

MEMORANDUM

To: Marian Olin

From: Dilip Trivedi, Astrid Vargas

Date: September 8, 2017

**Subject: Dredging Operations - Compliance with Permit Conditions
Santa Cruz Harbor Dredging
M&N Job No.: 9676**

1 INTRODUCTION

The present memorandum addresses compliance of the Santa Cruz Port District's (SCPD) dredging operations with the California Coastal Commission (CCC) special condition no. 9 of the coastal development permit, CDP 3-10-023. This document is intended to support SCPD's application to renew their five-year dredging permit commencing with the 2018-19 dredge season in the fall of 2018 and ending with the completion of the 2022-23 dredge season in the spring of 2023.

The main findings in this memorandum are summarized below.

- SCPD is addressing potential solutions to reduce emissions of H₂S related to their dredging operations by implementing a degassing eductor system on their dredge, and performing pothole dredging "sweeps," two of the seven modifications identified in earlier studies (Moffatt & Nichol, 2011).
- Implementation of "Protocol Avoidance Measures" have proved to effectively reduce the number of protocol shutdowns (i.e. H₂S air concentrations) and indirectly reduce pipeline handling and tractor usage.
- Odor complaints have decreased since the 2013-2014 season; the percentage of complaints with respect to the number of dredged days through the 2012-2017 season remains low (6.5%).

1.1 Background

The Santa Cruz Port District has performed maintenance dredging operations in Santa Cruz Harbor since 1986, under a Memorandum of Agreement with the U.S. Army Corps of Engineers. With the use of their own hydraulic suction dredge, the Port District has dredged sediment trapped in the entrance channel and inner harbor, and discharged it on the beach east of the harbor, where the sediment would have deposited in the absence of the harbor.

As in many other harbors around the world, sediment deposited in the entrance channel of Santa Cruz Harbor often contains decomposing organic material that can emit hydrogen sulfide gas (H₂S) upon dredging, and give rise to a nuisance odor at the point of sediment discharge. In response to odor complaints from the neighbors, the Monterey Bay Unified Air Pollution Control District (MBUAPCD) set a protocol for dredging operations. Per this protocol, air concentrations of H₂S downwind of the discharge point are to be monitored during dredge discharge on the beach, and are required to remain below 10 ppb on a 1-hour rolling average during "discretionary" operations. This threshold is equivalent to 1/3 of the state's nuisance standard. If the 10 ppb threshold is exceeded, then the protocol requires beach

discharge to be shut down for the day (or the discharge shifted to an underwater offshore pipeline). The protocol also allows air concentrations of H₂S to exceed the 10 ppb threshold (but without exceeding the state’s nuisance standard) during “emergency” operations.

SCPD currently carries out dredging operations under the specified terms in CDP 03-10-023, approved by the CCC in April 2012. This permit allows: 1) dredging up to 1,280,000 cubic yards of entrance channel sediment (composition > 80% sand) over a five year period, with discharge into the nearshore¹ and on the dry beach at Harbor Beach and Twin Lakes State Beach, and 2) dredging up to 20,000 cubic yards per year of clean inner harbor sandy sediment (composition > 80% sand), or alternatively, up to 10,000 cubic yards per year of silts/clays (composition < 80% sand) and 10,000 cubic yards per year of sandy sediment (>80% sand), at a rate of up to 550 cubic yards of silts and clay per day, with discharge in the nearshore environment.

Among the terms and conditions to which the permit is subject, special condition no. 9 related to evaluating potential modifications of dredging operations states the following:

“The Permittee shall further evaluate the options shown with a positive or superior score in Table 5 of the Options Study (page 30 of Exhibit C) with the goal of employing a method or variety of methods to reduce hydrogen sulfide releases and to reduce tractor and pipeline handling operations on the beach to the maximum extent feasible. If the results of these evaluations are positive in terms of controlling the release of hydrogen sulfide into the air, reducing the use of tractor on the beach, reducing the amount of above-ground pipeline on the beach, etc., and are otherwise feasible for the Permittee to implement and employ, the Permittee shall include the option(s) as part of the project description in its application for renewal of the dredging and disposal permit five years hence, and, if feasible, add them to this current permit if directed by the Executive Director.”

Per the above, Table 5 of the “options study” (Moffatt & Nichol , 2011) is provided in Figure 1. Per this study, a superior performance relative to the pre-2011 dredging operations is expected for the alternatives with a total score of +5 or higher.

1.2 Dredging Operations Prior to the 2012-2013 Season

Table 1 compiles information of the dredging operations in Santa Cruz Harbor from the 2007-2008 to 2011-2012 seasons. Over this 5-year period, the entrance channel was dredged for a total of 355 days, during which H₂S protocol shutdowns occurred on 55 days, representing an overall shutdown percentage of 16%. Additionally, 15 odor complaints were filed by neighbors during the same period.

Table 1 Entrance Channel Maintenance Dredging Operations 2007 to 2012

Dredge Season	Dredge Volume (cy)	Dredge Days	Protocol Shutdowns	Odor Complaints
2007-2008	243,700	65	7	4
2008-2009	210,960	54	13	7
2009-2010	456,830	78	5	0
2010-2011	331,727	62	25	4
2011-2012	270,441	96	5	0
Total	1,513,658	355	55	15

		MODIFICATION								
		1. Seawater Spray System	2. Poor Boy Degasser	3A. Degassing Eductor	3B. Degassing Booster Pump	4. Cutter-Head Sweeps	5. Pre-Dredge Plowing or Jetting	6. Upcoast Sand Trap	7. Extend Jetties	8. Offshore Disposal Pipeline
CRITERIA	Increase days of entrance channel navigation	+2	+4	+4	+4	+2	+2	+4	+4	+2
	Increase nourishment of down coast beaches	+3	+4	+4	+4	+3	+3	-4	-2	+2
	Decrease dozer operation on beaches	+3	+4	+4	+4	+3	+3	+2	+2	+2
	Decrease hydrogen sulfide releases	+2	+4	+4	+4	+3	+2	+2	+2	+3
	Decrease impact on Monterey Bay Habitat	+3	+4	+4	+4	+3	+3	-5	-3	-1
	Decrease cost maintenance dredging	-2	-2	-2	-3	-3	-2	-5	0	0
	Upfront costs/risks	-2	-3	-2	-3	-1	-2	-5	-5	-5
	Enhance permit ability	+1	-2	+5	+1	+3	+3	-3	-5	1
	TOTAL	+10	+13	+21	+15	+13	+12	-14	-7	+4

Figure 1 Evaluation of Potential Modifications to Dredging Operations (M&N, 2011).

2 EVALUATION OF POTENTIAL MODIFICATIONS

In response to special condition no. 9 of CDP 03-10-023, this section provides a follow-up evaluation of the potential modifications (scored positive or higher) to dredging operations listed in M&N (2011). For ease of discussion, these alternatives are grouped as follows: 1) Modification of dredge equipment, 2) Changes in dredge operations, and 3) Modification at the discharge site.

2.1 Modification of Dredge Equipment

2.1.1 Seawater Spray System

This alternative involves installation of a seawater spray system on the dredge pipeline at the discharge point, which allows the H₂S entrained in the sediment slurry to re-dissolve in a spray mist, therefore minimizing its downwind transport.

Testing of this alternative was not conducted by SCPD as it was considered infeasible. Primarily, implementation of this alternative would require placement of additional infrastructure on the beach, including pumps and pipelines to deliver seawater to the discharge point and a nozzle to discharge seawater as a fine mist. Although not permanent, since the system could be utilized on an as-needed basis, addition of such infrastructure would counteract one of the objectives of modifying the existing dredging operations, which is reducing the amount of above-ground pipeline on the beach. Furthermore, there is high potential for the sprayed seawater to pose a nuisance for beach users and downwind receptors, and potential for creating a beach hazard.

2.1.2 Poor Boy Degasser

This alternative consists of a degasser system, which utilizes a series of baffles to separate H₂S entrained in the sediment slurry, as well as a scrubber to capture the H₂S.

SCPD choose not to conduct tests on this alternative as other more promising degassing systems were proposed in M&N (2011) (Figure 1). The costs of conducting tests on this alternative were not justified since better options were available.

Among the reasons why this alternative was considered infeasible is its large footprint. Without considering the gas scrubber, the poor boy degasser is a 20-foot tall cylinder with approximately 8 foot diameter, posing a significant visual obstruction. This infrastructure would be added near the discharge point, i.e., on the beach. As the discharge pipeline is relocated frequently based on beach building needs (often multiple times within a day, depending on the organics content), the system would also need to be relocated, representing significant increase in tractor operations and possibly a reduction in dredging/discharge production rates. The required beach-side infrastructure and operations were deemed to be non-permittable, and temporary testing of equipment of this size and scale was deemed to be infeasible.

2.1.3 Degassing Eductor

For this option, a gas stripper is installed on the dredge suction line to separate the H₂S from the slurry, and the stripped gas is disposed by the dredge underwater, where it can re-dissolve. Therefore H₂S release into the air is avoided.

Among all the proposed modifications, the degassing eductor was evaluated with the highest score (Figure 1). Among the degasser systems, this option presents the advantage that it does not involve

addition of infrastructure on the beach. Instead, the degasser would be mounted on the dredge itself without impact on beach aesthetics or tractor usage.

This dredging alternative has been implemented by SCPD and tests are being conducted to determine its efficacy. A degassing eductor was first installed on SCPD's former dredge *Seabright*. Despite a \$17,000 investment in equipment, *Seabright's* degasser had only limited success. It was not optimally located for H₂S removal since it was a later addition to the dredge, and it was prone to becoming clogged with organic debris. It was taken out of service in its first season of operation. Based on lessons learned, a degassing eductor system was built in SCPD's recently acquired dredge *Twin Lakes*, which has been in operation since the 2016-2017 season. The eductor was built into the dredge using standard technology that also reduces cavitation of the pump. It is expected to perform well, and reduce H₂S prior to entering the pump and discharge system.

2.1.4 Degasser Booster Pump

This alternative consists of a booster pump/degasser system and a scrubber near the discharge point. The patent YOKOTA slurry pump differs from the poor boy degasser in that it separates gas from the slurry by means of the centrifugal mechanism of the pump's impeller. However, a power source is needed for the booster pump, either an electric drop or a diesel engine system.

Similar to the poor boy degasser, this alternative would require additional infrastructure on the beach. Although the YOKOTA pump may offer a lesser visual obstruction than the poor boy degasser, the need for a power source for its operation will produce another form of intrusion. Moreover, the largest YOKOTA slurry pump available is marginally sized for the needs of the Port's dredging operations.

Testing of this system was not carried out by SCPD, since the degassing eductor represented the most feasible alternative within this category, and the demonstration costs were not warranted. The beach-side power and infrastructure requirements were not deemed to be permissible options.

2.2 Changes in Dredge Operations

2.3.1 Cutter-head Sweeps

Sweeping is a dredging technique that involves removing sediment in a number of lifts, as opposed to the Port's usual dredging practice which involves pothole dredging. By implementing sweep dredging, intake of decayed organics is expected to be dispersed and hence H₂S releases less intense. As a larger footprint is dredged, it will avoid continuous removal of sediment from "organic hotspots", i.e. localized areas where organic material has accumulated.

A cutter-head is typically used for sweep dredging; however, use of a cutter-head is not feasible for use in the federal entrance channel due to wave and tidal surge, and the prevalence of organic material and kelp. The snorkel that was formerly utilized on the dredge *Seabright* was repurposed for use on the dredge *Twin Lakes*. The snorkel was specifically designed for use in the Santa Cruz Harbor entrance channel. The snorkel employs water jets which turn the sand into a slurry, dispersing some H₂S in situ prior to intake. While the snorkel cannot sweep in the same manner as a cutter-head, the crew has been trained to reposition the snorkel more frequently throughout the day.

The SCPD dredge crew has received training for frequent repositioning or "sweep" pothole dredging, and this dredging practice has been employed for the 2016-2017 season. Testing to determine the efficacy of this alternative in reducing H₂S emissions is being conducted. While it may have the

potential to reduce H₂S, it may reduce production and prolong dredging efforts. Further evaluation and testing of this methodology will continue.

2.3.2 Pre-dredge Plowing or Jetting

This alternative involves performing plowing and/or jetting operations on the seabed prior to dredging in such a way that buried pockets of decayed organics can be dislodged, and trapped H₂S released underwater. For such operations, acquisition of a plowing or jetting apparatus, and a sufficiently powerful tow boat would be required.

No testing of this alternative was carried out by SCPD. From a regulatory perspective, carrying out the pre-dredge seafloor modification would require additional permitting from the CCC as they involve activities which are not included in the current permit. Plowing also presents a safety concern that cannot be mitigated. Plowing equipment is likely to become lodged on unseen / unidentified organic debris (e.g., tree branches or logs) which puts the vessel, equipment and its crew at risk.

2.3 Modifications at the Discharge Site

2.3.1 Offshore Pipeline

This alternative aims to reduce the H₂S air emission by discharging dredged material underwater in the offshore zone. Continuous submerged discharge will allow H₂S to re-dissolve reducing its emission. Modifications of infrastructure for this alternative include a permanently buried pipeline through the dry zone of the beach that “daylights” on a trestle over the surf zone and continues to a depth of approximately 15 feet relative to Mean Lower Low Water (MLLW). Dredged material would then be discharged at various depths through a number of submerged outlet pipes spaced along the trestle mounted pipeline.

Since this alternative mainly involves shifting the location where dredged material is discharged by a major, very costly change the existing infrastructure, conducting tests to corroborate its efficacy is infeasible. Furthermore, while emissions of H₂S would be controlled and tractor usage for beach pipeline handling reduced, tractor usage for beach building purposes (i.e. redistributing the offshore sediments to the beach) will likely increase. Due to the required maintenance of the trestle system, its permanent placement is determined to be infeasible. Additionally, it would pose a significant impact on beach aesthetics, public access and usage, and is not deemed to be permissible in the Monterey Bay National Marine Sanctuary or maintainable.

2.4 Other: Sediment Bedload Collector System

SCPD evaluated feasibility of an additional dredging alternative, which was not included in M&N (2011), and could potentially replace dredging in the entrance channel. This alternative involves installation of a sediment trap on the sea bed consisting of a steel hopper that extends across the harbor entrance and collects the sediment before it enters the channel. The alternative was determined to be infeasible and not compatible with Santa Cruz Harbor requirements for a number of reasons, including the following:

- Implementation would require frequent vessel traffic disruption.
- During periods of high sediment transport, the rate might exceed the trap capacity, which could result in the trap getting overwhelmed, with additional dredging and craning operations being needed to restore the system.

- Approximate cost of the system per cubic yard would be more than two times higher than the average historic dredging costs in the entrance channel, making it economically infeasible.
- The equipment would create more impact and heavy equipment use beach-side and along the jetties than the seasonal dredge in the entrance channel and associated pipeline and dozer equipment on the beach utilized for current dredge disposal operations.

2.5 Summary of Potential Modifications

Many of the alternatives proposed in M&N (2011) were judged to be infeasible, non-permittable and unsafe and were not tested based on this evaluation. However, two of the alternatives have been implemented, as indicated in Table 2. With the addition of a degassing eductor system and implementation of dredging sweeps, two of the three groups of dredging modifications are accounted for.

Table 2 Implementation of Potential Modification to Dredging Operations

Alternative Type	Modification of Dredge Equipment				Changes in Dredge Operations		Modification at the Discharge Site	Other
	Dredge Alternatives	Seawater Spray System	Poor Boy Degasser	Degassing Eductor	Degassing Booster Pump	Dredging sweeps		
Implemented	Infeasible	Infeasible	✓	Infeasible	✓	Infeasible	Infeasible	Infeasible

3 COMPLIANCE WITH EXISTING PERMIT REQUIREMENTS

3.1 Actions taken by SCPD

With the aim of improving their dredging operations in order to reduce the release of H₂S into the air and to reduce tractoring and pipeline handling operations on the beach, the Port District has taken a number of actions, including:

3.1.1 Acquisition of a Diffuser for Sediment Discharge

A sediment diffuser was constructed by SCPD for purposes of beach-building. This equipment consists of a fan-like nozzle attached to the discharge pipeline which spreads material over a broader area on the beach. The diffuser was first put into service on December 14, 2011, as an effort to reduce the amount of dozer operations. Nevertheless, it has been concluded that dozer operations have not significantly been reduced, as grooming of the beach to restore natural contours is still needed. The diffuser is a higher profile disposal operation, and garnered some complaints from a neighbor who was concerned about its visual impacts.

3.1.2 Implementation of Protocol Avoidance Measures (PAM)

With the aim of reducing protocol emissions of H₂S, SCPD implemented a practice termed “Protocol Avoidance Measures (PAM)” first developed in the 2012-2013 dredging season. PAM consists of voluntarily ceasing beach discharge operations when H₂S levels escalate to a point that may result in exceedance of the discretionary protocol threshold. As soon as the discharge pipe is clear of

sediment, a zero filter is installed on the H₂S meter, and after a “cool down” period of one hour, beach discharge is resumed.

Implementation of PAM has helped to reduce the number of protocol shutdowns. Table 3 provides an indication of the efficacy of PAM in avoiding a protocol shutdown, i.e., the percentage of occasions where beach discharge operations were resumed after implementation of PAM. Dredge seasons 2015-2016 and 2016-2017 are not included in the table, since dredging followed the emergency operations protocol for the majority of the season, therefore PAM were not needed. Furthermore, it is noted that protocol shutdowns have occurred on days when PAM were not employed.

Table 3 Efficacy of Protocol Avoidance Measures

Dredge Season	Efficacy of Protocol Avoidance Measures (%)
2012-2013	60
2013-2014	91
2014-2015	100

The efficacy of PAM indirectly reduces the amount of tractor usage, since relocation of the discharge pipeline into an underwater position is no longer required if a protocol shut down is avoided.

3.1.3 Acquisition of a Rubber-tired Tractor

As an effort to reduce the amount of tractor-related noise complaints on the beach, the Port District acquired a used rubber-tired loader. However, based on its performance, SCPD has determined that the loader is not efficient for moving pipe and actually increases heavy equipment operation on the beach. Its only benefit was to reduce noise as the loader’s rubber tires were quieter than a track-style dozer. SCPD will pull the dozer from future service.

3.1.4 Acquisition of a New Hydraulic Dredge with a Built in Degasser

The Port District recently acquired *Twin Lakes*, a \$4.8 million dredge, which was first put into service in the 2016-2017 dredging season. Similar to SCPD’s former dredge, an 18-inch diameter nozzle is lowered to the bed, which employs the snorkel previously used on its dredge *Seabright*, which features a suction head assisted by water jets to agitate sediment into a slurry. The slurry is then sucked up and discharged to the adjacent beach through a 16-inch diameter pipe. A degassing eductor to strip H₂S from the discharge has been built into the new dredge. H₂S concentrations at the discharge site are expected to be reduced, decreasing the need for protocol shutdowns and the number of odor complaints.

3.2 Dredging Operations Since the 2012-2013 Season

Table 4 compiles information of the dredging operations from the 2012-2013 to 2016-2017 seasons. Out of 353 days in which dredging of the entrance channel occurred, 17 protocol shutdowns occurred representing a shutdown percentage of 5% (percentage of days dredged). Protocol avoidance was carried out in 33 occasions, 28 of which allowed beach discharge operations to continue later in the day (Table 3). Additionally, 23 odor complaints have been filed.

It should be noted that a direct comparison between dredged volumes in 2016-2017 and the earlier seasons cannot be made since the former have been estimated with the density meter aboard *Twin Lakes*, while the latter have been estimated based on pump curve assumptions.

Table 4 Entrance Channel Maintenance Dredging Operations 2012 to 2017

Dredge Season	Dredge Volume (cy)	Dredge Days	Protocol Shutdowns	PAM	Odor Complaints
2012-2013	185,684	71	9	10	5
2013-2014	111,952	47	5	11	6
2014-2015	222,865	69	1	12	7
2015-2016*	483,465	111	6**	0	5
2016-2017***	48,456	55	2	0	0
Total	1,052,422	353	17	33	23

*Operated under emergency protocol, PAM not implemented.

**Although no shutdown occurred, H₂S levels exceeded “discretionary” limit on 6 days while dredging under emergency protocol.

***Data as of Feb 09, 2017. Dredging volumes estimated from *Twin Lakes* density meter.

A direct comparison of Table 1 and Table 4 indicates a reduction in the number of protocol shutdowns and an increase in odor complaints since the 2012-2013 dredging season. However, in order to provide a more accurate comparison, an average of protocol shutdowns and odor complaints per day of dredging was estimated for each dredge season since 2012, and normalized with respect to the average of the pre-2012 dredge seasons (from now on referred to as the “base” season).

In this way, Figure 2 through Figure 4 provide an indication of how the H₂S related events have evolved through the dredging seasons covered in CDP-3-10-023. Since introduction of PAM, a decreasing trend of shutdowns (or exceedance of the discretionary protocol threshold) can be observed (Figure 2), which would likely have been an increasing trend in the absence of PAM during the 2012-2013 and 2013-2014 seasons (Figure 3). The reduction in shutdowns and exceedance of discretionary threshold is most evident in the 2014-2015 season (i.e. approximately 80% decrease with respect to the base season), for which a 100% efficacy of PAM occurred; but is also significant for the last two dredging seasons, where no PAM were carried out. This could suggest that implementation of the degassing eductor system and dredging pothole sweeps (2016-2017) contributed to decreased emissions, though no direct analysis has been completed.

It is important to note that H₂S emissions will not only depend on the efficacy of the modifications to counteract its release. The amount of decomposed organics accumulated on the seabed, which varies randomly in time and space, is also a determining factor. For periods following a storm that carries organic debris towards the harbor, H₂S emissions will be higher than in the case where the seabed is clear of organic debris, regardless of the efficacy of the implemented modifications.

With respect to Figure 4, the (normalized) number of odor complaints is equal or higher than that in the base season, with exception of the 2016-2017 season. However, after a maximum during the 2013-2014 season, the number of complaints decreases. Furthermore, the percentage of complaints through the

2012-2017 dredging season with respect to the number of days dredged remains within low figures (i.e. 6.5%).

While the data in Figure 4, shows a trend similar to Figure 3, the number of odor complaints is not a reliable indicator of H₂S air concentration, as it depends on beach usage and perception of users, among others. As an example, one of the filed odor complaints during the 2015-2016 season was specific to diesel odor and not H₂S. Complaints rarely coincide with protocol exceedances.

4 CONCLUSIONS

With respect of compliance of special condition no. 9 of CDP 03-10-23, the following can be concluded:

- Out of the seven modifications to dredging operations proposed in M&N (2011), addition of a degassing eductor system and implementation of dredging pothole repositioning or “sweeps” were found to be the most feasible. By implementing these alternatives, SCPD is addressing the need to reduce emissions of H₂S related to their dredging operations.
- In addition to the alternatives proposed in M&N (2011), implementation of PAM have proved to effectively reduce the number of protocol shutdowns (i.e. exceedance of the discretionary protocol threshold), which indirectly contributes to reduction of pipeline handling and tractor usage.
- Regardless of the efficacy of the implemented dredging modifications to decrease release of H₂S into the air, emissions will be influenced by the amount of organic debris accumulated on the seabed, which vary randomly in time and space.
- Odor complaints have decreased since the 2013-2014 season; the percentage of complaints with respect to the number of dredged days through the 2012-2017 season remains low (6.5%).

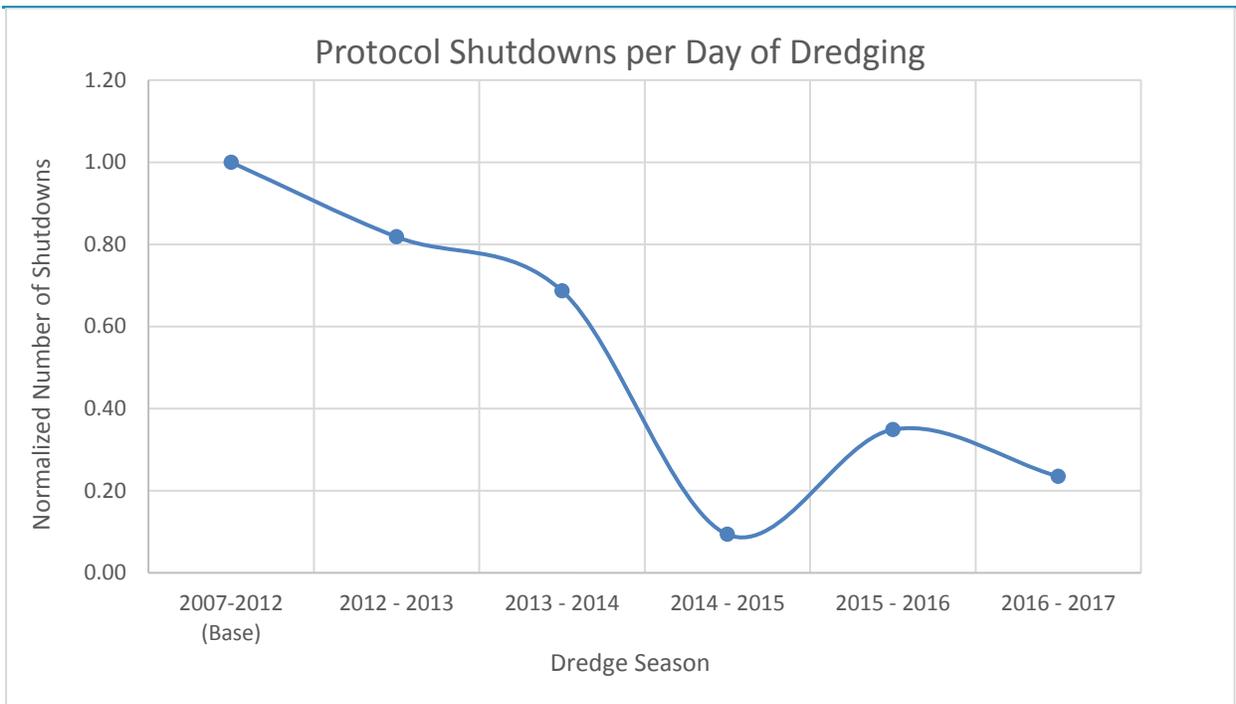


Figure 2 Number of Shutdowns per Day Compared to Base Dredge Season

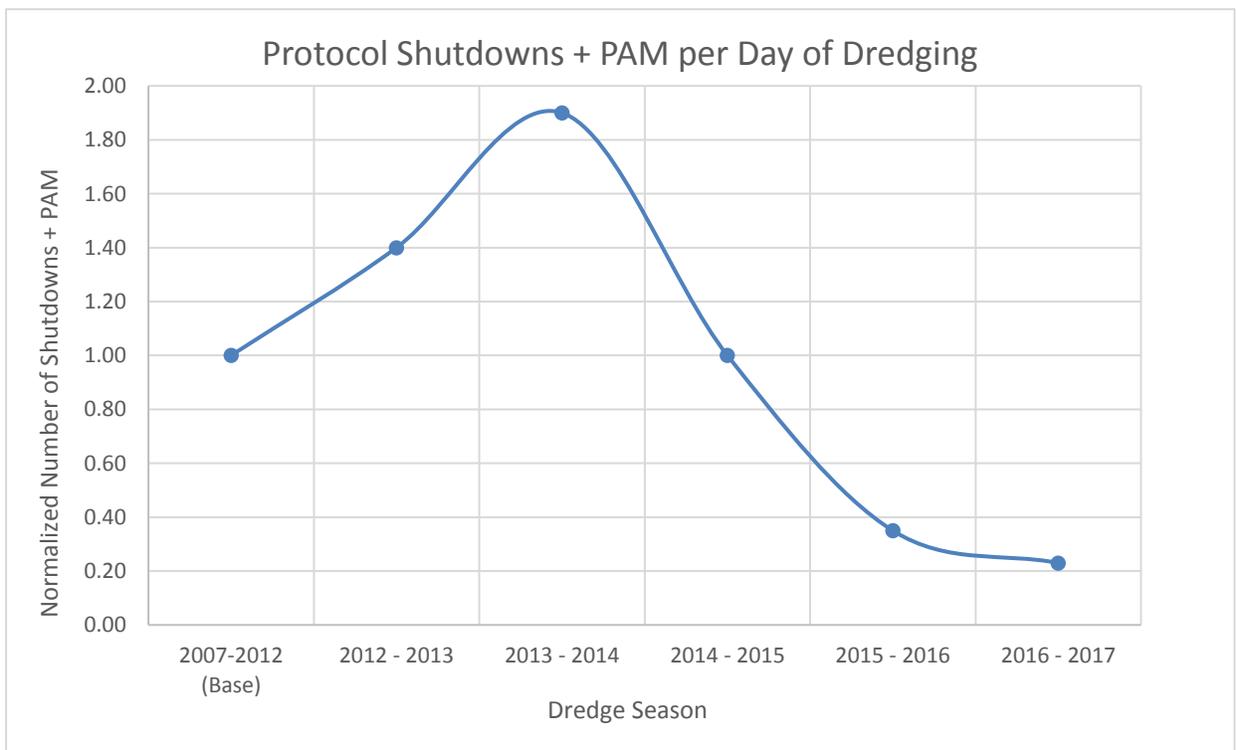


Figure 3 Number of Shutdowns +PAM per Day Compared to Base Dredge Season

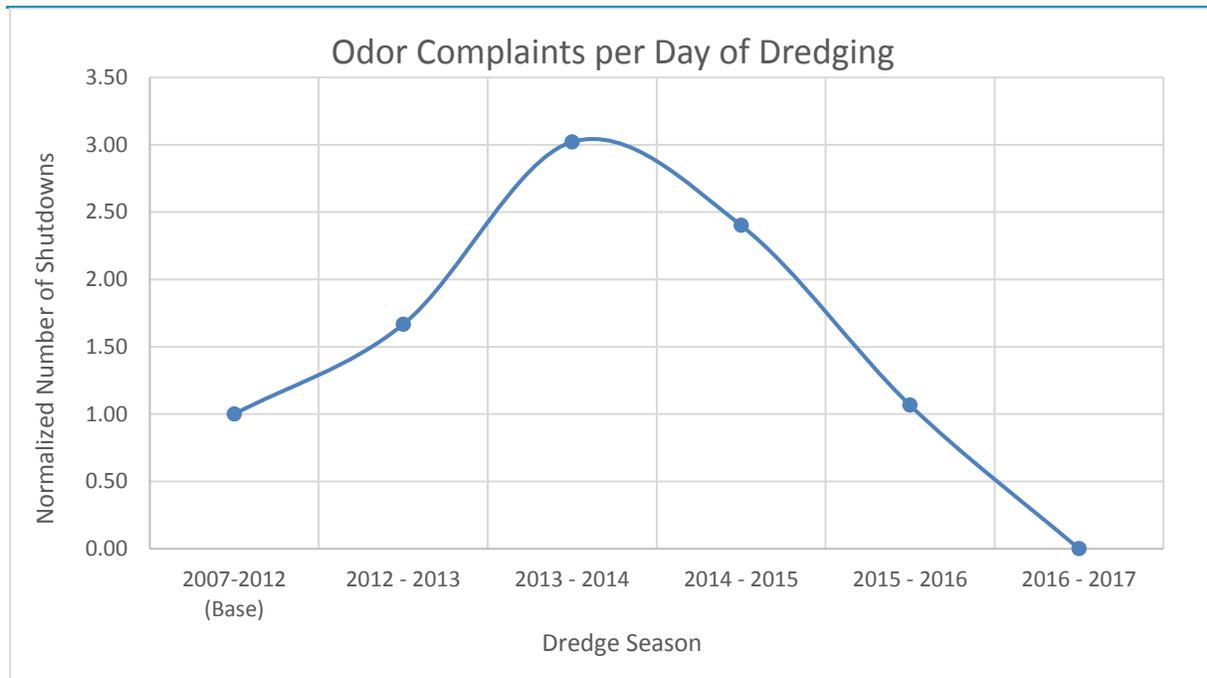


Figure 4 Number of Odor Complaints per Day Compared to Base Dredge Season

5 REFERENCES

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