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**Analysis of Red King Crab Data from the 2014 Alaska
Department of Fish and Game Trawl Survey of
Norton Sound**

by

Joyce Soong

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November 2015

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Joyce Soong
Alaska Department of Fish and Game, Division of Commercial Fisheries, Nome
and
Toshihide Hamazaki
Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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*Joyce Soong,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
103 E Front Street, Nome, Alaska 99762 USA*

and

*Toshihide Hamazaki,
Alaska Department of Fish and Game, Division of Commercial Fisheries
333 Raspberry Road, Anchorage, Alaska, 99518 USA*

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ABSTRACT

A trawl survey was conducted from July 18 to July 30, 2014, in Norton Sound in northwest Alaska to collect and analyze information on the distribution and abundance of demersal fishes and invertebrates, with primary focus on red king crab *Paralithodes camtschaticus*. Population abundance was estimated using an area-swept method. Abundance of legal male crab was approximately 1.75 million crab, or 4.90 million pounds. Abundance of prerecruit-1 male was approximately 2.57 million crab and that of prerecruit-2 male abundance was approximately 1.55 million crab.

Key words: Norton Sound, red king crab, *Paralithodes camtschaticus*, trawl survey, abundance, biomass estimate, population estimate, catch sampling, distribution, shell age, species composition.

INTRODUCTION

Norton Sound is located in the Norton Sound Section in the Northern District of the Alaska Department of Fish and Game (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). Commercial fisheries for red king crab *Paralithodes camtschaticus* in Norton Sound occur in 2 seasons: (1) June 15 to September 3 (summer), and (2) November 15 to May 15, through the ice only (winter). Although the commercial fishery commenced in 1977, subsistence users who primarily fish through the ice have long harvested red king crabs. The summer commercial fishery harvests approximately 500,000 pounds annually, ranging from 20,000 in 1999 to 3,000,000 pounds in 1979. Winter commercial fishery harvests are nominal, averaging about 10,000 pounds annually since 1990. However, in the 2012–13 season it had a record harvest of over 60,000 pounds (Menard et al. 2015).

A triennial Norton Sound trawl survey has been conducted since 1976. Prior to this survey, several investigations provided information on the distribution and abundance of demersal biota (Andriyashev 1937; Ellison et. al. 1950), including an Atomic Energy Commission assessment survey of demersal fishes and invertebrates of the southeast Chukchi Sea/Norton Sound region (Wilimovsky 1966). From 1976 through 1991, the National Marine Fisheries Service (NMFS) conducted comprehensive triennial stock assessment trawl surveys of Norton Sound to gather information on the distribution and abundance of demersal fishes and invertebrates (Wolotira et. al. 1977; Sample and Wolotira 1985; NMFS 1982; Stevens and MacIntosh 1986; Stevens 1989 and 1992¹). Additionally, red king crab summer pot surveys were conducted by ADF&G in 1980, 1981, 1982, and 1985 to provide annual distribution and abundance, as well as preseason information to fishery managers regarding stock size and recruit composition (Powell et al. 1983; ADF&G 1982a-b; Schwarz 1984; and Brannian 1987).

Due to budget constraints, NMFS did not survey the Norton Sound area in 1994. In 1996 ADF&G initiated a trawl survey of Norton Sound (Blau et al. 1996; Fair 1997). Since then, ADF&G has conducted trawl assessment surveys in 1999, 2002, 2006, 2008, and 2011 (Fair and Brennan 2001; Brennan 2002; Soong and Banducci 2006; Soong 2008; Soong and Hamazaki 2012). In 2005 the survey was not conducted due to difficulties in chartering a vessel. Starting with the 2006 survey, contributions from the Norton Sound Economic Development Corporation (NSEDC) enabled a larger area of Norton Sound to be surveyed than during the previous

¹ 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.

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.

ADF&G surveys. The main objectives of the ADF&G triennial trawl survey are to provide abundance estimates of the Norton Sound red king crab population, crab recruit class composition, and related biological characteristics, as well as to document benthic species composition in Norton Sound.

OBJECTIVES

Prioritized objectives for the 2014 Norton Sound red king crab trawl survey are as follows:

1. Estimate the Norton Sound red king crab population using an area-swept method and describe the size composition by sex and recruit class.
2. Describe the spatial distribution of the Norton Sound red king crab population and relative abundance of associated marine life.
3. Maintain continuity with previous trawl survey databases in Norton Sound, which were conducted by NMFS and ADF&G triennially from 1976 through 2014, by using the same station midpoints, grid pattern, and general sampling procedures.
4. Collect lengths, weights, and additional biological data from other commercial or potentially commercial species captured: specifically, blue king crabs *Paralithodes platypus*, Pacific halibut *Hippoglossus stenolepis*, Pacific cod *Gadus macrocephalus*, walleye pollock *Theragra chalcogramma*, and yellowfin sole *Limanda aspera*.
5. Collect additional biological samples, as requested, for other related research projects.

METHODS

TRAWL SURVEY

Norton Sound is divided into 10 by 10 nautical mile (nmi) grids, each grid cell is identified by a station number (Figure 2). The coverage area is grouped into 4 zones: Core and tier 1 making up a standard zone, tier 2, and tier 3 (Fair 1998). The core zone consists of 36 stations, excluding stations 177, 178, 201, 204, and 205, which were removed because rocky bottom resulted in torn nets (Blau et al. 1996; Soong and Banducci 2006; Soong 2008). Tier 1 zone consists of 11 stations, excluding stations 162, 188, 206, 207, 222, and 223 because of rocky bottom (Blau et al. 1996). Tier 2 and tier 3 zones consist of 14 and 7 stations, respectively. During the survey, the core and tier 1 stations are given the highest priority. Tier 2 and 3 stations are to be surveyed when time is available. The center of each station was trawled for approximately 30 minutes, at approximately 2 knots/hour, covering a distance of 1 nmi. A 400 eastern otter trawl net with two 1.5 by 2.1 m Astoria “V” doors is used. The trawl sweep width is 40 feet, yielding an area swept of approximately 40 feet by 1.0 nmi trawled area. Location and towed distance was recorded with a global positioning system (GPS) device, and bottom temperature was logged with a submersible probe attached to the net, recording at 3-minute intervals.

The 2014 ADF&G Norton Sound assessment survey was conducted aboard the chartered R/V *Pandalus* from July 18 to July 30 (Figure 3).

In past surveys, if a tow resulted in 5 or more legal red king crabs, then that station was resurveyed once more, either immediately or as logistics allowed. Resurveys were towed at the same depth, in close proximity to the initial tow track without crossing it, and at similar distances

and times at each respective station. However, due to a tighter vessel schedule and adverse weather, no stations were retowed, and stations in tiers 2 or 3 were not trawled.

CATCH SAMPLING

As the net was retrieved, all species, including fishes and crabs, were shaken from the intermediate portion of the net down to the codend. Once the codend was on board, a boom was used to lift and weigh the codend using a crane scale. The contents of the trawl were then emptied on deck, and the tare weight of the net section originally weighed was reweighed and recorded to calculate the net haul weight.

The trawl catch was then sorted for large debris and large fish. In addition to king crab, all Pacific halibut, large walleye pollock, and large Pacific cod were retrieved from each haul before subsampling so that accurate numbers of these commercially valuable species were recorded and quickly released, reducing mortality. Other large fish of potential commercial value (Alaska skate) were also retrieved and their data recorded as time allowed. Number, total weight (except for Pacific halibut), and individual lengths (snout tip to end of tail, in mm) were recorded before returning these species to the sea. Due to the difficulty of weighing large halibut, individual weight for halibut was calculated using the length to weight conversion equation from the International Pacific Halibut Commission ($W = 0.000009205 * L^{3.24}$ where W is in pounds and L is in cm), then added together for the total weight. The combined weight of these species and large debris were subtracted from the net haul weight to get the adjusted haul weight.

While 2 crewmembers recorded measurements from king crab and large fish, other crewmembers filled 2 or 3 baskets from the remaining haul and shoveled the rest overboard. The combined weight of the sampling baskets was recorded, then the contents were separated to the lowest taxon, and any additional debris (sticks, rocks, etc.) was removed. Each taxon was counted, weighed, and assigned a NMFS species code.

RED KING CRAB DISTRIBUTION, SHELL AGE, AND SIZE STRUCTURE

All red and blue king crabs from each trawl were sampled for sex, size, legality, shell age, and egg development, if applicable. Total number and weight of each crab species captured was also recorded. Carapace lengths (CL) were measured to the nearest millimeter from the posterior margin of the right eye socket to the midpoint of the rear margin of the carapace (Wallace et. al. 1949).

Male crabs were classified into following categories.

Legal male: having a minimum carapace width (CW; including spines) of 121 mm (4.75 in), or $CL \geq 104$ mm when CW was not measured.

Prerecruit-1 male: sublegal of $CL \geq 90$ mm

Prerecruit-2 male: sublegal between $CL \geq 76$ mm and $CL \leq 89$ mm

Prerecruit-3 male: sublegal of $CL \leq 75$ mm

Recruits male: legal new-shell of $CL \leq 115$ mm

Postrecruits male: legal new-shell of $CL \geq 116$ mm and legal old-shell

Shell-age classes were defined by shell condition according to the following definitions:

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. Crabs with this type of shell have 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. Crabs with this type of shell have had their present exoskeletons for 4–12 months. Some crabs show characteristics of both new-shell-hard and old-shell (i.e., coxa rimmed with brown scratches but exoskeletal spines and dactyls are sharp). Because red king crabs found in Norton Sound are thought to molt in September and October and therefore should start to show wear at the time of the trawl survey, these crabs were classified as new-shell-hard.

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. Crabs with this type of shell have 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. Crabs with this type of shell have had their present exoskeletons more than 24 months.

A different method was used to determine female crab maturity compared to years prior to 2006. In previous reports, adult 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 will be mature at ≥ 72 mm CL. During the 2006 and all later surveys, instead of CL, female maturity was determined by examining the extent of development of the abdominal flap (Donaldson and Byersdorfer 2005).

RED KING CRAB POPULATION ESTIMATION

Population estimates for red king crabs were generated using the area-swept method, for direct comparison to previous analyses (Alverson and Pereyra 1969). Abundance estimates were standardized only for 47 trawlable stations in core and tier 1 zone (Figure 2) for 3 crab classes: legal, prerecruit-1, and prerecruit-2.

Using the area-swept method, a_j was the swept area at the station (j); and n_j was the number of crab captured at the station (j). The swept area a_j was computed by multiplying the width of the

net mouth opening (0.00658 nmi) by the distance trawled. Abundance \hat{N}_j for the station (j) was estimated as:

$$N_j = n_j \frac{A_j}{a_j}. \quad (1)$$

Total crab abundance (N) was estimated as the sum of estimated station abundances:

$$\hat{N} = \sum_j N_j. \quad (2)$$

The variance of N was estimated as:

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

where n was the number of stations trawled.

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

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

NON-CRAB TAXA

For non-crab taxa, an average catch per unit effort (CPUE) was calculated.

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

$$W_{i,j} = w_{i,j} \frac{T_j}{t_j}. \quad (5)$$

Where $w_{i,j}$ 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/km²) for each tow was calculated as:

$$CPUE_{i,j} = \frac{W_{i,j}}{a_j}, \quad (6)$$

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

RESULTS

TRAWL SURVEY OPERATIONS

Although the vessel was available on July 17, the survey did not start until July 18 due to weather concerns. Deteriorating weather and rough seas cut short trawling on the first day (July 18), as well as on July 20 and July 23. In addition, adverse weather prevented trawling altogether on July 19, July 21, and July 27. Despite the limited time available, the survey was

still able to successfully complete all 47 trawlable stations in the core and tier 1 (standard) zones, with some minor gear issues (Table 1, 2). One station (78) was aborted halfway because the net was bogging down, but was retowed immediately without problems. At station 150, the doors almost collapsed and the skipper had to speed up the haul. The net was torn at stations 151, 176, and 184. The entire haul catch was not weighed at station 151 because of a huge rock. Two stations (159 and 160) were trawled west of center point (Figure 3).

Bottom temperatures for all tows ranged between 3.2° C and 10.3° C. The coldest temperature was recorded at station 151 in eastern Norton Sound, and the warmest temperature was recorded at stations 184, 185, and 128 (Table 1; Figure 4). The average trawl depth was 10.5 fathoms, ranging from 7.0 fathoms at station 181 to 17.1 fathoms at station 135 (Table 1).

RED KING CRAB POPULATION ESTIMATION

Total number of male crabs caught was 115 legal, 139 prerecruit-1, and 102 prerecruit-2 (Table 1). Of those, the majority of crabs were caught at station 186, followed by nearby stations (184, 185, and 187) (Figures 5–7). The area 30 to 40 miles south of Nome (stations 105, 106, and 132) also contained high numbers of crab. At station 186, a high number of prerecruit-1 and prerecruit-2 were caught (Figures 2 and 4–6). Abundance of legal male red king crabs was 1,747,720 (CV 52%) or approximately 4.89 million pounds (Table 3). Abundance of prerecruit-1 males was 2,566,201, and that of prerecruit-2 males was 1,547,538. Total female crab catch was 60, and they were most abundant at south of Nome (stations 183 and 185) (Figure 8). Female population abundance was not estimated because of low catch (60 samples).

RED KING CRAB DISTRIBUTION, SHELL AGE, AND SIZE STRUCTURE

Male crabs consisted of 72.0% prerecruits, 15.3% recruits, and 12.7% postrecruits, ranging in size from 16 mm to 152 mm CL ($n = 411$) (Figure 9). Of legal crabs ($n = 115$), slightly more than half were new-shell (Figure 10), whereas 88% of sublegal crabs ($n = 296$) were new-shell (Figure 11). Size composition of legal males from the 2014 trawl survey was similar to that in the 2014 spring tagging study, except for the smallest size class (100–104 mm) (Figure 12). On the other hand, size composition of the 2014 summer commercial fishery consisted of greater percentage of larger crabs ($n = 4,682$) because marketable size is CW ≥ 127 mm (5.00 in), or an approximate CL ≥ 104 mm even though minimum legal size is CW of 121 mm (4.75 in).

Females consisted of 62% adults ($n = 37$) and 38% juvenile crabs ($n = 23$; Table 4). Of the adults, about half had relatively full ($\geq 60\%$) egg clutches. The majority of the clutches were purple in color, and all clutches appeared uneyed without dead eggs apparent.

CATCH COMPOSITION

A total of 110 taxa were identified in 2014. Based on CPUE (weight caught per area trawled), the 5 top-ranking taxa in decreasing order consisted of the purple-orange sea star (*Asterias amurensis*), saffron cod (*Eleginus gracilis*), black-spined sea star (*Lethasterias nanimensis*), giant sea star (*Evasterias echinosoma*), and starry flounder (*Platichthys stellatus*) (Table 5). Invertebrate species accounted for 22 of the 40 top-ranking taxa by CPUE. One mature female blue king crab with an almost full egg clutch was captured at station 186. Among the large fish, 19 were Pacific halibut with an average length of 755 mm and a calculated average weight of 5.7 kg, 15 were Pacific cod with average length of 715 mm and average weight of 4.5 kg, and one was an Alaska skate with a weight of 8.7 kg (Table 6).

DISCUSSION

TRAWL SURVEY

The biggest impediment of the 2014 trawl survey was adverse weather conditions. Those resulted in 6 days of no surveys and trawling conducted only at core and tier 1 zones. While adverse weather conditions are unavoidable, optimizing trawl survey routes could improve survey efficiency.

KING CRAB POPULATION ESTIMATION

The 2014 trawl survey abundances were the highest since 1976 (Table 3). Especially, abundance of prerecruits were about 3.3 (prerecruit-2) and 7 (prerecruit-1) times higher than those of 2011. However, those increases were largely due to high catch at station 186 that accounted for 67% of legal, 57% of prerecruit-1, and 46% of total crab catches. This also resulted in high CVs. Those high estimates with high CV could have been improved, had the station been retowed. Retow is permitted in survey protocol when a tow resulted in 5 or more legal red king crabs (Soong and Hamazaki 2012). However, in 2014, this option was suspended to cover more area. Further, in recent years, retow protocol has been terminated in other Bering Sea bottom trawl surveys. Termination of retow protocol is also recommended for the Norton Sound trawl survey. Despite those survey uncertainties, we believe that red king crab abundance increased from 2011 to 2014 because crab catches at other stations were also higher (Soong and Hamazaki 2012).

For females, although stations 183 and 185 produced the highest numbers of crabs in both 2011 and 2014 (Figure 8), fewer crabs were caught in both numbers per station and total number of stations with female crabs (Table 3). This may indicate decline of female abundance. Little is known about the biology of female Norton Sound red king crab, including distribution and abundance. Few female red king crabs are caught in surveys and fisheries. Further investigation on female red king crab is needed.

Distribution of red king crab showed similarities in 2014 to historical trends: high abundance immediately south of Nome (stations 184–187) and in southeastern sides of the core zone (stations 123–127, 150, 176) (bordering tier 2 and 3 zones). Although abundance in the south of Nome has been consistent since 1976, abundance in southeastern sides has increased since 1976. Further surveys in those areas are warranted.

CATCH COMPOSITION

Norton Sound epifauna is characterized as purple-orange sea star (*Asterias amurensis*) dominated (Hamazaki et al. 2005). This characteristic has remained the same since 1976. For non-red king crab taxa, total number of taxa identified declined from 124 to 110 in 2011 (Soong and Hamazaki 2012). Unidentified tunicates and Opilio crab entered the top 10 rank in 2014, replacing unidentified sponges and green sea urchin. Rankings of unidentified tunicates and Opilio crab were in the 20s in 2011. Rankings of unidentified sponges and green sea urchin are 36 and 18 in 2014, respectively. It is unknown whether those changes are due to changes in abundance or sampling stochasticity. The trawl survey represents the long-term monitoring of the Norton Sound epifauna. Importance of those long-term time series data will increase in the face of expected changes in Arctic environment.

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TABLES AND FIGURES

Table 1.—Station location and number of red king crabs captured, by sex and size, during the Norton Sound trawl survey, July 18 to July 30, 2014.

Station number	Date trawled	Start location				Compass heading (true)	Distance towed (nmi)	Average depth (fm)	Bottom temp. (°C)	Males							
		N Lat		W Long						Females		Sublegal			Legal ^f		
		Deg.	Min.	Deg.	Min.					Juvenile ^a	Adult ^b	3s ^c	2s ^d	Ones ^e	Recruit ^g	Postrecruit ^h	
78	7/29	63	40.00	164	58.21	111	1.0	7.4	8.4	0	0	0	0	0	0	0	0
79	7/29	63	39.99	165	20.66	93	1.0	8.7	7.5	0	0	0	0	0	0	0	0
80	7/29	63	40.02	165	42.98	98	1.0	11.2	6.2	0	0	0	1	1	0	0	1
81	7/30	63	39.98	166	5.55	222	1.0	13.7	5.1	0	0	0	0	0	0	0	0
82	7/30	63	39.95	166	28.04	222	1.0	14.3	5.1	0	0	0	0	0	0	0	0
103	7/29	63	50.00	164	58.18	264	1.0	8.0	8.7	0	2	0	2	2	0	0	0
104	7/29	63	50.01	165	20.77	262	1.0	9.2	7.6	0	0	0	1	1	0	0	0
105	7/29	63	50.01	165	43.35	121	1.0	10.7	6.3	0	1	0	1	1	1	1	5
106	7/30	63	49.99	166	5.91	182	1.0	13.6	6.2	0	0	0	0	0	3	3	3
107	7/30	63	49.96	166	28.46	165	1.0	15.7	4.8	0	0	0	0	0	0	0	0
123	7/23	63	59.99	162	19.14	270	1.0	9.1	4.4	0	0	0	0	0	0	0	0
124	7/23	64	0.02	162	41.68	263	1.0	9.5	5.3	0	0	3	1	0	1	1	1
125	7/22	64	0.01	163	4.66	270	1.0	9.2	5.6	0	0	1	2	0	2	2	2
126	7/22	64	0.01	163	27.32	272	1.0	9.7	5.0	2	0	7	5	3	2	2	1
127	7/22	64	0.02	163	50.08	167	1.0	9.0	6.4	0	0	1	2	2	2	2	1
128	7/25	64	0.00	164	12.84	63	1.0	8.4	10.3	0	2	0	0	0	0	0	0
129	7/26	64	0.00	164	35.45	282	1.0	9.7	9.1	0	2	0	0	0	0	0	0
130	7/26	64	0.00	164	58.19	238	1.0	9.1	8.4	0	0	0	0	0	0	0	0
131	7/26	64	0.01	165	20.85	93	1.0	8.8	8.1	0	1	0	0	0	1	0	0
132	7/29	63	59.99	165	43.59	284	1.0	10.1	8.2	0	0	3	10	7	3	0	0
133	7/28	64	0.01	166	6.31	116	1.0	11.7	7.0	0	0	0	1	2	1	2	2
134	7/28	63	59.99	166	29.01	116	1.0	15.0	5.8	0	0	0	0	0	0	0	0
135	7/28	64	0.02	166	51.82	292	1.0	17.1	4.1	0	0	0	0	0	0	0	0
150 ⁱ	7/24	64	10.00	162	18.23	110	1.0	8.7	4.6	0	0	0	0	0	0	0	2
151 ^j	7/24	64	10.00	162	41.12	79	1.0	10.8	3.2	0	0	1	0	1	0	0	2
152	7/24	64	10.02	163	3.96	105	1.0	13.2	4.1	2	0	0	0	0	0	0	0
153	7/24	64	10.02	163	26.86	106	1.0	10.0	4.6	0	0	1	0	0	0	0	0
154	7/24	64	10.01	163	49.70	113	1.0	9.7	5.4	0	0	0	1	0	0	0	0
155	7/22	64	9.99	164	12.51	122	1.0	9.8	6.4	0	1	4	1	2	0	0	0
156	7/22	64	9.99	164	35.43	64	1.0	7.6	9.0	0	3	0	0	0	1	0	0

-continued-

Table 1.–Page 2 of 2.

Station number	Date trawled	Start location				Compass heading (true)	Distance towed (nmi)	Average depth (fm)	Bottom temp. (°C)	Males							
		N Lat		W Long						Females		Sublegal			Legal ^f		
		Deg.	Min.	Deg.	Min.					Juvenile ^a	Adult ^b	3s ^c	2s ^d	Ones ^e	Recruit ^g	Postrecruit ^h	
157	7/26	64	9.99	164	58.24	90	1.0	7.9	8.9	0	0	1	0	0	0	0	
158	7/26	60	10.01	165	21.09	116	1.0	9.0	8.0	0	0	0	0	0	0	0	
159 ^k	7/20	64	10.02	165	53.18	239	1.0	10.6	7.1	0	0	0	1	0	3	0	
160 ^k	7/20	64	10.10	166	21.84	185	1.0	12.7	5.1	0	0	0	0	0	0	0	
161	7/28	64	10.00	166	29.56	101	1.0	13.5	6.2	0	0	0	0	0	0	1	
176 ^l	7/23	64	20.01	162	17.36	180	1.0	9.4	4.3	0	0	1	10	14	1	3	
179	7/25	64	19.99	163	26.31	90	1.0	9.7	6.5	0	1	0	3	3	0	0	
180	7/25	64	19.96	163	49.16	148	1.0	8.7	7.4	1	0	0	0	0	0	0	
181	7/25	64	19.99	164	12.28	100	1.0	7.0	9.6	0	0	0	0	0	0	0	
182	7/22	64	20.00	164	35.67	99	1.0	7.5	10.2	0	0	0	0	0	0	0	
183	7/30	64	19.89	164	57.59	120	1.0	14.9	9.0	7	6	1	2	2	0	0	
184 ^l	7/18	64	19.93	165	21.44	330	1.0	12.5	10.3	2	1	9	2	7	1	1	
185	7/18	64	19.74	165	44.82	11	1.0	11.1	10.3	3	13	6	8	13	0	2	
186	7/20	64	20.00	166	6.81	250	1.0	12.1	8.1	1	4	13	40	74	37	23	
187	7/28	64	20.01	166	30.11	73	1.0	14.1	7.3	1	0	1	7	3	4	2	
202	7/25	64	30.00	163	48.86	253	1.0	7.7	6.2	1	0	0	0	1	0	0	
203	7/25	64	29.29	164	11.97	273	1.0	9.8	7.2	3	0	2	1	0	0	0	

^a Juvenile female red king crabs include all females that were non-ovigerous, had clean pleopodal setae, and had abdominal flaps that did not extend over the coxa.

^b Adult female red king crabs include all ovigerous females and all non-ovigerous females with abdominal flaps that extended over the coxa.

^c Prerecruit-3 include all sublegal male crabs <76 mm carapace length (CL).

^d Prerecruit-2 include all sublegal male crabs 76 mm to 89 mm CL.

^e Prerecruit-1 include all sublegal male crabs >89 mm CL.

^f Legal male red king crabs are ≥ 121 mm (4.75 in) carapace width, including lateral spines.

^g Recruits are legal new-shell male crabs ≤ 115 mm CL.

^h Postrecruits are legal new-shell male crabs >115 mm CL and all old-shell legal crabs of legal width.

ⁱ Doors almost collapsed, so had to speed up the tow.

^j Net damaged due to huge boulder. Haul weight from net was not taken, but one basketful was sampled.

^k Station was towed west of center point due to glitch in computer program.

^l Tow contained a large amount of mud and either large rocks or large branches.

Table 2.—Norton Sound trawl survey dates, gear type, total number of successful tows, total number of stations completed in the core and tiers 1–3, number of resampled stations, and sampling time schedule.

Year	Dates	Gear type	Total number of successful tows	Total number of stations completed in core & tiers 1-3	Number of resampled stations	Sampling time
1976	9/2-9/5, 9/16-10/6	83-112 Eastern Otter Trawl	192	na	17	24 hour basis
1979	7/26-8/5	83-112 Eastern Otter Trawl	115	na	16	24 hour basis
1982	9/5-9/11	83-112 Eastern Otter Trawl	53	na	0	24 hour basis
1985	9/16-10/1	83-112 Eastern Otter Trawl	78	na	0	Daylight hours
1988	8/16-8/30	83-112 Eastern Otter Trawl	82	na	4	24 hour basis
1991	8/22-8/30	83-112 Eastern Otter Trawl	53	na	0	Daylight hours
1996	8/7-8/18	400 Eastern Otter Trawl	69	48	21	Daylight hours
1999	7/28-8/7	400 Eastern Otter Trawl	59	50	9	Daylight hours
2002	7/27-8/6	400 Eastern Otter Trawl	60	56	3	Daylight hours
2006	7/25-8/8	400 Eastern Otter Trawl	75	69	4	Daylight hours
2008	7/24-8/11	400 Eastern Otter Trawl	68	67	2	Daylight hours
2011	7/18-8/15	400 Eastern Otter Trawl	70	63	5	Daylight hours
2014	7/18-7/30	400 Eastern Otter Trawl	47	47	0	Daylight hours

Table 3.—Standardized results from population assessment surveys for red king crabs in Norton Sound, 1976–2014.

Year	Dates	Research agency	Gear	Number of red king crabs captured ^{a,b}				Population abundance estimates ^c			Standard error		
				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	N/A	N/A	90(86)	N/A	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

^a Number of crabs captured on 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.

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

^d Legal male red king crabs 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 of the NMFS trawl surveys.

^e Prerecruit-1 and prerecruit-2 male and female data is 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 inaccurate due to an under-reporting of recovered tagged crabs.

Table 4.-Length frequency and percent ovigerity of female red king crabs captured during the 2014 Norton Sound trawl survey.

Carapace length (mm)	Adult percent ovigerity					Total adults	Juveniles (immature)	All females
	0%	1-29%	30-59%	60-89%	90-100%			
18	0	0	0	0	0	0	1	1
19	0	0	0	0	0	0	2	2
20	0	0	0	0	0	0	1	1
25	0	0	0	0	0	0	2	2
34	0	0	0	0	0	0	1	1
35	0	0	0	0	0	0	1	1
62	0	0	0	0	0	0	1	1
64	0	0	0	0	0	0	1	1
65	0	0	0	0	0	0	1	1
66	0	0	0	0	0	0	2	2
68	0	0	0	1	0	1	2	3
69	0	0	1	0	0	1	1	2
70	0	0	1	0	0	1	1	2
72	0	0	0	0	0	0	3	3
74	0	0	2	1	0	3	0	3
75	0	0	4	1	0	5	0	5
76	0	0	1	1	0	2	1	3
77	0	0	0	2	0	2	1	3
78	0	0	2	0	1	3	0	3
79	0	0	2	1	1	4	1	5
80	0	0	1	0	0	1	0	1
81	0	0	1	0	0	1	0	1
82	0	0	1	1	0	2	0	2
83	0	0	0	1	1	2	0	2
85	0	0	1	1	0	2	0	2
86	0	1	0	1	0	2	0	2
87	0	0	0	2	0	2	0	2
90	0	0	1	0	0	1	0	1
91	0	0	0	1	0	1	0	1
94	0	0	0	1	0	1	0	1
Total	0	1	18	15	3	37	23	60

Table 5.–The top 40 taxa, ranked by CPUE, identified during the 2014 ADF&G Norton Sound red king crab trawl survey.

Rank	NMFS species code	Common name	Scientific name or taxon	CPUE (kg/km ²)
1	81742	Purple-orange sea star	<i>Asterias amurensis</i>	24,770
2	21735	Saffron cod	<i>Eleginus gracilis</i>	4,423
3	80200	Black-spined sea star	<i>Lethasterias nanimensis</i>	1,897
4	80020	Giant sea star	<i>Evasterias echinosoma</i>	1,289
5	10220	Starry flounder	<i>Platichthys stellatus</i>	1,282
6	10210	Yellowfin sole	<i>Limanda aspera</i>	1,264
7	21375	Myoxocephalus unidentified	<i>Myoxocephalus</i> sp.	1,038
8	69322	Red king crab	<i>Paralithodes camtschaticus</i>	1,029
9	98000	Tunicate unidentified	<i>Ascidacea</i> sp.	666
10	68580	Opilio crab	<i>Chionoecetes opilio</i>	624
11	10285	Alaska plaice	<i>Pleuronectes quadrituberculatus</i>	581
12	80595	Leptasterias unidentified	<i>Leptasterias</i> sp.	540
13	68781	Helmet crab	<i>Telmessus cheiragonus</i>	490
14	10120	Pacific halibut	<i>Hippoglossus stenolepis</i>	355
15	43000	Sea anemone unidentified	<i>Actinaria</i> sp.	350
16	71884	Northern neptune	<i>Neptunea heros</i>	347
17	69010	Hermit crab unidentified	<i>Paguridae</i> sp.	324
18	82510	Green sea urchin	<i>Strongylocentrotus droebachiensis</i>	279
19	66611	Kuro argid	<i>Argis lar</i>	269
20	21720	Pacific cod	<i>Gadus macrocephalus</i>	243
21	21388	Antlered sculpin	<i>Enophrys dicerca</i>	238
22	83020	Basket sea star	<i>Gorgonocephalus eucnemis</i>	200
23	40500	Jellyfish unidentified	<i>Scyphozoa</i> sp.	170
24	10260	Rock sole unidentified	<i>Lepidopsetta</i> sp.	103
25	471	Alaska skate	<i>Bathyraja parmifera</i>	102
26	41201	Sea raspberry	<i>Gersemia</i> sp.	92
27	23801	Lumpenus unidentified	<i>Lumpenus</i> sp.	87
28	24189	Polar eelpout	<i>Lycodes turneri</i>	55
29	71882	Fat whelk	<i>Neptunea ventricosa</i>	53
30	68577	Circumboreal toad crab (Lyre crab)	<i>Hyas coarctatus</i>	42
31	24185	Wattled eelpout	<i>Lycodes palearis</i>	42
32	21313	Gymnocanthus unidentified	<i>Gymnocanthus</i> sp.	41
33	71511	Moonsnail eggs unidentified	<i>Naticidae</i> eggs	36
34	95030	Leafy bryozoan	<i>Flustra serrulata</i>	29
35	71753	Warped whelk	<i>Pyrulofusus deformis</i>	29
36	91000	Sponge unidentified	<i>Porifera</i> sp.	28
37	75284	Serripes unidentified	<i>Serripes</i> sp.	26
38	10211	Longhead dab	<i>Limanda proboscidea</i>	25
39	21740	Walleye pollock	<i>Theragra chalcogramma</i>	20
40	66203	Spiny lebbeid	<i>Lebbeus groenlandicus</i>	20

Table 6.—Data on large fish collected during the ADF&G Norton Sound red king crab trawl survey for 2002, 2006, 2008, 2011, and 2014.

Year	# of stations sampled	Species	# of fish sampled	Average length (mm)	Average weight (kg)
2002	60	Pacific cod	27	650	3.2
		Pacific halibut	10	750	7.4
		Walleye pollock	38	730	2.7
2006	75	Pacific cod	17	754	4.1
		Pacific halibut	28	702	5.1
		Walleye pollock	27	698	3.1
2008	68	Pacific cod	30	696	4.7
		Pacific halibut	27	692	4.9
		Walleye pollock	11	736	2.8
2011	70	Pacific cod	1	896	7.2
		Pacific halibut	19	700	5.4
		Yellowfin sole	1	440	1.6
2014	47	Alaska skate	1	na	8.7
		Pacific cod	15	715	4.5
		Pacific halibut	19	755	5.7

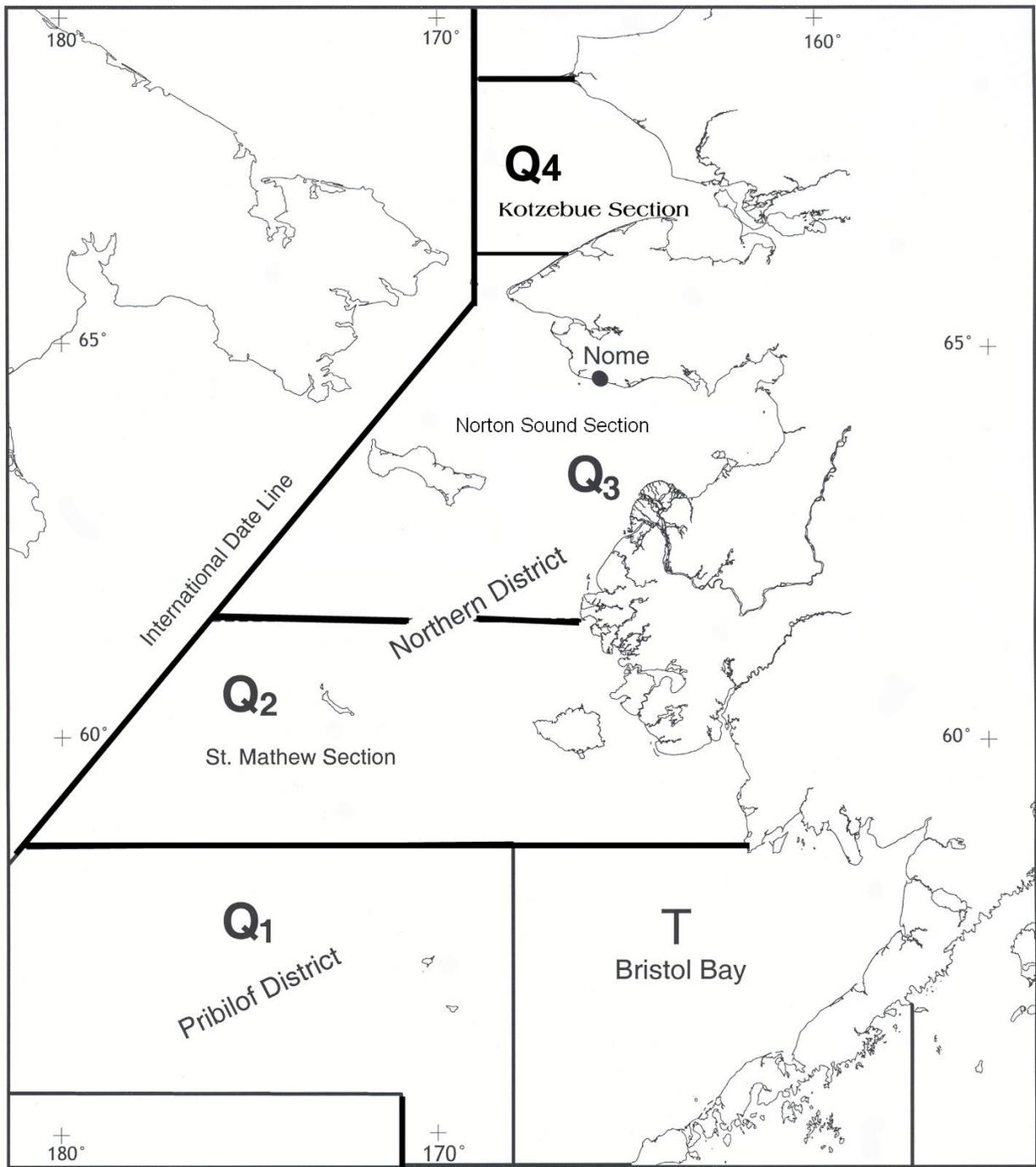


Figure 1.—King crab fishing districts and sections of Registration Area Q.

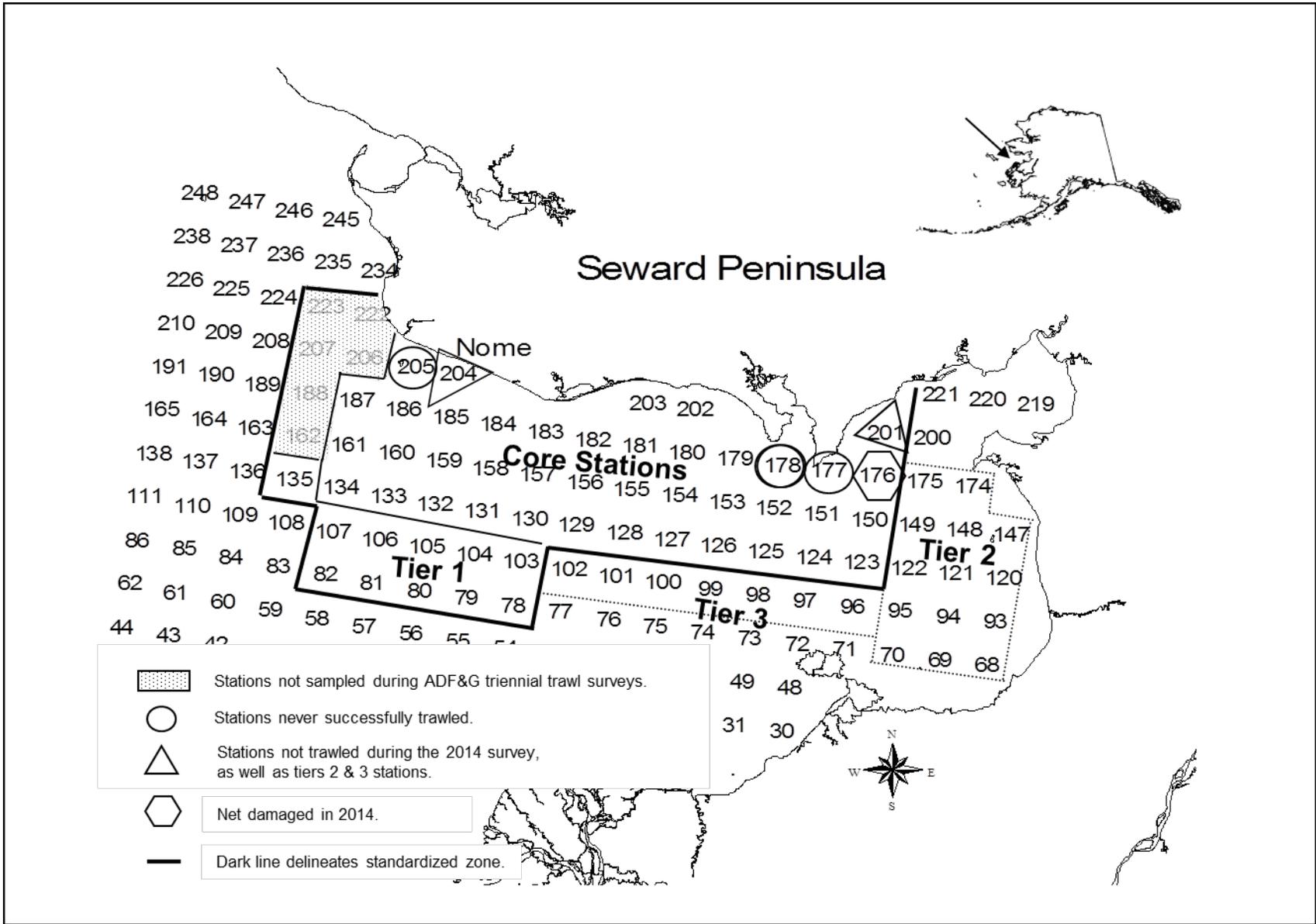


Figure 2.—Station identification numbers for the 2014 ADF&G Norton Sound trawl survey.

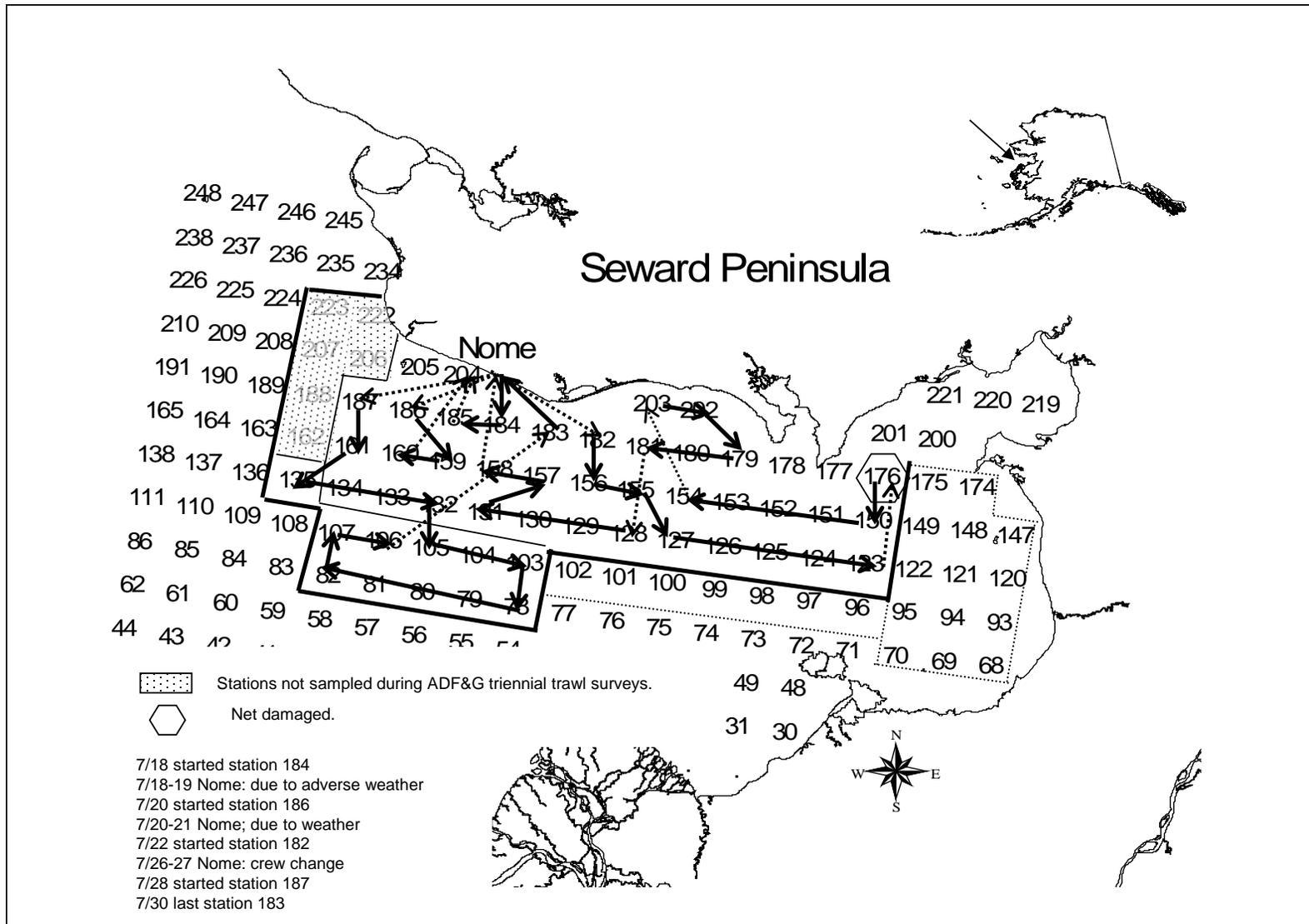


Figure 3.—Trawl survey route from the 2014 ADF&G Norton Sound trawl survey.

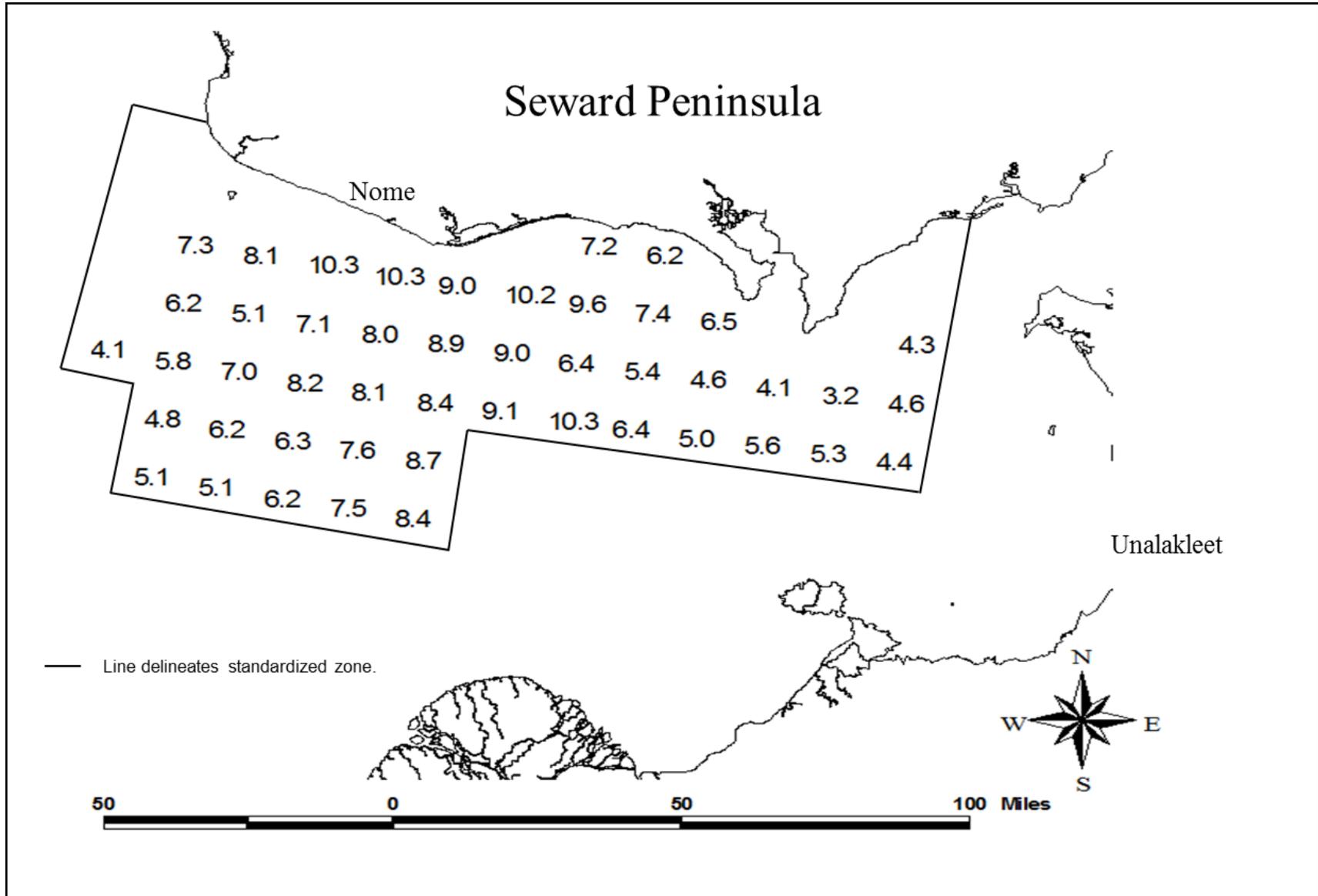


Figure 4.—Mean bottom temperatures (°C) from the 2014 ADF&G Norton Sound trawl survey.

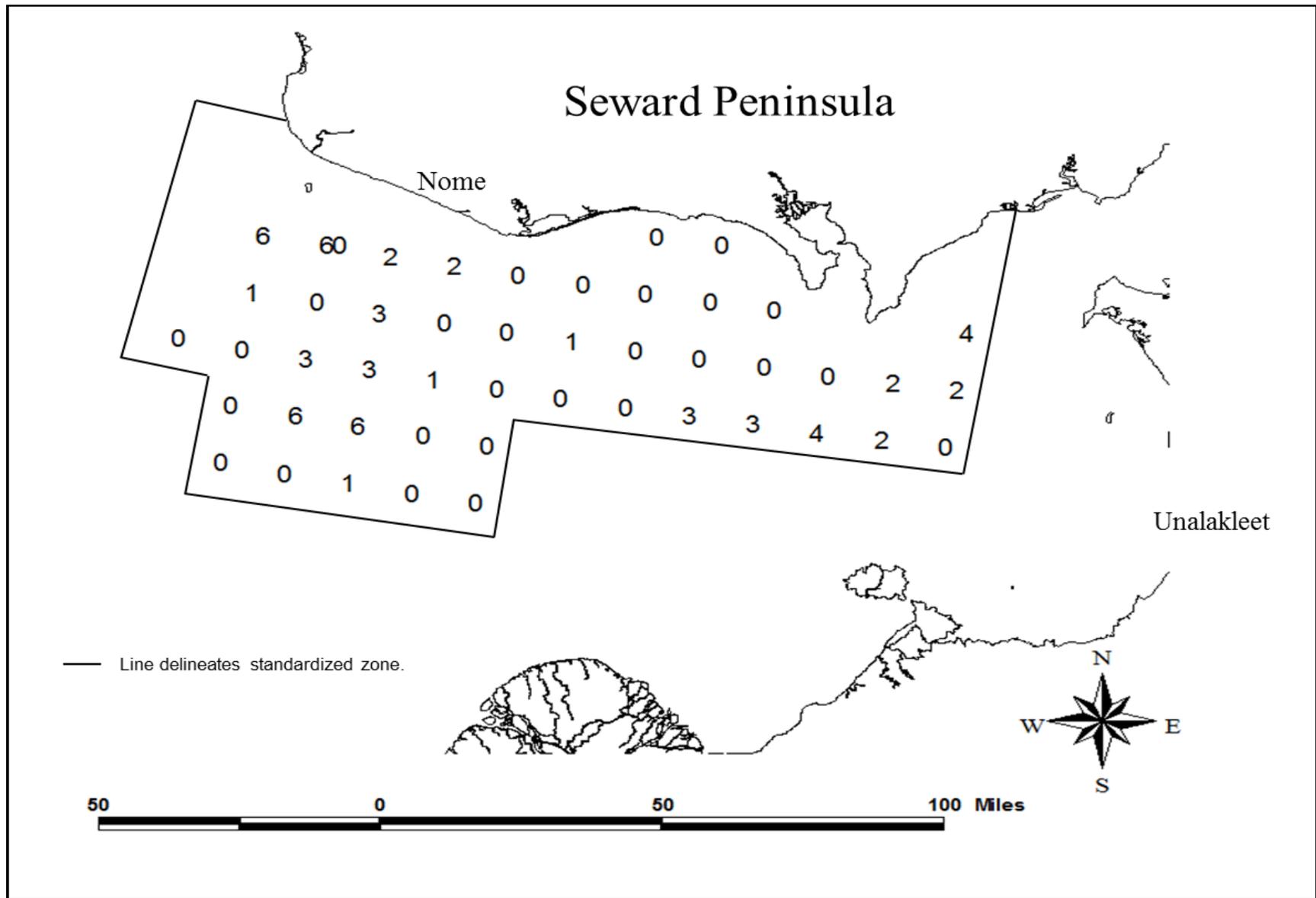


Figure 5.—Legal male red king crab catches from the 2014 ADF&G Norton Sound trawl survey.

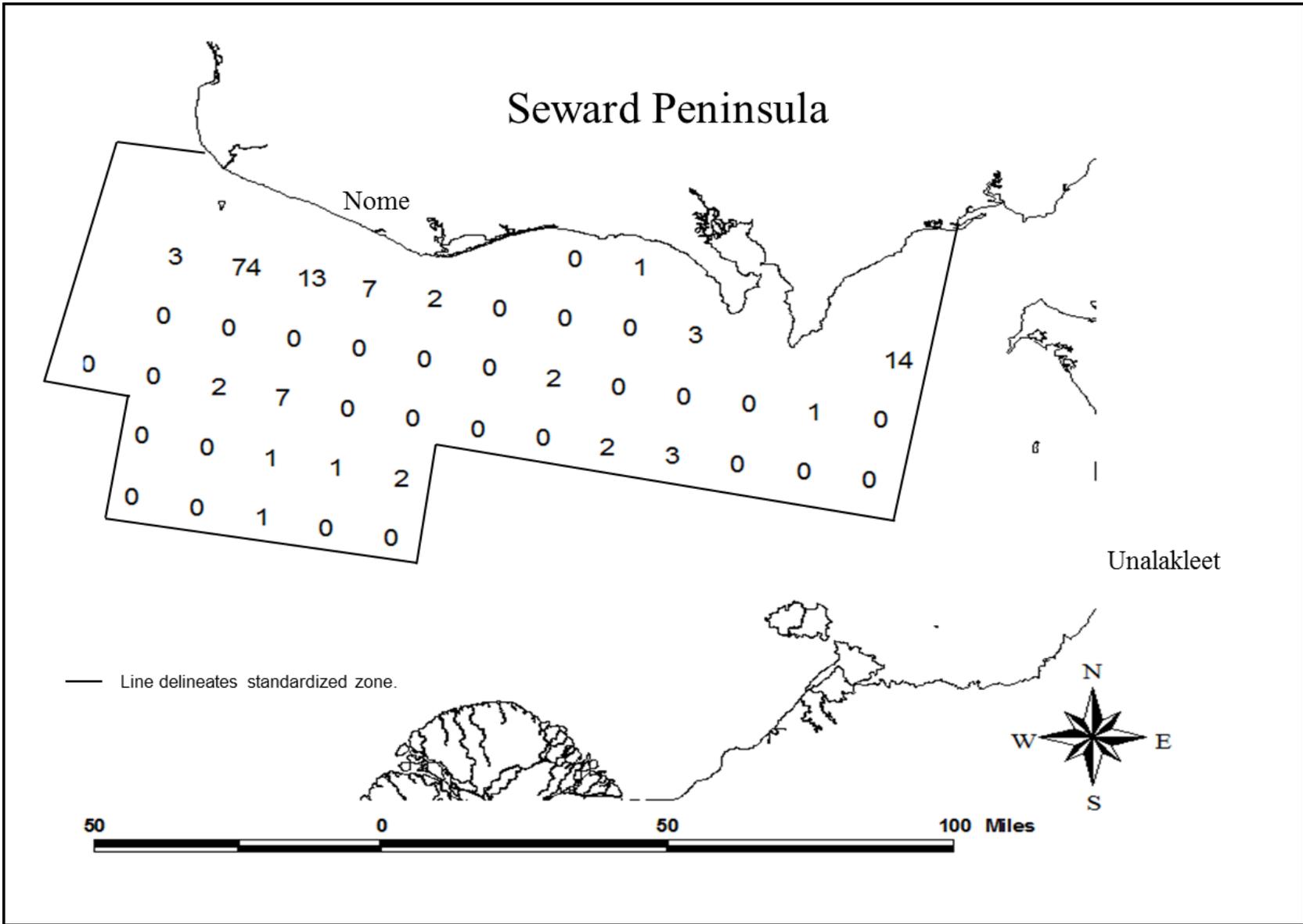


Figure 6.—Prereduit-1 male red king crab catches from the 2014 ADF&G Norton Sound trawl survey.

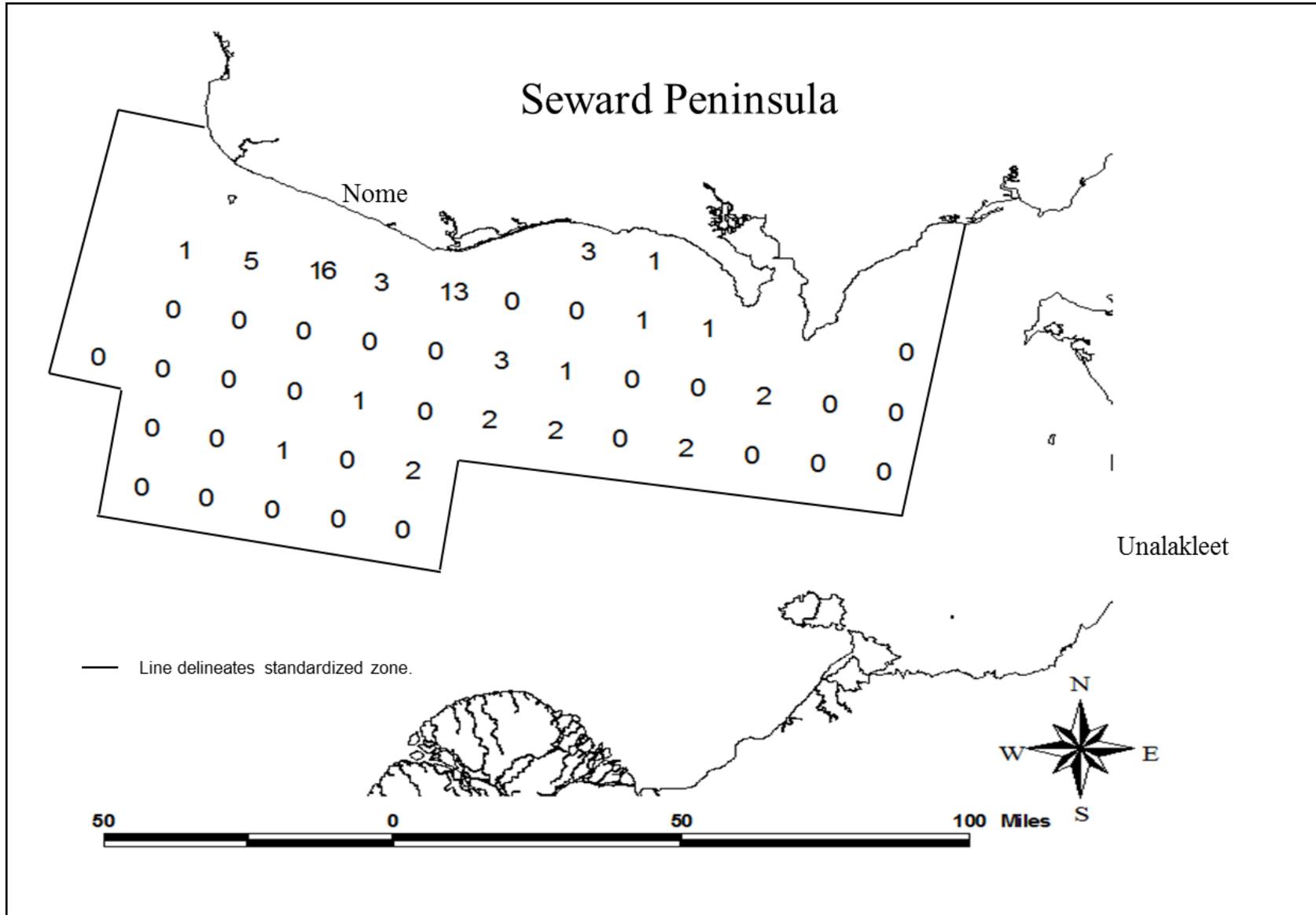


Figure 8.—Female red king crab catches from the 2014 ADF&G Norton Sound trawl survey.

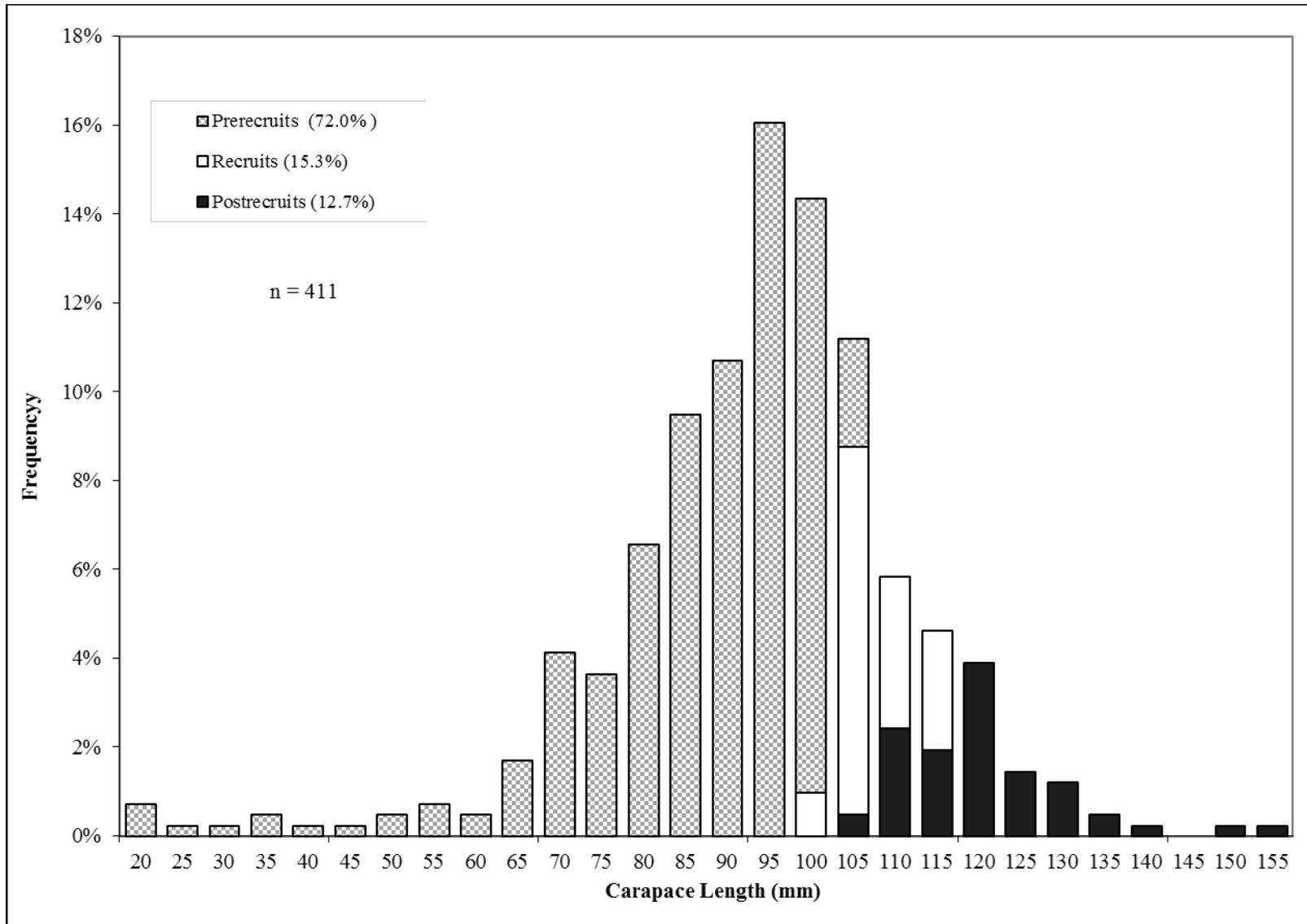


Figure 9.—Size composition of male red king crabs measured at standard stations during the 2014 ADF&G Norton Sound trawl survey.

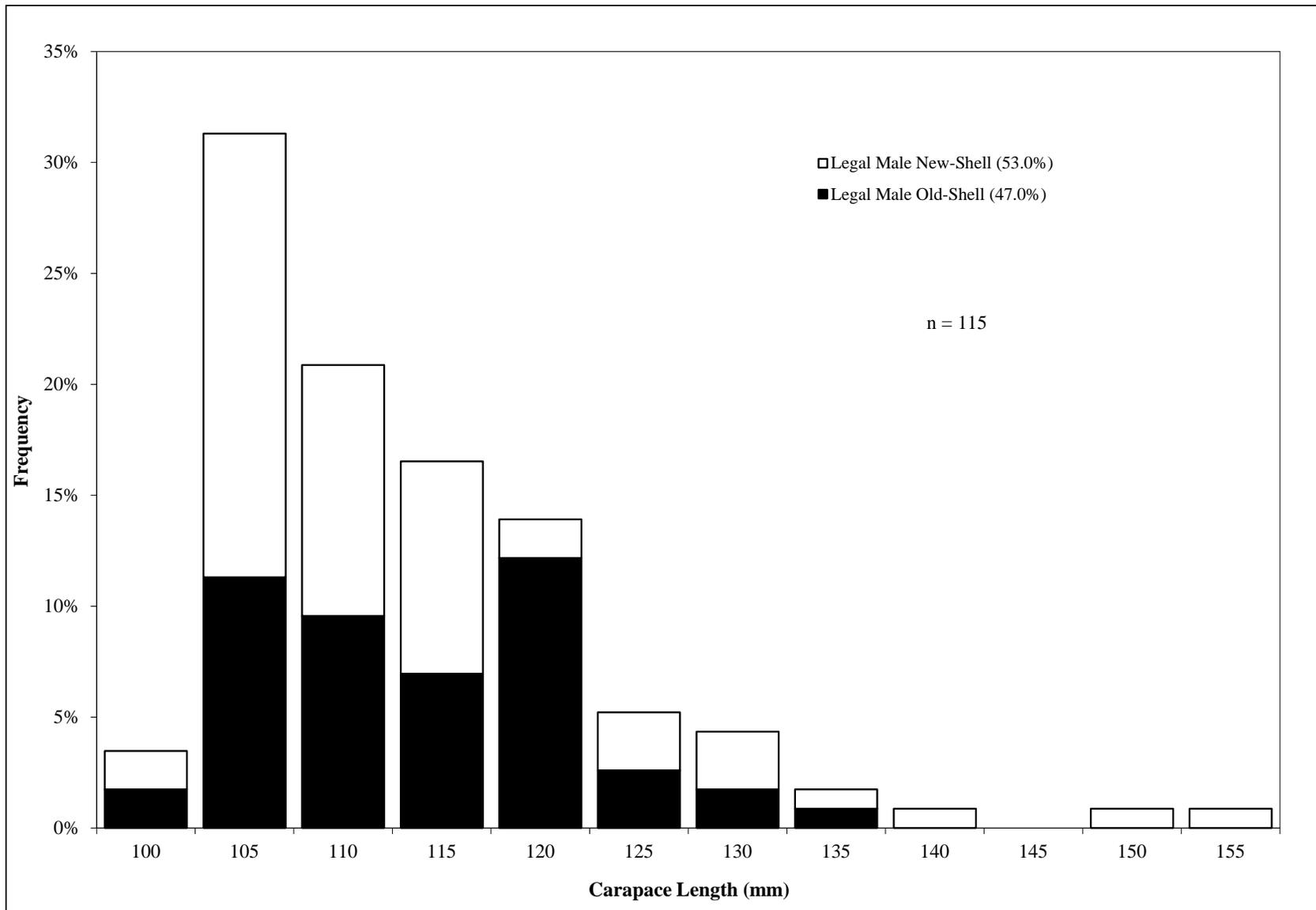


Figure 10.—Size composition by shell age of legal male red king crabs captured at standard stations during the 2014 ADF&G Norton Sound red king crab trawl survey.

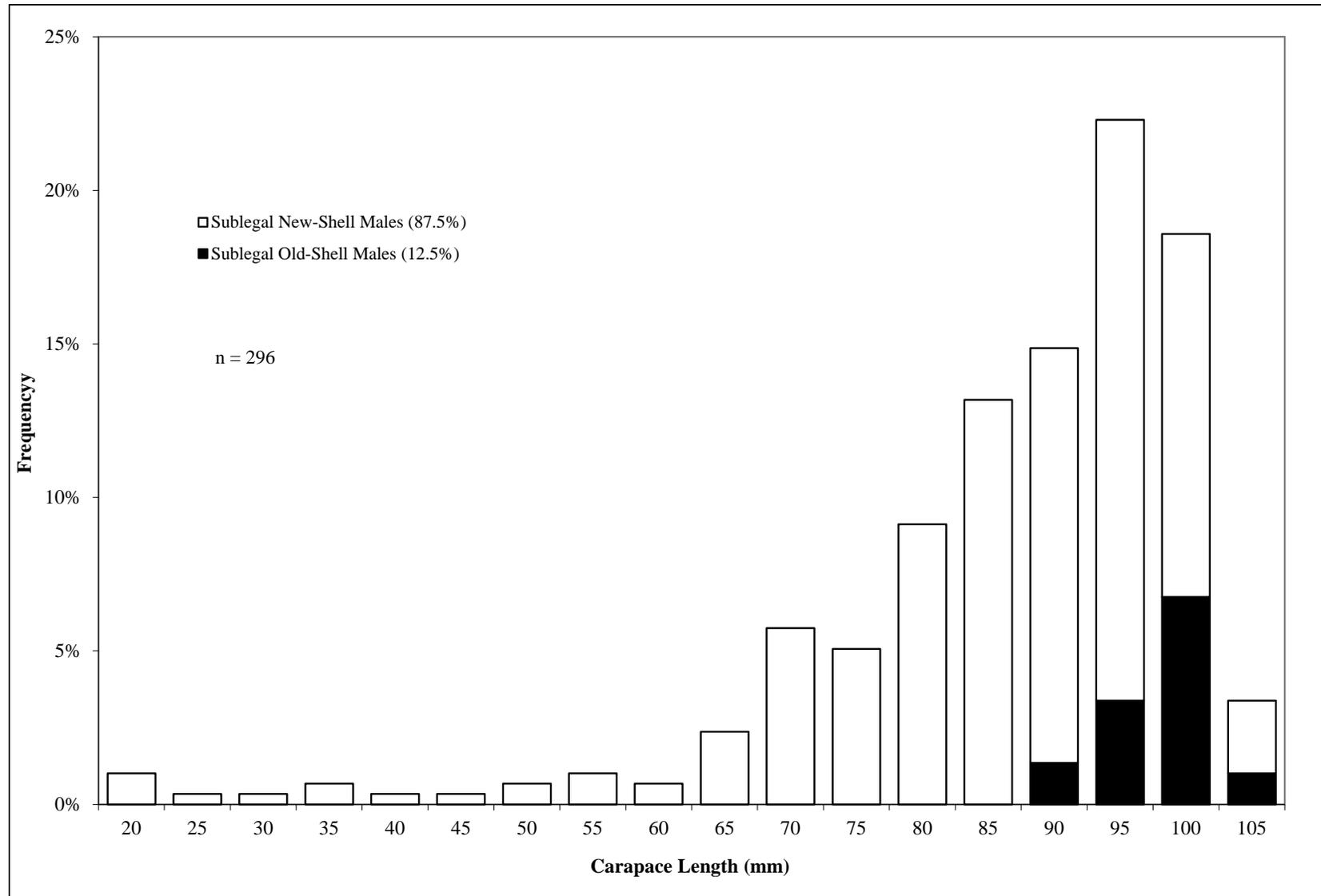


Figure 11.—Size composition by shell age of undersized male red king crabs captured at standard stations during the 2014 ADF&G Norton Sound red king crab trawl survey.

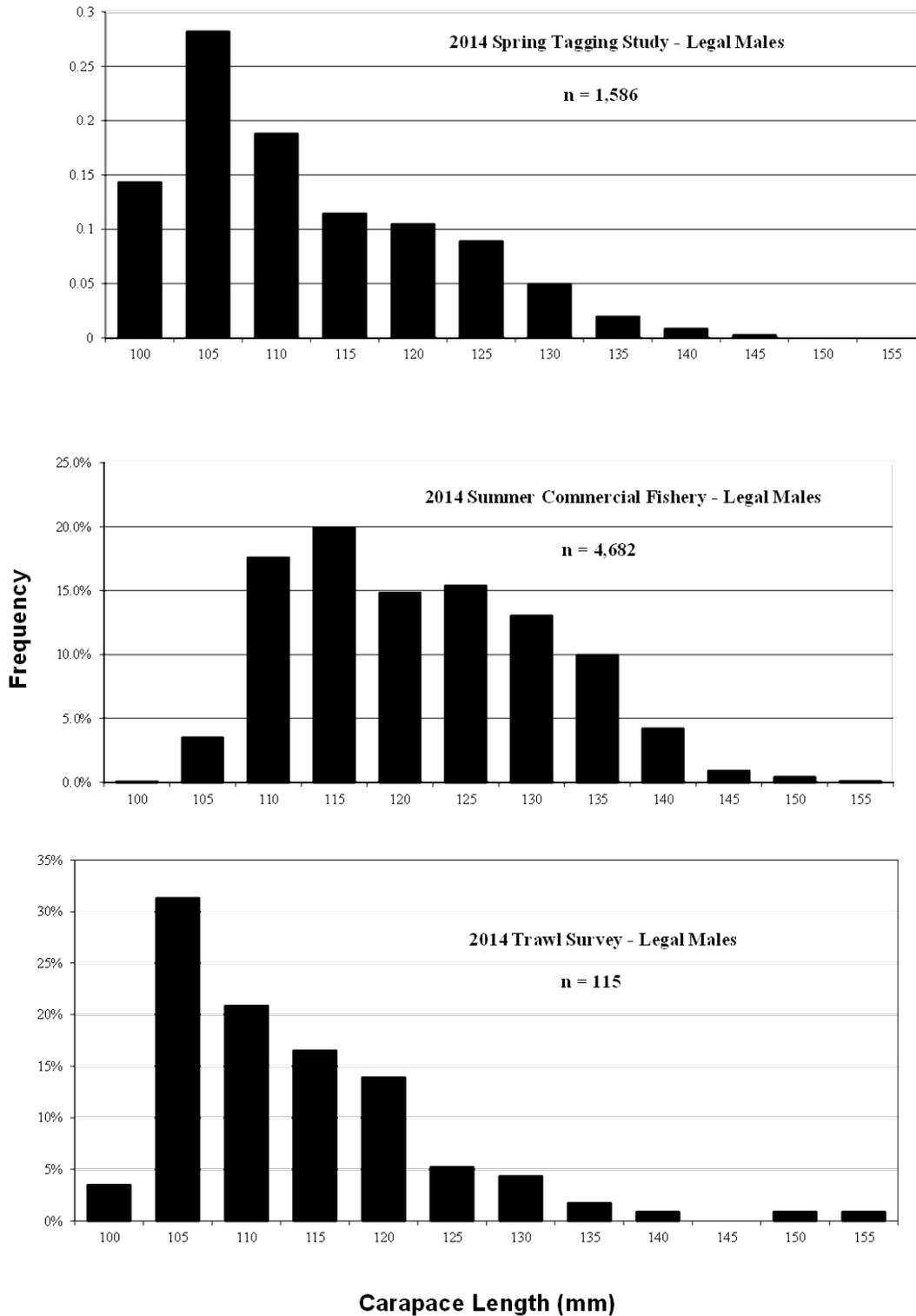


Figure 12.—Norton Sound legal male red king crab size compositions from the 2014 spring tagging study (top), 2014 summer commercial fishery (middle), and 2014 ADF&G trawl survey (bottom).

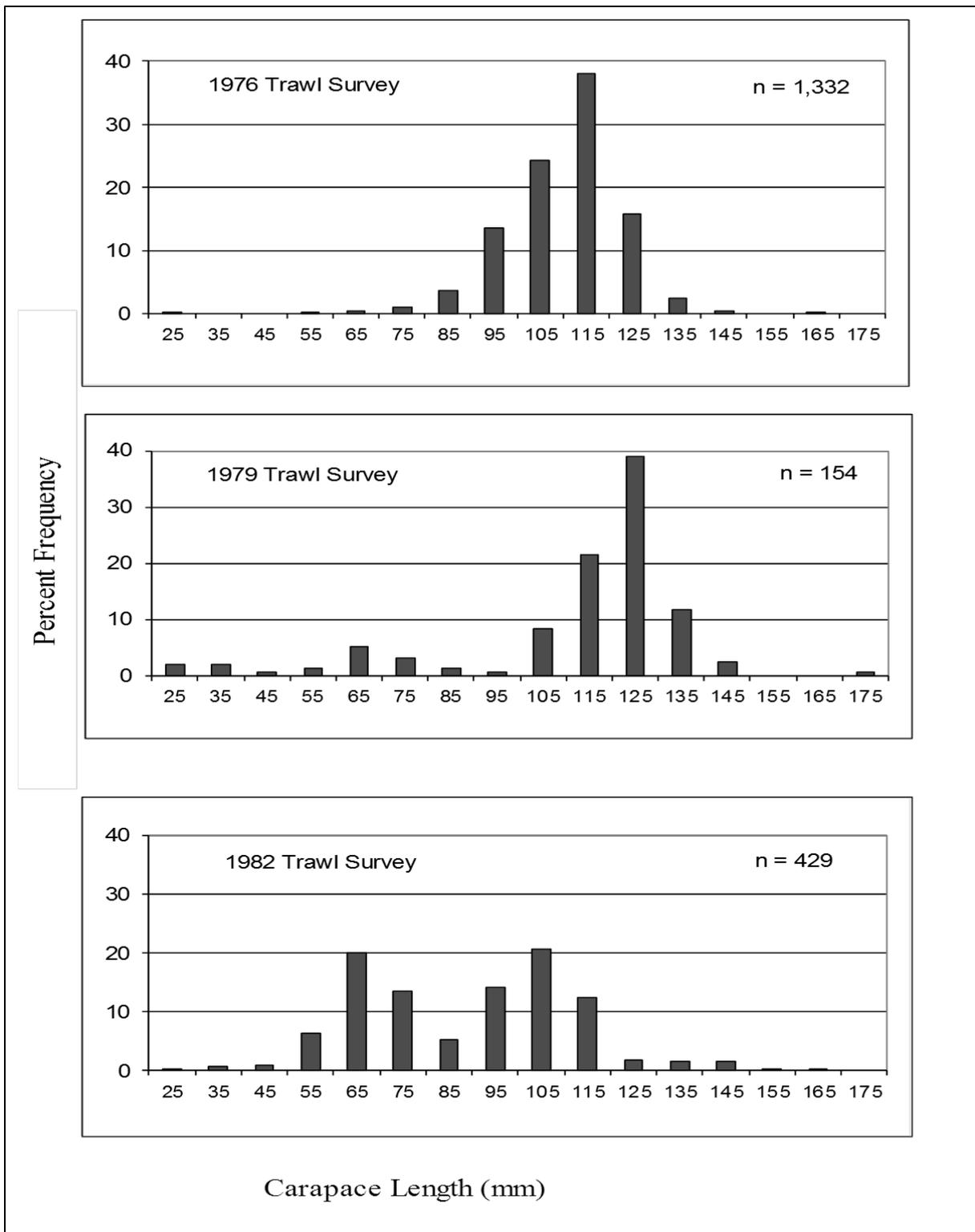


Figure 13.—Norton Sound size compositions for male red king crabs captured at standard and nonstandard stations during the 1976–2014 trawl surveys.

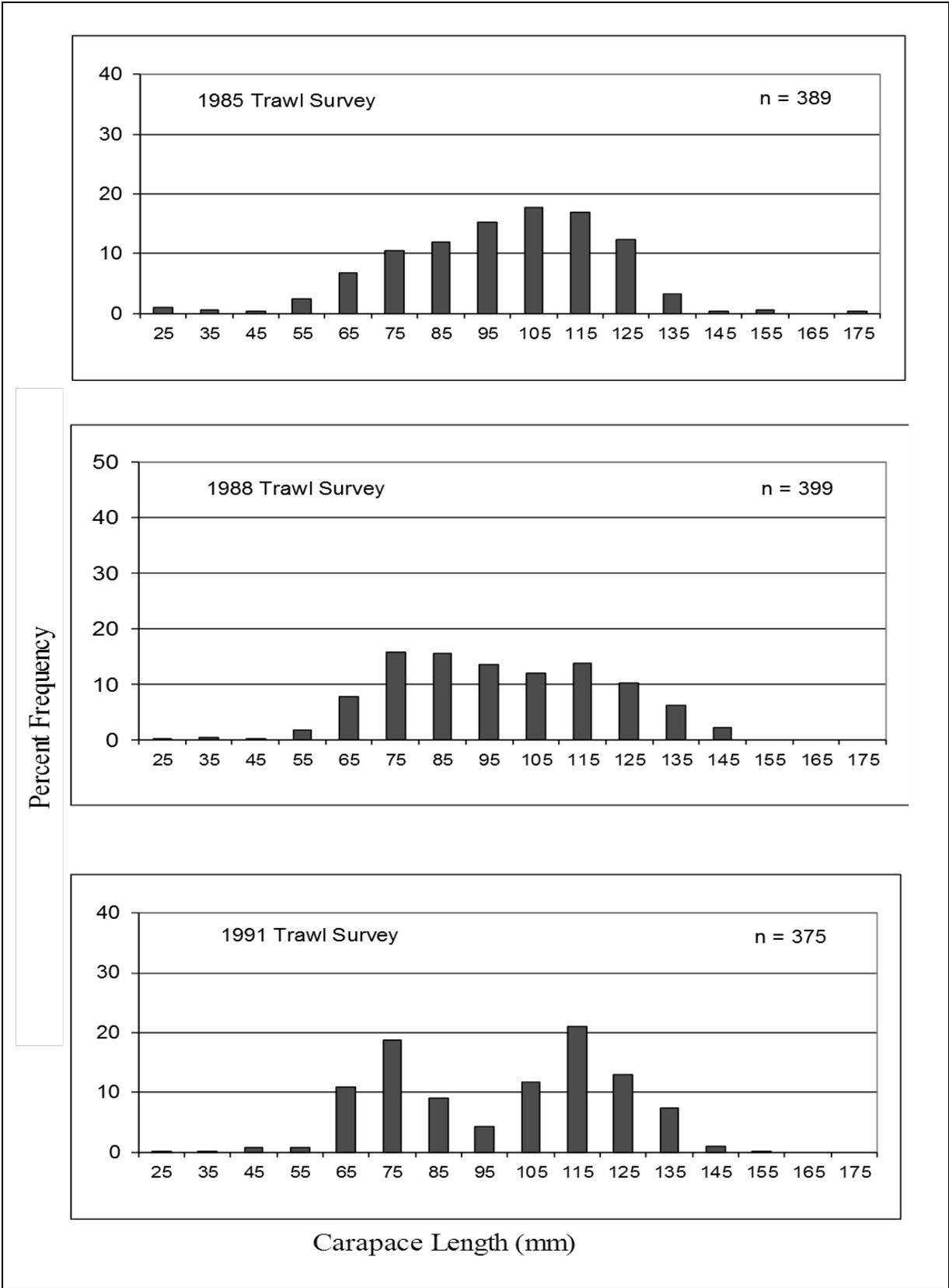


Figure 13.-Page 2 of 5.

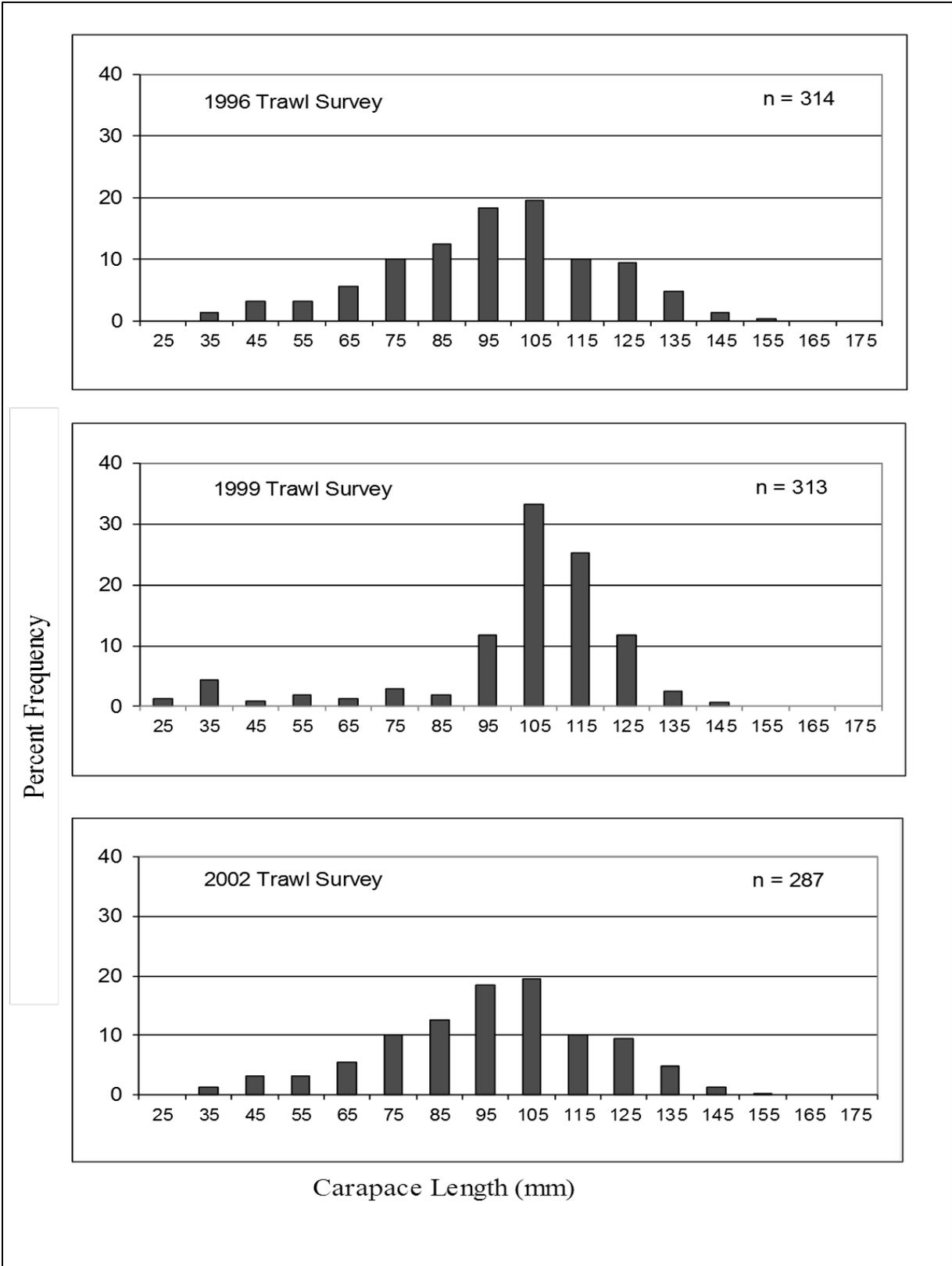


Figure 13.–Page 3 of 5.

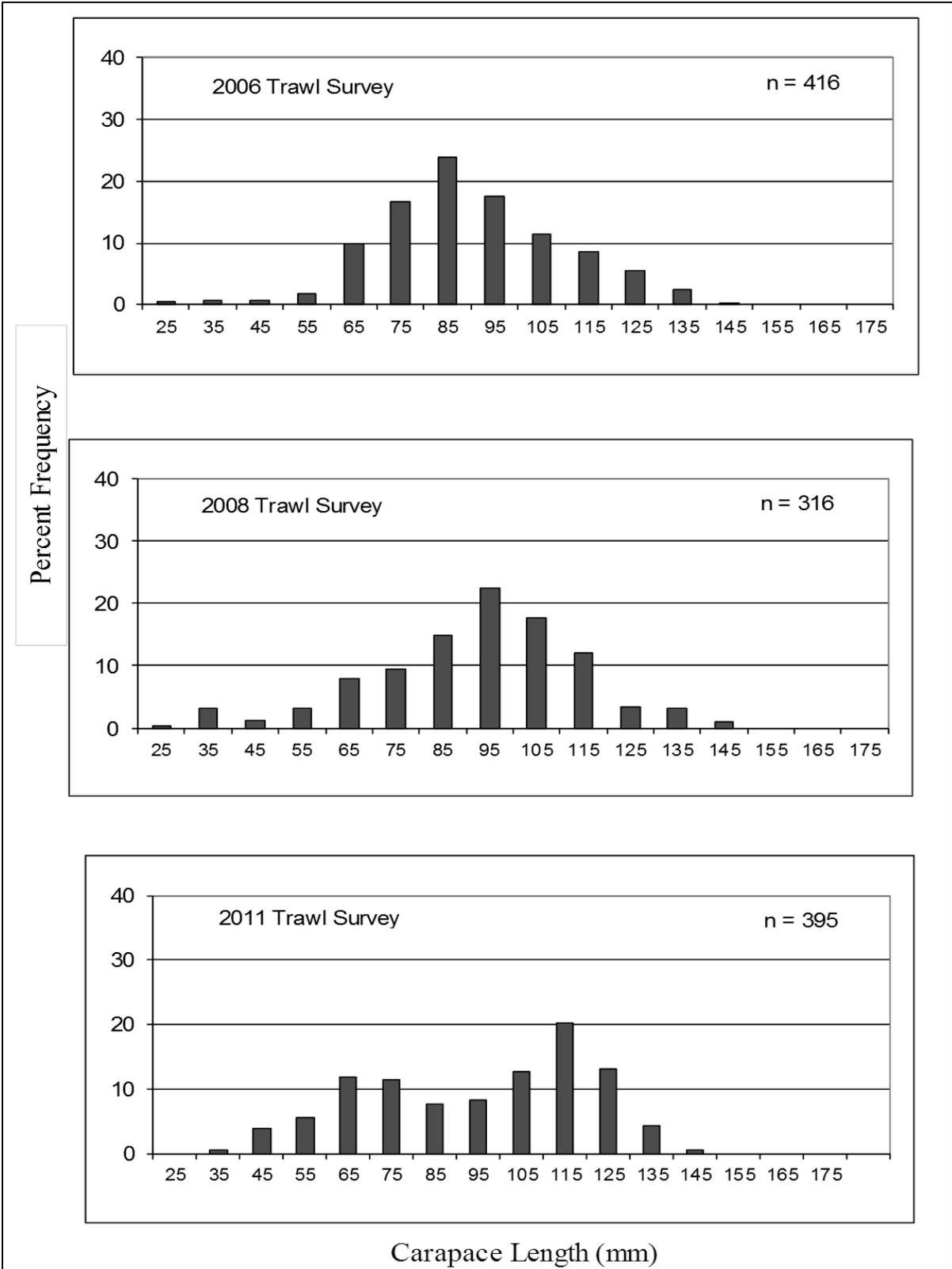


Figure 13.–Page 4 of 5.

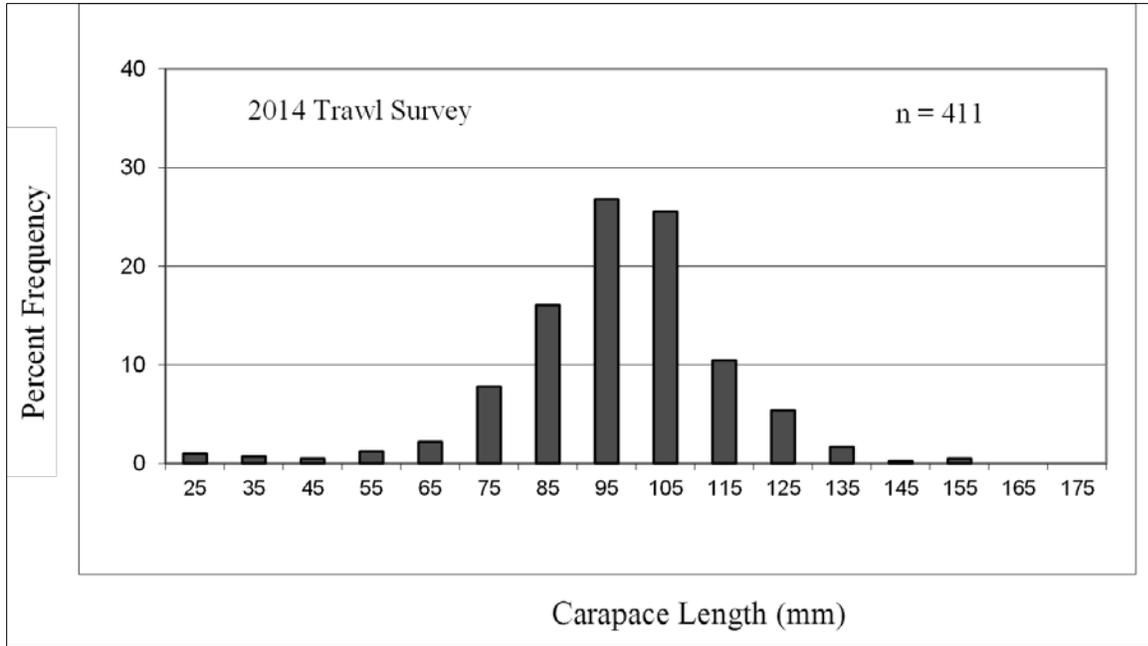


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APPENDIX A

Appendix A1.–Norton Sound ADF&G trawl survey data for the standard stations that produced any legal male crab catch in 2014.

Station number	No. of legal crabs	Area trawled (sq. miles)	Total area (sq. miles)	Estimated abundance
80	1	.0065800	100	15,198
105	6	.0065800	100	91,185
106	6	.0056588	100	91,185
124	2	.0065800	100	30,395
125	4	.0065800	100	60,790
126	3	.0065800	100	45,593
127	3	.0065800	100	45,593
131	1	.0065800	100	15,198
132	3	.0065800	100	45,593
133	3	.0065800	100	45,593
150	2	.0065800	100	30,395
151	2	.0065800	100	30,395
156	1	.0065800	100	15,198
159	3	.0065800	100	45,593
161	1	.0065800	100	15,198
176	4	.0065800	100	60,790
184	2	.0065800	100	30,395
185	2	.0065800	100	30,395
186	60	.0065800	100	911,854
187	6	.0065800	100	91,185