

Evaluation of Puget Sound Pilots' Scheduling Efficiency and Recommendations for Improvement: Final Report

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Introduction

The Puget Sound Pilots (PSP) work a challenging schedule to provide round-the-clock service to guide ships through the Sound. In order to be available 24/7 365 days per year, the pilots are on-watch for 15 consecutive days, followed by a 13-day respite. The schedule is complicated by each pilot being required to work an additional peak weekend (3 additional days) per year and each pilot earns a week of time off (Earned Time Off, ETO) followed by a week of respite after every fifth on-watch rotation.

When on-watch, pilots are available for both day and night jobs. The on-watch pilots are assigned work by a dispatcher using a strict 'first-in, first-out' rotation schedule. Because the pilots' work times are dependent on shipping traffic, which can be highly variable, their schedules are irregular and often challenging.

San Jose State Research Foundation and the NASA Ames Research Center Fatigue Countermeasures Laboratory conducted a review of Puget Sound Pilot Schedules over two analysis intervals, October 2017 to September 2018 and January 2018 to December 2018. The authors concluded that insufficient PSP staffing levels made the system of calling off-watch pilots back to work and then providing them with a compensation day unsustainable.

The objective of this report is to provide recommendations to increase the efficiency of the PSP schedules with the goal of reducing the need to call-back pilots when off-watch, thereby reducing the number of compensation days awarded. Any recommendation to improve efficiency must be balanced with the mitigation of fatigue that is inherent in shift work schedules and associated with errors and/or accidents.

Methods

To begin, we reviewed the San Jose State Foundation/NASA Ames Research Center Fatigue Countermeasure Laboratory Puget Sound Pilot Fatigue Study Report (2019) and the previous presentation Dr. Czeisler made to the State of Washington Board of Pilotage Commissioners in 2017 ("Best Practices for Fatigue Management," in Seattle, WA, 2017). We also read the PSP Operation Rules (September 2017, revised version May 2021).

To learn more about the PSP scheduling practices, we conducted structured interviews with each of the three PSP dispatchers. We also conducted a series of 1-hour pilot focus groups. Approximately 34 (~68%) pilots participated in the focus groups, some joining more than one group. Each moderator took separate notes during the interviews/focus groups. Afterwards, investigators compared and analyzed notes to uncover common themes and ideas. Additionally, PSP management also provided schedule change recommendations to improve efficiency.

PSP provided a large dispatcher file of pilot activities from Jan 1, 2019 to May 31, 2021, representing pilot schedules pre-pandemic, at the height of the COVID-19 pandemic and as the US emerges from the pandemic. PSP also provided a second database containing all order time changes from Jan 1, 2021, to July 31, 2021.

We transformed the schedules into usable databases for analysis and queried PSP management when questions arose regarding the data. We conducted a series of analysis to better understand the PSP scheduling policies and each efficiency recommendation.

Analysis and Recommendations

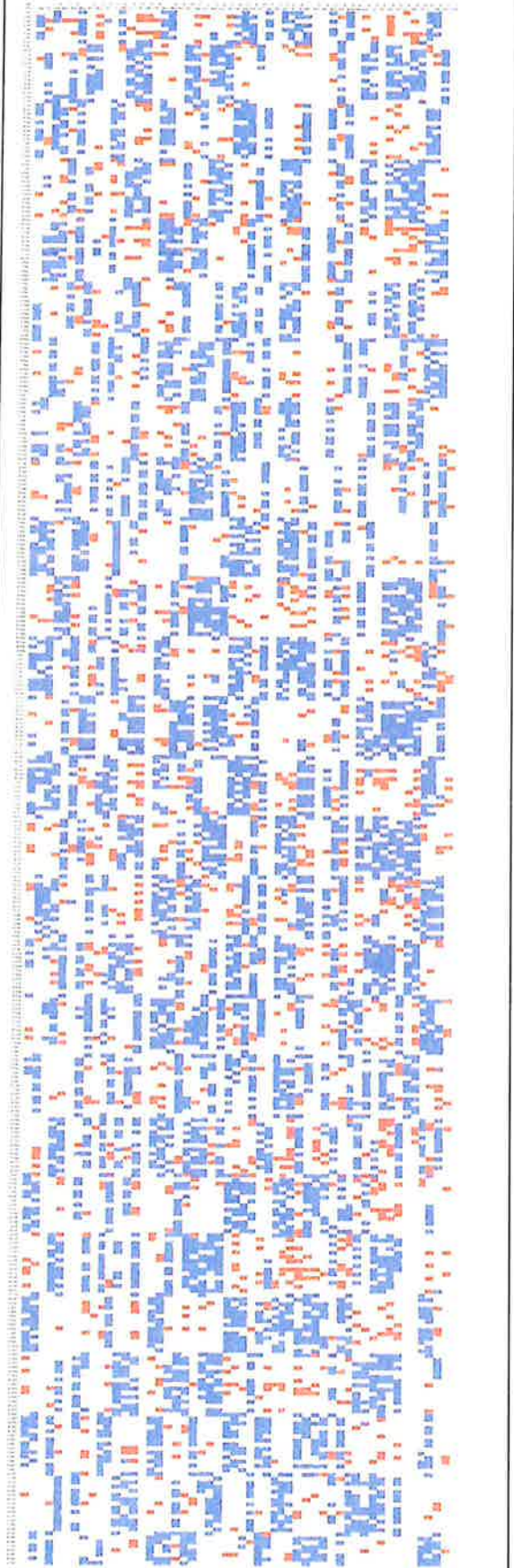


Figure 1. 2019 pilot schedule overview. Each column represents one pilot working a job (blue) or call-back job (red) throughout the year.

Schedule overview. Figure 1 illustrates the PSP schedules over a one-year interval (2019). The 15-day on-watch/13-day respite pattern is evident. Pilots work a varying number of call-back jobs, averaging approximately one per week while on respite, with substantial variability in frequency by pilot.

RECOMMENDATION 1. Assignment following a meeting. PSP must attend meetings as part of their piloting responsibilities. Although the data show there are a number of day-long meetings, there are also a substantial number of shorter meetings where pilots could potentially be assigned a follow-on job that would be completed within the 13-hour duty day (Figure 2). To further facilitate dispatchers awareness of the time personnel will be available and efficiently assign a follow-on job, hard stops for all meetings should be implemented.

This recommendation, direct dispatch following a meeting for an assignment to be concluded within 13 hours from the start of the meeting, was presented to the PSP membership. The rule change passed membership in August 2021.

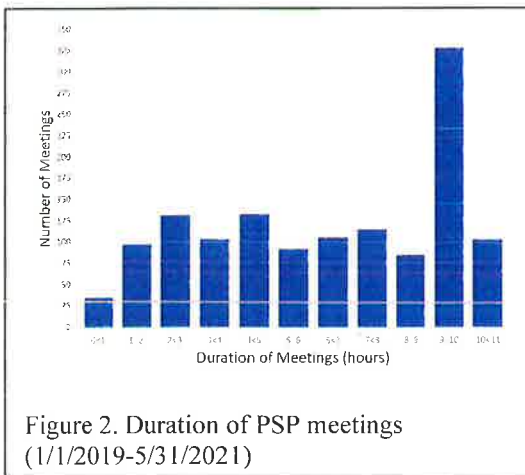


Figure 2. Duration of PSP meetings (1/1/2019-5/31/2021)

We anticipate that efficiency will improve as pilots will not be required 10 hours mandatory rest following a meeting but will be made available to complete a job assignment immediately after.

PSP LEADERSHIP RECOMMENDATION 2. Outbound job followed by immediate inbound reposition. In August 2021, the following recommendation was presented to the PSP membership: When it would reduce the likelihood of having to request a pilot's service while on respite, pilots may be dispatched from the Pilot Station to outbound vessels originating in the ports listed in Operating Rule 2(B) (all ports except those on the east side of Puget Sound north of Seattle). This rule change passed membership in August 2021. After implementation, this new rule, which was referred to as the "outbound job" or OBJ rule, proved unworkable and was terminated.

PSP leadership developed a revised approach to achieving efficiencies from Port Angeles where the pilot is expected to spend six hours at Port Angeles without an assignment. In these instances, the pilot will be immediately repositioned back to Seattle. This change will allow for relocating pilots where they are needed most rather than waiting for them to rest on the Port Angeles side and then be repositioned, or alternatively, remain idle in Port Angeles until next assignment. This change will be limited in that the combination of assignment and reposition must be achieved within 12 hours.

RECOMMENDATION 3. Minimize shipping agent delays. There is a need to address the significant effect of shipping agents either delaying established assignment times or using only a tentative job start time subject to one or more subsequent changes. These have a cascading effect on the dispatch system. In the study interval (January 1, 2019-May 31, 2021), there were 15,761 total jobs, 15% (2,391) were call-back jobs. Nearly all trips had order time changes, 74% of which (11,593) changed the job by more than 30 minutes. Cumulative order time changes that changed the final job time by more than 30 minutes were associated with a 31% increased rate of call-back pilot usage. When the last order time change was a delay, the incidence of call-back pilot usage was more than doubled. When analyzed separately, the results were comparable across the years of data (2019, 2020, 2021).

This analysis isolated the database to jobs (conducted by pilots who were on-watch) and call-back jobs (conducted by pilots who were off-watch). We used descriptive statistics to report on the frequency of order time changes and call-back jobs. Order time changes occurred multiple times on most jobs but may not have meaningfully impacted PSP operations in all instances. We defined meaningful changes to have occurred if the result of all order time changes (many were changed more than once) changed the final job time by more than 30 minutes. We considered call-back jobs as the outcome and meaningful changes as the exposure in a Poisson

regression model to quantify the impact of order time changes on the rate of call-back jobs. This analysis quantified the association between order time changes and the rate of call-back pilots associated with *that* job. There are certainly downstream effects. We did not identify a way to quantify how scheduling changes affect the likelihood of using a call-back pilot on *other* jobs as a result of these changes.

To minimize the number of call-back assignments, innovative ways to incentivize the shipping industry to avoid changing assignment start times will need to be implemented and/or disincentives (e.g., surcharges for delaying arrival times) to discourage order time changes that increase the risk of the use of call-back pilots. Time change orders that would interrupt the pilot's sleep should not be made after 1730. Interruption of sleep by a time change order should mark the start time of the assignment.

RECOMMENDATION 4. Combined harbor and transit assignments. Current PSP work rules allow multiple harbor jobs to be completed in one day. This recommendation would allow a pilot to be available for 13 hours to complete any combination of harbor and transit assignments between the hours of 0800 and 2200.

Dr. Czeisler, in his 2017 presentation, Best Practices for Fatigue Management, recommended "Each work episode of a Puget Sound Pilot should be limited to no more than 12 consecutive hours during the daytime (all work hours between 6 am to midnight) [maximum extended day work duration] and should be limited to no more than 8 consecutive hours if more than one of the work hours occurs between midnight to 6 am [maximum night work duration] before a mandatory rest break is started." Despite this recommendation, PSP work rules nominally allow 13 hours of duty.

Given that the PSP management affirmed that one type of assignment is not inherently more dangerous than another, the work hour limit does not need to limit multiple shifts to just harbor assignments. In the retrospective analysis, it is not possible to quantify how many opportunities there would have been to combine harbor and transit jobs. However, we anticipate that combining assignments will reduce the need for using call-back pilots.

RECOMMENDATION 5. Use of regional check-in times to achieve travel efficiencies. It is not possible to quantify the improved efficiency that could be achieved with this change as doing so would necessitate knowing where each pilot lives. That is, it would require knowing how long it took each pilot to get home following a job compared to how long each pilot is assigned following a job. Although unpopular, we recommend considering policy changes to improve efficiency in this area.

The PSP are required to cover 7,000 square miles of waterway and 14 major ports using two dispatch hubs (i.e., Port Angeles Pilot Station and Seattle) [San Jose State Foundation/NASA Ames Research Center Fatigue Countermeasure Laboratory Puget Sound Pilot Fatigue Study Report, 2019]. A standard amount of time is allowed for a pilot to travel to the port necessary to begin their assignment, independent of the amount of time it actually takes to travel there. A pilot in focus group discussion estimated transportation to/from an assigned job accounts for 60% of the work hours. Leadership estimated that transportation accounted for approximately 40% of work hours. In either case, it would be prudent to look for efficiencies to this practice as it represents a substantial proportion of the work hours (Figure 3).

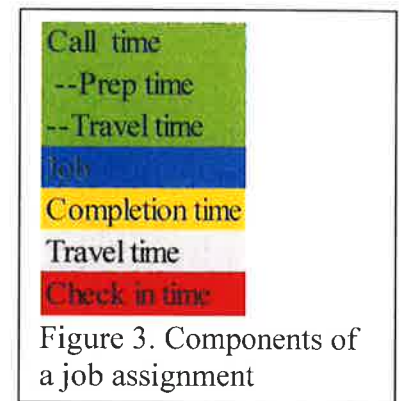


Figure 3. Components of a job assignment

Although we recommend improving efficiency of transportation rules, we recognize that changes to this aspect of the operating rules would be a large cultural change for the PSP organization. Using a stepped approach, regional check-in times could be implemented for all assignments and then regional call times for call-back jobs.

RECOMMENDATION 6. Reduce prep time from two hours to one hour for assignments, 1830-0800. In focus group discussion, pilots, especially less experienced pilots expressed the need for two hours of prep time. Therefore, it would not be prudent to reduce all prep times from two to one hour. Reducing the prep time from two to one hour for nighttime jobs is reasonable. Nighttime jobs are assigned at 1730, therefore pilots would still have ample time for preparatory work, albeit on their own time. We quantified the estimated gain in efficiency this rule change would provide. We assumed all jobs with a call time between 1830 and 0800 that had at least two hours between their call time and travel time would be eligible for the 50% reduction in prep time. In 2019 and 2020 that was 29% of jobs (1632 and 1556 jobs, respectively) and 31% in the limited 2021 dataset (1312 jobs). Based on the 2019-2020 data, this rule change would increase available pilot hours by approximately 1600 hours, the equivalent of 67% of a full-time pilot for one year.

RECOMMENDATION 7. Decouple reposition times from ferry times. In pilot focus group discussions, it was recommended to decouple repo times from ferry times as a way to improve efficiency. Some in pilot group discussions reported that the ferry is used infrequently. In discussions with leadership, it was suggested that many pilots do take the ferry when repositioned. In order to determine whether this recommendation would minimize inefficiency, a survey must be conducted to quantify how often the ferry is used in repositioning. We recommend each time a pilot is repositioned in the coming months, they report if they used the ferry. In this way, ferry use could be more objectively quantified. If the ferry is not often used as the means to reposition, then repositions could become more efficient by decoupling the reposition times from ferry times.

RECOMMENDATION 8. Rolling start. We hypothesized that changing half of the workforce at the same time could create inefficiency as there may be a back-up of assigning all the newly available pilots into the schedule. There are temporal changes in the use of call-back pilots throughout the watch (Figures 4-6). As stated above, it is unclear from the dataset what is driving these changes. We anticipate that rolling starts would smooth out the use of call-back pilots throughout the watch interval, as a new set of pilots would regularly become available throughout the interval. We developed and proposed an 8-watch rolling start schedule with starts on Monday – Thursday. The PSP Efficiency Committee was opposed to this suggested schedule due to operational concerns. The PSP then created and implemented a 5-watch rolling start schedule with starts on Tuesdays and Thursdays. (Figure 7). Our evaluation of the new PSP rolling start schedule shows that it increases the potential to reduce callbacks. At least 24 pilots are scheduled to be on-duty at any time (mean number of pilots available = 26.7 ± 3 [SD], median = 25 [IQR 25-30]). The lower 10th percentile of days provides 25 pilots, as does the 5th percentile. The maximum number of pilots available is 34. On this schedule, there are never fewer people scheduled to be on duty than in the standard non-rolling schedule. We estimate on-duty capacity increases by at least 1 scheduled pilot for 99% of days and by 2 or more scheduled pilots for 29% of days.

RECOMMENDATION 9. 72-hour shoulders on each side of on-watch interval and rolling starts. Dr. Czeisler, in his 2017 presentation, Best Practices for Fatigue Management, recommended “The maximum number of scheduled days on watch should not exceed 15.” Figures 4 and 5 demonstrate that pilots are being called back for jobs (comp-time jobs, CTJ) in the three days following and the three days after their on-watch interval. These additional continuous days of duty may present a safety risk. In order to minimize that risk, we recommend a prohibition on off-watch pilots taking callbacks during 72-hour shoulder intervals immediately

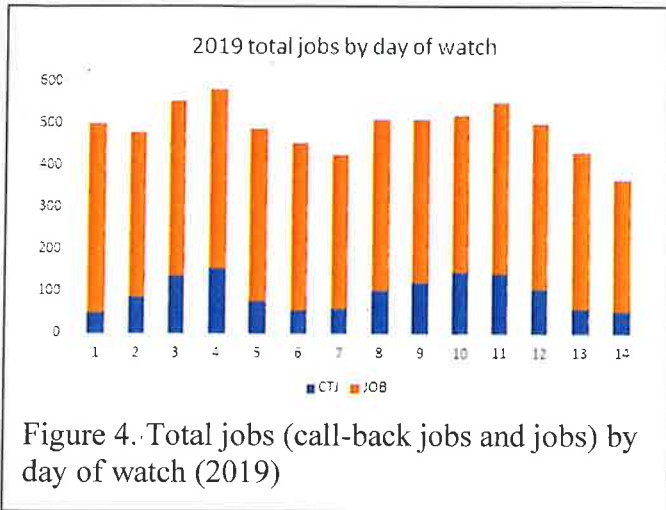


Figure 4. Total jobs (call-back jobs and jobs) by day of watch (2019)

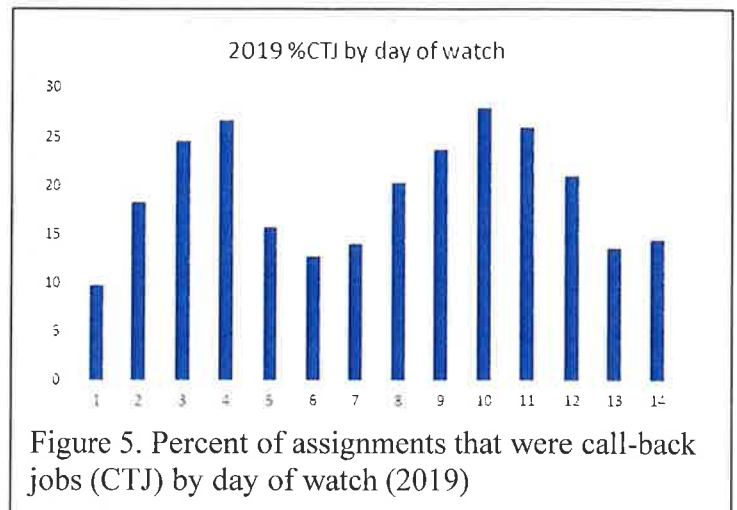


Figure 5. Percent of assignments that were call-back jobs (CTJ) by day of watch (2019)

following and preceding a pilot’s on watch interval.

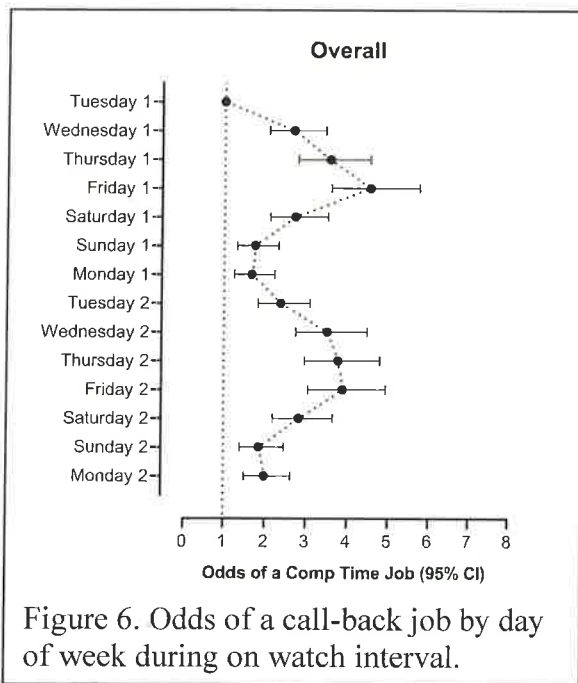


Figure 6. Odds of a call-back job by day of week during on watch interval.

Figure 6 shows the variation in call-back pilot usage by day of week during the on-watch interval. It is hypothesized that the first peak on Friday may be due to increased shipping traffic on the weekend or as a consequence of the required rest for a pilot following three night shifts. Efficiency gains from other rule changes will be required to minimize the need for call-back pilots during these shoulder intervals and throughout the entire watch interval.

Rolling starts are necessary for implementation of the 72-hour shoulder prohibition. If PSP are not able to implement the 72-hour shoulders at this time, consideration should be given to implementing 24-hour or 48-hour shoulders.

RECOMMENDATION 10. Annual cap on maximum number of call-backs. There is a wide variation of call-back jobs taken by pilots, ranging from 5-56, in 2019. Figure 8 illustrates the number of call-back jobs worked by individual pilots and the Figure 9 illustrates the portion of off-watch days worked by individual pilots, assuming that all pilots were available off-watch 184 days per year

The recommendations in this report are interconnected. Adding the 72-hour shoulders immediately prior to and after the on-watch interval reduces the number of consecutive days of work as a safety measure. It also effectively limits the number of call-backs a pilot could work while off-watch, perhaps obviating the need to place a cap on annual call-back jobs

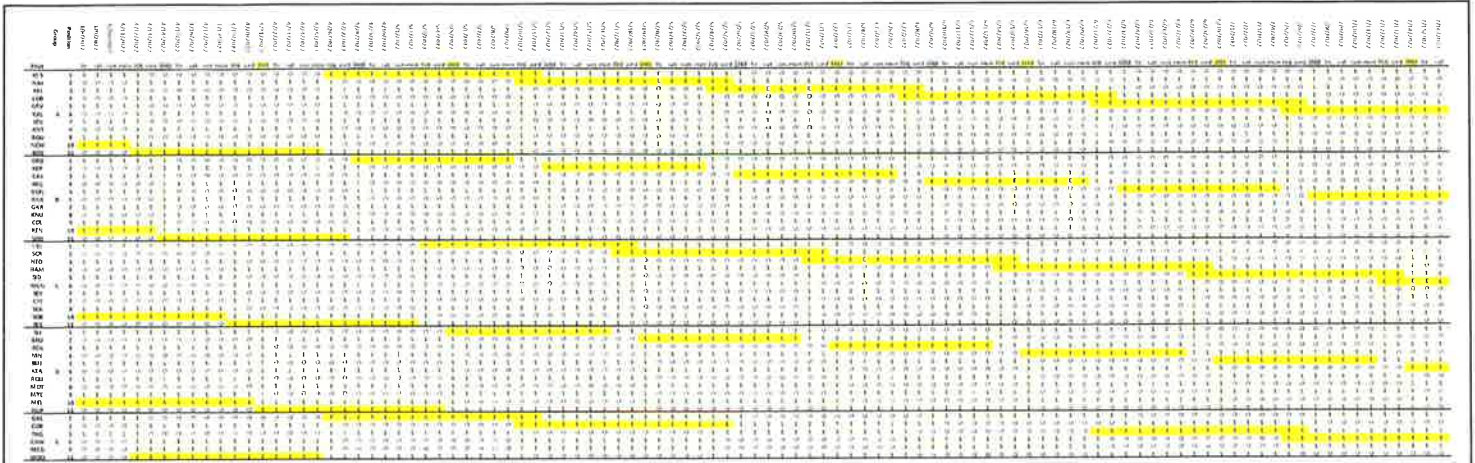


Figure 7. New PSP rolling start schedule

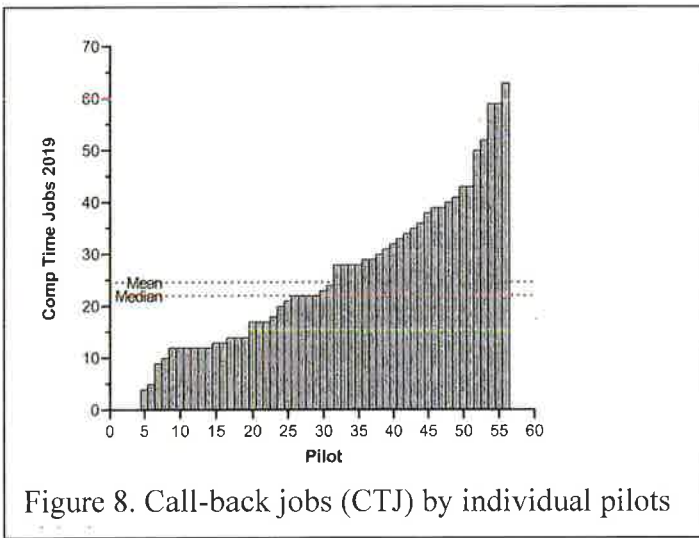


Figure 8. Call-back jobs (CTJ) by individual pilots

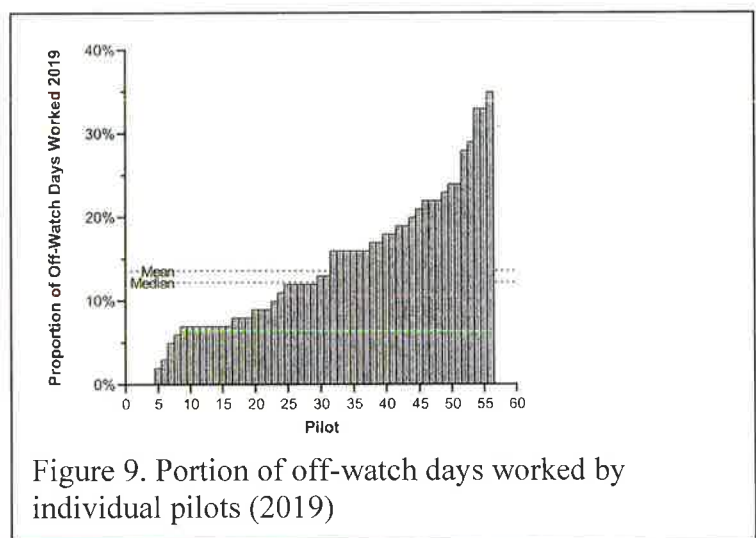


Figure 9. Portion of off-watch days worked by individual pilots (2019)

RECCOMENDATION 11. Limit workload by increasing the number of pilots

The following workload data (Figure 10) were provided by the PSP, summarizing pilot hours of engagement. Engagement hours include the time that pilots were on standby at the pilot station. These data are consistent with Figures 8-9 that show pilots are working an average of 24.6 off-watch jobs per year (mean of 13.6% of off-watch days). In 2018 and 2019, on average, pilots were engaged more than 2100 hours per month on-watch and more than 400 hours per month off-watch. Thus, in the weeks pilots are on-watch, they average approximately 88 hours of engagement per week or approximately 12 hours of engagement per day. Extended workdays and long work weeks increase risk for accident and injury. Increasing the number of pilots could help to reduce pilot engagement.

**PILOT WORKLOAD SUMMARY
2018 AND 2019**

2018 On Watch Workload Data	Number of Assignments	Assignment Time	Meeting Duration	Training Duration	Repo	Standby Pilot Station	Total Engagement Time	Bridge Hours
2018 Median On Watch Workload	130.50	1160:46	11:02	0:00	111:15	799:41	2189:50	672:37
2018 Average On Watch Workload	127.53	1145:38	46:01	43:14	118:35	785:32	2158:43	657:05
2018 Off Watch Workload Data		Assignment Time	Meeting Duration	Training Duration	Repo	Standby Pilot Station	Total Engagement Time	Bridge Hours
2018 Median Off Watch Workload		294:26	4:10	4:45	30:30	56:28	449:58	132:01
2018 Average Off Watch Workload		299:19	23:27	35:12	40:13	65:53	464:07	124:37
2019 On Watch Workload Data	Number Of Assignments	Assignment Time	Meeting Duration	Training Duration	Repo	Standby Pilot Station	Total Engagement Time	Bridge Hours
2019 Median On Watch Workload	127.00	1151:34	5:46	0:00	115:00	862:04	2178:01	663:34
2019 Average On Watch Workload	124.73	1141:14	37:50	16:25	115:21	863:58	2174:50	665:22
2019 Off Watch Workload Data		Assignment Time	Meeting Duration	Training Duration	Repo	Standby Pilot Station	Total Engagement Time	Bridge Hours
2019 Median Off Watch Workload		257:12	2:22	0:00	21:12	66:03	414:22	113:30
2019 Average Off Watch Workload		278:46	26:53	21:12	24:21	76:45	427:58	121:00

Figure 10. Workload summary provided by Puget Sound Pilots.