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Alternative Sampling Designs for the 2017 Annual Deployment Plan of the North Pacific Observer Program

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U.S. DEPARTMENT OF COMMERCE
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C. H. Faunce

Fisheries Monitoring and Analysis Division
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE
Seattle, WA 98115-6349

www.afsc.noaa.gov

U.S. DEPARTMENT OF COMMERCE
Penny. S. Pritzker, Secretary
National Oceanic and Atmospheric Administration
Kathryn D. Sullivan, Under Secretary and Administrator
National Marine Fisheries Service
Eileen Sobeck, Assistant Administrator for Fisheries

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Abstract

Changes in regulation enacted in 2013 have enabled the Alaska Fisheries Science Center's Fishery Monitoring and Analysis Division (FMA) and the Alaska Regional Office's Sustainable Fisheries Division to work collaboratively on an Annual Deployment Plan (ADP). Each ADP documents how the National Marine Fisheries Service (NMFS) plans to deploy observers into fishing activities for the coming year under the limits of available funding. Draft ADPs are presented to the North Pacific Fishery Management Council (Council) during September - October and are finalized in December. The sampling design for observer deployment has two elements: how the population is subdivided (i.e., stratification schemes) and how available samples are allocated (i.e., allocation strategies).

Here the relative performance of four alternative sampling designs (at the primary sampling unit- the trip) are compared in support of the 2017 draft ADP. Each alternative design has different strata configurations and optimizes the allocation weighting of samples (observed trips) in each stratum based on the number of trips, the variance of groundfish catch, and the cost of observing a trip. Total sample size is determined by the available budget and the cost of observing each trip during the calendar year. Resulting coverage rates are presented for optimal allocations based on only retained catch, only discarded catch, and a compromise blend of retained and discarded catch. Gap analyses that examine the chance of at least one or three observed trips in a NMFS Area × Gear type combination were used as a performance metric. Total sample size (trips observed) is expected to be reduced by nearly a third due to a halt in Federal funding. Gap analyses illustrated that stratifications based on gear type (3 strata) or gear type × tendering activity (6 strata) outperform stratifications that include a separate strata comprised of five vessels that act as both catcher processors and catcher vessels and fish using hook-and-line gear (i.e., partial CP HAL strata). However, these partial CP HAL vessels disproportionately fish in Aleutian Island NMFS Areas that have been problematic for obtaining observer coverage in the past.

All sampling designs were forwarded to the Council for consideration during their October 2016 meeting in recognition of 1) the tradeoff between obtaining data from a small subset of vessels in the Aleutian Islands at the cost of increasing the number of cells with a high chance of zero coverage elsewhere, and 2) all the designs examined here are variants of the best performing design considered for the 2016 ADP. Of these, the NMFS recommended - and the Council approved - that the 6 strata design with optimal sample allocations based on discarded groundfish catch be used for the 2017 ADP.

CONTENTS

INTRODUCTION

The North Pacific Observer Program (observer program) uses a hierarchical sampling design with randomization at all levels to achieve unbiased data from fishing operations in the region. The fishing trip represents the primary sampling unit of this design. Since 2013, fleet operations in Alaska have been divided into two portions: vessels and shore-based industry operations that are subject to complete observation at the level of the trip or delivery are termed "full-coverage" while the remainder are termed "partial-coverage". Definitions of full- and partial coverage are set in the Federal Regulations.

Observer deployment, and the term 'sampling design' hereafter refer to how trips and deliveries are selected for observer coverage in the partial-coverage category of the Alaska fishing industry. All fishing trips subject to partial observer coverage constitute the target population for observer deployment. A sampling frame for the deployment of observers is constructed though the use of a mandatory log-in system known as the Observer Declare and Deploy System (ODDS)[1].

Since 2013, the observer program has been required to provide an Annual Report and an Annual Deployment Plan (ADP) to the North Pacific Fishery Management Council (Council). The Annual Report is presented in June and contains information on how well various aspects of the observer program are performing in addition to recommendations for future ADPs. The draft and final ADP are presented in September and December, respectively, and describe the observer deployment for the coming year. Three separate advisory bodies provide their comments and perspectives to the Council at each meeting. These include the Observer Advisory Committee, the Advisory Panel, and the Science and Statistical Committee (SSC). Members on the Observer Advisory Committee and the Advisory Panel represent major segments of the fishing industry as well as observers, consumers, environmental/conservation, and sport fishermen. Science and Statistical Committee members are scientists with expertise in biology, economics, statistics, and social science.

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[1] http://odds.afsc.noaa.gov

Partial coverage observers are trained prior and debriefed after their respective deployments by the observer program. Observers are employees of an observer provider company who is responsible for the logistical aspects of deployment. Funds to deploy observers in partial coverage are obtained by NMFS through a landings fee, and these funds are contracted to the observer provider company. The Council has the authority to change the fee up to a maximum of 2% of landed value. The fee currently stands at 1.25% and is scheduled to be re-assessed in 2018.

Concerns over the costs of the observer program and resulting data quality has led to scrutiny, even legal challenge of observer deployment. The ADP process provides a mechanism for NMFS and the Council to re-evaluate deployment and improve efficiency in the sampling design. In 2016, the NMFS forwarded 12 alternative designs for the deployment of observers for the 2016 ADP to be considered by the Council (NMFS 2015a). The adopted 2016 ADP design allocates observed trips among three gear-based strata according to a blend of optimal allocations resulting from the interactions of stratum size and variance in total retained catch and total discarded catch (NMFS 2015b). The most recent Annual Report (NMFS 2016) and subsequent Council motion (9 June, 2016) have instructed that the NMFS continue to build upon the 2016 ADP design by evaluating the possibility of including additional strata for tendering activity, wherein a vessel delivers its catch to another vessel at-sea to be eventually delivered to a shore-based processor without returning to shore itself. In addition, the Observer Science Committee hosted by the observer program has recommended in 2014 and 2015 Annual Reports that expansion of so-called "partial coverage CPs" – vessels that have catcher processor endorsements but are not subject to full observer coverage - warrant examination as potential separate strata (NMFS 2015c, NMFS 2016). In 2016 the NMFS expanded the list of partial coverage CP vessels from two to seven. What follows is a comparison of the relative performance of alternative stratum definitions and allocation strategies for the deployment of observers into the fleet of vessels in partial coverage for consideration in the 2017 ADP.

METHODS

Data Preparation – Defining the Partial Coverage Fleet

The partial coverage fleet for 2017 needs to be defined for all potential design comparisons. The partial coverage fleet in general consists of the catcher vessel fleet when not participating in a catch-sharing or cooperative style management program. Changes to this general design have resulted from NMFS policy, Council Action, and regulations. Activities expected to occur in 2017 that have been excluded from observer coverage in the past include 1) catcher vessels while fishing in state managed fisheries, 2) catcher vessels fishing with jig gear, 3) catcher vessels fishing that are sized < 40 feet in length overall (LOA), and 4) vessels that volunteer for electronic monitoring (EM) research and pre-implementation by 20 September, 2016. In addition, fishing by seven vessels that carry both catcher vessel and catcher processor endorsements have been moved from full- to partial coverage, and AFA -endorsed trawl catcher vessels that voluntary choose to by the end of 2016[2] will carry full observer coverage when fishing in the Bering Sea and Aleutian Islands (hereafter termed Voluntary 100% BSAI vessels).

Since the actual list of vessels participating in EM and voluntary 100% BSAI coverage are not known prior to the 2017 Draft ADP, assumptions must be made as to their composition. The list of 76 vessels expected to participate in EM during 2017 was obtained by first generating a list of all vessels that have volunteered for EM between 2014 and August 2016, and subtracting those vessels that have indicated as of August 2016 they will not be participating for EM in 2017. The number of voluntary 100% BSAI vessels volunteering has fallen from 41 in 2013, to 38 in 2014, to 32 in 2015, to 27 in 2016. A linear regression was used to predict that 22.5 vessels will volunteer in 2017. Each vessel that volunteered between 2013 and 2016 was given a score of 1 for each year it volunteered. This score,

[2] This date is expected to be 15 October after regulations are set in place in 2017. S. Bibb (AKRO-SF pers. comm. 30 August, 2016).

divided by four (number of years examined) yielded an occurrence score. The list of 21 vessels that had an occurrence score of 1 were used as a surrogate for voluntary vessels in 2017.

A database containing 2014 and 2015 species-specific catch amounts, dates, locations disposition, and observation status was first enhanced with additional information from the Alaska Regional Office and FMA, then parsed to reflect the partial coverage fleet subject to observer coverage in 2017, and finally re-labelled according to the alternative stratification schemes described below.

Deployment Design

The sampling design for observer deployment (herafter 'Deployment Design') involves two elements: how the population of partial coverage trips are subdivided, and what proportion of the total observer deployments are to occur within these subdivisions. The first of these is termed *stratification,* while the second is termed *allocation*.

Stratification Schemes

Stratification is the division of sample units in the population into subpopulations. The subpopulations are individually called stratum (strata if plural). Stratified random sampling is the act of obtaining independently random samples from within each stratum in the population. For this reason, strata need to be defined based on criteria known prior to the draw of the sample. This means that elements of fishing trips known prior to departure are valuable in defining deployment strata, whereas catch is not.

There are numerous reasons for creating strata. These include the following: when a separate estimate for a subpopulation is desired, when administrative convenience (field logistics) permits it, and to increase the precision of sample-based estimates of the total. Increased precision is accomplished through the division of a heterogeneous population into homogenous subpopulations since the variance in the population total is dependent on the variances of the individual stratum means (Cochran 1977).

The collection of strata that together subdivide the population of trips in partial coverage constitutes a *stratification scheme*. In this study four stratification schemes were considered. These stratification schemes (with the number of the individual strata in parentheses) are as follows:

1. Gear (3)

This *status quo* stratification divides the partial-coverage trips into three strata:

1) Hook-and-line ≥ 40 feet LOA.

2) Pot ≥ 40 feet LOA.

3) Trawl.

2. Gear + Partial CP HAL (4)

This stratification scheme is the same as the first with the addition of a new stratum. The new stratum is defined as trips undertaken by vessels with both a catcher vessel and catcher processor endorsement that have been granted exemption from full observer coverage when fishing with hook-and-line gear. During 2014-2015, five vessels would have participated in this new "Partial CP HAL" stratum. Although two pot vessels with both a catcher vessel and catcher processor endorsement have also been granted exemption from full observer coverage this is too few to warrant a separate stratum since all resulting data would be confidential under NMFS observer data reporting protocols.

3. Gear × Tender (6)

This stratification uses the three gear types of stratification scheme No. 1 but subdivides each of these into trips that either delivered catch to a tender vessel and those that did not.

4. Gear × Tender + Partial CP HAL (7)

This stratification combines the six strata in stratification scheme #3 with the new stratum of stratification scheme No. 2.

The stratification schemes 1-4 can be thought of as a continuum. The first scheme represents the chosen design of the 2016 Draft ADP and serves as a baseline for other comparisons. The relative "impact" of introducing either a new partial CP HAL stratum or new tender-based gear strata can be determined by comparing stratification schemes No. 2 and No. 3 to No. 1 respectively. Likewise, the relative "impact" of introducing all of these new strata can be determined by comparing stratification scheme #4 to #1, or by comparing stratification scheme #4 to stratification schemes #2 or #3.

Sample Allocation

Sample allocation is the term for how available observer deployments are apportioned to strata. "Optimal" allocation is that which achieves the most precision for the least cost (c). If n is the number of observed trips afforded for the year among all partial coverage fishing trips (N) that occur within H strata, and the estimate of catch from these trips has S^2 variance, the number of samples that is considered optimum for each stratum (n_h) is denoted by the product of the total sample size and the optimal weighting (W_{hopt}),

$$n_h = n * W_{hopt}, \ where \ W_{hopt} = \frac{N_h S_h / \sqrt{c_h}}{\sum_{h=1}^{H}\left(N_h S_h / \sqrt{c_h} \right)} \text{(Cochran 1977).} \qquad \text{Eq. (1)}$$

The partial coverage contract of the observer program pays for observer days according to the intersection of two variables: fixed costs for each deployment day, and variable costs in terms of transportation. While the fixed cost component of observer days are known and equal between deployments of observers, variable costs are not. However, there is a portion of the contract between NMFS and its partial-coverage observer provider that accounts for travel costs for the year. Assuming this cost is fully utilized, the monies available for observer deployment become total funds (C) minus travel costs (C_T). Likewise, because not all trips are of equal duration, the cost of an observed trip in each stratum (c_h) can be derived from the multiplication of its average trip duration and the cost of an observer day. While Equation 1 gives the allocation of observed trips among strata, it does not give the total sample size. To obtain this we can rearrange Equation 1 as

$$n = \frac{(C - C_T) \sum_{h=1}^{H}\left(N_h S_h / \sqrt{c_h} \right)}{\sum_{h=1}^{H}\left(N_h S_h \sqrt{c_h} \right)} \text{ (Cochran 1977).} \qquad \text{Eq. (2)}$$

Once Equation 2 is solved, the value for n can then be used to solve for the sample size in each stratum using Equation 1. The resulting coverage rates in each stratum is obtained from the division of n_h

by N_h. Optimized sample allocations were generated using both variances for total retained catch and total discarded catch. However a challenge is how to allocate when there is more than one target metric. In these cases, Cochran (1977) shows that the *compromise optimal allocation* (m_h) is derived from the average number of optimal sample sizes measured across L metrics,

$$m_h = \bar{n}_{h\ opt,} \text{ where } \bar{n}_h = \frac{\sum_{l=1}^{L} n_{lh}}{L}. \qquad \text{Eq. (3)}$$

It is worth noting that unless n_h among all metrics are positively correlated, the resulting compromise allocations may be substantially different from n_h for any individual target metric.

Data from 2014 and 2015 were combined and treated as a single meta-year for the calculation of optimal allocation weightings (W_{hopt}) in each strata, the sample size available for the 2017 ADP (Equation 2), and sample sizes for each strata (Equation 1). This process was repeated using variance of retained catch and variance of discarded catch. The compromised optimal allocations of samples in each stratum for 2017 was calculated from Equation 3. Using the N_h values from 2015 data only, anticipated rates of coverage for 2017 were obtained for 2017 under the assumption that 2017 fishing effort will be equivalent to 2015 (r_h, Fig. 1). Distributions of the average trip duration and retained and discarded catch for each stratification scheme were plotted since these form the raw ingredients for the sample size allocation formulae.

Evaluation of Alternative Designs

The evaluation of alternative designs was determined through gap analysis following previous evaluations of observer program deployments (NMFS 2015a, NMFS 2015c). This is because of the invaluable service observers provide in the generation of total catch estimates; if there is no observer data in a given domain of interest, then data must be borrowed from similar or adjacent sampling units and incorrect inference about the total catch can result. This has implications for the in-season quota management used in Alaska.

In gap analysis the interest is in predicting the performance of each sampling plan using the most recent data. For this reason gap analyses and all subsequent analyses were performed on the 2015 subset of the source data (Fig. 1). Following the June 2016 Council motion, the number of partial coverage trips corresponding to each stratification scheme was summed into domains defined by Gear and NMFS Area; unlike examinations of potential designs for the 2016 ADP- Target species was not included and NMFS Areas in the Bering Sea were not combined.

The hypergeometric distribution was used to calculate the probability of observing at least one and three trips within a domain for each sampling scheme based on the three optimal allocations. These probabilities were made Boolean based on whether or not they exceeded 50%. This value was chosen as the minimum acceptable value since it represents equal chance of meeting the needs of variance calculation within a domain. The proportion of domains that passed the three or more criteria were calculated for comparison and represented as a G score (*G*) for each stratification scheme. This G score for each sampling scheme was then divided by its minimum among sampling designs to provide a relative metric. This relative G score ranges from 0 to 100, where 100 is best.

RESULTS AND DISCUSSION

The total number of observer days available for deployment in the observer program is dependent upon the available budget and the average cost of an observed day. This analysis uses a total amount of observer days that should remain constant for 2017 and 2018 given equal annual fee revenues and no additional Federal funding resulting in a financially sustainable observer program. The number of total observer days that results from this projection is 3,505. Depending on the deployment design chosen, approximately 53-59% of available sea days will be used between 1 January and 16 June of each calendar year.

The resulting coverage rates for observer deployment depend upon the amount of fishing effort and the available number of observer days. Since this analysis is focused on the relative performance of alternative stratification schemes, it uses a simplified assumption of future fishing effort - namely that fishing in 2015 will be identical to that in 2017. This assumption is made in anticipation that for the Final 2017 ADP, when a stratification scheme is selected, a more careful estimate of anticipated fishing effort would be made for 2017, and resulting rates adjusted to reflect this new prediction. This approach was adopted for the draft and final 2016 ADPs. For the final 2016 ADP, a stable trend in hook-and-line and pot fishing was evident from 2013 to 2015 but a noticeable and consistent linear increase in the number of trawl fishing days was evident during that time (NMFS 2015b). This resulted in new predictions for the number of sea-days that would occur in the trawl fishery for 2016 and coverage rates were adjusted between the draft and final 2016 ADP.

The optimization algorithms in this analysis account for the differential potential costs associated with observing longer trips in some strata - an improvement upon prior analyses that used simplified Neyman optimization that assumes the cost of each observed trip is the same. The optimization algorithm employed here puts more samples where 1) strata are larger, 2) variance is larger, and 3) costs are lower (Cochran 1977). The methods used herein truly maximize the observer program “bang for the buck” and can not only be used to accommodate differential trip durations but also differential costs between observation types (e.g., human vs. cameras) in future ADPs.

Whether resulting rates of observer coverage differ between deployment designs depends upon how the rates are compared. While rates of coverage substantially differ among strata within each design (Tables 1-3), they do not substantially differ within a given stratum (Fig. 2). This lack of differences in coverage rates within a stratum with changes in stratification schemes is due to the fact that the new strata in schemes 2-4 are relatively small in terms of total trips compared to the strata based on gear alone. The distributions of trip durations and catches are presented in Figures 3 and 4. Compromise optimal allocation results in the lowest rates within the hook-and-line stratum (7.7 %) and the highest rates within the tender trawl stratum (32.7 %, Table 1), discarded optimal allocation results in the lowest rates within the pot gear stratum (4.4 %) and the highest rates within the trawl stratum (19.5 %, Table 2) and retained optimal allocation results in the lowest rates within the hook-and-line gear stratum (3.3%) and the highest rates within the tender trawl stratum (49.4 %, Table 3).

Some of the sampling rates result in very low number of observed trips within a stratum. For example, under any optimal allocation strategy the number of expected observed trips in the tender hook-and-line stratum is between 2 and 3, despite a 20-30 % coverage rate. This is because only 10 trips occur in that stratum. Similar low samples sizes are expected within the partial CP HAL under all optimal allocations (n_h = 2-10, Tables 1-3) and tender POT strata under discard optimal allocation (n_h = 12, Table 2). This is problematic because the ODDS trip-selection system currently allows for up to three trips to be logged at once and trips can be cancelled. With these policies in place, and the captains prior knowledge of observed and unobserved trips, it is likely that no observed trips will be realized in these strata under these designs during 2017 unless near 100% probability of selection for observer coverage is implemented.

An alternative to increasing the selection rate on small strata is to select stratification schemes that have fewer, but larger strata. Indeed, the Gear (3) stratification scheme outperformed all other stratification schemes in gap analyses since each stratum contains over a thousand trips each (Table 4). The presence of the partial CP HAL stratum in some stratification schemes causes those schemes to have a disproportionate number of NMFS Areas with low likelihoods of one or more observed trips in each of them (Fig. 5). This phenomenon is because this stratum is associated with low numbers of fishing trips in numerous NMFS Areas (Tables 5-10).

Whether or not it is warranted to include the partial CP HAL stratum in the 2017 ADP depends upon how valuable resulting information would be. If, for instance, these vessels fish in similar areas, fisheries, etc., from other hook-and-line vessels of similar size, then it would not make sense to create a separate stratum. Examination of the fishing characteristics of the partial CP HAL stratum trips to other catcher vessel hook-and-line trips is presented in Figure 6[3]. Although on average partial CP HAL vessels had fewer discards, less diverse retained catch, landed fewer species, and some were larger in vessel length than other hook-and-line catcher vessels fishing with hook-and-line gear, none of these differences were very striking (Fig. 6 top panels). In contrast, while the proportion of management program codes fished and tender trips undertaken were similar between these two groups of hook-and-line vessels, partial CP HAL vessels fish later in the year, predominantly in the sablefish fishery, and fish nearly exclusively in the Aleutian Islands (NFMS Areas 541:543; Fig. 6 bottom panels).

The fact that the partial CP HAL vessels fish predominantly in the Aleutian Islands is important since the review of the 2015 observer program deployment found that no trips had been observed within the 40-57.5 foot class of vessels from the Aleutian Islands when sampled at a 12% rate, and there were no observed trips within NMFS Areas 543 and less than expected coverage in NMFS Area 542 within the 57.5 foot ≥ class of vessels when sampled at a 24% rate (NMFS 2016). Given the anticipated low coverage rates for 2017 and beyond, it seems prudent to attempt to improve the ability of the observer program to obtain samples from within this unique set of vessels in the Aleutian Islands. Similarly, prior observer program Annual Reports have highlighted the differences between tender and non-tender trips and the difficulty of the observer program in observing tender deliveries, particularly from within the trawl pollock fishery in the Gulf of Alaska (NMFS 2015a).

The 3,505 anticipated observer days for 2017 and beyond is an amount that will result in multi-year sample size and financial stability for the observer program given only a 1.25% fee revenue. Unfortunately, it represents the lowest total sample size since the restructured program was initiated in 2013. For comparison, the observer program deployed observers for 3,533 days in 2013, 4,573 days in 2014, 5,318 days in 2015, and is expected to deploy observers for 4,900 days in 2016 (NMFS 2015b, NMFS 2016). The number of observed days for 2017 and beyond represent a 30.7 % decrease from the

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[3] Due to the nature of the way partial CP HAL vessels were created, the amount of their catch is much more like catcher vessels than catcher processors so full-coverage CP data was excluded from comparisons.

average number of sea-days deployed during 2013-2016. For the number of observed days for 2017 and beyond to be equal to the prior 4-year average (4,581) would require an increase in the observer fund fee from 1.25% to 1.63%.

The resulting coverage rates presented here are well below the rates already demonstrated to result in temporal and spatial bias in observer deployment. For example, in simulated sampling evaluations of 2014 data, most observer data gaps disappeared or were severely minimized at deployment rates greater than or equal to 15% (NMFS 2015d, p.98). In 2015, selection rates in the 40-57.5 foot class of vessels were 12%, and an actual observation rate of 11.2% was achieved (NMFS, 2016). At this level of coverage numerous NMFS Areas without any observer coverage resulted. The temporal bias present in the 57.5 foot ≥ class of vessels in 2014 when selection rate was 15% was no longer present in 2015 when selection rates were set at 24% (NMFS, 2016). It is likely that observer coverage in 2017 and beyond will be both spatially and temporally biased with several strata unlikely to be sampled at all under some deployment designs.

Conclusions, Caveats, and Potential Improvements

This analysis builds upon those presented for the 2016 Draft ADP. As such, the methods presented in Figure 1 are somewhat streamlined from those presented in that former document. Herein the relative performance of the stratifications schemes in terms of precision and accuracy are not evaluated- only gap analyses were used as a performance metric. This simplification was done in recognition that the resulting variances are already captured in the optimization algorithm and resulting rates of coverage are already set according to where they benefit the most in terms of variance reduction and cost.

The catch on each sampled trip was assumed to be known without variance, and a simple single stage estimator of trip variances are used in optimization algorithms. This is a necessary oversimplification. The variances used in this analysis are not the same that will arise from the five-stage sampling design of the observer program (Cahalan et al. 2014). Previous studies have demonstrated that although the vessel was a significant factor in estimating total discards, the first stage of nested sampling designs (vessel or trip) is often, but not always, the stage with the *least* amount of variance (Allen et al. 2002, Borges et al. 2004). More appropriate estimates of variance for each stratum and metric will be used in subsequent analyses when they become available.

Some of the assumptions used in this analysis were adequately addressed through additional analysis while some could not. While regression analysis could be used to estimate the number of voluntary 100% BSAI trawl vessels when fishing Pacific cod in the Bering Sea, there are no such tools or information available to estimate the number of EM boats for 2017. As of 31 August, 2016, the observer program estimates only 30 hook-and-line vessels will participate in EM in 2017. This number is far below the list of 76 vessels used in this analysis, and still further below the 90 hook-and-line boats targeted by the Councils EM Workgroup (NPFMC, 2016). If the number of EM participants in 2017 is below 76, coverage rates for human observation presented here for strata using hook-and-line gear will decrease further. This is because their fishing effort would now be included in the number of fishing trips in the appropriate stratum. A list of vessels participating in EM should be known prior to the November 2016 Council meeting to reduce the uncertainty in the anticipated rates for 2017.

Finally, for all of the reasons already listed in this section, the resulting coverage rates presented in this study should only be considered preliminary estimates that are likely high relative to what will be presented in the final ADP or realized in 2017. Once a stratification design for the final ADP is established, more robust simulated sampling procedures that take true trip duration into account will be used to estimate expected coverage rates following the final 2016 ADP (NMFS 2015b).

While in the 2016 Draft ADP only designs that had above average G scores were forwarded as candidates for the 2016 Final ADP, here all designs are forwarded as potential candidates for the 2017 Final ADP**.** This is in recognition that the observer program has had considerable difficulty in both 1) observing tender vessel trips and 2) trips in the Aleutian Islands where the partial CP HAL stratum vessel trips occur. However, the ‘all inclusive’ seven strata design was the worst performer in terms of gap analyses. If only one either tendering or partial CP HAL were to be included as additional strata beyond the *status quo* Gear (3) stratification scheme, gap analyses show that the Gear × Tender (6) stratification scheme tends to outperform the Gear + partial CP HAL stratification scheme.

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TABLES AND FIGURES

Table 1. -- Comparison of the number of trips in a stratum (N_h), the optimal sample weighting (W_{hopt}), preliminary draft observer coverage rates (r_h) and days observed (d_h) resulting from four stratification schemes and compromise optimal sample allocations.

Stratification Scheme	Stratum (*h*)	N_{h2017}	W_{hopt}	n_h	r_h (%)*	d_h
Compromise Optimal Allocation						
Gear (3)	HAL	2800	0.243	220	7.86	1053
Gear (3)	POT	1162	0.143	137	11.79	488
Gear (3)	TRW	2538	0.614	576	22.7	1963
Gear + Partial CP HAL (4)	HAL	2745	0.236	213	7.76	1011
Gear + Partial CP HAL (4)	POT	1162	0.143	137	11.79	488
Gear + Partial CP HAL (4)	TRW	2538	0.615	576	22.7	1963
Gear + Partial CP HAL (4)	Partial CP HAL	55	0.007	6	10.91	40
Gear x Tender (6)	HAL	2790	0.243	219	7.85	1050
Gear x Tender (6)	Tender HAL	10	0.003	2	20	8
Gear x Tender (6)	POT	979	0.102	96	9.81	331
Gear x Tender (6)	Tender POT	183	0.036	34	18.58	142
Gear x Tender (6)	TRW	2370	0.558	516	21.77	1714
Gear x Tender (6)	Tender TRW	168	0.058	55	32.74	254
Gear x Tender + Partial CP HAL (7)	HAL	2735	0.235	212	7.75	1008
Gear x Tender + Partial CP HAL (7)	Tender HAL	10	0.003	2	20	8
Gear x Tender + Partial CP HAL (7)	POT	979	0.102	96	9.81	331
Gear x Tender + Partial CP HAL (7)	Tender POT	183	0.036	34	18.58	142
Gear x Tender + Partial CP HAL (7)	TRW	2370	0.559	516	21.77	1714
Gear x Tender + Partial CP HAL (7)	Tender TRW	168	0.058	55	32.74	254
Gear x Tender + Partial CP HAL (7)	Partial CP HAL	55	0.007	6	10.91	40

*NOTE: RATES PROVIDED HERE ARE FOR COMPARISON PURPOSES ONLY AND ARE MADE UNDER THE ASSUMPTION THAT EACH TRIP IN A STRATUM IS IDENTICAL IN LENGTH, THAT OBSERVER DEPLOYMENTS ARE PERFECTLY EXECUTED, AND FISHING EFFORT IN 2015 IS EQUIVALENT TO FISHING EFFORT IN 2017.

Table 2. -- Comparison of the number of trips in a stratum (N_h), the optimal sample weighting (W_{hopt}), preliminary draft observer coverage rates (r_h) and days observed (d_h) resulting from four stratification schemes and discarded optimal sample allocations.

Stratification Scheme	Stratum (*h*)	N_{h2017}	W_{hopt}	n_h	r_h (%)*	d_h
Optimal Discarded Groundfish Allocation						
Gear (3)	HAL	2800	0.39	346	12.36	1657
Gear (3)	POT	1162	0.059	52	4.48	185
Gear (3)	TRW	2538	0.551	488	19.23	1663
Gear + Partial CP HAL (4)	HAL	2745	0.377	334	12.17	1586
Gear + Partial CP HAL (4)	POT	1162	0.059	52	4.48	185
Gear + Partial CP HAL (4)	TRW	2538	0.552	488	19.23	1663
Gear + Partial CP HAL (4)	Partial CP HAL	55	0.012	10	18.18	66
Gear x Tender (6)	HAL	2790	0.388	344	12.33	1649
Gear x Tender (6)	Tender HAL	10	0.004	3	30	12
Gear x Tender (6)	POT	979	0.042	37	3.78	128
Gear x Tender (6)	Tender POT	183	0.014	12	6.56	50
Gear x Tender (6)	TRW	2370	0.523	464	19.58	1541
Gear x Tender (6)	Tender TRW	168	0.03	27	16.07	125
Gear x Tender + Partial CP HAL (7)	HAL	2735	0.374	332	12.14	1578
Gear x Tender + Partial CP HAL (7)	Tender HAL	10	0.004	3	30	12
Gear x Tender + Partial CP HAL (7)	POT	979	0.042	37	3.78	128
Gear x Tender + Partial CP HAL (7)	Tender POT	183	0.014	12	6.56	50
Gear x Tender + Partial CP HAL (7)	TRW	2370	0.524	464	19.58	1541
Gear x Tender + Partial CP HAL (7)	Tender TRW	168	0.03	27	16.07	125
Gear x Tender + Partial CP HAL (7)	Partial CP HAL	55	0.012	10	18.18	66

*NOTE: RATES PROVIDED HERE ARE FOR COMPARISON PURPOSES ONLY AND ARE MADE UNDER THE ASSUMPTION THAT EACH TRIP IN A STRATUM IS IDENTICAL IN LENGTH, THAT OBSERVER DEPLOYMENTS ARE PERFECTLY EXECUTED, AND FISHING EFFORT IN 2015 IS EQUIVALENT TO FISHING EFFORT IN 2017.

Table 3. -- Comparison of the number of trips in a stratum (N_h), the optimal sample weighting (W_{hopt}), preliminary draft observer coverage rates (r_h) and days observed (d_h) resulting from four stratification schemes and retained optimal sample allocations.

Stratification Scheme	Stratum (h)	N_{h2017}	W_{hopt}	n_h	r_h (%)*	d_h
Optimal Retained Groundfish Allocation						
Gear (3)	HAL	2800	0.096	94	3.36	450
Gear (3)	POT	1162	0.226	222	19.1	790
Gear (3)	TRW	2538	0.678	664	26.16	2263
Gear + Partial CP HAL (4)	HAL	2745	0.094	92	3.35	437
Gear + Partial CP HAL (4)	POT	1162	0.226	222	19.1	790
Gear + Partial CP HAL (4)	TRW	2538	0.678	664	26.16	2263
Gear + Partial CP HAL (4)	Partial CP HAL	55	0.002	2	3.64	13
Gear x Tender (6)	HAL	2790	0.098	94	3.37	451
Gear x Tender (6)	Tender HAL	10	0.002	2	20	8
Gear x Tender (6)	POT	979	0.162	156	15.93	538
Gear x Tender (6)	Tender POT	183	0.059	57	31.15	238
Gear x Tender (6)	TRW	2370	0.593	569	24.01	1890
Gear x Tender (6)	Tender TRW	168	0.086	83	49.4	384
Gear x Tender + Partial CP HAL (7)	HAL	2735	0.096	92	3.36	437
Gear x Tender + Partial CP HAL (7)	Tender HAL	10	0.002	2	20	8
Gear x Tender + Partial CP HAL (7)	POT	979	0.162	156	15.93	538
Gear x Tender + Partial CP HAL (7)	Tender POT	183	0.059	57	31.15	238
Gear x Tender + Partial CP HAL (7)	TRW	2370	0.593	569	24.01	1890
Gear x Tender + Partial CP HAL (7)	Tender TRW	168	0.086	83	49.4	384
Gear x Tender + Partial CP HAL (7)	Partial CP HAL	55	0.002	2	3.64	13

*NOTE: RATES PROVIDED HERE ARE FOR COMPARISON PURPOSES ONLY AND ARE MADE UNDER THE ASSUMPTION THAT EACH TRIP IN A STRATUM IS IDENTICAL IN LENGTH, THAT OBSERVER DEPLOYMENTS ARE PERFECTLY EXECUTED, AND FISHING EFFORT IN 2015 IS EQUIVALENT TO FISHING EFFORT IN 2017.

Table 4. -- Results of gap analysis for each design and optimal allocation. G scores are the proportion of domains with at least a 50% chance of three (G3) or more or one (G1) or more observed trips during the year. Grelative is the G score of each stratification scheme divided by the maximum. Stratifications are listed in descending order by G3; order by G1 is not always equal to G3 order since the likelihood of having three or more observed trips in a cell sized < 3 is zero.

Stratification scheme	G3	G3 relative	G1	G1 relative
Compromise Optimal Allocation				
Gear (3)	0.66	1.00	0.80	1.00
Gear x Tender (6)	0.57	0.87	0.77	0.96
Gear + Partial CP HAL (4)	0.52	0.80	0.68	0.85
Gear x Tender + Partial CP HAL (7)	0.48	0.73	0.68	0.85
Discard Optimal Allocation				
Gear (3)	0.66	1.00	0.86	1.00
Gear + Partial CP HAL (4)	0.55	0.83	0.80	0.93
Gear x Tender (6)	0.53	0.81	0.83	0.97
Gear x Tender + Partial CP HAL (7)	0.46	0.71	0.79	0.92
Retained Optimal Allocation				
Gear (3)	0.57	1.00	0.69	0.98
Gear x Tender (6)	0.55	0.97	0.70	1.00
Gear x Tender + Partial CP HAL (7)	0.46	0.81	0.61	0.86
Gear + Partial CP HAL (4)	0.45	0.80	0.57	0.81

Table 5. -- The number of trips and the associated likelihood of observing at least one trip within each NMFS Area Stratum combination in the Bering Sea and Aleutian Islands for each of the four stratification schemes compared with Compromise Optimal Allocation. The number of trips in an Area Stratum combination are not whole numbers since some actual fishing trips span more than one NMFS Area.

BSAI Compromise Optimal Allocation					
NMFS Area_Stratum	Trips	Gear (3)	Gear + Partial CP HAL (4)	Gear x Tender (6)	Gear x Tender + Partial CP HAL (7)
509_POT	120.50			1.00	1.00
509_POT	131.83	1.00	1.00		
509_Tender_POT	11.33			0.90	0.90
509_TRW	129.83	1.00	1.00	1.00	1.00
513_HAL	5.50	0.39	0.38	0.39	0.38
513_TRW	0.50	0.23	0.23	0.22	0.22
514_HAL	9.00	0.52	0.52	0.52	0.52
516_TRW	1.83	0.40	0.40	0.39	0.39
517_HAL	8.92	0.52	0.52	0.52	0.52
517_POT	60.50			1.00	1.00
517_POT	63.83	1.00	1.00		
517_Tender_POT	3.33			0.46	0.46
517_TRW	145.00	1.00	1.00	1.00	1.00
518_HAL	34.92		0.94		0.94
518_HAL	36.25	0.95		0.95	
518_Partial_CP_HAL	1.33		0.11		0.11
518_POT	24.00	0.95	0.95	0.92	0.92
519_HAL	57.17	0.99	0.99	0.99	0.99
519_POT	248.00			1.00	1.00
519_POT	254.00	1.00	1.00		
519_Tender_POT	6.00			0.71	0.71
519_TRW	33.83	1.00	1.00	1.00	1.00
521_HAL	18.92	0.79	0.79	0.79	0.79
523_HAL	7.08	0.44	0.43	0.44	0.43
524_HAL	9.50	0.56	0.55	0.56	0.55
541_HAL	54.17		0.99		0.99
541_HAL	72.33	1.00		1.00	
541_Partial_CP_HAL	18.17		0.92		0.92
541_POT	3.00	0.31	0.31	0.27	0.27
542_HAL	14.83		0.70		0.70
542_HAL	31.50	0.93		0.93	
542_Partial_CP_HAL	16.67		0.90		0.90
543_HAL	1.83		0.15		0.15
543_HAL	4.67	0.34		0.34	
543_Partial_CP_HAL	2.83		0.30		0.30

Table 6. -- The number of trips and the associated likelihood of observing at least one trip within each NMFS Area Stratum combination in the Gulf of Alaska for each of the four stratification schemes compared with Compromise Optimal Allocation. The number of trips in an Area Stratum combination are not whole numbers since some actual fishing trips span more than one NMFS Area.

GOA Compromise Optimal Allocation					
NMFS Area_Stratum	Trips	Gear (3)	Gear + Partial CP HAL (4)	Gear x Tender (6)	Gear x Tender + Partial CP HAL (7)
610_HAL	211.50	1.00	1.00	1.00	1.00
610_POT	190.00			1.00	1.00
610_POT	264.83	1.00	1.00		
610_Tender_POT	74.83			1.00	1.00
610_Tender_TRW	154.50			1.00	1.00
610_TRW	414.50			1.00	1.00
610_TRW	569.00	1.00	1.00		
620_HAL	171.00				1.00
620_HAL	172.00			1.00	
620_HAL	175.50		1.00		
620_HAL	176.50	1.00			
620_Partial_CP_HAL	1.00		0.11		0.11
620_POT	42.00			0.99	0.99
620_POT	82.00	1.00	1.00		
620_Tender_HAL	4.50			0.73	0.73
620_Tender_POT	40.00			1.00	1.00
620_Tender_TRW	13.50			1.00	1.00
620_TRW	770.00			1.00	1.00
620_TRW	783.50	1.00	1.00		
630_HAL	1048.50				1.00
630_HAL	1051.00		1.00		
630_HAL	1052.50			1.00	
630_HAL	1055.00	1.00			
630_Partial_CP_HAL	4.00		0.38		0.38
630_POT	291.00			1.00	1.00
630_POT	338.50	1.00	1.00		
630_Tender_HAL	2.50			0.49	0.49
630_Tender_POT	47.50			1.00	1.00
630_TRW	872.50	1.00	1.00	1.00	1.00
640_HAL	201.83		1.00		1.00
640_HAL	206.83	1.00		1.00	
640_Partial_CP_HAL	5.00		0.45		0.45
640_TRW	2.00	0.40	0.40	0.39	0.39
649_HAL	105.50		1.00		1.00
649_HAL	109.50	1.00		1.00	
649_Partial_CP_HAL	4.00		0.38		0.38
650_HAL	506.33				1.00
650_HAL	507.33		1.00		
650_HAL	508.33			1.00	
650_HAL	509.33	1.00			
650_Partial_CP_HAL	2.00		0.21		0.21
650_Tender_HAL	1.00			0.20	0.20
659_HAL	268.50			1.00	1.00
659_HAL	270.50	1.00	1.00		
659_Tender_HAL	2.00			0.38	0.38

Table 7. -- The number of trips and the associated likelihood of observing at least one trip within each NMFS Area Stratum combination in the Bering Sea and Aleutian Islands for each of the four stratification schemes compared with Discard Optimal Allocation. The number of trips in an Area Stratum combination are not whole numbers since some actual fishing trips span more than one NMFS Area.

BSAI Discard Optimal Allocation					
NMFS Area_Stratum	Trips	Gear (3)	Gear + Partial CP HAL (4)	Gear x Tender (6)	Gear x Tender + Partial CP HAL (7)
509_POT	120.50			0.99	0.99
509_POT	131.83	1.00	1.00		
509_Tender_POT	11.33			0.54	0.54
509_TRW	129.83	1.00	1.00	1.00	1.00
513_HAL	5.50	0.55	0.54	0.55	0.54
513_TRW	0.50	0.19	0.19	0.20	0.20
514_HAL	9.00	0.70	0.69	0.69	0.69
516_TRW	1.83	0.35	0.35	0.35	0.35
517_HAL	8.92	0.70	0.69	0.69	0.69
517_POT	60.50			0.91	0.91
517_POT	63.83	0.95	0.95		
517_Tender_POT	3.33			0.19	0.19
517_TRW	145.00	1.00	1.00	1.00	1.00
518_HAL	34.92		0.99		0.99
518_HAL	36.25	0.99		0.99	
518_Partial_CP_HAL	1.33		0.18		0.18
518_POT	24.00	0.67	0.67	0.61	0.61
519_HAL	57.17	1.00	1.00	1.00	1.00
519_POT	248.00			1.00	1.00
519_POT	254.00	1.00	1.00		
519_Tender_POT	6.00			0.34	0.34
519_TRW	33.83	1.00	1.00	1.00	1.00
521_HAL	18.92	0.92	0.92	0.92	0.92
523_HAL	7.08	0.60	0.60	0.60	0.60
524_HAL	9.50	0.73	0.73	0.73	0.73
541_HAL	54.17		1.00		1.00
541_HAL	72.33	1.00		1.00	
541_Partial_CP_HAL	18.17		0.99		0.99
541_POT	3.00	0.13	0.13	0.11	0.11
542_HAL	14.83		0.86		0.86
542_HAL	31.50	0.99		0.99	
542_Partial_CP_HAL	16.67		0.98		0.98
543_HAL	1.83		0.23		0.23
543_HAL	4.67	0.48		0.48	
543_Partial_CP_HAL	2.83		0.46		0.46

Table 8. -- The number of trips and the associated likelihood of observing at least one trip within each NMFS Area Stratum combination in the Gulf of Alaska for each of the four stratification schemes compared with Discard Optimal Allocation. The number of trips in an Area Stratum combination are not whole numbers since some actual fishing trips span more than one NMFS Area.

GOA Discard Optimal Allocation					
NMFS Area_Stratum	Trips	Gear (3)	Gear + Partial CP HAL (4)	Gear x Tender (6)	Gear x Tender + Partial CP HAL (7)
610_HAL	211.50	1.00	1.00	1.00	1.00
610_POT	190.00			1.00	1.00
610_POT	264.83	1.00	1.00		
610_Tender_POT	74.83			1.00	1.00
610_Tender_TRW	154.50			1.00	1.00
610_TRW	414.50			1.00	1.00
610_TRW	569.00	1.00	1.00		
620_HAL	171.00				1.00
620_HAL	172.00			1.00	
620_HAL	175.50		1.00		
620_HAL	176.50	1.00			
620_Partial_CP_HAL	1.00		0.18		0.18
620_POT	42.00			0.81	0.81
620_POT	82.00	0.98	0.98		
620_Tender_HAL	4.50			0.88	0.88
620_Tender_POT	40.00			0.95	0.95
620_Tender_TRW	13.50			0.92	0.92
620_TRW	770.00			1.00	1.00
620_TRW	783.50	1.00	1.00		
630_HAL	1048.50				1.00
630_HAL	1051.00		1.00		
630_HAL	1052.50			1.00	
630_HAL	1055.00	1.00			
630_Partial_CP_HAL	4.00		0.56		0.56
630_POT	291.00			1.00	1.00
630_POT	338.50	1.00	1.00		
630_Tender_HAL	2.50			0.66	0.66
630_Tender_POT	47.50			0.98	0.98
630_TRW	872.50	1.00	1.00	1.00	1.00
640_HAL	201.83		1.00		1.00
640_HAL	206.83	1.00		1.00	
640_Partial_CP_HAL	5.00		0.65		0.65
640_TRW	2.00	0.35	0.35	0.35	0.35
649_HAL	105.50		1.00		1.00
649_HAL	109.50	1.00		1.00	
649_Partial_CP_HAL	4.00		0.56		0.56
650_HAL	506.33				1.00
650_HAL	507.33		1.00		
650_HAL	508.33			1.00	
650_HAL	509.33	1.00			
650_Partial_CP_HAL	2.00		0.33		0.33
650_Tender_HAL	1.00			0.30	0.30
659_HAL	268.50			1.00	1.00
659_HAL	270.50	1.00	1.00		
659_Tender_HAL	2.00			0.53	0.53

Table 9. -- The number of trips and the associated likelihood of observing at least one trip within each NMFS Area Stratum combination in the Bering Sea and Aleutian Islands for each of the four stratification schemes compared with Retained Optimal Allocation. The number of trips in an Area Stratum combination are not whole numbers since some actual fishing trips span more than one NMFS Area.

BSAI Retained Optimal Allocation					
NMFS Area_Stratum	Trips	Gear (3)	Gear + Partial CP HAL (4)	Gear x Tender (6)	Gear x Tender + Partial CP HAL (7)
509_POT	120.50			1.00	1.00
509_POT	131.83	1.00	1.00		
509_Tender_POT	11.33			0.99	0.99
509_TRW	129.83	1.00	1.00	1.00	1.00
513_HAL	5.50	0.19	0.19	0.19	0.19
513_TRW	0.50	0.26	0.26	0.24	0.24
514_HAL	9.00	0.26	0.26	0.27	0.27
516_TRW	1.83	0.45	0.45	0.42	0.42
517_HAL	8.92	0.26	0.26	0.27	0.27
517_POT	60.50			1.00	1.00
517_POT	63.83	1.00	1.00		
517_Tender_POT	3.33			0.68	0.68
517_TRW	145.00	1.00	1.00	1.00	1.00
518_HAL	34.92		0.70		0.70
518_HAL	36.25	0.71		0.71	
518_Partial_CP_HAL	1.33		0.04		0.04
518_POT	24.00	0.99	0.99	0.99	0.99
519_HAL	57.17	0.86	0.86	0.86	0.86
519_POT	248.00			1.00	1.00
519_POT	254.00	1.00	1.00		
519_Tender_POT	6.00			0.90	0.90
519_TRW	33.83	1.00	1.00	1.00	1.00
521_HAL	18.92	0.48	0.48	0.48	0.48
523_HAL	7.08	0.21	0.21	0.21	0.21
524_HAL	9.50	0.29	0.29	0.29	0.29
541_HAL	54.17		0.84		0.85
541_HAL	72.33	0.92		0.92	
541_Partial_CP_HAL	18.17		0.55		0.55
541_POT	3.00	0.47	0.47	0.41	0.41
542_HAL	14.83		0.40		0.40
542_HAL	31.50	0.67		0.67	
542_Partial_CP_HAL	16.67		0.53		0.53
543_HAL	1.83		0.07		0.07
543_HAL	4.67	0.16		0.16	
543_Partial_CP_HAL	2.83		0.11		0.11

Table 10. -- The number of trips and the associated likelihood of observing at least one trip within each NMFS Area Stratum combination in the Gulf of Alaska for each of the four stratification schemes compared with Retained Optimal Allocation. The number of trips in an Area Stratum combination are not whole numbers since some actual fishing trips span more than one NMFS Area.

GOA Retained Optimal Allocation					
NMFS Area_Stratum	Trips	Gear (3)	Gear + Partial CP HAL (4)	Gear x Tender (6)	Gear x Tender + Partial CP HAL (7)
610_HAL	211.50	1.00	1.00	1.00	1.00
610_POT	190.00			1.00	1.00
610_POT	264.83	1.00	1.00		
610_Tender_POT	74.83			1.00	1.00
610_Tender_TRW	154.50			1.00	1.00
610_TRW	414.50			1.00	1.00
610_TRW	569.00	1.00	1.00		
620_HAL	171.00				1.00
620_HAL	172.00			1.00	
620_HAL	175.50		1.00		
620_HAL	176.50	1.00			
620_Partial_CP_HAL	1.00		0.04		0.04
620_POT	42.00			1.00	1.00
620_POT	82.00	1.00	1.00		
620_Tender_HAL	4.50			0.73	0.73
620_Tender_POT	40.00			1.00	1.00
620_Tender_TRW	13.50			1.00	1.00
620_TRW	770.00			1.00	1.00
620_TRW	783.50	1.00	1.00		
630_HAL	1048.50				1.00
630_HAL	1051.00		1.00		
630_HAL	1052.50			1.00	
630_HAL	1055.00	1.00			
630_Partial_CP_HAL	4.00		0.14		0.14
630_POT	291.00			1.00	1.00
630_POT	338.50	1.00	1.00		
630_Tender_HAL	2.50			0.49	0.49
630_Tender_POT	47.50			1.00	1.00
630_TRW	872.50	1.00	1.00	1.00	1.00
640_HAL	201.83		1.00		1.00
640_HAL	206.83	1.00		1.00	
640_Partial_CP_HAL	5.00		0.18		0.18
640_TRW	2.00	0.45	0.45	0.42	0.42
649_HAL	105.50		0.97		0.98
649_HAL	109.50	0.98		0.98	
649_Partial_CP_HAL	4.00		0.14		0.14
650_HAL	506.33				1.00
650_HAL	507.33		1.00		
650_HAL	508.33			1.00	
650_HAL	509.33	1.00			
650_Partial_CP_HAL	2.00		0.07		0.07
650_Tender_HAL	1.00			0.20	0.20
659_HAL	268.50			1.00	1.00
659_HAL	270.50	1.00	1.00		
659_Tender_HAL	2.00			0.38	0.38

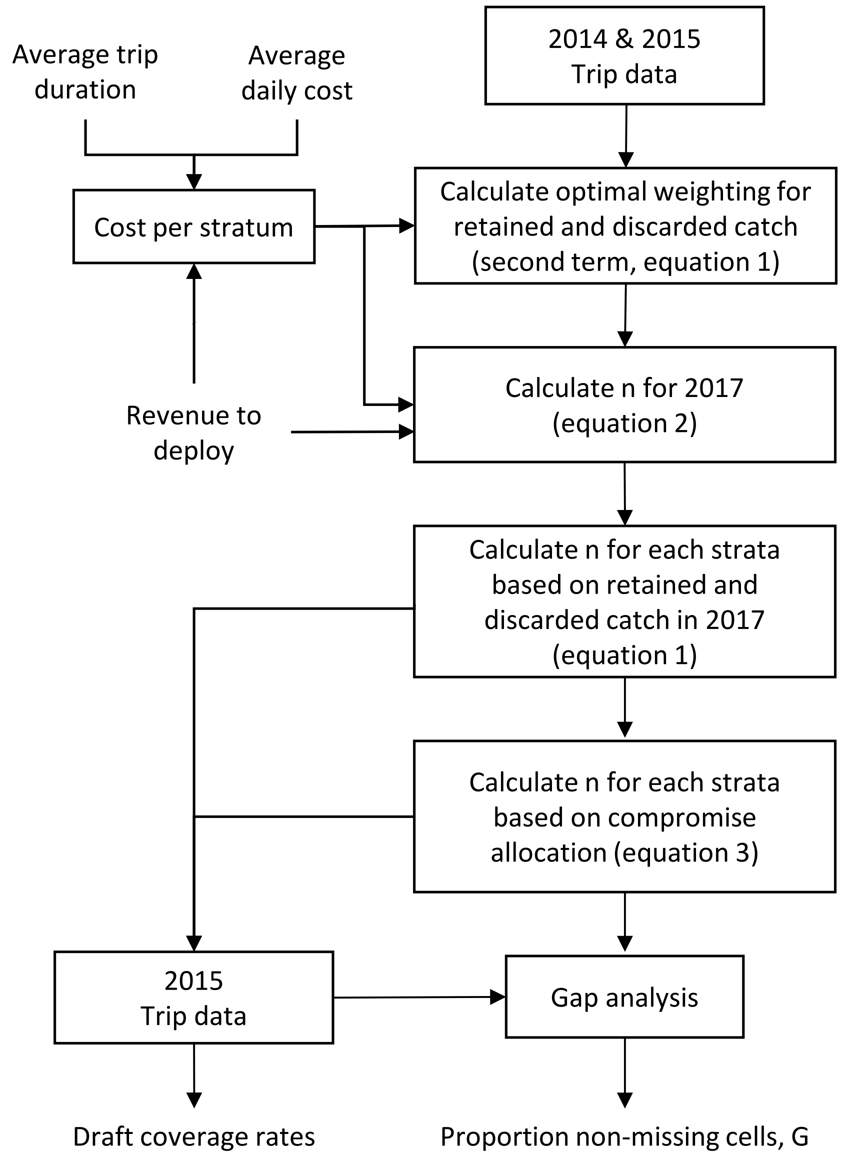

Figure 1. -- Flow chart depicting methods used in this analysis for each stratification scheme under consideration for the 2017 ADP.

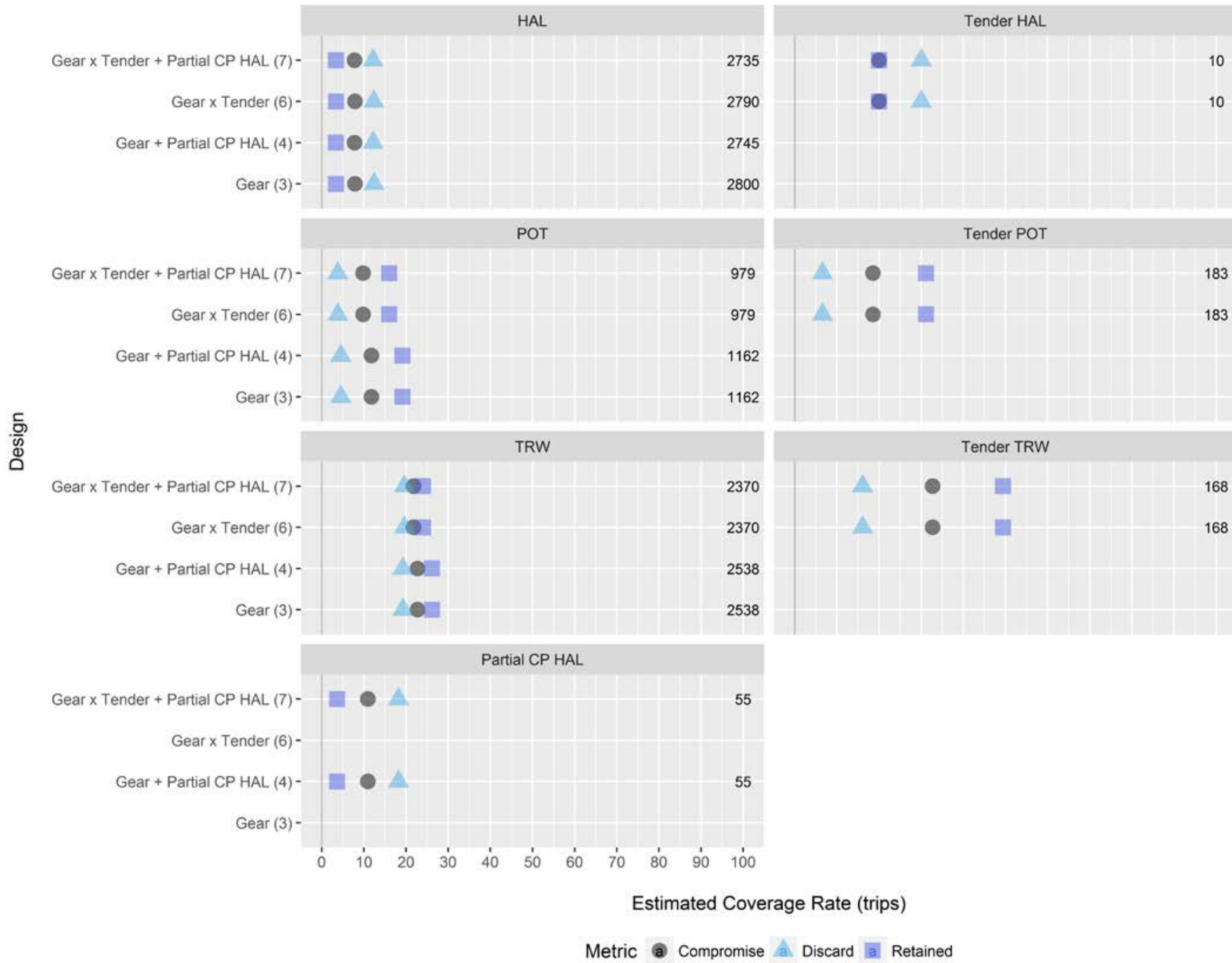

Figure 2. -- Comparison of preliminary draft coverage rates resulting from four stratification schemes and discarded, retained, and compromise optimal sample allocations. Vertical bars denote zero and 100 % values. Values to the right of 100 depict the number of trips in a stratum.

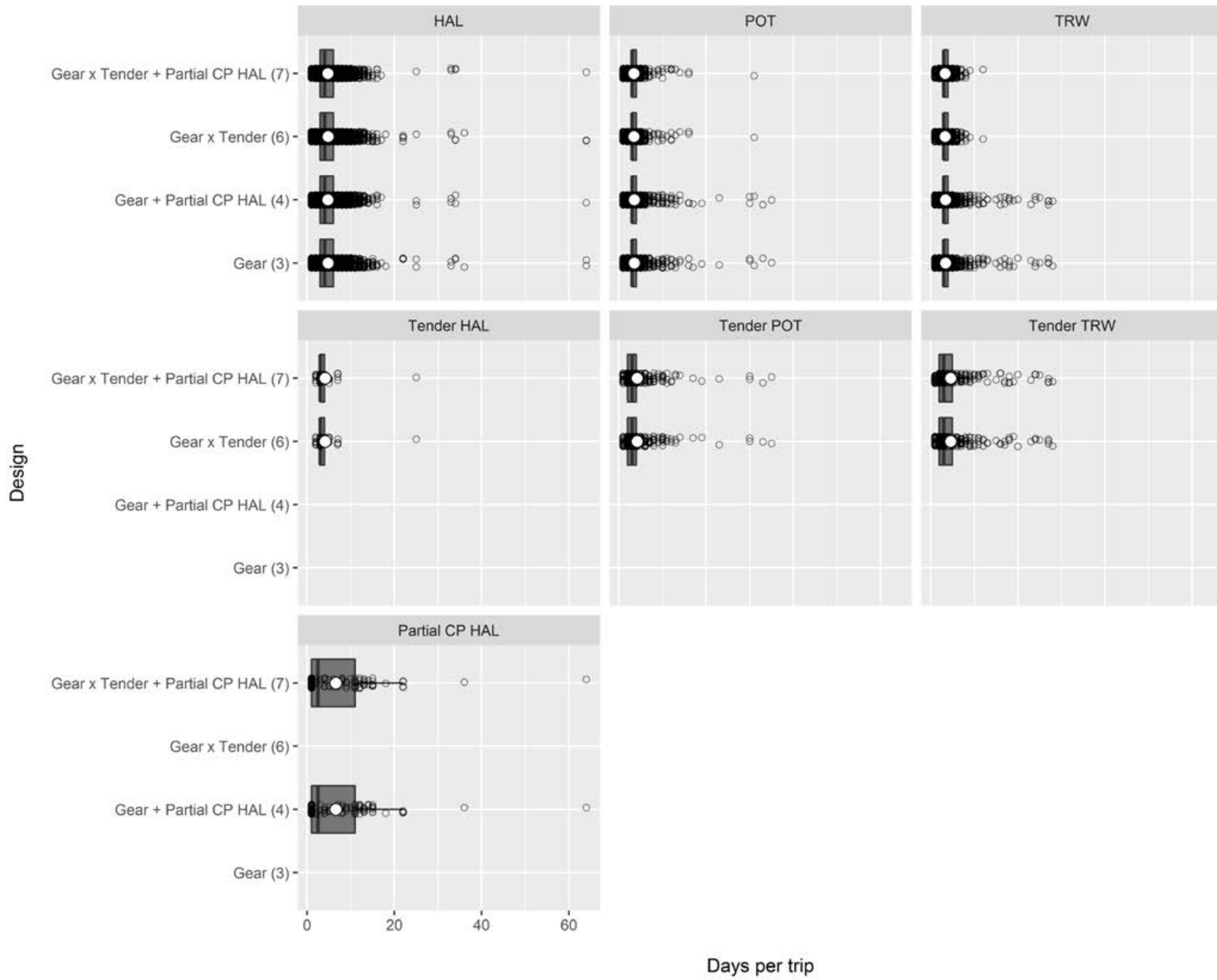

Figure 3. -- Distribution of trip duration in days for each stratum in four stratification schemes. Mean trip durations are denoted by white circles while shaded boxes denote the 25th, 50th, and 75th percentiles. Individual trip durations are denoted as open circles.

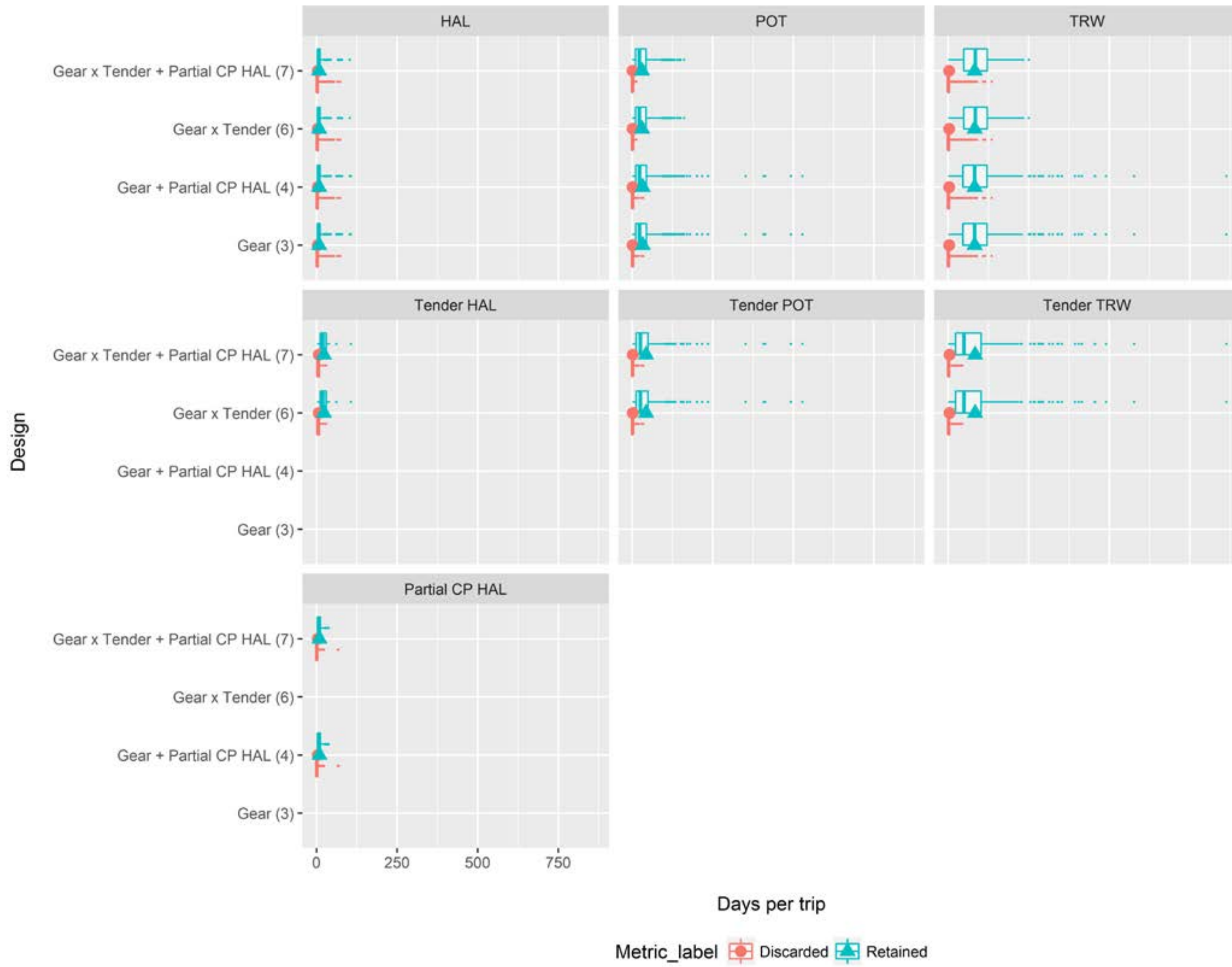

Figure 4.-- Distribution of catches of total discarded and total retained groundfish for each stratum in four stratification schemes. Mean trip catches are denoted by filled circles or triangles while boxes denote the 25th, 50th, and 75th percentiles. Trip catches outside of the 25th and 75th percentiles are shown as small dots

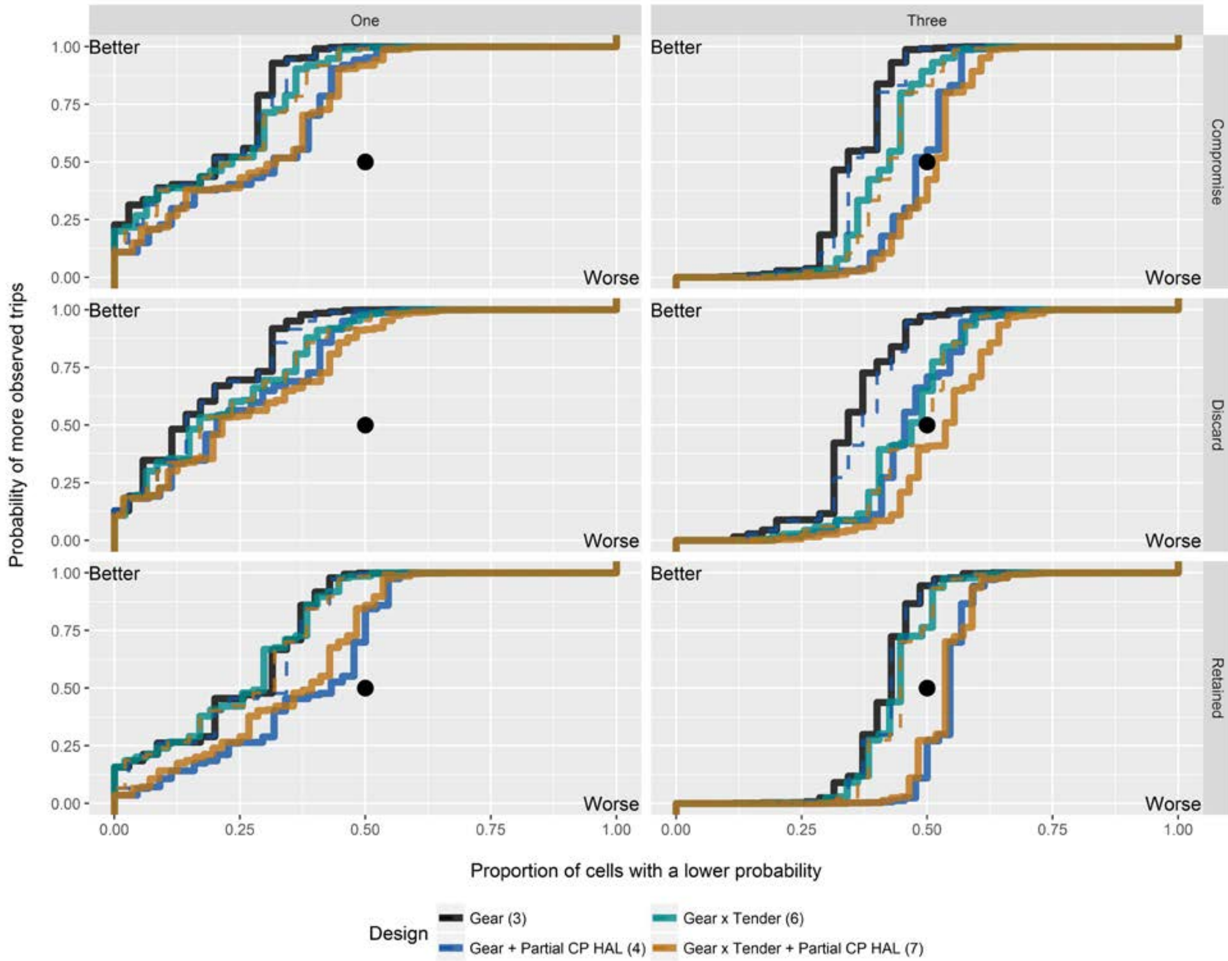

Figure 5.-- Empirical cumulative distribution curves for the probability of obtaining at least one (left column) and three (right column) trips in a domain defined by NMFS Area and stratum from four stratification schemes and allocations based on retained, discarded, and both of these metrics (=compromise, depicted as rows). Better performing stratification schemes are those that reach a value of 1 furthest to the left of the plot. Relatively poor performance is caused by the Partial CP HAL stratum- dashed lines denote when this stratum's fishing is removed.

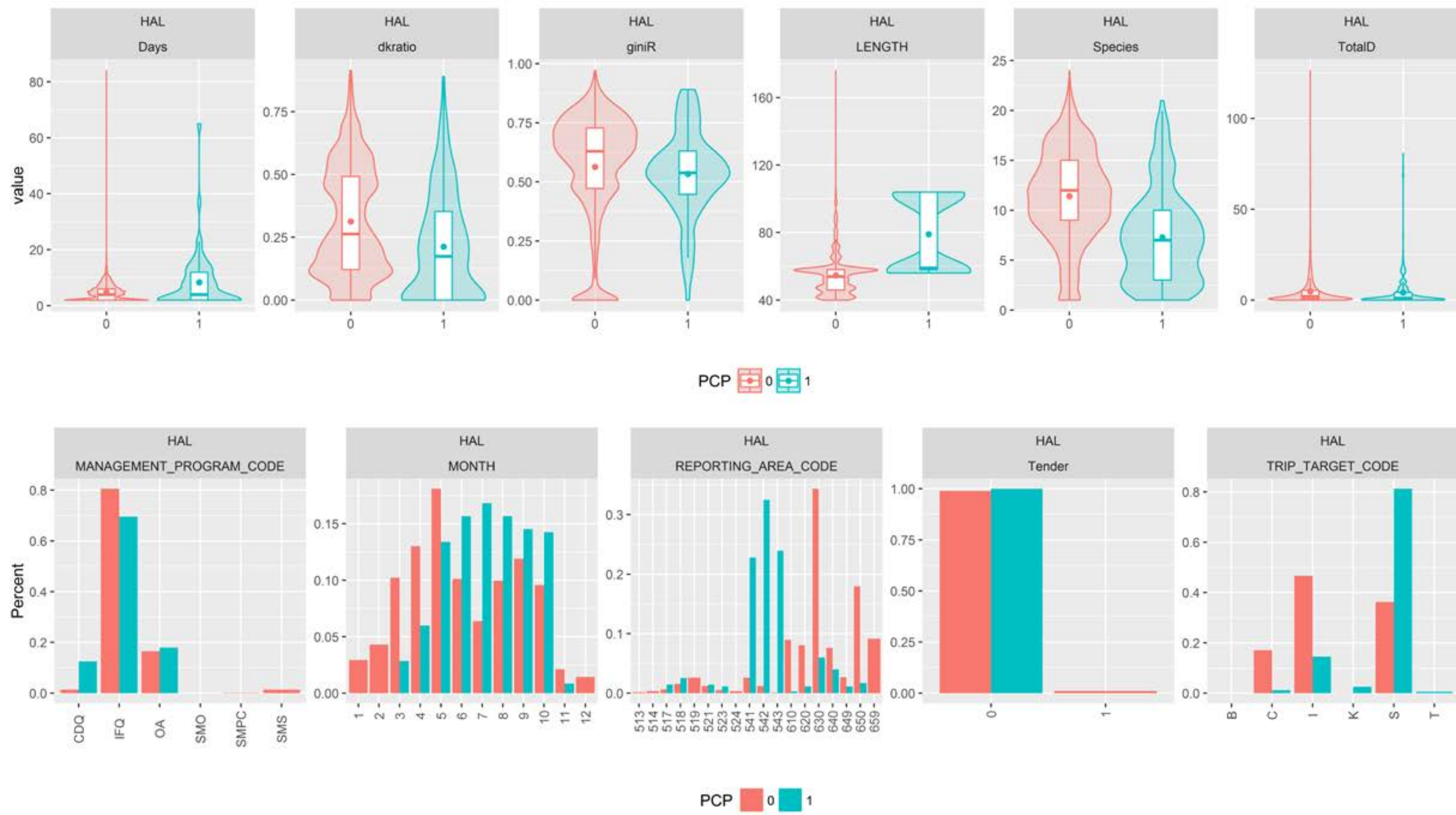

Figure 6.-- Comparisons between the trip catch metrics (top panels) and the fishing factors (bottom panels) of partial CP HAL vessels (PCP = 1) and non-partial CP vessels that fished with hook-and-line. Although partial CP vessels also fished with pot gear, only two vessels did so during 2014-2015 so their data is considered confidential and a pursuit of this activity as a separate stratum was not conducted. HAL = hook-and-line; Days = Days fished in a trip; dkratio = ratio between discarded weight and total weight; giniR = Gini index on retained catch measured over retained species (a value of 1 is perfect equality while a value of zero is perfect inequality); LENGTH = vessel length overall; Species = number of species in the total catch; TotalD = Total weight of discarded catch; Management Program Codes: CDQ = Community Development Quota, IFQ = Individual Fishing Quota, OA = Open Access, SMO = State Managed Other, SMPC = State Managed Pacific Cod, SMS = State Managed Sablefish; Month = calendar month where 1 = January; Tender = did the trip tender (= 1) or not (=0); Trip Target Codes: C = Pacific cod, I = Halibut, K = Rockfish, S = Sablefish, T = Turbot.

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