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Migratory Timing and Abundance Estimates for Sockeye Salmon in Upper Cook Inlet, Alaska, 2016

by

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and

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

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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

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ABSTRACT

In 2016, the southern offshore test fishery (OTF) conducted from July 1 through July 29 captured 2,155 sockeye salmon *Oncorhynchus nerka*, which represented 1,792 catch per unit of effort (CPUE) index points. The midpoint of the 2016 sockeye salmon run at the southern OTF occurred on July 18. A formal inseason estimate of the 2016 run size was made on July 25 and this analysis predicted a total run to Upper Cook Inlet (UCI) of 6.83 million sockeye salmon. The best-fit total run estimate deviated from the estimated total run of 5.11 million fish by 33.7%. An inseason estimate was also made for the Kenai River sockeye salmon run on July 25 and this analysis predicted a total run to the Kenai River range of 3.53–5.57 million fish. Sockeye salmon and coho salmon *O. kisutch* genetic samples were collected and archived for future analysis.

Key words: Pacific salmon *Oncorhynchus* spp., test fishery, migratory behavior, mixed stock analysis, MSA, Upper Cook Inlet, Alaska

INTRODUCTION

In 1979, the Alaska Department of Fish and Game (ADF&G) began an offshore test fishery (OTF) project (hereafter referred to as the southern OTF) near the southern boundary of the Upper Cook Inlet (UCI) salmon management area between Anchor Point and the Red River Delta (Figure 1). The project was designed to estimate the total sockeye salmon *Oncorhynchus nerka* run (including run timing) returning to UCI during the commercial salmon fishing season. These data are used to help adjust commercial fishing times and areas to most efficiently harvest surplus sockeye salmon or restrict fisheries that may overharvest specific stocks. In recent years, the Alaska Board of Fisheries (BOF) has assembled management plans requiring inseason abundance estimates of the annual sockeye salmon run to implement specific plan provisions. The southern OTF project has increasingly become one of the most important tools Upper Cook Inlet fishery managers utilize to make inseason fishery management decisions that comply with BOF management directives. Test fishery results have been reported annually since 1979 (e.g., Dupuis et al. 2016).

In 2012, a second test fishery project (hereafter referred to as the northern OTF) was added. This project collected tissue samples from sockeye salmon for genetic stock identification in order to assess the spatial and temporal separation of Susitna River sockeye salmon as they migrate through Cook Inlet. From 2012 to 2013, the northern OTF vessel fished 7 stations along a single transect; in 2014, the vessel fished 8 stations along 2 transects running from Kalifornsky Beach to the northern tip of Kalgin Island (Stations 2–5) and from the southern tip of Kalgin Island to Clam Gulch Beach (Stations 8–11; Figure 2). The modification to the northern OTF was made because it was believed that, due to the lack of fish encountered at the omitted stations (Dupuis et al. 2015), ADF&G could more efficiently gather spatial and temporal information by adding the second transect. The northern OTF project was discontinued prior to the 2015 season due to a lack of funding. This report presents the results of the 2016 southern offshore test fishing project and historic genetic stock identification information collected from both the northern and southern test fisheries.

OBJECTIVES

The objectives of the southern OTF project were as follows:

1. Develop an inseason estimate of the 2016 UCI sockeye salmon total run;
2. Develop an inseason estimate for the 2016 Kenai River sockeye salmon total run; and

3. Estimate the spatial and temporal distribution of various sockeye salmon and coho salmon *O. kisutch* stocks entering UCI.

METHODS

TEST FISHERY

The southern OTF sampled salmon returning to UCI by fishing 6 geographically fixed stations, which were numbered consecutively from east to west (Figure 1). The current southern OTF stations have been fished since 1992 (Tarbox 1994) and provide the most reliable estimates of inseason run size and timing. Station 6.5 was not fished prior to 1992; analyses concluded that the addition of Station 6.5 increased sampling power, but did not alter estimates of run timing (Tarbox and King 1992). The ADF&G vessel R/V *Solstice* sampled all 6 stations of the southern OTF transect daily, traveling east to west on odd-numbered days, and west to east on even-numbered days. Sampling began on July 1 and the project concluded on July 29. Catch and catch per unit effort (CPUE) data for missed stations were interpolated using a maximum likelihood method (Millar 2011) or a simple average of catches from the day before and the day after for each station not fished.

The following physical and chemical measurements were taken at the start of each gillnet set at each station: air temperature, water temperature and salinity (at 1 m below the surface), wind velocity and direction, tide stage, water depth, and water clarity. Air and water temperatures (°C) and salinity (ppt) were measured using an YSI[1] Model Pro30 conductivity/salinity/temperature meter (YSI Inc.; Yellow Springs, OH). Wind speed was measured in knots and direction was recorded as 0 (no wind), 1 (north), 2 (northeast), 3 (east), 4 (southeast), 5 (south), 6 (southwest), 7 (west), or 8 (northwest) using a pocket weather tracker. Tide stage was classified as 1 (high slack), 2 (low slack), 3 (flooding), or 4 (ebbing) by observing the movement of the vessel while drifting with the gill net. Water depth was measured in fathoms (fm) using an echo sounder and water clarity was measured in meters (m) using a 17.5 cm secchi disk, following methods described by Koenings et al. (1987).

A conductivity temperature depth profiler (CTD) was also deployed at each station each day along the southern OTF transect. The CTD measured temperature (°C), salinity (psu; psu is defined as practical salinity unit and is equivalent to ppt), chlorophyll *a* (mg/m^{-3}), oxygen (percent saturation) and photosynthetically active radiation (PAR, percent surface maximum) throughout the water column. The CTD was lowered to within about 3 m of the bottom and retrieved at 1 m/sec. In this report, a cross-section of monthly mean parameter distributions along the southern OTF transect is presented.

The southern OTF vessel fished 366 m (1,200 ft or 200 fathoms) of multi-filament drift gillnet with a mesh size of 13 cm (5 1/8 inches). The net was 45 meshes deep and constructed of double knot Super Crystal shade number 1, with filament size 53/S6F. At each station, all salmon captured in the drift gillnet were identified by species and enumerated. Sockeye salmon captured at the southern OTF ($n \leq 30$ at each station) were measured for length (mideye to fork of tail) to the nearest mm.

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[1] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

For each species of salmon, the number of fish captured at each station (*s*) on each fishing day (*i*) was expressed as a CPUE statistic, or index point, and standardized to the number of fish caught in 100 fathoms of gear in 1 hour of fishing time:

$$CPUE_{s,i} = \frac{100\,fm \;\times\; 60\min \;\times\; number\ of\ fish}{fm\ of\ gear \;\times\; MFT} \;. \tag{1}$$

Mean fishing time (*MFT*) was:

$$MFT = (C - B) + \frac{(\mathrm{B} - \mathrm{A}) + (\mathrm{D} - \mathrm{C})}{2} \;, \tag{2}$$

A is the time that net deployment started, *B* is the time that the net fully deployed, *C* is the time net retrieval started, and *D* is the time the net was fully retrieved.

Once deployed at a station, the drift gillnets fished 30 minutes before retrieval. However, the net was capable of capturing fish prior to being fully deployed and during the time it was being retrieved. *MFT* was therefore adjusted by summing the total time it took to set and retrieve the net, then dividing this time in half, and adding it to the time when the entire net was deployed and fished (Equation 2).

Daily $CPUE_i$ data were summed for all *m* stations (typically 6) as follows:

$$CPUE_i = \sum_{s=1}^{m} CPUE_{s,i} \;. \tag{3}$$

Cumulative $CPUE_i$ ($CCPUE_d$) was given by:

$$CCPUE_d = \sum_{i=1}^{d} CPUE_i \;, \tag{4}$$

where *d* is the date of the estimate.

GENETIC STOCK IDENTIFICATION SAMPLING

Tissue Sampling

Sockeye salmon captured at each station on the southern OTF ($n \leq 50$) had the left axillary process removed for genetic analysis (Habicht et al. 2007). Additionally, in 2016, all coho salmon captured had the left axillary process removed for future genetic analysis. Once removed, the axillary process from individual fish were then placed on a sample card for later analysis. For data continuity, sockeye salmon tissue samples from the southern OTF were paired with corresponding length information. These data were collated and archived by division staff at ADF&G office in Soldotna.

DESCRIBING THE SALMON MIGRATION AND PROJECTING TOTAL RUN

For the southern OTF, the sockeye salmon run was described for each of the previous years based on the respective test fishery data, as described in Mundy (1979):

$$Y_{yr,d} = 1 \big/ \left(1 + e^{-(\mathrm{a} + \mathrm{bd})}\right) \;, \tag{5}$$

where $Y_{yr,d}$ is the modeled cumulative proportion of $CCPUE_{yr,f}$ (f = final day of season) for year (yr) as of day (d), and a and b are model parameters.

Variables without the subscript yr refer to the current year's estimate. To determine which of the previous run timing curves most closely fit the current year's data on day (d), and to estimate total run for the entire season (TR_f), a projection of the current year's $CCPUE_d$ at the end of the season ($CCPUEF$) was estimated as per Mundy (1979):

$$CCPUEF = \frac{\sum_{d=0}^{D} CCPUE_d{}^2}{\sum_{d=0}^{D} Y_{yr,d} \cdot CCPUE_d}. \tag{6}$$

This model assumes that the modeled cumulative proportions ($Y_{yr,d}$) for previous year (yr) are the same as for the current year (Mundy 1979). To test this assumption, inseason Y_d was estimated as:

$$Y_d = \frac{CCPUE_d}{CCPUEF}, \tag{7}$$

and the mean squared error (MSE) between Y_d and $Y_{yr,d}$ was estimated as:

$$MSE = \frac{\sum_{d=0}^{D} \left(Y_{yr,d} - Y_d\right)^2}{D+1}. \tag{8}$$

Years were ranked from lowest MSE (best model) to highest (worst), and the best fit years were used to estimate $CCPUEF$ for the current year. Catchability, or the fraction of the available population taken by a defined unit of fishing effort, was estimated as:

$$q_d = \frac{CCPUE_d}{r_d}, \tag{9}$$

where q_d is the estimated cumulative catchability as of day (d), and r_d is the cumulative total run as of day (d).

The cumulative total run on day (d) was the sum of all estimates for commercial, recreational, and personal use harvests to date, total escapement to date, and the number of residual (i.e., residing) sockeye salmon in the district. The commercial harvest was estimated inseason from mandatory catch reports called or faxed into the ADF&G office. Personal use and recreational harvests were estimated inseason by examining catch statistics from previous years' fisheries on similar sized runs. Total passage to date included estimated passage into all monitored systems (Susitna, Kenai, and Kasilof rivers, and Fish Creek) and unmonitored systems, which are assumed to be 15% of the passage into monitored systems (Tobias and Willette 2003). The number of residual fish in the district was estimated by assuming exploitation rates of 70% in setnet fisheries, 35–40% in districtwide driftnet fisheries (based on the number of boats that fished), and 25% in reduced district driftnet fisheries (Mundy et al. 1993). For example, if the drift gillnet fleet harvested 500,000 sockeye salmon during an inletwide fishing period, then the number of sockeye salmon originally in the district would be 1,250,000 (500,000/0.40 =

1,250,000) and the number remaining, or the residual, is 750,000 (1,250,000–500,000 = 750,000).

The passage rate (PR_d), as of day (d) is the expansion factor used to convert CPUE into estimated numbers of salmon passing the test fishery transect line into UCI:

$$PR_d = 1/q_d \ . \tag{10}$$

The total run at the end of the season (TR_f) was:

$$TR_f = PR_d \cdot CCPUEF. \tag{11}$$

The midpoint of the run (M), defined as the day that approximately 50% of the total run has passed the southern OTF transect from day 1 (June 24), was:

$$M = -a/b, \tag{12}$$

where a and b are model parameters.

The last day of test fishing typically occurs on July 30 each year, which means the "tail-end" of the sockeye salmon run was not assessed by the project. In 2016, the southern OTF project ended on July 29, but escapement monitoring continued through August 14 in the Kasilof River, August 19 in the Kenai River, August 14 at Fish Creek, and into late August at Judd, Chelatna, and Larson lakes. Commercial fishing also continued into September.

Because the test fishery does not encompass the entire sockeye salmon run, the total *CCPUEF* for the test fishery was estimated postseason using 2 methods (Equations 13 and 14):

$$CCPUE_f^h = CCPUEF \cdot \frac{H_t}{H_L} \ , \tag{13}$$

where $CCPUE_f^h$ is the total estimated *CCPUEF* for the season, based on harvest, H_t is the total commercial harvest for the season, H_L is total commercial harvest through final day of test fishery (f+2), and L is the number of days (lag time) it took salmon to travel from the test fishery to commercial harvest areas (2 days, Mundy et al. 1993).

$$CCPUE_t^r = CCPUEF \cdot \frac{E_t + H_t}{E_L + H_L}, \tag{14}$$

where $CCPUE_t^r$ is the total estimated *CCPUEF* for the season, based on the total run. E_t is the total escapement for the season. H_t is the total commercial harvest for the season. E_L is the total UCI escapement through the final day of the test fishery, summed from 6 different streams. H_L is the total UCI commercial harvest through the final day of the test fishery, and L is the number of days (lag time) it took salmon to travel from the test fishery to spawning streams or commercial harvest areas.

The total run adjustment to *CCPUEF* (Equation 14) has replaced adjustments based on harvest alone (Equation 13), primarily due to changes to commercial fishing management plans made by the Alaska Board of Fisheries. Management plans now provide less fishing time in August than in the past; therefore, adjustments based on harvest alone would not have accurately reflected the additional fish that entered the district after the test fishery ceased. The total run to date on the last day of the test fishery was the sum of all commercial harvest data and escapement.

Escapement estimates were derived by summing passage from 2 sockeye salmon sonar enumeration sites (Kenai and Kasilof rivers) and adding to that an expansion of the cumulative weir counts at Chelatna, Judd, and Larson lakes to reflect the total Susitna River sockeye salmon escapement, plus the weir count at Fish Creek, and an estimate of escapement to all unmonitored systems through day (*d*). Total Susitna River sockeye escapement (E_S) was estimated by expanding the sum of weir counts at Chelatna lake weir (E_C) by a factor of 3.8 and the Larson lake weir count (E_L) by a factor of 1.9, e.g.:

$$E_S = (E_C \cdot 3.8) + (E_L \ 1.9). \quad (15)$$

The expansion factor for Chelatna Lake was estimated from mark–recapture studies conducted in 2008–2015 (Yanusz et al. 2007, 2011a, 2011b; Willette et al. 2016) and the expansion factor for Larson Lake was estimated from mark–recapture studies conducted in 2006–2008 (Yanusz et al. 2007, 2011a, 2011b).

An estimate of escapement to all non-monitored systems in UCI was considered to be 15% of the monitored runs (Tobias and Willette 2003). Lag times are the approximate time for fish to migrate from the test fishery transect to a particular destination. As suggested by Mundy et al. (1993), lag times must be considered when estimating the total run passing the test fishery transect on day (*d*). A lag time of up to 2 days was assumed for fish harvested in the commercial fishery. We estimated lag times between the test fishery and escapement projects as follows: Kasilof and Kenai rivers, 4 days; Fish Creek, 7 days (Mundy et al. 1993); and Susitna River weirs, 14 days. The number of sockeye salmon harvested in sport and personal use fisheries after test fishing has ceased that have not been estimated in the escapement are assumed to be insignificant, and therefore are not utilized in the *CCPUEF* post-test-fishery adjustment.

Adjusted estimates of *CCPUEF* ($CCPUE_t^h$ and $CCPUE_t^r$) were used for postseason estimates of TR_f.

PROJECTING THE KENAI RIVER TOTAL RUN

In addition to making inseason estimates of the total size of the annual sockeye salmon run, UCI commercial fishery management plans require ADF&G to make an inseason estimate of the number of Kenai River sockeye salmon in the run. Various management actions in both sport and commercial fisheries are tied to the total abundance of Kenai River sockeye salmon, which is characterized by 3 different size ranges: less than 2.3 million fish, between 2.3 and 4.6 million fish, and greater than 4.6 million fish (Shields and Dupuis 2012). As previously described, the *CCPUED* curves from the top 5 best fits of previous year's test fishery data were used to project the *CCPUEF* in 2016, which was then used to estimate the UCI total run. The Kenai River component of the run was determined, in part, from a weighted age-composition allocation method to estimate the stock composition of the commercial harvest (Tobias and Tarbox 1999). This method (Bernard 1983) allocates the commercial harvest to various stocks by comparing the age composition of the escapement in the major river systems of UCI to the age composition of sockeye salmon harvested commercially (Tobias and Willette 2004). Three important assumptions of the weighted age-composition method are that: 1) the age compositions of fish escaping into the various river systems are representative of the age composition in the commercial harvest; 2) the commercial harvest in specific areas is composed of nearby stocks; and 3) exploitation rates are equal among stocks within age classes. The Kenai River run to date (TRK_d) was estimated by summing: 1) the commercial harvest of Kenai River stocks; 2) the estimated (using dual-frequency identification sonar (DIDSON)) passage of sockeye salmon in the Kenai River; and 3) an estimate of sport and personal use harvest below the river mile 19 sonar site. Finally, the remainder of the run that will be Kenai River origin was projected by subtracting the run to date from the total run estimate, and then applying an estimate of the proportion of the run remaining that will be Kenai River (PK_d) by reviewing previous years' data for runs of similar timing. The total Kenai River run (TRK_f) was estimated from:

$$TRK_f = ((TR_f - r_d) \cdot PK_d) + TRK_d. \tag{16}$$

RESULTS AND DISCUSSION

TEST FISHERY

In 2016, the southern OTF boat fished 154 of the possible 180 gillnet sets (e.g., 6 possible sets per day for 30 days; Table 1). A total of 2,155 sockeye salmon were captured during the 2016 test fishery, as well as 312 pink salmon *O. gorbuscha*, 356 chum salmon *O. keta*, 440 coho salmon, and 2 Chinook salmon *O. tshawytscha* (Tables 1–3; Appendices A1–A13). Sockeye salmon daily catches ranged from 7 fish on July 11 to 259 fish on July 20. The sockeye salmon *CCPUEF* for the 2016 project was 1,792, and daily CPUE values ranged from 5 to 177 (Tables 1 and 3). Linear regression of historic data showed that the 1992–2016 annual test fishery unadjusted *CCPUEF* and the total annual run of sockeye salmon to UCI (Figure 3) were significantly (α = 0.05) correlated (P = 0.02 and r^2 = 0.21), and 79% of the variation was unexplained. Because so much of the variation remains unexplained, the southern OTF *CCPUEF* by itself may not be a reliable predictor of the total annual sockeye salmon run.

INSEASON ABUNDANCE ESTIMATES

Tarbox and Waltemyer (1989) provided detail about the assumptions used in the curve fitting procedures to estimate the *CCPUEF* statistic during the season. One of the major assumptions was that 24 June represents the first day of the sockeye salmon run to UCI. Variability in estimated runs can therefore result in an average or early run being misclassified as late, especially during the first 2 weeks of the test fishery program. For this reason, 20 July was chosen as the earliest date that inseason formal estimates of each year's total run size and run timing should be made. By then, there are enough data points in the current year's run timing curve to provide a more accurate estimate of the *CCPUEF*. In addition, Tarbox and King (1992) and later *Migratory timing and abundance estimates of sockeye salmon into Upper Cook Inlet, Alaska* annual project reports demonstrated that the initial first choice (best fit) estimate of the *CCPUEF* statistic and total run made around mid-July was often not the best-fit estimate later in July. Therefore, when making formal inseason estimates of the total run, the top 5 or 6 best fits are evaluated. Careful consideration was given to years whose fits reveal the least day to day change in the predicted *CCPUEF*. These years are identified as potentially being the final best fit at the end of the season, especially if the *MSE* statistic (Equation 8), also referred to as the mean sum of squares, was also improving. Salmon run timing information from other areas of Alaska are also considered to help predict UCI run timing (Willette et al. 2010).

The formal abundance estimate of the 2016 UCI sockeye salmon run occurred on July 25, using commercial, sport, and personal use harvests, escapement, and test fishery data through July 25 (Table 4). The 2016 test fishery *CCPUED* curve was mathematically compared to run curves from 1979 through 2015 (no estimate was made for 2013), and the estimates were ranked from best to worst based on *MSE*. The passage rate was estimated to be 2,417 based on a run of 2.45 million fish through July 25 (includes residual fish abundance in the district). The 2016 test fishery *CCPUED* curve most closely tracked the 2005 run, estimating a *CCPUEF* of 2,825 index points. Given a passage rate of 2,417, the total run estimate was 6.83 million fish. As cautioned earlier, the first best fit (lowest *MSE*) on approximately 20 July often turns out not to be the best fit by the end of July, therefore the top 5 fits were considered, which included run timing curves from 2006, 1994, 1997, and 1998 (in order of best fit). Using these data, total run estimates ranged from 5.33 million to 8.35 million sockeye salmon. The best fits included runs that were between 1 and 9 days late.

The total sockeye salmon run to UCI in 2016 was estimated at approximately 5.11 million fish, including commercial, sport, and personal use harvests, as well as escapement to all systems (Table 5). Therefore, the first best-fit total run estimate from the formal inseason projection of the 2016 run was approximately 33.7% higher than the actual run size. However, because the top 5 best fits from each analysis were given careful consideration inseason, the ranges in error from these projections are highlighted in this report. Based on data through July 25, the difference between the projected total run to UCI and the actual value ranged between 2.9% and 63.4%.

Using the July 25 total UCI run estimate, the total Kenai River sockeye salmon run was projected to range between 3.53 million and 5.57 million fish (Table 6). Assuming 2.55 million Kenai River sockeye salmon had returned to date, that meant between 980,000 and 4.57 million fish remained in the run. The preseason forecast for the Kenai River had projected a total run of 4.7 million fish, which required commercial fisheries management to follow guidelines for a run greater than 4.6 million sockeye salmon. Three of the 5 best-fit estimates from the July 25 assessment projected a Kenai River run between 2.3 million and 4.6 million fish; the remaining estimates projected a run at or above 4.6 million fish. The July 25 assessment indicated to ADF&G that the appropriate commercial fishery management approach would be to continue to follow the guidelines for a run to the Kenai River greater than 4.6 million fish. Using postseason data, the 2016 sockeye salmon run to the Kenai River was estimated to be approximately 3.55 million fish.

OTF ERROR

OTF run forecast errors are largely a function of errors in estimating *CCPUEF*, which result from the algorithm that fits the current year's cumulative *CPUE* to run timing curves from earlier years. Early in the season, the curve fitting algorithm tends to estimate that the current year's run timing best-fits curves from prior years with later run timings resulting in overestimates of *CCPUEF*. Thus, forecast errors for total run, *CCPUEF*, and run timing tend to be positive early in the season and decrease significantly as the season progresses (Figure 4). After approximately July 23, run forecast errors tend to stabilize within plus or minus 20%. Mean absolute percent errors (MAPE) average 40% from July 19–23, 9% from July 24–26 and 7% from July 27–31 (1996–2014). Prior to July 24, the model tends to over-forecast small runs and more accurately forecast large runs, whereas forecast errors from July 24–26 are weakly positively related to run size, and forecast errors from July 27–31 are not related to run size (Figure 5). Prior to July 24, forecast MAPE was also a function of actual run timing (Table 5; Figure 6). MAPE was 34% for early runs and 15% for on-time or late runs. Forecast errors are also a function of actual run size.

In 2016, the first best-fit estimate on July 25 was not the most accurate and overestimated the final UCI total sockeye salmon run by 33.7%. The model selected the 2005 sockeye salmon run as the best fit. The 2005 run was late and above average in run size; by late July, there was confidence among ADF&G management staff that 2016 would be late by an unknown amount and would probably not be as large as forecasted. The 1998 run (fifth best fit) was the better fit because it was very close to the 2016 run with respect to run timing and total run size. Therefore, management staff should always consider the top 5 best-fit estimators as possible predictors of run timing and run strength.

RUN TIMING

Although differences between annual inseason and postseason (adjusted by either harvest or total run) *CCPUEF* statistics were often relatively minor, they affected calculations of the *a* and *b* coefficients in the equations used to describe historical run timing curves (Equation 5), which in turn had an effect on estimates of subsequent *CCPUEF* values (Table 7). Beginning in 2002, the total run method was used to make postseason adjustments to all previous years' *CCPUEF* statistics (Shields 2003).

In 2016, the test fishery *CCPUEF* of 1,792 was adjusted to 2,138 based on the number of fish that were commercially harvested and escaped after the test fishery ceased (Table 7). Therefore, this method estimated that approximately 14% of the sockeye salmon run occurred after the test fishery terminated (Appendix A14). Historical *a* and *b* coefficients calculated using total run adjusted *CCPUEF* values are now used for all inseason run projections.

A nonlinear mathematical model (Mundy 1979) was fit to the *CCPUED* proportions of the 2016 sockeye salmon run to UCI. Using the total run adjusted *CCPUEF*, this analysis suggested that 7% of the run had passed the OTF transect line prior to the start of test fishing on July 1, and that the run was approximately 86% complete at project termination on July 29 (Appendix A14). Therefore, the mathematical model suggests the 2016 test fishery covered approximately 79% of the run. The test fishery passage rate for the season can be calculated by dividing the total number available to capture by the test fishery by the unadjusted *CCPUEF*. In 2016, the estimated final passage rate was approximately 2,253.

The midpoint of the 2016 UCI sockeye salmon run, or the day on which approximately 50% of the total run had entered UCI at the test fishery transect, occurred on day 24.5, or July 18, which was 2 days late compared to the historical mean date of July 16 (Table 8).

ENVIRONMENTAL VARIABLES

In 2016, surface water temperatures measured along the southern OTF transect ranged from 10.0°C to 14.8°C and averaged 12.2°C for the year (Appendices A15–A16). These water temperature data were higher than the 1992–2015 average surface water temperature of 10.4°C (Appendix A17). Air temperatures ranged from 11°C to 23°C and averaged 16°C. Wind velocity averaged 10 knots for the month. Wind direction was variable, but in general, winds originated out of the south, the predominate wind orientation in UCI during July. The 2016 seasonal average salinity of 27.6 ppt was lower than the 1992–2015 average of 29.7 ppt. Koenings et al. (1987) describe a secchi disk as a black and white circular plate that was used to easily estimate the degree of visibility in natural waters. Secchi disk readings in 2016 were similar to the averages from all previous years. In general, water clarity along the test fishery transect decreases as you travel from east to west as a result of numerous glacial watersheds draining into the west side of Cook Inlet. From 2002 to 2016, the average secchi disk depth was 7.9 m at Station 4 and decreased to 3 m at Station 8. Finally, Station 4 was the shallowest station and averaged 25.6 fathoms (154 feet) in depth. Changes in depth are a result of different stages of tide as well as minor differences in set location from day to day.

Monthly mean distributions of temperature and salinity along the southern OTF transect in 2016 indicated a surface layer of relatively warm, turbid, low salinity water along the west side of the transect (Figure 7). A core of relatively low temperature, high salinity water was evident below about 30 m depth along the west side of the transect sloping upward to the surface along the east side of the transect. Oxygen saturation and chlorophyll *a* levels were generally higher near this core of cooler water at depth. Surface layer water temperatures were about 1°C warmer and surface-layer vertical stratification was stronger in 2016 than in 2015 (Dupuis et al. 2016).

Changes in surface layer (0–5 m) distributions of temperature and salinity were related to changes in tidal range during July. In mid-and late July, relatively warm, low salinity surface layers formed during neap tides (Figure 8). Water temperatures exceeded 13ºC and salinities decreased below 27 ppt in these surface layers. Patterns of sockeye salmon CPUE indicated that fish may have been travelling along the boundaries of these warm, low salinity layers. High sockeye salmon CPUE along the east side of the transect near the middle of July corresponded with a strong easterly intrusion of this warm, low salinity layer (Figure 8). Willette et al. (2010) concluded that salmon in Cook Inlet appeared to swim below low salinity surface (<29 ppt) layers making them less vulnerable to surface drift gillnets.

Water temperatures are believed by many to play a significant role in the timing of salmon runs (Burgner 1980), therefore these data have been closely monitored. In general, warmer water temperatures are thought to result in early runs and cooler temperatures produce later runs. For example, in Bristol Bay, Burgner (1980) reported that the arrival dates of sockeye salmon were early during years when water temperatures were warmer than average. A later Bristol Bay study, Ruggerone (1997), found that the change in temperature from winter to spring was a better predictor of run timing than water temperature alone. However, water temperature data alone may or may not be an accurate predictive tool to gauge the run timing of UCI salmon stocks. The 2005 UCI sockeye salmon run was the second latest run ever observed, yet surface water temperatures along the test fishery transect were the warmest ever measured. Conversely, the 2008 run was 4 days early, yet surface water temperatures were much cooler than average. Therefore, it appears that factors other than just water temperature probably play a role in determining salmon run timing in UCI. Pearcy (1992) summarized some of the factors that affect the coastal migration of returning adult salmon and found that prior to entering estuaries adult salmon probably rely on cues that are different from those used in the open ocean phases of their migration.

Although salinity, water temperature, currents, and bathymetry are all believed to play a role in migration, another dynamic to consider that could affect run timing to UCI is the stock composition of the run. When classifying total sockeye salmon run timing in UCI, the magnitude of the Kenai River run should be considered. Because Kenai River sockeye salmon return to UCI later and in larger numbers than any other stock, UCI runs classified as late tend to include large Kenai River runs. For example, from 1988 to 2015, the average Kenai River total run (DIDSON based) for years when the UCI return was classified as early (n = 12) was 3.4 million fish, yet for UCI runs classified as on time or late (n = 17), the Kenai River run averaged 4.2 million fish. A combination of these factors (water temperature, salinity, currents, bathymetry, and stock composition of the run) probably affects fish migration and ultimately classification of the run timing as early or late.

To better understand and predict sockeye salmon migrations into UCI, ADF&G conducted a companion study on the test fishery vessel from 2002 to 2005. Using side-looking sonar, fish distribution in the water column was measured in relation to various oceanographic data, such as water temperature, salinity, tide stage, and water clarity. This study also examined various methods to improve the OTF inseason run forecasts (Willette et al. 2010).

GENETIC STOCK IDENTIFICATION TISSUE SAMPLING AND ANALYSES

In 2016, southern OTF tissues suitable for genetic analysis were sampled from 1,864 sockeye salmon and these samples were archived for future analysis. In 2016, 440 coho salmon were sampled from the southern OTF project. Data retrieval and quality control results for the baseline collections are reported in Barclay and Habicht (2012).

Genetic information has been collected and analyzed from the southern OTF since 2006 and from the northern OTF from 2012 to 2014 (Dupuis and Willette 2016). The efficacy of using MSA in combination with the test fishery for inseason management of the UCI commercial fishery remains unclear. Although it could be useful to know when specific stocks are entering the Central District, inter- and intra-annual variability in migration routes through the district would make adjusting commercial fishing periods to increase or decrease stock-specific exploitation problematic. Willette et al. (2016) provides a review of the temporal and spatial distributions of Kenai and Susitna River sockeye and coho salmon in UCI. The UCI test fishery continues to provide fishery managers with important data about sockeye salmon stock composition, abundance, and run timing. Because commercial, sport, and personal use fishery management plans depend on inseason sockeye salmon run estimates, the UCI test fishery project remains one of the most essential tools available for the implementation of these plans.

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TABLES AND FIGURES

Table 1.–Summary of sockeye salmon fishing effort, daily and cumulative catch and CPUE, and mean fish length, Upper Cook Inlet southern offshore test fishery project, 2016.

Date	Number of stations	Total mean fishing time (min)	Catch		CPUE		Mean length (mm)
			Daily	Cum	Daily	Cum	
1 July	6	238.1	117	117	84	84	558
2 July	6	230.0	19	136	14	98	525
3 July	6	246.0	108	244	79	177	551
4 July	6	212.0	32	276	29	205	550
5 July	6	219.5	63	339	51	256	553
6 July	6	225.0	125	464	91	347	546
7 July	6	223.5	74	538	59	406	550
8 July	6	219.0	85	623	66	471	558
9 July	6	218.0	55	678	43	514	555
10 July	6	229.5	41	719	32	546	559
11 July	6	216.5	7	726	5	551	546
12 July	6	217.5	30	756	25	575	554
13 July	6	216.5	55	811	46	621	557
14 July	6	232.0	95	906	72	693	559
15 July	6	254.0	257	1,163	177	870	558
16 July	5[a]	179.0	31	1,194	38	908	557
17 July	6	235.5	152	1,346	107	1,015	556
18 July	6	223.0	85	1,431	67	1,082	559
19 July	0[a]	0.0	0	1,431	121	1,204	
20 July	6	239.0	259	1,690	175	1,379	550
21 July	3[a]	99.5	14	1,704	27	1,406	539
22 July	6	232.5	126	1,830	93	1,499	560
23 July	6	224.5	87	1,917	68	1,567	555
24 July	4[a]	141.0	24	1,941	27	1,594	556
25 July	6	211.0	15	1,956	13	1,607	559
26 July	6	218.0	54	2,010	43	1,650	558
27 July	0[a]	0.0	0	2,010	40	1,689	
28 July	6	226.0	45	2,055	34	1,723	552
29 July	4[a]	168.0	100	2,155	69	1,792	553

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Table 2.–Estimated sockeye salmon catch by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	18	79	17	3	0	117
2 July	0	0	19	0	0	0	19
3 July	19	1	40	35	8	5	108
4 July	4	18	1	8	0	1	32
5 July	4	35	18	0	1	5	63
6 July	11	21	93	0	0	0	125
7 July	0	15	11	6	16	26	74
8 July	0	48	0	1	3	33	85
9 July	0	10	32	3	4	6	55
10 July	0	14	5	5	13	4	41
11 July	0	0	2	5	0	0	7
12 July	1	9	1	17	2	0	30
13 July	7	5	11	10	5	17	55
14 July	3	10	16	56	6	4	95
15 July	104	33	68	19	31	2	257
16 July[a]	14	5	12	0	–	0	31
17 July	0	64	6	75	6	1	152
18 July	37	13	20	7	6	2	85
19 July[a]	–	–	–	–	–	–	–
20 July	1	2	76	104	73	3	259
21 July[a]	–	–	–	0	14	0	14
22 July	1	51	25	13	30	6	126
23 July	0	0	15	33	29	10	87
24 July[a]	0	–	5	6	13	–	24
25 July	0	0	8	5	1	1	15
26 July	4	1	0	17	30	2	54
27 July[a]	–	–	–	–	–	–	–
28 July	0	0	1	6	23	15	45
29 July[a]	–	–	46	30	23	1	100
Total	210	373	610	478	340	144	2,155
Percent	10%	17%	28%	22%	16%	7%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Table 3.–Estimated sockeye salmon CPUE by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	14	54	14	3	0	84
2 July	0	0	14	0	0	0	14
3 July	15	1	28	25	6	4	79
4 July	3	17	1	6	0	1	29
5 July	4	27	15	0	1	4	51
6 July	9	18	64	0	0	0	91
7 July	0	13	9	5	13	20	59
8 July	0	36	0	1	3	26	66
9 July	0	8	23	3	3	5	43
10 July	0	10	4	4	11	3	32
11 July	0	0	2	3	0	0	5
12 July	1	8	1	14	2	0	25
13 July	6	4	9	8	4	14	46
14 July	2	7	13	42	5	3	72
15 July	73	19	47	15	23	2	177
16 July[a]	11	4	9	0	14	0	38
17 July	0	46	5	51	5	1	107
18 July	29	10	16	6	5	2	67
19 July[a]	15	6	35	37	27	2	121
20 July	1	2	53	69	48	3	175
21 July[a]	3	5	8	0	11	0	27
22 July	1	36	19	10	23	5	93
23 July	0	0	11	25	23	9	68
24 July[a]	0	5	4	5	11	2	27
25 July	0	0	7	4	1	1	13
26 July	3	1	0	13	24	2	43
27 July[a]	2	1	1	9	21	7	40
28 July	0	0	1	4	17	12	34
29 July[a]	1	0	29	21	17	1	69
Total	177	297	478	393	318	128	1,792
Percent	10%	17%	27%	22%	18%	7%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Table 4.–Total run estimates for sockeye salmon to Upper Cook Inlet, Alaska, 2016.

Based on data through 7/25/2016						
Escapement						1,373,775
Cumulative catch (Commercial, Sport, & PU)						2,446,407
Residual in district						61,298
Total run through 7/25/2016 =						3,881,480
2016 Cumulative OTF CPUE through 7/25 =						1,606
Passage rate (total run/cumulative CPUE) through 7/25 =						2,417
Run estimates based on model results (fit of current year to past years)						
	Mean sum	Estimated total CPUE				Estimated
Year	of squares	Current	Previous day	Difference	Timing	total run
2005	0.00043	2,825	2,853	-28	Late 7 days	6,827,706
2006	0.00045	3,454	3,517	-63	Late 9 days	8,348,565
1994	0.00049	2,641	2,672	-32	Late 4 days	6,382,617
1997	0.00067	2,207	2,215	-8	Late 1 day	5,334,497
1998	0.00069	2,176	2,183	-7	Late 3 days	5,259,840
2014	0.00084	1,980	1,983	-3	Late 1 day	4,786,353
1983	0.00101	1,907	1,910	-3	On Time	4,609,680
1986	0.00116	1,904	1,901	2	Late 1 day	4,600,883
1982	0.00120	1,945	1,942	3	Late 2 days	4,700,723
1991	0.00129	2,098	2,118	-19	Late 2 days	5,070,962
2004	0.00131	2,133	2,155	-22	Late 2 days	5,156,108
1987	0.00140	2,414	2,453	-39	Late 2 days	5,833,410
2007	0.00140	2,396	2,435	-38	Late 4 days	5,791,646
1995	0.00149	1,835	1,837	-2	On Time	4,434,989
1993	0.00161	1,812	1,806	7	Early 1 day	4,380,368
2003	0.00174	1,754	1,749	5	Early 2 days	4,239,514
1985	0.00202	1,857	1,848	8	On Time	4,486,952
1996	0.00241	1,682	1,673	9	Early 2 days	4,065,137
1988	0.00242	1,806	1,796	11	Early 2 days	4,365,166
1999	0.00259	2,185	2,219	-34	Late 3 days	5,281,398
2012	0.00285	1,690	1,685	5	Early 1 day	4,083,989
2009	0.00309	1,636	1,623	13	Early 2 days	3,952,922
1992	0.00330	2,115	2,147	-32	Late 2 days	5,112,146
2011	0.00352	1,935	1,953	-18	Late 2 days	4,676,917
2010	0.00398	1,841	1,827	14	Early 1 day	4,450,288
2002	0.00439	1,596	1,579	17	Early 1 days	3,856,804
1990	0.00452	2,387	2,447	-60	Late 3 days	5,769,073
2015	0.00454	4,970	5,362	-391	Late 10 days	12,012,672
2000	0.00459	1,565	1,550	15	Early 2 days	3,782,630
2001	0.00479	1,589	1,571	18	Early 2 days	3,839,354
1989	0.00638	1,911	1,892	19	On Time	4,619,348
1984	0.00869	1,550	1,527	23	Early 4 days	3,746,981
2008	0.01195	1,600	1,574	25	Early 4 days	3,866,689
1979	0.01774	1,421	1,391	29	Early 5 days	3,433,974
1980	0.04103	1,362	1,327	35	Early 9 days	3,292,225
1981	0.04140	1,331	1,295	35	Early 9 days	3,216,577

Table 5.–Absolute percent error (APE) using the first best-fit estimate of southern test fishery data on or after July 20 to project the estimated total annual UCI sockeye salmon run, 1988–2016.

Year	Actual run (millions)	July 20 estimate	APE	Run timing
1988	8.52	11.30	32.6%	1 day early
1990	5.00	4.90	1.9%	4 day late
1991	3.66	3.90	6.5%	2 day late
1992	10.90	11.40	4.5%	2 day late
1993	6.48	6.40	1.2%	on time
1994	5.51	5.30	3.8%	5 day late
1995	4.51	4.50	0.2%	on time
1996	5.63	8.50	51.0%	1 day early
1997	6.41	6.00	6.4%	3 day late
1998	3.00	3.40	13.3%	3 day late
1999	4.57	5.20	13.7%	3 day late
2000	2.94	3.20	8.8%	2 day early
2001	3.53	6.20	75.4%	2 day early
2002	4.84	5.50	13.6%	2 day early
2003	6.29	6.79	8.0%	1 day early
2004	7.92	8.94	12.8%	2 day late
2005	7.92	9.17	15.8%	7 day late
2006	4.96	3.60	27.5%	9 day late
2007	5.44	4.65	14.6%	4 day late
2008	4.13	5.17	25.3%	4 day early
2009	4.29	9.11	112.5%	2 day early
2010[a]	5.26	4.69	10.8%	1 day early
2011	8.60	11.56	34.4%	2 day late
2012	6.61	6.73	1.8%	1 day early
2013[b]	–	–	–	–
2014	5.28	9.10	72.3%	1 day late
2015	6.30	5.89	6.5%	10 day late
2016	5.11	6.83	33.7%	2 day late
			Average APE	Median APE
		All runs	23%	13%
		On time +	16%	13%
		All early	34%	19%

[a] Total run was estimated by summing harvest and escapement throughout Upper Cook Inlet; in the Kenai and Kasilof rivers, escapements were converted to Bendix-equivalent units.

[b] Due to number of missed fishing days, the program was not used in 2013.

Table 6.–Projected total Kenai River sockeye salmon run (millions) estimated from total southern OTF CPUE and age composition stock allocation, 2016.

Data through 25 July												
		Est. total OTF CPUE			Passage rate	Estimated UCI	Estimated UCI run	Estimated UCI run	Estimated Kenai		Estimated Kenai run	Estimated total Kenai
Year	MSS	Current	Prev. day	Timing	(total run/cum. CPUE)	total run	to date[a]	remaining	run to date	Prop. Kenai	remaining	run
2005	0.00043	2,825	2,853	Late 7 days	2,417	6.83	3.78	3.05	2.550	66%	2.01	4.57
2006	0.00044	3,454	3,517	Late 9 days	2,417	8.35	3.78	4.57	2.550	66%	3.02	5.57
1994	0.00048	2,641	2,672	Late 4 days	2,417	6.38	3.78	2.61	2.550	66%	1.72	4.27
1997	0.00066	2,207	2,215	Late 1 day	2,417	5.33	3.78	1.56	2.550	66%	1.03	3.58
1998	0.00068	2,176	2,183	Late 3 days	2,417	5.26	3.78	1.48	2.550	66%	0.98	3.53

Note: MSS is the mean sum of squares

[a] Does not include residual fish still resident in the Central District.

Table 7.–The final unadjusted CPUE and total run adjusted CPUE for the southern offshore test fishery with the corresponding *a* and *b* coefficients used to describe the run timing curves, 1979–2016.

Year	Final OTF CPUE	Total run adjusted	Total run adjusted *a*	Total run adjusted *b*
1979	602	664	-3.3380	0.2004
1980	740	777	-2.2403	0.1612
1981	364	387	-2.5243	0.1819
1982	651	786	-3.7156	0.1633
1983	2,464	2,474	-4.2732	0.1884
1984	1,331	1,341	-3.4018	0.1834
1985	1,422	1,563	-3.5633	0.1626
1986	1,653	1,714	-3.8642	0.1719
1987	1,404	1,428	-4.6385	0.1785
1988	1,131	1,169	-3.5655	0.1662
1989	619	692	-2.7031	0.1238
1990	1,358	1,426	-5.7085	0.2211
1991	1,574	1,740	-4.6331	0.1919
1992	2,021	2,195	-5.4043	0.2217
1993	1,815	1,913	-3.9018	0.1797
1994	1,012	1,199	-3.9757	0.1453
1995	1,712	1,850	-4.6219	0.2078
1996	1,723	1,796	-4.4605	0.2144
1997	1,656	1,826	-3.7000	0.1496
1998	1,158	1,313	-3.7142	0.1515
1999	2,226	2,419	-5.1500	0.2081
2000	1,520	1,565	-4.9141	0.2480
2001	1,586	1,630	-3.9823	0.2041
2002	1,736	1,825	-4.0642	0.2068
2003	1,787	1,848	-4.4402	0.2068
2004	2,028	2,345	-4.6374	0.1903
2005	2,643	3,191	-3.7152	0.1302
2006	1,507	1,969	-4.0762	0.1308
2007	2,584	2,924	-4.6427	0.1793
2008	1,594	1,675	-2.8021	0.1521
2009	2,487	2,616	-4.4130	0.2173
2010	2,055	2,266	-3.1347	0.1459
2011	3,715	3,835	-5.5481	0.2304
2012	2,052	2,141	-5.0793	0.2399
2013[a]	1,342	–	–	–
2014	2,505	2,769	-3.9579	0.1711
2015	1,609	2,287	-7.0977	0.2216
2016	1,792	2,138	-3.8479	0.1569

[a] No estimate for 2013 due to the high number of missed fishing days.

Table 8.–Midpoint of the Upper Cook Inlet sockeye salmon run at the southern offshore test fishery transect relative to day 1 (June 24), 1979–2016.

	Date[a]	
Year	Coded	Calendar
1979	16.7	10 Jul
1980	13.9	7 Jul
1981	13.9	7 Jul
1982	22.8	16 Jul
1983	22.7	16 Jul
1984	18.5	12 Jul
1985	21.9	15 Jul
1986	22.5	15 Jul
1987	26.0	19 Jul
1988	21.5	14 Jul
1989	21.8	15 Jul
1990	25.8	19 Jul
1991	24.1	17 Jul
1992	24.4	17 Jul
1993	21.7	15 Jul
1994	27.4	20 Jul
1995	22.2	15 Jul
1996	20.8	14 Jul
1997	24.7	18 Jul
1998	24.5	18 Jul
1999	24.7	18 Jul
2000	19.8	13 Jul
2001	19.5	13 Jul
2002	19.7	13 Jul
2003	21.5	14 Jul
2004	24.4	17 Jul
2005	28.5	22 Jul
2006	31.2	24 Jul
2007	25.9	19 Jul
2008	18.4	11 Jul
2009	20.3	13 Jul
2010	21.5	14 Jul
2011	24.1	17 Jul
2012	21.2	14 Jul
2013[b]		
2014	23.1	16 Jul
2015	32.0	25 Jul
2016	24.5	18 Jul
Average	22.6	16 Jul

[a] Coded date 1 (June 24) represents the first day of the sockeye salmon run across the southern OTF transect.

[b] No estimate for 2013 due to the high number of missed fishing days.

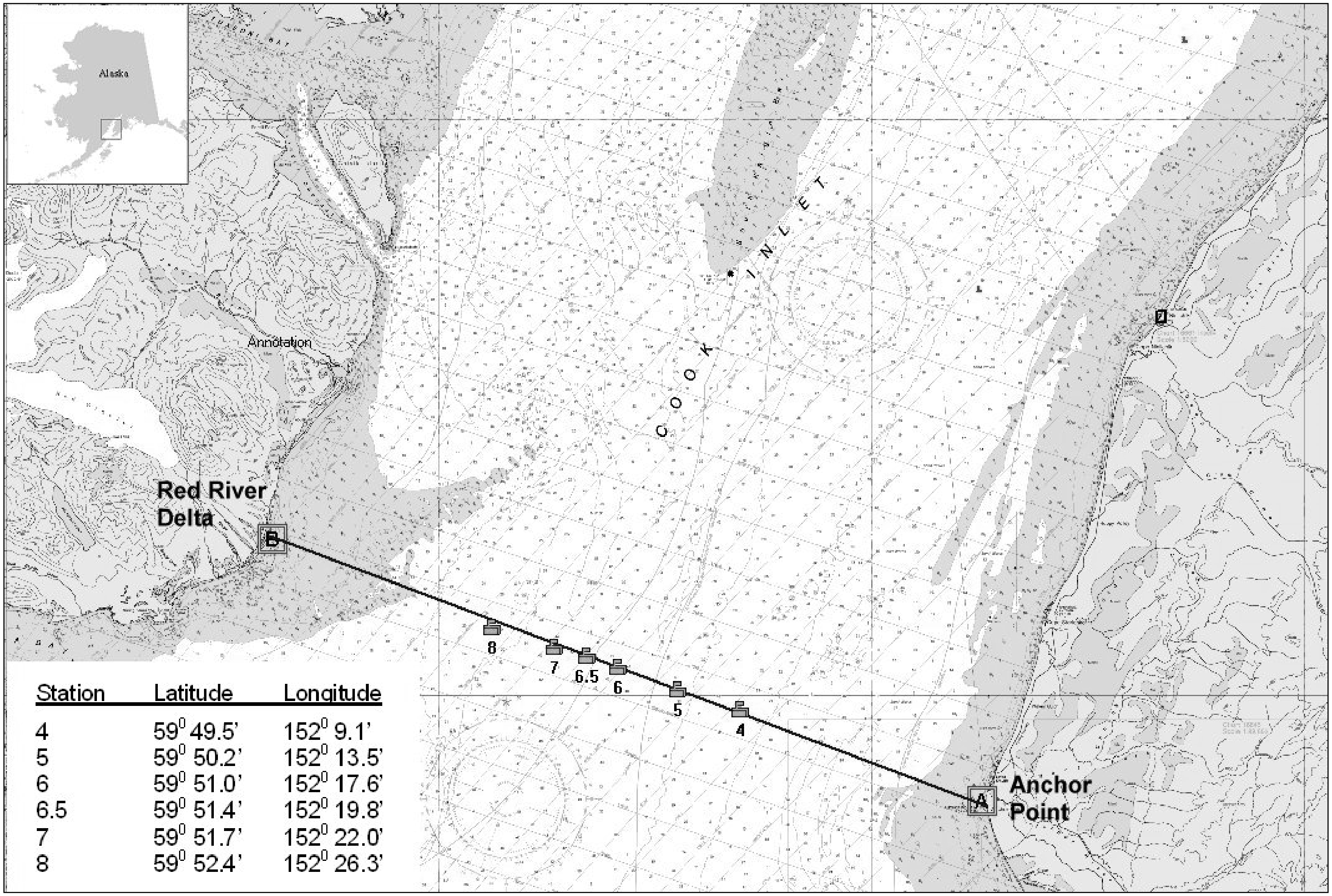
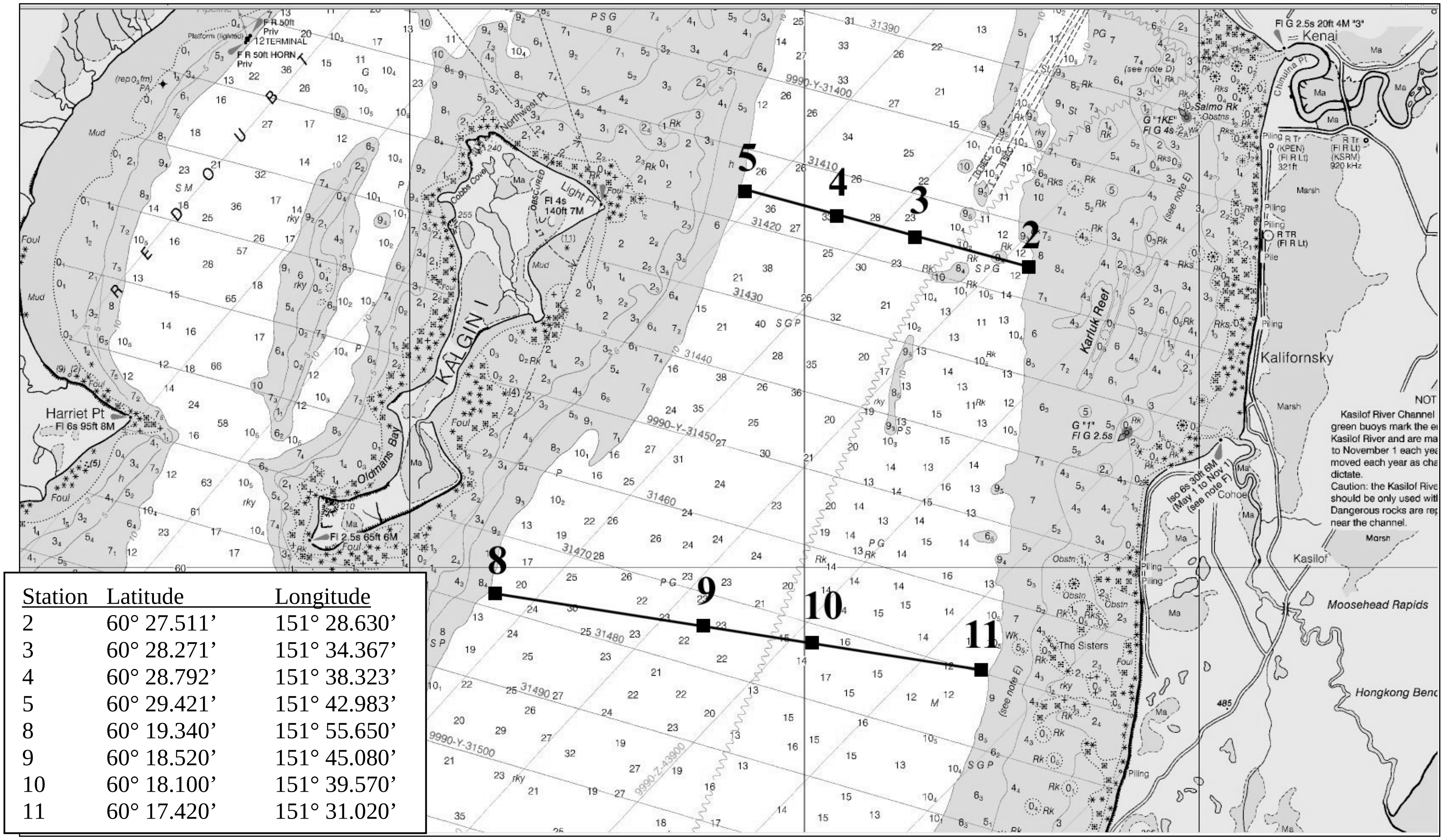


Figure 1.–Location of the southern offshore test fishery transect and fishing stations in Cook Inlet, Alaska, 2016.



Station	Latitude	Longitude
2	60° 27.511’	151° 28.630’
3	60° 28.271’	151° 34.367’
4	60° 28.792’	151° 38.323’
5	60° 29.421’	151° 42.983’
8	60° 19.340’	151° 55.650’
9	60° 18.520’	151° 45.080’
10	60° 18.100’	151° 39.570’
11	60° 17.420’	151° 31.020’

Figure 2.–Location of the northern offshore test fishery transects and fishing stations in Upper Cook Inlet, Alaska, 2014.

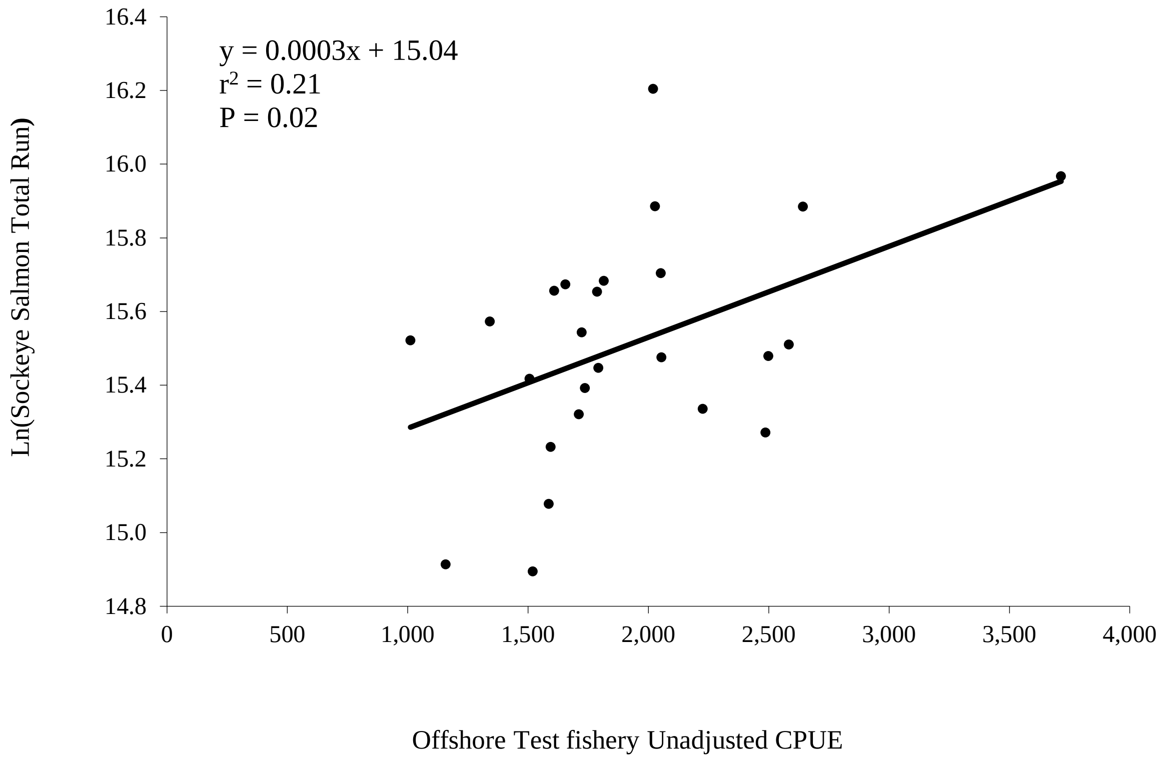


Figure 3.–Linear regression of the relationship between southern offshore test fishery unadjusted cumulative CPUE and Upper Cook Inlet logged (ln) sockeye salmon total annual run, 1992–2016.

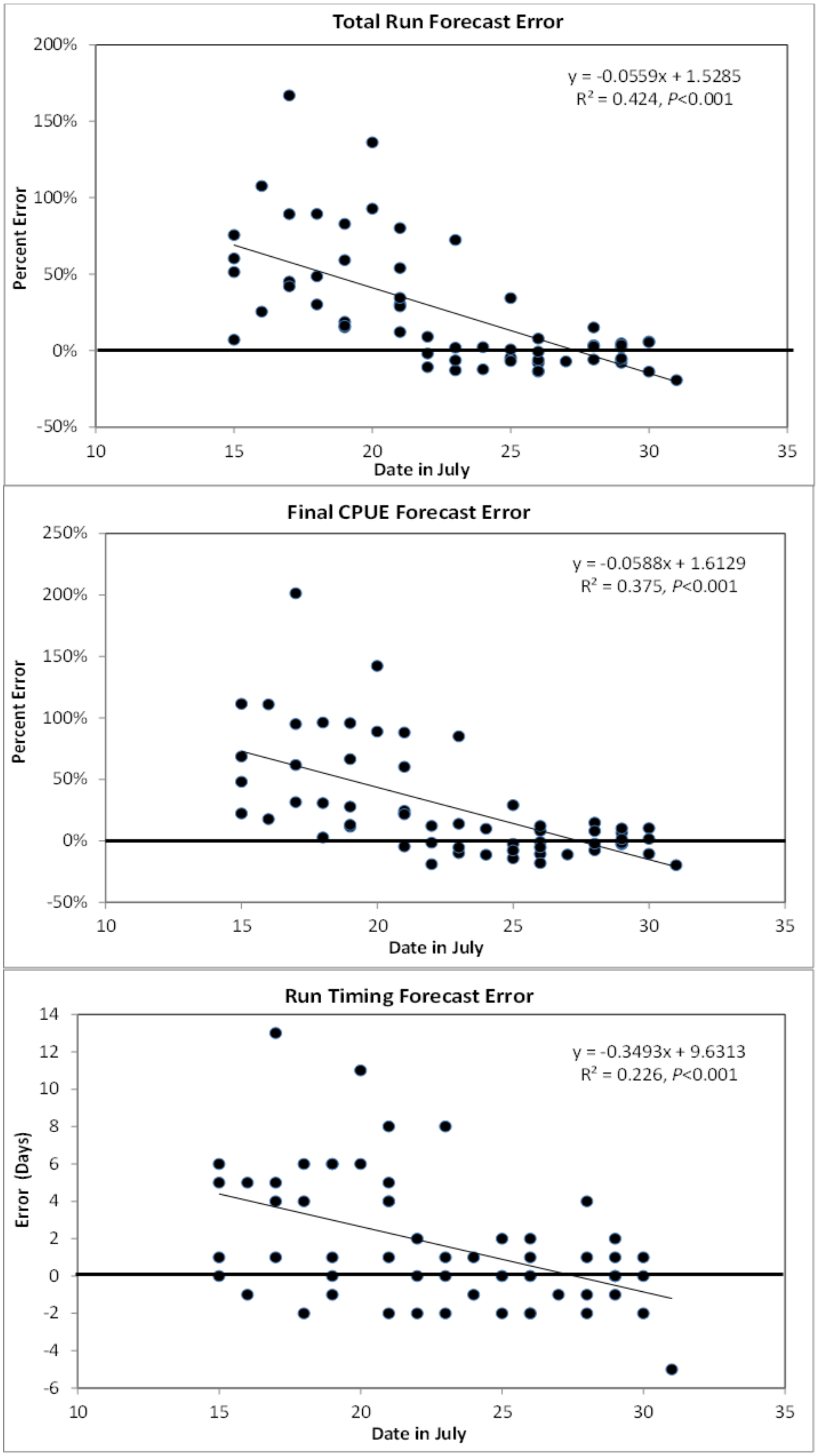


Figure 4.–Relationships between run forecast, final CPUE forecast and run timing forecast errors and date in July when the forecasts were generated.

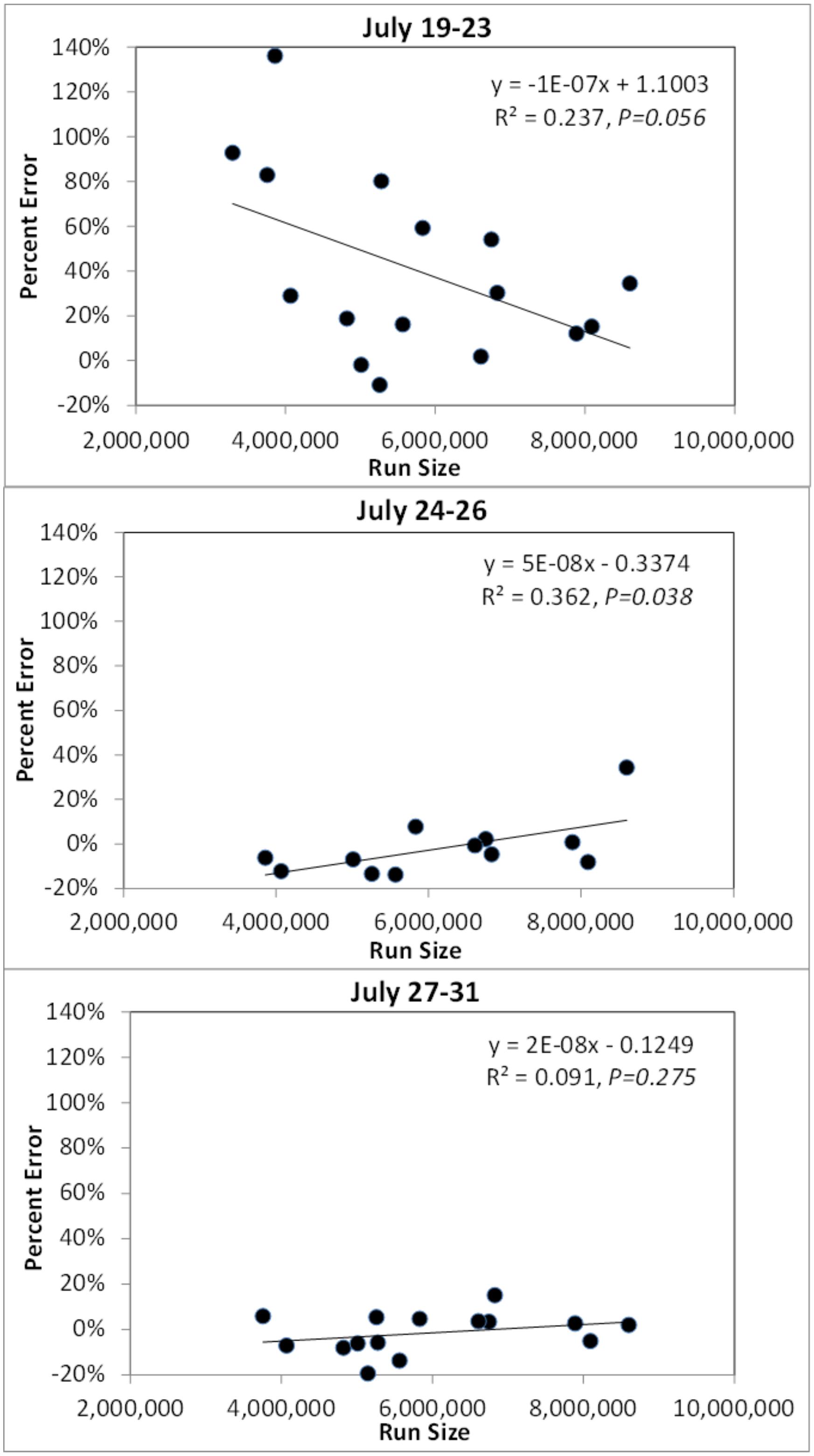


Figure 5.–Relationships between run forecast errors and actual run size for 3 date periods in July when the forecasts were generated, 1996–2014.

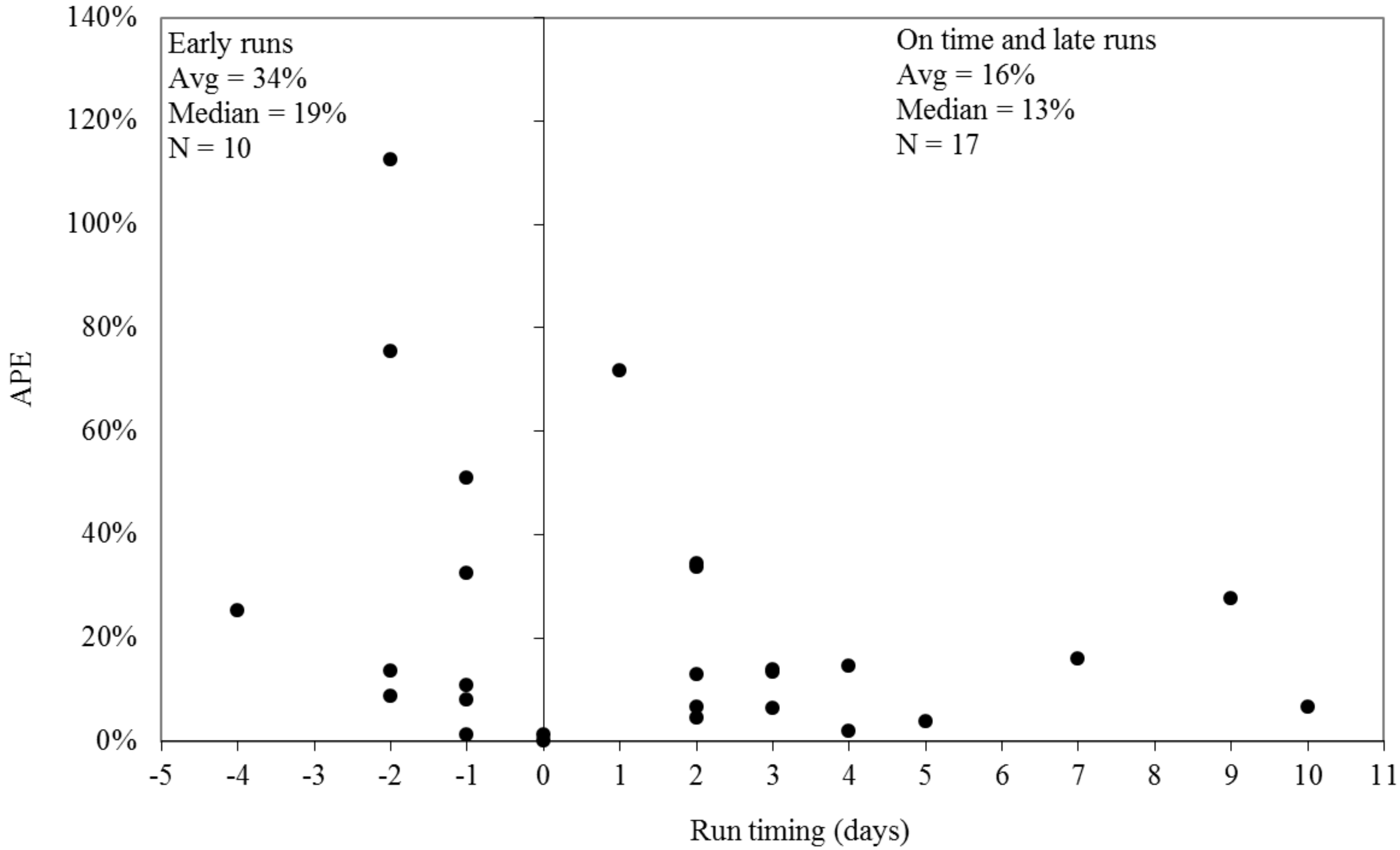


Figure 6.–Absolute percentage error (APE) in forecasting the total sockeye salmon run to Upper Cook Inlet using the July 20 best-fit estimate, 1988–2016.

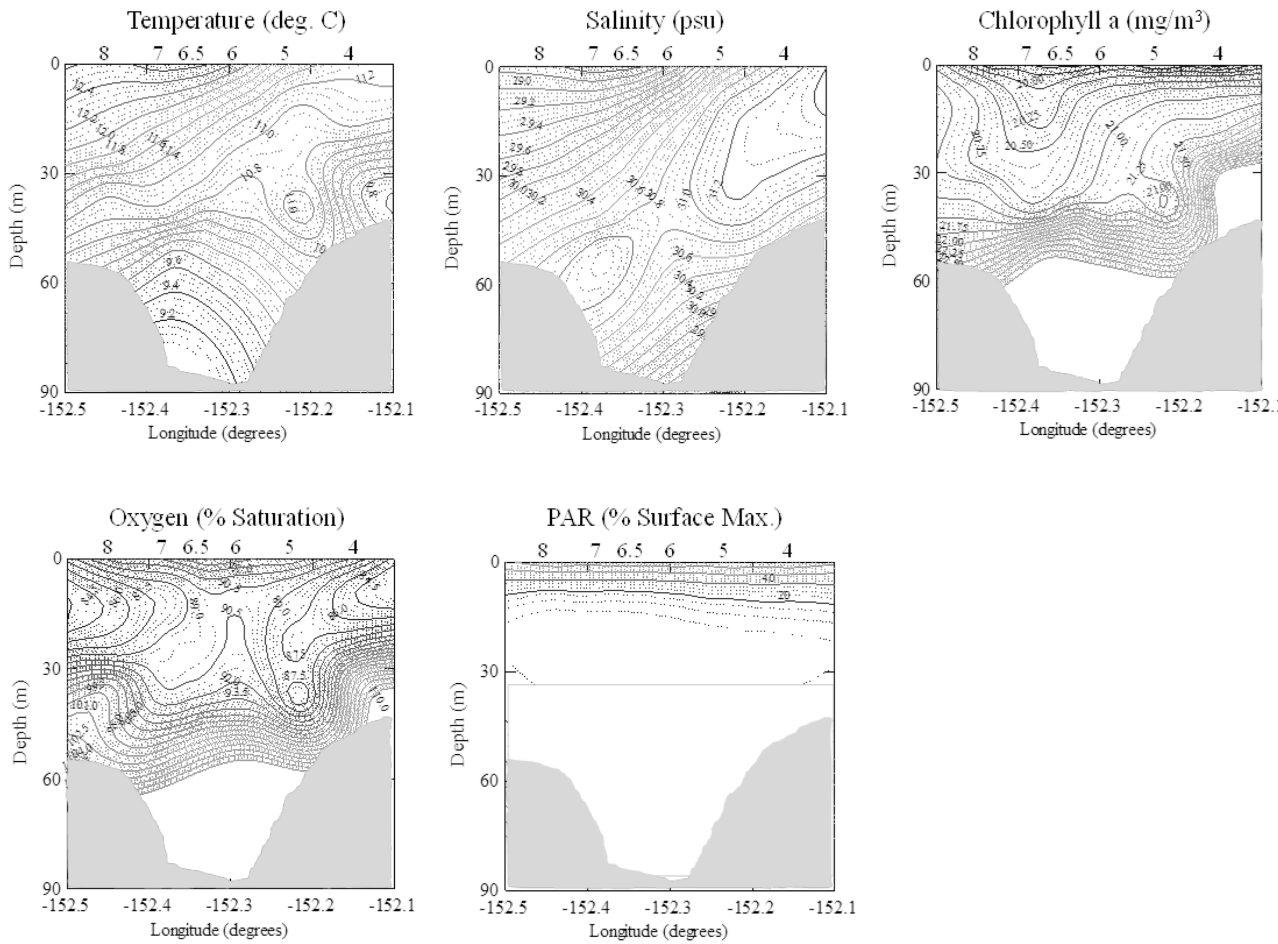


Figure 7.–Monthly mean distributions of temperature (oC), salinity (psu), chlorophyll a (mg/m3), oxygen (percent saturation), and photosynthetically active radiation (PAR, percent surface max.) along the southern OTF transect, 2016.

Note: The solid areas indicate the bottom. Numbers across the top of each panel indicate stations along the transect.

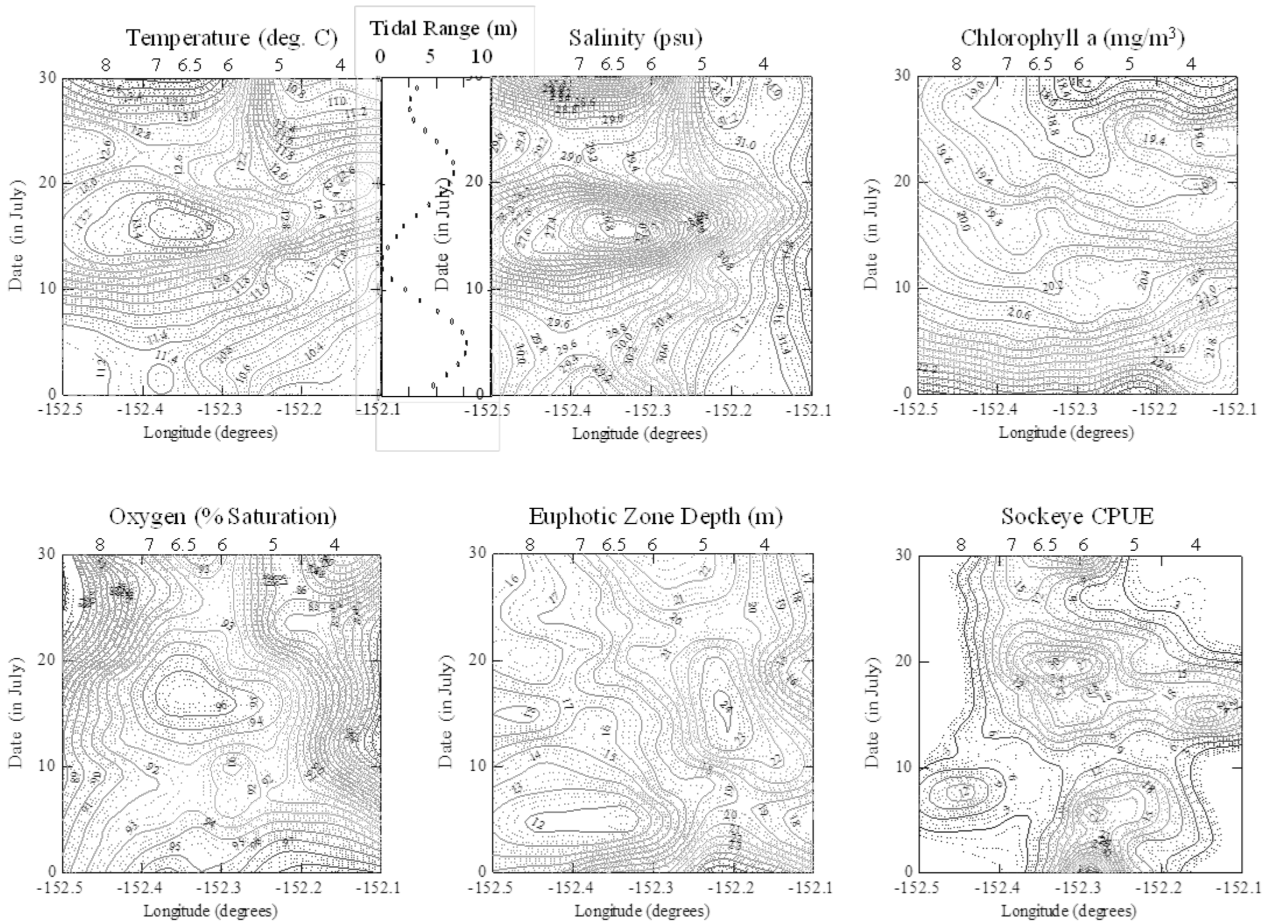


Figure 8.–Distributions of daily surface layer (0–5 m) temperature (deg. C), salinity (psu), chlorophyll *a* (mg/m^3), oxygen (percent saturation), euphotic zone depth (m) and sockeye salmon CPUE along the southern OTF transect, 2016.

Note: Numbers across the top of each panel indicate stations along the transect.

APPENDIX A: SOUTHERN OFFSHORE TEST FISHERY 2016 SEASON DATA

Appendix A1.–Summary of pink salmon fishing effort, daily and cumulative catch, and daily and cumulative CPUE, Upper Cook Inlet southern offshore test fishery project, 2016.

Date	Number of stations	Total mean fishing time (min)	Catch		CPUE	
			Daily	Cum	Daily	Cum
1 July	6	238.1	6	6	4	4
2 July	6	230.0	2	8	2	6
3 July	6	246.0	7	15	5	11
4 July	6	212.0	3	18	3	14
5 July	6	219.5	1	19	1	15
6 July	6	225.0	10	29	8	22
7 July	6	223.5	6	35	5	27
8 July	6	219.0	2	37	2	28
9 July	6	218.0	17	54	13	42
10 July	6	229.5	20	74	16	57
11 July	6	216.5	3	77	3	60
12 July	6	217.5	16	93	13	73
13 July	6	216.5	6	99	5	78
14 July	6	232.0	27	126	20	97
15 July	6	254.0	59	185	40	137
16 July	5[a]	179.0	7	192	6	143
17 July	6	235.5	19	211	14	157
18 July	6	223.0	4	215	3	160
19 July	0[a]	0.0	0	215	0	160
20 July	6	239.0	12	227	8	168
21 July	3[a]	99.5	3	230	2	171
22 July	6	232.5	26	256	20	190
23 July	6	224.5	3	259	2	193
24 July	4[a]	141.0	1	260	1	194
25 July	6	211.0	5	265	4	198
26 July	6	218.0	14	279	11	209
27 July	0[a]	0.0	0	279	0	209
28 July	6	226.0	8	287	6	215
29 July	4[a]	168.0	25	312	17	232

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A2.–Estimated pink salmon catch by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	0	4	2	0	0	6
2 July	0	1	1	0	0	0	2
3 July	1	0	3	3	0	0	7
4 July	1	1	0	0	1	0	3
5 July	0	0	1	0	0	0	1
6 July	2	2	6	0	0	0	10
7 July	1	0	0	1	2	2	6
8 July	0	0	1	0	0	1	2
9 July	0	5	4	1	7	0	17
10 July	0	9	1	1	7	2	20
11 July	0	0	2	0	1	0	3
12 July	1	0	0	15	0	0	16
13 July	0	0	3	1	1	1	6
14 July	1	11	3	11	0	1	27
15 July	7	15	17	2	17	1	59
16 July[a]	0	0	5	2	0	0	7
17 July	3	10	0	6	0	0	19
18 July	1	2	1	0	0	0	4
19 July[a]	0	0	0	0	0	0	0
20 July	0	0	1	5	6	0	12
21 July[a]	0	0	0	0	3	0	3
22 July	7	10	4	1	3	1	26
23 July	0	0	1	1	1	0	3
24 July[a]	1	0	0	0	0	0	1
25 July	1	2	2	0	0	0	5
26 July	5	2	1	5	0	1	14
27 July[a]	0	0	0	0	0	0	0
28 July	1	1	0	2	3	1	8
29 July[a]	0	0	8	14	3	0	25
Total	33	71	69	73	55	11	312
Percent	11%	23%	22%	23%	18%	4%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A3.–Estimated pink salmon CPUE by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	0	3	2	0	0	4
2 July	0	1	1	0	0	0	2
3 July	1	0	2	2	0	0	5
4 July	1	1	0	0	1	0	3
5 July	0	0	1	0	0	0	1
6 July	2	2	4	0	0	0	8
7 July	1	0	0	1	2	2	5
8 July	0	0	1	0	0	1	2
9 July	0	4	3	1	6	0	13
10 July	0	7	1	1	6	2	16
11 July	0	0	2	0	1	0	3
12 July	1	0	0	12	0	0	13
13 July	0	0	3	1	1	1	5
14 July	1	8	2	8	0	1	20
15 July	5	8	12	2	13	1	40
16 July[a]	0	0	4	2	0	0	6
17 July	3	7	0	4	0	0	14
18 July	1	2	1	0	0	0	3
19 July[a]	0	0	0	0	0	0	0
20 July	0	0	1	3	4	0	8
21 July[a]	0	0	0	0	2	0	2
22 July	6	7	3	1	2	1	20
23 July	0	0	1	1	1	0	2
24 July[a]	1	0	0	0	0	0	1
25 July	1	2	2	0	0	0	4
26 July	4	2	1	4	0	1	11
27 July[a]	0	0	0	0	0	0	0
28 July	1	1	0	1	2	1	6
29 July[a]	0	0	5	10	2	0	17
Total	27	50	50	54	42	9	232
Percent	11%	22%	21%	23%	18%	4%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A4.–Summary of chum salmon fishing effort, daily and cumulative catch, and daily and cumulative CPUE, Upper Cook Inlet southern offshore test fishery project, 2016.

Date	Number of stations	Total mean fishing time (min)	Catch		CPUE	
			Daily	Cum	Daily	Cum
1 July	6	238.1	0	0	0	0
2 July	6	230.0	1	1	1	1
3 July	6	246.0	18	19	13	14
4 July	6	212.0	0	19	0	14
5 July	6	219.5	2	21	2	16
6 July	6	225.0	9	30	9	25
7 July	6	223.5	4	34	3	28
8 July	6	219.0	1	35	1	29
9 July	6	218.0	11	46	8	37
10 July	6	229.5	9	55	7	44
11 July	6	216.5	4	59	3	47
12 July	6	217.5	1	60	1	48
13 July	6	216.5	21	81	18	66
14 July	6	232.0	8	89	6	72
15 July	6	254.0	25	114	18	90
16 July	5[a]	179.0	5	119	4	94
17 July	6	235.5	18	137	13	107
18 July	6	223.0	10	147	8	115
19 July	0[a]	0.0	0	147	0	115
20 July	6	239.0	60	207	40	155
21 July	3[a]	99.5	2	209	2	157
22 July	6	232.5	35	244	26	183
23 July	6	224.5	13	257	10	193
24 July	4[a]	141.0	7	264	6	199
25 July	6	211.0	3	267	3	201
26 July	6	218.0	15	282	12	213
27 July	0[a]	0.0	0	282	0	213
28 July	6	226.0	28	310	21	234
29 July	4[a]	168.0	46	356	32	266

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A5.–Estimated chum salmon catch by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	0	0	0	0	0	0
2 July	0	0	1	0	0	0	1
3 July	4	1	4	8	1	0	18
4 July	0	0	0	0	0	0	0
5 July	0	0	0	0	0	2	2
6 July	0	4	4	1	0	0	9
7 July	0	1	1	1	1	0	4
8 July	0	0	0	0	0	1	1
9 July	0	1	7	0	3	0	11
10 July	0	1	5	1	2	0	9
11 July	0	0	1	2	0	1	4
12 July	0	1	0	0	0	0	1
13 July	0	0	2	14	3	2	21
14 July	0	1	0	3	2	2	8
15 July	1	1	8	3	11	1	25
16 July[a]	1	0	3	0	0	1	5
17 July	0	2	3	10	3	0	18
18 July	0	8	0	1	1	0	10
19 July[a]	0	0	0	0	0	0	0
20 July	0	0	7	20	32	1	60
21 July[a]	0	0	0	0	1	1	2
22 July	1	19	6	4	4	1	35
23 July	0	1	7	3	1	1	13
24 July[a]	0	0	2	3	2	0	7
25 July	0	0	0	2	1	0	3
26 July	1	0	0	11	3	0	15
27 July[a]	0	0	0	0	0	0	0
28 July	0	0	0	4	21	3	28
29 July[a]	0	0	9	16	21	0	46
Total	8	41	70	107	113	17	356
Percent	2%	12%	20%	30%	32%	5%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A6.–Estimated chum salmon CPUE by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	0	0	0	0	0	0
2 July	0	0	1	0	0	0	1
3 July	3	1	3	6	1	0	13
4 July	0	0	0	0	0	0	0
5 July	0	0	0	0	0	2	2
6 July	0	3	5	1	0	0	9
7 July	0	1	1	1	1	0	3
8 July	0	0	0	0	0	1	1
9 July	0	1	5	0	3	0	8
10 July	0	1	4	1	2	0	7
11 July	0	0	1	2	0	1	3
12 July	0	1	0	0	0	0	1
13 July	0	0	3	12	3	2	18
14 July	0	1	0	2	2	2	6
15 July	1	1	6	2	8	1	18
16 July[a]	1	0	2	0	0	1	4
17 July	0	1	2	7	2	0	13
18 July	0	6	0	1	1	0	8
19 July[a]	0	0	0	0	0	0	0
20 July	0	0	5	13	21	1	40
21 July[a]	0	0	0	0	1	1	2
22 July	1	13	5	3	3	1	26
23 July	0	1	5	2	1	1	10
24 July[a]	0	0	2	3	2	0	6
25 July	0	0	0	2	1	0	3
26 July	1	0	0	9	2	0	12
27 July[a]	0	0	0	0	0	0	0
28 July	0	0	0	3	16	3	21
29 July[a]	0	0	6	11	16	0	32
Total	6	30	54	78	83	14	266
Percent	2%	11%	20%	29%	31%	5%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A7.–Summary of coho salmon fishing effort, daily and cumulative catch, and daily and cumulative CPUE, Upper Cook Inlet southern offshore test fishery project, 2016.

Date	Number of stations	Total mean fishing time (min)	Catch		CPUE	
			Daily	Cum	Daily	Cum
1 July	6	238.1	3	3	2	2
2 July	6	230.0	0	3	0	2
3 July	6	246.0	9	12	7	9
4 July	6	212.0	0	12	0	9
5 July	6	219.5	2	14	2	11
6 July	6	225.0	4	18	3	14
7 July	6	223.5	5	23	4	18
8 July	6	219.0	2	25	2	19
9 July	6	218.0	6	31	5	24
10 July	6	229.5	5	36	4	28
11 July	6	216.5	0	36	0	28
12 July	6	217.5	5	41	4	32
13 July	6	216.5	9	50	8	40
14 July	6	232.0	11	61	8	48
15 July	6	254.0	17	78	12	60
16 July	5[a]	179.0	9	87	7	67
17 July	6	235.5	22	109	15	82
18 July	6	223.0	24	133	19	102
19 July	0[a]	0.0	0	133	0	102
20 July	6	239.0	66	199	45	146
21 July	3[a]	99.5	5	204	4	151
22 July	6	232.5	42	246	32	183
23 July	6	224.5	67	313	51	233
24 July	4[a]	141.0	35	348	30	263
25 July	6	211.0	6	354	5	268
26 July	6	218.0	32	386	25	293
27 July	0[a]	0.0	0	386	0	293
28 July	6	226.0	19	405	14	307
29 July	4[a]	168.0	35	440	24	331

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A8.–Estimated coho salmon catch by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	1	1	0	1	0	3
2 July	0	0	0	0	0	0	0
3 July	1	0	1	5	1	1	9
4 July	0	0	0	0	0	0	0
5 July	0	0	2	0	0	0	2
6 July	0	2	2	0	0	0	4
7 July	0	0	2	2	0	1	5
8 July	0	1	0	0	0	1	2
9 July	0	1	4	0	1	0	6
10 July	0	0	0	3	2	0	5
11 July	0	0	0	0	0	0	0
12 July	0	0	2	3	0	0	5
13 July	1	0	1	2	5	0	9
14 July	0	3	2	6	0	0	11
15 July	2	2	6	3	2	2	17
16 July[a]	0	0	9	0	0	0	9
17 July	1	5	2	14	0	0	22
18 July	0	1	14	9	0	0	24
19 July[a]	0	0	0	0	0	0	0
20 July	0	3	12	29	21	1	66
21 July[a]	0	0	0	1	4	0	5
22 July	1	8	12	7	7	7	42
23 July	0	0	44	6	14	3	67
24 July[a]	0	0	13	17	5	0	35
25 July	2	0	0	4	0	0	6
26 July	0	2	1	23	0	6	32
27 July[a]	0	0	0	0	0	0	0
28 July	0	0	1	6	12	0	19
29 July[a]	0	0	11	18	6	0	35
Total	8	29	142	158	81	22	440
Percent	2%	7%	32%	36%	18%	5%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A9.–Estimated coho salmon CPUE by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	1	1	0	1	0	2
2 July	0	0	0	0	0	0	0
3 July	1	0	1	4	1	1	7
4 July	0	0	0	0	0	0	0
5 July	0	0	2	0	0	0	2
6 July	0	2	1	0	0	0	3
7 July	0	0	2	2	0	1	4
8 July	0	1	0	0	0	1	2
9 July	0	1	3	0	1	0	5
10 July	0	0	0	2	2	0	4
11 July	0	0	0	0	0	0	0
12 July	0	0	2	2	0	0	4
13 July	1	0	2	2	4	0	8
14 July	0	2	2	4	0	0	8
15 July	1	1	4	2	2	2	12
16 July[a]	0	0	7	0	0	0	7
17 July	1	4	2	9	0	0	15
18 July	0	1	11	7	0	0	19
19 July[a]	0	0	0	0	0	0	0
20 July	0	3	8	19	14	1	45
21 July[a]	0	0	0	1	3	0	4
22 July	1	6	9	6	5	6	32
23 July	0	0	33	5	11	3	51
24 July[a]	0	0	11	15	4	0	30
25 July	2	0	0	3	0	0	5
26 July	0	2	1	18	0	5	25
27 July[a]	0	0	0	0	0	0	0
28 July	0	0	1	4	9	0	14
29 July[a]	0	0	7	12	5	0	24
Total	6	22	107	117	60	19	331
Percent	2%	6%	32%	35%	18%	6%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A10.–Summary of Chinook salmon fishing effort, daily and cumulative catch, and daily and cumulative CPUE, Upper Cook Inlet southern offshore test fishery project, 2016.

Date	Number of stations	Total mean fishing time (min)	Catch		CPUE	
			Daily	Cum	Daily	Cum
1 July	6	238.1	0	0	0	0
2 July	6	230.0	0	0	0	0
3 July	6	246.0	0	0	0	0
4 July	6	212.0	1	1	1	1
5 July	6	219.5	0	1	0	1
6 July	6	225.0	0	1	0	1
7 July	6	223.5	0	1	0	1
8 July	6	219.0	0	1	0	1
9 July	6	218.0	0	1	0	1
10 July	6	229.5	0	1	0	1
11 July	6	216.5	0	1	0	1
12 July	6	217.5	0	1	0	1
13 July	6	216.5	0	1	0	1
14 July	6	232.0	0	1	0	1
15 July	6	254.0	1	2	1	1
16 July	5[a]	179.0	0	2	0	1
17 July	6	235.5	0	2	0	1
18 July	6	223.0	0	2	0	1
19 July	0[a]	0.0	0	2	0	1
20 July	6	239.0	0	2	0	1
21 July	3[a]	99.5	0	2	0	1
22 July	6	232.5	0	2	0	1
23 July	6	224.5	0	2	0	1
24 July	4[a]	141.0	0	2	0	1
25 July	6	211.0	0	2	0	1
26 July	6	218.0	0	2	0	1
27 July	0[a]	0.0	0	2	0	1
28 July	6	226.0	0	2	0	1
29 July	4[a]	168.0	0	2	0	1

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A11.–Estimated Chinook salmon catch by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	0	0	0	0	0	0
2 July	0	0	0	0	0	0	0
3 July	0	0	0	0	0	0	0
4 July	0	0	0	0	0	1	1
5 July	0	0	0	0	0	0	0
6 July	0	0	0	0	0	0	0
7 July	0	0	0	0	0	0	0
8 July	0	0	0	0	0	0	0
9 July	0	0	0	0	0	0	0
10 July	0	0	0	0	0	0	0
11 July	0	0	0	0	0	0	0
12 July	0	0	0	0	0	0	0
13 July	0	0	0	0	0	0	0
14 July	0	0	0	0	0	0	0
15 July	0	0	1	0	0	0	1
16 July[a]	0	0	0	0	0	0	0
17 July	0	0	0	0	0	0	0
18 July	0	0	0	0	0	0	0
19 July[a]	0	0	0	0	0	0	0
20 July	0	0	0	0	0	0	0
21 July[a]	0	0	0	0	0	0	0
22 July	0	0	0	0	0	0	0
23 July	0	0	0	0	0	0	0
24 July[a]	0	0	0	0	0	0	0
25 July	0	0	0	0	0	0	0
26 July	0	0	0	0	0	0	0
27 July[a]	0	0	0	0	0	0	0
28 July	0	0	0	0	0	0	0
29 July[a]	0	0	0	0	0	0	0
Total	0	0	1	0	0	1	2
Percent	0%	0%	50%	0%	0%	50%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A12.–Estimated Chinook salmon CPUE by date and station, Upper Cook Inlet southern offshore test fishery project, 2016.

	Station number						
Date	4	5	6	6.5	7	8	Total
1 July	0	0	0	0	0	0	0
2 July	0	0	0	0	0	0	0
3 July	0	0	0	0	0	0	0
4 July	0	0	0	0	0	1	1
5 July	0	0	0	0	0	0	0
6 July	0	0	0	0	0	0	0
7 July	0	0	0	0	0	0	0
8 July	0	0	0	0	0	0	0
9 July	0	0	0	0	0	0	0
10 July	0	0	0	0	0	0	0
11 July	0	0	0	0	0	0	0
12 July	0	0	0	0	0	0	0
13 July	0	0	0	0	0	0	0
14 July	0	0	0	0	0	0	0
15 July	0	0	1	0	0	0	1
16 July[a]	0	0	0	0	0	0	0
17 July	0	0	0	0	0	0	0
18 July	0	0	0	0	0	0	0
19 July[a]	0	0	0	0	0	0	0
20 July	0	0	0	0	0	0	0
21 July[a]	0	0	0	0	0	0	0
22 July	0	0	0	0	0	0	0
23 July	0	0	0	0	0	0	0
24 July[a]	0	0	0	0	0	0	0
25 July	0	0	0	0	0	0	0
26 July	0	0	0	0	0	0	0
27 July[a]	0	0	0	0	0	0	0
28 July	0	0	0	0	0	0	0
29 July[a]	0	0	0	0	0	0	0
Total	0	0	1	0	0	1	1
Percent	0%	0%	50%	0%	0%	50%	100%

[a] Not all stations fished due to weather; the data for missing stations were interpolated.

Appendix A13.–Final cumulative catch and CPUE values by year for pink salmon, chum salmon, coho salmon, and Chinook salmon from the Upper Cook Inlet southern offshore test fishery project, 1992–2016.

	Pink		Chum		Coho		Chinook	
Year	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
1992	326	227	667	443	444	299	3	3
1993	53	45	205	153	325	258	5	4
1994	227	166	521	345	752	513	1	1
1995	155	97	1,129	687	941	595	3	2
1996	119	84	491	319	758	534	3	2
1997	203	158	420	306	502	375	4	3
1998	556	406	438	312	547	403	3	2
1999	31	23	451	331	404	307	7	6
2000	908	608	1,031	672	1,157	766	2	1
2001	283	229	933	655	1,209	838	11	8
2002	809	572	1,537	1,013	1,184	798	6	4
2003	182	126	1,000	713	506	368	13	10
2004	650	439	652	447	1,119	785	4	3
2005	186	150	448	300	546	344	8	6
2006	1,023	655	988	635	1,613	1,037	12	8
2007	348	247	398	265	692	482	5	4
2008	306	226	405	273	1,024	718	3	2
2009	701	526	454	303	512	361	11	8
2010	266	176	1,155	736	700	454	3	2
2011	90	64	768	532	374	264	7	5
2012	277	210	664	527	200	154	5	4
2013	53	36	302	197	800	495	4	3
2014	848	694	579	457	752	655	4	3
2015	129	92	1,091	704	411	277	7	4
1992–2015 Avg	364	261	697	472	728	503	6	4
2016	312	232	356	266	440	331	2	1

Appendix A14.–Entry pattern of sockeye salmon into Upper Cook Inlet, Alaska estimated from daily CPUE data fit to the run timing model, 2016.

Day	Date	Input y	Model estimated ($Y_{yr,d}$)	Residual	Change in input Y	Change in estimated Y
8	1 Jul	0.0394	0.0696			
9	2 Jul	0.0458	0.0805	-0.0347	0.0064	0.0109
10	3 Jul	0.0826	0.0929	-0.0103	0.0369	0.0124
11	4 Jul	0.0960	0.1070	-0.0110	0.0133	0.0141
12	5 Jul	0.1196	0.1229	-0.0033	0.0237	0.0159
13	6 Jul	0.1621	0.1409	0.0212	0.0425	0.0179
14	7 Jul	0.1898	0.1610	0.0288	0.0276	0.0201
15	8 Jul	0.2204	0.1833	0.0371	0.0307	0.0223
16	9 Jul	0.2403	0.2080	0.0323	0.0199	0.0247
17	10 Jul	0.2551	0.2350	0.0201	0.0148	0.0270
18	11 Jul	0.2575	0.2644	-0.0069	0.0024	0.0294
19	12 Jul	0.2691	0.2960	-0.0269	0.0116	0.0316
20	13 Jul	0.2904	0.3297	-0.0394	0.0213	0.0337
21	14 Jul	0.3239	0.3653	-0.0414	0.0335	0.0356
22	15 Jul	0.4069	0.4024	0.0045	0.0830	0.0371
23	16 Jul	0.4246	0.4406	-0.0161	0.0177	0.0382
24	17 Jul	0.4747	0.4796	-0.0048	0.0502	0.0390
25	18 Jul	0.5062	0.5188	-0.0126	0.0315	0.0392
26	19 Jul	0.5630	0.5578	0.0052	0.0567	0.0390
27	20 Jul	0.6449	0.5960	0.0488	0.0819	0.0383
28	21 Jul	0.6577	0.6332	0.0245	0.0128	0.0371
29	22 Jul	0.7012	0.6688	0.0324	0.0435	0.0356
30	23 Jul	0.7328	0.7026	0.0302	0.0316	0.0338
31	24 Jul	0.7455	0.7343	0.0112	0.0127	0.0317
32	25 Jul	0.7515	0.7638	-0.0123	0.0060	0.0295
33	26 Jul	0.7716	0.7909	-0.0194	0.0201	0.0271
34	27 Jul	0.7900	0.8157	-0.0257	0.0185	0.0248
35	28 Jul	0.8060	0.8381	-0.0321	0.0160	0.0224
36	29 Jul	0.8381	0.8583	-0.0202	0.0320	0.0202

Appendix A15.–Chemical and physical observations made in Upper Cook Inlet, Alaska, southern offshore test fishery project, 2016.

Date	Sta	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Tide stage	Salinity (ppt)	Water depth (f)	Secchi (m)
1 Jul	4	11	10.3	16	south	flood	30.0	49.0	3.0
	5	12.0	10.2	20.0	south	flood	29.8	67.0	4.0
	6	12.0	11.2	18.0	southeast	high	28.3	87.0	3.5
	6.5	12.0	11.4	15.0	southeast	ebb	27.8	79.0	3.5
	7	12.0	11.4	10.0	southeast	ebb	27.9	80.0	3.0
	8	12.0	11.3	5.0	southeast	ebb	28.0	50.0	2.5
2 Jul	8	12	11.3	5	northeast	ebb	28.0	27.3	1.5
	7	13	12.4	8	southeast	flood	26.2	43.7	2.5
	6.5	13	11.0	0	–	flood	28.4	41.0	3.0
	6	13	10.6	0	–	flood	28.9	47.0	5.0
	5	14	10.6	0	–	flood	29.3	35.0	7.5
	4	12	10.0	0	–	flood	29.6	24.5	9.0
3 Jul	4	16	10.7	15	south	flood	29.2	23.4	4.5
	5	13	10.5	15	south	flood	29.2	35.4	4.5
	6	13	10.6	18	south	flood	28.9	47.4	4.0
	6.5	12	10.4	15	south	flood	29.1	42.5	4.5
	7	13	11.1	20	south	ebb	28.2	45.2	3.0
	8	13	11.1	20	south	ebb	28.3	27.3	2.5
4 Jul	8	12	11.4	10	west	ebb	27.8	29.4	2.5
	7	13	11.4	12	northwest	flood	27.7	34.8	2.0
	6.5	12	11.5	10	southwest	flood	27.9	36.5	2.5
	6	13	11.1	10	southwest	flood	28.3	45.8	4.0
	5	13	10.9	7	southwest	flood	29.4	29.4	4.5
	4	13	10.0	5	west	flood	29.5	30.0	5.0
5 Jul	4	12	10.6	5	east	low	29.2	22.4	5.5
	5	12	10.8	5	southeast	flood	28.3	34.9	5.0
	6	12	11.3	5	southeast	flood	28.2	44.7	3.5
	6.5	13	11.3	5	south	flood	28.2	39.2	3.0
	7	14	11.3	5	south	flood	28.2	46.3	3.0
	8	15	11.6	5	southwest	flood	27.9	29.8	3.5
6 Jul	8	12	11.3	0	–	ebb	28.0	26.2	4.0
	7	12	11.6	0	–	ebb	27.7	41.4	3.0
	6.5	13	12.0	0	–	ebb	27.9	38.2	2.5
	6	13	11.0	0	–	low	28.5	41.4	3.0
	5	12	10.7	7	east	flood	29.1	32.7	6.0
	4	12	10.2	0	–	flood	29.5	23.4	5.5

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Date	Sta	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Tide stage	Salinity (ppt)	Water depth (f)	Secchi (m)
7 Jul	4	17	10.7	0	–	flood	29.1	22.9	7.5
	5	16	10.8	0	–	flood	29.0	33.3	6.5
	6	15	11.2	5	southwest	flood	28.4	46.3	4.5
	6.5	15	11.8	5	southwest	flood	28.0	39.8	4.0
	7	16	11.9	5	southwest	flood	27.8	43.6	3.0
	8	17	11.7	5	southwest	flood	27.8	31.1	3.5
8 Jul	8	16	11.8	5	south	flood	27.7	31.1	4.0
	7	16	11.9	0	–	high	28.0	41.4	3.5
	6.5	18	11.5	0	–	ebb	28.0	40.3	4.5
	6	17	11.3	6	south	ebb	28.2	46.9	5.0
	5	19	10.9	5	south	ebb	28.9	33.3	8.0
	4	18	10.6	0	–	ebb	29.4	20.7	7.5
9 Jul	4	18	10.7	0	–	low	29.0	22.9	6.5
	5	15	12.5	10	southwest	flood	27.0	38.2	3.0
	6	15	12.4	15	southwest	flood	27.1	47.4	2.5
	6.5	15	12.8	15	southwest	flood	26.6	41.5	2.5
	7	14	12.3	15	southwest	flood	27.0	45.2	2.5
	8	13	12.2	20	southwest	flood	27.4	25.6	2.5
10 Jul	8	20	12.2	15	southeast	flood	27.3	24.5	2.5
	7	15	12.1	16	southeast	ebb	27.3	43.6	3.0
	6.5	14	12.2	10	southeast	ebb	27.3	42.5	4.0
	6	17	12.2	12	southeast	ebb	27.4	20.2	3.0
	5	15	11.0	10	southeast	ebb	29.0	31.6	4.0
	4	16	11.1	5	southwest	flood	29.0	21.8	7.5
11 Jul	4	15	10.8	10	north	ebb	29.2	24.5	5.5
	5	15	10.9	5	northwest	ebb	29.1	31.1	7.5
	6	16	12.6	5	northwest	ebb	27.0	45.8	3.0
	6.5	19	12.6	0	–	ebb	27.2	39.7	3.5
	7	20	12.5	0	–	ebb	27.2	42.5	3.0
	8	21	13.2	5	northwest	low	27.8	24.5	3.5
12 Jul	8	17	12.9	0	–	flood	26.3	28.9	2.5
	7	19	12.8	0	–	flood	26.7	44.2	3.5
	6.5	18	11.8	0	–	flood	28.3	41.9	6.0
	6	21	11.2	0	–	high	28.9	45.8	7.5
	5	19	11.1	0	–	ebb	29.1	35.4	9.5
	4	18	10.8	0	–	ebb	29.3	22.9	10.0

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Date	Sta	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Tide stage	Salinity (ppt)	Water depth (f)	Secchi (m)
13 Jul	4	16	11.2	5	southwest	high	29.2	24.5	10.0
	5	17	11.4	5	southwest	ebb	29.1	31.6	7.5
	6.0	21	13.7	12	southwest	ebb	25.0	45.2	3.5
	7	20	13.7	12	southwest	ebb	25.0	40.9	3.0
	7	20	13.7	12	south	ebb	24.9	44.2	3.0
	8	21	13.9	15	southwest	ebb	25.0	29.9	3.0
14 Jul	8	17	13.4	15	southwest	low	25.6	28.3	3.5
	7	19	13.4	16	southwest	flood	25.3	42.5	4.5
	6.5	19	13.6	10	southwest	flood	24.6	41.9	4.5
	6	20	14.0	10	southwest	flood	24.4	36.5	4.0
	5	19	11.0	0	–	flood	29.2	31.1	12.5
	4	19	11.1	0	–	ebb	29.3	22.9	13.5
15 Jul	4	17	12.2	15	southwest	flood	28.1	24.5	6.0
	5	19	14.5	16	south	ebb	24.4	35.9	3.0
	6	20	14.7	18	southwest	ebb	23.6	36.5	4.0
	6.5	20	14.3	20	south	ebb	24.7	41.9	4.0
	7	23	14.3	19	south	ebb	24.5	41.9	4.0
	8	19	13.8	15	south	low	25.8	25.6	4.0
16 Jul	8	19	13.4	4	south	ebb	25.7	28.9	4.0
	7	–	–	–	–	–	–	–	–
	6.5	18	14.4	5	northeast	flood	23.7	41.9	3.0
	6	20	14.3	5	northeast	flood	25.2	46.9	2.5
	5	19	14.4	5	southwest	flood	25.8	33.8	4.0
	4	17	11.5	3	southwest	flood	28.9	24.5	10.0
17 Jul	4	18	13.7	15	southwest	flood	25.9	21.8	4.5
	5	18	14.2	12	south	flood	24.5	34.9	4.0
	6	21	14.8	10	southwest	flood	24.2	46.9	4.5
	6.5	21	14.1	5	south	flood	24.6	40.9	3.5
	7	20	14.8	3	south	flood	24.7	44.3	3.5
	8	21	13.5	4	south	high	25.4	29.4	4.0
18 Jul	8	18	13.5	20	southwest	ebb	25.7	28.9	3.0
	7	19	14.5	20	southwest	low	24	40.9	3.0
	6.5	18	14.2	15	southwest	flood	26.2	40.9	3.0
	6	17	14.1	10	southwest	flood	25.8	32.2	4.0
	5	19	12.9	16	southwest	flood	27.8	35.4	6.0
	4	17	11.7	15	southwest	flood	28.9	24.5	5.0

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Date	Sta	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Tide stage	Salinity (ppt)	Water depth (f)	Secchi (m)
19 Jul	4	–	–	–	–	–	–	–	–
	5	–	–	–	–	–	–	–	–
	6	–	–	–	–	–	–	–	–
	6.5	–	–	–	–	–	–	–	–
	7	–	–	–	–	–	–	–	–
	8	–	–	–	–	–	–	–	–
20 Jul	4	23	11.9	5	southwest	flood	29.1	20.7	7.0
	5	20	11.6	5	southwest	flood	28.8	37.1	10.0
	6	20	11.8	5	southwest	flood	28.6	45.2	6.0
	6.5	18	12.2	17	southwest	flood	28.6	41.9	5.0
	7	18	12.0	7	southwest	high	28.6	42.5	7.0
	8	17	13.7	6	southwest	ebb	27.3	52.0	5.0
21 Jul	8	17	12.6	25	southwest	ebb	27.3	22.9	2.5
	7	16	13.1	27	southwest	ebb	26.8	42.8	2.5
	6.5	17	12.8	28	southwest	ebb	27.2	40.9	1.5
	6	–	–	–	–	–	–	–	–
	5	–	–	–	–	–	–	–	–
	4	–	–	–	–	–	–	–	–
22 Jul	4	–	11.5	18	southeast	low	29.2	22.4	4.0
	5	–	11.8	17	southeast	flood	28.7	31.1	5.0
	6	–	12.4	6	southeast	flood	28.1	44.7	4.5
	6.5	–	12.8	5	south	flood	27.7	40.3	4.0
	7	–	12.8	4	south	flood	27.7	44.7	4.5
	8	–	12.5	9	southeast	flood	27.6	27.8	3.0
23 Jul	8	–	12.6	11	southwest	high	27.2	31.1	3.0
	7	–	12.3	10	southwest	ebb	27.8	42.5	5.5
	6.5	–	12.3	5	southwest	ebb	27.8	43.6	4.5
	6	–	13.4	15	southwest	ebb	26.8	43.1	3.5
	5	–	11.5	11	southwest	ebb	29.0	32.7	6.0
	4	–	11.7	4	–	low	29.2	21.3	5.5
24 Jul	4	17	11.2	5	–	low	29.2	21.8	4.0
	5	–	–	–	–	–	–	–	–
	6	16	12.2	20	south	flood	27.4	45.2	3.5
	6.5	15	13.5	13	south	flood	26.7	40.9	3.0
	7	15	13.6	15	south	flood	26.9	42.5	3.0
	8	–	–	–	–	–	–	–	–

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Date	Sta	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Tide stage	Salinity (ppt)	Water depth (f)	Secchi (m)
25 Jul	8	15	12.2	20	northeast	ebb	27.4	30.5	3.0
	7	14	12.7	15	north	ebb	27.5	44.2	4.0
	6.5	14	13.0	16	north	ebb	27.2	41.9	3.5
	6	14	12.8	11	north	ebb	27.5	45.8	4.5
	5	13	11.2	13	north	ebb	29.2	32.7	4.5
	4	14	11.5	15	north	flood	29.2	21.8	4.0
26 Jul	4	13	10.7	15	north	ebb	29.3	25.1	7.5
	5	14	10.6	12	north	ebb	29.2	35.4	5.0
	6	14	12.7	20	north	ebb	27.6	43.6	4.0
	6.5	15	12.3	19	north	ebb	27.8	43.6	4.0
	7	15	13.1	15	north	low	26.9	42.5	3.0
	8	15	13.0	10	north	flood	27.1	28.9	4.0
27 Jul	4	–	–	–	–	–	–	–	–
	5	–	–	–	–	–	–	–	–
	6	–	–	–	–	–	–	–	–
	6.5	–	–	–	–	–	–	–	–
	7	–	–	–	–	–	–	–	–
	8	–	–	–	–	–	–	–	–
28 Jul	4	15	11.0	0	–	flood	29.2	27.1	7.5
	5	14	11.0	0	–	high	29.2	35.4	7.0
	6.0	15	13.2	4	south	ebb	27.0	44.7	4.0
	6.5	16	13.7	3	south	ebb	26.5	42.5	4.5
	7	16	13.4	12	southwest	ebb	26.7	44.2	4.5
	8	15	13.4	15	southwest	ebb	26.6	25.1	3.0
29 Jul	8	16	13.8	18	southwest	flood	25.4	28.3	2.5
	7	15	14.0	16	southwest	flood	25.0	43.6	2.0
	6.5	15	14.1	22	southwest	flood	24.8	41.9	2.0
	6	14	11.7	22	southwest	flood	28.6	43.6	2.0
	5	–	–	–	–	–	–	–	–
	4	–	–	–	–	–	–	–	–
Averages		16	12.2	10	south	ebb	27.6	37.0	4.4
Min		11	10.0	0			23.6	20.2	1.5
Max		23	14.8	28			30.0	87.0	13.5

Note: Dashes indicate missing data.

Appendix A16.–Yearly mean values of physical observations made from the southern offshore test fishery project, 2002–2016.

Sta	Year	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Salinity (ppt)	Water depth (f)	Secchi (m)	Sta	Year	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Salinity (ppt)	Water depth (f)	Secchi (m)
4	2002	12.6	9.5	12.6	S	31.4	23.6	8.1	6	2002	12.8	10.1	13.4	S	30.4	45.1	4.2
	2003	14.1	10.6	12.0	S	31.2	23.4	8.3		2003	14.7	11.5	12.9	S	29.5	46.4	4.9
	2004	10.7	9.6	7.1	E	31.3	23.8	7.9		2004	10.6	10.3	8.0	SE	30.1	46.6	4.6
	2005	12.9	10.9	6.2	S	31.0	24.5	7.4		2005	12.8	11.6	8.0	S	29.4	45.8	4.7
	2006	11.1	9.9	6.0	SE	30.7	23.9	7.7		2006	12.8	11.6	8.0	S	29.8	45.8	4.7
	2007	10.8	8.6	4.7	SE	31.2	23.9	8.1		2007	11.0	9.5	6.0	S	30.0	47.2	4.8
	2008	11.0	9.3	8.0	SE	30.6	22.8	8.5		2008	10.4	9.3	6.2	S	29.5	47.3	5.0
	2009	11.0	9.1	6.2	SE	33.3	24.4	7.3		2009	11.5	10.2	6.0	SE	31.3	46.7	4.0
	2010	10.7	9.6	5.9	S	31.2	24.1	7.6		2010	11.2	9.9	6.1	S	30.1	46.6	4.7
	2011	10.8	8.8	3.7	S	31.5	23.9	7.7		2011	11.7	9.8	3.2	S	30.6	45.7	5.0
	2012	10.8	8.9	4.8	SE	30.5	25.4	8.9		2012	11.1	9.7	5.6	SE	29.2	48.2	5.1
	2013	11.4	9.4	5.2	S	30.9	45.4	8.4		2013	11.6	10.0	6.7	S	31.1	84.2	3.9
	2014	12.5	10.3	6.0	SE	32.9	24.9	7.8		2014	12.7	11.0	6.5	S	31.3	48.2	4.3
	2015	15.0	10.6	4.4	SE	30.9	24.9	7.8		2015	15.0	11.5	3.6	S	29.5	47.3	4.3
	2016	15.8	11.1	6.8	SE	29.1	24.5	6.6		2016	16.2	12.4	10.1	SE	27.2	44.8	4.0
	Avg	12.1	9.7	6.6	SE	31.2	25.6	7.9		Avg	12.4	10.6	7.4	S	29.9	49.1	4.6

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Sta	Year	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Salinity (ppt)	Water depth (f)	Secchi (m)
5	2002	12.8	9.7	13.9	S	30.9	35.8	6.3
	2003	14.0	11.0	13.3	SE	30.6	35.7	6.3
	2004	10.7	9.9	7.2	SE	30.7	34.7	7.1
	2005	13.1	11.1	5.9	S	30.6	36.3	6.5
	2006	11.1	10.2	7.6	S	30.2	35.4	5.6
	2007	10.8	8.7	4.6	S	30.9	35.4	7.2
	2008	10.4	8.8	6.7	SE	30.4	35.4	6.4
	2009	11.1	9.6	6.6	SE	32.4	35.9	5.8
	2010	11.0	9.5	5.5	SE	30.8	35.3	6.7
	2011	11.6	9.2	4.0	S	31.1	36.0	6.4
	2012	11.0	9.2	5.7	SE	30.1	36.8	7.2
	2013	11.0	9.8	5.4	S	31.1	68.5	5.4
	2014	12.7	10.7	5.9	SE	32.2	37.0	6.6
	2015	14.8	11.1	4.2	SE	30.5	35.3	6.3
	2016	15.8	11.5	8.2	SE	28.4	35.2	6.0
	Avg	12.1	10.0	7.0	SE	30.7	37.9	6.4

Sta	Year	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Salinity (ppt)	Water depth (f)	Secchi (m)
6.5	2002	12.6	10.4	13.7	S	30.0	42.6	3.3
	2003	14.4	11.7	14.9	S	29.1	41.3	4.1
	2004	10.7	10.8	10.1	SE	29.4	41.6	3.6
	2005	13.2	12.2	7.4	S	28.7	42.8	4.2
	2006	11.2	10.3	8.5	SE	29.7	41.6	3.4
	2007	11.1	9.7	6.2	S	29.8	42.9	4.3
	2008	10.4	9.6	6.3	S	29.2	42.3	4.4
	2009	11.8	10.4	6.4	S	31.0	42.5	3.7
	2010	11.2	10.1	6.2	S	29.7	41.7	3.7
	2011	11.3	10.2	4.5	S	29.9	42.5	4.2
	2012	11.3	9.9	4.5	SE	28.9	44.0	4.7
	2013	11.3	10.5	5.8	S	31.2	79.4	3.5
	2014	13.0	11.3	6.8	S	30.8	42.0	3.9
	2015	15.3	11.5	4.8	S	28.1	42.5	3.7
	2016	16.0	12.6	4.0	SE	26.9	42.5	3.6
	Avg	12.3	10.7	7.3	S	29.5	44.8	3.9

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Sta	Year	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Salinity (ppt)	Water depth (f)	Secchi (m)
7	2002	12.4	10.4	12.4	SE	29.9	44.0	2.8
	2003	14.3	11.6	13.0	S	29.0	44.3	3.6
	2004	10.6	11.0	9.7	SE	28.8	44.7	2.7
	2005	12.9	12.3	7.6	S	28.3	44.8	3.6
	2006	10.8	9.9	6.8	S	29.4	42.4	3.1
	2007	11.2	9.9	6.2	S	29.5	45.5	3.8
	2008	10.6	9.8	6.2	S	29.4	44.9	4.2
	2009	11.7	10.4	5.5	S	31.2	45.0	3.5
	2010	11.4	10.3	5.7	S	29.4	44.9	2.9
	2011	11.5	10.4	3.9	S	29.8	44.8	3.8
	2012	11.3	10.0	5.1	SE	28.8	46.4	3.8
	2013	11.4	10.6	4.6	S	31.1	79.8	3.1
	2014	13.0	11.3	6.1	S	30.8	45.4	3.6
	2015	14.8	11.7	4.9	S	27.9	46.4	3.2
	2016	16.1	12.7	10.8	SE	26.8	44.4	3.4
	Avg	12.3	10.8	7.2	S	29.3	47.2	3.4

Sta	Year	Air temp (c)	Water temp (c)	Wind vel. (knots)	Wind dir	Salinity (ppt)	Water depth (f)	Secchi (m)
8	2002	12.1	10.3	11.8	SE	30.0	29.4	2.4
	2003	13.7	11.2	11.6	SE	28.1	28.9	3.1
	2004	10.8	11.0	9.1	SE	29.3	28.7	2.4
	2005	12.8	12.1	7.7	S	28.5	29.8	3.3
	2006	11.8	10.5	6.7	S	29.0	30.4	3.0
	2007	11.2	9.9	5.5	S	29.5	29.8	3.2
	2008	10.9	9.7	5.9	SW	29.2	29.9	3.7
	2009	11.6	10.5	5.9	S	31.2	29.6	3.4
	2010	11.7	10.2	5.2	SE	29.3	29.9	2.7
	2011	12.2	10.3	3.8	S	29.8	29.6	3.2
	2012	10.8	10.0	4.8	SE	28.6	30.4	3.2
	2013	17.7	10.5	4.8	S	30.7	55.2	2.8
	2014	13.2	11.3	6.3	S	30.8	31.5	3.5
	2015	15.2	11.6	5.8	S	27.7	30.1	2.6
	2016	16.3	12.6	10.8	S	27.0	29.7	3.2
	Avg	12.8	10.8	7.1	S	29.2	31.5	3.0

Appendix A17.–Yearly mean values for selected chemical and physical variables collected during the southern offshore test fishery project, 1979–2016.

Year	Air temp. (c)	Water temp. (c)	Wind vel. (knots)	Salinity (ppt)	Secchi (m)
1979	12.4	12.2	5.9	25.0	5.7
1980	12.4	10.0	8.2	24.8	4.2
1981	13.4	11.0	10.1	23.1	4.1
1982	12.0	8.5	9.0	20.3	5.0
1983	14.9	10.9	9.4	20.6	4.7
1984	13.5	10.8	9.1	-	5.3
1985	10.8	8.2	9.2	28.0	5.5
1986	10.6	9.1	8.2	-	5.4
1987	12.6	10.1	4.1	28.4	5.1
1988	14.2	9.1	8.9	30.2	4.7
1989	13.1	10.0	4.4	27.7	4.7
1990	12.3	11.4	8.5	21.3	4.6
1991	10.9	9.9	6.6	-	4.1
1992	12.0	11.1	5.4	28.4	4.3
1993	13.5	10.5	6.9	26.2	5.0
1994	13.0	10.0	9.3	29.0	6.0
1995	13.1	9.5	7.9	26.5	4.6
1996	12.6	10.0	9.1	30.8	4.7
1997	13.8	10.5	10.0	30.6	4.0
1998	12.5	10.3	8.3	30.0	5.4
1999	13.4	10.3	12.4	30.2	4.5
2000	13.5	10.5	12.2	30.1	5.2
2001	12.9	10.7	10.7	30.1	5.2
2002	12.5	10.1	13.0	30.4	4.5
2003	14.2	11.3	12.9	29.6	5.0
2004	10.7	10.4	8.5	30.0	4.7
2005	13.0	11.7	7.1	29.4	5.0
2006	11.3	10.3	7.2	28.4	4.6
2007	11.0	9.4	5.5	30.2	5.3
2008	10.5	9.3	6.3	29.7	5.3
2009	11.4	10.0	6.1	31.8	4.7
2010	11.2	9.9	5.8	30.1	4.7
2011	11.5	9.8	3.9	30.4	5.1
2012	11.0	9.6	5.1	29.4	5.5
2013	11.0	12.5	5.5	31.0	4.7
2014	12.8	10.9	6.1	31.4	4.9
2015	15.0	11.3	4.6	29.1	4.7
1992-2015 Avg	12.4	10.4	7.9	29.7	4.9
2016	16.0	12.2	10.0	27.6	4.4