The 2015 Refugio Beach Oil Spill: Fish and Invertebrate Mortality Observations

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I. Introduction

On May 19, 2015, a pipeline owned and operated by Plains All America Pipeline ruptured near Refugio State Beach. Over 100,000 gallons of crude oil spilled, much of which ran down a storm drain and into a ravine under the freeway, entering the ocean. As part of the Natural Resource Damage Assessment (NRDA) process, field teams documented species and habitats that were exposed to oil or may have been impacted by response activities.

During approximately the first month of response all live and dead birds and marine mammals were reported to the oiled wildlife hotline, where staff in the Wildlife Operations Branch responded. Other marine organism mortalities (e.g., fish, lobsters, octopus, sea hares, etc.) were documented by NRDA staff through the deployment of boxes as a repository for clean-up crews to deposit dead fish and invertebrates for the NRDA team to later document (a.k.a. dead organism surveys). Due to the collection being done by a variety of clean-up crews, there was no standardized methodology established for the 2015 dead organism surveys. NRDA staff also documented beached, dead organisms during other ephemeral data collection efforts.

An anniversary beached organism survey was conducted over three weeks in June of 2016. The intent of the anniversary sampling was to compare results of 2016 surveys to deposition of marine organisms during the period when Line 901 oil was present in 2015 to further evaluate baseline conditions. The comparison of the two surveys was qualitative due to the fact that the sampling methodology varied between years and within the 2015 sampling period. Protocols utilized in the anniversary sampling may provide a model for future response efforts.

II. Survey Methods

A. 2015 Dead Organism Surveys

Fish kills in the shoreline or nearshore environment are difficult to document and quantify because the causes of acute mortality are often ephemeral and dead organisms are subject to intense scavenging. Past coastal oil spills in California did not include reports or observations of fish and invertebrate mortality at the scale seen at during the Refugio Beach Oil Spill, so the Trustees had not developed a pre-defined protocol for documenting dead fish and invertebrates as part of an ephemeral data plan.

In the first days following the pipeline release to the ocean, a number of oiled, dead fish and invertebrates representing species from subtidal and intertidal habitats were reported washed up on heavier oiled beaches, prompting the Trustees to undertake documenting these mortalities. From May 19, 2015 to June 19, 2015, the Trustees documented and photographed oiled, dying, and/or dead fish and large invertebrates that had washed up on the beach. This documentation was performed opportunistically under three scenarios:

(1) NRDA staff recorded and photographed mortalities as they were observed during planned NRDA rocky intertidal and sandy beach ephemeral data collection efforts;

(2) The Wildlife Operations Branch noted fish and large invertebrate mortalities observed during its surveys in the Wildlife Search Effort Logs (WSELs), and

(3) NRDA staff recorded daily observations and photo-documented dead animals that were placed in boxes along beach cleanup segments by the clean-up crews. Because clean-up crews were directed by the response, collection of organisms in boxes occurred according to response cleanup priorities.

These approaches ensured some documentation of dead and dying fish and invertebrates, but since there was no standardized survey design for data collection during 2015, quantifying loss was not possible.

Documentation of small invertebrate organisms (beach hoppers, mole crabs, amphipods etc.) is difficult due to their small size and the large number of dead organisms. However, photo documentation was used to capture mortality/oiling of these small invertebrates, which play a critical role in food chain dynamics. Impacts to these small invertebrate organisms are addressed in Appendix D, Shoreline Exposure and Injury Evaluation Studies.

B. 2016 Beached Organism Surveys

The 2016 beached organism survey was pre-planned and included a structured survey design, which means that comparisons with the 2015 data are limited. Three teams of two people each (one natural resource trustee and one responsible party representative) used a modified BeachCOMBERS (Coastal Ocean Mammal and Bird Education and Research Surveys) protocol to observe and document beached marine organisms along the shoreline in three segments (Figure 1):

Segment 1: Tajiguas to Refugio
Segment 2: Refugio to El Capitan
Segment 3: Haskell's to Ellwood

Each team utilized the NRDA Daily Field Team and BeachCOMBERS datasheets. The surveys were conducted one day a week for three weeks (June 1, 8 and 13, 2016). Surveys utilized the same two-person sampling teams for each survey segment. Each survey was initiated from the western end of the survey segment and continued eastward along sandy portions of the survey segment. Survey segments were designed to avoid rocky headlands that disrupted safe movement along the survey area. The two-person team walked in parallel for the targeted segments; one walked at the low tide and the other the high tide line to cover the tidal exchange area. Additionally, the two-person team rotated their parallel walking path mid-way through the survey segment to ensure accuracy and quality of each survey.

Figure 1. 2016 anniversary survey segments: Tajiguas to Refugio in blue (2.0 miles); Refugio to El Capitan in yellow (2.9 miles); and Haskell's to Ellwood in green (2.9 miles)

III. Data Analysis

A. 2015 Survey Analysis

In order to track the dead fish and large invertebrates observed during the first month of response, all raw photographic documentation collected by NRDA staff prior to 8 September 2015 were reviewed and compiled to summarize the observed mortality. Mortalities documented in the WSEL datasheets were also tallied and all fish and invertebrate mortality observations were compiled.

B. 2016 Anniversary Survey Analyses

In 2016, counts were tallied separately for a few key species: lobster, sea hares, octopus, fish, and crabs. The remaining taxa counts were combined in an "other" invertebrate category for all the anniversary sampling dates.

California spiny lobster mortality counts required further evaluation due to the initially high number of potential molts observed during the 2016 sampling. Photographs were carefully examined to distinguish molts (exoskeletons that are shed multiple times a year by juvenile lobsters and one or two times a year by adults) from actual carcasses (Engle 2016). Additionally, lobster molts have the tendency to be in multiple parts, which further complicated the Trustees'

ability to accurately estimate of the number of dead individuals observed. A low and high estimate of dead individuals observed was developed to address this uncertainty.

C. 2015 and 2016 Survey Comparison

Due to the variability in survey methodologies, there was no statistically relevant way to compare the 2015 and 2016 sampling events. However, basic comparisons were done to provide qualitative evidence of the impacts from the 2015 oiling event to fish and invertebrates. The first comparison of the 2015 and 2016 surveys was the single day maximum observations for both sampling periods at Refugio Beach. Due to the difference in the number of species observed, a diversity analysis was also completed for the two sampling years. Invertebrates were compared at the species level. Fish were classified to the lowest taxonomic level possible, to genus level, using the photos.

IV. Results

The 2015 Trustee fish and invertebrate mortality counts and the 2016 Trustee fish and invertebrate high/low estimates are presented in Table 1. Invertebrate taxonomic groups were organized by closely related taxa that could be obviously distinguishable through photographs. For example, northern and southern kelp craps were grouped into one category of "kelp crabs" instead of two separate groups for "northern kelp craps" and "southern kelp crabs". Over 467 dead invertebrate observations were noted in 2015, excluding observations of dead beach hoppers, sand crabs, and hermit crabs that weren't quantified, but are identified by a plus symbol (+) in Table 1.

The 2016 Trustee dead invertebrate estimates were significantly lower, totaling between 36 and 38 individuals (Table 1). The variation in high and low estimates reflects uncertainties associated with photo analyses. Additionally, variation in high and low estimates were affected by carapace fragments (e.g., if a head and tail portion were the same individual or potentially multiple individuals). The condition of lobsters observed in 2015 was notably distinguishable from the 2016 sampling (Figure 2). Many of the lobsters documented in 2015 showed flesh/tissue, indicating that the specimen was a dead animal not a molt. In 2016, all lobsters documented were clearly identified as molts, with only two noted as "likely a molt" and one "unclear from photo" (Engle 2016).

Table 1. The 2015 Trustee fish and invertebrate dead counts and Trustee fish and invertebrate high/low estimates. While silversides (members of the Artherinidae) were not specifically identified in 2015 it is unclear if silversides were represented in the "unidentified fish" and therefore denoted by a # instead of a zero.

SPECIES	2015 TRUSTEE Total Counts	2016 TRUSTEE Low/High
INVERTEBRATES	**467**	**36/38**
Crabs, subtidal	20+	13
Crabs, sandy beach	50+	0
Crabs, rocky intertidal	17+	0
Unidentified crabs	4	0
Rock crabs/Cancer spp.	8	6
Shore crabs	17	0
Sand crabs	50+	0
Sheep crabs	1	4
Kelp crabs	11	2
Hermit crabs	50+	0
Anemone spp.	1	0
Bat star	3	0
Beach hopper	51+	0
Keyhole limpet	1	0
Limpet spp.	9	0
Lobster	67	1/3
Octopus/squid	10	0
Sea Star/Pisaster spp.	1	0
Purple urchin	16	1
Red urchin	3	1
Salp	2	0
Sea hare	75	8
FISH	**28**	**8**
Rockfish spp.	5	0
Perch spp.	3	0
Silversides (*Atherinidae*)	#	7
Sharks/rays/skates	6	1
Unidentified fish	14	0

Figure 2. (TOP right and left) 2015 oiled lobster carapaces with visible tissue in tail segment. (BOTTOM) 2016 lobster carapace portions required close examination by Trustees to distinguish dead individuals from molts.

The species composition of dead organisms varied between 2015 and 2016 sampling years (Table 2). Twenty-one different taxonomic groups (taxa) of invertebrates were identified in the 2015 sampling and only eight invertebrate taxa were observed in 2016. Similarly, at least 15 different genera of fish were observed in 2015 and only 2 genera in 2016. Fish initially unidentified were later identified to include species such as midshipman (*Porichthys*), brotula (*Brosmophycis*) blenny (*Hypsoblennius*), kelpfish (*Heterostichus*), sculpin, and kelp greenling (*Hexagrammos*).

Table 2. Dead organism diversity comparison between 2015 amd. 2016

Dead Organisms Observed	2015 Diversity	2016 Diversity
Invertebrate taxa	21	8
Fish Genera	15	2

The maximum observed deposition of dead fish and invertebrates at Refugio beach occurred on May 21, 2015 (116 observed) for the 2015 surveys and June 8, 2016 for the 2016 anniversary surveys (16 observed; Figure 3). Seven of the 16 observations in 2016 were fish observations and represented all but one other fish observation for the entire 2016 anniversary sampling. It should be noted that many specimens documented in 2015 had visible oiling, while in 2016 only one invertebrate was documented with a small globule of oil.

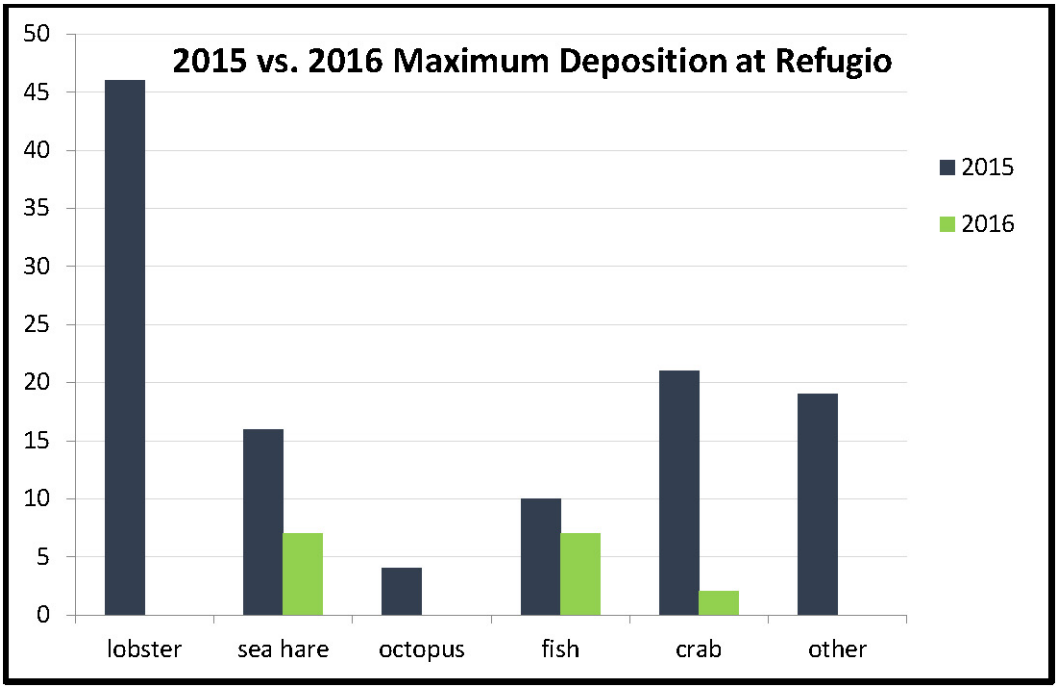

Figure 3. 2015 vs. 2016 Maximum Observed Deposition at Refugio State Beach.

Figure 4. (TOP) During 2015, fish documented in the photos "FishMortalityPhotosA-TL edits" and "FishMortalityPhotosB-TL edits" showed 8 of the 12 fish observed on 5/21/15 to be visibly oiled. (BOTTOM) None of the seven fish observed in 2016 were oiled.

V. Discussion and Conclusions

The lack of standardized methodology for the 2015 response sampling and the unique strategy employed for the 2016 anniversary sampling made it difficult to compare dead organism observations between the two years. It is rare to have the ability to implement a highly structured and statistically robust field study in response to emergency events (Paine et. al 1996). Nonetheless, these surveys provided important qualitative evidence regarding the impact of the May 19, 2015, Plains All American pipeline spill. Studies have shown that only a fraction of animals killed by an oil spill are washed ashore (Ford et al, 1996; French-McCay et al, 2003), indicating that the observed 2015 mortality counts were an underestimate. It is not uncommon for dead intact organisms to wash up on shore and in fact, southern California beach ecosystems depend on these inputs (Polis and Hurd 1996, Dugan et al 2003). What was unusual about the 2015 observations was the diversity of species, unusually high number of carcasses, and the oiled condition of carcasses observed.

The diversity of fish genera observed in the 2015 surveys was not only 7.5 times higher than 2016 surveys, but was also unique in composition. Some of these species, such as the plainfin midshipman (*Porichthys notatus*), are rarely observed alive off the southern California Coast despite monitoring of recreational catches (CERFS Mortality Report). The 2015 surveys identified at least three and likely a fourth midshipman (all included in the "FishMortalityPhotosA-TL edits" and "FishMortalityPhotosB-TL edits" files). Three of the four midshipman carcasses observed in 2015 were visibly oiled. During the late spring and early summer midshipman migrate from their offshore winter habitat to the rocky intertidal and subtidal zones where spawning and rearing of young take place. The male of this nocturnal species digs a burrow under a rock and prepares a nest. The female locates the male, attaches her eggs to the nesting rock and returns to deeper water leaving the male to guard and care for the brood (Hubbs 1920, Arora 1948). The life history of midshipman links deeper subtidal habitat and the shallow subtidal/intertidal zone thus making this species particularly vulnerable to impacts in either habitat zone.

Similarly, the ecology of the California spiny lobster makes the timing of the Plains All American spill potentially detrimental to the lobster population in the impacted subtidal area (Withy-Allen and Hovel 2013, Engel 1979). The condition of the individuals observed and how drastically they differed between the two sampling years was of greatest note. A total of 67 lobsters were observed by the Trustees during the 2015 response sampling (Table 1). None of the 2016 survey photos were specifically identified as lobster carcasses (potentially all molts). Of the 38 potential lobster carcasses observed in the 2016 surveys, all were identified as molts except two noted as "likely a molt" and one "unclear from photo". While the total number of oiled dead lobsters could not be determined through the 2015 surveys the surveys provided some understanding of oiling impacts on lobsters in 2015 following the spill.

VI. Sources Cited

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Attachment 1: Example photos of invertebrates and fish observed on May 20, 2015 and May 21, 2015 at Refugio State Beach (Photo Credit: Jenny Marek, USFWS)