How the partial coverage pool (subject to human observation) changes as vessels are removed to implement electronic observation in the North Pacific[1]

Introduction

The NPFMC's EM Workgroup is considering expanding the pool of vessels eligible to participate in EM pre-implementation for 2017. There are plans by the EM workgroup, supported by the Council, to widen the EM pool in 2017 to 90 vessels in the Hook and Line fleet and to 30 vessels in the Pot fleet.[2] To obtain EM coverage, the EM workgroup plans to purchase 44 new control boxes in the Hook and Line (to a total of 60 control boxes) fleet and 15 control boxes for the Pot fleet (for a total of 30 control boxes)[3].

Current NMFS policy (as specified in past and current ADPs) is that any vessel that volunteers for EM is exempted from human observation. The purpose of this analysis is to inform the Council's EM Workgroup at their July 2016 meeting of the potential implications of expanding the pool of vessels eligible for EM since those vessels would no longer be subject to human observation. The analysis that follows is focused on evaluating the potential impacts to total catch accounting for in-season quota management that currently relies on data from human observation of fishing operations. The impact of EM expansion on this important management tool in the North Pacific depends upon whether or not data from EM vessels is used for this purpose.

Methods

Database

A special database for the evaluation of observer deployment resulting from past Annual Deployment Plans was utilized for this exercise. Briefly, this database combines data from the AKRO's CAS and the AFSC Observer Program Database NORPAC and *e*Landings information to associate observer deployment strata and coverage with past fishing trips. Data corresponding to the most recent full year of fishing (2015) belonging to partial-coverage strata of the 2016 ADP was used in this analysis (broadly speaking these include: Trawl, Hook and Line, and Pot Gear > 40'). An EM vessel list was generated from each vessel that had volunteered at any time during 2015 and January 1st to July 25th, 2016 *excepting* those that had indicated to the AFSC/FMA that they would not be participating in EM during 2017. Fishing trips undertaken by vessels in the EM list were labelled as EM trips. Trips were aggregated into "cells" defined by observer deployment strata, NMFS Area, and trip target code. Trip target codes are defined by CAS by the predominant species landed after fishing has occurred, and so not necessarily reflect what the fishermen intended to catch.

[1] Prepared by C. Faunce (Alaska Fisheries Science Center, Division of Fisheries Monitoring and Analysis) for AFSC/FMA Director C. Rilling and presented to EM workgroup July 27th, 2016.
[2] http://www.npfmc.org/wp-content/PDFdocuments/conservation_issues/Observer/EM/EMmotion0216.pdf
[3] http://www.npfmc.org/wp-content/PDFdocuments/conservation_issues/Observer/EM/Revised_EM_ImplementationPlan_Budget.pdf

Scenarios

Here three scenarios are evaluated for comparison. In the first, called the Control scenario, there are no EM trips and the entire strata are subject to human observer coverage. In the second, called the Experimental scenario, all trips undertaken by the EM vessels are subject to EM coverage and the remainder are subject to human observer coverage. In this second scenario, it is assumed that resulting EM data is used in catch accounting (i.e. the expected case for 2018). The third scenario, called the Experimental No EM scenario, is identical to the second scenario with the exception that it is assumed that no resulting EM *data* (not to be confused with not carrying EM) is used for catch estimation. This scenario was the case for 2015-2016 and may be expected for 2017. The terms Control and Experimental come from statistical terminology, and should not be confused with EM as an experiment- it is assumed here that EM is currently in pre-implementation and is scheduled for full implementation as part of the 2018 ADP. Trawl data were not included in analyses since there is no expected change among scenarios for this 2016 Strata with EM implementation.

Metrics

In each scenario, the metric of interest is a measure of resulting data gaps for catch accounting. Specifically, following similar analysis in Observer Program Annual Reports, the probability associated with having at least *X* trips observed with a human in a cell was calculated since in all scenarios it is assumed that where no EM-derived data exist, estimates resulting from human-derived data are used in catch estimation, which has been the case to date. The probability estimated is derived from the hypergeometric distribution and depends upon the total number of trips in the strata, the total number of human observed trips in the strata, the number of trips in a cell, and the number of human observed trips in a cell. This last metric was calculated from the product of the stratum-specific deployment rate in the 2016 ADP and the number of trips in a cell, rounded to the nearest whole number. This method is a simplification since it assumes perfect deployment of observers into all cells, but should reflect the mean expected condition had simulations of observer deployment been conducted. Unlike Observer Program Annual Reports where the focus has been on catch and associated variance, here *X* is defined as zero trips, and is denoted as p0, since it represents the true impact (no human observer coverage) and its inverse represents the minimum needed to generate catch estimates (human observed trips greater than zero).

Data were summarized to highlight three aspects of impact to the human observer pool through EM participation: 1) potential magnitude of impact, 2) susceptibility to impact, and 3) relative risk of impact.

The potential magnitude of change was evaluated in three ways. First, the p0 resulting from the Control scenario was compared to that of the Experimental scenario for each cell and expressed as a percent change; [(Experimental - Control) / Control] * 100. Second, the expected proportion of cells subject to human observer coverage in each cell was compared for each scenario. Finally, the cumulative distributions of p0 was plotted as a function of the total number of trips in a cell. These cumulative distributions were used to determine how the distribution of cell size changes and to determine the overall proportion of total cells in Control and Experimental scenarios that had p0 values greater than 0.5. This threshold value of 0.5 represents an equal chance of having zero or at least one human observed trip in a cell. Cells with p0 values > 0.5 were deemed particularly susceptible to changes in their composition as a consequence of implementing EM since the total number of trips in that cell can

only be reduced thereby increasing the p0 for the remaining trips subject to the chance of human observation.

The metric p0 represents a likelihood of no observer coverage in a cell, whereas the potential magnitude of impact by having no observer coverage is represented by the total number of trips in a cell. The product of p0 and the total number of trips in a cell were used to generate a metric of risk of impact since risk is comprised not only of the severity of impact but also of its likelihood of happening. Cells with risk values in the top third of all non-zero risk values for each stratum were labelled as "risk prone".

Simulations

The impact to the human observer pool of vessels with expanded number of EM vessels was investigated through simulated sampling. The Experimental scenario described so far was used as the base scenario from which further expansions the EM pool were made. Simulations were performed for nine increasing increments in sample size to the EM workgroups considered expansions to 90 Hook and line vessels and 30 Pot vessels. In each simulation, the number of EM vessels was expanded from the base condition by an increment number of vessels in each stratum, and a random selection of vessels remaining in the human observer pool was made. All trips associated with these additional vessels were labelled as EM, and removed from the human observer pool. Metrics and summaries follow those described already.

Results

There were 76 unique vessels that participated in EM research and pre-implementation during 2015 and 2016 or indicated they would do so in 2017. Partial coverage rates in 2016 for human observation were set at 15.24% for Pot, 15.41% for Hook and Line gear and 28.31% for Trawl gear. The number of EM boats in this list represented 12.4% and 2.8% of the Hook and Line and Pot gear vessels that fished in 2015 respectively (Note that EM was not intended to be deployed on Pot gear during this time, so these are likely underestimates for 2017).

The p0 declines sharply for cell sizes between one and 20 trips at the sampling rates present in 2015 (Figure 1). Changes to the distribution of cell sizes between no-EM (Control) and EM (Experimental) scenarios are evident in Hook and Line in cells as small as ten trips but are not observed in Pot gear at cell sizes < 25 (Figure 1). Cells with p0 values > 0.5 were confined to those with total trips less than 7 for Hook and Line and 5 for Pot (Figure 1, Table 1). Roughly 13 and 20% of cells were identified as "vulnerable" in the Hook and Line and Pot gears respectively, however no EM vessels fished in these areas during 2015 (Table 1, Table 2).

The relative changes between p0 values of the no-EM (Control) and EM (Experimental) scenarios is depicted in Figure 2. While large changes in the percent difference in p0 were evident, with only one exception - the Hook and line halibut 514 (BSAI Western Alaska)- these resulted from relatively large changes in very small values of p0 (Figure 2).

The relative risk to changes in human observer coverage is illustrated for each cell in Figure 3. Ten of 47 unique cells were either susceptible cells or had mean risk values in the top third. All but one of these ten cells - (i. e. hook and line Cod in 610 (E. GOA) - had fewer than ten trips in them resulting in relatively high p0 values. Sablefish fishing in NMFS area 519 (Unalaska BSAI) was the most risk prone cell.

The Experimental no EM data scenario had greater risk values than the Control or Experimental scenarios with only one exception (Figure 3, Table 3). This is because the total number of trips for which estimates are needed are smallest for the Experimental scenario and are the same for the Control and Experimental No EM scenario while as the same time the number of observed trips expected is greatest for the Control scenario and the same between both Experimental scenarios. Consequently the proportion of the total cells expected to carry observer coverage is lowest for the Experimental no EM scenario, since in this scenario the amount of trips subject to human coverage is diminished by implementing EM, although estimates for all trips in the cell (human and EM) are still required to be made (from the remaining human observed vessels). The relative differences in cell-specific coverage values is demonstrated in Figure 4.

The number of EM vessels included in simulations was steadily increased at three vessel increments from baseline levels until 92 hook and line and 30 Pot vessels were included (Table 4). What these vessels represent in terms of the proportion of the total number of vessels that fish in each gear type differ substantially between gear types (Figure 5). For example, having 16 EM vessels in Pot gear is roughly equivalent to 78 vessels in Hook and Line gear.

The distribution of cell sizes change as more vessels are added to EM and removed from human observation. The changes are less evident among iterations in Hook and line than they are for Pot gear since the removal of three vessels represents a larger proportion of the total for the latter 2016 strata (Figure 6). For the same reason changes in the cell coverage rate associated with removing vessels from human observation is more dramatic among iterations for the Pot gear than for Hook and line gear (Figure 7). While the median coverage rate remained close to the expected coverage rate in the Control and Experimental scenarios, substantial drops in this metric were observed in the Experimental no EM scenario. For example, the interquartile ranges for the Experimental no EM scenario stop overlapping the other scenarios when > 80 Hook and line EM vessels are included and > 9 Pot vessels are included.

Concluding comments

- The majority of susceptible or risk prone cells exist in the BSAI due to small NMFS Areas and relatively sparse fishing activities. Since the impact to these cells is unknown and can be dramatic, **it is recommended that EM be limited to vessels fishing in the Gulf of Alaska for 2017.**

- The impacts of EM implementation in Pot gear is especially unclear since this activity has been very limited to date. That 20% of the cells are vulnerable is concerning. Since the impacts to vulnerable cells is comparatively great to that of cells where more fishing occurs, **it is recommended that EM expansion not include vessels that intend to fish within the cells listed in Table 2.**

- Since the definition of cells that are considered vulnerable can be changed and will change in time**, it is recommended that the NMFS attempt to address alternative post-stratifications (which may already exist) to reduce the number of vulnerable cells.**

- This analysis assumes that fishing effort in 2017 will be identical to fishing effort in 2015 and that coverage rates in 2017 and beyond will be at least as high in the Hook and Line and Pot gears as in the 2016 ADP. Even with *perfect deployment* (which has not been demonstrated in 2013-2015 Annual Reports) expansion of EM reduces observer coverage in the expected

situation where EM data is not used in quota management for 2017. This lack of data increases the multiplier (1/coverage rate) of human observer data (that is, each observed trip represents more unobserved trips). Without any expansion of the EM pool from current levels, human coverage rates without EM data drop to 12-13%. For this reason, and since the interquartile ranges for the Experimental no EM scenario stop overlapping the other scenarios when > 80 Hook and line EM vessels are included and > 9 Pot vessels are included, **it is recommended that coverage rates in 2017 ADP be at least 15% for hook and line and pot gear strata, and that EM should not be greatly expanded in 2017. Should expansion be pursued and possible given volunteers, then expansion beyond 80 hook and line vessels and 6 pot vessels is not recommended for 2017. When EM data can be used in lieu of data from human observers, this recommendation should be re-evaluated.**

- (Relating to future ADPs not examined here) The current deployment method used for EM pre-implementation is similar to vessel selection methods in the 2013 and 2014 ADP. However, it appears that selection rates were set on a pre-determined rate (30%). This is different from a more efficient approach that utilizes all available units. It would be better to have rates set by the ratio of the number of available units in a time period to the number of vessels expected to fish in that time period. This is how vessel selection rates were set in past ADPs. For example, if ten EM control boxes and ten EM camera systems are available, then one can deploy EM onto ten vessels. The sampling rates should be determined by dividing ten by the number of vessels that pre-register to fish in a time period. If 100 vessels register, then the sampling rate = 10 / 100 = 10%, if twenty vessels register then the sampling rate = 10 / 20 = 0.5 (50%). If nine vessels register, than 10 / 9 = 1.1 = all vessels are equipped with EM. When separate time period strata are used, it is not important to have the same sampling rate within each time period. Instead, it is important that vessels belong to one, and only one strata during that time period.

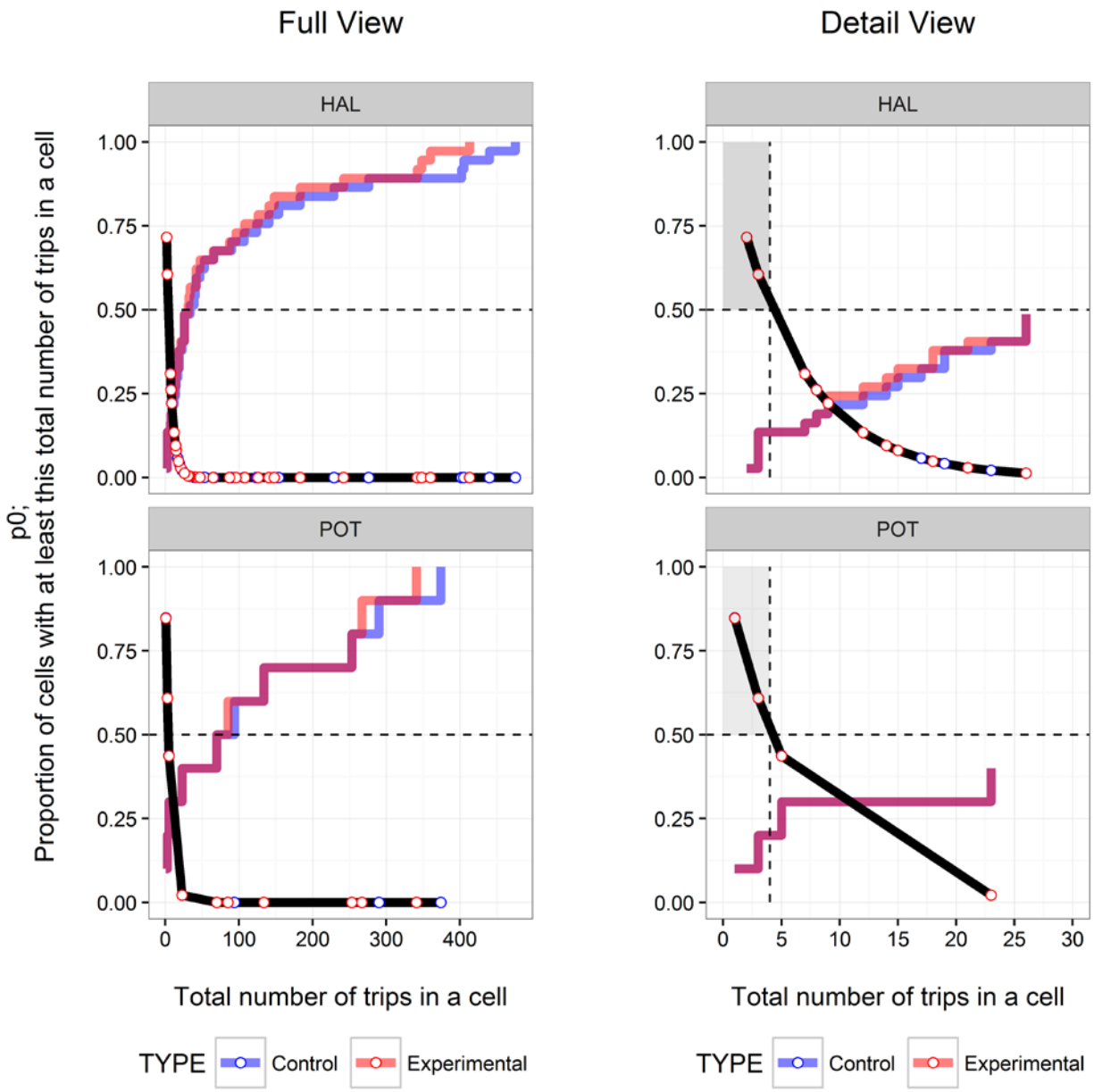

Figure 1. Both views: How the p-value associated with having no observed trips subject to human observation (p0) changes with the total number of trips in a cell (black lines) plotted with the cumulative proportion of all cells represented by cells below a certain size. The red and blue step lines represent the cumulative number of "cells" without EM ("Control") and with EM ("Experimental"). Note how the red line is shifted to the left from the blue line. These deviations are the impacts of the EM strata on the human observer pool. A shift to the left means that there is a decrease in the number of trips in a cell subject to human observation, thereby increasing p0 (black lines). Detail views (Right panels) illustrate the size of cells and their representation of the total that have p0 values > 0.5 (shaded area). For actual values the reader should refer to Table 2.

Table 1. Summary of the cell size (measured in number of trips) below which the p0 estimated by the hypergeometric distribution is greater than 0.5 (i.e Min. size cell). The cumulative proportion of all cells in a fishing year with sizes below the min. cell size is also depicted. Exclusion of EM vessels from the population of trips subject to human observer coverage did not result in changes in the minimum size cell or the cumulative proportion of cells with trips up to the minimum size (It is desirable to have this proportion as low as possible).

Strata	Hook and Line	Pot
Min. size cell	7	5
Proportion of all cells containing fewer than the "minimum cell size"	0.13	0.2

Table 2. Cells with p0 values > 0.5 that are particularly susceptible to changes in their composition as a result of EM implementation. None of these areas would be affected by implementing EM from the list of 65 prior EM vessels in this analysis given fishing activities in 2015. p0 values assume selection rates from the 2016 ADP. HAL = Hook and Line, POT = Pot gear.

#	Strata	NMFS Area	Target Code	Trips		Trips in EM (%)	p0	
				Control	Experimental		Control	Experimental
1	POT	518	Cod	1	1	0	0.847	0.847
2	HAL	640	Cod	2	2	0	0.715	0.715
3	POT	541	Sablefish	3	3	0	0.609	0.608
4	HAL	518	Cod	3	3	0	0.605	0.605
5	HAL	543	Halibut	3	3	0	0.605	0.605
6	HAL	543	Sablefish	3	3	0	0.605	0.605
7	HAL	659	Cod	3	0	0	0.605	0.605

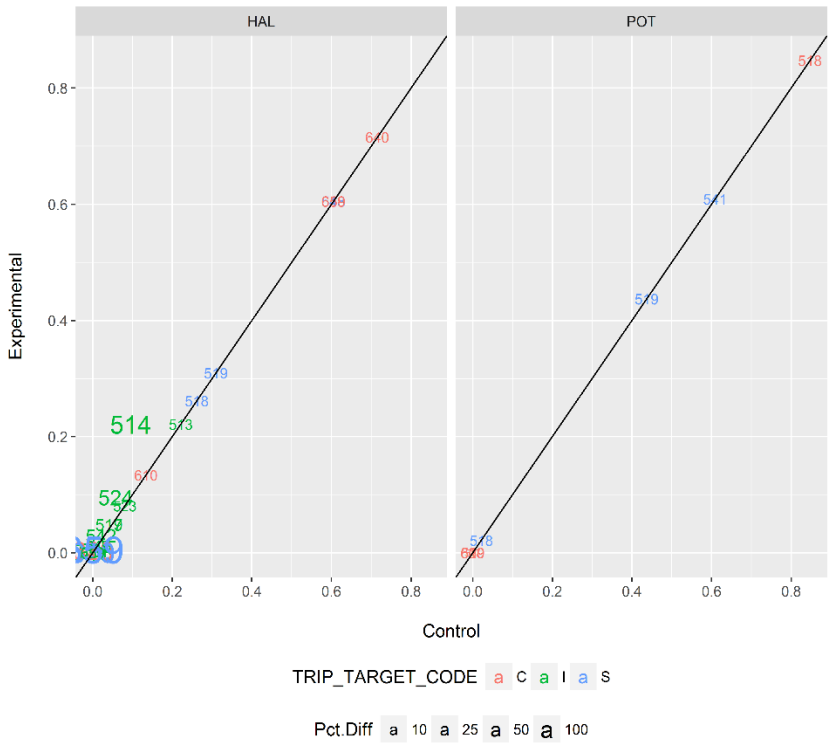

Figure 2. Comparison between the p-values associated with having no observer coverage between control and experimental scenarios. Each data point depicts the NMFS area colored by the trip target code and sized according to the percent difference in p-values between scenarios. Large percent differences associated with low p-values result from changes in very small values and can be safely ignored.

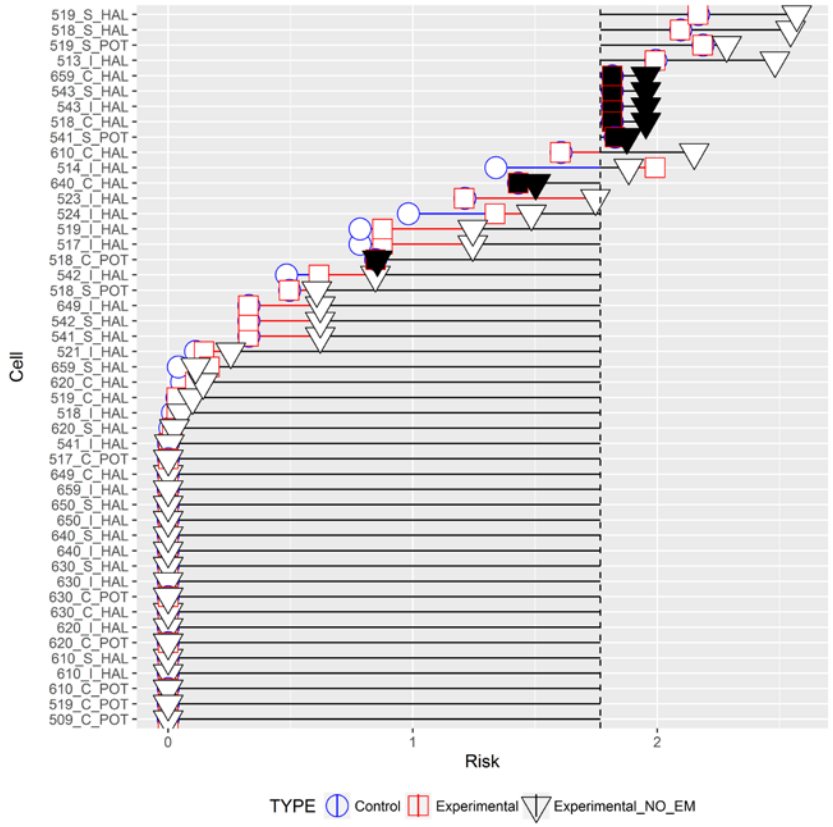

Figure 3. Non-zero risk scores for each cell and scenario ranked in descending order of the mean among scenarios. The horizontal reference line represents the 67th quantile of mean non-zero values. Points to the right of this dashed line are in the top third of non-zero risk values. Cells containing scenarios with p-values > 0.05 (Table 2) are denoted by points with black colored fill.

Table 3. Summary of vulnerable or risk prone cells. Cells are coded as a combination of NMFS Area, Trip Target Code, and 2016 ADP Strata, where I = Halibut, S = Sablefish, HAL = Hook and Line, POT = Pot. pObserved = proportion of trips in a cell expected to carry human observer coverage.

Row #	Cell	Scenario	Total in cell	Observed in cell	*p*Observed	*p*0	Risk	Mean Risk
1	519_S_HAL	Control	7	1	0.143	0.310	2.168	2.301
2	519_S_HAL	Experimental	7	1	0.143	0.309	2.166	2.301
3	519_S_HAL	Experimental_NO_EM	7	1	0.143	0.367	2.570	2.301
4	518_S_HAL	Control	8	1	0.125	0.262	2.096	2.244
5	518_S_HAL	Experimental	8	1	0.125	0.262	2.093	2.244
6	518_S_HAL	Experimental_NO_EM	8	1	0.125	0.318	2.545	2.244
7	519_S_POT	Control	5	1	0.200	0.437	2.187	2.218
8	519_S_POT	Experimental	5	1	0.200	0.437	2.185	2.218
9	519_S_POT	Experimental_NO_EM	5	1	0.200	0.457	2.283	2.218
10	513_I_HAL	Control	9	1	0.111	0.222	1.994	2.155
11	513_I_HAL	Experimental	9	1	0.111	0.221	1.991	2.155
12	513_I_HAL	Experimental_NO_EM	9	1	0.111	0.276	2.480	2.155
13	518_C_HAL	Control	3	0	0.000	0.605	1.816	1.862
14	518_C_HAL	Experimental	3	0	0.000	0.605	1.815	1.862
15	518_C_HAL	Experimental_NO_EM	3	0	0.000	0.651	1.953	1.862
16	543_I_HAL	Control	3	0	0.000	0.605	1.816	1.862
17	543_I_HAL	Experimental	3	0	0.000	0.605	1.815	1.862
18	543_I_HAL	Experimental_NO_EM	3	0	0.000	0.651	1.953	1.862
19	543_S_HAL	Control	3	0	0.000	0.605	1.816	1.862
20	543_S_HAL	Experimental	3	0	0.000	0.605	1.815	1.862
21	543_S_HAL	Experimental_NO_EM	3	0	0.000	0.651	1.953	1.862
22	659_C_HAL	Control	3	0	0.000	0.605	1.816	1.862
23	659_C_HAL	Experimental	3	0	0.000	0.605	1.815	1.862
24	659_C_HAL	Experimental_NO_EM	3	0	0.000	0.651	1.953	1.862
25	541_S_POT	Control	3	0	0.000	0.609	1.827	1.843
26	541_S_POT	Experimental	3	0	0.000	0.609	1.826	1.843
27	541_S_POT	Experimental_NO_EM	3	0	0.000	0.625	1.875	1.843
28	610_C_HAL	Control	12	2	0.167	0.134	1.607	1.787
29	610_C_HAL	Experimental	12	2	0.167	0.134	1.603	1.787
30	610_C_HAL	Experimental_NO_EM	12	2	0.167	0.179	2.150	1.787

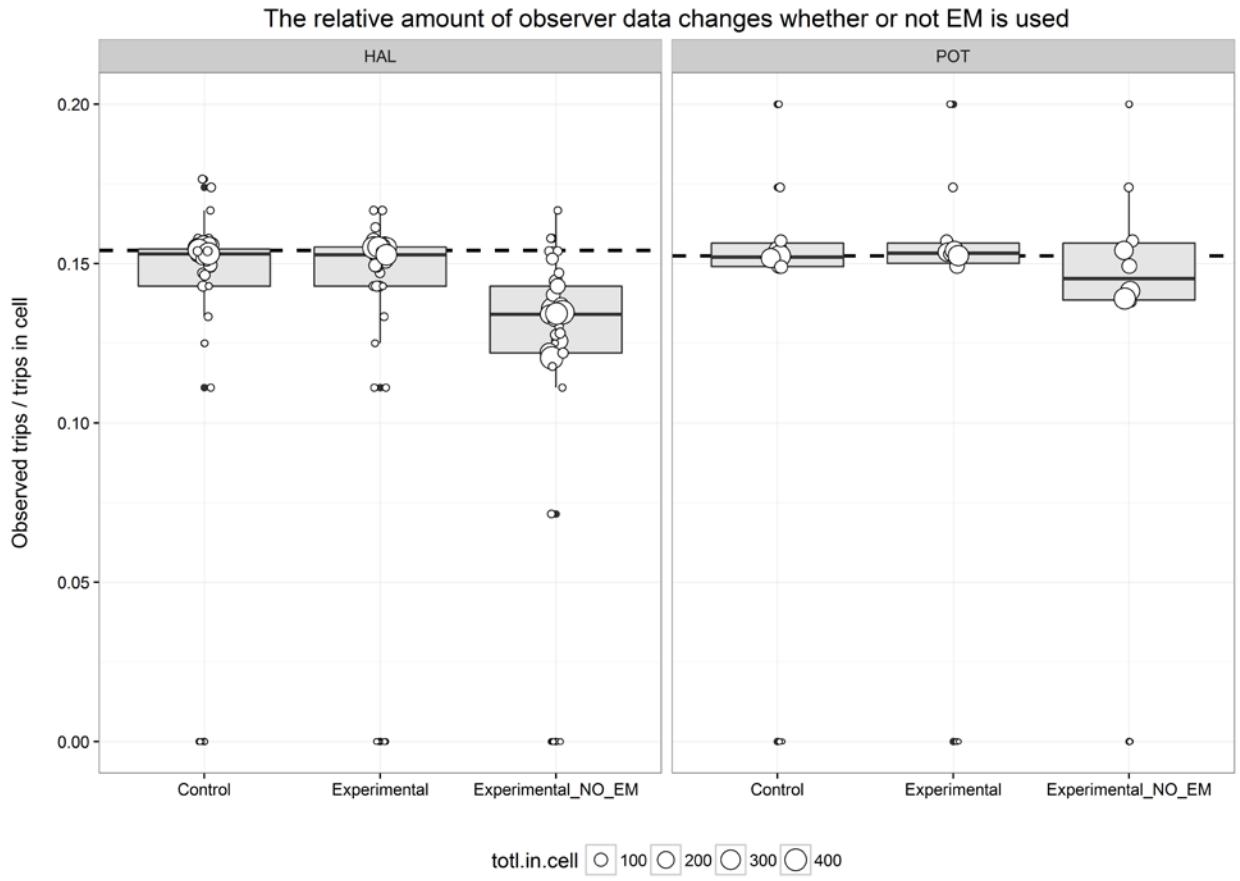

Figure 4. The amount of expected observer coverage in a cell expected to result given the 2016 stratum specific deployment rates (dashed lines) and perfect deployment proportional to the number of trips in each cell in each scenario: No EM trips (Control), EM trips removed from human observation but EM data used in catch accounting (Experimental), and EM trips removed from human observation but no data for catch accounting derived from EM (Experimental_NO_EM). In this last scenario, there are fewer observed trips with data relative to the total number of trips in each cell that require estimates.

Table 4. Iteration number (j) and the corresponding number of vessels in EM for Hook and Line and Pot vessels. A j = 0 denotes the "baseline" condition where there is no expansion of former EM vessels.

j	Total Vessels in EM	
	Hook and Line	Pot
0	65	3
1	68	6
2	71	9
3	74	12
4	77	15
5	80	18
6	83	21
7	86	24
8	89	27
9	92	30

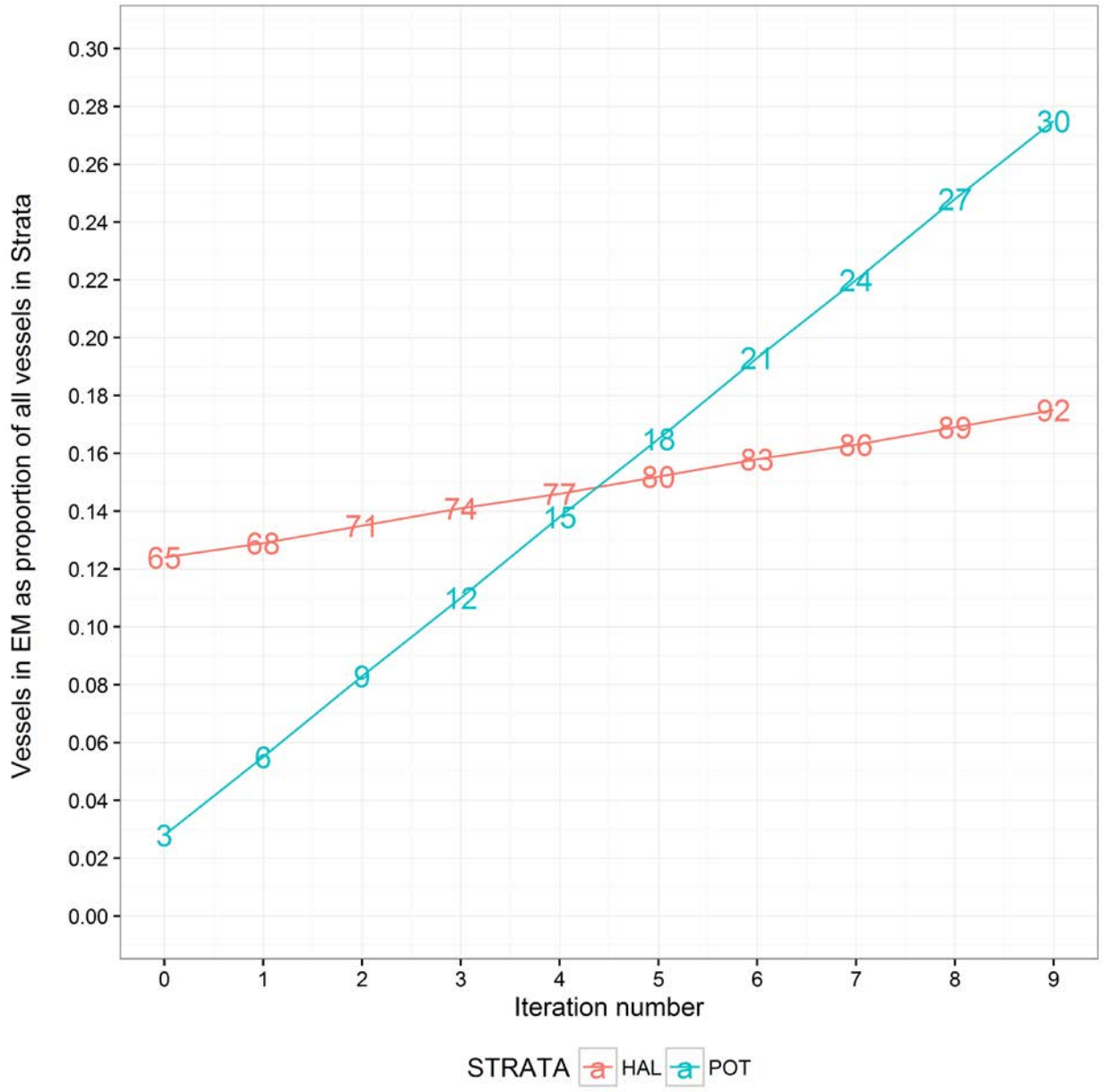

Figure 5. Visual depiction of the number of vessels in EM as a proportion of the total number of vessels that fished in 2015 by iteration number.

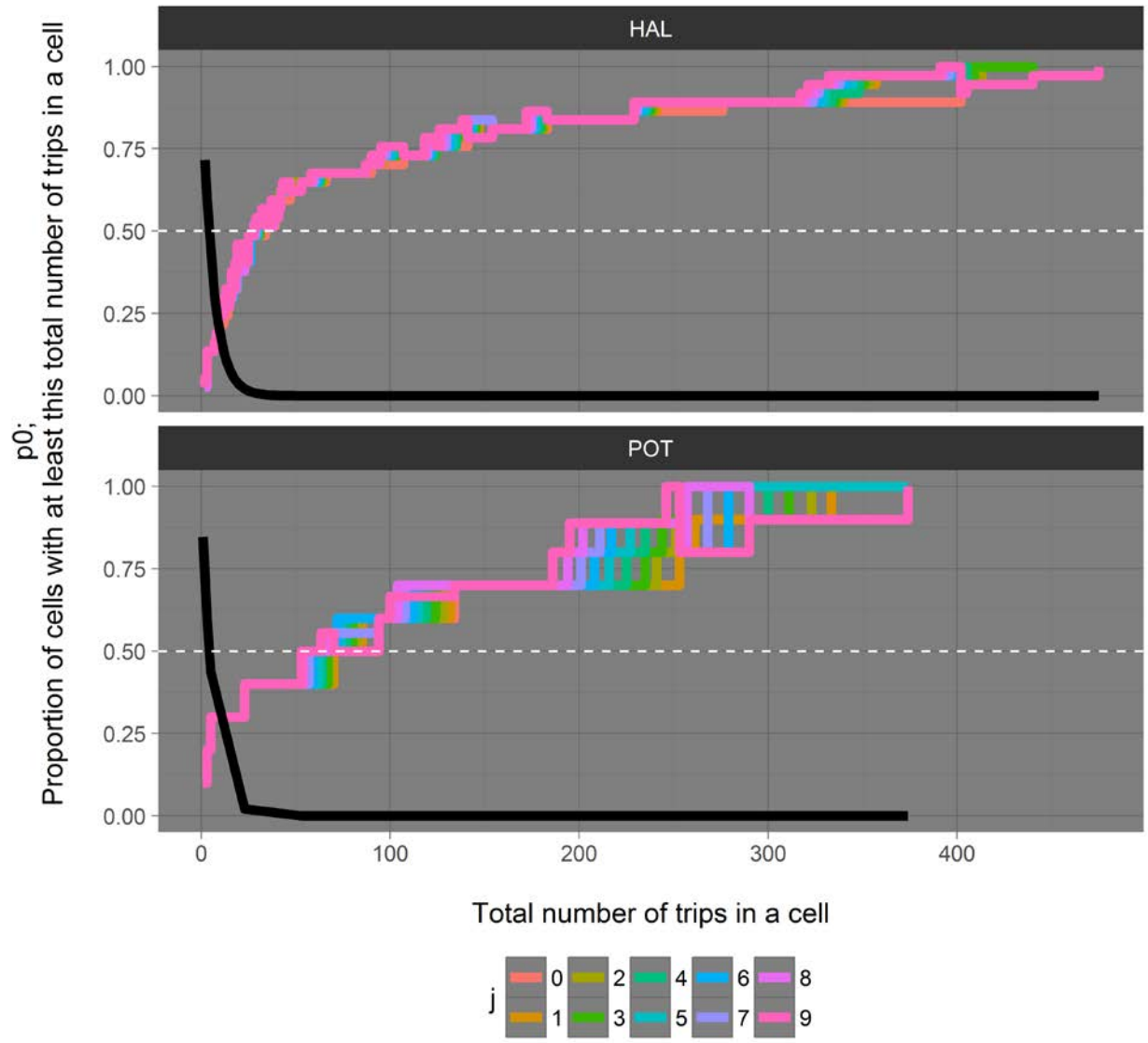

Figure 6. Comparison of how the cumulative distribution of cell sizes changes as more vessels are removed from the human observer pool and into EM pre-implementation. j = simulation iteration number. For number of vessels associated with each j, see Table 4.

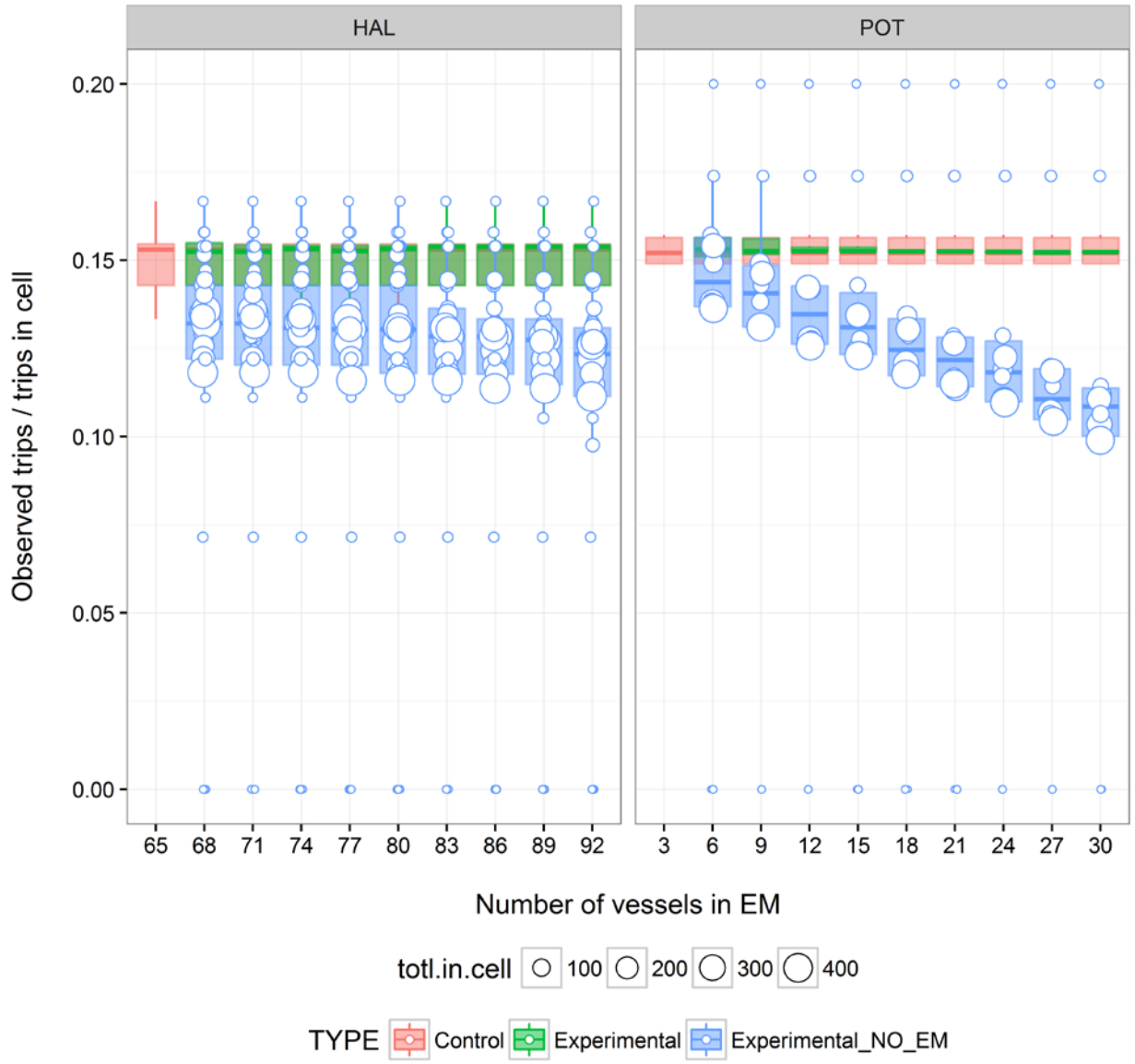

Figure 7. How increases in the number of EM vessels impacts cell-specific coverage rates when the underlying selection rate for human observers is set at 2016 levels (roughly 15%) depends on whether the EM data is used (Experimental) or not used (Experimental No EM). Individual dots represent individual cells in the Experimental No EM (2017) scenario. Dots are sized according to the number of trips in the cell.