STATE OF WASHINGTON
BOARD OF PILOTAGE COMMISSIONERS

In Consideration of the Number of Licensed Pilots Pursuant to WAC 363-116-065 Regular Meeting of the Board of Pilotage Commissioners, July 18, 2019.	**SUBMISSION OF THE PUGET SOUND PILOTS ASSOCIATION**

On behalf of the Puget Sound Pilots Association, this submission is made to the Board of Pilotage Commissioners to assist it in making findings and conclusions necessary to determine the appropriate number of authorized pilot licenses for the Puget Sound Pilotage District under WAC 363-116-065.

I. INTRODUCTION

The Board of Pilotage Commissioners ("Board" or "BPC") is not frequently asked to consider a major overhaul of the number of pilots or assignment level because the circumstances necessitating such a request are infrequent. This, however, is such a request.

As you may know, the BPC once determined the number of pilots by establishing a Safe Assignment Level to guide how many pilots are needed given a projection of vessel traffic. Eventually, the Board became concerned about whether the term "Safe Assignment Level" might create the risk of liability if pilots were permitted to take assignments in excess of that level and coined the alternative expression "Target Assignment Level" ("TAL") in March, 2010. Despite that change, the notion remains the same. In furthering its legislated mission,[1] the BPC sets an expectation of how many assignments a pilot can handle given the constraints of their overall workload, travel, rest periods, respite, and the terrain and geography of the Puget Sound Pilotage District. In other words, an assignment level should be set based on what level of assignments permits adequate opportunity for rest when appropriate fatigue countermeasures are considered.

Since the last significant discussion of the TAL by the Board in 2010, BPC policies, PSP operating rules, and legislation to implement improved fatigue management practices have been implemented. Even without those changes, a lack of sufficient licensed pilots has caused the continued accrual of Compensatory Days ("Comp Days" or "Callback Days") for pilot Callbacks and strained the watch system and availability of pilots to perform board on arrival service without vessel delays.

[1] RCW 88.16.035.

In the past, the process by which the Board has considered and authorized a number of licenses under WAC 363-116-065 has examined data analysis and proposed methodology offered by both PSP and industry. However, due to competing methodologies and perhaps some trepidation, the Board has never formally adopted a set methodology for establishing an assignment level or number of pilots. For that reason, PSP sought the assistance of credible outside experts to assess the fatigue risks of PSP, make recommendations regarding fatigue risks identified in current policies and practices, and create a statistical model for determining the minimum number of licensed and working pilots needed to fulfill the duty of pilots in the Puget Sound.

As you are aware, those experts are a team of scientists and researchers who previously performed a fatigue study of the San Francisco Bar Pilots: Kevin Gregory, Nicholas Bathurst, and Dr. Cassie Hilditch, Ph.D. of San Jose State University Research Foundation and Dr. Erin Flynn-Evans Ph.D. of the National Aeronautics and Space Administration Ames Research Center Fatigue Countermeasures Laboratory (collectively “NASA”). Their “Puget Sound Pilot Fatigue Study Report” is partially summarized below and also provided in its entirety with this submission as Exhibit 1.   The ultimate conclusion of that study is that in order to provide board-on-arrival service without delays, manage Callbacks, and accommodate work hour rules drastically needed to reduce the likelihood of schedule-induced fatigue, 63 pilots are required in the Puget Sound Pilotage District.

To address other factors the Board should consider under WAC 363-116-065 and the objectives announced by the Commissioners in the current process, PSP provides additional analysis and explanations of questions raised about its workload and watch system below.

Considering the significant increase in additional licensed pilots required to accomplish the primary duty of the Board and the Pilots, preventing loss of human lives, and protecting property and the environment of the Puget Sound, it is imperative that the Board of Pilotage Commissioners act now, without delay, to take all actions within its authority to authorize 63 pilot licenses, set a lower assignment level, and license additional pilots as expediently and prudently possible.

II. SUMMARY OF NASA’S REPORT

As noted, the Puget Sound Pilots employed scientists at NASA’s Ames Research Center Fatigue Countermeasures Laboratory and San Jose State University Research Foundation to analyze dispatch data and assess potential impacts of implementing the fatigue countermeasure recommendations made by Dr. Charles Czeisler to the BPC, some of which are now codified in Washington law. The stated goal of the study was to:

> …identify the characteristics of the Puget Sound Pilot schedules that could increase the likelihood of fatigue and develop a model to project the number of

pilots needed to provide board-on-arrival service, while accounting for new work hour rules to reduce the likelihood of schedule-induced fatigue.[2]

As is set forth in greater detail below, NASA performed a comprehensive analysis of available dispatch data for 2018 to assess how the implementation of fatigue countermeasures would impact pilot workload. In evaluating dispatch data, NASA looked for a number of practices that would raise concern from the standpoint of reducing the potential for fatigue-related accidents. Those work schedule factors included the length of work periods, the length and timing of time off between work periods, the time of day or assignments, working consecutive days/nights, work period start time variability, recovery periods between work cycles, and the number of Callbacks.[3]

NASA's conclusions noted that pilots in the Puget Sound Pilotage District maintain work practices with variable and unpredictable work times and workloads, frequent nighttime assignments, insufficient time off relative to the new mandatory rest interval, and heavy reliance on calling back pilots during their respite period.[4] To reduce the negative impact on fatigue caused by these factors, NASA made a number of recommendations, including: (1) considering limiting the total time period over which a pilot may perform multiple harbor shifts to below the new 13-hour statutory limit[5]; (2) eliminating round-trip cruise ship assignments and requiring that a separate pilot handle each leg of a cruise ship assignment[6]; (3) treating repositioning like vessel assignments for purposes of the application of mandatory rest periods[7]; and (4) limiting the number of Callbacks an individual pilot is permitted to perform.[8]

In order to put these recommendations into practice without delaying vessels, NASA then applied a linear regression analysis to PSP's workload data to determine the number of on-duty pilots needed to handle projected vessel traffic while creating only a reasonable number of additional Callbacks. After considering an additional number of pilots needed to reduce the accumulation of Callback Days, the workload of the President, and the number of pilots receiving earned time off, NASA concluded that the projected number of pilots needed to fulfill staffing requirements, while also minimizing fatiguing work shifts is 63.[9]

Based upon the number of vessel assignments experienced during the period analyzed and the number of pilots projected by NASA to be required to reduce impacts of fatigue, NASA also concluded that the assignment level would be approximately 118.[10]

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[2] Gregory, Bathurst, Hildetch, and Flynn-Evans (2019). Puget Sound Pilot Fatigue Study Report. San Jose State University Research Foundation and National Aeronautics Space Administration, 15, attached hereto as **Exhibit 1.**
[3] Exhibit 1, p. 16.
[4] Exhibit 1, p. 42.
[5] Exhibit 1, p. 43
[6] Exhibit 1, p. 43.
[7] Exhibit 1, p. 43.
[8] Exhibit 1, p. 44.
[9] Exhibit 1, p. 42.
[10] Exhibit 1, p. 42.

III. DISCUSSION OF WAC 363-116-065 FACTORS

It should be of no surprise that in authorizing the Board of Pilotage Commissioners to determine the number of pilots, the Legislature focused on safety first.[11] The Legislature in fact expressly declared that the purpose of both compulsory pilotage and establishment of the Board of Pilotage Commissioners is to "prevent the loss of human lives, loss of property and vessels, and to protect the marine environment of the state of Washington…"[12]

Although safety must always come before concerns about profit and expense, the factors that may be considered by the Board in setting the number of pilots necessarily include factors that promote the other express legislative mission of both the pilots and the BPC: ensuring "Washington's position as an able competitor for waterborne commerce from other ports and nations of the word…"[13]

Consistent with its core mission and the first factor the Board considers in setting the number of pilots under WAC 363-116-065(2)(a) (ensuring the safety of persons, vessels, property and the environment) the BPC has set goals for the current process of (1) managing fatigue, (2) managing Callbacks, and (3) reducing delays. The Board may also consider the other factors set forth for to optimizing the operation of a safe, fully regulated, efficient and competent pilotage service:

> (b) The importance of the maritime industry to the state balanced by the potential hazards presented by the navigation of vessels requiring pilots;
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> (c) The lead time necessary to select and train new pilots;
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> (d) Regional maritime economic outlook, including without limitation: Current economic trends in the industry, fluctuations in the number of calls, the types of assignments, the size of vessels, the cyclical nature of the traffic and whether traffic is increasing or decreasing and the need to minimize shipping delays;
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> (e) Workload, assignment preparation and rest needs of pilots;
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> (f) Trends in size of piloted vessels;
>
> (g) Time lost to injury and illness;
>
> (h) Anticipated retirements;
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> (i) Administrative responsibilities, continuing education and training requirements consistent with the policy of chapter 88.16 RCW; and
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> (j) Surface transportation and travel time consumed in pilots getting to and from assignments.

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[11] RCW 88.16.035(d)(" Determine from time to time the number of pilots necessary to be licensed in each district of the state to optimize the operation of a *safe*, fully regulated, efficient, and competent pilotage service in each district")(emphasis added).

[12] RCW 88.16.005.

[13] *Id.*

1. Safety and environmental protection

Historically, PSP has focused on safety through a vigorous training and licensing program, continuing education, and through fatigue mitigation practices including mandatory rest periods and institution of a day-for-day watch schedule that is based upon equivalent days of work and respite to permit pilots to recover from the long and irregular hours worked during their on-duty days.

Since the last significant meeting to consider the number of pilots, in 2010, fatigue management practices have improved. In November of 2015, resulting from an improved understanding of how to manage fatigue, PSP adopted an eight-hour rest requirement and implemented the three-and-out rule, by which pilots are not permitted to work more than three consecutive nighttime assignments without an opportunity to rest at night.

Further enhancing pilot safety, the Legislature's recent amendment to RCW 88.16.103 mandates that pilots receive a rest period of at least 10 hours with an opportunity for eight hours of uninterrupted sleep after completion of an assignment, and limits multiple assignments within a harbor area to 13 hours of total assignment time. Based on the fatigue countermeasure recommendations of Dr. Czeisler, these mandatory rest periods are critical additions to the fatigue principles already in place. Yet, implementing this mandate will require that pilots stretch their dispatch even further, attempting to cover the same number of assignments that would otherwise exist with even fewer available pilots.[14]

Although the pilots have consistently adhered to rest rules (no rest rule violations were identified in a review of data for 2018 and 2019), a persistent shortage of pilots has also consistently cut into the pilots' other needed recovery period – days off watch. As addressed below, the use of Callbacks, which were implemented to avoid delays during periods of high demand, have now become a proxy for having an adequate number of pilots. The number of accumulating Callback Days is staggering, and as addressed in NASA's report, is equivalent to 16 years of pilot work.[15]

This high level of Callback Jobs decreases safety margins and, on average, has resulted in all pilots exceeding the safe assignment level last set by the Board at 145 assignments per pilot. During 2018, the total number of vessel assignments[16] was 7,324. Yet, the average number of available pilots was 47.86. This resulted in an actual assignment level of **153.03** assignments per available pilot. Had a full complement of 51 licensed pilots been available (52 minus the President), the assignment level would still have averaged 143.6 assignments per pilot. Considering the pilot workload recommended by NASA, 118 vessel assignments per pilot, 143 assignments remains an excessive number that has the added potential to jeopardize human health, the environment of the Puget Sound, not to mention vessels and property.

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[14] NASA quantifies the number of pilots needed to cover the additional unavailability of resting pilots at 2 on-duty pilots, which amounts to more than 4 total pilots in the watchstanding rotation. Exhibit 1, pp. 41-42.
[15] Exhibit 1, p. 36.
[16] Not including repositioning, training, upgrades, or meetings.

2. Efficiency, port competitiveness and reducing delays

a. PSP's continual efforts to improve efficiency

In addition to safety, the Board should also consider efficiency in establishing the number of pilot licenses it should issue. Measuring efficiency can be accomplished in a number of ways. PSP has long measured efficiency by the number of vessel delays, and has continually worked to provide board-on-arrival service without delay. As part of those efforts, PSP has made changes to its operating rules that would increase pilot availability. For example, since 2010, PSP instituted the Peak Period Worker ("PPW") policy. Initially PPW was instituted to ensure sufficient pilot coverage during the summer cruise season by requiring each pilot to work three PPW days during summer that would then be offset by three additional days of respite in the fall or winter. PSP found that this helped get through the cruise season with fewer pilots, but failed to diminish Callbacks because of training, meetings and important administrative work performed in the offseason. To reduce Callbacks, PSP eventually eliminated the PPW payback days, thus requiring each pilot to work three PPW days during their respite, and with no additional respite in the fall or winter. Similarly, PSP schedules both its extensive regular and irregular training to off-duty and off peak traffic periods to the extent possible, with no payback during on-duty periods.

PSP also worked to improve efficiency through changes to its operating rules relating to time spent at the pilot station. Prior to 2012, PSP limited each pilot to 26 hours at the pilot station awaiting an assignment. If no assignment was available after 26 hours, the pilot would be repositioned to Seattle. That practice reduced overall pilot availability, however, and in 2012 PSP eliminated that rule.

Aided by measures such as these, PSP has long been successful at avoiding vessel delays until 2018.

b. PSP has long sought to avoid delays, but delays can be caused by a number of factors

Consistent with PSP's efficiency metric, the BPC also identified reducing delays as one of the objectives of the present process in setting the number of pilots. Indeed, the need to minimize shipping delays is, by rule, one of the regional economic considerations of the Board in setting the number of pilots pursuant to WAC 363-116-065(d).

Because delays awaiting pilots are costly to the shipping industry, and are generally agreed to have a higher impact on the overall cost of shipping goods than pilotage charges themselves, they should be avoided whenever possible for the protection of port competitiveness. It is for that reason that PSP has consistently strived to provide "board on arrival" service, so that a vessel may commence its movement on its own schedule rather than waiting on a pilot to arrive.

Due to the unpredictable timing, and sometimes high volume, of vessel movements, Board on arrival service, however, requires built-in inefficiency. For pilots to be available whenever a ship calls on the Puget Sound, there must be available pilots awaiting vessels.

Understanding why this is such an essential corollary is perhaps best illustrated by examining recent vessel delays.

i. Delays by customers

In examining vessel delays, it is important to distinguish between vessel delays and cancellations outside of the control of the pilot on the one hand, and delays awaiting pilots on the other hand. Delays to pilotage caused by a vessel that arrived or departed later than the time for which it ordered a pilot are routine occurrences that likely have no direct impact on port competitiveness or regional economic health. However, these delays consume the time of pilots who are waiting for an assignment to begin and must rest before taking their next assignment. They also make dispatching far more difficult, resulting in decreased usage of pilot's total available time in vessel assignments, and can cause the need for repositioning additional pilots.

In 2018, there were more than 709 delays by customers.[17] When evaluated by month, delays ranged from 39 to 82, with a mean of 59.1 delays per month. Similarly, cancellations by the vessel are a somewhat common occurrence. During 2018, vessels cancelled their vessel movement a total of 161 times.[18] The cancellations per month range from 6 to 24 and average 13.4 cancellations per month.[19] As a result of these common delays and cancellations, even if the schedule of all vessels was known in advance, on-duty pilots staffing additional pilots awaiting vessel arrivals (i.e., built-in inefficiency) is necessary to providing board-on-arrival service.

ii. Delays awaiting pilots

When there are sufficient available pilots to handle this unpredictable workload on-demand, there are no delays awaiting pilots. In fact, until 2018, delays awaiting a pilot were a rare if not unheard of event. When on-duty pilot availability has been insufficient to meet intervals or days with high demand for pilotage service, pursuant to an agreement between the pilots and the Puget Sound Steamship Operators Association ("PSSOA")[20], PSP has historically called off-duty pilots to perform Callback Jobs. In this way, Callbacks have long served as a relief valve for the pressures of having insufficient pilot numbers during periods of high demand. However, the use of Callbacks has also generated Callback Days that may be taken by a pilot during his or her watch period. Thus, use of Callbacks is an inadequate substitute for licensing a sufficient number of pilots to handle most periods of high demand solely through on-duty pilots. Moreover, because pilots are and should be free to refuse Callback Jobs (contrary to PMSA's

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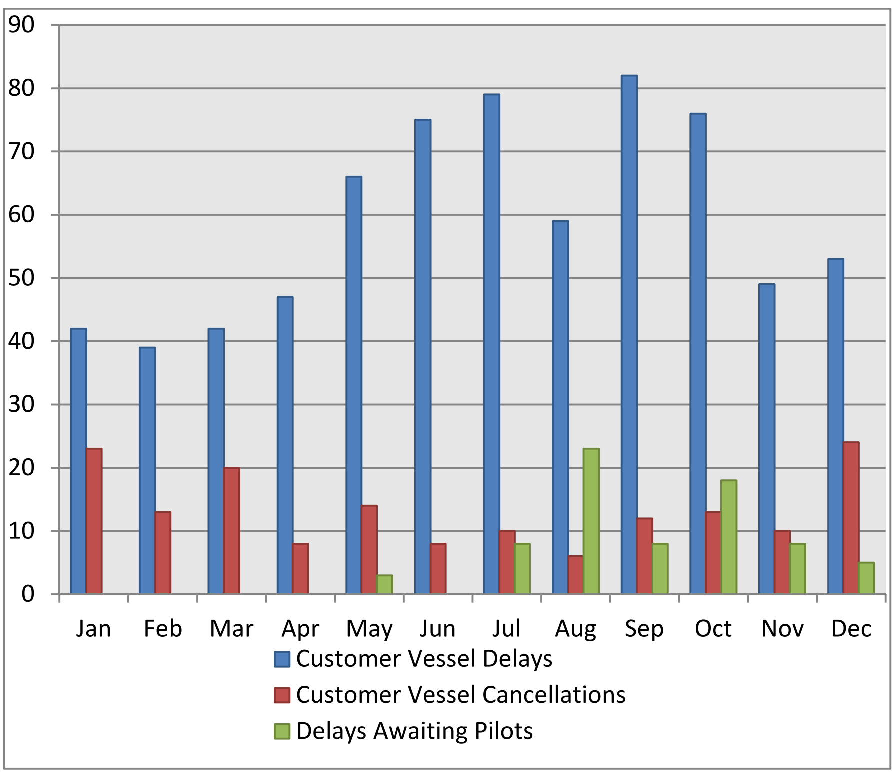
[17] Exhibit 2.
[18] Exhibit 2.
[19] Exhibit 2.
[20] The predecessor to the PMSA

recent suggestion of mandating a minimum level of Callbacks), the reliance on Callbacks to supply pilots during periods of peak demand also risks the possibility of a vessel delay.

That risk came to a head in May, 2018, when three vessels were delayed due to the lack of available rested pilots.[21] No vessels were delayed in June, but delays began to climb in July and saw peaks in August and October.[22] Overall, a total of 73 vessels were delayed awaiting pilots in 2018, with a monthly delay range of zero to 23, and an average of 6.[23]

Puget Sound Vessel Delays and Cancellations in 2018 by Month														
2018	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean
Delays by Customer	42	39	42	47	66	75	79	59	82	76	49	53	709	59.1
Delays Awaiting Pilot	0	0	0	0	3	0	8	23	8	18	8	5	73	6.1
Pilot Order Cancelations	23	13	20	8	14	8	10	6	12	13	10	24	161	13.4



[21] Exhibit 2.
[22] Exhibit 2. Each of the peak months of delay were also, without coincidence, month in which the number of available pilots dropped to or below 48.
[23] Exhibit 2.

iii. Illustrations of delay causation

The cause of delays by pilots is singular: the lack of sufficient rested pilots. However, to understand why, the circumstances under which these delays result should be considered. Below, are four examples of situations leading to such delays.

Example 1 – July 7

Watch*	Pilot Delays	Customer Delays	Cancel	Vessel Assign.	Repos	CTJ/Pilots*	CDT*	Meetings/ Training	MM*	DNC*
21	1	4	0	25	4	10/8	4	0	2	8
*Watch = Pilots scheduled to be on-watch, including pilots on major medical; CTJ/Pilots = Callback jobs/pilots working Callback jobs; CDT=Callback Days taken; MM = pilots on major medical; DNC = pilots off-duty and unavailable for Callbacks										

On July 7, 2018, a vessel was delayed three hours due to the lack of an available rested pilot. A pilot was requested ("ordered") for an assignment with an order time of 04:30, but no pilot was available to move the vessel until 07:30.

In this instance, there were 25 vessel assignments that day, with 21 pilots who were scheduled for duty. In addition to the above-average demand for pilotage service, there were also four delays by customers of between of 8-12 hours each, that tied up available pilots. The scheduled pilots were further reduced with two pilots unavailable on major medical leave (one on-duty and one off-duty), eight pilots off-duty who were not available for Callbacks, four on-duty pilots who took Callback Days (i.e., used earned Callback Days to take a day of respite), and 4 repos. Making up for the shortfall in available on-duty pilots were eight off-duty pilots working 10 Callback jobs and three on PPW. However, Callbacks were unable to provide complete relief for the high demand that day because of even higher demand the day before. On July 6 there were 34 assignments that lead to 20 pilots taking mandatory rest beyond the call time for the 04:30 assignment on July 7. As a result, PSP had no choice but to delay that vessel assignment on July 7 until 07:30.

Example 2 – July 20

Watch	Pilot Delays	Customer Delays	Cancel	Vessel Assign.	Repos	CTJ/Pilots	CDT	Meetings/ Training	MM	DNC
22	2	3	0	24	8	11/6	4	0	2	8

Another example of vessels delayed awaiting pilots occurred on July 20, 2018. On that date, two vessels were delayed: one was delayed from 14:30 to 17:00, and another was delayed from 17:00 to 18:30.

On July 20, there were 22 on-duty pilots scheduled to perform 24 vessel assignments and eight repos. However, pilot availability was reduced by three customer delays between four to seven hours each, four pilots taking Callback Days, two pilots out on major medical, and eight pilots who were unavailable for Callbacks. Six pilots did perform Callbacks, for a total of 11 jobs.

As with the delay on July 7, the shortage of available pilots was exacerbated by high demand the preceding day: there were 27 assignments on July 19. Of those 27 assignments, 17 pilots had check-in times that required rest well into July 20, leaving an inadequate number of rested pilots to avoid a delay.

Example 3 – August 6

Watch	Pilot Delays	Customer Delays	Cancel	Vessel Assign.	Repos	CTJ/Pilots	CDT	Meetings/ Training	MM	DNC
21	1	1	1	13	6	2/2	6	2	2	2

On August 6, 2018, a single vessel was delayed awaiting a pilot. That vessel ordered a pilot for 15:30, but no rested pilot was available until 12:00 on August 7, a delay of 20.5 hours. Before delaying the vessel the lack of available pilots was discussed with the vessel's agent, who was accepting of the delay due to the nature of the assignment.

Although 21 pilots were scheduled to be on-watch, on August 6, the available pilots were reduced by one customer delay of 1-2 hours, one cancellation, two pilots on major medical, six on-duty pilots taking Callback Days and two pilots attending meetings. Despite that this delay occurred on a day with relatively low demand (only 13 assignments) it nonetheless resulted from insufficient rested pilots available to take an assignment.

On this occasion, the principal driver of the extreme pilot shortage was the need for pilots to obtain rest in advance of Train the Trainer meetings scheduled by the Board for 08:00 August 7, which PSP had recommended be scheduled at a slower time of year. Six pilots attended the meeting (two on-duty, three off-duty, and one on major medical), and in order to ensure compliance with rest rules, none were available to take an assignment with a late check-in time on August 6. PSP also had a regularly scheduled Board Meeting at 09:00 on August 7, attended by two on-watch pilots and four off-watch pilots, which further reduced pilot availability on the afternoon of August 6. Combined with a number of assignments commencing late on August 5 and early on August 6, there were simply no rested and available pilots to take the assignment until August 7 at 12:00.

Example 4 – August 24

Watch	Pilot Delays	Customer Delays	Cancel	Vessel Assign.	Repos	CJ/Pilots	CDT	Meetings/ Training	MM	DNC
21	4	2	0	24	2	6/6	3	1	2	12

Four vessels were delayed awaiting pilots on August 24, 2018: (1) a bulk ship was delayed starting at 22:00 on August 23 until 0:300 on August 24; (2) a container ship was delayed from 03:00 to 07:00; (3) a tanker was delayed from 08:00 to 09:00; and (4) one ATB was delayed from 16:00 until 19:00.

This was yet another high-demand day, with 24 assignments and two repos, completed when only 21 pilots were scheduled for duty. However, the available pilot pool was reduced by two on-watch pilots on major medical, three pilots taking Callback Days, two customer delays of 2-4 hours each, one upgrade trip performed by an off-duty pilot, and 12 pilots unavailable for repositioning.

Despite the fact that six pilots accepted a total of six Callback jobs, again, each of these delays was the result of the lack of available rested pilots following a day with high demand. In this instance, there were 28 assignments on August 23, and the check-in times for those assignments resulted in pilots taking mandatory rest on August 24. Those rest intervals ended between 02:00 and 17:30 on August 24, leaving an insufficient number of rested on-duty pilots to provide board-on-arrival service without delay.

b. An appointment system would increase pilot efficiency, but dramatically increase vessel delays and costs

One way to alleviate the possibility that a pilot is unavailable to move a vessel at its order time is to move to an appointment system. Under an appointment system, pilots would create a schedule of appointments available for vessel movements. Based on daily average vessel movements, the number of pilots could be calculated to ensure that the number of pilots on-watch matches the number of appointments, and each pilot would be provided a regular schedule of ship movements.

Such a system would reduce fatigue, permitting dispatchers to create a schedule that optimizes rest and pilot utilization. However, because the industry's pilotage needs are not seamlessly coordinated to available time slots, such a system would actually drastically *increase* delays. Although technically, the vessel would not be delayed awaiting the pilot, the vessel would nonetheless be unable to commence a movement until the next available appointment time and would essentially sit in a queue like passengers in line for a taxi at the airport.

While that might optimize the efficient use of pilots, it would also come at the expense of the economic health of the region, as fewer vessels would be willing to suffer unexpected additional costs and consequences that would result when sitting in line for a pilot.

c. Pilot efficiency and utilization

A number of questions have also been raised regarding pilot dispatch efficiency, utilization rates, and workload. While there may be circumstances under which individual pilots have a low number of assignments in a particular month, on average the pilots are working an excessive amount.

As noted, although the Target Assignment Level was set at 145, in 2018 the pilots available for duty worked an average of 153 vessel assignments.[24]

[24] Exhibit 3.

i. Duty day utilization rate

One way to look at pilot utilization would be to consider all work tasks performed by pilots necessary to carry out an efficient and organized pilotage system in the Puget Sound. In 2018, the pilots combined to work 7324 assignments, of which 872 were harbor shifts. Combining harbor shifts into groups worked by individual pilots in succession, pilots worked a total of 6,808 vessel movement days. Pilots also had 1,546 repos, 275 training days (of which only 110 were on-watch), and 577 meetings (of which 361 were on-watch), not including work performed at home in preparation for and in furtherance of the important goals of committee and BPC meetings.

Work Task	Days
Assignments	6808
Repos	1546
Meetings	577
Training	275
TOTAL	**9206**

With an average of 47.86 pilots available for duty each month in 2018, this means pilots worked an average of 192.35 days. Out of 181 duty days, this amounts to pilots working the equivalent of 106% of their total duty days in 2018.

Total Work Days	9206
Average No. of Pilots	47.86
Work Days per Pilot	192.35
Duty Days	181
Duty Day Utilization Rate	106%

ii. Meetings and training further the core mission of PSP and the BPC

It should also be noted that while some industry members have questioned whether meetings are discretionary and can be scheduled in off-watch periods, cutting even further into available respite, administrative functions of the pilots are expressly considered in setting the number of pilots in WAC 363-116-065(2)(i). This is because the meetings and training scheduled by PSP serve to further the mission of compulsory pilotage under RCW 88.16.005.

Most meeting can be categorized in three ways: (1) meetings for safety and environmental concerns, (2) Board of Pilotage Commissioners' meetings, and (3) meetings to serve administrative purposes of the PSP that are important to its continued functioning.

A non-exhaustive list providing examples of these three categories includes:

Meetings to Promote Safety and the Environment
SRKW Task Force meeting regarding Orcas
AMSC meeting on emergency and disaster preparation
Meeting with the Army Corp of Engineers regarding Tacoma waterway issues
Harbor Safety meetings
Safe Practices Committee meetings
United States Coast Guard meetings on Tsunami preparedness
Bollard Pull meetings with tugs to discuss information on tug capabilities
Board of Pilotage Commissioners Meetings
Trainee orientation
BPC regular meetings
BPC examinations
Exam analysis
Exam committee meetings
Exam beta testing
Exam work groups
Fatigue Management Committee meetings
Simulator evaluations
TEC Committee meetings
PSP Administration Meetings
Monthly board meetings (scheduled on change day to reduce impact on pilot availability)
Work rules meetings (to explore best dispatch practices)
General membership meetings (held quarterly on a wide variety of topics)
Tariff committee meetings (evaluates potential tariff redesigns and ratesetting issues)

These meetings are scheduled in advance to help create a predictable schedule and assist with managing fatigue. While meetings are frequently scheduled on Tuesdays (change days) to avoid a lack of available pilots, they are also frequently taken during off-days. However, scheduling meetings during respite also limits time for rest, and thus meetings are not limited strictly to off-duty pilots.

Similarly, pilots must spend time training, through upgrade trips, continuing education, and simulator training to ensure that pilots maintain the high level of skill necessary to continue PSP's track record of no major incidents in the Puget Sound.

iii. Pilots with low assignments

Despite the high overall workload for pilots in 2018, a number of questions have also been raised about why some pilots worked fewer assignments than others in certain months. Specifically, the question was raised as to why pilots have worked fewer than six assignments. Because the answer often relates to sensitive medical information of particular pilots, to protect the privacy of those individuals PSP will not be addressing the explanations on a month or pilot-specific basis. However, after examining the reasons each pilot working six or less assignments in a month in 2018, the following is a complete list of the explanations for such occurrences (typically in combination with each other):

- Pilot was scheduled for Earned Time Off;
- Pilot was taking Callback Days;
- Pilot was unfit for duty and taking Callback Days;
- Pilot was on Major Medical leave;
- Pilot was the President or engaged in administrative tasks; and
- Pilot was training/facilitating training

3. Managing Callback jobs and the accumulation of Callback Days

As noted above, the use of Callbacks and creation of Callback Days was originally intended to provide a relief valve for days of high vessel traffic in order to avoid delaying vessels despite the lack of available on-duty pilots. At that time, PSSOA supported the use of Callbacks because it meant more jobs could be completed with fewer pilots. However, the use of Callbacks was never intended to serve as a long-term substitute for staffing the Puget Sound Pilotage District with a sufficient number of pilots or to permit pilots to essentially retire early by burning Callback Days for long time periods in advance of retirement.

While Callbacks are manageable and often decrease when there are adequate pilot numbers, in recent years, workloads have rarely subsided long enough to actually decrease the total accumulation of callbacks. During times of pilot shortage, in fact, Callback Days have dramatically increased.

a. Growth of accumulated Callback Days

In 2010, at the time of the last major decision by the BPC regarding the number of pilots, the total accumulation of Callback Days was already becoming a significant problem. At that time, PSP requested relief from BPC in lowering the assignment level and increasing the number of pilots due to the accumulation of Callbacks that naturally occur when pilot workload is excessive.

The 2010 PSP submission reflected that Callbacks had little growth during times of a reasonable pilot workload: [25]

[25] Puget Sound Pilots Report of Information in Aid of WAC 363-116-065 Determination, February 11, 2010.

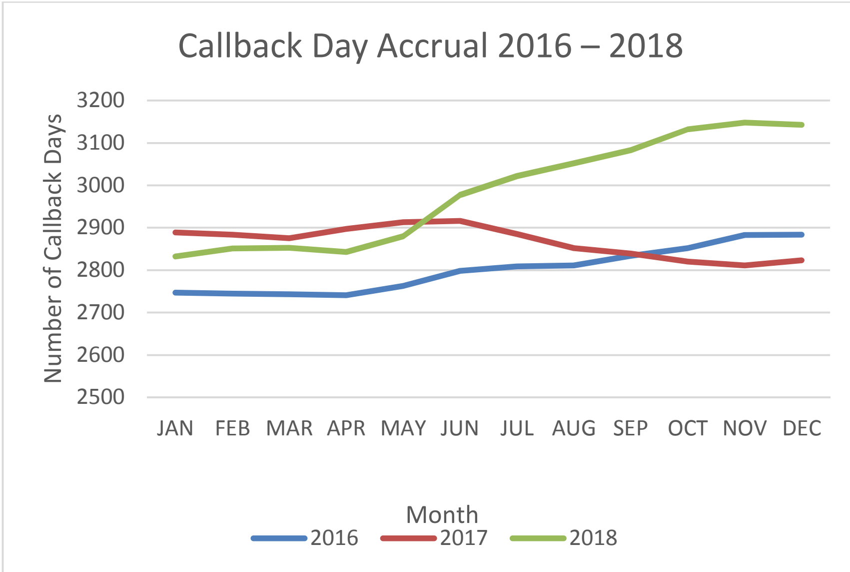
Year	Net Change in Callback Days
1995	61
1996	141
1997	-47
1998	-104
1999	35
2000	-111
2001	-119
2002	23
2003	187
TOTAL 1995-2003	**66**

However, when pilot workloads were excessive during the 2004-2008 period, Callback Days accumulated at a much higher rate:[26]

Year	Net Change in Callback Days
2004	184
2005	491
2006	169
2007	208
2008	207
TOTAL 2004-2008	**1259**

Between the end of 2008 and the end of January, 2016, the total accumulation of Callback Days doubled. In fact, as reflected below, the total number of Callback Days has now grown to over 3,100.

[26] *Id.*



ACCUMULATED CALLBACK DAYS			
Month	**2016**	**2017**	**2018**
JAN	2747	2889	2832
FEB	2745	2884	2851
MAR	2743	2875	2853
APR	2741	2897	2843
MAY	2763	2913	2880
JUN	2798	2916	2977
JUL	2809	2885	3022
AUG	2811	2852	3052
SEP	2834	2839	3083
OCT	2852	2820	3132
NOV	2883	2811	3148
DEC	2884	2823	**3143**

According to NASA, the current total of accumulated Callback Days represents 16 years of pilot time, suggesting chronic understaffing of pilots and an indicated need for a significant increase in the number of authorized pilots.[27]

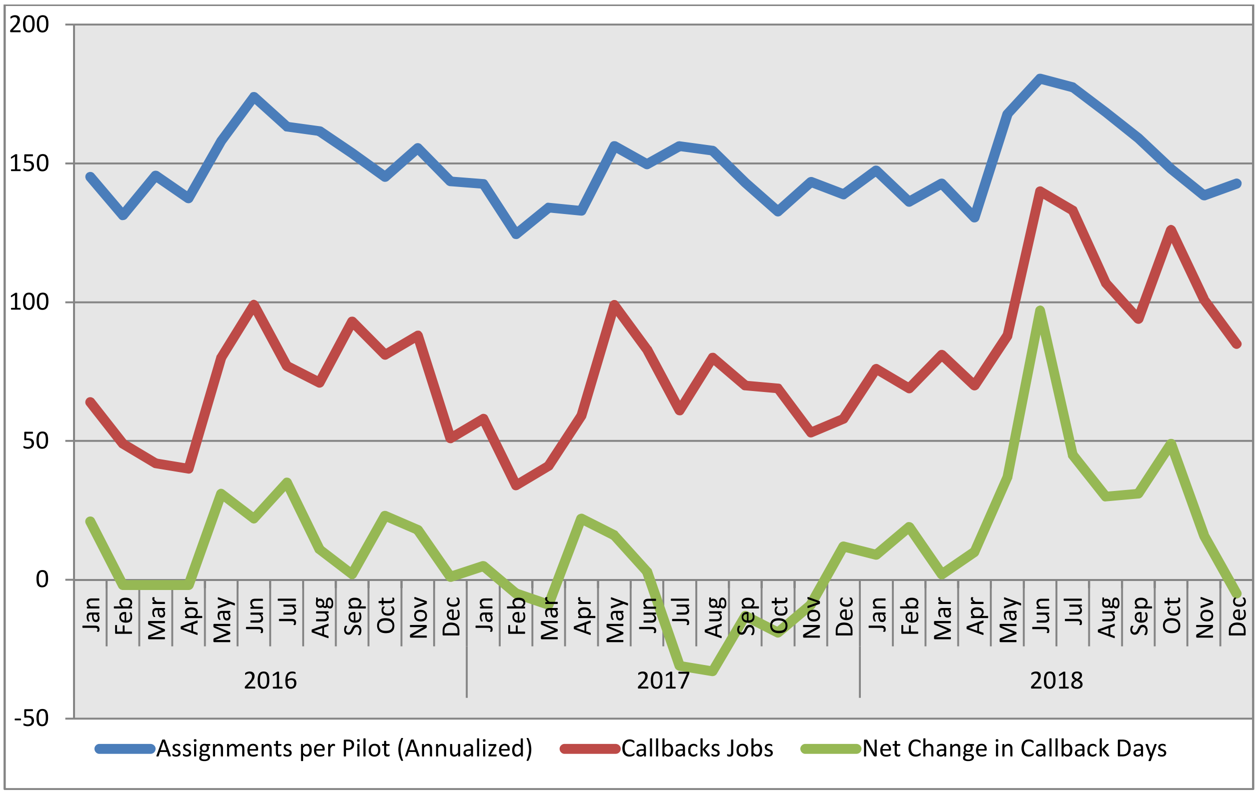
b. Managing Callback Days by capping does not work without adequate pilots

Because Callback Days serve as a mechanism to avoid vessel delays when there are inadequate numbers of on-duty pilots, there are only two options to potentially manage Callbacks: (1)

[27] Exhibit 1, p. 36.

increasing the number of pilots and reduce the workload per pilot, or (2) intentionally delaying vessels.

That the accumulation of Callback Days is tied directly to workload should be apparent. Observing a comparison of the last three years of Callback Jobs taken, net accumulation of Callback Days, and pilot workload on a monthly basis demonstrates a clear relationship between these values,[28] and reflects that when pilot workload decreases, more Callback Days can be taken than Callback Jobs performed, resulting in a reduction of total Callback Days.



NASA confirms this relationship, and within its recommendation for pilot staffing it includes two additional pilots simply to reduce the number of accumulated Callback Days in addition to the number of pilots needed to stop the growth of Callbacks.[29]

It is a further recommendation of NASA that once the accumulated Callbacks are reduced and pilot numbers are adequate that PSP should consider putting a cap on the accumulation of Callback Days.[30] This method of managing Callback Days has been attempted by PSP in the past. Between 2012 and August, 2018, PSP operating rules provided that all Callback Days over

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[28] Exhibit 3.
[29] Exhibit 1, pp. 36-38, 44.
[30] Exhibit 1, p. 44.

60 expired one year following their creation. However, that system simply did not work. Even though the cap existed from 2012 to 2018, over 2800 Callback Days had accumulated by the end of 2017. This is because when there are an insufficient number of pilots, capping Callback Days forces pilots to use them, even at times of high demand for pilotage services. Under that former system, pilots would take Callback Days to avoid losing them, and thereby generate a new Callback Job in a different pilot who was inevitably called back to cover an assignment. Additionally concerning about such a policy is that when the system is highly strained, as it was in 2018, it results in vessel delays by forcing pilots to take Callback Days even when there is no pilot to take a Callback Job.

As a result of its history with capping Callback Days, PSP believes that increasing the number of licensed pilots is the only way to manage the creation of Callback Days. Once there are sufficient pilot numbers to cease the net-positive accumulation of Callback Days, PSP can reconsider whether to amend its operating rules to limit Callback Day accumulation once again.

4. Watch Systems

By its memo on January 17, 2019, the Board of Pilotage Commissioners requested that the interested parties present information regarding the watch system utilized in the Puget Sound Pilotage District and how it compares to other pilotage districts. Although that presentation remains available for BPC consideration, a brief recap is provided here.

a. Watch systems are rooted in the concept of "day-for-day" duty cycles

Like nearly all other pilotage districts, the watch system utilized by PSP attempts to honor the long-held custom and practice by which professional mariners earn one day of respite for each duty day worked. As attested to by Captain George Quick, Vice President of International Organization of Masters, Mates and Pilots, maintaining the day-for-day watch schedule is critical to attracting pilots, who seek to maintain their customary schedule and to provide much needed rest after periods on-duty, which typically require pilots to be available for duty around the clock, and maintain variable sleep schedules during their watch period.[31]

There are more than 60 pilotage groups in the coastal states, plus Puerto Rico and the Virgin Islands. It is customary for pilots to be divided into watch groups, with one group on-duty while another is off-duty, and the vast majority maintain a day-for-day balance to watchstanding.[32]

b. Puget Sound Pilots

PSP's watch system requires each pilot who is fit for duty to stand watch for 181, 24-hour days. PSP's watch standing system relies on 11 groups of pilots, in which there are typically 4-5 pilots per group. Five groups of pilots are on duty at any given time while five other groups are on respite and one watch group is off for an additional week of scheduled earned time off.

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[31] Statement of Captain George Quick, Exhibit 4.
[32] Exhibit 4.

The watch schedule requires each on-watch group to work 15 consecutive days during which each pilot is on-duty 24 hours per day (excepting mandatory rest periods). This watch system can be graphically represented as follows:

	M	T	W	TH	F	S	SU
Week 1							
Week 2							
Week 3							
Week 4							
Week 5							
Week 6							
Week 7							
Week 8							
	On-watch days						
	Off-watch days						

PSP divides pilots into 11 watch groups, each of which typically has 4-5 pilots. As presented at the April 18, 2019 regular meeting of the BPC, those groups are scheduled to work in a rotation system in which each group cycles between on-watch and off-watch through 10 cycles, followed by a cycle of earned time off. Graphically, that calendar is depicted as follow:

Watch Period	Start Date	ETO	Groups on Watch					Groups off Watch				
1	01/08/19	3	2	11	9	7	5	1	10	8	6	4
2	01/22/19	4	3	1	10	8	6	2	11	9	7	5
3	02/05/19	5	4	2	11	9	7	3	1	10	8	6
4	02/19/19	6	5	3	1	10	8	4	2	11	9	7
5	03/06/19	7	6	4	2	11	9	5	3	1	10	8
6	03/19/19	8	7	5	3	1	10	6	4	2	11	9
7	04/02/19	9	8	6	4	2	11	7	5	3	1	10
8	04/16/19	10	9	7	5	3	1	8	6	4	2	11
9	04/30/19	11	10	8	6	4	2	9	7	5	3	1
10	05/14/19	1	11	9	7	5	3	10	8	6	4	2
11	05/28/19	2	1	10	8	6	4	11	9	7	5	3

After 10 cycles of this watch system, a pilot will have worked 150 days on-duty, and 130 days off-duty, thus, during each watch group's 11th rotation, they are scheduled for earned time off before returning on-duty. By the end of the calendar year, this system results in a pilot having worked 178 days on-watch. Adding to those days, pilots work an additional three days of "Peak Period Work" ("PPW"), bringing the total number of duty days to 181.

In those 181 duty days, pilots have been expected to work 145 assignments per year. During 2018, the available pilots actually worked an average of 153 vessel assignments and 192 work-day equivalents.

b. Watch System for other pilotage districts

While other pilotage districts frequently use varying watch system, each typically results in roughly a day-for-day watch calendar.

San Francisco:

The San Francisco Bar pilots also maintain a day-for-day watch system. Most of the San Francisco pilots work one week on followed by one week off, with the remaining portion of pilots working two weeks on and two weeks off.[33]

With this day-for-day system, and despite having much shorter commutes to and from assignments that avoid the need for repositionings,[34] San Francisco Bar Pilots work 174 duty days, with an assignment level of 128 assignments per pilot.[35]

Columbia River Pilots:

The Columbia River Pilots ("COLRIP") in Oregon also maintain a day-for-day watch schedule, with each pilot working two weeks on and two weeks off, with each pilot working a different period by staggering the start days rather than in watch groups. In addition to their off-watch days, COLRIP pilots receive 10 days of earned time off per year, which can either be used or accumulated.

The COLRIP pilots work an average of 182 duty days before their 10 days of ETO, and have an assignment level of 106 assignments per pilot.[36]

BC Coast Pilots

As presented on April 18, 2019, the BC Coast pilots work a complicated four-year watch schedule, which amounts to a day-for-day system at its conclusion.[37] The BC Coast pilots worked an assignment level of 108 assignments per pilot in 2018.[38]

Fraser River Pilots

The Fraser River Pilots also work a complicated schedule that follows a pattern of two cycles of 12 days on and 16 days off followed by 12 days on and 28 days off.[39] The Fraser River Pilots

[33] "San Francisco Bar Pilot Fatigue Study," Hobbs, Gregory, Parke, Pradhan, Caddick, Bathurts, Flynn-Evans, National Aeronautics and Space Administration, Ames Research Center Fatigue Countermeasures Laboratory (2018), p. 24.
[34] *Id*. at 26.
[35] As of the time of NASA's San Francisco Bar Pilots Fatigue Study.
[36] Final Order 10-01, Oregon Board of Maritime Pilots, May 19, 2010, p. 6.
[37] *See* Exhibit 5, Email from Rick Hamner, BC Coast Pilots. Exhibit 5 was further explained via telephone call between Rick Hamner and Captain vonBrandenfels.
[38] Information derived from Pacific Pilotage Authority 2017 Annual Report, p. 14, attached as Exhibit 6.

ultimately work only 137.5 duty days per year and maintain an assignment level of 144 assignments per pilot.[40]

Port Everglades:

Although the pilotage district is not comparable to the Puget Sound, the Port Everglades Pilots' Association also maintains a day-for-day duty cycle that is publicly available:

> The Port Everglades Pilots' Association work schedule calls for having nine pilots on for four weeks, while the other nine are off the board. The nine pilots on watch are on call 24/7, however the watch is divided into two, 12 hour periods whereby there are primarily 5 pilots on day watch and 4 pilots on night watch. At times of peak traffic, some of which are predictable and others are not, pilots are called in across the day/night divide as needed to prevent delays. There is a higher prevalence of this occurring during the 20 week winter cruise ship season. To cover the foreseeable, significant spikes in traffic that occur on the weekends during the peak of cruise ship season, two of the off-watch pilots are often called in to provide the other regular watch pilots sufficient time to rest between work periods.[41]

5. Expected Retirements

Pilot retirements are driven by a variety of reasons, including (among others) health, workload pressures, and reaching the mandatory retirement age. In recent history, the number of pilots retiring each year has been increasing, as is reflected below:

Year Period	Average Retirements Per Year
1992 to 2008	**1.2**
2009 to 2014	**2.7**
2015 to 2019	**3.4**

Annual retirements are expected to continue at no less than 3.4 pilots per year. In fact, the current data suggests the relatively high retirement rate may continue for some time. The current average age of PSP's members is 57 with a median of 59. Baby Boomers are aging and due to a variety of health concerns, the data suggests pilots are retiring at slightly younger age than was

[39] Information provided by Mike Armstrong, President of the Fraser River pilots.
[40] Information derived from Pacific Pilotage Authority 2017 Annual Report, p. 14, attached as Exhibit 6.
[41] Excerpts of the Report of the Investigative Committee Department of Business and Professional Regulation Pilotage Rate Review Committee Applications for Change of Rates of Pilotage at Port Everglades, 2018, Exhibit 7.

the norm, historically. This suggests that the pilot ranks are aging and will likely be retiring more quickly than they can be replaced in the near future.

In light of this concerning retirement trend and the present pilot shortage, BPC and PSP should take prompt remedial action to recruit and train pilot candidates whose eventual licensure will reduce the likelihood that PSP will fall even further behind its operational requirements for providing expeditious board-on-arrival service.

IV. CONCLUSION

As described above, NASA's review of PSP's dispatch records identified a number of practices which significantly implicated risks of fatigue, including insufficient rest between assignments under the former rest rules, inadequate rest after repositionings and other intervals on task outside the classic definition of "assignment," as well as Callback Jobs performed with too great a frequency during pilot respite. As has been demonstrated, in adopting NASA's fatigue countermeasures, a material number of additional pilots will be needed to provide compulsory pilotage in the Puget Sound Pilotage District without causing further vessel delays.

In order to maximize fatigue management and avoid vessel delays, PSP strongly urges the Board of Pilotage Commissioners to take action now to increase the number of pilot licenses to 63 and to undertake all necessary actions to recruit, train and license new pilots in order to meet this increased pilot level. In so doing, PSP believes the Board of Pilotage Commissioners will be furthering its public interest mission by ensuring to the maximum degree possible that pilotage services in Puget Sound continue to protect against the loss of human lives, loss of property and vessels and to preserve the fragile marine environment of the State of Washington while maintaining Washington's premier position in the development, expansion and proliferation of waterborne commerce.

Respectfully submitted this 6th Day of May, 2019,

WILLIAMS KASTNER & GIBBS, PLLC

By:____________________________________
Blair I. Fassburg, State Bar No. 41207

Attorneys for Puget Sound Pilots Association

EXHIBIT 1

Puget Sound Pilot Fatigue Study Report

Kevin Gregory, B.S., Nicholas Bathurst, M.A., Cassie Hilditch Ph.D.

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Table of Contents

Maritime pilot: "… a mariner with expert knowledge of local waters and special ship handling skills. The pilot directs and controls the movement of a vessel through near-shore and inshore waters (referred to as pilotage waters or pilot grounds) unfamiliar to the master or provides navigation advice to or through the master for this purpose. The pilot is expected to integrate local knowledge with operational information to effect a safe passage."

(*Minding the Helm: Marine Navigation and Piloting*, 1994)

1 Glossary

Term	Description
Assignment	A duty period including vessel movements, repositions, upgrades, meetings, and training
Calendar year analysis	The one-year period between January 1, 2018 and December 31, 2018
Callbacks	Work shifts where pilots are called to work at times when they were off call.
Call time	The time when a pilot is given an assignment.
Check-in time	The end of a work assignment.
Circadian low	The point in the circadian rhythm associated with lower body temperature, reduced alertness, reduced cognitive performance, and increased drive for sleep. It typically occurs between 0100-0600 in individuals who are entrained to the light-dark cycle of their local environment.
Circadian rhythm	The rhythmic 24-hour variability of certain behavioral and physiological functions (e.g., sleep/wake cycle, body temperature).
Compensation days (‘comp’ days)	Days off accrued by the pilots for days worked during off call periods.
Work period/duration	The duration of time from the call time until the check-in time.
Fatigue	A biological drive for recuperative rest.
Job start time (job time)	The time when the pilot boards a vessel.
Completion time	The time when the pilot disembarks a vessel.
Multiple harbor shift (MHS)	A series of harbor moves completed by a single pilot during one work period.
Off-watch	The 13-day period during which a pilot is not available for pilotage.
On-watch	A week or weeks during which a pilot is available for work at any time.
Rest period	The period from check-in time to call time.
Reposition (‘repo’)	An assignment that involves moving a pilot from one location to another in order to position pilots in a location appropriate for completing vessel movements.
Skill fatigue	The degradation in skilled performance that can occur after sustained periods of intense concentration.
Sleep apnea	A medical condition in which the upper airway is obstructed during periods of sleep, resulting in intermittent hypoxia, episodic arousals, and sleep fragmentation.

Sleep debt	The deficit between the amount of sleep needed and the amount of sleep obtained. Sleep debt can accumulate over multiple nights, producing progressively more severe performance impairment.
Sleep inertia	The “grogginess”, “disorientation”, and associated performance impairments experienced upon waking.
Trailing 12 months	The 12 month period from October 2017 until the end of September 2018
Upgrade	A vessel move assignment completed by a pilot in order to upgrade his/her pilot license.
Work period	The period from the call time to the check-in time.

2 Structure of this document

This document begins with an introduction to the topic of fatigue, its causes, and its impact on human performance. The work of Puget Sound Pilots (referred to simply as "pilots") is then described. We then review the literature on fatigue in transport and industry, including prior studies of maritime pilots. We next present our two primary data analysis efforts 1) descriptive statistics summarizing factors likely to influence fatigue, including questions posed by the Board of Pilot Commissioners Fatigue Management Committee based on 12 months of dispatch data that was provided to us by the pilots, 2) a model estimating staffing requirements to account for the assignment level and adherence to fatigue risk management policies. Following a final summary and conclusions section, we list a series of recommendations intended to assist the Puget Sound Pilots as it develops mitigation systems and regulations to manage the risk of pilot fatigue.

3 Background

The Puget Sound Pilots

In 1789, the US Congress passed the Lighthouse Act to provide the legal framework of maritime piloting (Hobbs et al., 2018). Over a century later, the Puget Sound Pilots (PSP) were established. The first record of pilotage on the Puget Sound was made in 1840 and the hazards and risks of the job are largely the same now as they were at that time (Smith, 2014). The PSP are licensed for 52 highly skilled independent professional contractors authorized by the Washington Board of Pilotage Commissioners (BPC) to safely pilot container ships, oil tankers, cargo vessels, and cruise ships through Puget Sound waters. On average, there are more than 7,000 pilot driven ship movements per year in the Puget Sound. The mission of the Puget Sound Pilots is to safely pilot vessels through the Puget Sound in order to prevent loss of lives, damage to property and vessels, and harm to the marine environment ("Puget Sound Pilots," 2019).

The Puget Sound waterway is bordered by the Olympic Mountain Range to the West, Canada to the North, Tacoma to the South, and Seattle to the East (Figure 1). Puget Sound includes 7,000 square miles of waterway, 14 major ports and two dispatch hubs (i.e., Port Angeles Pilot Station and Seattle) ("Puget Sound Pilots Website," 2019). The geographical location of Puget Sound can produce extreme and unpredictable weather conditions and waterway changes when compared to other ports around the US (*Washington state pilotage final report and recommendations*, 2018). For example, fog, storm cells moving directly through the sound, and drastic changes in tides and currents complicate navigation of ship traffic through the Sound.

The Puget Sound Pilots service vessels using a “board-on-arrival” model of service, where a pilot is dispatched to guide a ship through the Sound upon arrival in the waterway or as requested for departure or other ship movements. In order to provide board-on-arrival service, the pilots work an on-call watch schedule, where half of the licensed pilots are scheduled for 15 consecutive days on at a time. During the on-watch period, pilots may be called to board a vessel at any time of day or night. The pilots available for work on a given watch are assigned work by dispatch in a rotation, whereby after a pilot completes a vessel move, s/he will be moved to the bottom of the watch list and will not be assigned another assignment until all available qualified pilots on the list have been assigned work. Ship traffic is monitored, and projected arrival times are reviewed by dispatchers, but a variety of factors can influence the actual arrival time relative to the scheduled arrival time. The unpredictable nature of the rotation of pilots, coupled with unpredictable ship arrival times leads to irregular and unpredictable schedules. Adding to these challenges, the border with Canadian waters and differences between maritime operations in the two countries can reduce the predictability of ship arrivals. Ship traffic is only allowed to the ports in British Columbia during specific windows of time. If a Canada-bound ship misses a window, then they will go to the Puget Sound. (Communication from the President of the Puget Sound Pilots, September 14, 2018). A consequence of irregular schedules and the unpredictable nature of PSP operations introduces the concern that pilots may not be able to obtain sleep of adequate quantity and quality. Such sleep deficiency increases the risk of performance impairment.

As a result, the goal of the current study was to evaluate one year of PSP dispatch records to identify potential areas of concern, to recommend work hour changes based on any issues identified, and to determine how many pilots should be licensed in order to continue board-on-arrival service, while also minimizing the impact of fatigue.

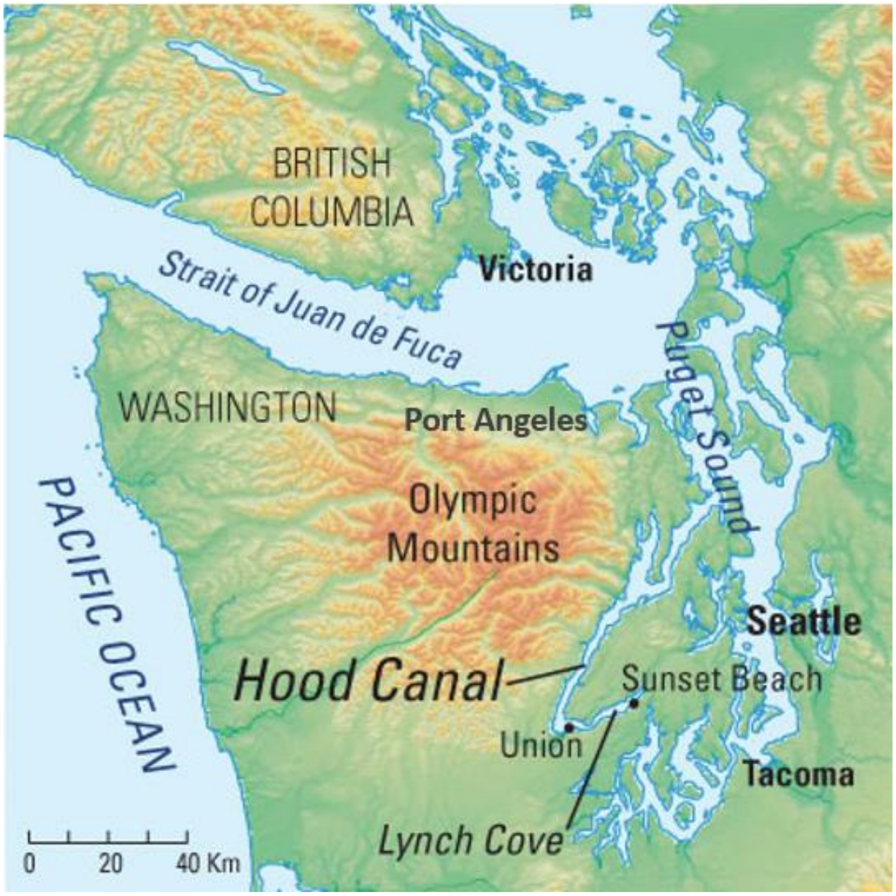


Figure 1. Map of the Puget Sound waterway.

Causes and Consequences of Fatigue

Fatigue is a major threat to safety in industries that require irregular schedules and 24-hour operations with numerous incidents and accidents being attributed to fatigue (Mitler et al., 1988). Indeed, in approximately 20% of incidents investigated by the National Transportation Safety Board (NTSB) over a 12-year span, fatigue was implicated as a causal factor (Marcus & Rosekind, 2016). The reduction of fatigue-related accidents in all transport modalities and a requirement for medical screening and treatment for sleep apnea are both included on the NTSB's list of ten "most wanted" safety priorities.

3.1.1 Definition of Fatigue

This report will use the term fatigue to describe changes in alertness and cognitive performance arising from sleep loss, circadian misalignment, and sleep inertia. Each of these factors are described in detail below. We recognize that the term fatigue can be used to describe other conditions, such as physical discomfort stemming from muscle exertion and degradation of performance due to elevated workload or sustained mental focus. While these forms of fatigue may degrade performance, they are difficult to quantify and are outside the scope of this report.

3.1.2 Sleep and Circadian Rhythms

The drive for sleep is regulated by two processes: homeostatic sleep pressure and the circadian rhythm. Homeostatic sleep pressure builds up with hours of wakefulness and is dissipated by time spent asleep. Therefore, the longer an individual is awake, the higher sleep pressure will be. The circadian rhythm is often referred to as the body clock. It typically promotes sleep at night and wakefulness during the day. When an individual obtains regular, nighttime sleep opportunities, these two processes interact to promote consolidated sleep at night (Dijk & Czeisler, 1994). Under these optimal conditions, homeostatic sleep pressure builds up across the day until sleep onset. In order to maintain wakefulness until bedtime, the circadian rhythm in alertness is highest in the hours just before regular bedtime, counteracting the high sleep drive until it is time to sleep. As bedtime approaches, the circadian rhythm starts to promote sleepiness which, in combination with a high homeostatic drive, initiates sleep. As sleep pressure dissipates throughout the sleep episode, the circadian rhythm in alertness drops to its lowest level in the last third of the sleep episode in order to promote a consolidated bout of nighttime sleep. Perturbations to this balanced interaction can lead to sleep loss and fatigue, as described below.

3.1.3 Acute Sleep Loss

Acute sleep deprivation arises from spending too many continuous hours awake, i.e., increasing the homeostatic sleep drive past the regular threshold for sleep (Dijk & von Schantz, 2005). Laboratory studies have shown that as hours of wakefulness increase past 16 hours, cognitive performance rapidly degrades (Dijk, Duffy, & Czeisler, 1992) with sustained wakefulness of 18 hours leading to performance decrements equivalent to having a blood alcohol concentration of 0.05%, the legal drink drive limit in several countries (Dawson & Reid, 1997).

Acute sleep loss can also be referred to as extended wakefulness and is common in shiftwork environments with long shifts or irregular schedules that make it difficult to plan pre-shift sleep. For example, prior to a night shift, it is often difficult to sleep during the daytime. Therefore, workers are often awake for more than 24 hours at the end of the night shift. This first night shift is associated with impaired performance (Santhi, Horowitz, Duffy, & Czeisler, 2007). Furthermore, working overtime and extended shifts is associated with a higher rate of injuries and accidents (Barger et al., 2005; Lombardi, Folkard, Willetts, & Smith, 2010).

3.1.4 Chronic Sleep Loss

Recent consensus statements from the National Sleep Foundation and American Academy of Sleep Medicine suggest that adults need 7-9 hours of sleep per night for optimal alertness during the day (Hirshkowitz, 2015; Watson et al., 2015). If an individual obtains as little as two hours less sleep than they need each night, this sleep debt can accumulate leading to chronic sleep loss and impaired performance (Belenky et al., 2003; Van Dongen, Maislin, Mullington, & Dinges, 2003). With each additional night of reduced sleep, performance will be worse than it was the day before. Indeed, chronic sleep loss can have impacts on performance that are as severe as those from acute sleep loss. For example, following sleep restriction of a six-hour opportunity per night across 10 days, performance impairment was degraded to the equivalent of one whole night of sleep loss (Van Dongen et al., 2003).

Despite sleep duration recommendations, work and life demands, poor sleep hygiene and sleep disorders result in most adults obtaining less sleep than they require, with nearly 30% of the US population reportedly obtaining six or fewer hours of sleep per night (Krueger & Friedman, 2009; Luckhaupt, Tak, & Calvert, 2010). Further, several studies have demonstrated that airline pilots, truck drivers, and heath care providers working non-standard hours regularly obtain two or three hours less sleep than their optimal daily requirement (Rosekind, 2005). Analysis of time-use data reveals that work and sleep time are inversely related (Basner & Dinges, 2009), suggesting that work schedules can be a primary cause of sleep loss. In addition, fatigue has been shown to increase with the number of consecutive shifts (Folkard, Lombardi, & Tucker, 2005), especially across consecutive night shifts (Aisbett & Nichols, 2007).

3.1.5 Circadian Misalignment

Sleep timing, along with many other physiological processes, is coordinated by a biological clock that operates on a near-24-hour daily (circadian) cycle (Czeisler & Gooley, 2007). In order to align the circadian rhythm with the 24-hour solar light-dark cycle on Earth, the internal biological clock must be reset each day. Exposure to light is the single most powerful resetting agent (Czeisler, Weitzman, Moore-Ede, Zimmerman, & Knauer, 1980). If an individual is not exposed to light, the circadian rhythm will revert to its own internal time-keeping, which can create a transient misalignment between the solar day and internal timing (Flynn-Evans, Tabandeh, Skene, & Lockley, 2014). Light exposure at different times has different effects. For example, light in the biological evening (i.e., at habitual bedtime) can delay sleep timing, pushing sleep and wake times later, while light in the biological morning can shift sleep and wake times earlier. There are many factors which determine the effectiveness of light to reset the body clock, including the intensity, wavelength, pattern, and duration of the light exposure. When an individual is exposed to light during the biological night, such as is the case for shift workers and those experiencing jet lag, misalignment between the drive to sleep and the need to be awake, can occur.

With careful control of light exposure, it is possible for individuals to adjust to jet lag or stable shift schedules; however, it can take many days to adapt. Although such adaptation is possible, it is typically not practical in most shiftwork situations, where individuals revert to being awake during the day and asleep at night on days off (Smith & Eastman, 2012). Under typical circumstances, shiftwork or non-standard working hours may move the body clock by a few hours either side of the local norm (Flynn-Evans et al., 2018); however, the powerful effect of sunlight exposure prevents all but a few shiftworkers from adapting fully to non-standard hours (Hursh, Balkin, & Van Dongen, 2017).

A range of cognitive performance measures (including reaction time and short-term memory) have been shown to exhibit circadian rhythms, with reduced performance during the night hours, and improved performance during the normal hours of daylight and evening. Alertness and cognitive performance typically improve throughout the morning, as a function of the circadian drive to wake, even for a person who is sleep-deprived (Angus & Heslegrave, 1985).

The low point of the circadian rhythm typically occurs between 0200-0600h in individuals who sleep during the night and are awake during the day. The circadian low is characterized by lowered body temperature, diminished alertness, reduced cognitive performance, and an increased drive for sleep. A second, less pronounced period of increased fatigue and lowered performance typically occurs at around 1500h (Hursh, Balkin, Miller, & Eddy, 2004; Minors & Waterhouse, 1985). This period is sometimes referred to as the "post-lunch dip" however, it occurs even when no meal has been eaten. If an individual has partially adapted to a new circadian timing due to shiftwork or jetlag, this low may occur at other clock times that may be misaligned with the need to sleep or be alert.

There is individual variation in the preference for wake and sleep timing (known as chronotype). Morning types, commonly referred to as "larks" have a preference for waking early and going to bed early, whereas "night owls" evening types prefer to wake late and go to bed late (Horne & Ostberg, 1976). Beyond the preference for wake and sleep times, there is often an associated behavioral preference for when to perform mentally demanding tasks. Night owls tend to perform better later in the day when compared to their lark counterparts (Horne, Brass, & Petitt, 1980).

Daytime work hours are aligned with our circadian tendencies as work is set within the period characterized by a high circadian drive for alertness. However, shift work schedules covering 24-hour operations, especially night shifts, set work when the body is primed for sleep. This misalignment between the body clock and work timing leads to fatigue in two ways: (1) working at times when the circadian pressure for sleep is high (e.g. at night); and (2) by reducing the quality of preparatory and recovery sleep during the day when the circadian rhythm is promoting wakefulness. For example, studies of shiftworkers show a distinct peak in performance inefficiency (Folkard & Tucker, 2003) 2003), occupational injuries (Folkard, Lombardi, & Spencer, 2006) and subjective sleepiness (Folkard et al., 2005) between 0200-0600h. Further, shift workers report less sleep on night shifts than on day shifts or days off (Ferguson, Baker, Lamond, Kennaway, & Dawson, 2010).

3.1.6 Sleep Inertia

The term sleep inertia refers to the transient feeling of "grogginess", disorientation, and associated performance impairment experienced upon waking (Jewett et al., 1999). Typically, sleep inertia dissipates in an asymptotic manner until approximately two hours after waking (Jewett et al., 1999), with most severe impairments occurring in the first 3-20 minutes after waking (Wertz, Ronda, Czeisler, & Wright, 2006). In the short-term, the performance impairment associated with sleep inertia can outweigh the recuperative effect of a nap (Ruggiero & Redeker, 2014). For example, it has been observed that performance after waking from a nap can be worse than performance after 21h of continuous wakefulness (Hilditch, Centofanti, Dorrian, & Banks, 2016) and modelling estimates that this may be the case following 48h of continuous wakefulness (Wickens, Laux, Hutchins, & Sebok, 2014).

The severity and duration of sleep inertia is dependent upon a number of factors including prior sleep history, sleep length, time of awakening, and sleep stage prior to waking (Tassi & Muzet, 2000). Sleep inertia tends to worsen with prior sleep loss (both acute and chronic), when awakening during the biological night, following long naps (>30min), and when woken from deep sleep (Scheer, Shea, Hilton, & Shea, 2008). The impact of sleep inertia also appears to be dependent on the type of task that is being completed during the sleep inertia episode with selective attention being particularly sensitive (Burke, Scheer, Ronda, Czeisler, & Wright, 2015). Although the factors described above can exacerbate sleep inertia severity and duration, it is important to note that sleep inertia can still occur following habitual sleep, brief naps, awakening from any sleep stage, and at any time of day (Achermann, Werth, Dijk, & Borbely, 1995; Hilditch, Dorrian, Centofanti, Van Dongen, & Banks, 2017).

Sleep inertia is of concern in workplaces where people must perform a critical function immediately after awakening, such as those who work on-call, or nap on-shift. There are several instances of real-world accidents in which sleep inertia was listed as a contributing factor (Transportation Safety Board of Canada, 2011; Government of India Ministry of Civil Aviation, 2010). Data from the Air Force suggest that the risk of a plane crash is higher in the first hour after waking (Ribak et al., 1983). In the maritime industry, an incident involving the heavy contact of two vessels was suspected to be partially due to sleep inertia. The chief officer of a platform supply vessel had only been awake for four minutes before arriving on the bridge to be briefed and make critical decisions that led to the incident (Marine Accident Investigation Branch, 2011).

3.1.7 Sleep Disorders

Chronic sleep loss may also arise from untreated sleep disorders, notably obstructive sleep apnea (OSA) and insomnia. OSA is a medical condition in which the upper airway is obstructed during periods of sleep, resulting in periods of reduced blood oxygen levels, and frequent arousals from sleep leading to sleep fragmentation (Young et al., 1993). Up to 18% of the population may be affected by OSA (Kang, Seo, Seo, Park, & Lee, 2014; Young et al., 2002).

OSA is a particular concern in the transport industry (Moreno et al., 2004). In the maritime sector, attention focused on this issue following a collision at Port Arthur, TX involving a vessel under the control of a maritime pilot who was suffering from untreated OSA (Strauch, 2015). Reid, Turek, and Zee (2016) found that personnel in the tug, towboat and barge industry had a higher level of risk factors for OSA compared to the general population. Based on this finding, it was recommended that the maritime industry follow the lead of other industries to improve screening and treatment for OSA and other sleep disorders.

3.1.8 Performance Effects of Fatigue

The effects of fatigue on cognitive performance are well-documented. The ability of an individual to self-assess their own fatigue, however, can be poor (Van Dongen et al., 2003). The detrimental effects of fatigue on human performance include slowed reaction time, impaired decision making, reduced attention, and increased incidence of human error (Van Dongen et al., 2003; Wickens, Hutchins, Laux, & Sebok, 2015).The International Maritime Organization lists the following possible effects on fatigue on job performance of maritime pilots (Table 1) (*Guidelines on Fatigue*, 2001).

Table 1 Signs And Symptoms of Fatigue-Related Performance Impairment

<u>Inability to concentrate</u> *Unable to organize a series of activities *Preoccupation with a single task *Focuses on a trivial problem, neglecting more important ones *Less vigilant than usual
<u>Diminished decision-making ability</u> *Misjudges distance, speed, time, etc. *Fails to appreciate the gravity of the situation *Fails to anticipate danger *Fails to observe and obey warning signs *Overlooks items that should be included *Chooses risky options *Has difficulty with simple arithmetic, geometry, etc
<u>Poor memory</u> *Fails to remember the sequence of task or task elements *Has difficulty remembering events or procedures *Forgets to complete a task or part of a task
<u>Slow Response</u> *Responds slowly (if at all) to normal, abnormal or emergency situations

Mood change
*Quieter, less talkative than usual
*Unusually irritable

Attitude change
*Unaware of own poor performance
*Too willing to take risks
*Ignores normal checks and procedures
*Displays a "don't care" attitude
International Maritime Organization, 2001

3.1.9 Impact of Fatigue in the Maritime Industry

Fatigue is a long-recognized hazard that must be managed in the maritime industry (*Guidelines on Fatigue*, 2001; Sanquist, Raby, Maloney, & Carvalhais, 1996). This is in line with McCallum, Raby, and Rothblum (1996), who estimate that 16% of maritime accidents are related to fatigue. It is not necessary here to summarize the extensive literature on maritime fatigue, however, the following examples serve to illustrate the extent of the problem.

Folkard (1999) and Filor (1998) reported that groundings were more common at night than during the day. Another study showed a similar peak in ship collisions in the morning hours based on data drawn from 123 insurance claims (Folkard, 1997). Although the timing of these incidents may also reflect the relative availability of visual cues at night, the peaks are in line with data from other industries in which light is not a factor (e.g. in factories). An examination of 279 maritime accidents identified other major factors as contributing to fatigue in these incidents such as the number of consecutive days worked, days worked in the prior month, and hours on duty prior to the accident (McCallum et al., 1996). In estimating the risk of groundings, Akhtar and Utne (2014) analyzed 93 incidents and concluded that a fatigued operator on the ship's bridge increased the probability of groundings by 23%. This finding is similar to that reported by Starren et al. (2008) who found that between 11 - 25% of groundings and collisions are at least partly due to fatigue.

The broader sleep, circadian, and fatigue literature from in-laboratory studies together with the analysis of sleep, fatigue, performance, and safety indicators across multiple industries support the evidence of fatigue-related events in the maritime industry. These studies and events point to a direct need for greater study and management of fatigue in this industry.

Relationship Between Work Assignments, Scheduling and Staffing Levels

The relationship between work assignments, work scheduling and staffing levels are intertwined. The number and duration of tasks required to complete job assignments directly informs scheduling and staffing needs. Task assignments are typically the primary driver of staffing needs for a given organization, but task assignments are not the only consideration in determining staffing levels. Other factors, such as training, skills/licensing level of workforce, attrition, administrative responsibilities, and workload must all be considered when determining staffing needs. In addition, in industries where the timing of task execution is uncertain, particularly in transportation where weather and other factors can cause schedule delays, additional personnel may be needed to provide flexibility in service requirements. Similarly, in 24-hour operations, sleep loss and circadian misalignment interact with work hours, such that the risk of an operational error or accident after work increases due to fatigue. As a result, work hour restrictions may be necessary to manage fatigue, which also influence staffing levels.

The relationship between work hour rules and staffing needs is not always straight forward, particularly in industries that have unpredictable or safety-critical operations. In many safety-sensitive occupations, regulation determines the maximum work shift length and/or how many individuals are required to perform a given task. These parameters directly inform the number of individuals that are needed to complete task assignments. For example, in US passenger-carrier aviation operations, the Federal Aviation Administration (FAA) restricts the number of hours that a pilot is allowed to work based on the time-of-day and type of operation (i.e. long-haul or short-haul flight) (FAA regulation part 121, section 117). When weather or other factors lead to flight delays, reserve pilots are scheduled to be on call to take over flights from pilots who would otherwise exceed work hour limits. Similarly, in locations where pilot staffing is needed, but where few pilots live, airlines must arrange to position pilots to meet all service requirements (i.e. "deadheading). In addition, the FAA requires that additional pilots are scheduled to operate long-haul flights in order to provide rest opportunities during extended duty work shifts. These factors must be taken into account when determining how many pilots are required to meet service needs.

Given the nature of on-call schedules and board-on-arrival service in the maritime industry, more staffing may be needed to ensure that all ship traffic can be accepted as requested. According to an analysis of the San Francisco Bar Pilot operations, 23 pilots were estimated to be available to move ships on an average day, despite having 60 licenses (Hobbs et al., 2018).

4 Analysis of Dispatch Records

The goal of the study was to identify characteristics of the Puget Sound Pilot schedules that could increase the likelihood of fatigue and to develop a model to project the number of pilots needed to provide board-on-arrival service, while accounting for new work hour rules to reduce the likelihood of schedule-induced fatigue. There were two analysis activities undertaken to better understand the characteristics of the PSP work scheduling practices: (1) analyzing scheduling patterns for both work and off-watch period durations with time of day considerations; (2) using the dispatch data to generate a predictive model to estimate the number of pilots needed to provide board-on-arrival service. The scheduling factors considered were based on those identified by Rosekind (2005) and based on a request provided to PSP from the Board of Pilotage Commissioners (BoPC; memo dated August 10, 2018). Model-building required inclusion of additional factors such as volume of vessel traffic, types of assignments, retirements, travel, and administrative requirements (memo from BoPC to PSP on January 17, 2019).

Table 2. Scheduling factors considered in the present study.

Work Scheduling	*Fatigue Risks*	*Fatigue Management*
1. Length of work period	Long hours awake and time on task lead to increased risks	Limits hours awake and time on task
2. Length/timing of time off between work periods	Inadequate or poor sleep leading to acute sleep loss	Provide adequate sleep opportunity
3. Night work/time of day	Window of circadian low and early morning starts related to increased sleepiness and reduced performance	Limitations on time working when physiological alertness reduced
4. Consecutive days/nights working	Accumulated effects of operational demands and short-term chronic sleep loss	Limit cumulative effects of work and sleep loss
5. Work period start time variability	Disruption of circadian rhythms	Stability in daytime work timing allows circadian clock to stay in sync
6. Recovery periods between work cycles	Long-term chronic sleep restriction	Provide adequate nighttime recovery sleep opportunities
7. Number of callbacks	Long-term chronic sleep restriction	Provide sufficient opportunity for recovery and rest

Data and Processing

Scheduling data were obtained from PSP dispatch records. A total of 7,369 vessel moves completed by 54 unique pilots from October 2017 to September 2018 (the "trailing 12 months") were included in the current analysis (including some who did not work the entire year due to retirements and new hires). A second analysis comprised 7,334 vessel moves for the calendar year from January 2018 to December 2018 was also performed ("calendar year analysis"). These separate analyses were completed, because PSP instituted a 10-hour minimum rest period beginning in October 2018. The trailing 12-month analysis allowed us to evaluate schedules before the implementation of these changes, while the calendar year analysis was completed to conform to the period of time typically assessed for the evaluation of pilot staffing needs.

In our statistical analyses, administrative work by the President of the Puget Sound Pilots was excluded. Dispatch information provided included "call time" and "check-in time" times for every work period (used to define start and end of work periods), "travel time" (i.e. allotment of time to travel to the assignment),"job time" (time of vessel boarding) and "completion time" (time of disembarking from the vessel) for every job within each work period, along with the *to* and *from* locations for each job. In addition, "reposition times" were included in the data (times when an individual must be moved from one duty station to another, similar to deadheading in aviation).

The dispatch data that was evaluated for this report was entered as an archival record and not for the purposes of surveillance and analysis. As a result, there were inconsistencies in some data entries that had to be reconciled prior to analysis. For example, when an individual had a series of training days, this was typically noted only on the first day in the series. Some types of vessel moves were modified from the dispatch dataset to account for common work scheduling practices as follows:

4.1.1 Multiple Harbor Shifts

Data were pre-processed to identify situations where a single pilot completed multiple short harbor moves within a work period. In these cases, the work period was defined as a multiple harbor shift (MHS) and was considered to last from the call time for the first vessel move to the check-in time of the last vessel move. In our analyses and plots multiple harbor shifts are listed as a single vessel move.

4.1.2 Cruise Ship Moves

During the timeframe reviewed, a single pilot would typically complete the inbound and outbound sailings for cruise operations. For these operations, each cruise ship move was considered as a separate assignment, with the time between the two moves considered a rest break.

4.1.3 Reposition Associated Moves

When vessel moves occurred within six hours of a reposition assignment, the reposition shift was combined with the vessel move in the data file and was considered a "reposition job." The work period for these moves was considered to last from the call time for the first assignment to the check in time for the vessel move.

Statistical Analysis

Descriptive statistics were calculated from the 'trailing 12 month' dataset.

4.1.4 Linear Regression Modeling

We used a linear regression model to estimate the number of pilots required to handle all work assignments while reducing the frequency of callbacks and while accounting for work hour rules aimed at mitigating fatigue. Model building was conducted twice, once for the trailing 12 dataset and once for the calendar year dataset. Data were structured as frequency counts per day in order to allow for estimation of the impact of parameter changes on pilot staffing levels using intuitive inputs (i.e. inputs that could be modified by PSP to estimate the impact of a variety of hypothetical changes). Candidate predictors for the model were selected *a priori,* based on scheduling factors identified by Rosekind (2005) and a fatigue risk management review that was presented to the Board of Pilot Commissioners (Table 2). Predictors were screened to confirm a linear relationship to staffing levels. Predictors that were significant at the $p < 0.20$ level in the initial model were included in the final model. Beta coefficients and their associated confidence intervals were calculated for each predictor. These beta coefficients were then multiplied by hypothetical changes in work factors to estimate the number of pilots needed to complete work tasks given potential changes. For example, a beta coefficient was calculated to estimate the relative impact of callbacks on pilot staffing needs. This allows for input of different estimates for the number of callbacks per day and the associated impact on staffing levels by multiplying the beta coefficient by the estimated change in callbacks.

Given the current scheduling convention in maritime operations, approximately half of the pilots are scheduled to work most days, therefore the model estimates the number of pilots required on a single watch day. In order to determine total pilot staffing needs within this day-off-for-day-on framework, the final model estimate was doubled.

One pilot was added to the estimate in order to account for the Puget Sound President, who is not typically scheduled for ship movement activities. Finally, predictors that were not included in the final model, but that influence pilot staffing levels (e.g. accrued callbacks, hypothetical work hour changes, earned time off), were considered in separate analyses and added to the model estimate.

5 General Findings

Distribution and Timing of Assignments

Dispatch data included information on vessel movements, including number of callbacks to move ships on days off (callbacks), repositions of personnel (“repos”), jobs performed to upgrade one’s license (upgrades), training, meetings, compensation days taken for callback days worked (“comp days”), earned time off, and other activities (e.g. bereavement). The total number of activities in each of these categories is shown in Figure 2.

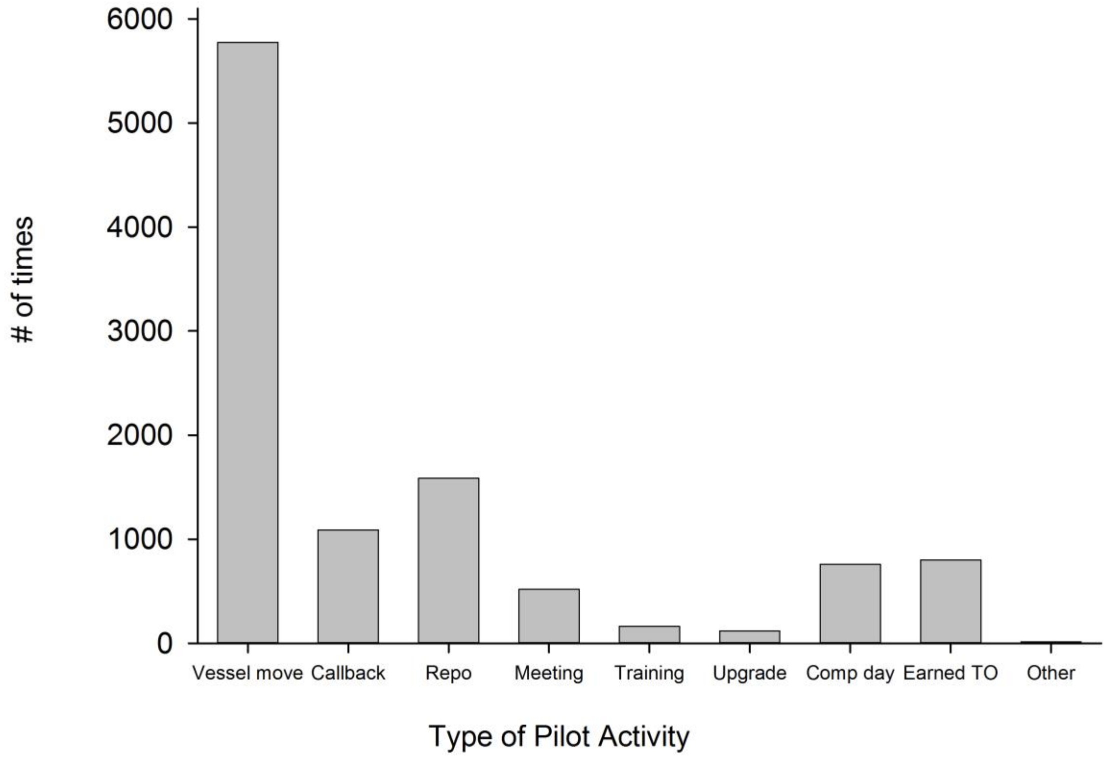


Figure 2. All pilot-related activities during the trailing 12-month period. Vessel move = vessel move completed by pilot while on watch, Callback = vessel move completed by pilot while off watch, Repo = repositions (includes those related to comp days), Meeting = pilot attending meeting, Training = pilot training, Upgrade = vessel move for upgrading pilot license, Comp Day = day off taken during watch as compensation for completing a callback job, Earned TO = earned time off, Other = bereavement, drug test and unfit for duty. Multiple harbor shifts are counted as a single vessel move assignment.

All assignments were inspected to identify patterns in the pilots' schedules. It was apparent that some individual pilots became available for piloting assignments part way through the year or ceased working as a pilot before the year was over. Four pilots worked less than 20 days during the trailing 12 month period. The distribution of assignments for the remaining fifty pilots is shown in Figure 3, although some pilots retired or became unavailable for work partway through the year.

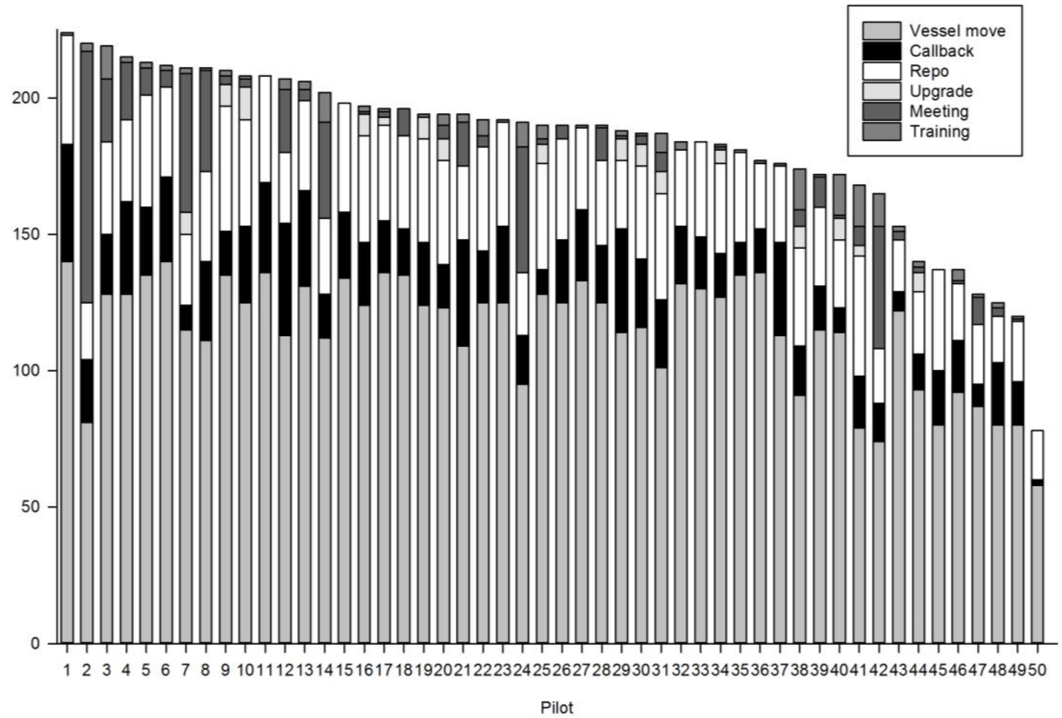


Figure 3. Assignments by pilot. Vessel move = vessel move completed by pilot while on watch, Callback = vessel move completed by pilot while of watch, Repo = repositions (includes those related to comp days), Meeting = pilot attending meeting, Training = pilot training, Upgrade = vessel move for upgrading pilot license. Multiple harbor shifts are counted as a single vessel move assignment.

Figures 4-5 show, the number of total work activities by month (Figure 4) and by day of the year (Figure 5). These figures highlight the sharp seasonal increase in vessel traffic that occurs during the cruise ship season from May until October. The daily variation in these patterns is apparent in Figure 5, where the average number of daily assignments is displayed as a dashed line. Overall, there were 25.3 assignments on an average day, with a minimum of 8 and a maximum of 47 (Figure 5).

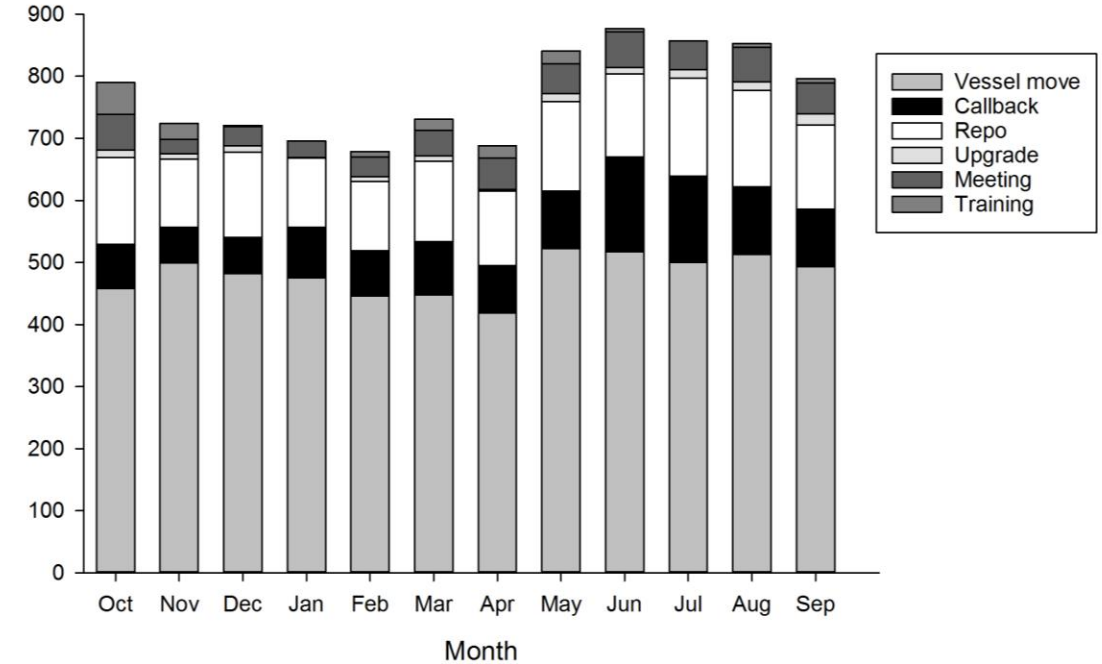
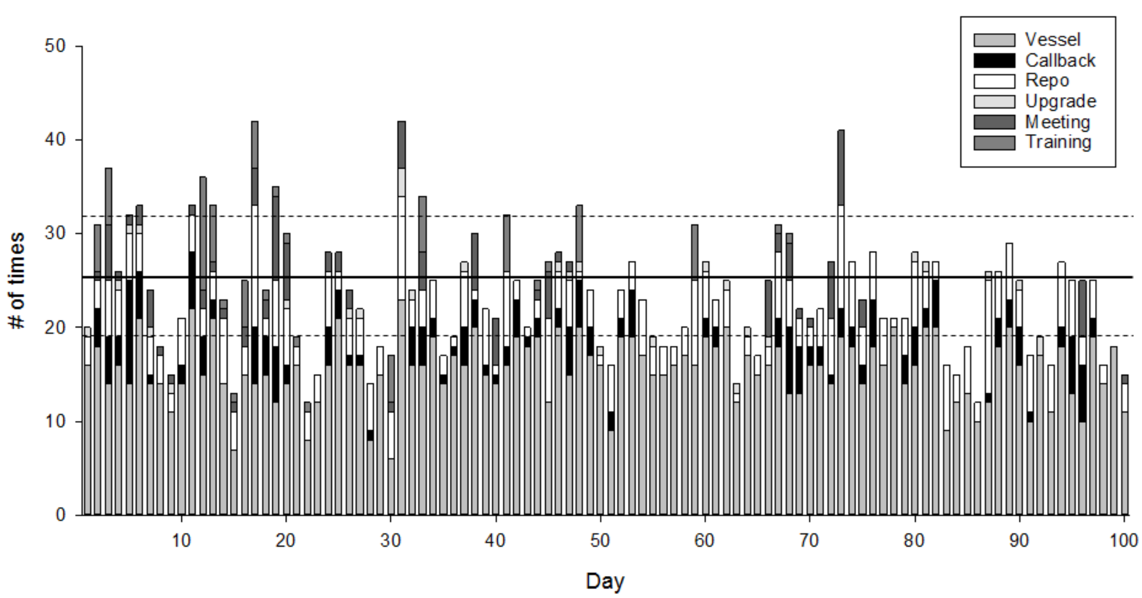
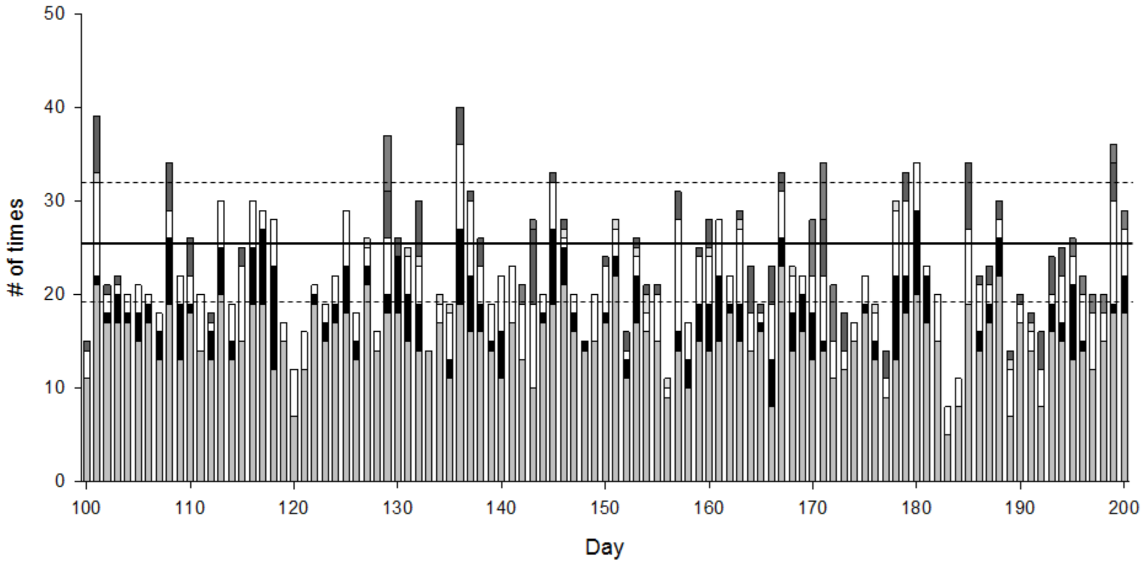
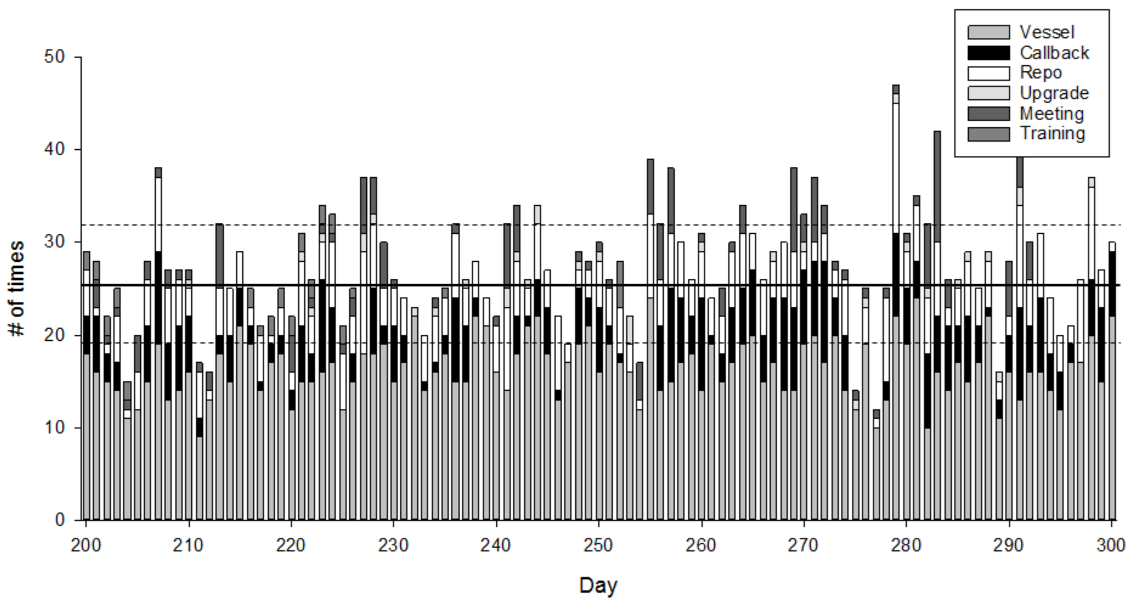


Figure 4. Assignments by month. Vessel move = vessel move completed by pilot while in rotation, Callback = vessel move completed by pilot while not in rotation, Repo = repositions (includes those related to comp days), Meeting = pilot attending meeting, Training = pilot training, Upgrade = vessel move for upgrading pilot license. Multiple harbor shifts are counted as a single vessel move assignment.





# of times
Day



Vessel
Callback
Repo
Upgrade
Meeting
Training
# of times
Day

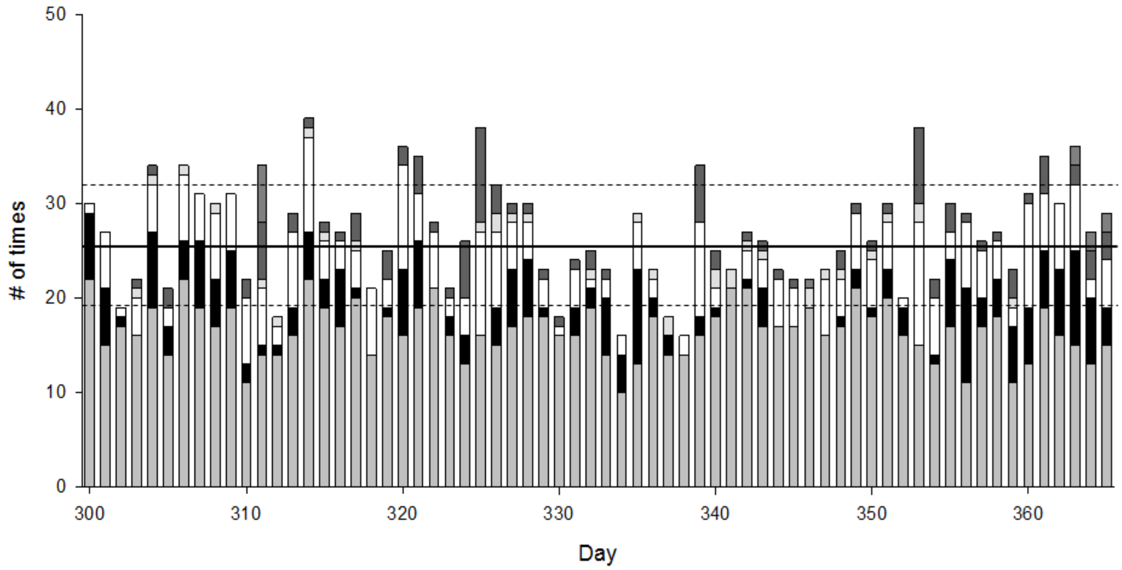


Figure 5. Assignments by day. Frequency of total daily pilot work-related activities across the 12-month period (top panel= days 1-100; following panels= days 101-200, days 201-300, days 301-365). The solid horizontal line represents the average daily total of 25.3 (+/- 6.5) activities with +1/-1 standard deviation presented above and below with dashed lines. Vessel = vessel move completed by pilot while in rotation, Callback = vessel move completed by pilot while not in rotation, Repo = repositions (includes those related to comp days), Meeting = pilot attending meeting, Training = pilot training, Upgrade = vessel move for upgrading pilot license. Multiple harbor shifts are counted as a single vessel move assignment.

There was minimal variation in the number of vessel moves by day of the week (Figure 6). Pilot repositioning and meetings peaked on Tuesdays, which is the change-over day between watch schedules.

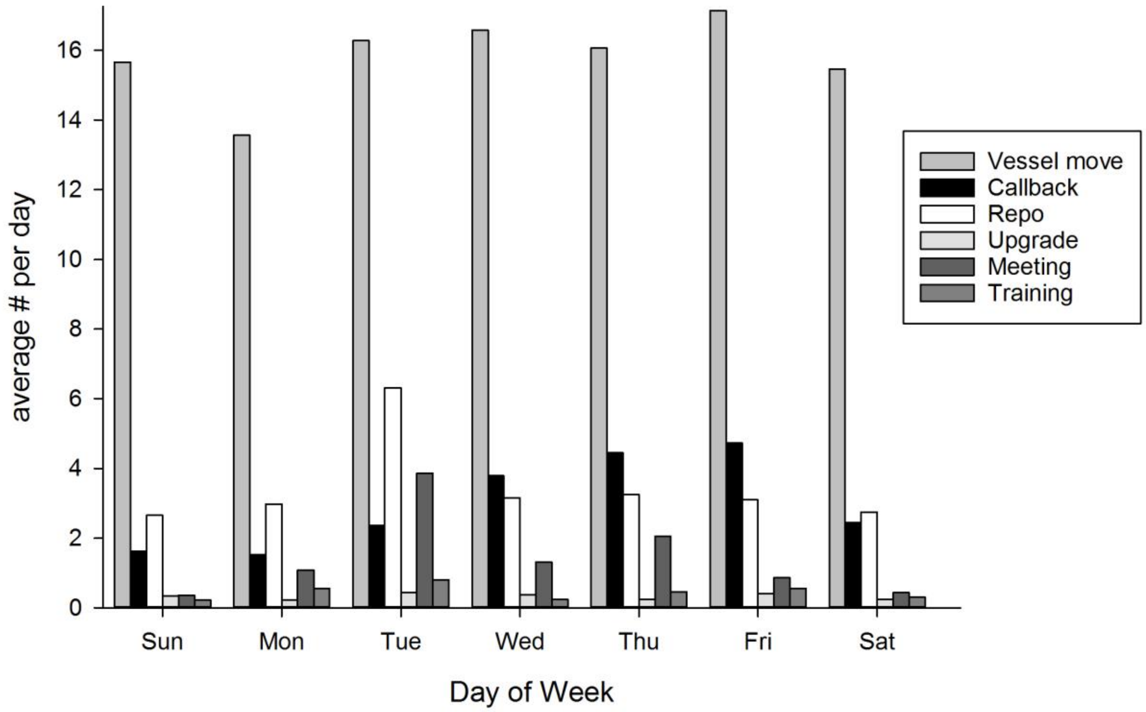


Figure 6. Assignment type averaged by day of the week. Vessel move = vessel move completed by pilot while in rotation, Callback = vessel move completed by pilot while not in rotation, Repo = repositions (includes those related to comp days), Meeting = pilot attending meeting, Training = pilot training, Upgrade = vessel move for upgrading pilot license. Multiple harbor shifts are counted as a single vessel move assignment.

Description of Work and Rest Periods

The timing of work and rest opportunities is an important factor in determining how fatiguing a work shift is likely to be. When individuals work during the biological night, circadian misalignment occurs, which causes individuals to feel sleepy during work periods and may inhibit one's ability to obtain adequate sleep during rest opportunities. In addition, pilots complete watch schedules of 15 days on, with 13 days off, which has the potential to cause chronic sleep deprivation, which can further degrade alertness and performance. As a result, it is critically important to understand how the timing of assignments is distributed throughout the day.

An example of the watch schedule for a single pilot is shown in Figure 7. The left panel shows the watch schedule, with each scheduled day of work shaded in gray. The right panel of Figure 7 shows the days the pilot actually worked during the same period of time. As illustrated in this figure, this pilot had numerous instances of work, including 10 callback shifts, during off-watch periods. As described previously, the timing of work assignments is an important factor in estimating fatigue risk. The timing of assignments over the 24-hour day for a single pilot is shown in Figure 8. This figure highlights the erratic timing of vessel assignments and also illustrates the number of times this pilot experienced a callback to help cover vessel moves on days off.

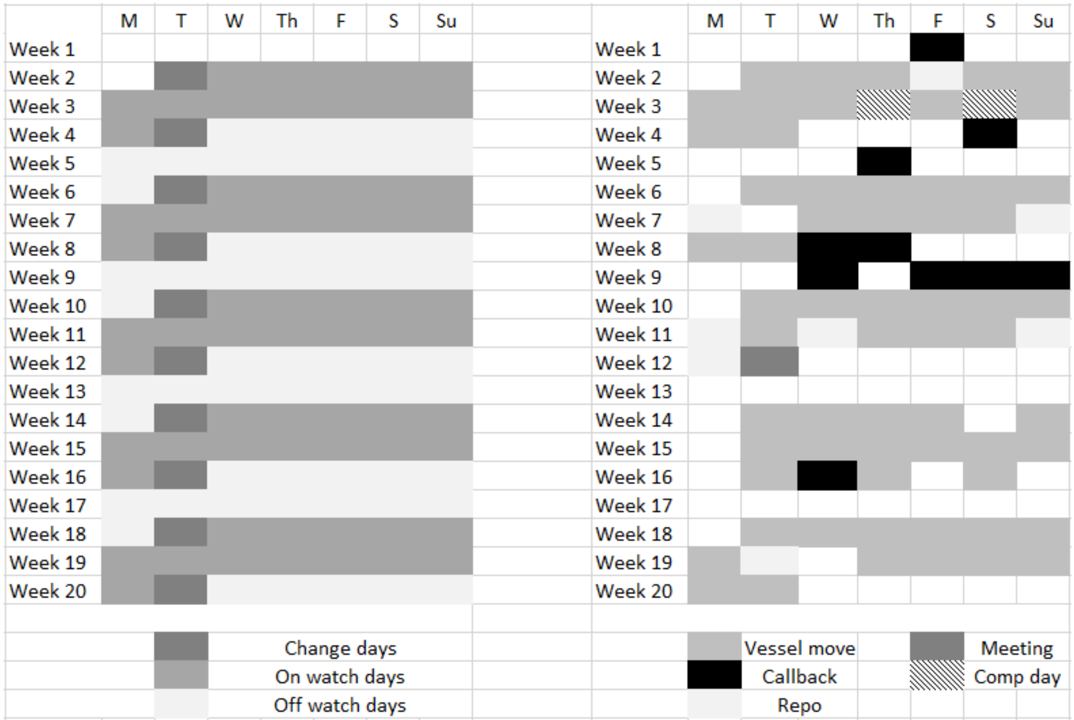


Figure 7. A comparison of the watch rotation as scheduled (left panel) and as worked (right panel) over a 20-week period. On the left, the 15-on/13-off rotation schedule is presented with change days highlighted at the start and end of each on watch period. On the right, the actual schedule worked by the pilot with type of work period indicated.

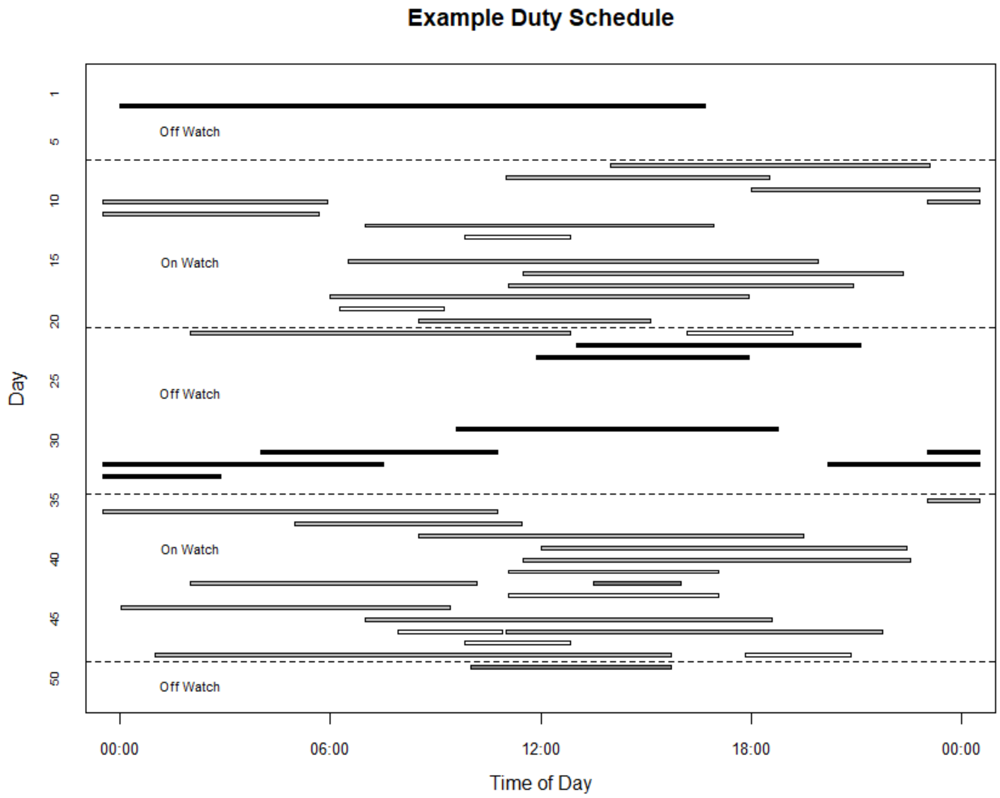


Figure 8. An example of a pilot's work schedule over a 50-day period by time of day. On and off-watch periods are identified with change days (dashed line). All work-related activities are presented by day from start to end time. For night work periods that cross midnight (00:00), a bar is presented from the work start time to midnight, then is continued on the next day from midnight to the work period end time (an example is at the end of day 10, continuing on day 11). Work type: vessel movements on watch days (gray bars), callback assignments on days off (black bars), repositions (light gray bars), and meetings (dark gray bars).

As described previously, during each watch, pilots are assigned vessel moves as ship movements are communicated to the pilot dispatch. A pilot "call time" reflects the time that the pilot begins preparations for work prior to traveling to an assigned vessel move. The pilot "job time" reflects the time the pilot boards the vessel, and the pilot "check-in time" reflects the time when a vessel move has been completed and when a pilot is able to rest.

Figure 9 illustrates the call time, travel time, and end (check-in time) times for all vessel moves. Overall, the peak call times occurred between 1100 and 1159. The peak job time (i.e. the time the pilot boarded the vessel) occurred between 1400 and 1459. The most common hour for the end of work periods was 1700.

Given the large geography of the Puget Sound, which includes multiple ports and a pilot station at Port Angeles, coupled with different types of vessel traffic (e.g. container vessels, cruise ships, tankers), we examined the call time, job time, and check-in time by location of assignment for origin points that included a large number of vessel moves. Figure 10 illustrates the call time, job time and check-in times for single inbound vessel moves from Port Angeles Pilot Station. For these types of moves, we found that peak call times occurred between 0900-1059 and between midnight and 0159. The peak job time (i.e. the time the pilot boarded the vessel) occurred between midnight and 0100, with a second peak 0900. The most common hour for the end of work periods was 0700, with secondary peaks between 1700 and 1959.

Outbound vessel moves originating in Tacoma followed a different pattern, with peak call times occurring between 1200 and 1359 (Figure 11). The peak job time (i.e. the time the pilot boarded the vessel) occurred between 1700 and 1859. The most common hour for the end of work periods originating in Tacoma was 2300. Outbound essel moves originating from Seattle, which involve the majority of outbound cruise ship operations, had a peak call time of 1100 (Figure 12). The job time peak occurred between 1400 and 1500. The peak check-in time in Seattle was 1700.

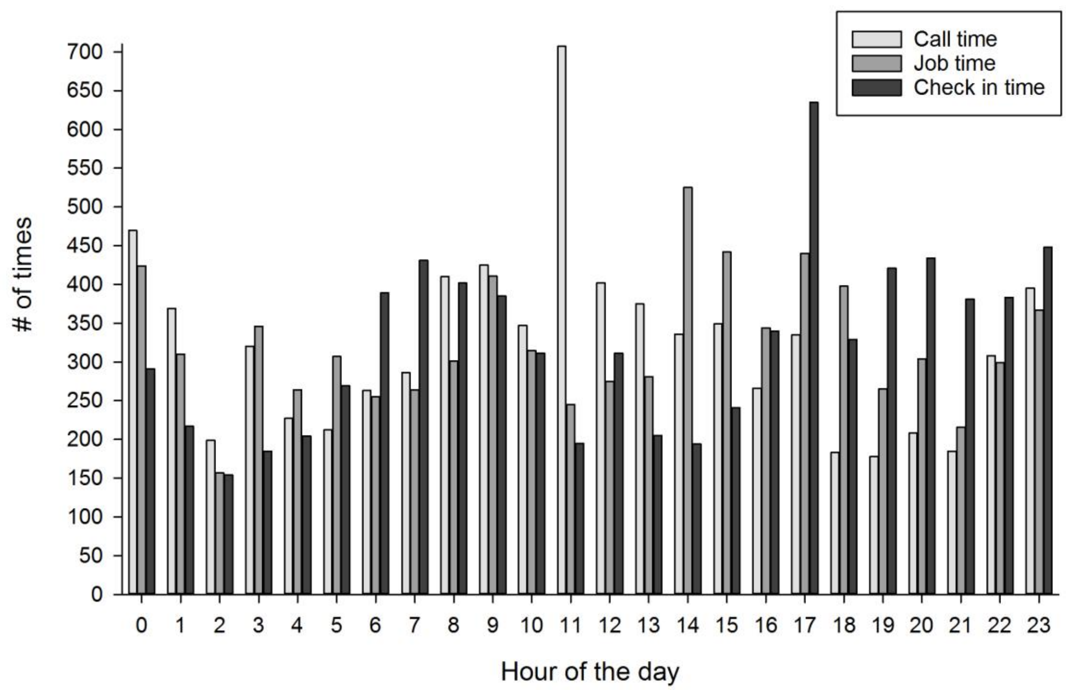


Figure 9. Distribution of vessel move-related activities by hour of the day for all vessel moves. The call time is the time that a work period begins, the job time is the time that the pilot boards the vessel, and the check-in time is the time that the work period ends following a vessel move.

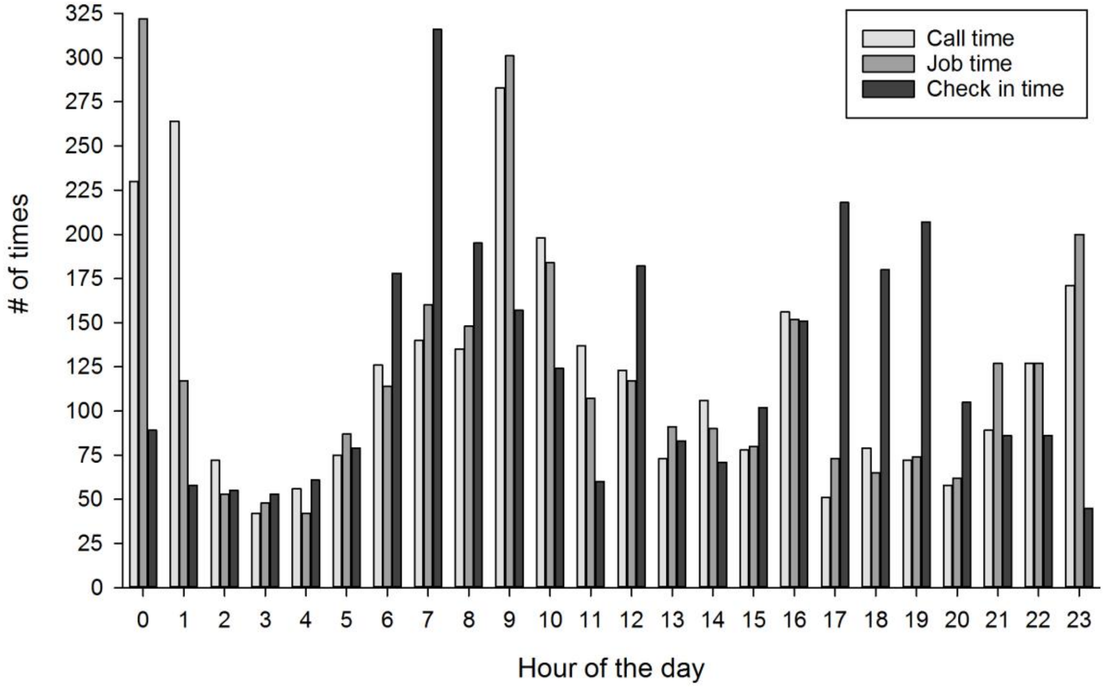


Figure 10. Distribution of vessel move-related activities by hour of the day for single vessel moves (i.e. excluding multiple harbor ship moves) for inbound traffic (from Port Angeles Pilot Station). The call time is the time that a work period begins, the job time is the time that the pilot boards the vessel, and the check-in time is the time that the work period ends following a vessel move.

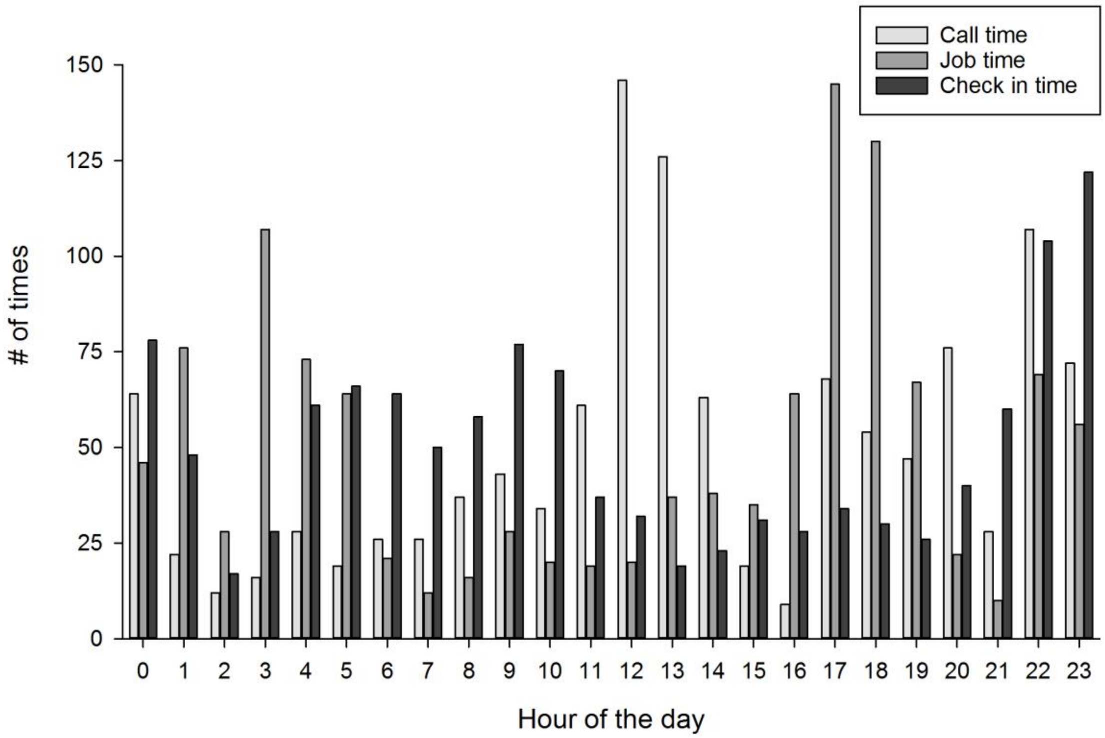


Figure 11. Distribution of vessel move-related activities by hour of the day for single vessel moves (i.e. excluding multiple harbor ship moves) from Tacoma. The call time is the time that a work period begins, the job time is the time that the pilot boards the vessel, and the check-in time is the time that the work period ends following a vessel move.

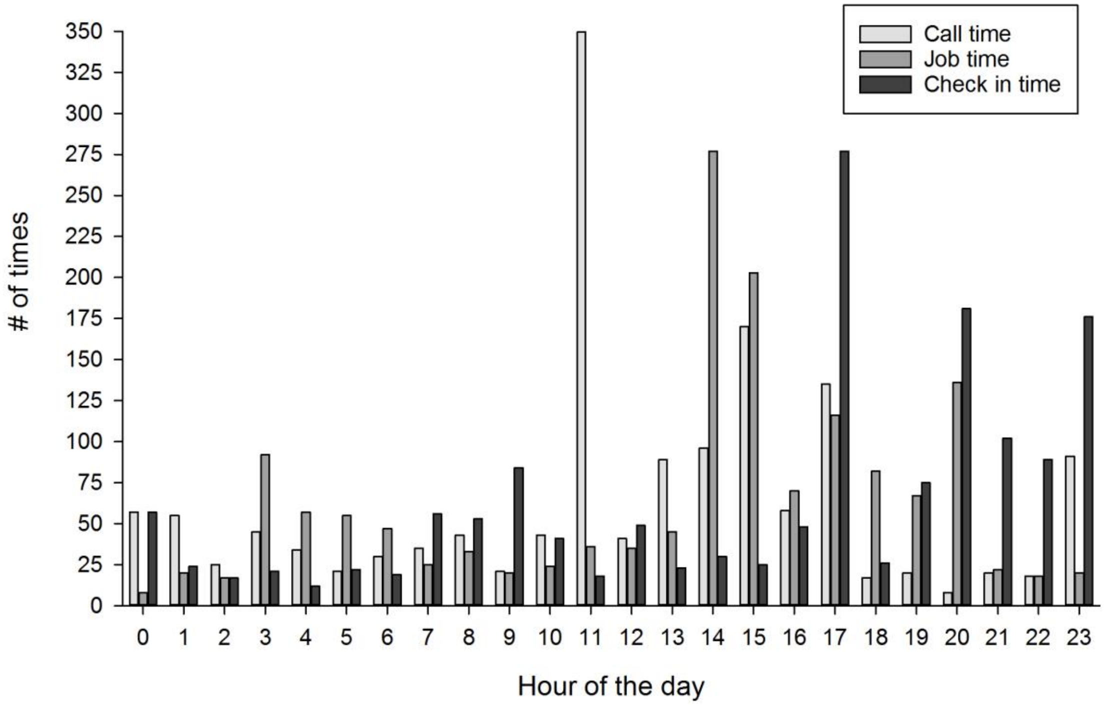


Figure 12. Distribution of vessel move-related activities by hour of the day for single vessel moves (i.e. excluding multiple harbor ship moves) from Seattle. The call time is the time that a work period begins, the job time is the time that the pilot boards the vessel, and the check-in time is the time that the work period ends following a vessel move.

The duration of a work shift also contributes to fatigue while at work. Pilots worked an average of 99.1 hours per on-watch period and 9.4 hours per work period, with a maximum recorded on-watch period of 157.8 hours. Pilots worked more than 12 hours in a work period 19% of the time and they worked 120 hours or more during an on-watch period about 24% of the time. Figure 13 illustrates the average work period duration based on start time (hour of day). Work period duration was found to be shortest when starting between 1500 and 1659. Work periods starting during the circadian low point, between 0100 and 0500, had the longest average work duration of approximately 10.5 hours. Work periods starting between 0600 and 1000 had an average work duration of approximately 8.8 hours. Pilots typically had 10.5 total piloting job assignments during an on-watch period with a maximum of 16. Pilots worked more than 12 times during an on-watch period about 27% of the time.

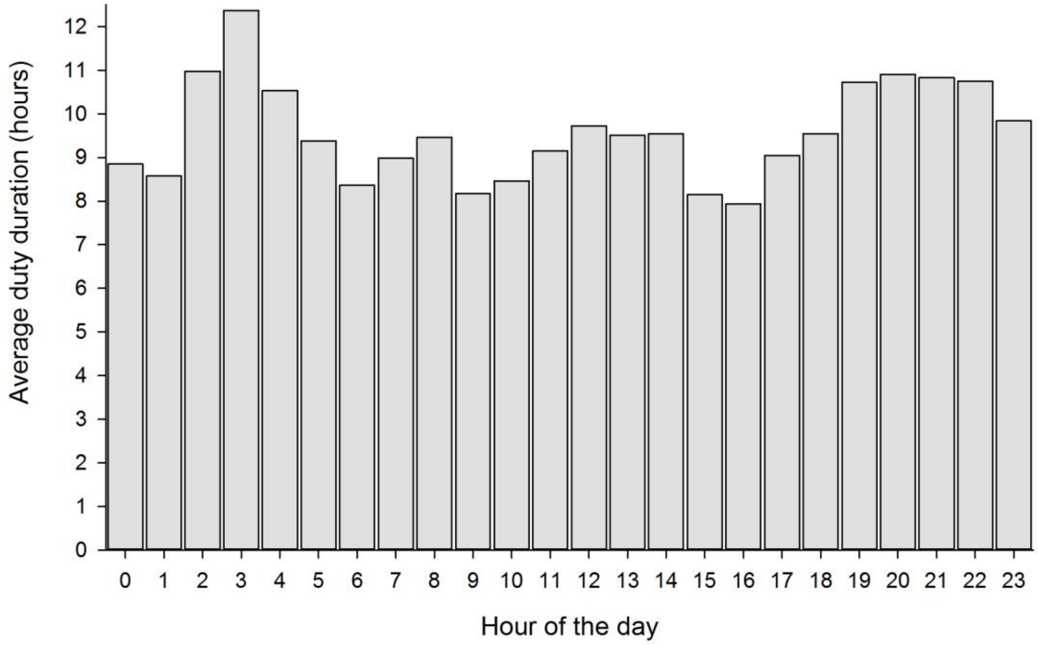


Figure 13. Work period duration by start hour.

Work Characteristics of Multiple Harbor Shifts and Cruise Operations

Multiple harbor shifts, cruise operations and repositions that allowed for immediate assignments were the primary reasons for extended-duty work shifts. Multiple harbor shift work periods (n= 257) averaged 13.0 h in duration and included an average of 2.3 vessel moves per assignment. The distribution of multiple harbor shift work hours is shown in Figure 14.

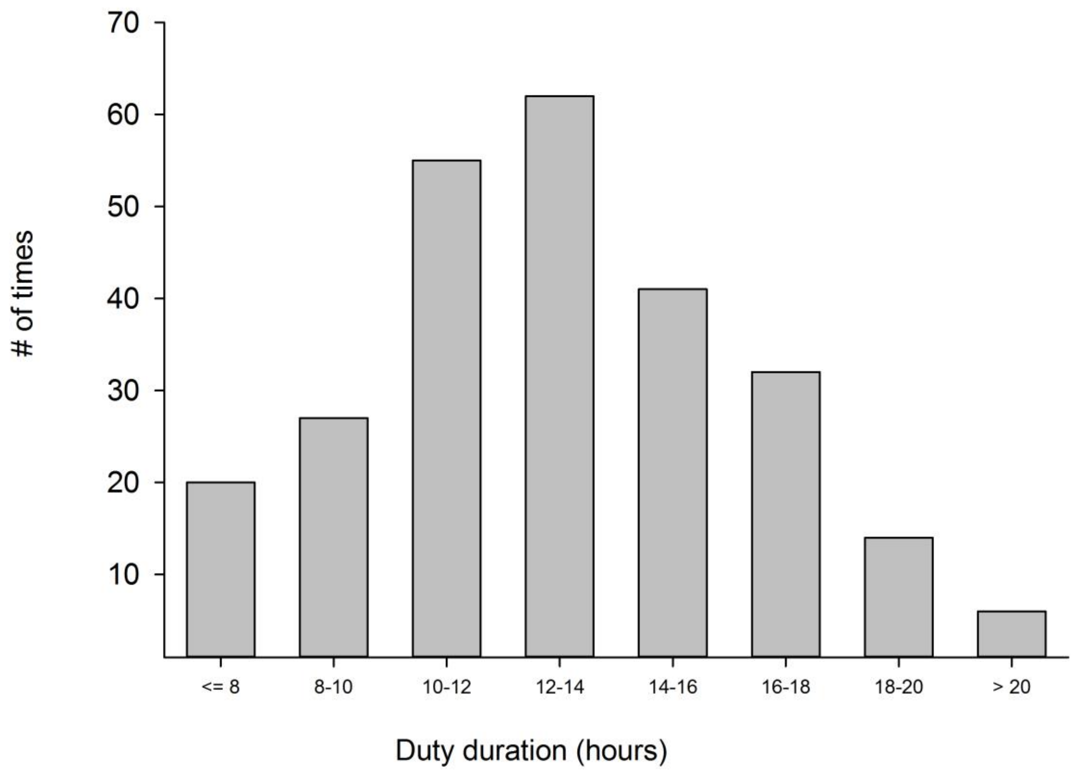


Figure 14. Distribution of multiple harbor shift work periods.

Inbound and outbound vessel moves to and from Seattle for cruise operations were typically handled by the same pilot. The majority of these vessel moves involved a night assignment for the inbound move, followed by a layover where a brief rest period might be possible, and a daytime assignment for the outbound move. Thirty-nine different pilots with the necessary license 5 served cruise ships during the 12-month period, with a maximum of seven by several pilots. An example of cruise operations for a single pilot is shown in Figure 15. Descriptive statistics summarizing cruise operations are shown in Table 3.

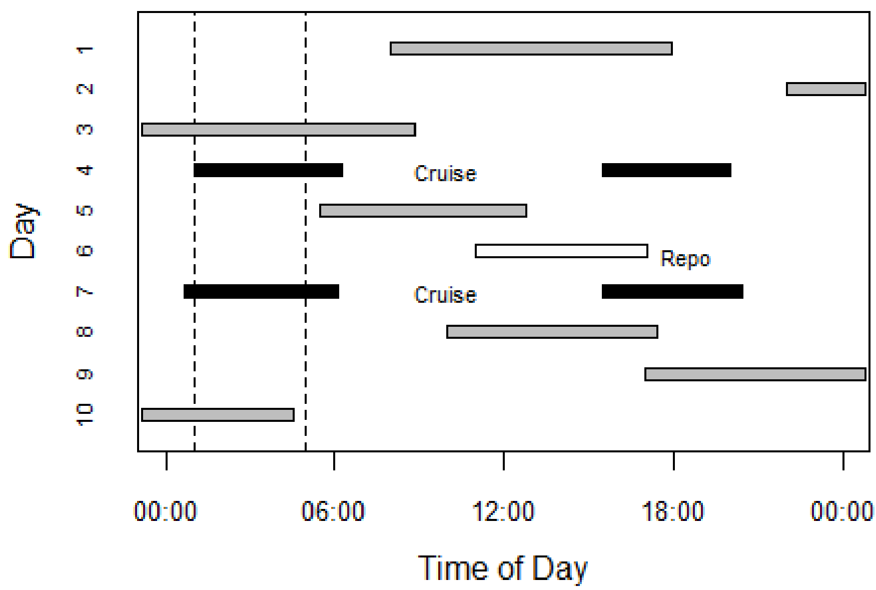


Figure 15. An example of a work schedule including 2 cruise operations by a single pilot during a 4-day period. Rotation assignments for the 2 days preceding the first cruise and for the 3 days following the second cruise are also shown. The 0100-0459 night period is highlighted with dashed lines. Cruise operations are shown in black, other assignments are shown in gray, and repositions are shown in white. For the inbound cruise operation, call time to job completion time is presented, while for the outbound, job time to check-in time is presented.

Table 3. Timing of cruise operations.

	n	Call/Job-time (h, SD)	Check-in time (h, SD)	Duration (h, SD)	Layover Period (h, SD)
Cruise Inbound	133	00:43 (0:26)	6:11 (0:22)	5.5 (0.4)	13.3 (8.6)
Cruise Outbound	133	15:13 (0:54)	20:34 (1:08)	4.8 (0.7)	8.9 (1.8)

h = hour, SD = standard deviation.

Description of Rest Periods

During on-watch periods, pilots worked 7 or more days in a row without a break of at least 24 hours about 8% of the time. The maximum number of consecutive days worked without such a break was 16 days.

We examined the number of hours off duty between consecutive work periods during on-watch periods (Figure 16). Pilots had an average of 17.1 hours off duty between consecutive work periods (based on check-in time to call time). Pilots received less than 10 hours off 16% of the time and less than 12 hours off duty 30% of the time.

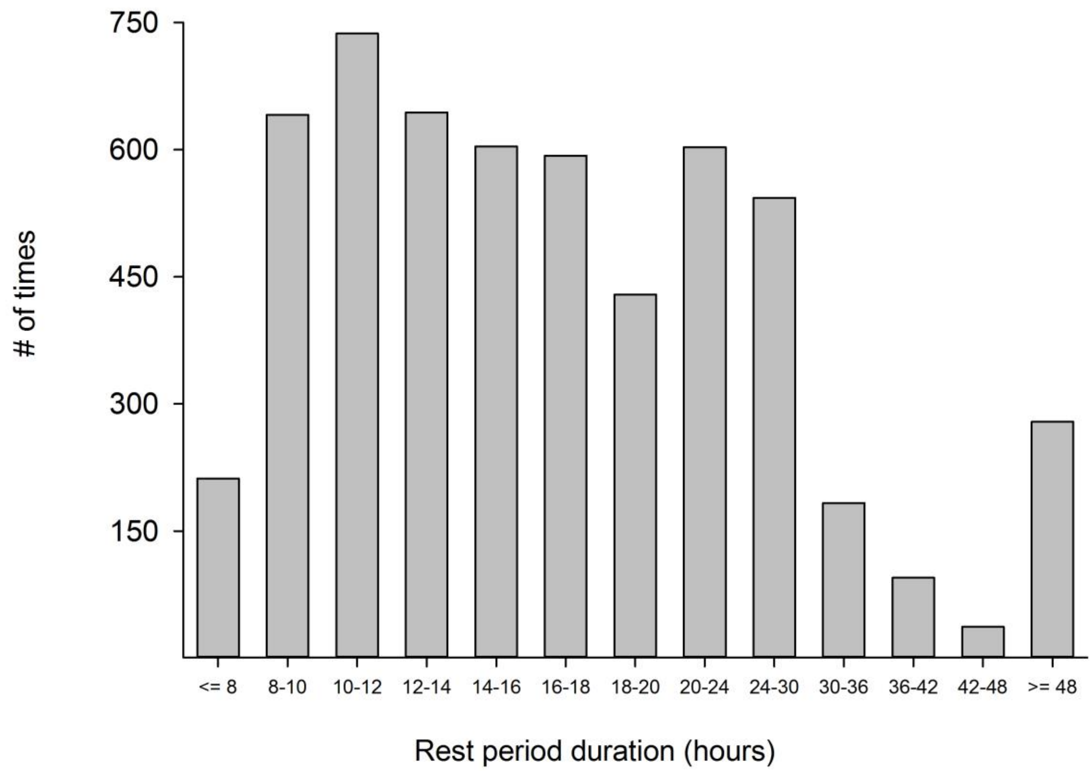


Figure 16. Distribution of hours off duty between consecutive on-watch work periods. Periods when one or more compensation days were taken were excluded from this analysis.

Retirement and Licensing

The Puget Sound Pilot workforce is skewed towards retirement, with seven pilots over 65 currently working, and an additional nine over 60 (Figure 17). More than 50% of the pilot workforce will be eligible for retirement within 10 years. This is reflected in the current license level of pilots, with the majority of ship moves being completed by pilots with license level five. The majority of vessels required Level 1 and Level 5 license holders, while pilots with Level 5 licenses completed the majority of vessel moves (Figure 18).

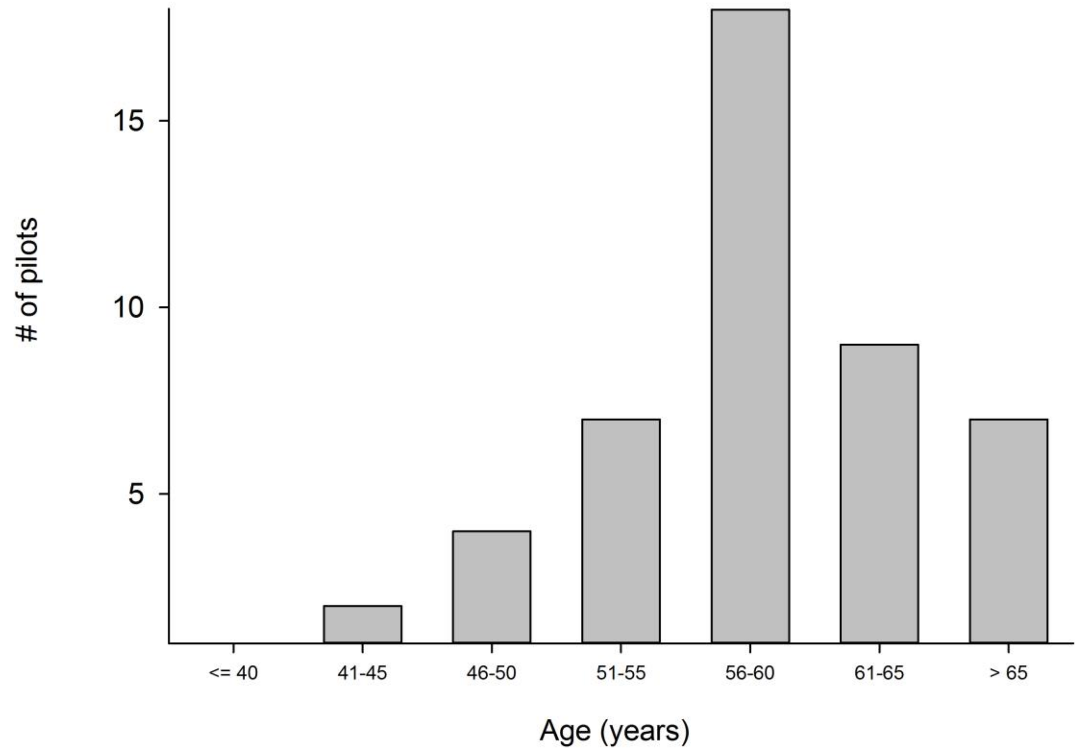


Figure 17. Distribution of Puget Sound Pilot age.

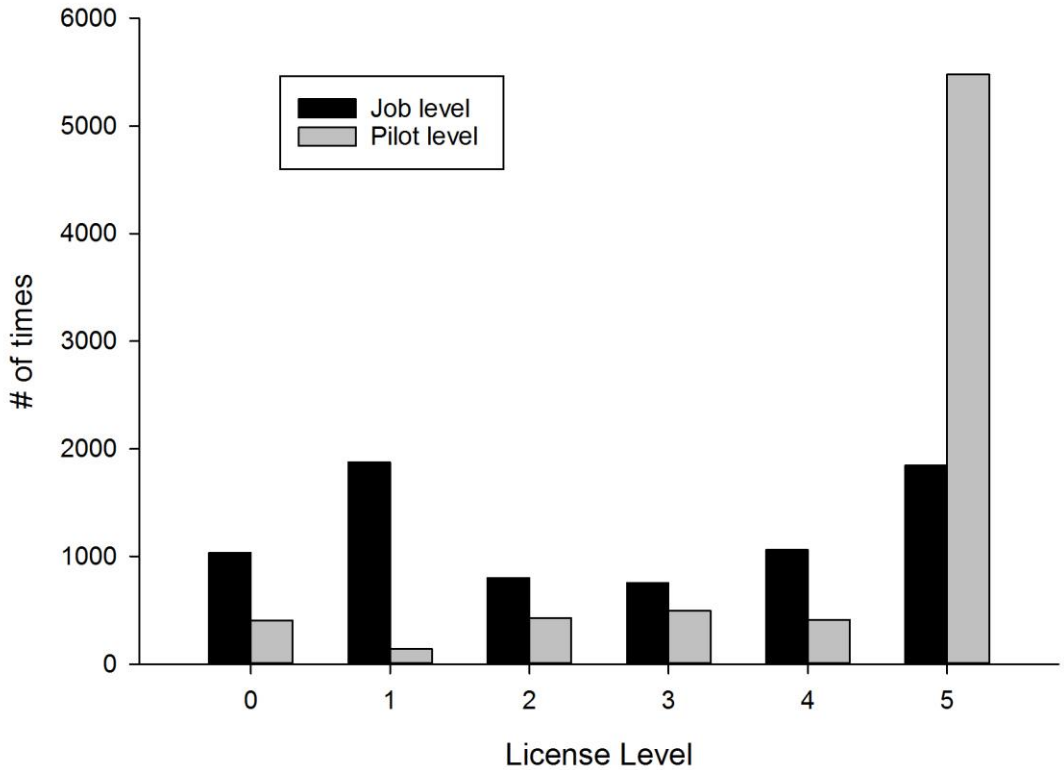


Figure 18. Distribution of license level required to pilot a vessel and the license level of pilots completing vessel moves.

Earned Time Off and Compensation Time

Pilots are granted 1.4 days of earned time off per watch worked (i.e. 7 days off after five watch periods, 5.5%). If a pilot has unused vacation days, then these days do not accrue and cannot be carried over year to year. This earned time off rate means that any day of the year the number of pilots available for watch would be reduced by 2-3 due to those using earned time off. In order to ensure enough pilots are on watch to provide board-on-arrival service, while covering earned time off, the total number of pilots must be increased by a factor of 0.055.

As described previously, pilots are provided with a day off as compensation for each day worked during days when they would otherwise be off watch. The current staffing levels appear to prevent pilots from taking compensation days, which means that they accrue at a rate that is faster than they are used. As a result, many pilots have a bank of unused compensation days. There were 1,210 compensation days earned by pilots for days worked during scheduled off-watch periods (calendar year dataset). During the same timeframe, only 785 compensation days were taken. The carry-forward of compensation days from prior years, combined with the positive accruals from 2018 led to a ‘bank’ of 3,143 compensation days, which is equivalent to 16 years of pilot work. Compensation days do not expire, therefore many pilots use all of their compensation days in the time leading up to retirement. If no changes are made to staffing, then this bank will continue to accrue. If four additional pilots had started work on January 1, 2019 and if callbacks were limited to an average of one every other day, then the "banked" compensation would still take more than 2 years to stabilize (Figure 20).

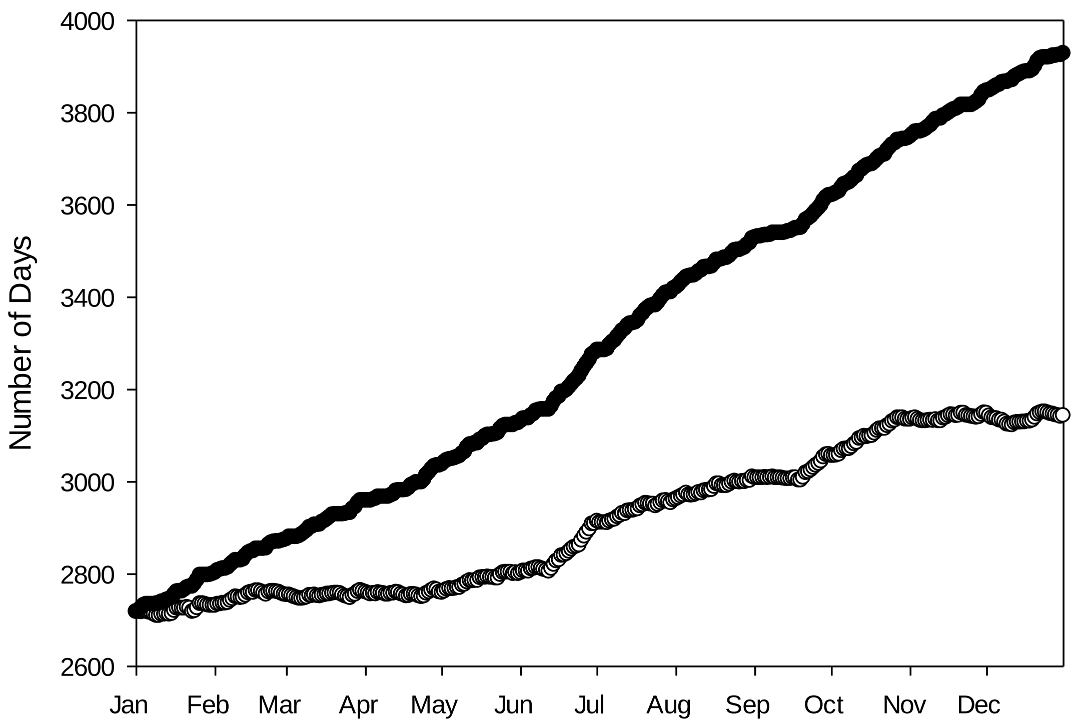


Figure 19. Compensation day accrual (black line) and compensation accrual minus compensation days taken (gray line) by day for the calendar year analysis.

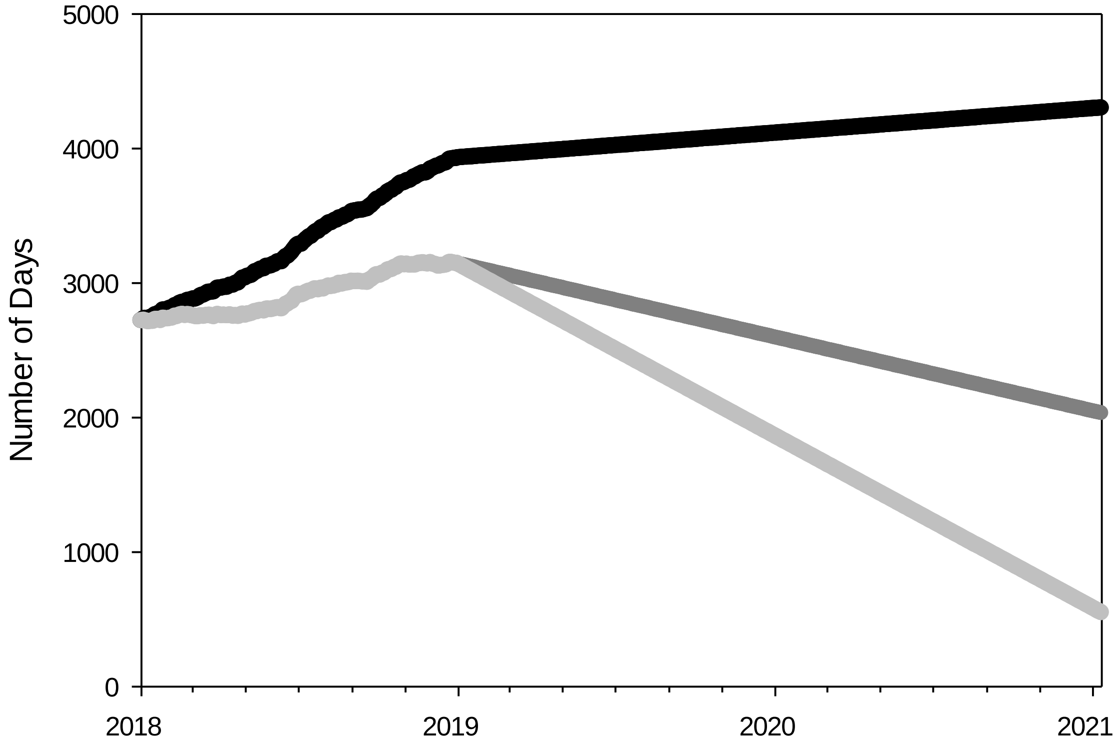


Figure 20. Hypothetical changes in compensation time accrual and payback based on different staffing models. Hypothetical changes would have started January 1, 2019. Black line projects compensation accrual if callbacks were limited to one every other day with no compensation days taken. Dark gray line projects compensation accrual if callbacks were limited to one every other day and if two compensation days were taken each day (e.g. linear regression model estimates with no additional pilots hired). Light gray line projects compensation accrual if callbacks were limited to one every other day and if two additional compensation days were taken per day (four additional pilots).

Linear Regression Modeling

Table 4 shows significant predictors in the model, their associated beta coefficients, and the average value for each predictor for the 'trailing 12-month' dataset. By multiplying the average values for each predictor by its corresponding beta coefficient, the total number of pilots that worked to complete all assignments is calculated. For Table 4, this calculation equals the equivalent number of pilots who worked during the year. That is, although there were 54 pilots included in the trailing 12-month dataset, due to retirements and injuries, there were only the equivalent of 47 pilots available for work throughout the year (i.e. 23.41 *2). This estimate can be considered the number of pilots needed to cover the average number of assignments for the year assessed. The confidence intervals reflect the potential range of pilots needed to complete all assignments on a given day. Given the large variability in ship traffic day-to-day, the confidence intervals can be considered as the number of pilots needed to cover all ship traffic on an average low day (lower confidence estimate) and the number of pilots needed to cover all ship traffic on an average high day (upper confidence estimate) without violating work hour rules and while accounting for other changes as factored into the model (e.g. reducing callbacks).

The average-by-day values for each predictor can be changed to determine how a given variable would affect staffing requirements. For example, Table 5 illustrates how eliminating callbacks alone would modify staffing requirements.

Based on best practices for fatigue risk management and expert recommendations provided to the Board of Pilot Commissioners, our final model is based on the introduction of work hour restrictions to minimize fatigue. Table 6 shows our final model using the trailing-12 dataset and Table 7 shows our final model using the calendar year dataset. Some of the variables that were significant in the models are different between the two datasets. This is likely due to the changes in work scheduling procedures that occurred during 2018. In addition, there were some factors that were not significant predictors in the model, but that are known important considerations in determining staffing needs. These variables were considered and added to the model in the next section.

Parameter	Beta Coefficient	p value	95% CI lower	95% CI upper	Average	Prediction estimate	95% CI estimate lower	95% CI estimate upper
Intercept	17.48	<.0001	15.10	19.85	--	17.48	15.10	19.85
Vessel movement	0.18	0.01	0.05	0.31	15.82	2.84	0.77	4.91
Callbacks	-0.46	<.0001	-0.60	-0.32	2.98	-1.37	-1.80	-0.94
Repositions	0.68	<.0001	0.52	0.84	4.35	2.95	2.25	3.65
Training	0.52	0.00	0.22	0.82	0.45	0.23	0.10	0.37
Meetings	0.84	<.0001	0.64	1.04	1.42	1.19	0.91	1.48
Comp days	0.44	0.00	0.18	0.70	2.08	0.92	0.38	1.46
> 60 h work/week	-0.12	0.02	-0.23	-0.02	5.21	-0.65	-1.18	-0.11
< 60 h rest 30 days	-1.52	0.11	-3.37	0.34	0.04	-0.07	-0.15	0.01
MHS > 13 h	-0.22	0.47	-0.82	0.38	0.53	-0.12	-0.43	0.20
Total						**23.41**	**15.95**	**30.88**

Table 4. Linear regression model showing the calculated beta coefficients and their associated confidence intervals and p-values for the predictors included in the model for the trailing-12 dataset. The average column shows the averages for each variable, derived from the dataset. The prediction estimate and associated confidence intervals are multiplied by the model predictions, then added together to reflect the number of pilots who completed assignments during the year in question. Comp days = compensation days, h = hour, MHS = multiple harbor shifts, CI = confidence interval.

Parameter	Beta Coefficient	p value	95% CI lower	95% CI upper	Expected per day	Prediction estimate	95% CI estimate lower	95% CI estimate upper
Intercept	17.48	<.0001	15.10	19.85	--	17.48	15.10	19.85
Vessel movement	0.18	0.01	0.05	0.31	18.80	3.37	0.91	5.84
Callbacks	-0.46	<.0001	-0.60	-0.32	0.00	0.00	0.00	0.00
Repositions	0.68	<.0001	0.52	0.84	4.35	2.95	2.25	3.65
Training	0.52	0.00	0.22	0.82	0.45	0.23	0.10	0.37
Meetings	0.84	<.0001	0.64	1.04	1.42	1.19	0.91	1.48
Comp days	0.44	0.00	0.18	0.70	2.08	0.92	0.38	1.46
> 60 h work/week	-0.12	0.02	-0.23	-0.02	5.21	-0.65	-1.18	-0.11
< 60 h rest 30 days	-1.52	0.11	-3.37	0.34	0.04	-0.07	-0.15	0.01
MHS > 13 h	-0.22	0.47	-0.82	0.38	0.53	-0.12	-0.43	0.20
Total						**25.32**	**17.89**	**32.75**

Table 5. Example of a predictive linear regression model showing the calculated beta coefficients and their associated confidence intervals and p-values for the predictors included in the model for the trailing-12 dataset. The 'expected per day' column shows the anticipated values for each predictor by day. In this example, callbacks were set at 0 in order to reflect pilot staffing needs in a hypothetical scenario where no callbacks occur. Given that callbacks are equivalent to vessel movements in the model, the vessel movement value is increased to reflect the expected average traffic by day. The prediction estimate and associated confidence intervals are multiplied by the model predictions, then added together to generate a prediction and range for the number of pilots needed to complete future work assignments given the inputs. Comp days = compensation days, h = hour, MHS = multiple harbor shifts, CI = confidence interval.

Parameter	Beta Coefficient	p value	95% CI lower	95% CI upper	Expected per day	Prediction estimate	95% CI estimate lower	95% CI estimate upper
Intercept	17.48	<.0001	15.10	19.85	--	17.48	15.10	19.85
Vessel movement	0.18	0.01	0.05	0.31	18.30	3.28	0.89	5.68
Callbacks	-0.46	<.0001	-0.60	-0.32	0.50	-0.23	-0.30	-0.16
Repositions	0.68	<.0001	0.52	0.84	4.35	2.95	2.25	3.65
Training	0.52	0.00	0.22	0.82	0.45	0.23	0.10	0.37
Meetings	0.84	<.0001	0.64	1.04	1.42	1.19	0.91	1.48
Comp days	0.44	0.00	0.18	0.70	4.00	1.76	0.72	2.80
> 60 h work/week	-0.12	0.02	-0.23	-0.02	0.00	0.00	0.00	0.00
< 60 h rest 30 days	-1.52	0.11	-3.37	0.34	0.00	0.00	0.00	0.00
MHS > 13 h	-0.22	0.47	-0.82	0.38	0.00	0.00	0.00	0.00
Total						**26.67**	**19.67**	**33.67**

Table 6. Linear regression model showing the calculated beta coefficients and their associated confidence intervals and p-values for the predictors included in the model for the trailing-12 dataset. The 'expected per day' column shows the anticipated values for each predictor by day. In this model, the expected per day values were set to reflect changes to pilot operations aimed at minimizing fatigue. Note: given that callbacks are

equivalent to vessel movements in the model, the vessel movement value is increased by the relative decrease in callbacks to reflect the expected average traffic by day. The prediction estimate and associated confidence intervals are multiplied by the model predictions, then added together to generate a prediction and range for the number of pilots needed to complete future work assignments given the inputs. Comp days = compensation days, h = hour, MHS = multiple harbor shifts, CI = confidence interval.

Parameter	Beta Coefficient	p value	95% CI lower	95% CI upper	Expected per day	Prediction estimate	95% CI estimate lower	95% CI estimate upper
Intercept	17.48	<.0001	15.10	19.85	--	17.48	15.10	19.85
Vessel movement	0.18	0.01	0.05	0.31	17.65	3.17	0.86	5.48
Callbacks	-0.46	<.0001	-0.60	-0.32	1.00	-0.46	-0.60	-0.32
Repositions	0.68	<.0001	0.52	0.84	4.22	2.87	2.19	3.55
Training	0.52	0.00	0.22	0.82	0.42	0.22	0.09	0.35
Meetings	0.84	<.0001	0.64	1.04	1.54	1.29	0.98	1.60
Comp days	0.44	0.00	0.18	0.70	4.00	1.76	0.72	2.80
> 60 h work/week	-0.12	0.02	-0.23	-0.02	0.00	0.00	0.00	0.00
> 12 h work/day	-0.22	0.47	-0.82	0.38	0.00	0.00	0.00	0.00
MHS > 13 h	-1.52	0.11	-3.37	0.34	0.00	0.00	0.00	0.00
Total						**26.33**	**19.35**	**33.31**

Table 7. Final Model. Linear regression model for the calendar year dataset. Presented are the calculated beta coefficients and their associated confidence intervals and p-values for the predictors included in the model. The ‘expected per day’ column shows the anticipated values for each predictor by day. In this model, the expected per day values were set to reflect changes to pilot operations aimed at minimizing fatigue while also reducing the bank of compensation day accruals (increasing by 2 comp days taken per day) and reducing the rate of callbacks to one per day. Note: given that callbacks are equivalent to vessel movements in the model, the vessel movement value is increased by the relative decrease in callbacks to reflect the expected average traffic by day. The prediction estimate and associated confidence intervals are multiplied by the model predictions, then added together to generate a prediction and range for the number of pilots needed to complete future work assignments given the inputs. Comp days = compensation days, h = hour, MHS = multiple harbor shifts, CI = confidence interval.

There are other schedule factors that were not significant predictors in the statistical model that should also be considered when assessing pilot staffing needs, but the most important variable that was not included in the model was the minimum rest period. The minimum rest period between assignments was changed from eight hours to 10 hours in October 2018. This variable was not a significant predictor in the model, likely because it was not possible to include mean rest period in the model for hypothetical modeling (see methods, the rest period variable was dichotomized and the frequency of rest < 10 h per day was included in the model). There were 1386 instances where pilots received less than 10 hours off following an assignment (including back-to-back callback assignments). The difference between the actual time off and the recommended time off of 10 hours was 2595 hours. This amount of time is equivalent to ~2 pilots per year.

Staffing Requirement Projections

The projected number of pilots needed to fulfill staffing requirements while also minimizing fatiguing work shifts is presented in Table 8. This projection includes the estimates from the linear regression model with adjustments made based on fatigue risk management recommendations. This model also includes the projected number of pilots needed to reduce the bank of compensation time accrued by the pilots and two pilots in rotation to cover future work hour restrictions that could not be modeled.

Projection Variable	Number of Projected Pilots	Projected 95% CI (lower)	Projected 95% CI (upper)
Linear regression estimate	53	39	67
Compensation day coverage	4	4	4
Additional work hour reduction coverage	2	2	2
President	1	1	1
Total	**60***	**46**	**74**

Table 8. Estimated number of pilots needed to cover all shifts while reducing work practices that induce fatigue. *Note that this does not include the pilots needed to account for earned time off.

The total number of pilots needed including earned time off coverage is 63 (60*0.055), with a range from 49-78.

Relationship between Number of Assignments and Staffing Levels

The goal of this analysis was to determine the number of pilots needed to provide board-on-arrival service at the current level of vessel traffic, while minimizing fatigue. The average number of vessels per day was 20.1 for the calendar year dataset (18.65 when MHS are combined into one shift per day). The total number of vessel moves in the calendar year dataset was 7,334. If the recommended number of pilots are hired (63), then each pilot should complete ~116 vessel moves (including the president, ~118 excluding the president).

6 Recommendations

We found that the Puget Sound Pilot work practices are associated with variable and unpredictable workload and work start times, frequent night work, frequent instances of insufficient time off between shifts, and numerous extended-duty work shifts. In addition, current scheduling practices rely heavily on calling pilots back to work during scheduled days off. This leads to an overall increase in the number of days and hours that pilots work in a month and also leads to the accrual of an unsustainable rate of compensation time. Finally, the attrition rate has the potential to out-pace the rate of recruiting and training. Recommendations on each of these factors is provided below. These factors were all considered in estimating the number of pilots that would be needed to cover all work assignments going forward.

Number of Pilots Needed to Cover Assignments

We estimate that the total number of pilots needed to cover all work assignments going forward is 63 (range 49-78). This estimate was derived from modeling the factors associated with work scheduling, including restrictions on work hours in order to minimize fatigue. In addition to model estimates, one pilot was added to account for the President of the Puget Sound Pilots, six pilots were added to cover compensation time and further work hour restrictions, and three were added to cover earned time off.

Extended Duty Work Shifts

The current Puget Sound Pilot scheduling practices allow for multiple harbor shifts of unlimited duration. In the dataset that we evaluated, pilots completed sequence of these short ship duration, short distance ship movements with little time off between each move. Although many of these assignments are short in duration, these moves are often spaced less than six hours apart. When coupled with the unpredictable nature of pilot scheduling, it is unlikely that pilots completing sequences of multiple harbor shifts have adequate time for rest between ship moves. PSP should consider limiting MHS work hours to reduce fatigue. Although it has been proposed that MHS be limited to 13 hours, this work shift may still lead to fatigue. PSP should consider evaluating fatigue during MHS to determine the appropriate limit, which may be less than 13 hours.

Night Work

The Puget Sound Pilots have already implemented a rule that prevents pilots from working more than three night shifts in a row. This change is consistent with fatigue risk management principles.

In the dataset that we evaluated, it was common practice for pilots to complete both the inbound and outbound moves for cruise ship operations. These operations provided a rest opportunity that was typically less than eight hours during the morning. The circadian rhythm promotes wakefulness during the biological day, which can reduce sleep quality and quantity. As a result, we recommend that individual pilots are only assigned inbound and outbound cruise operations when a sufficient rest opportunity is available between the inbound and outbound movements. PSP should also consider evaluating the quality and quantity of sleep obtained between cruise ship operations.

We found numerous instances of night work following a reposition assignment, where a pilot was repositioned to arrive in Port Angeles in the late afternoon, but then was assigned a ship move in the late evening/night. It appears that this stems from the current procedure that allows pilots to "begin work immediately" following any reposition that occurs early in the day. This practice is concerning, because the term "immediate" is not defined, which allows pilots to work many hours after arrival at Port Angeles station. We recommend that reposition assignments be treated in a similar manner to vessel movement assignments, whereby if the reposition assignment and any associated vessel movement assignments be considered a single work shift and be limited in duration. In cases where a reposition assignment is completed and no ship movement can be assigned and completed within the designated timeframe, then the pilot should be provided with a rest opportunity prior to scheduling the next assignment.

Time off Between Assignments

Subsequent to the trailing-12 data considered in this analysis, the Puget Sound Pilots implemented a rule that allowed for 10 hours of rest following work assignments. This amount of time off is consistent with fatigue risk management principles, which support providing workers with enough time off between shifts for eating, personal hygiene routines, and the opportunity for eight hours of sleep.

Callbacks and Compensation Time

The current practice of calling pilots back to work on days off and then providing them with a compensation day is unsustainable with current staffing levels. Additional staff are required in order to deplete the cumulative bank of accrued compensation days and to reduce or eliminate the rate of compensation day accruals. This is particularly important given that many pilots are nearing retirement and will use compensation time and will not be available for work. Going forward, the Puget Sound Pilots should increase staffing levels to eliminate the need for frequent callbacks. In addition, the Puget Sound Pilots may consider putting a limit on the number of callbacks that an individual pilot is required to perform. Similarly, only once when staffing levels are sufficient to minimize the need for callbacks, the Puget Sound Pilots should reevaluate the process for the accrual and use of compensation days.

Meetings

Peak meeting times were on Tuesdays, which is the day when pilots transition between on watch to off watch. This appears to be an appropriate process for conducting meetings while minimizing fatigue and disruption to service.

Retirement and Licensing

The Puget Sound Pilot workforce is aging, with a third of the population either of retirement age or eligible for standard retirement within the next five years. More than half of the pilots are eligible for retirement within 10 years. The current licensing level of the pilots appears to be appropriate for meeting work demands at the present time, with the majority of license holders at license level 5. However, the distribution of age among current pilots is skewed towards retirement and towards the highest license level. As current pilots retire, there may not be enough pilots of an appropriate license level to handle all license levels of ship movements. As a result, we recommend that efforts to recruit and train new pilots be prioritized. It would be worthwhile to conduct a separate evaluation to determine hiring needs to account for the expected attrition rate and license levels going forward.

Validation and Verification of Staffing/Scheduling Changes

Fatigue risk management programs provide a framework for implementing best practices aimed at mitigating the risk of fatigue in operational environments. Although implementation of such measures is intended to reduce the risk of fatigue, every operational environment involves unique challenges that may interact with staffing levels and scheduling changes. As a result, schedule and staffing changes should be evaluated to ensure that such changes do not lead to negative outcomes. Therefore, we recommend that the Puget Sound Pilots implement a fatigue risk management system for continued education of the PSP workforce and for ongoing surveillance of fatigue risk before and after the implementation of any of the changes described in this report. For example, although the Puget Sound Pilots have already pursued work hour restrictions to limit multiple harbor shifts to 13 hours in duration, it is possible that a shorter duration is necessary to promote optimal sleep, alertness, and performance.

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Exhibit 2

Puget Sound Pilots 2018 Vessel Delay and Cancellation Data

2018	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Customer Vessel Delays	42	39	42	47	66	75	79	59	82	76	49	53
Customer Vessel Cancellations	23	13	20	8	14	8	10	6	12	13	10	24
Delays Awaiting Pilots	0	0	0	0	3	0	8	23	8	18	8	5

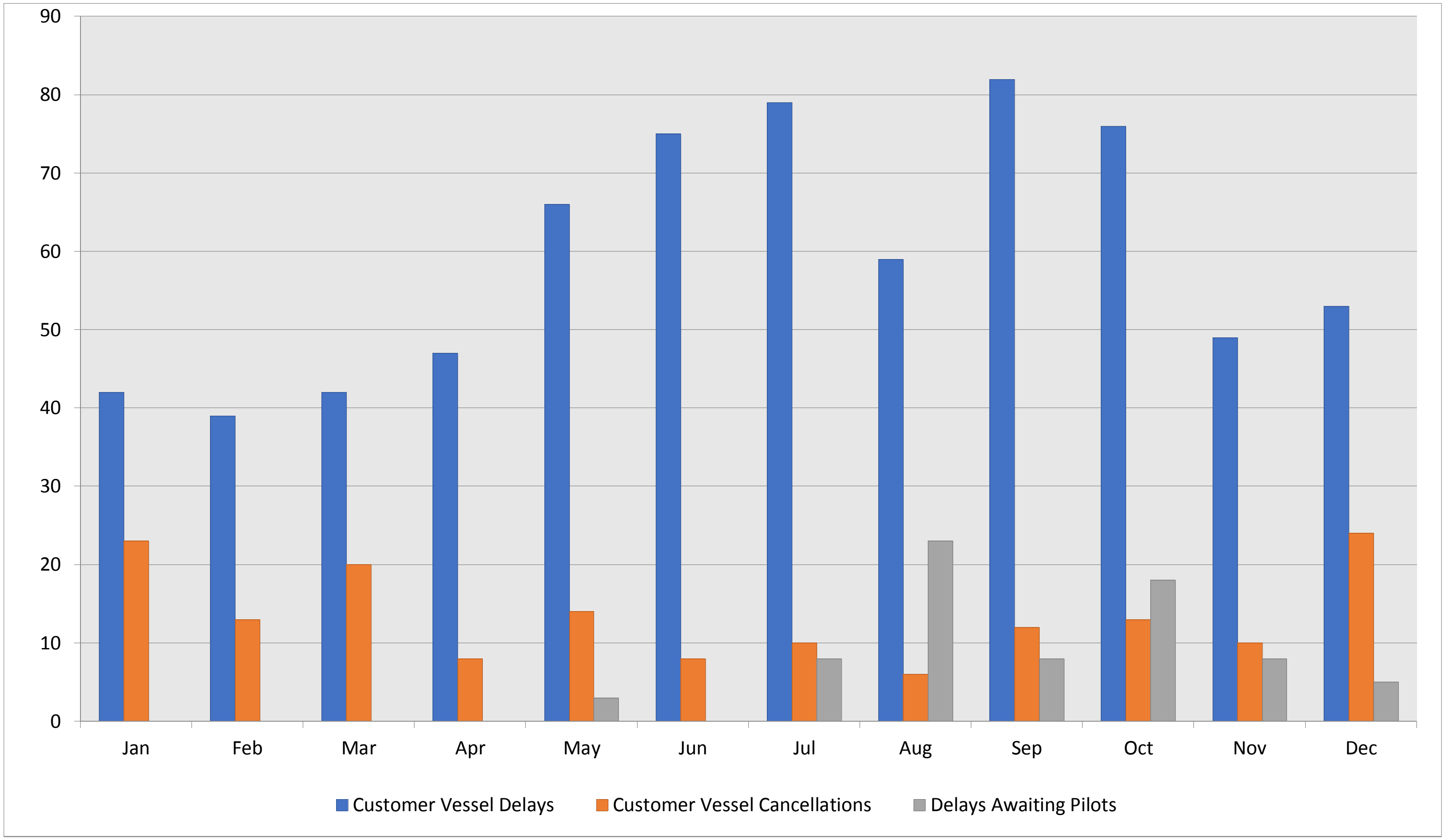


EXHIBIT 3

Puget Sound Pilots Workload Data 2016 - 2018

Vessell Assignments

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Monthly Average
2016	605	547	607	584	672	725	694	687	653	617	661	610	7662	638.50
2017	606	529	570	565	664	636	664	657	608	564	597	589	7250	604.08
2018	602	556	583	533	671	707	680	660	623	584	554	571	7324	610.33

Available Pilots

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
2016	50	50	50	51	51	50	51	51	51	51	51	51	50.67
2017	51	51	51	51	51	51	51	51	51	51	50	50.9	50.91
2018	49	49	49	49	48	47	46	47	47	47.33	48	48	47.86

Assignments per pilot

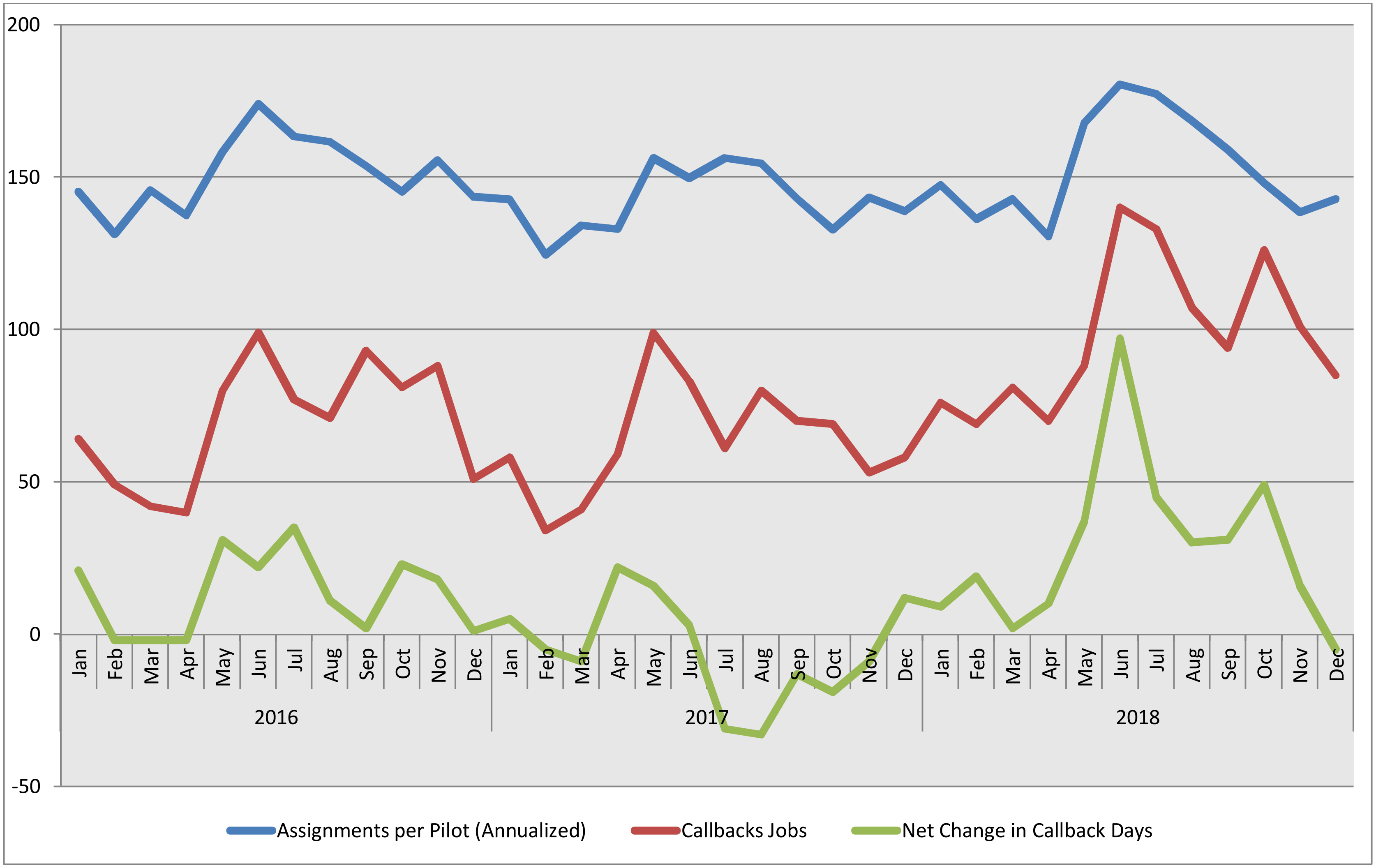
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average	Annual Assignment Level
2016	12.10	10.94	12.14	11.45	13.18	14.50	13.61	13.47	12.80	12.10	12.96	11.96	12.60	151.22
2017	11.88	10.37	11.18	11.08	13.02	12.47	13.02	12.88	11.92	11.06	11.94	11.57	11.87	142.41
2018	12.29	11.35	11.90	10.88	13.98	15.04	14.78	14.04	13.26	12.34	11.54	11.90	12.77	153.03

Net Callback Days by Month

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Net Annual
2016	21.00	(2.00)	(2.00)	(2.00)	31.00	22.00	35.00	11.00	2.00	23.00	18.00	1.00	158.00
2017	5.00	(5.00)	(9.00)	22.00	16.00	3.00	(31.00)	(33.00)	(13.00)	(19.00)	(9.00)	12.00	(61.00)
2018	9.00	19.00	2.00	10.00	37.00	97.00	45.00	30.00	31.00	49.00	16.00	(5.00)	340.00

Callbacks Jobs by Month

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2016	64	49	42	40	80	99	77	71	93	81	88	51
2017	58	34	41	59	99	83	61	80	70	69	53	58
2018	76	69	81	70	88	140	133	107	94	126	101	85



200
150
100
50
0
-50
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2016
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2017
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2018
Assignments per Pilot (Annualized)
Callbacks Jobs
Net Change in Callback Days

EXHIBIT 4

Statement on behalf of the
International Organization of Masters, Mates and Pilots
before the
Board of Pilotage Commissioners for the State of Washington
by
Captain George A. Quick, Vice President, MM&P

May 3, 2019

Background and Qualifications

My name is George A. Quick and I am the vice president of the International Organization of Masters, Mates and Pilots. Our organization represents the masters and deck officers on U.S. flag ships and State pilots in all the major ports throughout the United States. I head the Pilot Membership Group of that organization and as part of my duties I monitor pilotage rates and regulations in the various States. As a result of representing State pilots on a national level I am familiar with the conditions and standards that prevail in pilotage throughout the United States, including compensation, retirement programs and working conditions.

I am a graduate of the U.S. Merchant Marine Academy with a degree in Marine Transportation. I am also a graduate of the University of Baltimore Law School with a Juris Doctor degree. I hold a US Coast Guard license as master and first class pilot, and held a Maryland State pilot license from 1956 until 2000 when I was placed on the inactive list for medical reasons. I sailed as a deck officer on passenger and cargo ships from 1951 until 1956 when I was accepted into the pilot training program of the Association of Maryland Pilots. I have experience as a pilot on thousands of different ships in all categories and sizes from small tugs to the largest tanker, cargo and cruise ships.

I served as president of the Association of Maryland Pilots from 1969 until 1984 where I had the responsibility for administering a pilotage system with as many as 92 pilots. I was regional vice president for the North Atlantic region of the American Pilots' Association from 1974 until 1986. I represented the International Maritime Pilots' Association (IMPA), the London based trade association for pilots from Europe, Asia, North America, South America and Australia, at IMO in the late 1970's and early 1980's. I have been licensed by the US Coast Guard as a master and pilot and by the State of Maryland as an unlimited State pilot. I am also a member of the Maryland Bar Association and a Proctor member of the Maritime Law Association.

A copy of my c.v. is attached.

Pilot staffing, workload and fatigue

I understand that a major issue being considered by the Board is pilot staffing, workload and fatigue. Within all sectors of the maritime industry, including pilotage systems, operate 24/7/365, fatigue mitigation is a chronic problem and has occupied a considerable part of my time over the years. I would like to present the issues from my perspective for consideration by the Board in their deliberations.

The purpose of compulsory pilotage regulations

Washington, as every other coastal state in the U.S. and every major port in the world, has a regulated compulsory pilotage system that legally requires foreign flagged ships to be navigated under the direction and control of locally licensed pilots who are accountable to local authorities for the safe operation of the ship when it is within the territorial waters of the port State. Its purpose is to protect shipping, port infrastructure, the public and the marine environment from the consequences of maritime accidents when large ocean going ships are maneuvering in the tight confines of harbor approaches and in the vicinity of environmentally sensitive areas. A maritime accident can have catastrophic consequences for the port, the public and the environment as illustrated by the Exxon Valdez or Costa Concordia accidents.

Historically compulsory pilotage has been and continues to be the primary port safety system in every port. The pilot is an independent professional fee-for-service provider outside the control of the shipowner. Although pilots typically provide 24/7/365 service to benefit the shipowner, the public nature and regulation of the terms and condition of his service protect and insulate pilots from the demands and commercial pressures that can be placed on an ordinary employee, such as the master and ship's officers, to compromise the margins of safety for the competitive advantage of their employer - the shipowner.

The purpose and use of a rotation system and the system used by other pilotage groups

I understand that in the Puget Sound, as in nearly every pilot district in the United States, pilotage service is provided on a 24/7/365 basis so that pilotage may be provided as soon as a vessel reaches the boundary of intrastate waters. This "board on arrival" service is an important component of the economic health of the port because, when pilots are appropriately staffed, it limits if not eliminates, delays upon a ships arrival into the intrastate waters in which pilotage is compulsory.

For pilots to provide 24/7/365 board on arrival service, pilots cannot maintain a work schedule or life that is comparable to a normal 9 to 5, 40 hour a week job. When on the duty roster, the pilot must be available on short notice any time, day or night, for an assignment to a ship. Despite the best efforts of pilots to be aware of the movements of vessels and shipping schedules, ship arrivals are characteristically unpredictable. As a result, pilots are precluded from making medical or dental appointments, buying tickets to events, scheduling any type of social life or living what would be considered a normal life style. Working a random schedule can mean leaving for work at 2 AM one day or 6 PM the next and finishing work at 12 noon as often as 12 midnight. It means frequently working while out of sync with circadian rhythms and in a state of chronic "jet lag", as well as being out of sync with the schedules of the normal working world. A pilot's time for "living" at the completion of a day's work may come at 3 A.M. when the rest of the world, including his or her family, are asleep. In addition to working random ship assignments, pilots typically fit training, continuing education and other work duties into their on-duty period.

This type of work schedule is also not foreign to professional mariners, whose work on board vessels most frequently consists of weeks or months on duty. Following these lengthy on-duty periods, mariners typically receive an equal amount of off-duty time ashore. The same is also true for pilots. Among the over 60 pilot associations in the 24 coastal States plus Puerto Rico and the US Virgin Islands that have compulsory pilotage laws and regulations, it is customary for pilots to work in a rotation for a period, with one watch group working, while another is off-duty for the same period.

I understand that in the Puget Sound, pilots observe a watch rotation of roughly 15 days on-duty, followed by 13 days off-duty, with two weeks of scheduled earned time off per year. Other pilot groups observe similar watch systems, although they may vary in the time interval used on and off-duty. For example, the San Francisco Bar Pilots work either one week on and one week off or two-weeks on and two weeks off. The Oregon Columbia River Pilots similarly use a rotation system of two-weeks on and two-weeks off.

These customary watch schedules serve a number of purposes. They permit pilots to maintain the schedule they are most familiar with as mariners and help attract new pilots who desire to maintain that customary schedule. Rotation systems also importantly serve to mitigate fatigue.

In my experience and understanding, a pilot's work environment, including irregular and lengthy work hours, working at night, unpredictable duty rosters, and traveling to and from their jobs, can significantly contribute to fatigue. Moving a large vessel in confined waters is a high-risk task and the pilot assigned to that task is primarily responsible to the State to do it safely.

Unpredictable work and shipping schedules, intense concentration, temperature extremes, adverse weather, and exposure to high-risk situations can all contribute to fatigue. An Australian study revealed that pilots excreted high levels of adrenaline while providing pilotage services (sometimes taking up to two days to return to normal levels) and that pulse rates increased to over 160. This level of physiological stress is one factor of cumulative fatigue.

In order to relieve that stress and permit opportunities for multiple intervals of night-time rest, it is important that pilots limit if not eliminate call-backs during their off-duty period. In fact, among the over 60 pilot associations addressed above, it is most typical practice to staff a sufficient number of pilots to near anticipated peak demand to have a surge capacity that avoids delaying ships without reliance upon excessive callbacks of pilots on scheduled off duty. It is also generally acknowledged that the cost of pilot staffing to peak demand is less than the cost of the consequences of delays to shipping. Excessive call backs increase pilot workload and cause uncertainty and interruptions in needed off-duty time for recuperative rest and normal life after what can be a challenging and stressful on duty period.

Capt. George A. Quick, Vice President
International Organization of Masters, Mates and Pilots

Attachment A

CAPTAIN GEORGE A. QUICK

Curriculum Vitae

Academic
Bachelor of Science Degree in Marine Transportation,
U.S. Merchant Marine Academy at Kings Point, NY

Juris Doctor Degree, University of Baltimore Law School

Professional Qualifications
Licensed by U.S. Coast Guard as master and first class pilot
Licensed by State of Maryland as senior pilot for ships of unlimited draft
Admitted to practice of law in Maryland

Professional Associations
American Pilots' Association
Association of Maryland Pilots'
Council of American Master Mariners
Proctor member of Maritime Law Association

Past Positions

1. Navigating officer on cargo and passenger ships.

2. Senior pilot for all ports in the State of Maryland.

3. President of Association of Maryland Pilots' with responsibility for administration of State regulated pilot association with approximately 90 pilots and 50 support staff.

4. Member of Board of Examiners of Maryland Pilots - Appointed by the Governor of Maryland to the Board responsible for the selection, training, and licensing of pilots. The investigation of accidents and discipline of pilots, and oversight of the State pilotage regulatory system and the setting of pilotage rates.

5. President of the Baltimore Maritime Exchange - Responsible for port communications system, and data collection and information system.

6. Regional Vice President of the American Pilots' Association, representing State licensed pilots' in the North Atlantic Region from Maine to Virginia. Senior Vice President of the American Pilots' Association.

7. Legal advisor and Representative of the International Maritime Pilots' Association (IMPA), the London based organization that represents the global pilot community, to the International Maritime Organization (IMO), the United Nations Organization responsible for regulating international shipping.

8. Chairman of the International Officers Forum (IOF) of the London based International Transportworkers Federation (ITF) coordinating international policy for the officers' unions of the major maritime nations in Europe, North America, South America, Asia and Australia.

Current Positions

1. Vice President for the Pilot Membership Group of the International Organization of Masters, Mates and Pilots. Represents pilots in the United States that handle U.S. and foreign flagged ships engaged in international trade. Has participated in hearings or testified before Boards or Commissions, or legislative committees in most of the coastal states of the United States on pilotage regulation and rate making methodology. Represents the interests of ship's masters and officers, as well as pilots, before the U.S. Coast Guard, the U.S. Maritime Administration and the U.S. Congress on a national level and before the IMO on an international level.

2. Representative on ITF delegations to IMO, including head of delegation on IMO Legal Committee and IMO Flag State Implementation Committee. Has participated in IMO Working Groups drafting international standards covering a wide range of maritime related issues including the training and certification, and operational procedures for maritime pilots, and pilot boarding arrangements and pilot ladder standards. International Guidelines on manning, workload and fatigue mitigation in the maritime industry. As well as performance standards for Integrated Navigation Systems (INS) and Integrated Bridge Systems (IBS) that define the navigational equipment standards for new technologically advanced ships.

3. Chairman of the ITF Ship Automation Working Group, developing positions on shipboard autonomous systems and Maritime Autonomous Surface Ships (MASS).

4. Course developer and lecturer on "Bridge Resource Management for Pilots" for the Maritime Institute of Technology and Graduate Studies (MITAGS).

Awards

U.S. Merchant Marine Academy Alumni Association Outstanding Professional Achievement Award in 1976 and received the Award for a second time in 2011.

2009 Seafarers International House "Outstanding Friend of Seafarers Award" for work on behalf of seafarers' rights.

2016 Marine Society of the City of New York, Outstanding Life Time Achievement Award in the maritime industry.

EXHIBIT 5

From: Rick Hamner <director2@bcpilots.com>
Date: April 17, 2019 at 9:12:58 AM PDT
To: "president@pspilots.org" <president@pspilots.org>
Subject: Sent from Snipping Tool

This is an example of my 4 years rotation. I am in my 20th year so it has recycled 5 times for me now. We work two years starting at midnight and two starting at noon, it is a bit long every December to work 30 days however if you manage your rest period it works.

Capt. Rick Hamner
Director, BC Coast Pilots
1450-1130 West Pender Street
Vancouver, BC V6E 4A4
(604) 688-0291, ext. 311
(604) 813-5832

JAN	30 days Dec 29 to Jan 28	Jan 18 to Jan 28	Dec 29 to Jan 8	Jan 8 to Jan 18
FEB	Feb 17 to Feb 27	50 days	Jan 28 to Feb 7	Feb 7 to Feb 17
MAR	Mar 19 to Mar 29	Feb 27 to Mar 9	30 days Feb 27 to Mar 29	Mar 9 to Mar 19
APR	Apr 19 to Apr 29	Mar 29 to Apr 8	Apr 8 to Apr 19	31 days Mar 29 to Apr 29
MAY	51 days	Apr 29 to May 9	May 9 to May 19	May 19 to May 29
JUN	May 29 to Jun 9	30 days May 29 to Jun 28	Jun 9 to Jun 19	Jun 19 to Jun 29
JUL	Jun 29 to Jul 9	Jul 9 to Jul 19	30 days Jun 29 to Jul 29	Jul 19 to Jul 29
AUG	Jul 29 to Aug 8	Aug 8 to Aug 18	Aug 18 to Aug 28	50 days
SEP	30 days Aug 28 to Sept 27	Sept 7 to Sept 18	Sept 18 to Sept 28	Aug 28 to Sept 7
OCT	Oct 8 to Oct 18	30 days Sept 28 to Oct 28	Oct 18 to Oct 28	Sept 28 to Oct 8
NOV	Nov 7 to Nov 19	Nov 19 to Nov 29	52 days	Oct 28 to Nov 7
DEC	Dec 9 to Dec 19	Dec 19 to Dec 29	Nov 29 to Dec 9	30 days Nov 29 to Dec 29
ADVANCE DAYS - SYSTEM #4 - FULLTIME				
JAN	Jan 18 to Jan 28	Dec 29 to Jan 8	Jan 8 to Jan 18	30 days Dec 29 to Jan 28
Next year - read one column to the right - - - - - - - - - - - - - -				- > Read left column

EXHIBIT 6

PACIFIC PILOTAGE AUTHORITY

2017 Annual Report

Canada

Exhibit 6 provides a historical financial summary of the Authority from 2011 through 2017.

Exhibit 6
Historical Financial Summary (in thousands of dollars)

Financial Results	Actual 2011	Actual 2012	Actual 2013	Actual 2014	Actual 2015	Actual 2016	Actual 2017	Budget 2017	Budget 2018
Revenues	$65,797	$64,576	$71,959	$74,689	$73,016	$76,552	$85,795	$85,031	$86,415
Expenses	$61,572	$63,123	$72,313	$78,193	$77,411	$80,330	$86,541	$86,683	$87,538
Net Income (Loss)	$4,225	$1,453	($354)	($3,504)	($4,395)	($3,778)	($746)	($1,652)	($1,123)
Financial Position									
Current Assets	$12,428	$13,696	$14,854	$12,773	$10,260	$9,245	$11,671	$10,919	$9,769
Current Liabilities	$6,740	$7,172	$7,759	$9,440	$9,660	$10,506	$11,266	$10,991	$11,824
Working Capital	$5,688	$6,524	$7,095	$3,333	$600	($1,261)	$405	($72)	($2,055)
Net Capital Assets	$10,477	$10,255	$9,195	$12,577	$12,331	$11,698	$10,614	$10,760	$10,906
					Operating Indicators (Actual)				
Average Number of Pilots									
Coastal	98	98	100	98	98	103	114	113	112
River	7	7	7	7	8	8	8	8	8
Number of Assignments									
Coastal	11,422	11,211	12,144	12,146	11,813	11,638	12,249	12,414	12,139
River	1,100	1,081	1,122	1,120	1,079	1,023	1,148	1,107	1,152
Revenue per Assignment									
Coastal	$4,026	$4,118	$4,457	$4,465	$4,559	$4,800	$5,031	$4,940	$5,103
River	$2,205	$2,339	$2,471	$2,588	$2,794	$2,946	$3,144	$3,213	$3,318

Pilot Vessel Financing – Pacific Chinook

On July 23, 2014, the Authority's Pine Island contractor (the "Contractor") incorporated a company, 1008799 B.C. Ltd. ("Holdco"), with its sole purpose being the purchase, ownership and lease of a pilot vessel (called the Pacific Chinook) to the Contractor under a Bareboat Charter Agreement.

The Authority borrowed funds from a Canadian chartered bank in order to provide financing to Holdco for the purchase and additional costs related to refitting the vessel to Transport Canada standards. Holdco signed a Promissory Note and a Mortgage Agreement with the Authority, guaranteeing to pay back the mortgage on the vessel over an 11 year period and guaranteeing the repatriation of the asset for $10 at any point by the Authority. Annual blended payments over this period approximate $350,000 per annum. As at December 31, 2017, Holdco's mortgage payable to the Authority is $2.3 million.

A Shareholder's Agreement was signed on September 26, 2014 by the Contractor, which owns all shares of Holdco. The Agreement specified that the Contractor was obliged, in perpetuity, to vote its shares to appoint directors that are nominees of the Authority.

The Authority holds no ownership interest in Holdco and operating risks of the vessel rest with the Contractor under the conditions of a Bareboat Charter Agreement between the Contractor and Holdco. The Bareboat Charter Agreement enforces requirements on the Contractor regarding the use of the vessel. The Contractor has insured the vessel and Holdco against breach of warranty with the Authority as a named insured. Failure by the Contractor to act in accordance with the provisions of the Bareboat Charter Agreement enables the Authority to execute remedies across any and all of these agreements.

All of these actions were performed in order to protect the Authority's interest in the financing it provided to Holdco for the purchase and retrofitting costs associated with the vessel.

The Bareboat Charter Agreement calls for annual lease payments of $350,000 from the Contractor to Holdco which commenced when the vessel was placed into service in October 2015. Management estimated that the bareboat charter fees approximated the fair value for a vessel in similar condition and used under similar circumstances.

In accordance with International Financial Reporting Standards (IFRS), the protective actions performed by the Authority imply that, from an accounting perspective, the Authority acquired control of Holdco and accordingly the Authority was required to consolidate the financials of Holdco into the Authority. In determining control and the need for consolidation, the Authority was required to consider the elements of control in accordance with the provisions of IFRS 10 (Consolidated Financial Statements) as summarized below:

EXHIBIT 7

5. The amount of time each pilot spends on actual piloting duty and the amount of time spent on other essential support services.

FCCA asserts that PEP has too many pilots to handle a declining number of handles. In 2004, PEP had 17 state pilots to handle 12,778 movements – an average of 751 handles per year, per pilot. The average handles per year, per state pilot in 2017 are down to 8017 by 4761 – or down 37% from 2004.

PEP provided a number of explanations for the average workload decline:

1. During the peak levels of handles between 2003 to 2007, the 17 PEP pilots were understaffed and the average workload (between 628 and 751) was too high. This was the second highest average workload of the eleven Florida ports, but the volume was compounded by the number of small, daily cruise handles included in the mix of total vessels. Daily cruise handles totaled 3,930 in 2004, but declined to only 445 by 2013.
2. From 2003 to 2006, six new pilots were added to compensate for the peak workload years, but during the same period six pilots retired, keeping the pilot roster at 17 and understaffed.
3. The 37% precipitous drop in handles starting in 2004 through 2017 is not something the pilots can control or anticipate, in order to match the number of available pilots to the workload at any given time. The process of requesting a deputy; administering the exam; and providing a three year deputy training program; present a minimum, four year time frame to add new pilots. In addition, planning for retirements, sicknesses, injuries or other events causing pilots to be unavailable for duty, are unpredictable variables.

From 2013 to 2017, PEP had 17 state pilots and two to five deputy pilots. Deputy pilots are able to handle 40% of the smaller vessels. However, it is common for 2 pilots (a state pilot and a deputy) to perform a single handle. PEP asserts that an even number of pilots is desirable for the watch schedule and based upon the timing of traffic in the port, 18 pilots are necessary to effectively cover the needs of the port, considering all factors and contingencies.

PEP's application presents a comprehensive analysis of the time pilots spend on actual piloting duties and other essential support activities, which is summarized beginning on the next page:

5. The amount of time each pilot spends on actual piloting duty and the amount of time spent on other essential support services. (continued)

The Port Everglades Pilots' Association work schedule calls for having nine pilots on for four weeks, while the other nine are off the board. The nine pilots on watch are on call 24/7, however the watch is divided into two, 12 hour periods whereby there are primarily 5 pilots on day watch and 4 pilots on night watch. At times of peak traffic, some of which are predictable and others are not, pilots are called in across the day/night divide as needed to prevent delays. There is a higher prevalence of this occurring during the 20 week winter cruise ship season. To cover the foreseeable, significant spikes in traffic that occur on the weekends during the peak of cruise ship season, two of the off-watch pilots are often called in to provide the other regular watch pilots sufficient time to rest between work periods. This averages about 45.5 hours per pilot per year. As an additional backup, they place two of the off-duty pilots on a 24-hour recall status to handle any unexpected fluctuations in pilots due to injuries, sickness emergencies or business issues. This works out to 8 weeks every 17 months or 475 hours of additional standby time.

PEP elected not to hire dispatch personnel or managers for their corporation and consequently divide the workload between the active pilots on and off-watch. The pilots therefore not only provide pilotage duties, they serve as dispatchers for the port pilots. Given 8,760 hours in a year and that the pilots moved 8,017 vessels (in 2017), almost every hour of every day (92% of the time) a ship arrives or departs the port. PEP asserts that their dispatching duties are equivalent to a 24/7 task (8,760 hours ÷ 18 pilots) or 515 hours per pilot per year. There is no documented evidence to verify this assertion, but given that a dispatch takes place for each handle and that one of the 4.5 pilots on duty (within any 12 hour watch period) must be available to accept a request for dispatching and follow through with the process, it is not unreasonable to attribute this many hours of on-watch time to dispatching.

The recap of PEP's actual time requirements for each pilot includes the following:

1. Bridge time (1.75 hours) and other handle time (.85 hours) (8,017 vessels/year X 2.6 hrs/vessel/1 pilots) or 1158 hours/year.
2. Two **"managing pilots"** handle the pilot-related administrative workload, which rotates every three years and equates to an additional <u>31 hours/week</u> or 1612 hours each year or 95 hrs/pilot.
3. Pilots serve as **"dispatchers"** in lieu of hiring four extra people for that function for a savings of 515 hours/pilot.
4. Winter peak-time adds 45 hours per year to the on-watch requirement.
5. Other time requirements include the **"designated pilots"** who are on a "on-call" status (but off-watch) eight weeks every 17 months which equates to approximately 5.66 weeks/yr or 475 hours/pilot.
6. They are also involved in professional continuing education and training development time, managing watch rotations, political liaison /community service efforts.

5. The amount of time each pilot spends on actual piloting duty and the amount of time spent on other essential support services. (continued)

When considering the pilot's bridge and dispatch times, operational and administrative responsibilities, plus training requirements their workload is far greater than the 40-hour per week average. In addition, three pilots have served regular rotations overseas supporting America's war on terror as part of the naval reserve. A summary of on-watch and off-watch time is summarized below:

On-Watch / Off-Watch / On Duty / Off Duty

365	days per year
x 24	hours per day
8,760	total hours per year

	Hours	Explanation
On Duty: 8,760 ÷ 2 =	4,380	one half of year on duty
On Watch: 4,380 ÷2 =	2,190	12 hours on / off watch
Add winter peak time	45	Additional on-watch requirements
Total Hours on-watch	2,235	

Allocation of total time:		On-Watch	Off-Watch
Bridge Time:			
7,383 handles ÷ 17 x 1.75 hours	=	760	
Remaining Handle Time			
7,383 handles ÷ 17 x .85 hours	=	369	
Total Handle Time		1,129	
Standby			475
Dispatching		515	
Winter Peak Time		45	
Deputy Pilot Training		10	
Administration and Liaison		95	110
Continuing Education		12	
Continuing Education			40
Subtotal		1,806	625
Other Port, Professional and Regulatory Activities		384	N/A
PEP's on-watch/off-watch total		2,190	625