Fishery Data Series No. 19-33

Summary of 2017 and 2018 Norton Sound Red King Crab Bottom Trawl Surveys

by

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and

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December 2019

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

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December 2019

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This document should be cited as follows:
Bell, J., and T. Hamazaki. 2019. Summary of the 2017 and 2018 Norton Sound red king crab bottom trawl surveys. Alaska Department of Fish and Game, Fishery Data Series No. 19-33, Anchorage.

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ABSTRACT

Norton Sound bottom trawl surveys were completed in 2017 and in 2018 because the historical triennial cycle was adjusted to an annual schedule. Population abundance estimates for red king crab *Paralithodes camtschaticus* and annual catch per unit effort (CPUE) were calculated for all species using the area-swept method. The 2017 legal male red king crab abundance was 941,797 (coefficient of variation [CV] 29%) or 2.83 million pounds. The abundances of prerecruit-1 and prerecruit-2 crab were 288,615 (CV 35%) and 258,235 (CV 35%). The 2018 legal male red king crab abundance was 303,806 (CV 31%) or 0.97 million pounds. The 2018 legal male abundance was the lowest in the history of the trawl survey. The abundances of prerecruit-1 and prerecruit-2 crab were 151,903 (CV 41%) and 212,664 (CV 28%). Purple-orange sea stars were the most abundant species in both years, whereas adult walleye pollock *Theragra chalcogramma* and Pacific cod *Gadus macrocephalus* went from fourth and fifth most abundant species in 2017 to second and third most abundant in 2018. Adjustments to trawling methods increased the efficiency of the project and future surveys should attempt to address some of the basic assumptions used in the area-swept calculations.

Key words: red king crab, *Paralithodes camtschaticus*, bottom trawl survey, abundance estimate, area-swept method, Norton Sound

INTRODUCTION

Prior to 1976, information about the distribution and abundance of demersal biota in Norton Sound was found in early manuscripts (e.g., Andriyashev 1937; Ellison et. al. 1950) and included an Atomic Energy Commission assessment survey of demersal fishes and invertebrates of the southeast Chukchi Sea/Norton Sound region (Wilimovsky 1966). From 1976 to 1991, National Marine Fisheries Service (NMFS) conducted comprehensive triennial stock assessment trawl surveys of Norton Sound. During this same time, Alaska Department of Fish and Game (ADF&G) also conducted red king crab *Paralithodes camtschaticus* summer pot surveys in 1980, 1981, 1982, and 1985 to provide information on annual distribution and abundance, as well as preseason information to fishery managers regarding stock size and recruit composition (Powell et al. 1983; Schwarz et al. 1982; Schwarz 1984; and Brannian 1987). Due to budget constraints, NMFS did not survey the Norton Sound area in 1994 and it wasn't until 1996 that ADF&G reestablished the bottom trawl survey program in Norton Sound. With funding assistance from NMFS and Norton Sound Economic Development Corporation (NSEDC), ADF&G conducted surveys in 1996, 1999, 2002, 2006, 2008, 2011, 2014, 2017, and 2018 (Table 1). Although the survey provides information about all species captured, the focus of the survey is red king crab. Biological information about red king crab is used in harvest management.

Red king crab are harvested in Norton Sound subsistence and commercial fisheries in the summer and winter each year. Commercial fisheries for red king crab occur in 2 seasons: (1) June 15 to September 3 (summer); and (2) January 15 to April 30 through the ice only (winter). The commercial fishery commenced in 1977 but subsistence users, who primarily fish through the ice, were harvesting red king crab well before the commercial fishery began. The summer commercial fishery 5-year average (2012–2016) harvest was approximately 430,000 pounds and has ranged from a low of 20,000 pounds in 1999 to a high of 3,000,000 pounds in 1979. Winter commercial fishery harvests were nominal between 1990 and 2012 and averaged about 10,000 pounds annually. Since then, average harvest in the winter fishery has been closer to 70,000 pounds (Menard et al. 2017).

Guideline harvest levels for the summer and winter commercial red king crab fisheries are set using abundance estimated from the catch of red king crab in the bottom trawl. Therefore, the main objectives of the bottom trawl survey are to provide an abundance estimate of Norton

Sound red king crab and describe the red king crab recruit class composition. Additional objectives are to collect biological information about potential commercial species and estimate annual catch per unit effort (CPUE) for all non-red king crab species.

OBJECTIVES

1. Estimate Norton Sound red king crab abundance using the area-swept method.
2. Describe the size composition by sex and recruit class and the spatial distribution of Norton Sound red king crab.
3. Collect lengths and weights from commercial or potential commercial species captured, specifically: blue king crab *Paralithodes platypus*, Pacific halibut *Hippoglossus stenolepis*, Pacific cod *Gadus macrocephalus*, and walleye pollock *Theragra chalcogramma.*
4. Estimate annual CPUE for all non-red king crab organisms.

METHODS

STUDY LOCATION AND DESCRIPTION

The Norton Sound Section is located in the Northern District of the ADF&G Registration Area Q and includes all waters east of the International Date Line between the latitudes of Cape Romanzof and 66°N (Figure 1). Norton Sound was divided into a grid of 10 by 10 nmi stations and each station was identified by a number (Figure 2). Historically, the coverage area was grouped into levels of priority: Core stations, and Tier 1, Tier 2, and Tier 3 stations (Fair 1998). During the survey, Core and Tier 1 stations were given the highest priority, and Tier 2 and Tier 3 stations were surveyed as time allowed. The Core consisted of 41 stations, 36 of which were trawlable. Stations 177, 178, 201, 204, and 205 were not trawled because of poor substrate conditions (Blau et al. 1996; Soong and Banducci 2006; Soong 2008). Tier 1 consisted of 16 stations, 11 of which were trawlable. Stations 162, 188, 206, 207, 222, and 223 were not trawled because of rocky bottom (Blau et. al. 1996). Tier 2 consisted of 14 stations, 7 of which were trawlable without net damage. Stations 174, 147, 120, 93, 68, 69, and 70 were excluded due to unsuitable bottom substrate. Finally, Tier 3 consisted of 7 stations and 6 were trawlable.

TRAWL GEAR AND DEPLOYMENT

In 2017 and 2018, a 400 eastern otter trawl net with two 1.5 m x 2.1 m Astoria "V" doors was used to complete the survey. Each tow originated at the center of the station unless bottom conditions were not favorable. In those cases, the skipper selected a better starting location. Additionally, direction of towing was determined by the skipper. Each tow covered 1 nmi. Location and towed distance were recorded with a global positioning system (GPS) device and bottom temperature was logged with a HOBO[1] logger attached to the head rope of the net, recording at 3-minute intervals. A conductivity, temperature, depth (CTD) profiler was deployed at each station prior to putting the net in the water.

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

CATCH SAMPLING

In 2017, to attempt to consolidate the catch in the codend during net retrieval, the net was towed at the surface for approximately 2 minutes starting when the codend was about 50 feet from the boat. For some tows this method was not enough to move organisms to the codend and, therefore, the intermediate portion of the net was shaken down as the net was being retrieved. Towing was abandoned in 2018 because of the potential for net damage and the net was only shaken to move organisms to the codend. Once the codend was on board, the boat boom, with a crane scale attached, was used to lift the net and obtain a gross haul weight of the codend. The contents of the codend were emptied on deck, and the net re-weighed to calculate the net haul weight.

King crab and large fish species, such as Pacific halibut, large walleye pollock, large Pacific cod, and Alaska skate *Bathyraja parmifera* were removed from the catch before subsampling. Length and weight of each halibut (if practical), and the weight of the skates were recorded as quickly as possible, so the fishes could be released immediately. All other large fish were dealt with as time allowed. For large fish species number, total weight (except for Pacific halibut), and individual lengths (total body length, mm) were recorded before returning these species to the sea. Average weight for individuals was calculated by dividing total weight by the number caught. If halibut were too numerous to weigh quickly or too large to weigh, individual fish weight was calculated using the length to weight conversion equation:

$$W = 0.000009205 \times L^{3.24}$$

where W is weight in pounds and L is length in cm (R. Webster, International Pacific Halibut Commission, Seattle, WA, personal communication). In addition to large fish, any large debris was removed from the catch and weighed. The combined weight of king crab, large fish species, and large debris was subtracted from the net haul weight to obtain the adjusted haul weight. After all king crab and large fish were removed from the catch, 2 or 3 subsamples were collected from the rest of the catch before the remaining haul was shoveled overboard. The weight of each subsample was recorded, and the contents sorted to the lowest taxon. Each taxon was counted and total weight recorded. If the total catch was less than 100 kg (150 kg in 2018) then the entire catch was sorted and weighed.

Total number and weight of each king crab species captured was recorded and species, sex, carapace length [CL, mm, from the posterior margin of the right eye socket to the midpoint of the rear margin of the carapace (Wallace et. al. 1949)], legal size, shell condition, and egg development, if applicable, were recorded for each crab. Legal size was determined using a 4.75-inch legal stick to measure carapace width (CW). Male red king crab were classified into the following categories:

- Legal: CW (including spines) ≥121 mm (4.75 in) or CL ≥104 mm when CW was not measured.
- Sublegal: CW (including spines) <121 mm (4.75 in) or CL <104 mm when CW was not measured.
- Prerecruit-1: sublegal with CL ≥ 90 mm.
- Prerecruit-2: sublegal with 76 mm ≥ CL < 90 mm.
- Prerecruit-3: sublegal with CL < 76 mm.
- Recruit: legal new-shell with 104 mm ≥ CL < 116 mm.

- Postrecruit: legal new-shell with CL ≥ 116 mm and legal old-shell with 104 mm ≥ CL < 116 mm.

Shell condition was evaluated using criteria from the *Shellfish observer manual*[2]:

Soft-shell: The crab has molted within recent weeks. Exoskeleton is still soft and pliable from recent molt.

New-shell-pliable: The coxa and ventral surface of the exoskeleton are white. The legs are easily compressed when pinched (legs contain little muscle at this time). The exoskeleton is fragile and subject to breakage or puncture. With carapace removed, the gills appear translucent cream in color. Crab with this type of shell had their present exoskeletons for approximately 1–3 months.

New-shell-hard: The coxa and ventral surface of exoskeleton are white. Exoskeletal spines and dactyls are sharp but may show slight wear. The legs are mostly full of muscle, merus not easily compressed by pinching. If carapace is removed, the gills will be a light cream color. Crab with this type of shell had their present exoskeletons for 4–12 months.

Old-shell: The distal portion of the ventral coxa is partially or totally rimmed with brown scratches or dots. Exoskeletal spines and dactyls are worn and typically dull at the tips. The legs are full of muscle and the merus is difficult to compress when pinched. If carapace is removed, gills are tan in color from fouling microorganisms. Crab with this type of shell had their present exoskeletons for 13–24 months.

Very-old-shell: The distal portion of the ventral coxa is continuously rimmed with black scratches or dots. The legs are full of muscle and the merus is difficult to compress when pinched. The tips of the dactyls are worn round and black. If the carapace is removed, gills appear dark gray or dark gray-brown in color from fouling microorganisms. Crab with this type of shell had their present exoskeletons more than 24 months.

Prior to 2006 mature females were defined as ≥72 mm CL or had matted pleopodal setae or egg clutches, whereas juveniles were defined as <72 mm CL with clean pleopodal setae. This method was based on the statistical probability that 50% of female crabs are mature at ≥72 mm CL.[3] Beginning in 2006 female maturity was determined by examining the extent of development of the abdominal flap. If there were eggs present or the abdominal flap extended to the coxa, the female was considered mature (Donaldson and Byersdorfer 2005). For the 2017 trawl, female egg condition was noted when applicable, but maturity was not consistently assessed using the most recent method (i.e., abdominal flap extension). In 2018, female maturity was assessed using the presence of eggs and extension of the abdominal flap.

RED KING CRAB POPULATION ESTIMATION

To obtain a population estimate for red king crab, the area-swept method (Alverson and Pereyra 1969) was used for direct comparison to previous analyses. Abundance estimates were standardized for the number of trawlable stations (n) each year for legal, prerecruit-1, and prerecruit-2.

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[2] Alaska Department of Fish and Game Shellfish Observer Program. 2008. Crab Observer Training and Deployment Manual. Not published. Available by request from the Dutch Harbor ADF&G shellfish observer program office, (907) 581-1239.

[3] Bromaghin, J. 1996. Logistic analysis of female crab maturity at length. Alaska Department of Fish and Game, Division of Commercial Fisheries; memo to Fred Bue, September 5, 1996.

Area swept (a_j) was calculated by multiplying the width of the net opening (assumed to be the same for each trawl; 0.00658316 nmi) by the distance towed in station (j). Abundance for each crab class (N) for station (j) was estimated as:

$$N_j = n_j \frac{A_j}{a_j}, \tag{1}$$

where n_j is the number of crab from station (j) and A_j is the total area of station (j).

Total crab abundance ($\hat{N}$) was estimated as the sum of estimated station abundances:

$$\hat{N} = \sum_j N_j . \tag{2}$$

The variance of $\hat{N}$ was estimated as:

$$V(\hat{N}) = \frac{n\sum (N_j - \overline{N})^2}{n-1}, \tag{3}$$

where n is the number of stations trawled; including stations with 0 crab.

Coefficient of variation (CV) was calculated by dividing the square root of variance with the total abundance estimate:

$$CV = \frac{\sqrt{V(\hat{N})}}{\hat{N}} . \tag{4}$$

CATCH COMPOSITION

For all taxa, total catch weight ($\hat{W}_{i,j}$) of taxon (i) on station (j) was estimated as:

$$\hat{W}_{ij} = w_{ij} \frac{T_j}{t_j}, \tag{5}$$

where w_{ij} is the subsample weight of taxon (i) on tow (j), T_j is the adjusted haul weight, and t_j is the subsample weight.

Catch per unit effort (CPUE; kg/km^2) for each taxon (i) at each station (j) was calculated as:

$$CPUE_{ij} = \frac{W_{ij}}{a_j}, \tag{6}$$

where a_j is the swept area at station (j).

Annual CPUE for each taxon was calculated as the geometric mean of non-zero station CPUE multiplied by the proportion of non-zero tows (Hamazaki et al. 2005).

RESULTS

TRAWL GEAR AND DEPLOYMENT

The trawl survey was delayed about 10 days in 2017 and began on July 28. Trawling was complete on August 8 and there were 3 weather days: July 31–August 1 and August 4. All trawlable stations in the Core and Tier 1–3 sections were completed for a total of 60 stations in 9 days (Figure 3).

In 2018, the trawl survey began on July 22 and 60 stations were completed in 8 days (Figure 4). There were no weather delays in 2018 and calm weather allowed 8 stations per day, except for 1 day when 9 stations were completed to ensure the survey finished ahead of predicted bad weather.

In 2017, bottom temperatures ranged between 3.5°C and 14.6°C. The coldest temperature was recorded at Station 135, the furthest west station, and the warmest temperature was recorded at Station 202, one of the stations closest to land (Table 2; Figure 5). The average trawl depth was 10.1 fathoms, ranging from 7.1 fathoms at Station 181 to 17.2 fathoms at Station 135 (Table 2; Figure 3).

In 2018, bottom temperatures ranged between 2.9°C and 14.2°C. The coldest temperature was recorded at Station 134, one of the westernmost stations, and the warmest temperature was recorded at Station 176 (Table 3; Figure 6). The average trawl depth was 9.4 fathoms ranging from 6.8 fathoms at Station 102 to 15.3 fathoms at Station 121 (Table 3; Figure 4)

CATCH SAMPLING

In 2017, 56 of 60 trawls were subsampled including haul 2 at Station 185, where total catch was approximately 78 kg and subsamples were taken; only 4 stations were complete censuses. There were 105 types of organisms identified in the 2017 trawl survey. In 2018, a total of 53 stations were subsampled and 7 tows were full censuses of the catch. There were 111 types of organisms identified in 2018.

In 2017, a total of 145 male and 43 female red king crab were caught (Table 2). Male crab consisted of 83 (57.2%) prerecruits, 15 (10.3%) recruits, and 47 (32.4%) postrecruits, ranging in size from 16 mm to 152 mm CL (Table 2; Figure 7). Of the 62 legal crab, less than half (45.2%) were new-shell (Figure 8), whereas 83 (86.7%) of sublegal crab were new-shell (Figure 9). Female red king crab ranged in size from 20 mm to 109 mm CL and no female crab 68 mm CL and less (n = 16) had eggs. Conversely, only 5 female crab greater than 68 mm CL had no eggs. Of the 22 female crab carrying eggs, 17 crab (77.3%) had relatively full (>60%) clutches (Table 4). Most of the clutches were purple in color and appeared to be uneyed without dead eggs.

In 2017, red king crab were captured throughout the trawl area. Legal red king crab were predominantly captured in western stations (Figure 10) as were sublegal prerecruit-1 and precrecruit-2 crab (Figures 11 and 12). Sublegal prerecruit-3 crab were captured in western stations but were also captured in stations in the middle of the survey area (Figure 13). Female red king crab were generally present throughout the trawl area (Figure 14).

In 2018, a total of 518 male and 424 females red king crab were caught including 2 male crab whose carapace lengths could not be determined (Table 3). Male crab consisted of 496 (96.1%)

prerecruits, 2 (0.4%) recruits, and 18 (3.5%) postrecruits ranging in size from 7 mm CL to 146 mm CL (Table 3; Figure 15). Of the 20 legal crab, 13 (65.0%) were old- or very-old-shell (Figure 16) and most of the sublegal crab were new-shell (464, 93.5%; Figure 17). Additionally, 7 (1.4%) sublegal crab were soft-shell. Female red king crab were composed of 405 (95.5%) juvenile and 19 (4.5%) mature individuals ranging in size from 19 mm CL to 100 mm CL. Of the 19 mature females, 13 (68.4%) had relatively full (>60%) clutches (Table 5). All egg clutches were purple except 1 that was purple-brown and appeared to be uneyed with no dead eggs.

In 2018, legal red king crab were more abundant in the western stations (Figure 18). Most of the sublegal red king crab were captured in the middle of the trawl area (Figures 19, 20, and 21), which was where most females were captured (Figure 22).

RED KING CRAB POPULATION ESTIMATION

In 2017, abundance of legal male red king crab was 941,797 (CV 29%) or approximately 2.83 million pounds. Abundance of prerecruit-1 males was 288,615 (CV 35%) and prerecruit-2 males was 258,235 (CV 30%; Table 6).

In 2018, abundance of legal male red king crab was 303,806 (CV 31%) or approximately 0.97 million pounds. Abundance of prerecruit-1 males was 151,903 (CV 41%) and prerecruit-2 males was 212,664 (CV 28%; Table 6).

CATCH COMPOSITION

Based on 2017 annual CPUE, the 5 top-ranking taxa out of the 105 taxa identified were purple-orange sea star *Asterias amurensis*, saffron cod *Eleginus gracilis*, blackspined sea star *Lethasterias nanimensis*, adult walleye pollock, and Pacific cod. Invertebrate species accounted for over half (22) of the 40 top-ranking taxa by annual CPUE (Table 7). Four large fish species were captured in 2017: 18 Pacific halibut with an average length of 704 mm (SD = 165) and an average weight of 5.0 kg (SD = 4.8); 170 Pacific cod with an average length of 638 mm (SD = 76) and an average weight of 3.1 kg; 536 adult walleye pollock with an average length of 583 mm (SD = 60) and an average weight of 1.3 kg; and 3 Alaska skates with an average weight of 7.5 kg (Table 8).

Based on 2018 annual CPUE, the 5 top-ranking taxa out of the 111 taxa identified were purple-orange sea star, adult walleye pollock, Pacific cod, saffron cod, and blackspined sea star. Invertebrate species accounted for 22 of the 40 top ranking taxa by annual CPUE (Table 9). Similar to 2017, 4 large fish species were caught in 2018: 9 Pacific halibut, 8 of which had an average length of 643 mm (SD = 100) and an average weight of 3.3 kg (SD = 1.6), and 1 large halibut measuring 1,524 mm and weighing 19.4 kg; 159 Pacific cod with an average length of 665 mm (SD = 65) and an average weight of 3.7 kg; 950 adult walleye pollock with an average length of 576 mm (SD = 59) and an average weight of 1.4 kg; and 3 Alaska skates with an average weight of 10.0 kg (Table 8).

DISCUSSION

Highlighting the importance of the trawl survey for setting commercial fishery harvest guidelines, funding was secured in 2018 to conduct an annual trawl survey. Prior to 2017, the survey was conducted approximately every 3 years and starting in 2018, and into the foreseeable future, the survey will be conducted each year. In addition to increased frequency, trawl area and station priority have been adjusted. Prior to the 2018 trawl survey, stations were placed in

4 groups (Fair 1998): Core, Tier 1, Tier 2, and Tier 3. Survey priority was given to Core and Tier 1 stations as time and weather allowed. In 2017, all stations within the 4 groups were trawled except Station 97 (Figure 3), which had caused net damage in the past. In 2018, the 4 groups were removed and replaced with a large area encompassing 60 stations (Figure 4). The new standard stations were informed by the 4 groups but were adjusted slightly to include stations where crab have been caught while maximizing travel efficiency and minimizing potential net damage. All 60 stations were trawled in 2018.

In addition to changes in stations trawled in 2018, there were changes to the trawl methods starting in 2017. The captain felt the trawl doors were not opening correctly and suggested there was too much wire out when the net was deployed. National Oceanic and Atmospheric Administration (NOAA) bottom trawl protocol suggests the scope of the warp wire should be approximately 3:1; warp length to water depth and in shallow waters (i.e., <21 fathoms), protocol suggests 75 fathoms of wire be used with little to no adjustment for depth (Stauffer 2004). This is important because all Norton Sound trawl stations are in waters less than 21 fathoms. It was decided that scope would be maintained at an approximate ratio of 3:1 for hauls 23–60 in 2017, and the captain was pleased with how the net and doors performed under those conditions. Additionally, NOAA protocol suggests towing gear at 3 knots (Stauffer 2004), whereas the Norton Sound survey gear has historically been towed at 2 knots. Because the net appeared to fish better, the captain was confident in increasing towing speed to 2.4–2.7 knots for hauls 36–60 in 2017. These methods were also applied to the 2018 survey.

Adjustments to net towing and towing speed during calm weather allowed increased efficiency such that 7–8 tows were completed each day in both years, which contributed to the success of completing the survey. However, increased efficiency led to other concerns regarding how the net is fishing. Currently, abundance for red king crab and annual CPUE for other species captured in the bottom trawl are calculated using the area-swept method (Alverson and Pereyra 1969), which is based on distance towed and width of the trawl net. For the Norton Sound surveys, it is assumed net width is the same for all hauls and the net is making constant contact with the bottom. The width of a trawl net can be affected by the depth of fishing, how the trawl is rigged, and currents (West 1981) suggesting net width can vary between tows. Thus, inaccuracies in net width can lead to over or underestimating biomass (Weinberg and Kotwicki 2015). Additionally, a trawl net that is not operating at its optimum width can affect catchability (Rose and Walters 1989). For instance, a trawl net that is spread too wide creates tension on the foot rope causing it to lift off bottom thus decreasing catch efficiency (Main and Sangster 1981; von Szalay and Somerton 2005). Like net width, it is assumed the net is towed for 1 nautical mile at each station and is in constant contact with the bottom. Given the consequences of inaccurate net widths and distance towed assumptions, addressing current assumptions about net characteristics would improve or justify biomass estimates produced using the area-swept method. It is recommended on future surveys that net characteristics be evaluated.

After reaching a record high abundance estimate in 2014, legal red king crab abundance declined in 2017, and hit a record low in 2018 (Table 6). The decrease in legal crab was not unexpected because of the comparatively low number of prerecruit-3 crab caught in the 2014 trawl survey. In 2014, the abundance estimate of prerecruit-3 crab was less than half the prerecruit-1, and approximately half of the prerecruit-2 abundance estimates (Soong and Hamazaki 2015). Prerecruit-3 red king crab, or crab less than 76 mm CL, will generally recruit to the fishery in 3+ years. The abundance of prerecruit-3 crab in 2014 indicated the abundance of legal red king

crab would probably decrease within 3 to 4 years. Conversely, the number of crab less than 76 mm CL captured in 2018 (Figure 21) suggests there was a strong recruitment event that may result in increased abundance of legal crab in coming years. An annual trawl survey should be able to follow the growth of that cohort to get a better idea of its timing and potential recruitment into the fishery.

The number of female red king captured in 2017 (43) was the lowest number captured in the history of the survey, followed the next year by the highest number captured in the survey (424; Table 6). The implication of these differing counts is unknown because there is little information about female reproductive potential and the interactions within and between age cohorts during mating. Male and female red king crab have similar growth rates prior to maturity (Weber 1967), and after maturity, females have a smaller molt increment than males (Sakuda 1958). Additionally, Norton Sound male red king crab mature around 50 mm CL (Paul et al. 1991), whereas female red king crab reach maturity at a larger size (>65 mm CL; Powell et al. 1983; Brannian 1987; Otto et al. 1989). The differences in size at maturity make it difficult to discern patterns between the abundance of males and females and the possible effects it may have on the stock. Further, additional reproductive information remains relatively unknown such as reproductive success by age for both male and female crab and the effects of natural or fishery-induced sex ratios. Beyond the trawl survey, interactions between male and female red king crab need further study to better understand what the female data collected in the annual survey means.

Similar to past surveys, purple-orange sea stars had the highest annual CPUE of all taxa in 2017 and 2018 (Tables 7 and 9). Interestingly, there was a shift in the top 5 taxa between years. In 2017, behind purple-orange sea stars, the next highest annual CPUEs were saffron cod, blackspined sea stars, adult walleye pollock, and Pacific cod (Table 7). In 2018, adult walleye pollock and Pacific cod increased in abundance and displaced saffron cod and blackspined sea stars as the second and third highest annual CPUE (Table 9). Adult walleye pollock annual CPUE increased 92% and Pacific cod annual CPUE increased 42% between 2017 and 2018. Prior to 2017, the maximum number of adult walleye pollock captured in the survey was 62 in 1996, and 30 Pacific cod were captured in 2008 (Table 8). An annual survey would allow data collection of changes to abundance of these potential commercial species into the foreseeable future.

The abundance of Norton Sound red king crab as assessed by the bottom trawl survey is a major component of the *Norton Sound red king crab stock assessment and fishery evaluation* model (NPFMC 2018), a prediction model that determines commercial harvest allocations. As such, information needs to be collected consistently and accurately. Adjustments to survey methods have increased the overall efficiency of the survey and focus should now be directed to addressing assumptions that are currently being used in the abundance calculations. The increased frequency of the survey will also contribute to our understanding of recruitment and help track changes in composition that are happening quickly (e.g., walleye pollock and Pacific cod).

ACKNOWLEDGEMENTS

We wish to thank the crew of the R/V *Pandalus* Captain Ted Jewell, Engineer Dave Knight, and Mates Jed Gautier (in 2017) and Charlie Schollenberg (in 2018) for keeping the boat and gear running and helping to increase survey efficiency. We also thank Larry Neff, Sean Larson, Anvil Boeckmann, Sabrina Garcia, Luke Henslee, Myra Scholze, and Dawn Wehde (NSEDC) for their efforts in sampling and species identification, and an anonymous reviewer who improved this report.

REFERENCES CITED

Alverson, D. L., and W. T. Pereyra. 1969. Demersal fish explorations in the northeastern Pacific Ocean. Journal of Fisheries Research Board of Canada 26:1985–2001.

Andriashev, A. P. 1937. K poszaniyu ikhtiofauny Beringova i Chukotskogo Morei [A contribution to the knowledge of the fishes from the Bering and Chukchi seas]. Issled. Morei SSSR, 25:292-355. Translation by Fish and Wildlife Service, U.S, Department of the Interior, Special Scientific Report: Fisheries, 145:1–81, 1955.

Blau, S. F., L. J. Watson, and J. Blackburn. 1996. The 1996 Norton Sound red king crab trawl survey. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K96-54, Kodiak.

Brannian, L. K. 1987. Population assessment survey for red king crab (*Paralithodes camtschatica*) in Norton Sound, Alaska, 1985. Alaska Department of Fish and Game, Technical Data Report No. 214, Juneau.

Brennan, E. L. 2002. Analysis of red king crab data from the 2002 ADF&G trawl survey of Norton Sound. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-52, Anchorage.

Donaldson, W. E., and S. C. Byersdorfer. 2005. Biological field techniques for lithodid crabs. Alaska Sea Grant College Program, University of Alaska, AK-SG-05-03.

Ellison, J. G., B. Knake, and J. Dassow. 1950. Exploratory fishing expedition to the northern Bering Sea in June and July 1949. United States Fish and Wildlife Service, Fishery Leaflet 369, Washington, D.C.

Fair, L. F. 1997. Analysis of red king crab data from the 1996 ADF&G trawl survey of Norton Sound. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A97-10, Anchorage.

Fair, L. F. 1998. Standardization of Norton Sound trawl survey red king crab abundance estimates. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A98-36, Anchorage.

Fair, L. F., and E. L. Brennan. 2000. Analysis of red king crab data from the 1999 ADF&G trawl survey of Norton Sound. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A00-26, Anchorage.

Hamazaki, T., L. Fair, L. Watson, and E. Brennan. 2005. Analyses of Bering Sea bottom-trawl surveys in Norton Sound: absence of regime shift effect on epifauna and demersal fish. ICES Journal of Maine Science 62(8):1597–1602.

Main, J., and G. I. Sangster. 1981. A study of the fish capture process in a bottom trawl by direct observation from a towed underwater vehicle. Scottish Fisheries Research Report 23.

Menard, J., J. Soong, J. Bell, and L. Neff. 2017. 2016 Annual management report Norton Sound, Port Clarence, and Kotzebue. Alaska Department of Fish and Game, Fishery Management Report No. 17-41, Anchorage.

NMFS (National Marine Fisheries Service). 1982. Cruise results: cruise no. MF-82-3 NOAA R/V *Miller Freeman* (Norton Sound - northeastern Bering Sea crab - groundfish survey). National Marine Fisheries Service, December 1982.

NPFMC (North Pacific Fishery Management Council). 2018. Stock assessment and fishery evaluation report for the king and Tanner crab fisheries of the Bering Sea and Aleutian Islands regions: 2018 final Crab SAFE. North Pacific Fishery Management Council. Anchorage, AK.

Otto, R. S., R. A. MacIntosh, and P. A. Cummiskey. 1989. Fecundity and other reproductive parameters of female red king crab (*Paralithodes camtschatica*) in Bristol Bay and Norton Sound, Alaska. Pages 65–90 [*In*] Proceedings of the International Symposium on King and Tanner crabs.

Paul, J. M., A. J. Paul, R. S. Otto, and R. A Macintosh. 1991. Spermatophore presence in relation to carapace length for eastern Bering Sea blue king crab (*Paralithodes platypus*, Brandt, 1850) and red king crab (*P. camtschaticus* (Tilesius, 1815)). Journal of Shellfish Research. 10(1):157–163.

REFERENCES CITED (Continued)

Powell, G. C., R. Peterson, and L. Schwarz. 1983. The red king crab, *Paralithodes camtschatica* (Tilesius) in Norton Sound, Alaska: history of biological research and resource utilization through 1982. Alaska Department of Fish and Game, Informational Leaflet 222, Juneau.

Rose, C. S., and G. E. Walters. 1989. Trawl width variation during bottom trawl surveys: causes and consequences. L-L Low, editor. Pages 57–67 [*In*] Proceedings of the symposium on application of stock assessment techniques to gadids. International North Pacific Fisheries Commission Bulletin 50.

Sakuda, H. M. 1958. Observations of molting female king crabs (*Paralithodes camtschatica*). U.S. Fish and Wildlife Service. Special Scientific Report-Fisheries No. 274.

Sample, T. M., and R. J. Wolotira, Jr. 1985. Demersal fish and shellfish resources of Norton Sound and adjacent waters during 1979. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, NOAA Technical Memorandum NMFS F/NWC-89, October 1985.

Schwarz, L., C. Lean, J. Dinnocenzo, B. Bigler, and S. Merkouris-Smith. 1982. Annual management report 1982 Norton Sound-Port Clarence-Kotzebue. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

Schwarz, L. 1984. Norton Sound section of the Bering Sea 1983 king crab fishery report to the Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Region III: Shellfish Report No. 5, Anchorage.

Soong, J. 2008. Analysis of red king crab data from the 2008 ADF&G trawl survey of Norton Sound. Alaska Department of Fish and Game, Fishery Data Series No. 08-58, Anchorage.

Soong, J., and A. Banducci. 2006. Analysis of red king crab data from the 2006 ADF&G trawl survey of Norton Sound. Alaska Department of Fish and Game, Fishery Data Series No. 06-56, Anchorage.

Soong, J., and T. Hamazaki. 2012. Analysis of red king crab data from the 2011 ADF&G trawl survey of Norton Sound. Alaska Department of Fish and Game, Fishery Data Series No. 12-06, Anchorage.

Soong, J., and T. Hamazaki. 2015. Analysis of red king crab data from the 2014 Alaska Department of Fish and Game trawl survey of Norton Sound. Alaska Department of Fish and Game, Fishery Data Series No. 15-40, Anchorage.

Stauffer, G. (Compiler). 2004. NOAA protocols for groundfish bottom trawl surveys of the nation's fishery resources. NOAA Technical Memorandum NMFS-F/SPO-65.

Stevens, B. G., and R. A. MacIntosh. 1986. Analysis of crab data from the 1985 NMFS survey of the northeast Bering Sea and Norton Sound. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, NWAFC Processed Report 86-16, September 1986.

von Szalay, P. G., and D. A. Somerton. 2005. The effect of net spread on the capture efficiency of a demersal survey trawl used in the eastern Bering Sea. Fisheries Research 74:86–95.

Wallace, M. M., C. J. Pertuit, and A. R. Hvatum. 1949. Contribution to the biology of the king crab (*Paralithodes camtschatica* (Tilesius)). U.S. Department of the Interior, Fish and Wildlife Service, Technical Report 340:1–50.

Weber, D. D. 1967. Growth of the immature king crab *Paralithodes camtschatica* (Tilesius). Pages 21-53 [*In*]: INPFC Bulletin Report No. 21. International North Pacific Fisheries Commission. Vancouver, British Columbia, Canada.

Weinberg, K. L., and S. Kotwicki. 2015. Reducing variability in bottom contact and net width of a survey trawl by restraining door movement and applying a constant ratio of warp length to depth. Fishery Bulletin 113:180–190.

West, C. W. 1981. Factors affecting bottom trawl behavior: Results of experiments with 83/112 Eastern trawls towed from the NOAA Ship *Miller Freeman*. NOAA Technical Memorandum NMFS F/NWC-16.

REFERENCES CITED (Continued)

Wilimovsky, N. J. 1966. Synopsis of previous scientific explorations. Pages 1–5 [*In*] N. J. Wilimovsky and J. N. Wolf, editors, Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Washingon D.C.

Wolotira, R. J., Jr., T. M. Sample, and M. Morin, Jr. 1977. Demersal fish and shellfish resources of Norton Sound, the southeastern Chukchi Sea, and adjacent waters in the baseline year 1976. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Processed Report, October 1977.

TABLES AND FIGURES

Table 1.–Norton Sound bottom trawl survey dates, gear type, total number of successful tows, number of resampled stations, and report citations.

Year	Agency	Dates	Gear type	Total number of successful tows	Number of stations completed in Core & Tiers 1–3	Number of resampled stations[a]	Report citations
1976	NMFS	9/2–9/05, 9/16–10/06	83-112 Eastern Otter Trawl	192	NA	17	Wolotira et al. 1977
1979	NMFS	7/26–8/05	83-112 Eastern Otter Trawl	115	NA	16	Sample and Wolotira 1985
1982	NMFS	9/5–9/11	83-112 Eastern Otter Trawl	53	NA	0	NMFS 1982
1985	NMFS	9/16–10/01	83-112 Eastern Otter Trawl	78	NA	0	Stevens and MacIntosh 1986
1988	NMFS	8/16–8/30	83-112 Eastern Otter Trawl	82	NA	4	Stevens 1989[b]
1991	NMFS	8/22–8/30	83-112 Eastern Otter Trawl	53	NA	0	Stevens 1992[c]
1996	ADF&G	8/07–8/18	400 Eastern Otter Trawl	69	48	21	Blau et al. 1996; Fair 1997
1999	ADF&G	7/28–8/07	400 Eastern Otter Trawl	59	50	9	Fair and Brennan 2000
2002	ADF&G	7/27–8/06	400 Eastern Otter Trawl	60	56	3	Brennan 2002
2006	ADF&G	7/25–8/08	400 Eastern Otter Trawl	75	69	4	Soong and Banducci 2006
2008	ADF&G	7/24–8/11	400 Eastern Otter Trawl	68	67	2	Soong 2008
2011	ADF&G	7/18–8/15	400 Eastern Otter Trawl	70	63	5	Soong and Hamazaki 2012
2014	ADF&G	7/18–7/30	400 Eastern Otter Trawl	47	47	0	Soong and Hamazaki 2015
2017	ADF&G	7/28–8/08	400 Eastern Otter Trawl	60	60	NA	
2018	ADF&G	7/22–7/29	400 Eastern Otter Trawl	60	NA	NA	

[a] Retowing was removed from survey protocols in 2017.

[b] Stevens, B. G. 1989. Analysis of crab data from the 1988 NMFS survey of Norton Sound and the northeast Bering Sea. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, unpublished report. February 1989.

[c] Stevens, B. G. 1992. Results of the 1991 NMFS survey of red king crab in Norton Sound. National Marine Fisheries Service, Alaska Fisheries Science Center, unpublished memorandum to the State of Alaska, May 1992.

Table 2.–Station location and number of red king crab by gender and size captured during the Norton Sound bottom trawl survey, 2017.

Station number	Date trawled	Start location N Lat Deg.	Start location N Lat Min.	Start location W Long Deg.	Start location W Long Min.	Compass heading (true)	Distance towed (nmi)	Average depth (fm)	Bottom temp. (°C)	Females[a]	Males: Sublegal Prerecruit-3 <76 mm	Males: Sublegal Prerecruit-2 76–89 mm	Males: Sublegal Prerecruit-1 >89 mm	Males: Legal Recruit[b]	Males: Legal Postrecruit[c]
78	7/30	63	40.00	164	57.36	262	1.0	7.9	11.1	0	0	0	0	0	0
79	7/30	63	39.72	165	20.80	10	1.0	9.1	10.1	0	0	0	0	0	0
80	7/30	63	40.04	165	42.15	267	1.0	11.4	7.9	0	2	1	5	1	3
81	7/29	63	40.00	166	04.55	270	1.0	13.6	8.2	0	0	0	0	0	1
82	7/29	63	40.39	166	27.95	180	1.0	14.3	4.6	0	0	0	0	0	1
94 [d]	8/7	63	50.01	161	34.39	265	1.0	7.8		1	0	0	0	0	0
95 [d]	8/7	63	50.00	161	57.10	269	1.0	8.5		1	0	0	0	0	0
96 [d]	8/7	63	49.82	162	20.43	32	1.0	8		1	0	0	0	0	0
98	8/7	63	50.02	163	05.77	85	1.0	8.3	12.3	0	0	0	0	0	1
99	8/7	63	49.99	163	28.26	82	1.0	7.8	11.8	0	0	0	0	0	0
100	8/8	63	49.91	163	49.89	292	1.0	8.4	13.3	1	0	0	0	0	0
101	8/8	63	49.95	164	13.57	272	1.0	8.6	12.8	0	0	0	0	0	0
102	8/8	63	49.79	164	35.48	337	1.0	8.2	12.7	1	0	0	0	0	0
103	7/30	63	50.32	164	58.24	167	1.0	8.1	10.8	1	0	0	0	0	1
104	7/30	63	50.21	165	21.40	126	1.0	9.1	9.6	0	1	0	0	0	0
105 [e]	7/30					112	1.0	10.5	7.6	3	2	2	0	0	2
106	7/30	63	50.20	166	06.53	124	1.0	13.6	7.5	0	0	0	1	0	2
107	7/29	63	50.71	166	28.49	175	1.0	15.8	4.2	0	0	0	0	0	0
121	8/6	63	59.78	161	33.91	9	1.0	8.5	6.8	0	0	0	0	0	0
122 [d]	8/7	64	00.00	161	56.20	273	1.0	9.2		0	0	0	0	1	1
123 [d]	8/7	64	00.11	162	19.03	217	1.0	8.6		1	1	0	1	1	0
124 [d]	8/7	64	00.12	162	42.34	110	1.0	9.1		1	4	0	0	0	0
125	8/3	64	00.01	163	04.13	261	1.0	9.5	7.4	3	5	0	1	0	1
126	8/2	64	00.13	163	26.91	236	1.0	9.8	8.1	3	4	0	1	0	1
127	8/2	64	00.17	163	49.59	225	1.0	9.0	11.9	0	2	0	0	0	0
128	8/2	64	00.02	164	12.05	262	1.0	8.4	11.9	0	0	0	0	0	0
129	8/2	64	00.13	164	36.01	117	1.0	9.5	11.5	1	0	0	0	0	2
130	8/2	64	00.03	164	58.87	94	1.0	9.1	11.7	0	0	0	0	0	0
131	8/2	64	00.09	165	20.48	249	1.0	9.0	10.2	1	0	1	1	0	0
132 [e]	8/2					176	1.0	10.1	9.8	5	1	1	0	0	0
133	7/30	64	00.11	166	06.51	147	1.0	11.9	6.8	0	3	0	1	5	10
134	7/29	64	02.11	166	29.43	141	1.0	15.3	3.8	0	0	0	0	0	0

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Table 2.–Page 2 of 2.

Station number	Date trawled	Start location N Lat Deg.	Start location N Lat Min.	Start location W Long Deg.	Start location W Long Min.	Compass heading (true)	Distance towed (nmi)	Average depth (fm)	Bottom temp. (°C)	Females[a]	Males Sublegal Prerecruit-3 <76 mm	Males Sublegal Prerecruit-2 76-89 mm	Males Sublegal Prerecruit-1 >89 mm	Males Legal Recruit[b]	Males Legal Postrecruit[c]
135	7/29	64	00.15	166	51.88	191	1.0	17.2	3.5	0	0	0	0	0	0
148	8/6	64	09.89	161	32.50	340	1.0	8.2	6.2	0	0	0	0	0	0
149	8/6	64	10.10	161	55.52	162	1.0	9.2	4.5	0	0	0	0	0	2
150	8/6	64	09.86	162	18.56	41	1.0	8.7	6.2	1	2	0	0	0	0
151	8/6	64	09.85	162	41.00	335	1.0	10.8	5.4	2	1	0	0	0	1
152	8/5	64	09.88	163	04.49	67	1.0	12.6	5.5	1	0	0	0	1	1
153	8/3	64	09.99	163	26.29	278	1.0	10.1	6.7	0	1	0	0	1	0
154	8/3	64	10.01	163	50.23	89	1.0	10.0	8.2	1	2	3	3	0	0
155	8/3	64	10.02	164	13.27	89	1.0	9.7	10.2	2	0	1	0	0	0
156	8/3	64	10.01	164	36.11	90	1.0	7.7	11.2	0	0	0	0	0	0
157	8/3	64	10.02	164	58.95	93	1.0	8.0	12.1	0	0	0	0	0	0
158	8/3	64	10.07	165	21.84	102	1.0	9.0	10.2	0	0	0	0	0	0
159	8/2	64	10.25	165	43.85	186	1.0	10.1	9.7	0	0	1	0	0	0
160	7/31	64	10.27	166	06.11	229	1.0	11.5	7.3	0	1	1	2	1	6
161	7/29	64	10.34	166	28.97	213	1.0	13.8	4.9	0	1	0	0	0	1
175	8/6	64	19.99	161	54.03	271	1.0	8.5	8.0	0	0	0	0	0	0
176	8/6	64	20.09	162	17.32	173	1.0	9.3	7.0	0	1	0	0	0	0
179	8/5	64	20.10	163	26.06	224	1.0	9.6	10.5	0	0	0	0	0	0
180	8/5	64	20.21	163	49.59	137	1.0	8.7	14.3	1	0	0	0	0	0
181	8/5	64	20.01	164	12.85	95	1.0	7.1	12.5	1	0	0	0	0	3
182	8/5	64	19.98	164	36.01	73	1.0	7.6	12.4	0	0	0	0	0	0
183	8/5	64	19.56	164	55.07	280	1.0	15.3	12.4	4	0	1	0	0	0
184	7/28	64	20.04	165	21.34	262	1.0	12.5	11.8	0	6	1	0	0	1
185	7/28	64	19.98	165	45.15	94	1.0	10.9	11.9	5	5	3	1	1	3
186	7/28	64	19.98	166	07.93	86	1.0	12.0	8.5	0	0	1	0	1	0
187	7/29	64	20.02	166	30.03	92	1.0	13.7	7.1	1	2	0	2	2	3
202	8/5	64	30.18	163	49.26	131	1.0	7.8	14.6	0	0	0	0	0	0
203	8/5	64	30.18	164	12.17	155	1.0	9.6	11.6	0	0	0	0	0	0

Note: Average depth is listed in fathoms (fm).

[a] Maturity of female red king crab was not correctly assessed therefore there was no distinction between juvenile and adult female crab.

[b] Recruits are legal new-shell male crabs ≤115 mm CL.

[c] Postrecruits are legal new-shell male crabs >115 mm CL, and all old-shell legal crabs.

[d] Hobo logger was incorrectly deployed; therefore, bottom temperatures were not recorded during trawls.

[e] No start location recorded.

Table 3.–Station location and number of red king crab by gender and size captured during the Norton Sound bottom trawl survey, 2018.

Station number	Date trawled	Start location N Lat Deg.	Start location N Lat Min.	Start location W Long Deg.	Start location W Long Min.	Compass heading (true)	Distance towed (nmi)	Average depth (fm)	Bottom temp. (°C)	Females Juvenile	Females Mature	Males Sublegal Prerecruit-3 <76 mm	Males Sublegal Prerecruit-2 76-89 mm	Males Sublegal Prerecruit-1 >89 mm	Males Legal Recruit[a]	Males Legal Postrecruit[b]	Total crab
78	7/23	63	40.15	164	59.71	83	1.0	7.9	9.7	0	0	0	0	0	0	0	0
79	7/23	63	39.77	165	22.12	87	1.0	8.0	10.3	0	0	0	0	0	0	0	0
80	7/23	63	40.36	165	43.83	83	1.0	9.0	9.4	0	0	0	0	0	0	0	0
81	7/23	63	39.96	166	6.8	6	1.0	8.3	10.7	0	0	0	0	0	0	0	0
82	7/23	63	40.47	166	28.71	352	1.0	8.4	11.0	0	0	0	0	0	0	1	1
94	7/29	63	50.30	161	34.31	73	1.0	7.6	12.4	0	2	0	0	0	0	0	2
95	7/28	63	49.99	161	58.74	137	1.0	8.7	14.3	4	0	2	0	0	1	2	9
96	7/28	63	50.41	162	20.21	224	1.0	9.6	10.5	1	1	0	0	0	0	0	2
97	7/28	63	50.06	162	43.77	213	1.0	13.8	4.9	0	0	0	0	0	0	0	0
98	7/28	63	49.99	163	6.22	229	1.0	11.5	7.3	0	0	2	0	0	0	0	2
99 [c]	7/25	63	49.97	163	29.23	230	1.0	9.5		8	0	4	1	0	0	0	13
100 [c]	7/25	63	50.00	163	51.71	225	1.0	12.8		0	0	1	0	1	0	0	2
101	7/25	63	49.41	164	13.08	86	1.0	7.6	13.9	0	0	0	0	0	0	0	0
102	7/25	63	49.96	164	34.32	83	1.0	6.8	10.9	0	0	0	0	0	0	0	0
103	7/23	63	50.56	164	58.24	89	1.0	9.6	10.4	1	0	0	0	0	0	0	1
104	7/23	63	50.52	165	21.21	268	1.0	9.8	13.5	0	0	1	1	1	0	0	3
105	7/24	63	50.19	165	43.78	265	1.0	9.9	10.9	0	0	0	0	0	0	0	0
106	7/24	63	50.35	166	5.96	264	1.0	9.6	10.0	0	0	0	0	0	0	2	2
107	7/23	63	50.36	166	28.72	282	1.0	9.2	12.5	0	0	0	0	0	0	0	0
121	7/29	63	59.64	161	33.38	280	1.0	15.3	12.4	1	0	0	0	0	0	0	1
122	7/28	63	59.64	161	57.3	95	1.0	7.1	12.5	1	0	1	0	0	0	0	2
123	7/28	64	0.01	162	20.07	173	1.0	9.3	7.0	0	1	0	0	0	0	1	2
124	7/28	64	0.01	162	43.09	271	1.0	8.5	8.0	0	0	0	0	0	0	0	0
125	7/28	64	0.33	163	3.77	186	1.0	10.1	9.7	0	0	0	0	0	0	0	0
126 [c]	7/25	64	0.02	163	28.25	80	1.0	8.9		0	0	0	0	0	0	0	0
127	7/25	63	59.98	163	51.75	83	1.0	9.4	13.3	157	1	165	1	3	0	1	328
128	7/25	63	59.51	164	12.95	90	1.0	8.6	11.5	27	0	35	2	0	1	0	65
129	7/25	64	0.02	164	34.3	86	1.0	7.0	11.2	0	0	1	0	0	0	0	1
130	7/24	64	0.00	164	58.78	78	1.0	7.8	10.8	3	1	4	0	0	0	1	9
131	7/24	64	0.00	165	22.28	81	1.0	12.2	10.7	1	3	0	1	0	0	0	5
132	7/24	63	59.62	165	44.14	79	1.0	14.8	9.6	0	0	0	1	0	0	2	3 [d]
133	7/24	64	0.46	166	6.34	267	1.0	7.7	9.9	0	1	0	1	0	0	0	2
134	7/22	64	0.46	166	29.63	273	1.0	10.0	9.8	0	0	0	0	0	0	0	0

-continued-

Table 3.–Page 2 of 2.

Station number	Date trawled	Start location N Lat Deg.	Start location N Lat Min.	Start location W Long Deg.	Start location W Long Min.	Compass heading (true)	Distance towed (nmi)	Average depth (fm)	Bottom temp. (°C)	Females Juvenile	Females Mature	Males Sublegal Prerecruit-3 <76 mm	Males Sublegal Prerecruit-2 76-89 mm	Males Sublegal Prerecruit-1 >89 mm	Males Legal Recruit[a]	Males Legal Postrecruit[b]	Total crab
148	7/29	64	9.61	161	32.28	262	1.0	12.5	11.8	0	0	0	0	0	0	0	0
149	7/29	64	10.02	161	54.42	94	1.0	10.9	11.9	0	0	1	0	0	0	0	1
150	7/29	64	10.00	162	19.76	131	1.0	7.8	14.6	0	0	0	0	0	0	0	0
151	7/29	64	9.84	162	41.25	155	1.0	9.6	11.6	0	0	0	0	0	0	0	0
152	7/28	64	10.24	163	3.25	102	1.0	9.0	10.2	0	0	0	0	0	0	0	0
153 [c]	7/26	64	9.99	163	25.91	89	1.0	8.8		0	0	2	0	0	0	0	2
154 [c]	7/26	64	10.00	163	48.67	92	1.0	9.4		0	0	1	0	0	0	0	1
155 [c]	7/26	64	10.01	164	11.5	94	1.0	8.7		194	0	243	1	0	0	1	439 [d]
156 [c]	7/26	64	10.01	164	34.21	165	1.0	8.0		2	0	3	0	1	0	0	6
157 [c]	7/26	64	10.00	164	58.87	90	1.0	8.1		0	0	0	0	0	0	0	0
158 [c]	7/26	64	9.98	165	22.11	32	1.0	8.7		1	0	1	1	0	0	0	3
159	7/24	64	9.72	165	44.69	81	1.0	9.0	8.3	1	0	1	0	2	0	0	4
160	7/24	64	10.44	166	6.52	84	1.0	8.0	10.9	0	0	0	0	0	0	0	0
161	7/22	64	10.55	166	30.29	90	1.0	8.9	9.5	0	0	0	0	0	0	0	0
175	7/29	64	20.03	161	53.67	86	1.0	12.0	8.5	0	0	0	0	0	0	0	0
176	7/29	64	20.25	162	17.41	92	1.0	13.7	7.1	0	0	0	0	0	0	0	0
179	7/27	64	20.02	163	27.29	62	1.0	10.6	10.9	0	0	0	0	0	0	0	0
180	7/27	64	20.00	163	49.97	94	1.0	8.7	9.1	0	0	0	0	0	0	0	0
181	7/27	64	20.02	164	13.43	266	1.0	9.4	6.9	0	0	0	1	1	0	0	2
182	7/27	64	19.95	164	36.9	340	1.0	8.6	10.1	0	1	0	0	0	0	0	1
183	7/26	64	19.61	164	58.73	225	1.0	7.7	7.3	2	5	2	0	0	0	4	13
184	7/26	64	19.97	165	22.36	322	1.0	9.1	7.3	1	0	3	2	0	0	1	7
185	7/22	64	20.01	165	43.92	39	1.0	10.0	6.4	0	2	0	0	0	0	0	2
186	7/22	64	20.02	166	8.35	31	1.0	10.1	4.4	0	0	0	0	0	0	0	0
187	7/22	64	20.00	166	31.18	86	1.0	8.7	9.2	0	0	0	1	0	0	2	3
202	7/27	64	29.99	163	50.07	144	1.0	9.4	14.2	0	0	0	0	0	0	0	0
203	7/27	64	30.02	164	13.22	254	1.0	8.6	8.4	0	1	0	0	0	0	0	1

Note: Average depth is listed in fathoms (fm).

[a] Recruits are legal new-shell male crabs ≤115 mm CL.

[b] Postrecruits are legal new-shell male crabs >115 mm CL, and all old-shell legal crabs.

[c] Temperature logger was damaged.

[d] Total crab does not include 1 crab (male) at station 132 and 1 crab (male) at Station 155 that were not measured correctly.

Table 4.–Carapace length (mm) frequency and percent ovigerity of female red king crab captured during the Norton Sound trawl survey, 2017.

	Percent ovigerity[a]					
Carapace length	0%	1–29%	30–59%	60–89%	90–100%	Total
20	1					1
22	2					2
23	1					1
26	1					1
28	2					2
29	1					1
34	1					1
49	1					1
50	1					1
60	1					1
63	1					1
66	1					1
68	2					2
69				1		1
70	1	1				2
71	1					1
72			1	1	1	3
73	1					1
74		1				1
75	1					1
77				1		1
84				1		1
86				1		1
87					1	1
88			1			1
89					1	1
91					1	1
94				1		1
95				1		1
96					1	1
97		1				1
100				1		1
102				1	1	2
104	1					1
105					1	1
109					1	1
Total	21	3	2	9	8	43

[a] Maturity, as assessed by the size and extent of the coxa, was not examined in 2017. Crab without eggs cannot be classified as juvenile or mature.

Table 5.–Carapace length (mm) frequency and percent ovigerity of female red king crab captured during the Norton Sound trawl survey, 2018.

	Percent ovigerity					Total	Total	
Carapace length	0%	1–29%	30–59%	60–89%	90–100%	mature	immature	Total
<64	0	0	0	0	0	0	385	385
64	1	0	0	0	0	1	4	6
65	0	0	0	0	0	0	2	2
66	0	0	0	0	0	0	4	4
67	0	0	0	0	0	0	1	1
68	0	0	0	0	0	0	1	1
69	0	0	0	0	0	0	2	2
70	0	0	0	0	0	0	2	2
71	0	0	0	0	0	0	1	1
72	0	0	0	0	0	0	1	1
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	2	2
75	0	0	0	0	1	1	0	2
76	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0
80	0	0	1	2	0	3	0	6
81	0	0	0	1	0	1	0	2
82	0	0	0	1	1	2	0	4
83	0	0	0	0	1	1	0	2
84	0	0	1	1	0	2	0	4
85	0	0	0	0	0	0	0	0
86	0	0	0	1	0	1	0	2
87	0	0	0	1	0	1	0	2
88	1	0	0	0	0	1	0	2
89	0	0	0	1	0	1	0	2
90	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0
93	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0
95	1	1	0	0	0	2	0	4
96	0	0	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0
98	0	0	0	0	0	0	0	0
99	0	0	0	0	0	0	0	0
100	0	0	0	1	1	2	0	4
Total	3	1	2	9	4	19	405	443

Table 6.–Standardized results from population assessment surveys for red king crab in Norton Sound, 1976–2018.

				Number of red king crabs captured[a,b]				Population abundance estimates[c]			Standard error		
Year	Dates	Agency	Gear	Prerecruit-2 males	Prerecruit-1 males	Legal males[d]	Females	Prerecruit-2 males	Prerecruit-1 males	Legal males	Prerecruit-2 males	Prerecruit-1 males	Legal males
1976	9/02–9/05 9/16–10/07	NMFS	Trawl	58(38)	110(213)	180(614)	101(35)	653,106	1,414,353	2,491,086	285,637	642,876	801,298
1979 [e]	7/26–8/05	NMFS	Trawl	NA	NA	90(86)	NA	19,038	47,313	813,274	16,488	22,711	204,197
1980 [f]	7/04–7/14	ADF&G	Pots			3,290	158			1,900,000			
1981	6/28–7/14	ADF&G	Pots			3,415	1,933			1,285,195			
1982	7/06–7/20	ADF&G	Pots			2,001	424			353,273			
1982	9/05–9/11	NMFS	Trawl	42	107	97	256	379,347	1,012,272	918,686	120,610	295,984	243,467
1985	7/01–7/14	ADF&G	Pots			4,645	181			907,579			
1985	9/16–10/1	NMFS	Trawl	63	94	139	139	402,922	664,594	1,132,662	157,046	281,598	249,394
1988	8/16–8/30	NMFS	Trawl	82(0)	69(1)	135(3)	212(2)	583,924	486,570	972,757	146,733	249,394	354,901
1991	8/22–8/30	NMFS	Trawl	39	42	166	105	386,338	408,241	1,545,558	297,059	157,018	450,814
1996	8/07–8/18	ADF&G	Trawl	39(36)	32(17)	53(14)	98(70)	395,888	277,595	528,431	243,594	78,712	157,909
1999	7/28–8/07	ADF&G	Trawl	9(3)	64(38)	103(63)	64(18)	96,295	582,799	1,542,589	56,017	165,689	318,731
2002	7/27–8/06	ADF&G	Trawl	34(18)	42(23)	61(29)	116(35)	393,689	482,815	740,450	85,797	81,271	81,271
2006	7/25–8/08	ADF&G	Trawl	77(3)	37(16)	51(18)	66(1)	937,083	571,890	718,379	551,144	153,272	105,487
2008	7/24–8/11	ADF&G	Trawl	51(18)	46(19)	53(15)	90(2)	795,777	689,843	811,727	187,516	120,153	152,145
2011	7/18–8/15	ADF&G	Trawl	25(15)	19(10)	84(39)	98(25)	431,153	311,550	1,310,634	151,713	87,866	123,310
2014	7/18–7/30	ADF&G	Trawl	102	139	115	60	1,547,538	2,110,274	1,747,720	643,563	1,474,574	912,399
2017	7/28–8/08	ADF&G	Trawl	17	19	62	43	258,235	288,615	941,797	78,381	100,434	270,551
2018	7/22–7/29	ADF&G	Trawl	14	9	20	424	212,664	151,903	303,806	58,798	61,909	93,597

[a] Number of crabs captured during ADF&G pot surveys represent data standardized for a 24-hour soak.

[b] For the 1976, 1979, 1988, and all ADF&G trawl catches, the numbers outside of parentheses exclude catch from resampled stations. The numbers in parentheses represent catch from resampled stations. The 1979, 1996, 2006, and 2008 population estimates incorporated resampled stations by combining catches and tow distances for each station resampled. No stations were resampled in 2014 due to weather concerns and lack of time, and resampling was removed from protocol in 2017.

[c] Population estimates are valid for the date of the survey (i.e., either before or after the summer commercial fishery). In 2014, all historical abundances were updated based on newly recovered data.

[d] Legal male red king crab were defined as ≥121 mm (4.75 in) in carapace width (CW) for the pot surveys and all ADF&G trawl surveys, and ≥104 mm CL for all NMFS trawl surveys.

[e] Prerecruit-1 and prerecruit-2 male and female data were not available for the 1979 NMFS trawl survey, and the legal male abundance estimate is fully standardized.

[f] The 1980 pot survey estimate has been revised from the original estimate of 13.4 million pounds, which was thought to be inaccurate due to an underreporting of recovered tagged crabs.

Table 7.–The top 40 taxa, ranked by annual CPUE, identified during the ADF&G Norton Sound bottom trawl survey, 2017.

Rank	NMFS species code	Common name	Scientific name or taxon	CPUE
1	81742	Purple-orange sea star	*Asterias amurensis*	23,574.00
2	21735	Saffron cod	*Eleginus gracilis*	1,825.39
3	80200	Blackspined sea star	*Lethasterias nanimensis*	1,010.29
4	21740	Walleye pollock	*Theragra chalcogramma*	937.27
5	21720	Pacific cod	*Gadus macrocephalus*	806.21
6	80020	Giant sea star	*Evasterias echinosoma*	664.98
7	10210	Yellowfin sole	*Limanda aspera*	581.32
8	21375		*Myoxocephalus* spp.	548.47
9	10220	Starry flounder	*Platichthys stellatus*	517.61
10	68781	Helmet crab	*Telmessus cheiragonus*	311.63
11	10285	Alaska plaice	*Pleuronectes quadrituberculatus*	261.57
12	82510	Green sea urchin	*Strongylocentrotus droebachiensis*	152.77
13	10120	Pacific halibut	*Hippoglossus stenolepis*	146.25
14	43000	Sea anemone unid.		139.93
15	69120	Hairy hermit crab	*Pagurus capillatus*	129.35
16	83020	Basketstar	*Gorgonocephalus caryi*	105.42
17	98000	Tunicate unid.		103.00
18	69322	Red king crab	*Paralithodes camtschaticus*	101.20
19	40500	Jellyfish unid.		90.89
20	23055	Rainbow smelt	*Osmerus mordax*	85.48
21	71884	Northern neptune	*Neptunea heros*	56.23
22	471	Alaska skate	*Bathyraja parmifera*	54.91
23	75284	Cockles	*Serripes* spp.	50.58
24	23801		*Lumpenus* spp.	48.66
25	41201	Sea raspberry	*Eunephtya rubiformis*	44.82
26	80590	Knobby 6-ray seastar	*Leptasterias polaris*	42.13
27	24185	Wattled eelpout	*Lycodes palearis*	37.98
28	80595		*Leptasterias* spp.	37.61
29	71882	Fat neptune	*Neptunea ventricosa*	35.99
30	21388	Antlered sculpin	*Enophrys diceraus*	35.10
31	21313		*Gynmocanthus* spp.	24.19
32	68580	Opilio crab	*Chionoecetes opilio*	22.92
33	66611	Northern Argid	*Argis lar*	22.74
34	20322	Bering wolffish	*Anarhichas orientalis*	19.77
35	24189	Polar eelpout	*Lycodes turneri*	19.52
36	21932	Whitespotted greenling	*Hexagrammos stelleri*	19.41
37	21110	Pacific herring	*Clupea harengus*	19.15
38	66548	Sand shrimp	*Crangon septemspinosa*	18.12
39	69086	Fuzzy hermit crab	*Pagurus trigonocheirus*	13.69
40	68577	Circumboreal toad crab	*Hyas coarctatus*	12.92

Table 8.–Number of large fish sampled and their average length (mm) and weight (kg) during the Norton Sound bottom trawl survey, 1996–2018.

Species	Year	# of fish sampled	Average length (mm)	Average weight (kg)
Alaska skate	2014	1	NA	8.7
	2017	3	NA	7.5
	2018	3	NA	10.0
Pacific cod	1996	1	610	NA
	1999	2	730	NA
	2002	27	650	3.2
	2006	17	754	4.1
	2008	30	696	4.7
	2011	1	896	7.2
	2014	15	715	8.7
	2017	170	638	3.1
	2018	159	665	3.7
Pacific halibut	1996	74	NA	NA
	1999	6	410	NA
	2002	10	750	7.4
	2006	28	702	5.1
	2008	27	692	4.9
	2011	19	700	5.4
	2014	19	755	5.7
	2017	18	704	4.9
	2018	9	741	8.4
Walleye pollock	1996	62	NA	NA
(Adult)	1999	5	720	NA
	2002	38	730	2.7
	2006	27	698	3.1
	2008	11	736	2.8
	2011	0	0	0
	2014	0	0	0
	2017	536	583	1.3
	2018	950	576	1.4
Yellowfin sole	2014	1	440	1.6

Table 9.–The top 40 taxa, ranked by annual CPUE, identified during the ADF&G Norton Sound bottom trawl survey, 2018.

Rank	NMFS species code	Common name	Scientific name or taxon	CPUE
1	81742	Purple-orange sea star	*Asterias amurensis*	21,346.73
2	21742	Walleye pollock (adult)	*Theragra chalcogramma*	1,800.13
3	21720	Pacific cod	*Gadus macrocephalus*	1,145.87
4	21735	Saffron cod	*Eleginus gracilis*	981.94
5	80200	Blackspined sea star	*Lethasterias nanimensis*	783.04
6	80020	Giant sea star	*Evasterias echinosoma*	570.19
7	10220	Starry flounder	*Platichthys stellatus*	544.89
8	10210	Yellowfin sole	*Limanda aspera*	509.51
9	21375		*Myoxocephalus* spp.	441.52
10	68781	Helmet crab	*Telmessus cheiragonus*	295.60
11	82510	Green sea urchin	*Strongylocentrotus droebachiensis*	127.53
12	10285	Alaska plaice	*Pleuronectes quadrituberculatus*	124.17
13	10120	Pacific halibut	*Hippoglossus stenolepis*	107.44
14	69120	Hairy hermit crab	*Pagurus capillatus*	102.38
15	421	Alaska skate	*Bathyraja parmifera*	96.20
16	40500	Jellyfish unid.		86.31
17	43000	Sea anemone unid.		72.63
18	23801		*Lumpenus* spp.	59.94
19	69322	Red king crab	*Paralithodes camtschaticus*	54.40
20	98300	Compound ascidian unid.		51.64
21	10260	Rock sole unid.	*Lepidopsetta* spp.	43.26
22	41201	Sea raspberry	*Eunephtya rubiformis*	42.81
23	83020	Basketstar	*Gorgonocephalus caryi*	38.64
24	98082	Sea potato		37.02
25	71884	Northern neptune	*Neptunea heros*	34.53
26	23055	Rainbow smelt	*Osmerus mordax*	32.24
27	75240		*Macoma* spp.	29.36
28	80590	Knobby 6-ray sea star	*Leptasterias polaris*	23.23
29	24180		*Lycodes* spp.	23.01
30	71882	Fat neptune	*Neptunea ventricosa*	20.47
31	21932	Whitespotted greenling	*Hexagrammos stelleri*	20.41
32	80595		*Leptasterias spp.*	20.38
33	21110	Pacific herring	*Clupea harengus*	17.12
34	66548	Sand shrimp	*Crangon septemspinosa*	13.02
35	66611	Northern Argid	*Argis lar*	13.01
36	69061	Splendid hermit	*Labidochirus splendescens*	12.37
37	21741	Walleye pollock (juv.)	*Theragra chalcogramma*	12.32
38	20322	Bering wolffish	*Anarhichas orientalis*	10.15
39	69086	Fuzzy hermit crab	*Pagurus trigonocheirus*	9.86
40	21388	Antlered sculpin	*Enophrys diceraus*	9.52

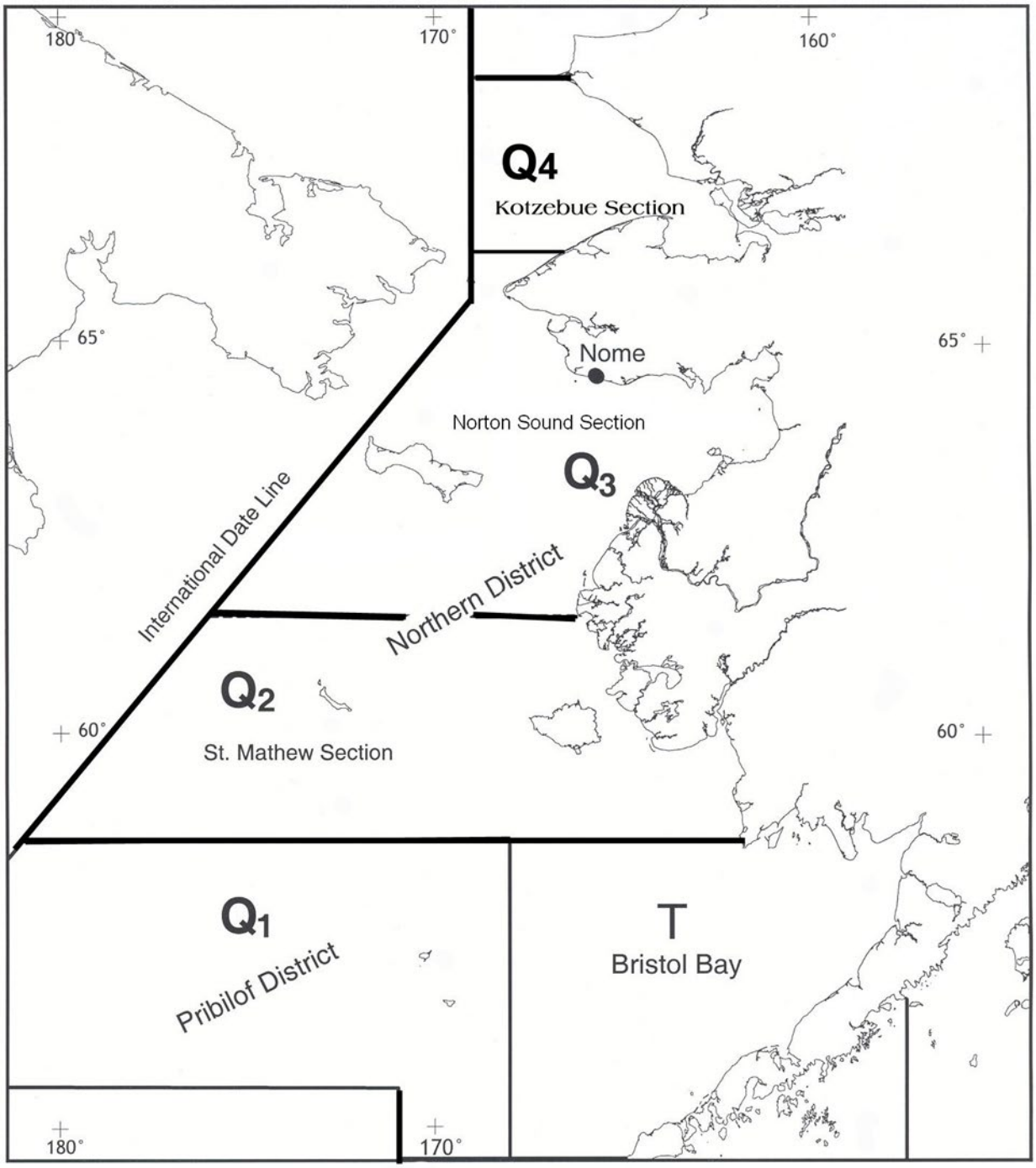

Figure 1.–Norton Sound king crab fishing districts and sections of Registration Area Q.

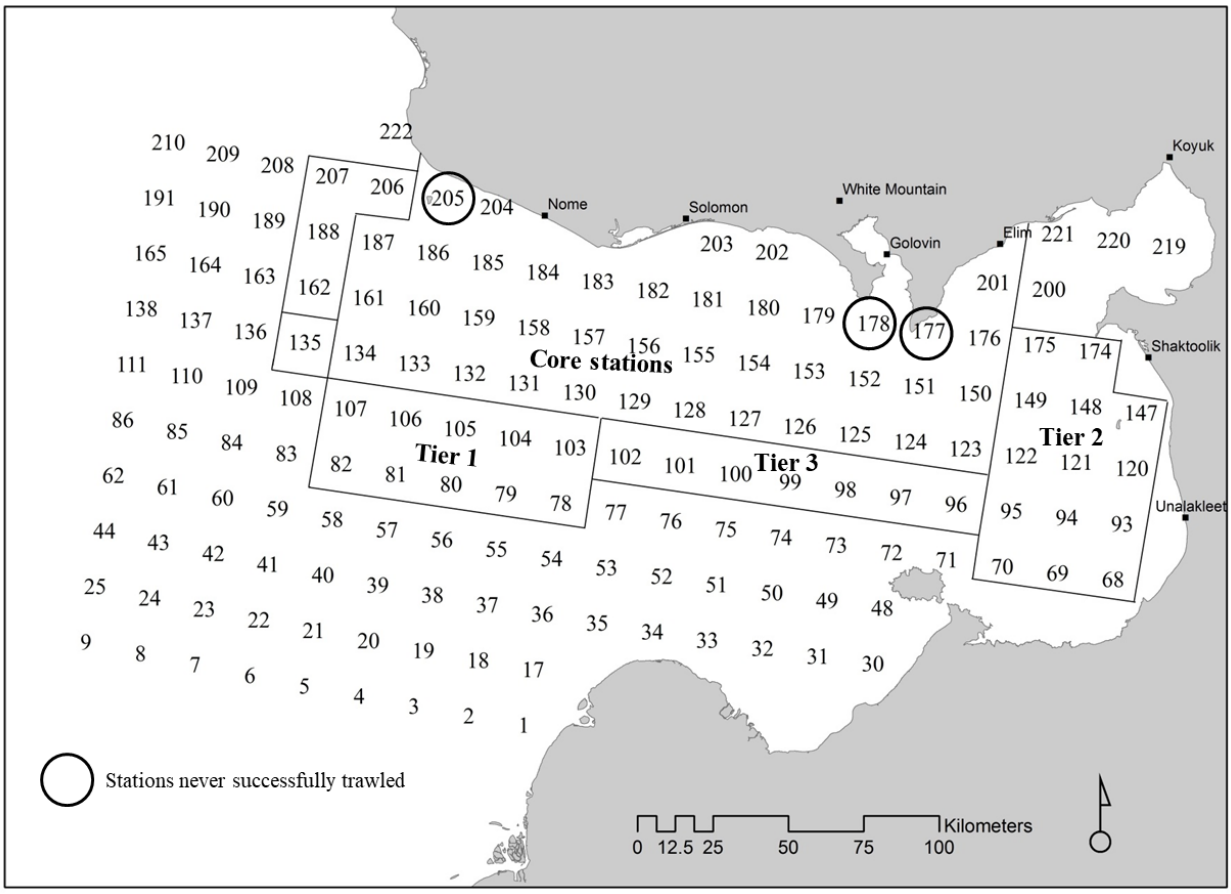

Figure 2.–The 10 x 10 nmi grid of bottom trawl survey stations and groupings of stations by priority (Core, Tier 1, Tier 2, and Tier 3) during the Norton Sound bottom trawl survey, 2017–2018.

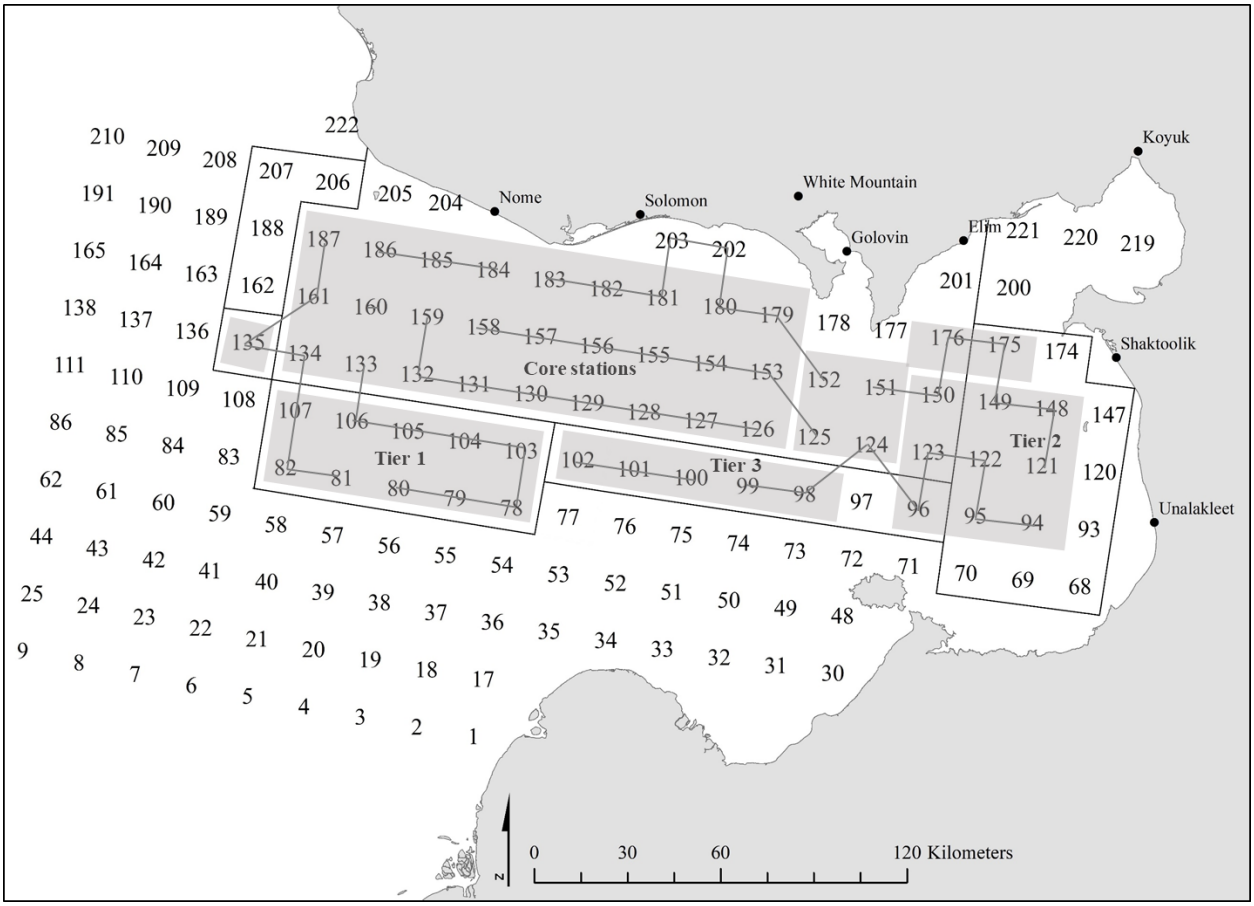

Figure 3.–Stations successfully trawled during the Norton Sound bottom trawl survey, 2017.

Note: Successful trawls indicated with gray shading. Dark gray lines indicate daily route of trawl survey.

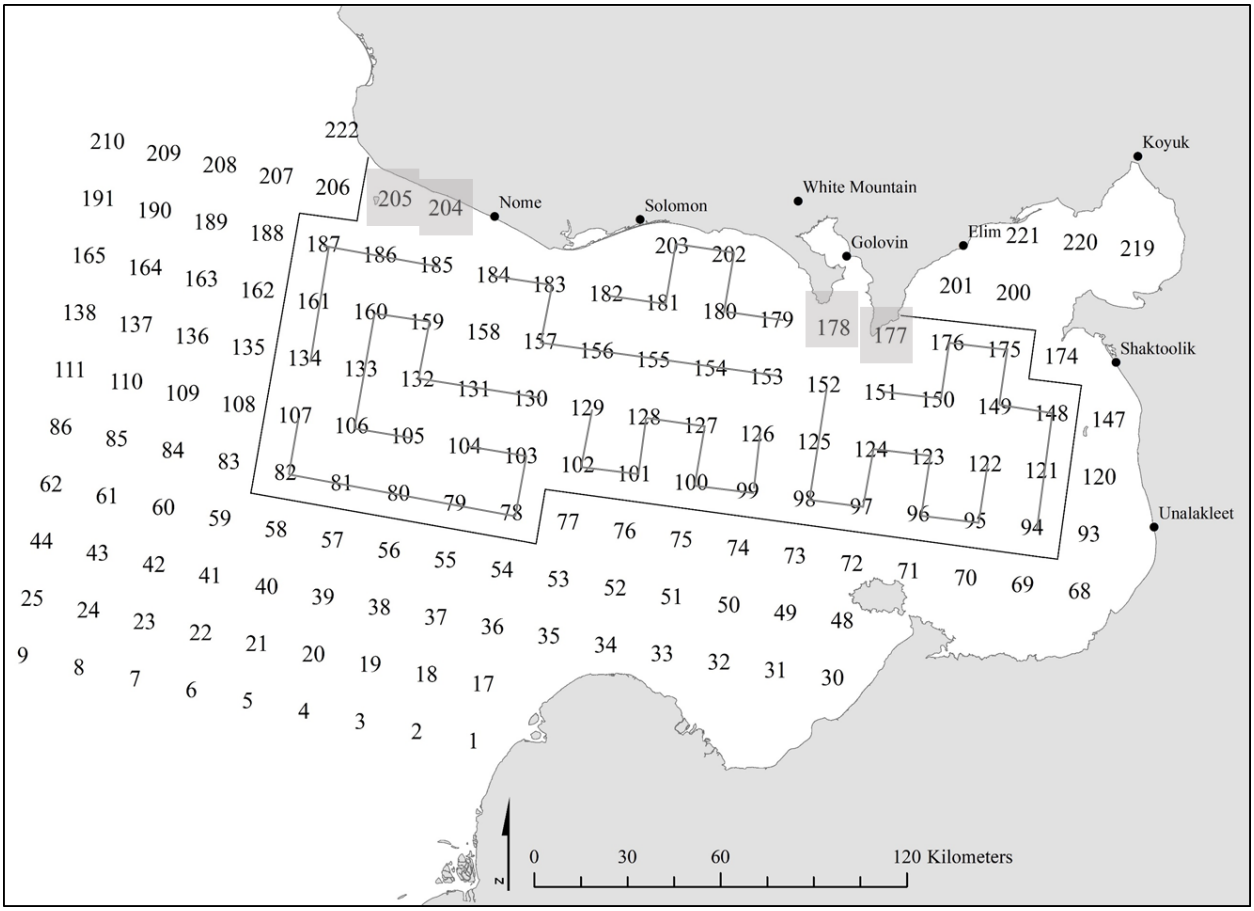

Figure 4.–Stations successfully trawled during the Norton Sound bottom trawl survey, 2018.

Note: Stations shaded in gray have never been successfully towed. Dark gray lines indicate daily route of trawl survey.

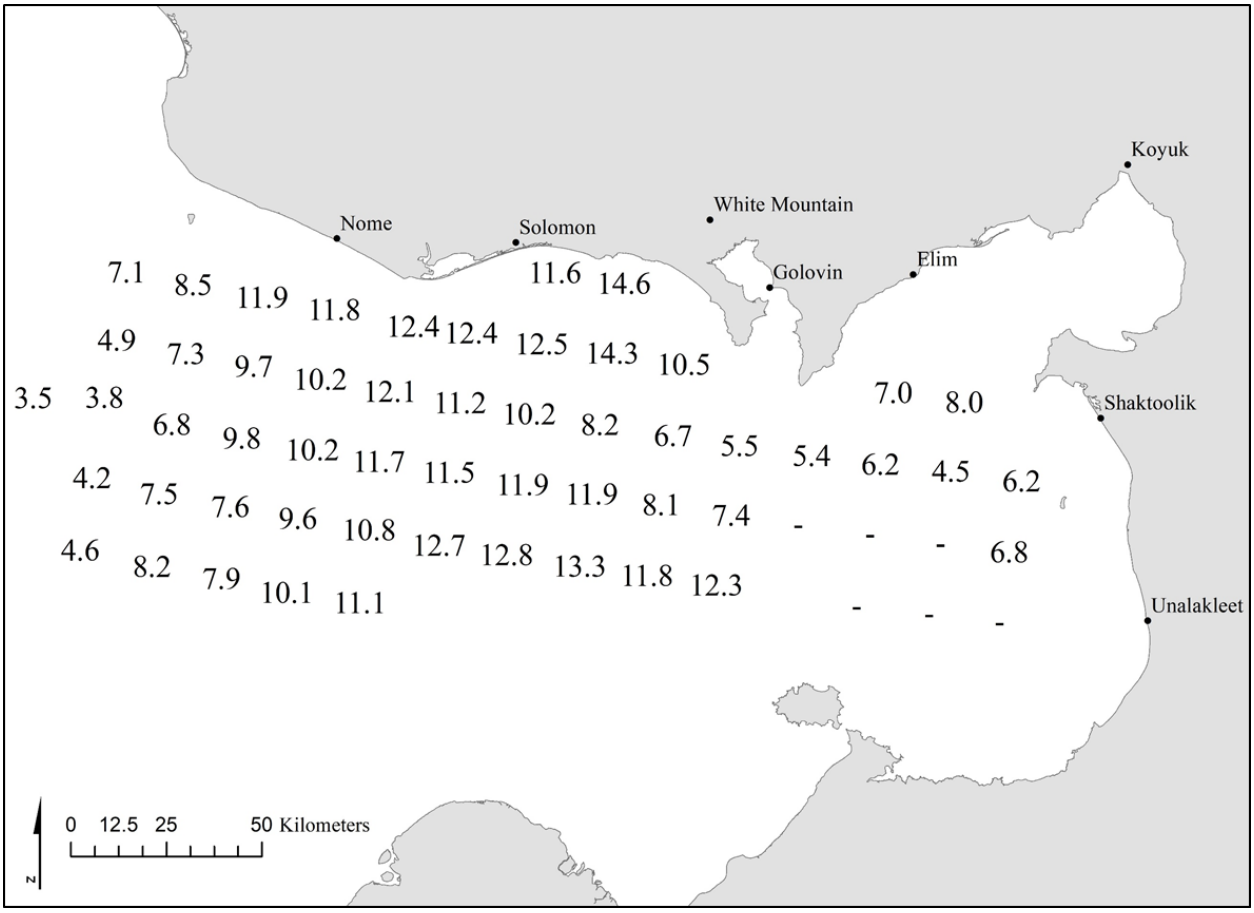

Figure 5.–Bottom temperatures at stations trawled during the Norton Sound bottom trawl survey, 2017.

Note: Dashes indicate stations where the temperature logger was not correctly deployed.

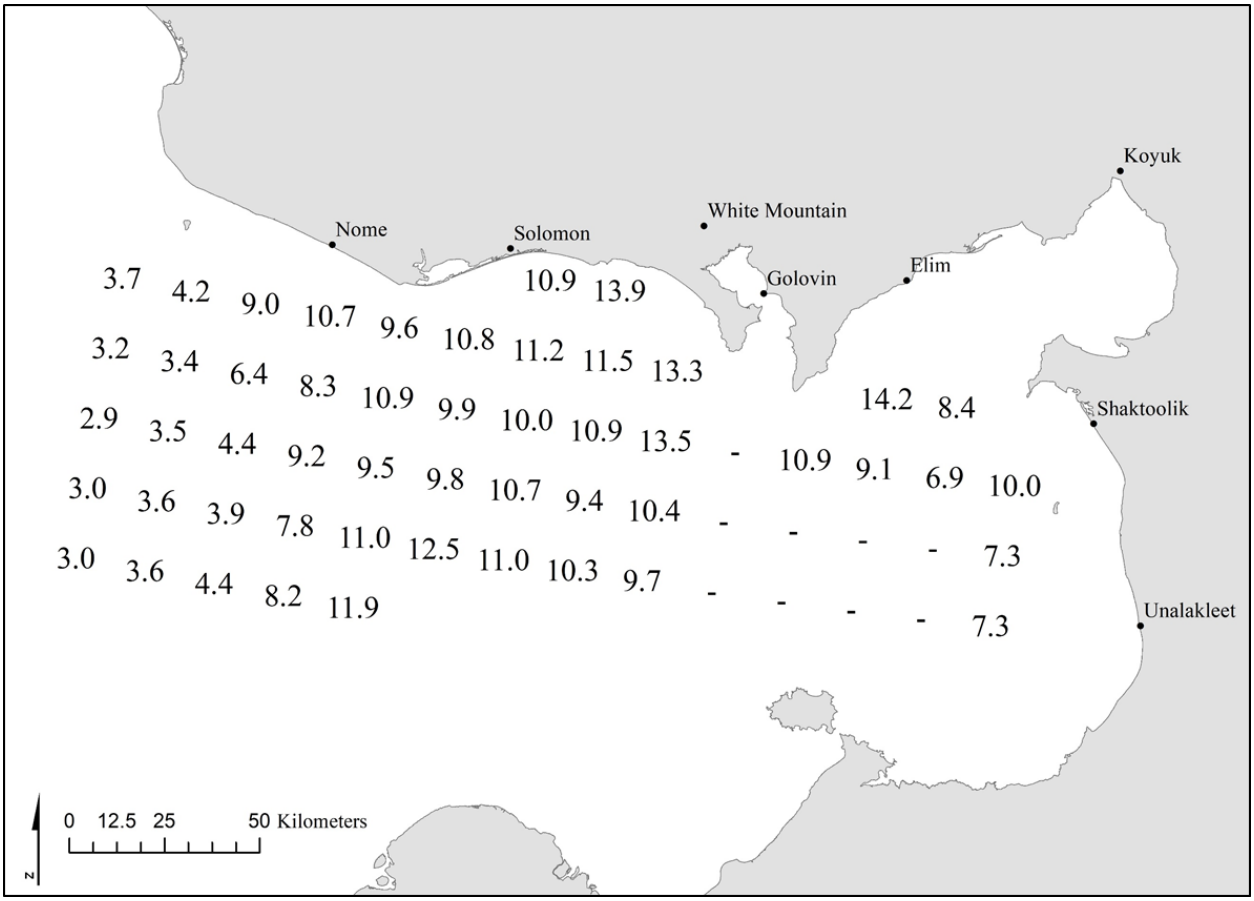

Figure 6.–Bottom temperatures at stations trawled during the Norton Sound bottom trawl survey, 2018.

Note: Dashes indicate stations where the temperature logger was damaged, and data are being recovered.

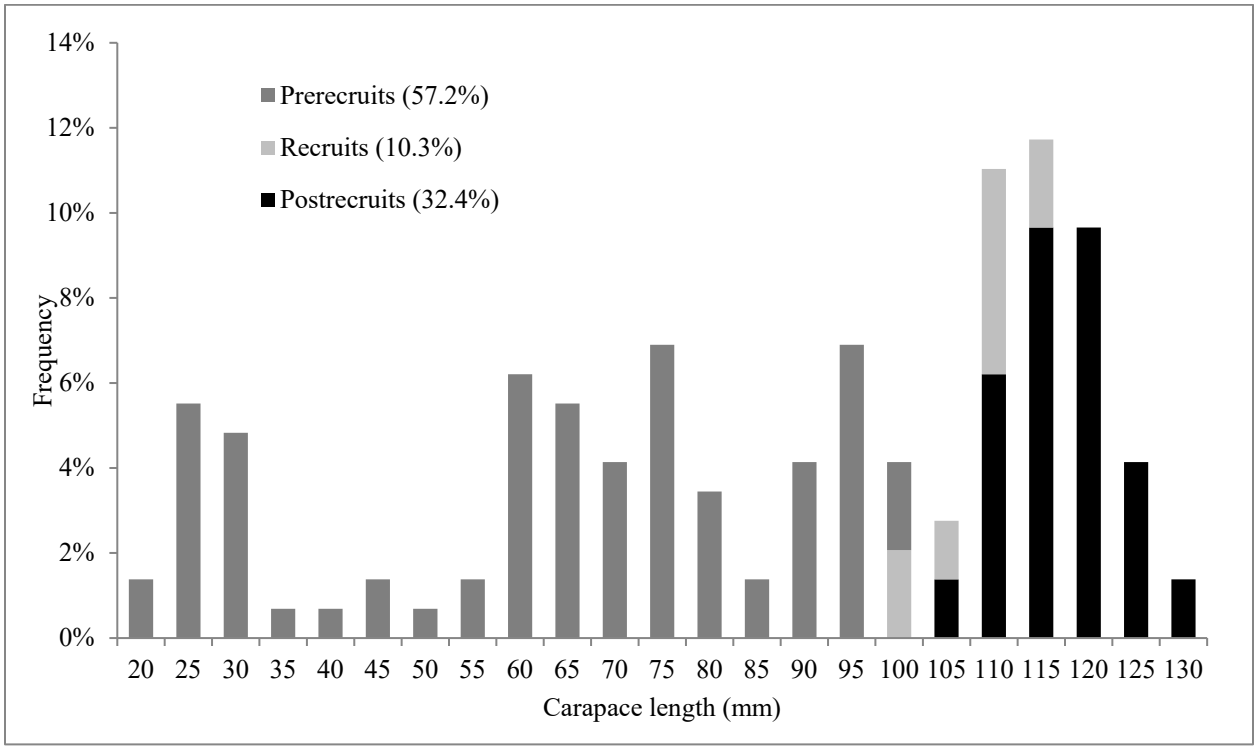

Figure 7.–Length frequency of prerecruit, recruit, and postrecruit red king crab captured during the Norton Sound the bottom trawl survey, 2017.

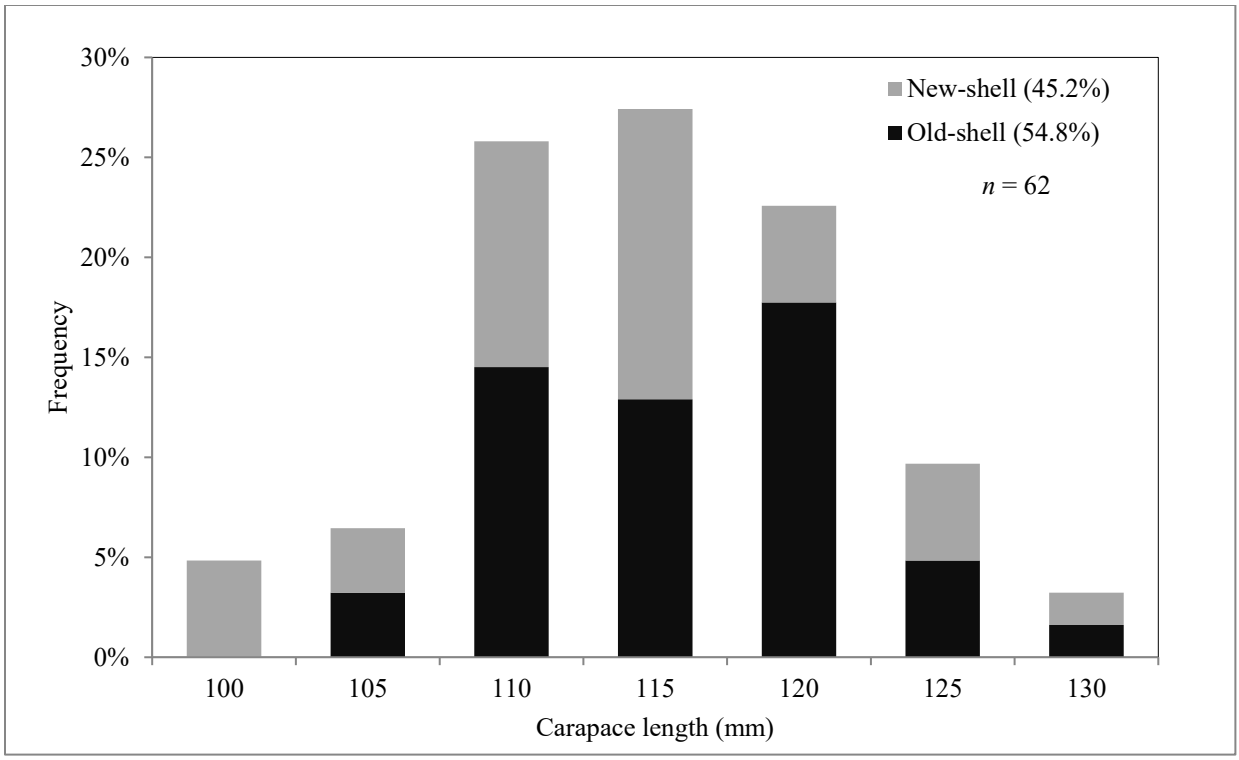

Figure 8.–Length frequency of new-shell and old-shell legal male red king crab captured in during the Norton Sound bottom trawl survey, 2017.

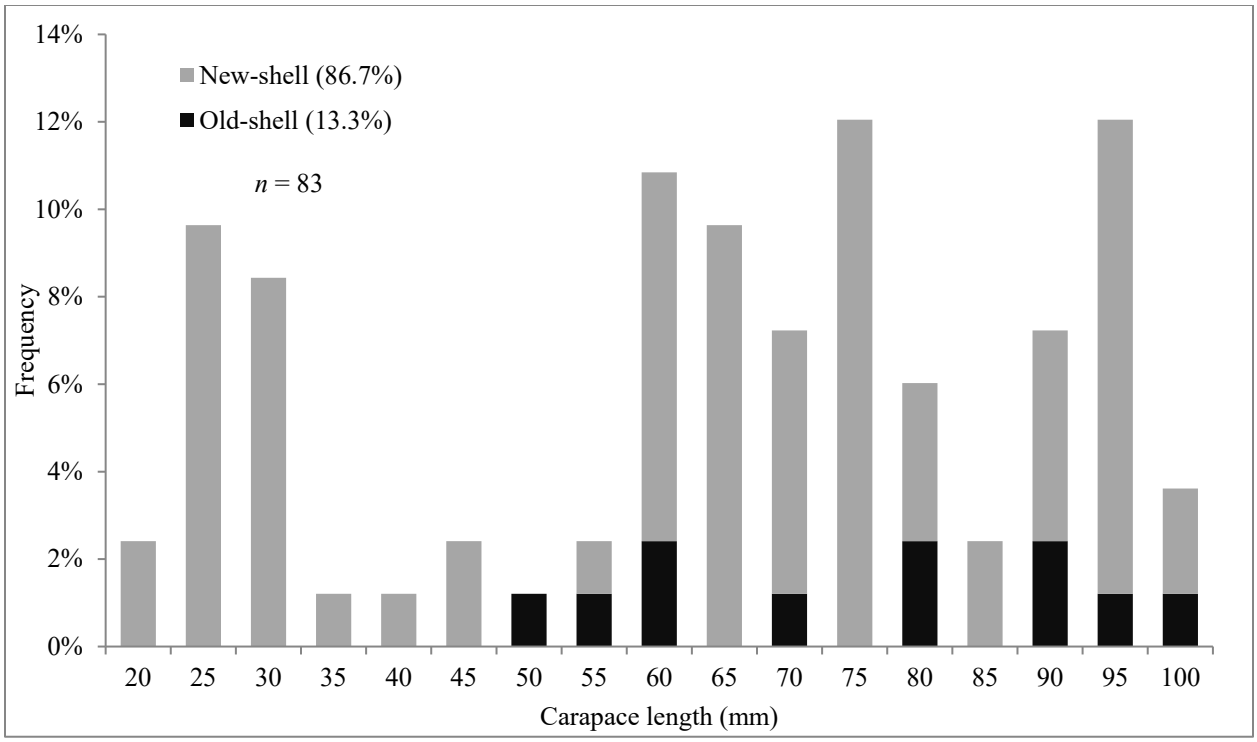

Figure 9.–Length frequency of new-shell and old-shell sublegal male red king crab captured during the Norton Sound bottom trawl survey, 2017.

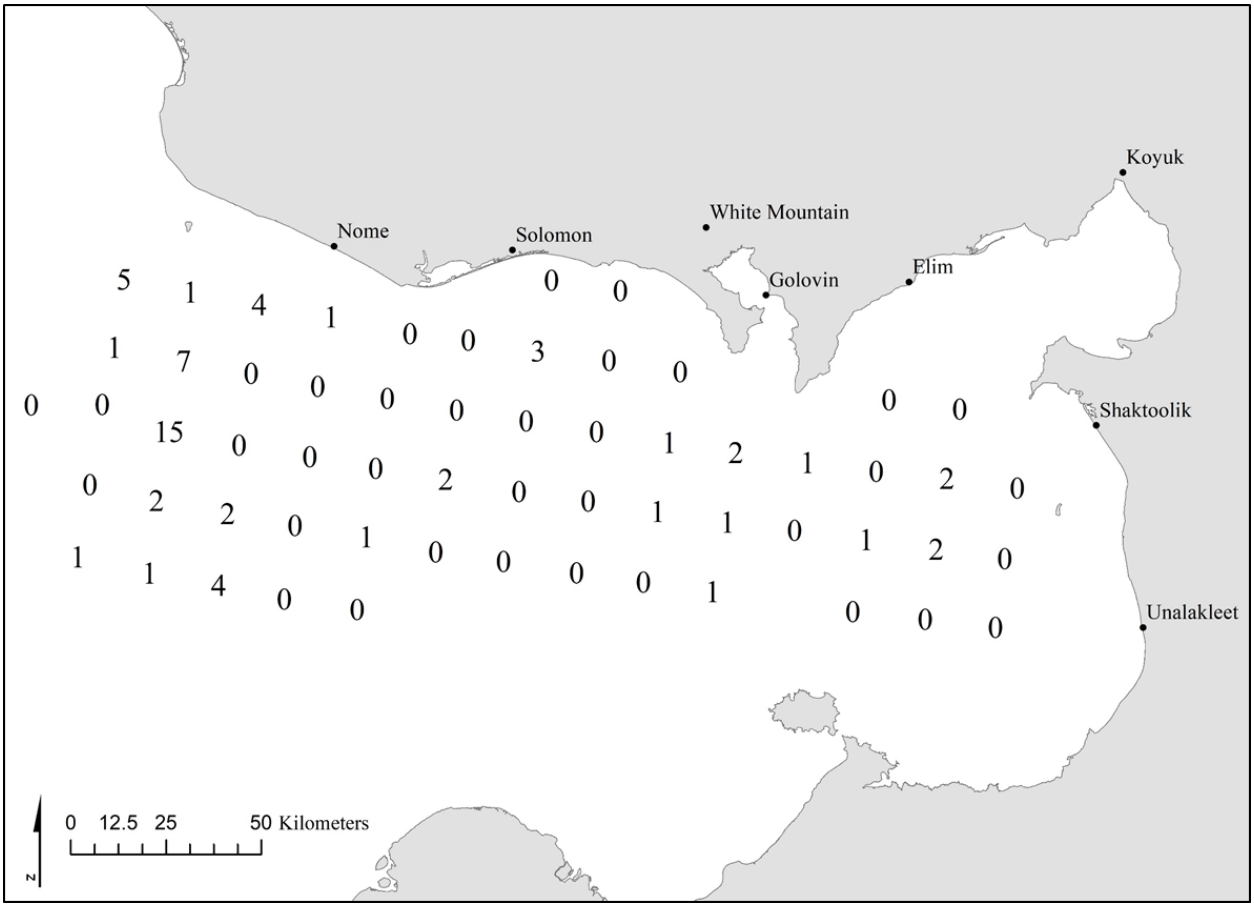

Figure 10.–Location and number of legal male red king crab captured during the Norton Sound bottom trawl survey, 2017.

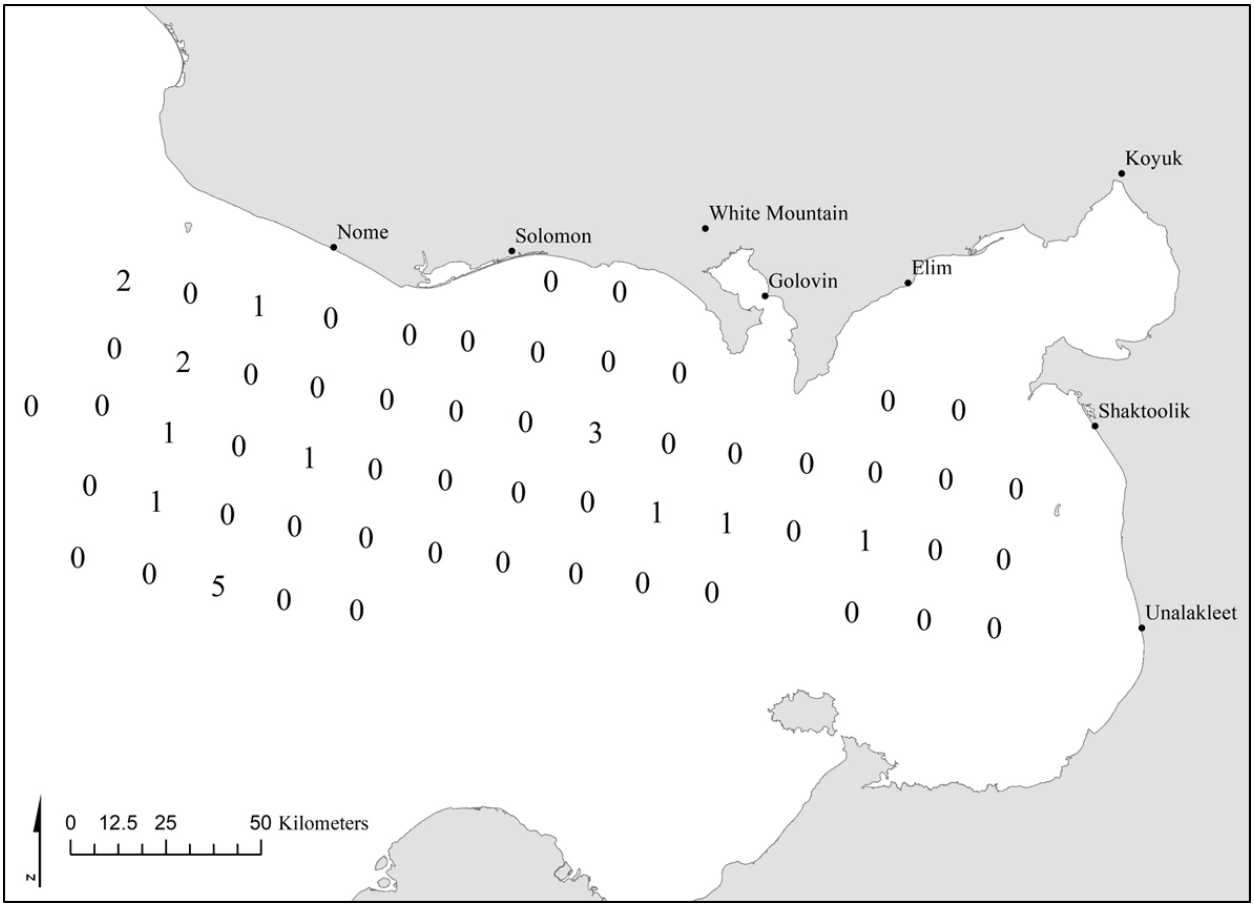

Figure 11.–Location and number of sublegal prerecruit-1 red king crab captured during the Norton Sound bottom trawl survey, 2017.

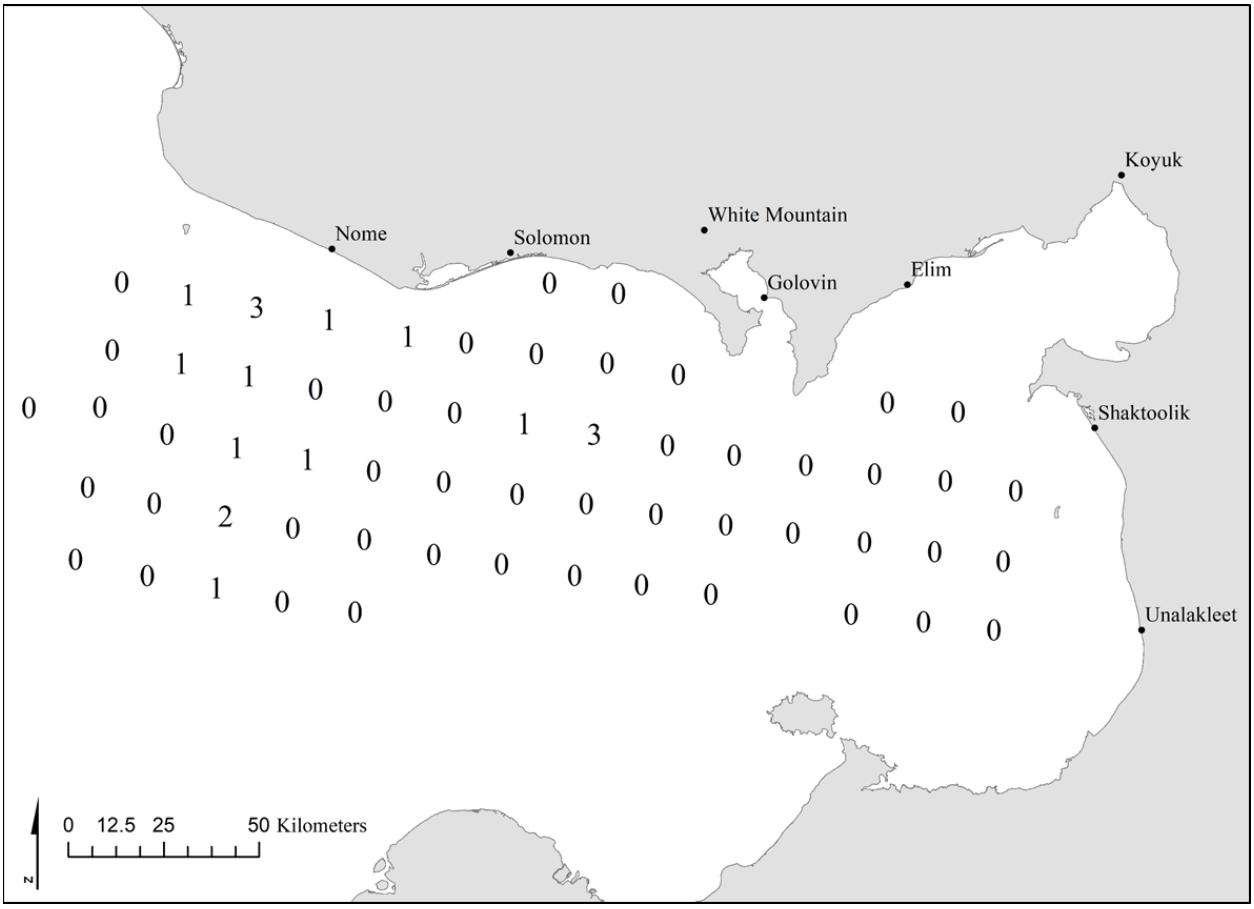

Figure 12.–Location and number of sublegal prerecruit-2 red king crab captured during the Norton Sound bottom trawl survey, 2017.

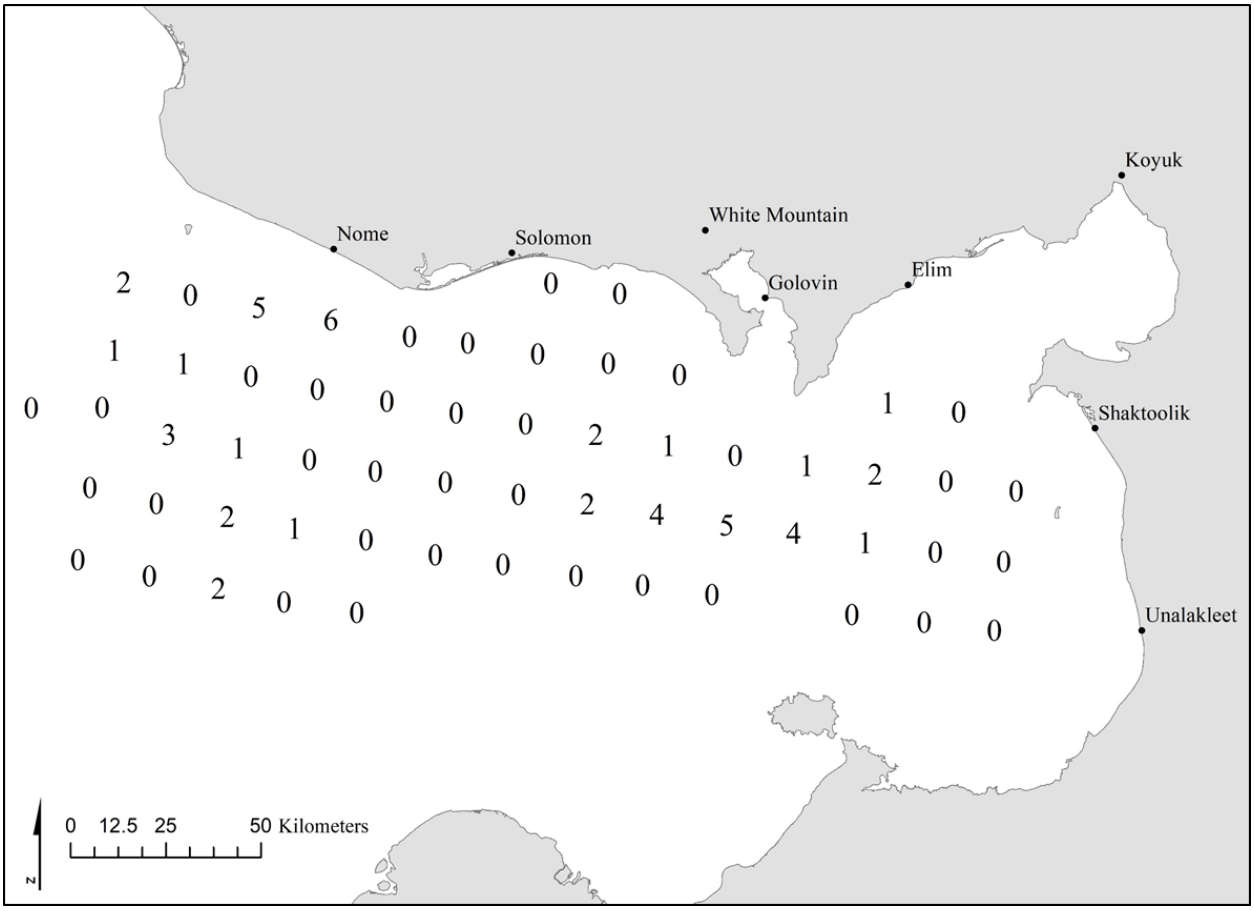

Figure 13.–Location and number of sublegal prerecruit-3 red king crab captured during the Norton Sound bottom trawl survey, 2017.

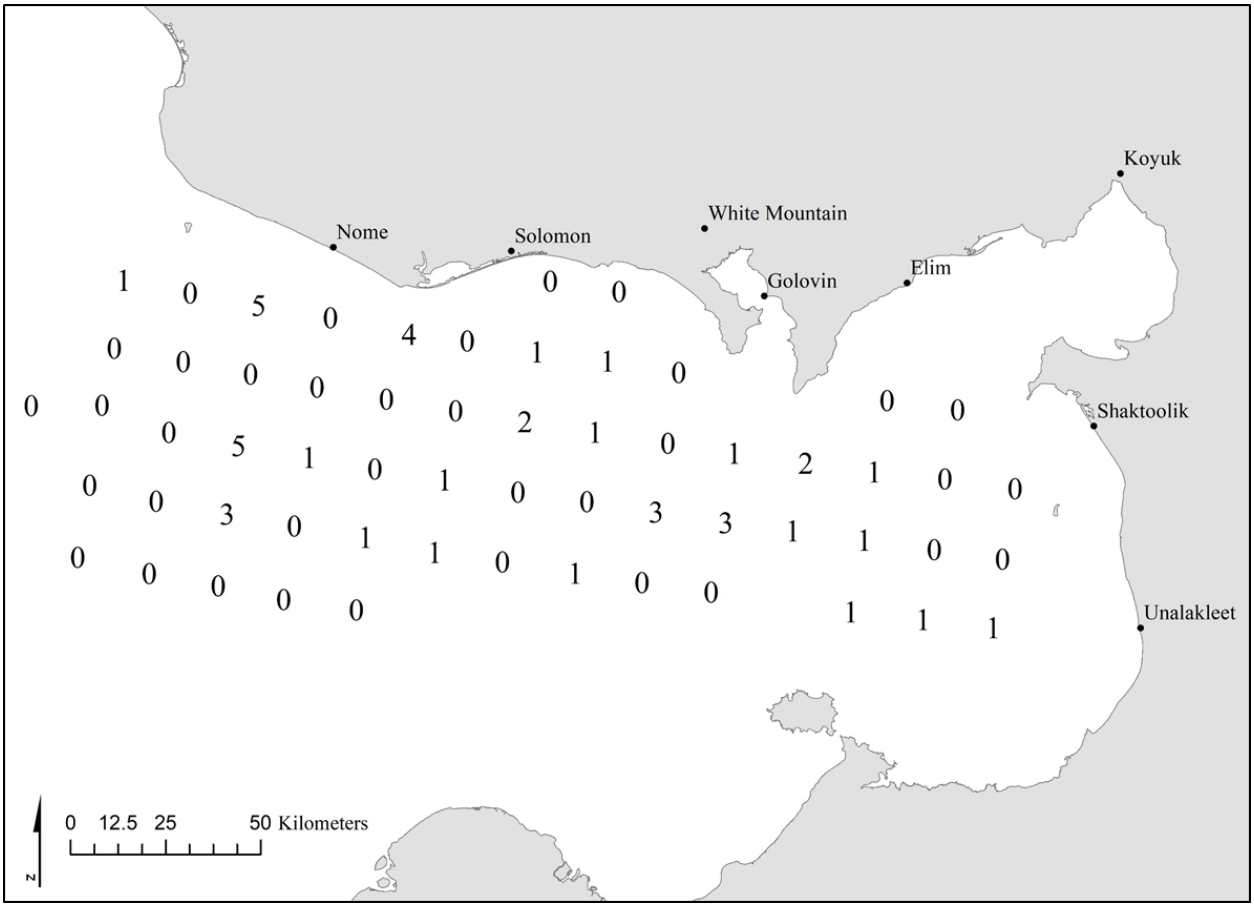

Figure 14.–Location and number of female red king crab captured during the Norton Sound bottom trawl survey, 2017.

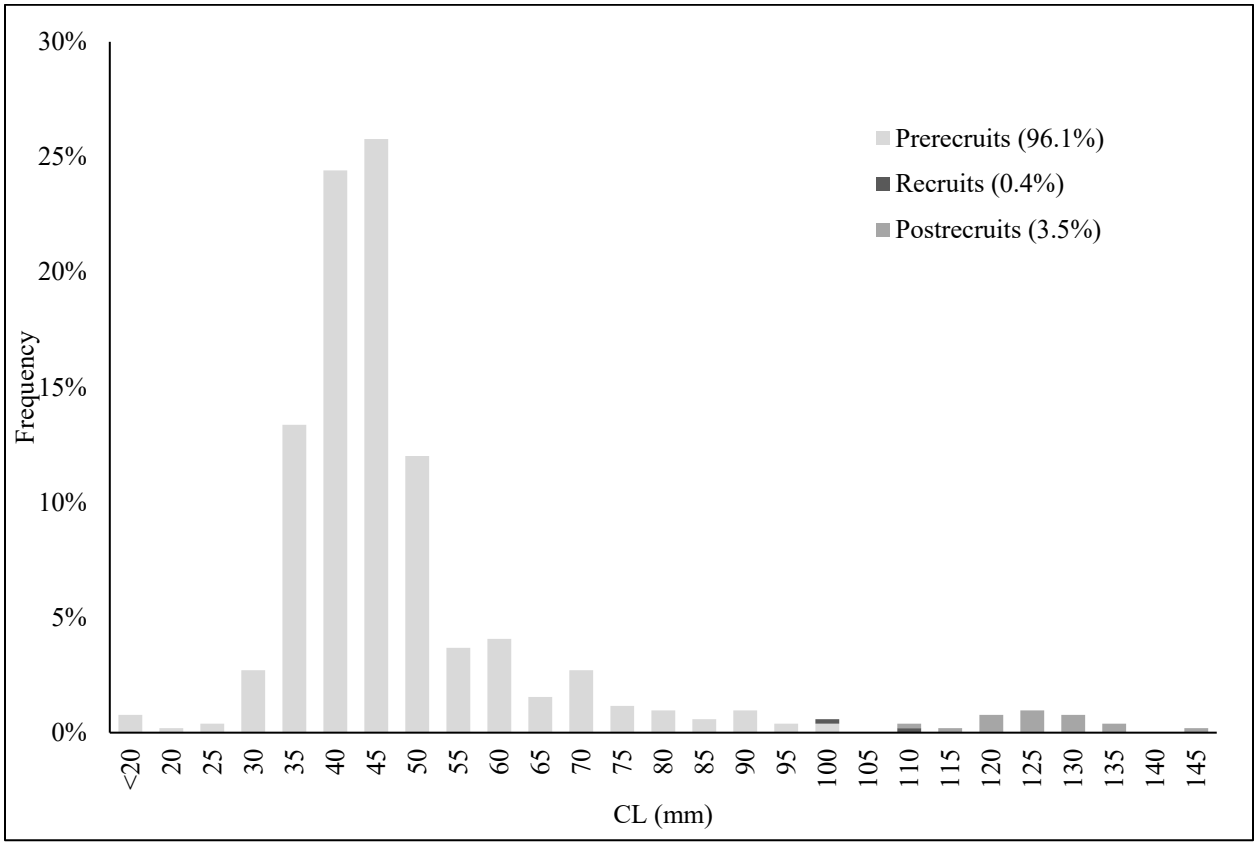

Figure 15.–Length frequency of prerecruit, recruit, and postrecruit red king crab captured during the Norton Sound bottom trawl survey, 2018.

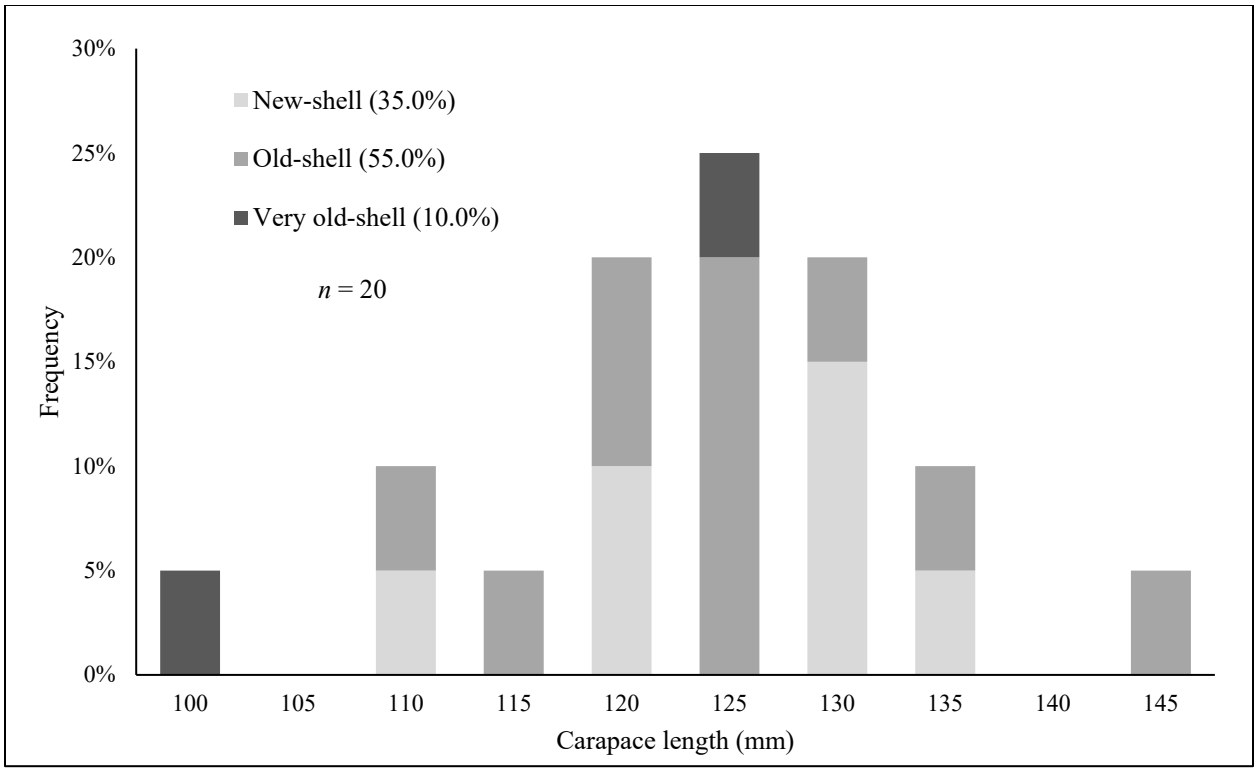

Figure 16.–Length frequency of new-shell, old-shell, and very-old-shell legal male red king crab captured during the Norton Sound bottom trawl survey, 2018.

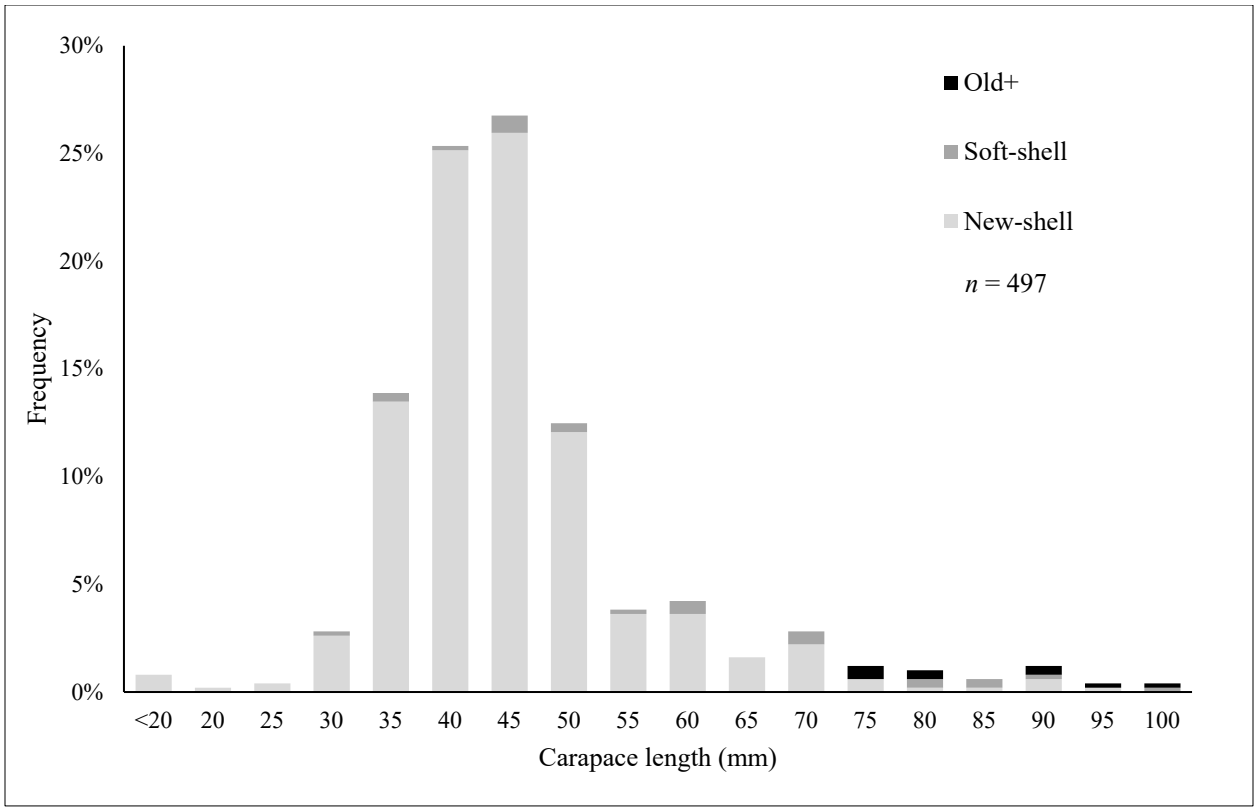

Figure 17.–Length frequency of new-shell, soft-shell, and old-shell sublegal male red king crab captured during the Norton Sound bottom trawl survey, 2018.

Note: Old+ represents old- and very-old-shell crab.

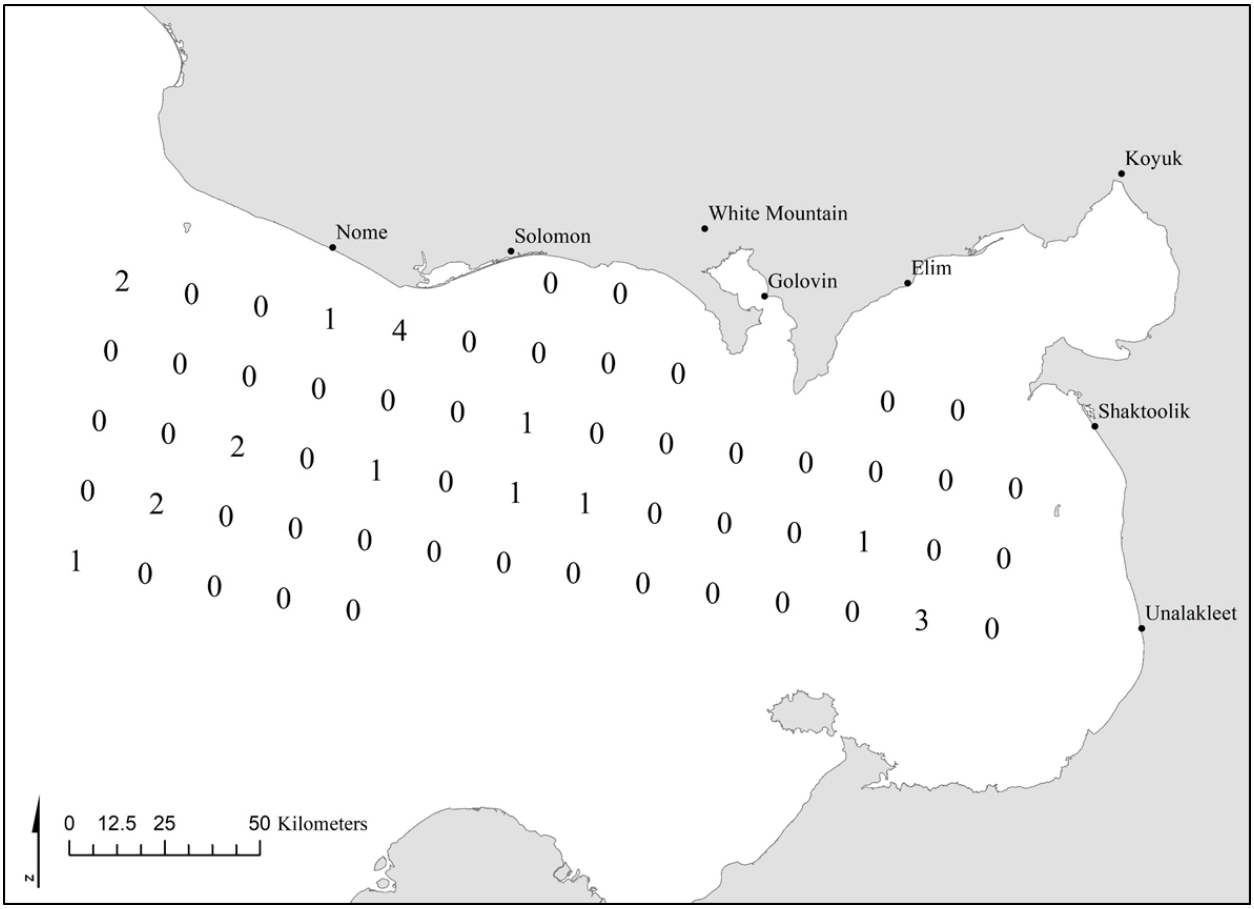

Figure 18.–Location and number of legal male red king crab captured during the Norton Sound bottom trawl survey, 2018.

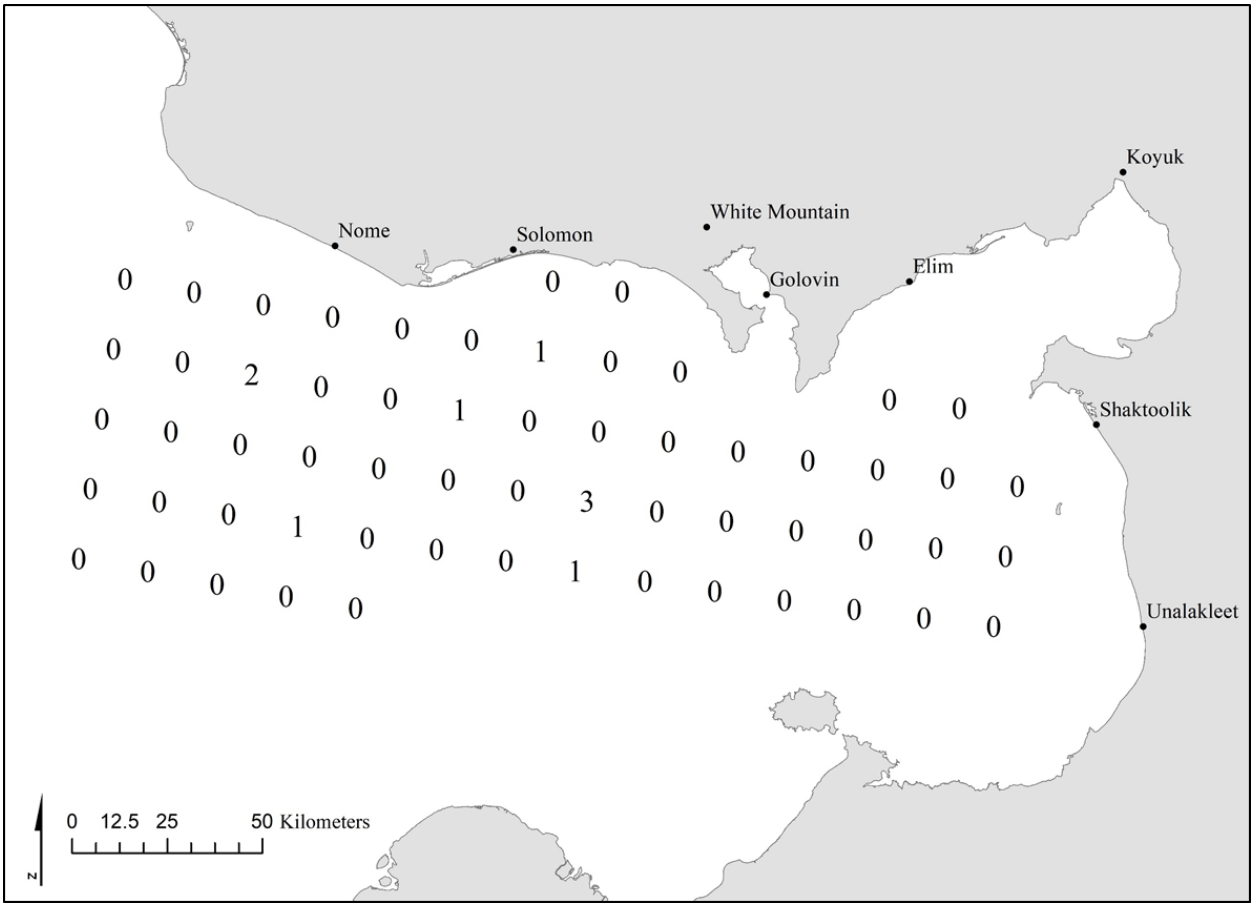

Figure 19.–Location and number of sublegal prerecruit-1 red king crab captured during the Norton Sound bottom trawl survey, 2018.

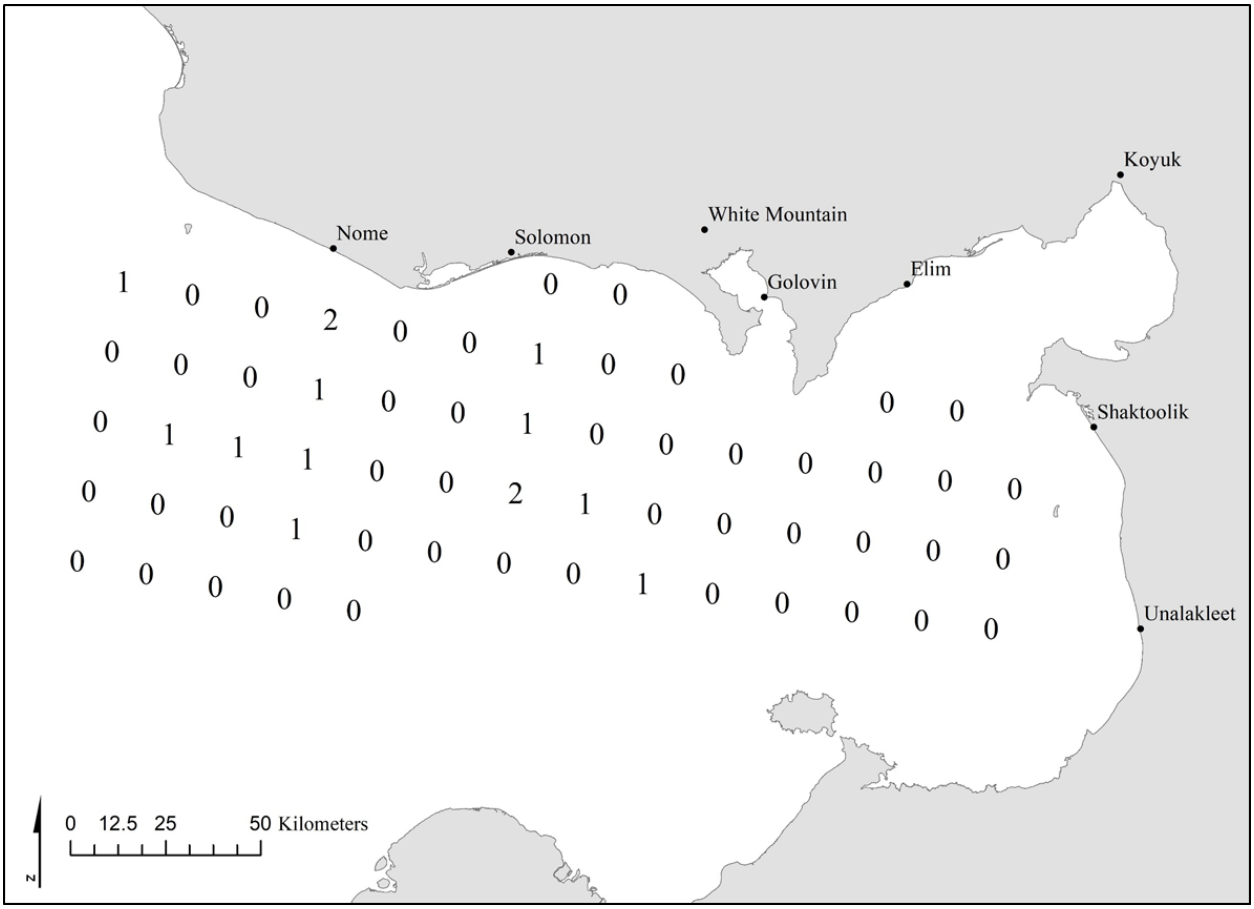

Figure 20.–Location and number of sublegal prerecruit-2 red king crab captured during the Norton Sound bottom trawl survey, 2018.

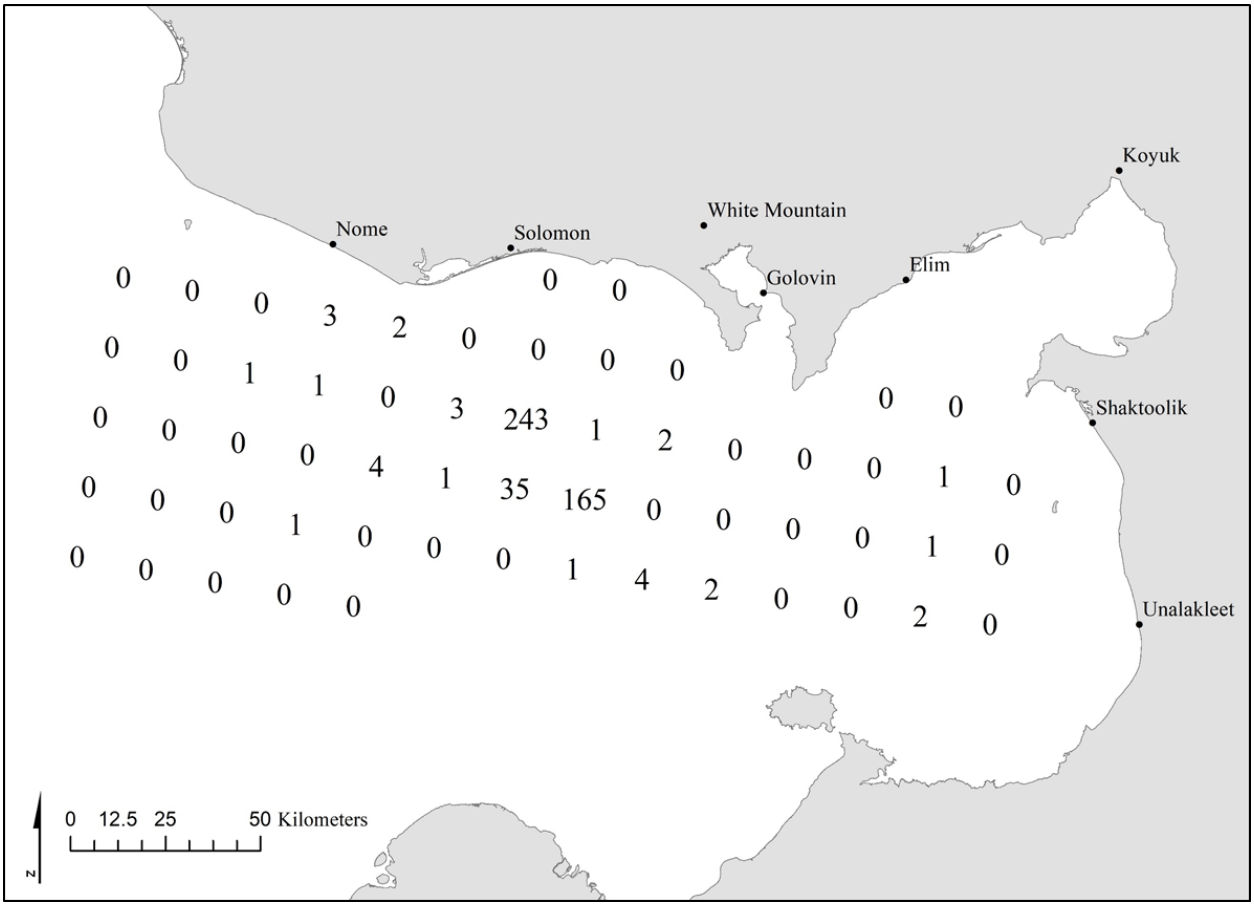

Figure 21.–Location and number of sublegal prerecruit-3 red king crab captured during the Norton Sound bottom trawl survey, 2018.

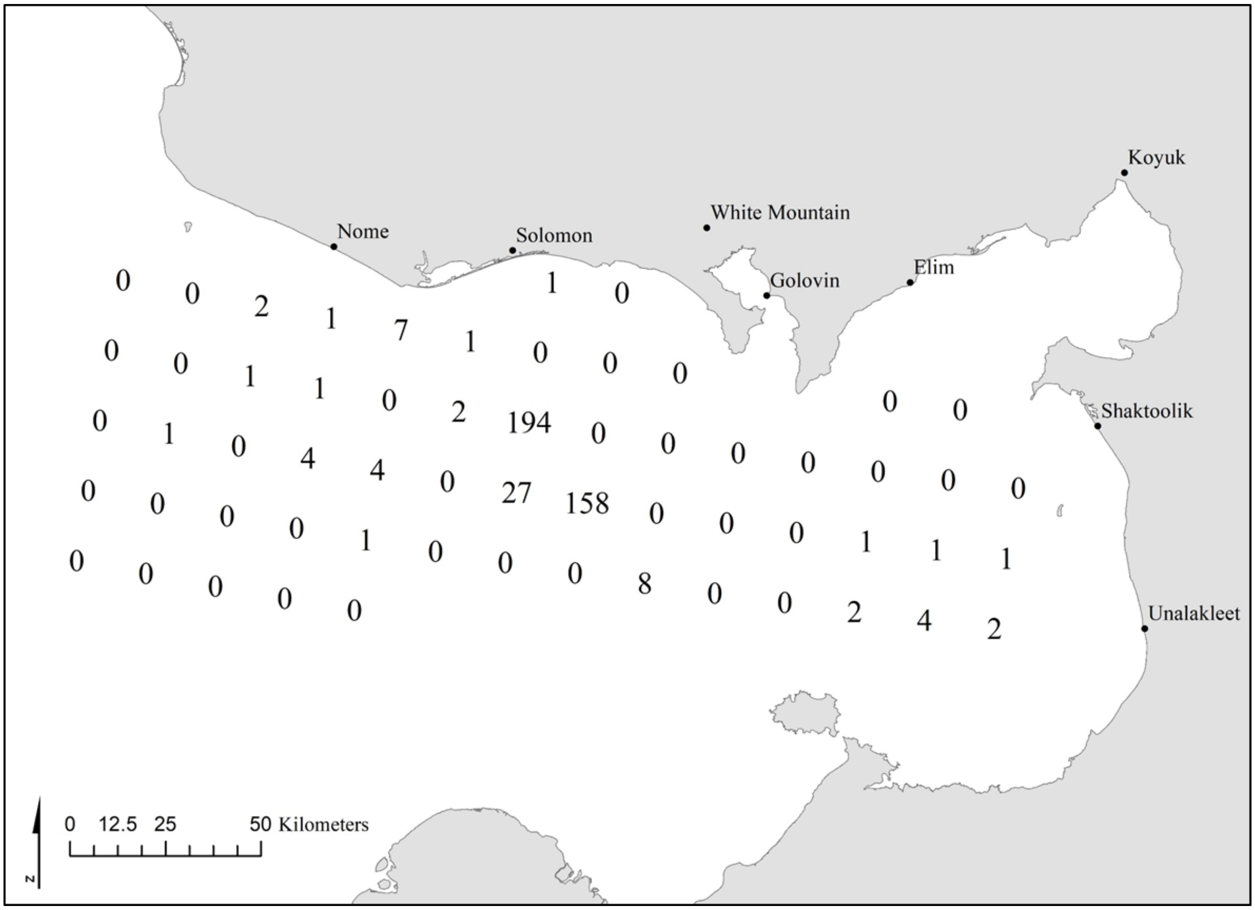

Figure 22.–Location and number of female red king crab captured during the Norton Sound bottom trawl survey, 2018.

APPENDIX A

Appendix A1.–Norton Sound bottom trawl survey data for the standard and nonstandard stations that produced legal male king crab catch, 2017.

Station number	No. of legal crabs	Area trawled (sq. miles)	Total area (sq. miles)	Estimated abundance
80	4	0.00658316	100	60,761
81	1	0.00658316	100	15,190
82	1	0.00658316	100	15,190
98	1	0.00658316	100	15,190
103	1	0.00658316	100	15,190
105	2	0.00658316	100	30,381
106	2	0.00658316	100	30,381
122	2	0.00658316	100	30,381
123	1	0.00658316	100	15,190
125	1	0.00658316	100	15,190
126	1	0.00658316	100	15,190
129	2	0.00658316	100	30,381
133	15	0.00658316	100	227,854
149	2	0.00658316	100	30,381
151	1	0.00658316	100	15,190
152	2	0.00658316	100	30,381
153	1	0.00658316	100	15,190
160	7	0.00658316	100	106,332
161	1	0.00658316	100	15,190
181	3	0.00658316	100	45,571
184	1	0.00658316	100	15,190
185	4	0.00658316	100	60,761
186	1	0.00658316	100	15,190
187	5	0.00658316	100	75,951

Appendix A2.–Norton Sound bottom trawl survey data for the standard and nonstandard stations that produced legal male king crab catch, 2018.

Station number	No. of legal crabs	Area trawled (sq. miles)	Total area (sq. miles)	Estimated abundance
187	2	0.00658316	100	30,381
82	1	0.00658316	100	15,190
106	2	0.00658316	100	30,381
132	2	0.00658316	100	30,381
130	1	0.00658316	100	15,190
128	1	0.00658316	100	15,190
127	1	0.00658316	100	15,190
155	1	0.00658316	100	15,190
183	4	0.00658316	100	60,761
184	1	0.00658316	100	15,190
123	1	0.00658316	100	15,190
95	3	0.00658316	100	45,571