Regional Operational Plan CF.2A.2015.01

Operational Plan: Assessment of Spot Shrimp, *Pandalus platyceros*, Abundance in Prince William Sound, 2015 through 2017

by

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April 2015

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN CF.2A.2015.01

ASSESSMENT OF SPOT SHRIMP, *PANDALUS PLATYCEROS*, ABUNDANCE IN PRINCE WILLIAM SOUND, 2015 THROUGH 2017

by

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Division of Commercial Fisheries

April 2015

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Signature Page

Project Title:	Assessment of Spot Shrimp, *Pandalus platyceros*, Abundance in Prince William Sound, 2015 though 2017
Project leader(s):	*Dr. Kenneth J. Goldman*
Other project participants	*Maria Wessel, Xinxian Zhang and Jan Rumble*
Division, Region and Area	Commercial Fisheries, Region II, Prince William Sound
Project Nomenclature:	
Period Covered	2015 through 2017
Field Dates:	Typical field dates are October 12-22
Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader	Dr. Kenneth J. Goldman		4/20/15
Biometrician	Xinxian Zhang		4/20/15
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PURPOSE

The goal of this project is to estimate the relative annual abundance of spot shrimp, *Pandalus platyceros*, in Prince William Sound (PWS), Alaska via a longline pot survey. The Alaska Department of Fish and Game (ADF&G) has the responsibility to sustainably manage the current commercial and noncommercial spot shrimp fisheries in PWS under 5 AAC 31.210, 5 AAC 31.214, 5 AAC 77.553 and 5 AAC55.055. Survey catch per unit effort (CPUE) of abundance and biomass (total catch weight) will be used in concert with the previous year's harvested amounts from commercial and noncommercial fisheries to estimate the harvestable surplus of spot shrimp via a surplus production model (Schaefer model). Model results provide the following year's Guideline Harvest Level (GHL) for both commercial and noncommercial spot shrimp fisheries.

Key words: Spot shrimp, *Pandalus platyceros*, Prince William Sound, abundance, pot survey

BACKGROUND

The Inside District of the PWS management area has historically supported commercial and noncommercial fisheries for spot shrimp, *Pandalus platyceros* (Figure1). Commercial fishing for spot shrimp in PWS was closed for 18 years starting in 1992 and reopened in 2010 under a regulatory measures adopted by the Alaska Board of Fisheries (BOF) in 2009 described in 5 AAC 31.210 and 5 AAC 31.214. While commercial fisheries were closed prior to the 1992 season by Emergency Order and then by regulation in 2000, noncommercial fisheries remained open (Wessel et al. 2012).

The department instituted an annual survey for spot shrimp in PWS in 1989 as part of the Exxon Valdez Oil Spill (EVOS) damage assessment process. Between 1989 and 1991, 6 stations were surveyed (Unakwik, Golden, Culross, Herring Bay, north Chenega (Junction Island) and Green Island (Figure 2). Two depth strata were fished during these 3 years; 20 to 70 fathoms and 70 to 120 fathoms. Starting in 1992, 2 more stations were added to the survey (south Chenega and Prince of Wales; Figure 2), and depths fished were standardized to a range of 20 to 80 fathoms because catch rates dropped precipitously at depths below 80 fathoms (Trowbridge 1994). In 2009, the Green Island station was eliminated due to regular gear loss from heavy currents at that survey site, and a new survey site was added at Long Bay. In 2012, another new survey site was added at Bald Head Chris (Figure 2) to provide better area coverage. Due to large noncommercial harvests in recent years in the Valdez Arm area, another station was added in 2013, so the department can obtain fishery independent data from that area (Figure 2).

Variable numbers of pots were set at each survey site during the first 3 years of the survey. Beginning in 1992, 4 strings of 11 pots each have been set at each survey site annually (Figure 2). Each string of standardized gear is made up of 11 pots spaced approximately 10 fathoms apart on a groundline with buoys at each end. Anchors were sporadically used over the course of the survey, but all strings of gear are now anchored at both ends. This ensures that the first and last pots on each string stay on bottom, and reduces gear drift and loss. An additional, experimental, string of pots has also been set on many surveys to examine catch relative to pot configuration and mesh size. Starting in 2011, we began an experiment to see if shorter soak times can be used in the survey, which would allow more stations to be set and enable area-specific estimates of spot shrimp abundance to be made. Survey timing has been consistent over

the years, with most surveys taking place in October (a few surveys in early years took place in November).

Between 1989 and 2005, the carapace length of all spot shrimp caught in each pot on every string in the survey was measured. In 2005, all female spot shrimp were measured and half the males were measured. Additionally, the Central Region biometrician in 2005 demonstrated that a minimum sample size to estimate relative abundance as stated in the objectives of this plan would be achieved for carapace length by measuring all shrimp from a single pot on each string of gear. Beginning in 2006, spot shrimp were measured from one (predetermined) randomly selected pot from each string of gear totaling 4 pots per survey site. Since 2006, individual shrimp from those selected pots were also weighed, providing a weight-length relationship that was applied to data from previous years.

Figure 1.– Alaska Department of Fish and Game, Central Region, Prince William Sound shellfish management districts.

OBJECTIVES

The objectives of this study are to

1. Estimate the annual relative abundance of spot shrimp in the Inside District of the PWS Management Area such that the estimate is within 15% of the actual annual relative abundance 95% of the time; and
2. Enumerate pot survey catches of other shrimp, invertebrate, and groundfish species.

Survey data (CPUE and total catch weight) are used in combination with harvest amounts from the commercial and noncommercial fisheries each year to model the harvestable surplus

(biomass) of spot shrimp in PWS. Model results provide the following year's Guideline Harvest Level (GHL) for both commercial and noncommercial spot shrimp fisheries.

METHODS

Data Collection

Over the years, the ADF&G research vessels, Montague, Solstice, and Pandalus have served as survey platforms. Surveys under this operational plan will be conducted on board the R/V Solstice based in Cordova, AK. There are 4 sampling stations at each survey site, which are designated as stations A, B, C, and D (Figure 2). One longlined string of 11 pots is set at each sampling station at each survey site (totaling 44 pots per survey site). The location of the 4 stations at each survey site has remained consistent since surveys began.

Spot shrimp will be captured using kite style pots that measure 16" x 16" x 36", and are covered with black colored woven plastic fabric (engineers cloth), which allows for all sizes of shrimp to be caught (i.e., minimal to no selectivity). All pots have 2 tunnels (one at each end of the pot) that are set 7" into the pot, covered by ½" stretched mesh web with a 2.5" opening into the pot. A single 2.5 qt. perforated plastic jug of chopped herring will be placed in each pot immediately prior to deployment. Gear will be staged on the back deck of the vessel and set going from shallow to deeper water. A sinking groundline will be used from the buoys to the string of gear with floating groundline between individual pots to prevent gear loss from gear snagging on the rocky bottom. Both ends of each string of gear will be anchored prior to the buoy line, ensuring that the first and last pot on each string stay on the bottom (and therefore have the same fishing ability as all other pots on the string), preventing gear drift and loss. Gear will be set in the morning and retrieved the following morning, with typical soak times averaging between 20-22 hours.

Upon retrieval of each string of gear, pots will be set on deck in the order they are retrieved and the first pot placed on the sampling/sorting table for workup to begin. All pots will be visually inspected as they come on board to see if any have been compromised (i.e., open door, predator present) and these pots will be noted on the sampling form and subsequently excluded from analysis. If the randomly selected pot chosen for individually sampling spot shrimp carapace length and weight is compromised, the next pot on the string will be used in its place. Catch will be sorted, counted and weighed by species and all data recorded on deck sampling forms. Primary species of interest are spot shrimp (*Pandalus platyceros*) and coonstripe shrimp (*P. hypsinotis*), but all shrimp and non-shrimp catch will also be documented (separated by species, enumerated and weighed). All catch will be discarded after workup except spot shrimp from the single randomly selected pot on each string, which will be bagged, labeled and kept for individual carapace length measurements and weights, which will be recorded at the end of each day.

Shrimp kept from the randomly sampled pots will be sorted by sex: male, female or transitional. Spot shrimp are protandric hermaphrodites; they are born as males, mature, and then transition into females. The sexual stage of each spot shrimp will be determined by examining the inner part of the endopod of the second pleopod, which has 2 appendages, the appendix masculina and the appendix interna, which vary in size depending on the sexual stage (Figure 3). Carapace length (from the front of the carapace directly behind the eyes to the terminal end of the

carapace) of all spot shrimp will be measured to the nearest 0.1 mm using Fowler electronic calipers. Individual weights will be taken to the nearest gram using a motion compensating digital scale, model Pols P15. If eggs are present in female shrimp, they will be examined and the number of dead eggs recorded.

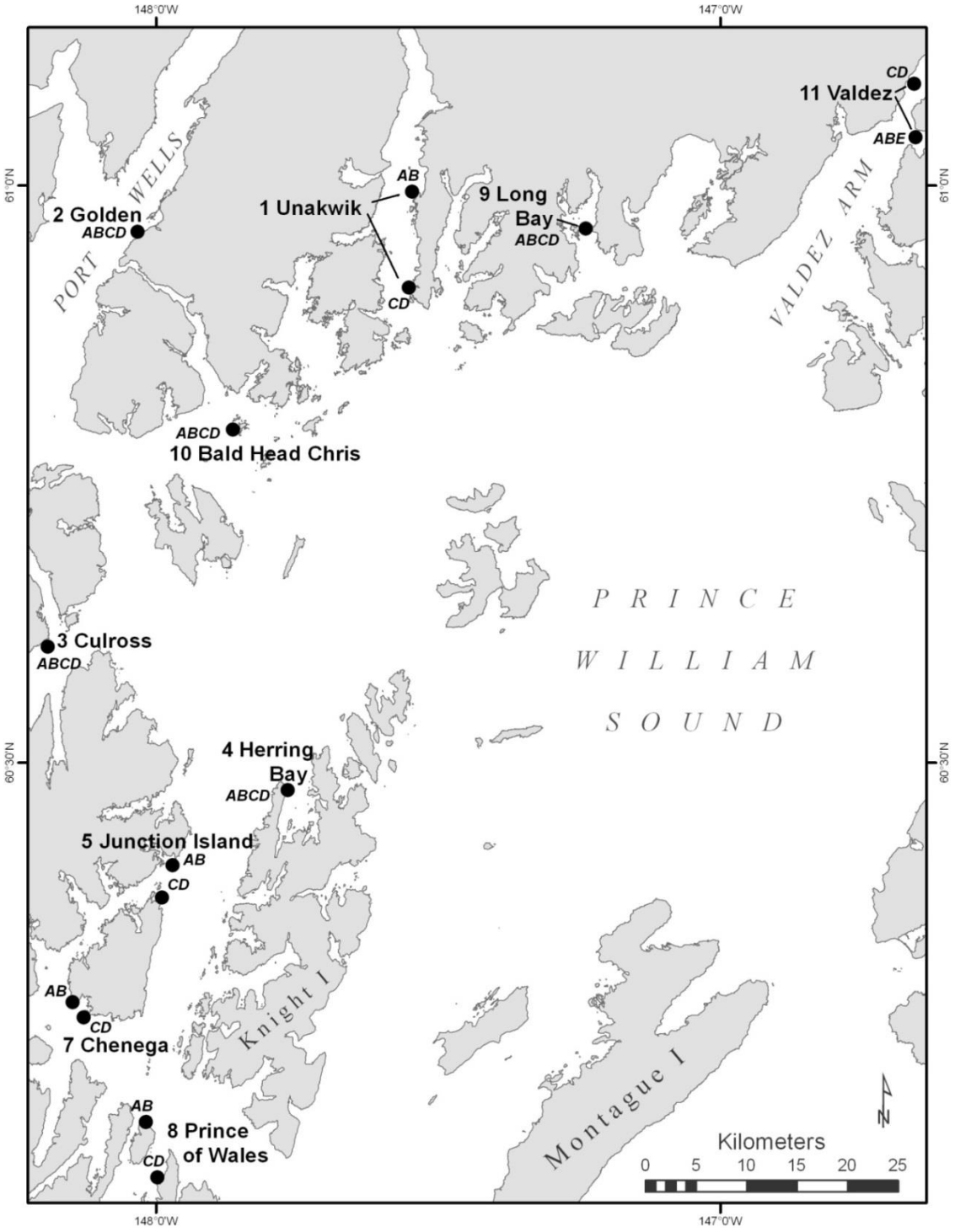

Figure 2.– Spot shrimp survey sites in Prince William Sound management area. Bald Head Chris (survey site 10), was added in 2012 and Valdez (survey site 11) was added in 2013.

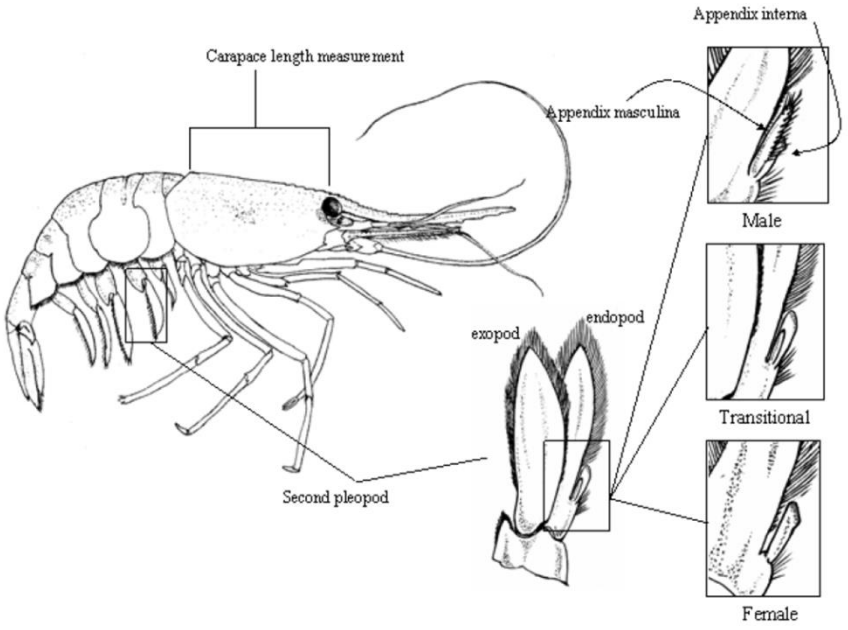

Figure 3.–. Sex determination in spot shrimp (from Lowry 2007).

Survey Data Analysis and Summary

Count and weight data on all species for each of the 4 strings at a single site are collected. Individual spot shrimp length and weight data from the randomly sampled pots are pooled within a site and the number and weight of spot shrimp with a carapace length of 32 mm or greater is divided by the number and weight of all spot shrimp in order to produce percentages of spot shrimp with a carapace length of 32 mm or greater by count and weight for each site. The total weight of spot shrimp caught (c) in the survey is calculated as:

$$c = \sum_{i=1}^{n} c_i \qquad (1)$$

where c_i is the weight of spot shrimp caught in pot i, and n is the number of pots successfully fished at each survey location (combination of all pots on all strings).

The total weight and count of spot shrimp of all sizes and those greater than or equal to 32 mm carapace length are then divided by the total number of pots hauled at a site (not including lost or compromised pots) in order to produce the CPUE for all spot shrimp and for those with a carapace length of 32 mm or greater for each site sampled during the survey. The average weight of spot shrimp caught per pot (CPUE) in the survey ($\overline{c}$) is calculated as:

$$\overline{c} = \frac{c}{n} \qquad (2)$$

Modeling Population Dynamics

The population dynamics, index of relative abundance and maximum sustainable yield (MSY) of spot shrimp in PWS is modeled using the Schaefer surplus production model (Haddon 2011). The equation is written as follows

$$B_{t+1} = B_t + rB_t\left(1-\frac{B_t}{K}\right) - C_t \quad (3)$$

where r is an intrinsic rate of population growth, K is a parameter that corresponds to the unfished equilibrium population size, B_{t+1} is the exploitable biomass at the end of year t or the beginning of year t+1, B_t is the exploitable biomass at the start of year t, and C_t is the biomass caught during year t.

Also, an index of relative abundance is generated from the equation

$$\hat{I}_t = q\frac{\hat{B}_{t+1}+\hat{B}_t}{2} \quad (4)$$

where $\hat{I}_t$ is an estimated index of relative abundance for year t and q is the catchability coefficient, proportion of the total stock taken by one unit of effort ($I = qB$). Because the stock biomass changes within the year (t) due to the stock growth and death (including catches) in that year, Equation 4 uses the average biomass at the start (B_t) and end of year t (B_{t+1}) so that the catches or catchability coefficient, q, relates to the biomass more realistically. The input data to the model are catches (C_t) and CPUE (observed I_t) from 1981 to present. The CPUE data are from 2 sources: one is the commercial fisheries (1981 to 1988); the other is the survey (1989 to present). The CPUE from commercial fisheries is adjusted to the level of the survey CPUE using the ratio of the average of CPUE from 1989 and 1990 to the average of CPUE from 1987 and 1988. The catch data are the total catch weight, which is summation of catches from the survey, the commercial and non-commercial fisheries.

The parameters r, K, initial biomass B_0, and q are estimated by minimizing the sum of squares error $\sum(I_t - \hat{I}_t)^2$. The maximum sustainable yield (MSY) is obtained from the equation

$$MSY = \frac{rK}{4}. \quad (5)$$

To determine the uncertainty in the estimate of MSY, a bootstrap analysis is conducted by resampling the residuals between estimated CPUE ($\hat{I}_t$) and observed CPUE (I_t). Ninety percent confidence intervals are constructed using at least 1,000 bootstrapping samples. The lower confidence interval (CI) bound is used instead of MSY as the harvestable surplus biomass in order to deal with the uncertainty of MSY and set more conservative, sustainable harvest levels.

Setting Guideline Harvest Levels

In 2009, the Alaska BOF reopened commercial fishing for spot shrimp in PWS under new regulatory measures described in 5 AAC 31.210 and 5 AAC 31.214. Under 5 AAC 31.214, a

commercial fishery can open only if ADF&G's estimate of harvestable surplus of spot shrimp (i.e., the lower 90% CI from the Schaefer model described above) is greater than 110,000 lbs.; under which conditions 40% of that amount is allocated to the commercial fishery with the other 60% allocated to the non-commercial fisheries. If the harvestable surplus amount is not greater than 110,000 lbs. there is no allocation to commercial fishing (i.e., commercial fishing is closed) and 60% of the harvestable surplus would still be allocated to the non-commercial fisheries.

SCHEDULE AND DELIVERABLES

The schedule of project activities is as follows:

Table 1.– Annual schedule for spot shrimp assessment project.

Date(s)	Activity
September into October	Prepare pot sampling gear.
Mid- to late-October	Spot shrimp pot survey.
November through January	Data analysis.
February	Obtain non-commercial fishery harvest data. Update surplus production model.
Early April	Obtain number of ADF&G registrants for commercial spot shrimp fishery. Set commercial fishery harvest and pot limits.

All research results will be compiled in an ADF&G Fisheries Data Series Report in 2016 with follow-up reports on a triennial basis.

RESPONSIBILITIES

Division of Commercial Fisheries Personnel:

Dr. Kenneth J. Goldman, Fishery Biologist III: Project planning, oversight and reporting. Assist with field work, lab work, data collection and analysis.

Maria Wessel, Fishery Biologist II: Assist with project planning and gear preparation, maintenance, repair and replacement. Lead biologist on survey.

Josh Mumm, GIS Analyst II: Generate survey maps. Assist with field work, lab work, data collection and produce annual survey data summary.

Karen Swartzbart, Fish and Wildlife Technician III: Gear preparation, maintenance, repair and replacement. Assist with field work, lab work and data collection.

Xinxian Zhang, Biometrician III: Run surplus production model from which annual commercial and non-commercial harvest limits are set.

Martin Schuster, Fishery Biologist I: Assist with field work, lab work and data collection.

Janet Rumble, Fishery Biologist III: Assist with field work, lab work, data collection and analysis, and provide commercial harvest results for surplus production model.

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