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

September 30, 2012

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.

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. Work on this project began October 1, 2011, and ceased on April 30, 2012.

METHODS

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 "winter" 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 a minimum of 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 entrance count: 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:

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

with variance:

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

Thus the estimated total number of angler-trips is:

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

with variance:

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

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

Bias correction for unsampled months

Creel sampling of months not currently covered by the ocean sampling program demonstrated that there is a small harvest of marine finfish during the typically non-sampled time period (Table 1). The catch is small during the winter period, ranging from 4.3% of total yearly catch in the south coast of Washington state (Ilwaco) to only 0.4% of the total in the Northern most port. The result is that current catch estimates are underestimated, although the bias is small. 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. Catch estimates 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** $\hat{C}_{OSP}$	**Variance** $\hat{Var}\left(\hat{C}_{OSP}\right)$	**Catch** $\hat{C}_W$	**Variance** $\hat{Var}\left(\hat{C}_W\right)$	**Catch**	**Variance**	**Percent Catch from "Winter" months**
Ilwaco	15,934	637,150	721	5,195	16,655	642,346	4.3%
Westport	170,045	19,321,068	2,105	47,621	172,150	19,368,689	1.2%
La Push	38,120	3,287,923	653	879	38,773	3,288,801	1.7%
Neah Bay	80,264	15,720,227	285	653	80,549	15,720,879	0.4%
Catch regardless of target trip type							

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

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

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

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

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

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

The MSE of total harvest calculated by sampling all months is

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

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,

$$\hat{C}_{corr} = \frac{\hat{C}_{OSP}}{BiasCorr}$$

where $BiasCorr = \frac{\hat{C}_{OSP}}{\hat{C}_{OSP} + \hat{C}_W}$. 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,

$$Var\left(\hat{C}_{corr}\right) \doteq \hat{C}_{corr}^2 \left(\frac{Var\left(\hat{C}_{OSP}\right)}{\hat{C}_{OSP}^2} + \frac{Var\left(BiasCorr\right)}{BiasCorr^2} \right) \qquad \text{Eq. 3}$$

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

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

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 2. The mean squared error among different estimates of 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

Estimates of total catch based on sampling in all months have the lowest MSE, followed by the corrected catch estimates and differences among MSEs decrease as the bias decreases. The MSE for estimates from Neah Bay are almost the same, as would be expected when the winter months only account for 0.4% of the total catch. 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 $MSE\left(\hat{C}\right)$, although the estimates are only based on one year's worth of data. If the percentage of winter catch is consistent across years, then the use of a bias corrected estimate could be recommended when resources are scarce.

DISCUSSION

A second season of winter sampling will begin in October, 2012 and conclude in April, 2013. These data should provide more information about the consistency of winter catch between years, and may help clarify recommendations on sampling distribution and estimation of catch in the future.