaco	COPPER	8	1	88%	12%
La Push	BLUEROCK	139	34	80%	20%
La Push	COPPER	24	7	78%	22%
La Push	CANARY (released)	144	31	82%	18%
La Push	KELPGREENLING	396	51	89%	11%
La Push	LINGCOD	5,830	790	88%	12%
La Push	QUILLBACK	117	21	85%	15%
La Push	TIGER	10	6	65%	35%
La Push	YELLOWEYE (released)	610	98	86%	14%
La Push	YELLOWTAIL	319	254	56%	44%
Neah Bay	BLACKROCK	36,641	5,889	86%	14%
Neah Bay	BOCACCIO	229	53	81%	19%
Neah Bay	CABEZON	1,655	186	90%	10%
Neah Bay	CANARY (retained)	87	15	85%	15%
Neah Bay	LINGCOD	8,780	1,572	85%	15%
Westport	BLACKROCK	132,931	25,370	84%	16%
Westport	BLUEROCK	80	74	52%	48%
Westport	CANARY (released)	326	63	84%	16%
Westport	COPPER	38	6	87%	13%
Westport	FLATFISH	1,087	182	86%	14%
Westport	KELPGREENLING	459	119	79%	21%
Westport	LINGCOD	18,028	4,085	82%	18%
Westport	PERCH	39	26	60%	40%
Westport	TIGER	7	1	84%	16%

[1/] Analysis of harvest includes released canary and yelloweye rockfish.