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Southeast Alaska Golden King Crab Onboard Observer Program Report for 1998 through 2010 Seasons

by

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and

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Alaska Department of Fish and Game **Division of 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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

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

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ABSTRACT

Observing onboard golden king crab commercial fishing vessels in Southeast Alaska began in 1998 with the objective of gathering biological data from management areas not sampled dockside. Over time, this has expanded to include sampling in all fishery management areas within Registration Area A of Southeast Alaska. As there is no fishery-independent stock assessment program for golden king crab, this is the only opportunity to collect data on sublegal and female crab. Vessels with observers onboard are asked to close the escape rings or a 9-in stretch mesh panel in up to 10 of their pots. Observers collect three types of data; skipper, pot, and specimen data. Skipper data includes pot depth and location (measured by differential GPS and accurate to 50 m), and soak time; pot data includes debris presence, substrate type, pot condition, pot type, pot dimensions and weight, escape device, escape device condition, bait type, and bycatch; specimen data includes crab carapace length, chela height, shell and leg condition, presence of eggs, egg condition, egg development stage, and presence of parasites. This data is summarized to determine the catch-per-unit-effort and size of crab in pots with open and closed escape rings, female egg development stage, range of chela heights, and ontogenetic depth distribution. The information assists with management of the golden king crab fishery in Southeast Alaska and to focus further research effort. To date, a total of 54,376 golden king crabs from 5,062 pots have been sampled during 68 trips in seven management areas from 1998 through 2004 and 2007 through 2010 seasons. Trends in size composition, chela height, depth range, and egg development stage are emerging as we begin to understand the stock structure of golden king crab in Southeast Alaska.

Key words: golden king crab, *Lithodes aequispinus*, observer program, stock assessment, management, Southeast Alaska

INTRODUCTION

In northern Southeast Alaska, golden king crabs, *Lithodes aequispinus*, (GKC) are found in deep waters, between 100 and 350 fathoms (182 to 640 m). Important fishing grounds are located at the confluences of Icy Strait, Lynn Canal, and Chatham Strait; of Chatham Strait and the western portion of Frederick Sound, and of Stephens Passage and Frederick Sound. Fishing conditions in the commercial GKC fishery are very demanding because the fishing grounds are exposed with great depths and strong tidal exchanges and currents (Hebert et al. 2005). Commercial vessels participating in the fishery are primarily salmon tenders, salmon purse seine vessels, and a few large drift gillnet boats. Fishing gear has gradually evolved from side-loading king crab pots (7-ft x 7-ft x 30-in) to top loading conical or pyramid-style pots. Because of the challenging fishing conditions fishermen prefer heavier gear, and use different buoy lines and buoy trains than when fishing for red king crab or Tanner crab. Soak times are also generally longer (24 to 48 h) for GKC than for red king crab or Tanner crab (18 to 24 h) (Messmer and Olson 2010).

The biology of GKC is poorly understood, but they are thought to have a 24-month reproductive cycle (Otto and Cummiskey 1985), ontogentic changes in depth distribution, and asynchronous timing of mating and molting (McBride et al. 1982; Otto 1984; Sloan 1985). GKC have large yolk-rich eggs with low fecundity–about 30,000 eggs per female clutch (Jewett et al. 1985). Male GKC in Southeast Alaska are thought to become sexually mature at a size of about 118 mm carapace length (CL) (Koeneman and Buchanan 1985; Otto 1984). Extrapolating the juvenile growth data forward, this size is approximately 8 years of age. GKC in Southeast Alaska enter the fishery at 178 mm carapace width (CW), which corresponds to about 151 mm CL (Paul and Paul 2001a). This is based on the length-width relationship of $CW = 44.336 + 0.8875*CL$ (Koeneman and Buchanan 1985). Adult male molt increment is the only biological parameter that has been well-described for this species in Southeast Alaska, where it is estimated as 16.4 mm CL (Koeneman and Buchanan 1985). Using this molt increment, the legal size is between two and three molts from the size of maturity. Since molt frequency is only slightly more than 12 months at this size this means that male GKC in Southeast Alaska have in excess of two years to

contribute to the reproductive potential of the population before they begin to be exploited by the commercial fishery at about 10.5 years of age. As such, to reach the maximum observed size of 215 mm CL from the legal size of 151 mm CL would require four molts. Since molt frequency begins to decline at sexual maturity, it is likely to take well in excess of four years to reach this maximum observed size. Using a molt frequency of 48 months, the maximum age of GKC captured in the commercial fishery would be approximately 18.5 years.

The GKC fishery in Southeast Alaska was designated "recovering" at the 2000 meeting of the Alaska Board of Fisheries (BOF). Harvest was negligible for 1988 through 1996 seasons, but gradually increased as guideline harvest ranges (GHRs) were stepped up for 2002 through 2006 seasons. Harvest averaged 0.60 million lbs for 2000 through 2010 seasons (Hebert et al. 2008).

Management measures in effect for the GKC fishery include male-only harvest with a minimum CW of 7 in, a vessel limit of 100 pots, seven separate fishery management areas (Figure 1), each with their own GHR and a concurrent season with the Tanner crab fishery, with a regulatory start date between February 10 and 17. Areas are closed by emergency order when GHLs are achieved for each fishery management area (Hebert et al. 2005).

Stock assessment consists of a triennial evaluation of four types of fishery-dependent information: commercial fish tickets, logbooks, dockside sampling and onboard observer sampling. Stock status is determined as a result of this evaluation. Based on stock status, guideline harvest levels (GHLs) within the regulatory GHRs are determined and targeted inseason by managers (Messmer and Olson 2010).

The program of voluntarily deploying observers onboard GKC vessels to sample the catch was established in 1998, but discontinued after 2004 due to lack of staff and funding. The primary objectives were gathering data on the fishing grounds, specifically in areas lacking biological data. The Alaska Department of Fish and Game (ADF&G) reinstated the program in 2007 when staff and funding again became available. Vessels with observers are asked to close escape rings, or a 9-in stretch mesh panel, on at least 10 of their pots. The program objectives are:

OBJECTIVES

1. Describe the commercial GKC fishing grounds, gear and methods within each management area.
2. Describe GKC size composition by sex in pots with open and closed escape rings.
3. Describe GKC female reproductive condition.
4. Obtain data on GKC chela height (CH) allometry.
5. Describe bycatch species composition in the GKC fishery.
6. Describe ontogenetic depth distribution of GKC.

This report summarizes GKC observer data collected to date, but does not provide detailed statistical analyses. For each fishery management area this summary will include spatial distribution of effort, CL frequencies by sex in open and closed pots, female reproductive condition, male CH versus CL relationships, bycatch and ontogenetic depth distribution.

METHODS

SAMPLE DESIGN

ADF&G biologists were placed onboard volunteer fishing vessels during the commercial GKC fishery to sample crabs. Observers tried to sample all pots while gathering biological data on

GKC that includes: shell condition, CL, CH, leg condition, presence of eggs, egg development, and the presence of parasites or any abnormalities observed. Methods are detailed elsewhere (Messmer et al. 2010). Data was collected using Archer Field PCs by Juniper Systems where data sheets were digitized and used in the Zander Crab Survey program developed by ADF&G programmers. Processing data this way enabled observers to sample pots at a higher rate than in previous years when using only paper data sheets (Messmer et al. 2010).

EXTRA PROJECTS

During the 2009 and 2010 fishing seasons, observers collected samples of the barnacle parasite, *Briarosaccus callosus* and muscle tissue of parasitized crab. Samples were frozen onboard and placed in 95% EtOH upon returning to port.

RESULTS

From 1998 through 2004 and 2007 through 2010, 54,376 crabs were sampled during 68 trips in seven management areas. During this period a total of 1,598 landings were made for a total of 6.1 million lbs of crab. Thus, 4.3% of commercial landings on average were observed annually.

EAST CENTRAL

Thirteen observed trips occurred in the East Central GKC management area (Figure 1) during the 2000 through 2004, 2007, 2008, and 2010 fishing seasons. Escape rings were closed on pots beginning in 2001 and a range of 19 to 71 pots with closed and 26 to 232 with open escape rings were sampled annually for a total sample size of 266 closed escape ring and 928 open escape ring pots. A range of 561 to 6,728 crabs were measured annually, for a total of 21,665 crabs sampled in this management area (Table 1).

Male GKC captured in pots with open escape rings ranged in size from 44 to 199 mm CL and their annual mean CL ranged from 152.6 to 157.7 mm (Figure 2). In pots with closed escape rings, size ranged from 67 to 235 mm CL with an annual mean size range of 128.0 to 151.4 mm CL (Figure 3). Juvenile and sublegal crab were particularly predominant in 2003, 2004, and 2007 when recruit grounds were heavily sampled (Figures 2 and 3).

Female GKC captured in pots with open escape rings ranged in size from 67 to 178 mm CL with an annual mean size range of 116.2 to 134.7 mm CL (Figure 4). In pots with closed escape rings, female size ranged from 52 to 155 mm CL with an annual mean size range of 112.3 to 126.2 mm CL (Figure 5). For both gear types, female size range decreased as abundance of the 80 to 120 mm CL mode decreased, resulting in increased mean size over the sample period (Figures 4 and 5).

Females captured typically had either no eggs or uneyed eggs (Figure 6).

CH measurements for male crab began in 2007 and a range of 1 to 1,281 crabs were measured annually, for a total of 1,564 crabs measured (Table 1). A visual examination of the scatter plot of CH versus CL for males shows an inflection point at approximately 140 mm CL (Figure 7).

Bycatch consisted of primarily rockfish, Tanner crabs, sea stars, spot shrimp, snailfish, snails, skates, urchins, sablefish, red king crab, Pacific halibut, Pacific cod, octopus, barnacles, and miscellaneous species (Table 2).

Legal male GKC depth distribution ranged from 31 to 268 fathoms with a mean depth of 157.1 fathoms Sublegal male crab depth ranged from 31 to 268 fathoms with a mean of 151.2 fathoms

Female GKC depth distribution ranged from 66 to 268 fathoms with a mean of 168.4 fathoms (Figure 8).

MID-CHATHAM

Ten observed trips occurred in the Mid-Chatham GKC management area (Figure 1) during the 2000 through 2003 and 2007 through 2010 fishing seasons. Escape rings were closed on pots beginning in 2001 and a range of 5 to 84 pots with closed escape rings and 41 to 228 with open escape rings were sampled annually for a total sample size of 215 closed escape ring and 751 open escape ring pots. Between 250 and 5,501 crabs were measured annually, for a total of 13,273 crabs sampled in this management area (Table 3).

Male GKC captured in pots with open escape rings ranged in size from 13 to 201 mm CL with an annual mean size range of 146.5 to 169.7 mm CL (Figure 9). In pots with closed escape rings, size ranged from 57 to 204 mm CL with an annual mean size range of 135.1 to 166.4 mm CL (Figure 10). Juvenile and sublegal crab were particularly predominant in pots with closed escape rings during the 2002 and 2008 fishing seasons (Figures 9 & 10).

Female GKC captured in pots with open escape rings ranged in size from 16 to 184 mm CL with an annual mean ranging from 116.2 to 142.4 mm CL (Figure 11). In pots with escape rings closed, female size ranged from 11 to 191 mm CL with an annual mean size range of 118.2 to 137.5 mm CL (Figure 12).

Females captured typically had either no eggs or eyed eggs (Figure 13).

Chela height measurements for male crab began in 2007 and between 188 to 628 crabs were measured annually, for a total of 1,857 crabs measured (Table 3). A visual examination of the scatter plot of CH versus CL for males shows an inflection point at approximately 135 mm CL (Figure 7).

Bycatch consisted of primarily walleye pollock, Tanner crabs, sponge, snails, sablefish, rockfish, red king crab, Pacific cod, decorator crabs, hermit crabs, octopus, barnacles, and miscellaneous groundfish (Table 2).

Legal male GKC depth distribution ranged from 29 to 399 fathoms with a mean of 275.9 fathoms Sublegal male crab depth ranged from 29 to 399 fathoms with a mean of 258.5 fathoms Female GKC depth distribution ranged from 29 to 399 fathoms with a mean of 253.7 fathoms (Figure 14).

NORTHERN

Fifteen observed trips occurred in the Northern GKC management area (Figure 1) during the 2001, 2003, 2004, and 2007 through 2010 fishing seasons. Escape rings were closed on pots beginning in 2001 and a range of 24 to 146 pots with closed escape rings and 7 to 309 with open escape rings were sampled annually for a total sample size of 307 closed escape ring and 816 open escape ring pots. Between 95 and 2,455 crabs were measured annually, for a total of 7,965 crabs sampled in this management area (Table 4).

Size of male GKC captured in pots with open escape rings ranged from 59 to 215 mm CL with an annual mean range of 160.4 to 173.1 mm CL (Figure 15). In pots with closed escape rings, size ranged from 59 to 215 mm CL with an annual mean size range of 152.3 to 169.6 mm CL

(Figure 16). Juvenile and sublegal crab were observed in 2001, 2007, and 2010 (Figures 15 and 16).

Size of female GKC captured in pots with open escape rings ranged from 100 to 178 mm CL with an annual mean size range of 127.6 to 150.7 mm CL (Figure 17). In pots with escape rings closed, size ranged from 98 to 180 mm CL with an annual mean size range of 126 to 138.7 mm CL (Figure 18). Similarly to males, modes of small females were observed in 2001 and 2007 (Figures 17 and 18).

Females captured were split fairly evenly between reproductive stages (Figure 19).

Chela height measurements for males began in 2007 and between 41 and 700 crabs were measured annually, for a total of 1,474 crabs measured (Table 4). A visual examination of the scatter plot of CH versus CL for males shows an inflection point at approximately 160 mm CL (Figure 7).

Bycatch consisted of primarily yellowfin sole, rockfish, Tanner crabs, snailfish, urchins, red king crab, Pacific halibut, Pacific cod, snails, decorator crabs, octopus, sea stars, sculpins, arrowtooh flounder, and miscellaneous species (Table 2).

Legal male GKC depth distribution ranged from 80 to 371 fathoms with a mean of 189.5 fathoms Sublegal male crab depth ranged from 90 to 331 fathoms with a mean of 176.3 fathoms Female depth distribution ranged from 90 to 331 fathoms with a mean of 201.5 fathoms (Figure 20).

ICY STRAIT

Nine observed trips occurred in the Icy Strait GKC management area (Figure 1) during the 2001, 2003, and 2007 through 2010 fishing seasons.

Escape rings were closed on pots beginning in 2001 and a range of 0 to 37 pots with closed escape rings and 17 to 93 with open escape rings were sampled annually for a total sample size of 152 closed escape ring and 316 open escape ring pots. Between 34 and 693 crabs were measured annually, for a total of 2,229 crabs sampled in this management area (Table 5).

Size of male GKC captured in pots with open escape rings ranged from 116 to 207 mm CL with an annual mean size range of 169.2 to 182.4 mm CL (Figure 21). In pots with closed escape rings, crab size ranged from 77 to 203 mm CL with an annual mean size range of 170.4 to 177.9 mm CL (Figure 22). Relatively large numbers of sublegal male crabs were observed in both gear types in 2001, however the proportion of small males has subsequently decreased to the extent that since 2003 the catch has been almost exclusively legal crab.

Very few females are captured in this area and sample sizes are small. Female GKC captured in pots with open escape rings ranged in size from 104 to 169 mm CL, with an annual mean size range of 135.4 to 147.3 mm CL (Figure 23). In pots with escape rings closed, female size ranged from 83 to 163 mm CL with an annual mean size range of 122.3 to 145.2 mm CL (Figure 24).

Females captured typically had either no eggs or eyed eggs (Figure 25).

Chela height measurements for male crab began in 2007 and between 5 and 444 crabs were measured annually, for a total of 491 crabs measured (Figure 7).

Bycatch consisted of primarily Tanner crabs, sea stars, snails, scale crabs, red king crab, Pacific halibut, rockfish, urchins, octopus (Table 2).

Legal male GKC depth distribution ranged from 89 to 240 fathoms with a mean depth of 140.1 fathoms Sublegal male crab depth distribution ranged from 99 to 247 fathoms with a mean depth of 149.3 fathoms Female depth distribution ranged from 89 to 240 fathoms with a mean depth of 165.1 fathoms (Figure 26).

NORTH STEPHENS PASSAGE

Eleven observed trips occurred in the North Stephens Passage GKC management area (Figure 1) during the 2002, 2004, and 2007 through 2010 fishing seasons.

Escape rings were closed on pots beginning in 2002 and 7 to 20 pots with closed escape rings and 31 to 109 with open escape rings were sampled annually for a total sample size of 101 closed escape ring and 386 open escape ring pots. Between 253 and 782 crabs were measured annually, for a total of 2,824 crabs sampled in this management area (Table 6).

Male GKC captured in pots with open escape rings ranged in size from 90 to 226 mm CL and their annual mean size ranged from 155.5 to 183.2 mm CL (Figure 27). In pots with closed escape rings size ranged from 110 to 210 mm CL with an annual mean size of 150.8 to 178.5 mm CL (Figure 28). A pulse of recruitment was observed in 2004 and the mean CL has increased since then.

Female GKC captured in pots with open escape rings ranged in size from 60 to 184 mm CL with an annual mean size ranging from 113.2 to 151.8 mm CL (Figure 29). In pots with escape rings closed, female size ranged from 98 to 176 mm CL with annual mean size ranging from 124 to 151.6 mm CL (Figure 30).

Females captured typically had either no eggs, eyed eggs or uneyed eggs (Figure 31).

Chela height measurements began in 2007 and a range of 24 to 47 chela height measurements have been made annually, for a total of 148 GKC chela height measurements to date (Figure 7).

Bycatch consisted of primarily rockfish, Tanner crabs, sea stars, snailfish, urchins, red king crabs, Pacific halibut, octopus, sculpins, barnacles, arrowtooth flounder, and miscellaneous groundfish (Table 2).

Legal male GKC depth distribution ranged from 89 to 201 fathoms with a mean depth of 132.3 fathoms Sublegal male crab depth ranged from in depth from 82 to 201 fathoms with a mean depth of 133.4 fathoms Female GKC depth distribution ranged from 104 to 201 fathoms with a mean of 138.2 fathoms (Figure 32).

LOWER CHATHAM

Five observed trips occurred in the Lower Chatham GKC management area (Figure 1) during the 2000, 2001, and 2008 through 2010 fishing seasons.

Escape rings were closed beginning in 2001, and a range of 0 to 20 pots with closed escape rings and 28 to 161 with open escape rings were sampled annually for a total sample size of 57 closed escape ring and 504 open escape ring pots. Between 299 and 1,186 crabs were measured annually, for a total of 1,526 crabs sampled in this management area (Table 7).

Male GKC captured in pots with open escape rings ranged in size from 30 to 191 mm CL with an annual mean size ranging from 146.9 to 155.2 mm CL (Figure 33). In pots with closed escape rings, size ranged from 66 to 187 mm CL with an annual mean size of 139.8 to 145.4 mm CL (Figure 34).

Female GKC captured in pots with open escape rings ranged in size from 56 to 151 mm CL with an annual mean size of 114.9 to 125.7 mm CL (Figure 35). In pots with escape rings closed, female size ranged from 55 to 144 mm CL with annual mean size ranging from 115.6 to 120.8 mm CL (Figure 36).

Females captured typically had either no eggs or eyed eggs (Figure 37).

Chela height measurements began in 2007 and a range of 415 to 689 chela height measurements have been made annually for a total of 1,526 GKC measured (Figure 7).

Bycatch consisted of primarily rockfish, walleye pollock, sculpins, Pacific halibut, snails, box crabs, and miscellaneous species (Table 2).

Legal male GKC depth distribution ranged from 151 to 367 fathoms with a mean of 279 fathoms Sublegal male crab depth ranged from 151 to 367 fathoms with a mean of 279 fathoms Female GKC depth distribution ranged from 152 to 366 fathoms with a mean of 283.4 fathoms (Figure 38).

SOUTHERN

Five observed trips occurred in the Southern GKC management area (Figure 1) during the 1998 through2000 fishing seasons (Table 8).

During this period, a range of 44 to 170 pots with open escape rings were sampled annually for a total sample size of 263 open escape ring pots. Between 254 and 1,271 crabs were measured annually, for a total of 1,910 crabs sampled from this management area (Table 8).

Male GKC captured in pots with open escape rings ranged in size from 77 to 200 mm CL with an annual mean size ranging from 162.2 to 163.9 mm CL (Figure 39).

Although sample sizes were small, little interannual variability was seen in female GKC size composition. Females captured in pots with open escape rings ranged in size from 86 to 188 mm CL with an annual mean size ranging from 139.8 to 145.0 mm CL (Figure 40).

Females captured typically had either no eggs or uneyed eggs (Figure 41).

No CHs have been measured to date for the Southern area.

Bycatch consisted of primarily walleye pollock, rockfish, Tanner crabs, red king crabs, spot shrimp, and octopus (Table 2).

There was very little depth segregation of size and sex classes. Legal male GKC depth distribution ranged from 130 fathoms to 340 fathoms with a mean of 215.8 fathoms Sublegal male crabs ranged in depth from 130 fathoms to 340 fathoms with a mean of 215.1 fathoms Female GKC depth distribution ranged from 130 fathoms to 333 fathoms with a mean of 215.4 fathoms (Figure 42).

DISCUSSION

The GKC observer program is providing valuable information on stock structure and life history parameters of GKC as well as on the commercial fishery in Southeast Alaska. Knowledge of stock structure and life history parameters would be needed for development of stock assessment models used in abundance-based management. The description of fishing grounds and methods is useful for interpreting fishery-dependent data and assessing effectiveness of proposed management measures. Knowledge of fishing grounds and methods would also be invaluable in

developing the sampling design for a fishery-independent survey program. Finally, description of fishing grounds is also important for predicting impacts to the GKC fishery from development projects or activities such as placement of undersea communication cables.

Trends in the data show high variability in size composition of male GKC catches within and between management areas. For example, in the East Central management area, a substantial portion of the male catch is sublegal, while in Icy Strait only a small portion is sublegal. This variability in catch and the between-year variability of observer pot locations within a management area make it difficult to attribute changes in size composition of observed catch to interannual trends in abundance or recruitment.

Observer data suggests that female GKC in Southeast Alaska inhabit greater depths than sublegal or legal male crabs. Female depth distribution ranged from 29 to 399 fathoms, on average 5 to 10 fathoms deeper than sublegal and legal males, which ranged from 132 to 285 fathoms in every management area except Southern. Similarly, in the Aleutian Islands, female GKC depth distribution ranged from 100 to 339 fathoms, while in contrast legal males were slightly shallower, evenly distributed between 60 to 339 fathoms and sublegal males were generally much shallower, being most abundant between 60 to 79 fathoms (Gaeuman 2011). These depth distributions should be statistically tested for differences.

The existence of discreet breeding and nursery grounds has been hypothesized due to the large number of female and sublegal GKC captured in East Central, Mid-Chatham and Lower Chatham management areas relative to other areas (Hoyt 2003; Lovrich and Vinuesa 1993). Additional spatial analyses of observer data could yield a better understanding of the presence and location of breeding and nursery grounds.

Female GKC were found with varying stages of egg development. The range of egg development stages captured at any one time generally supports the assertion that GKC are reproductively asynchronous (Paul and Paul 2001b). However, slight synchronicity seems to exist among certain management areas; females in East Central, Mid-Chatham and Lower Chatham management areas had mostly uneyed, eyed, or no eggs—with the latter being the most prevalent. In contrast females in the Northern, Icy Strait and North Stephens Passage management areas had very similar amounts of uneyed, eyed, and no eggs. This suggests both that some synchronicity in reproductive timing exists and that there is spatial variation in reproductive timing, although the timing of observer data collection should also be examined as an explanatory factor.

Chela height data collected to date are beginning to yield information on GKC size at sexual maturity, both throughout the Southeast Alaska, and by management area. Differences in physical characteristics such as the CH to CL relationship, carapace spine length and carapace shape suggest that spatial differences in size at sexual maturity may exist. The current size limit should be re-examined when Southeast Alaska-specific size at maturity information becomes available.

Although our observations suggest the existence of some stock structure for GKC in Southeast Alaska, Hoyt (2003) questioned the existence of a home range for this species. In his movement study, the average distance traveled was 11.5 km, with one crab moving 39 km (Hoyt 2003). These large movements imply a fairly simple stock structure for GKC in Southeast Alaska.

Bycatch data was first collected during the 2007 season; however, there is very little bycatch in the GKC fishery. This is most likely due to the fact that GKC are fished using cone pots at relatively great depth, employing long soak times, on slopes and rocky substrate inhabited by a limited number of species. The conversion of the fishery from square to cone pots has likely also significantly reduced bycatch of Pacific halibut (Koeneman and Buchanan 1985; Williams et al. 1982).

There are many logistical challenges to conducting a research program onboard fishing vessels while fishermen are simultaneously engaged in making a living. We began to close escape rings on some pots in 2001 in order to increase the catch of sublegal and female GKC. Although this is beneficial from an information-gathering standpoint, in areas with high sublegal catch rates, such as in the East Central management area, fishermen are concerned with closing escape rings because pots may become saturated with sublegal crabs, preventing the capture of additional legal crabs and ultimately reducing the fisherman's landing. This is not an issue in areas with low sublegal catch rates where it does not reduce the legal capture rate. Since the GKC observer program was reinitiated in 2007, data has been collected from all management areas except the Southern management area. Data on this area was last collected in 2000 and it has been difficult to deploy observers there because of low participation in the fishery. ADF&G will continue efforts to collect data in the Southern management area in upcoming seasons.

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FIGURES

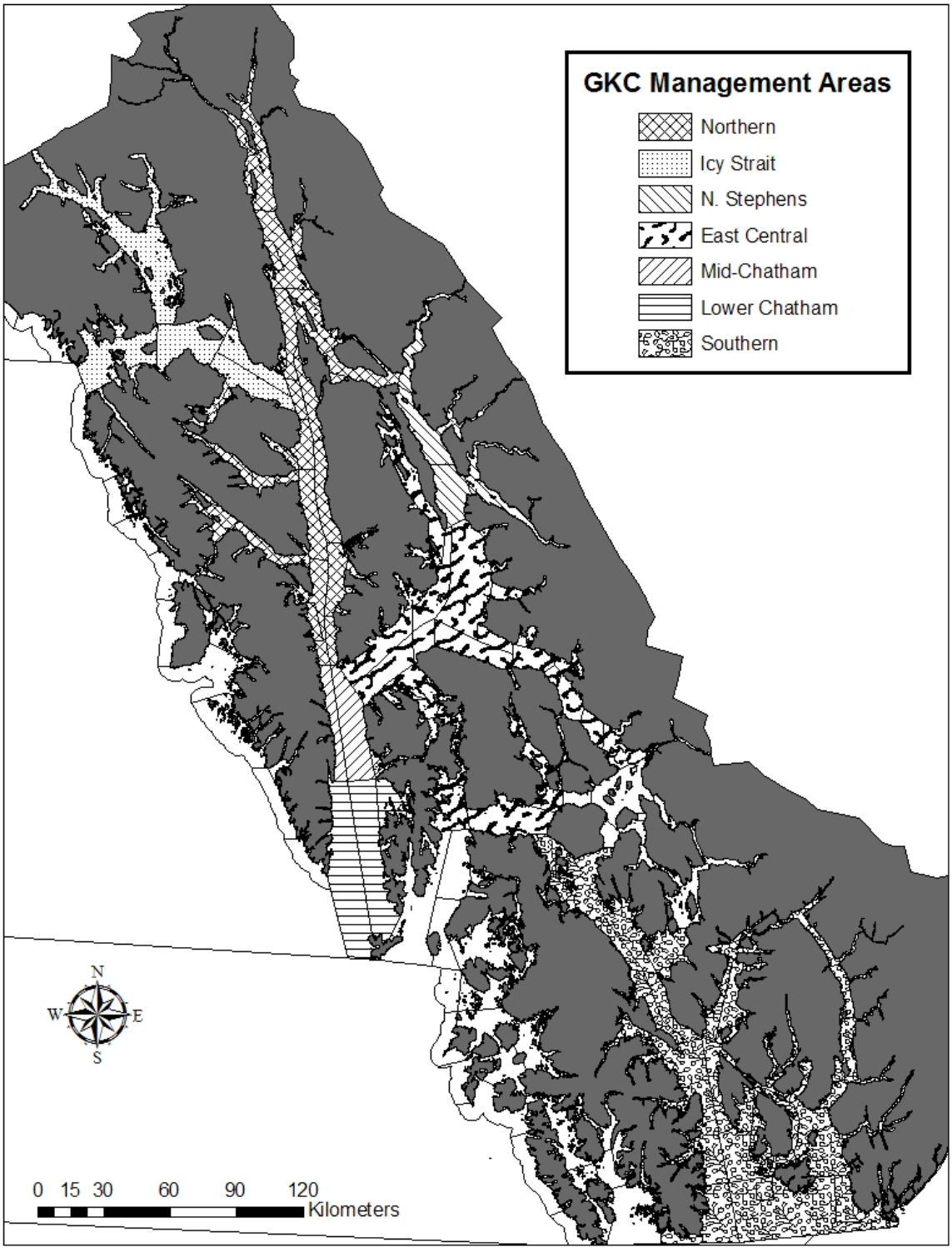

Figure 1.–Golden king crab management areas for Southeast Alaska.

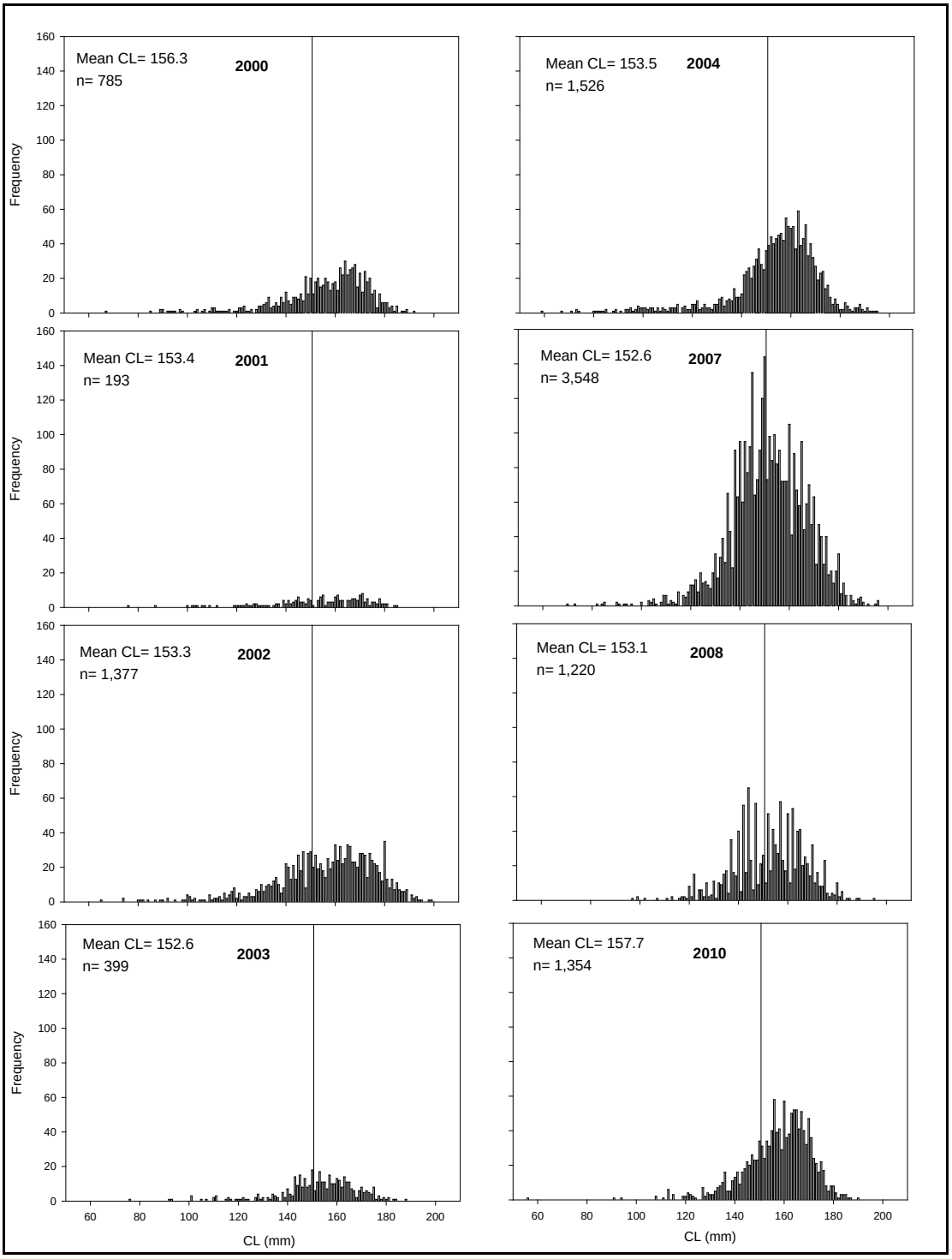

Figure 2.–Carapace length (CL) composition of male golden king crab sampled from pots with open escape rings while observing onboard in East Central management area during 2000 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

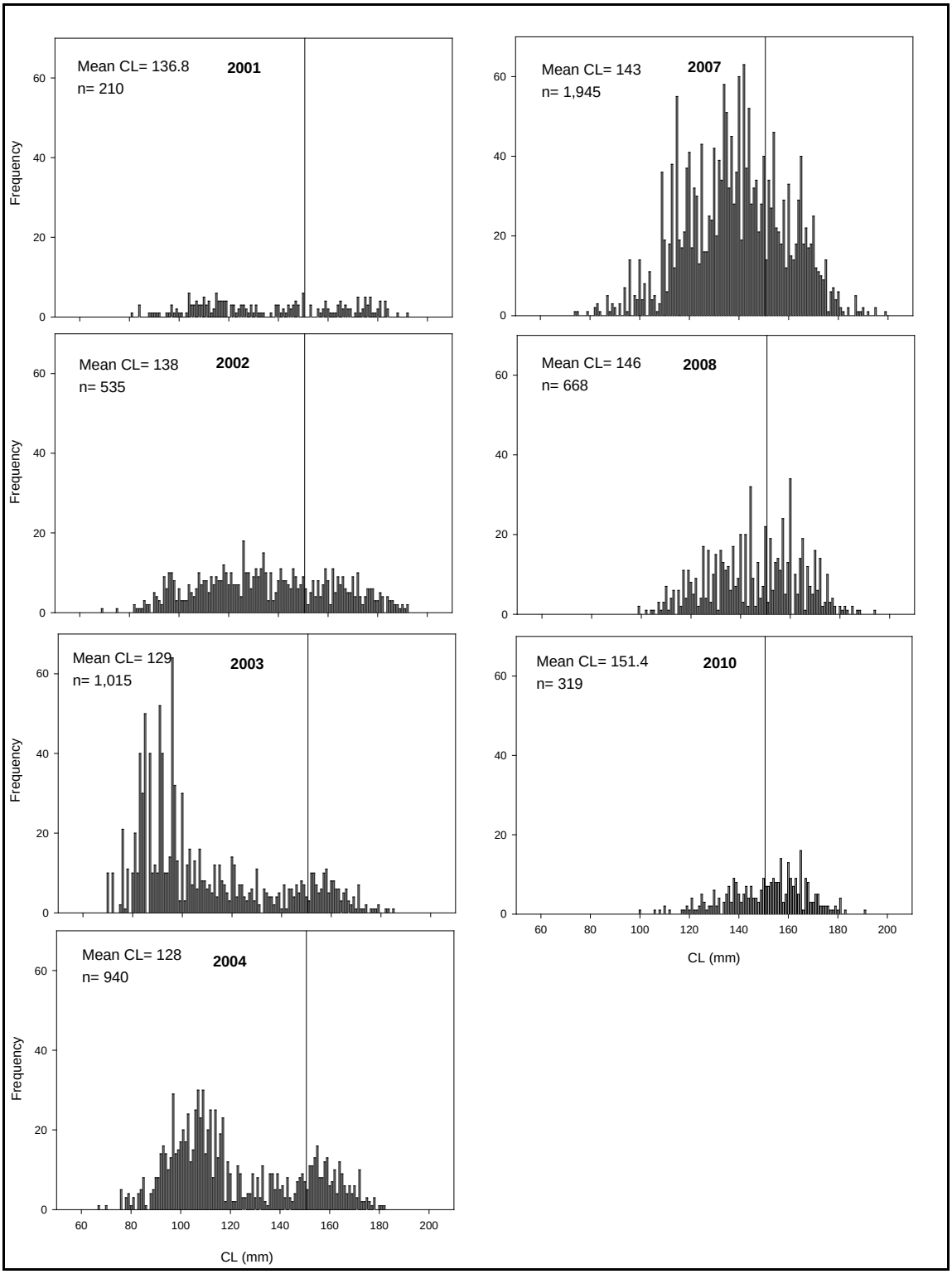

Figure 3.–Carapace length (CL) composition of male golden king crab sampled from pots with closed escape rings while observing onboard in the East Central management area during 2001 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

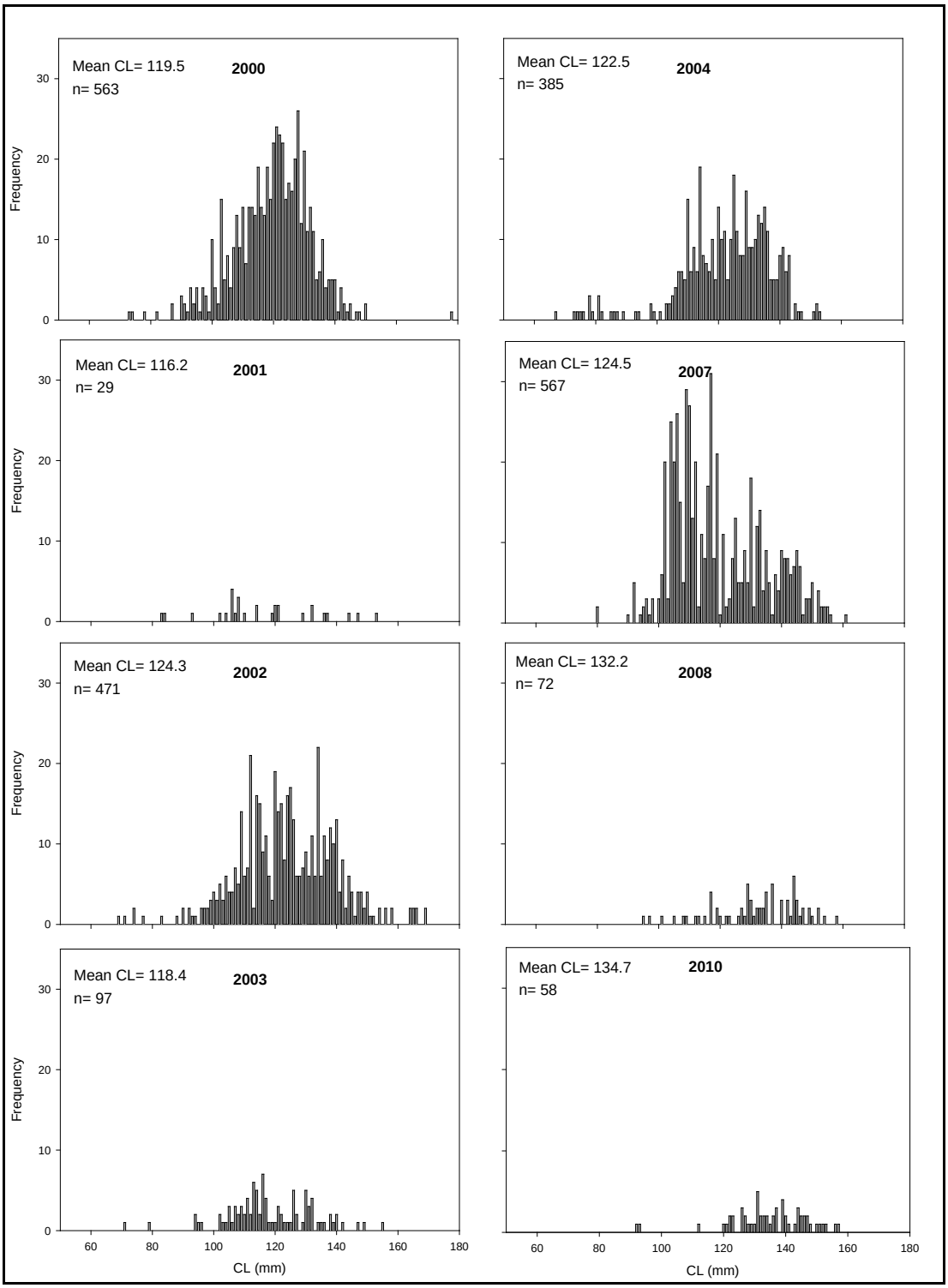

Figure 4.–Carapace length composition of female golden king crab sampled from pots with open escape rings while observing onboard in the East Central management area during 2000 through 2010 seasons.

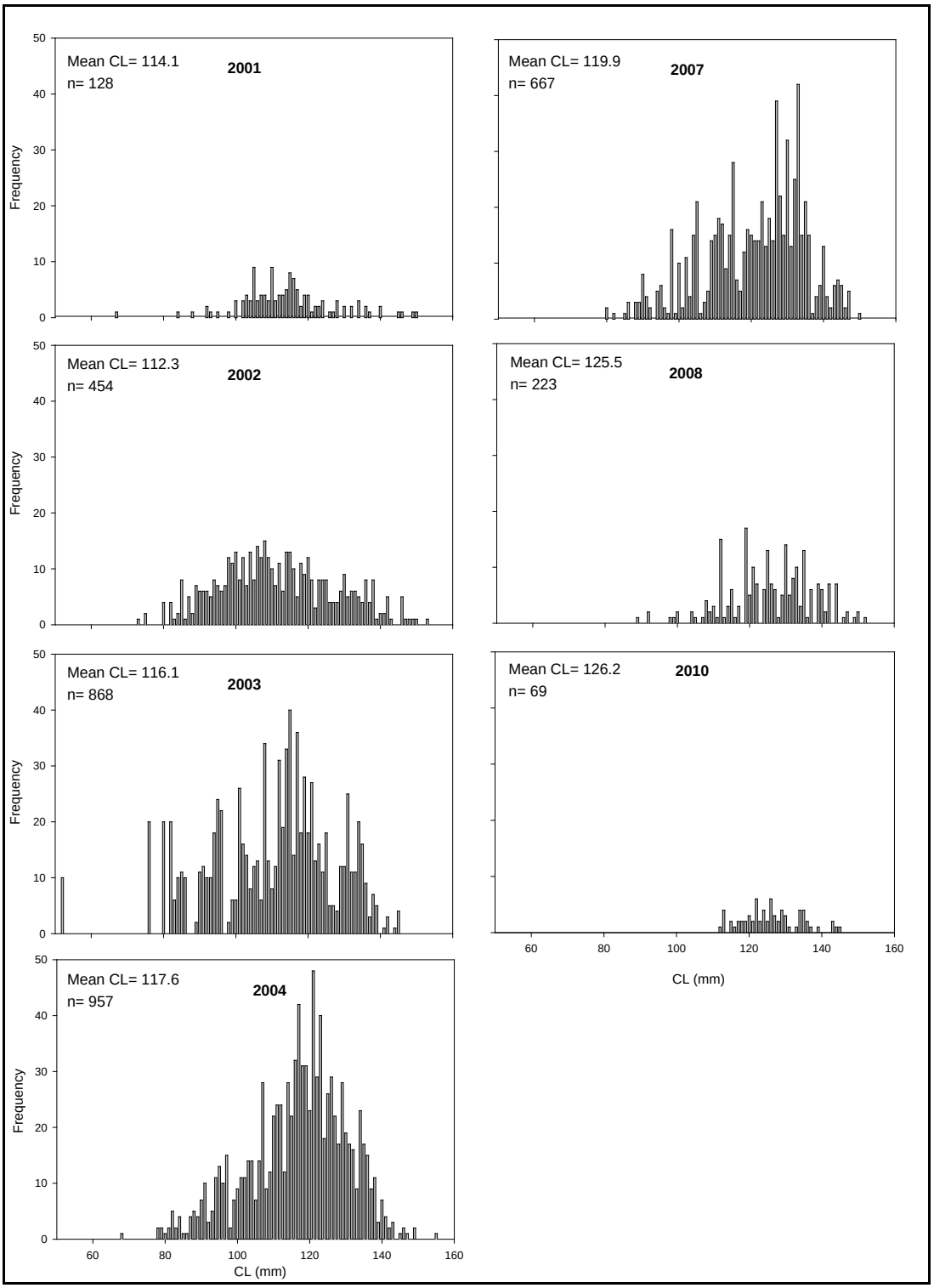

Figure 5.–Carapace length composition of female golden king crab sampled from pots with closed escape rings while observing onboard in the East Central management area during 2001 through 2010 seasons.

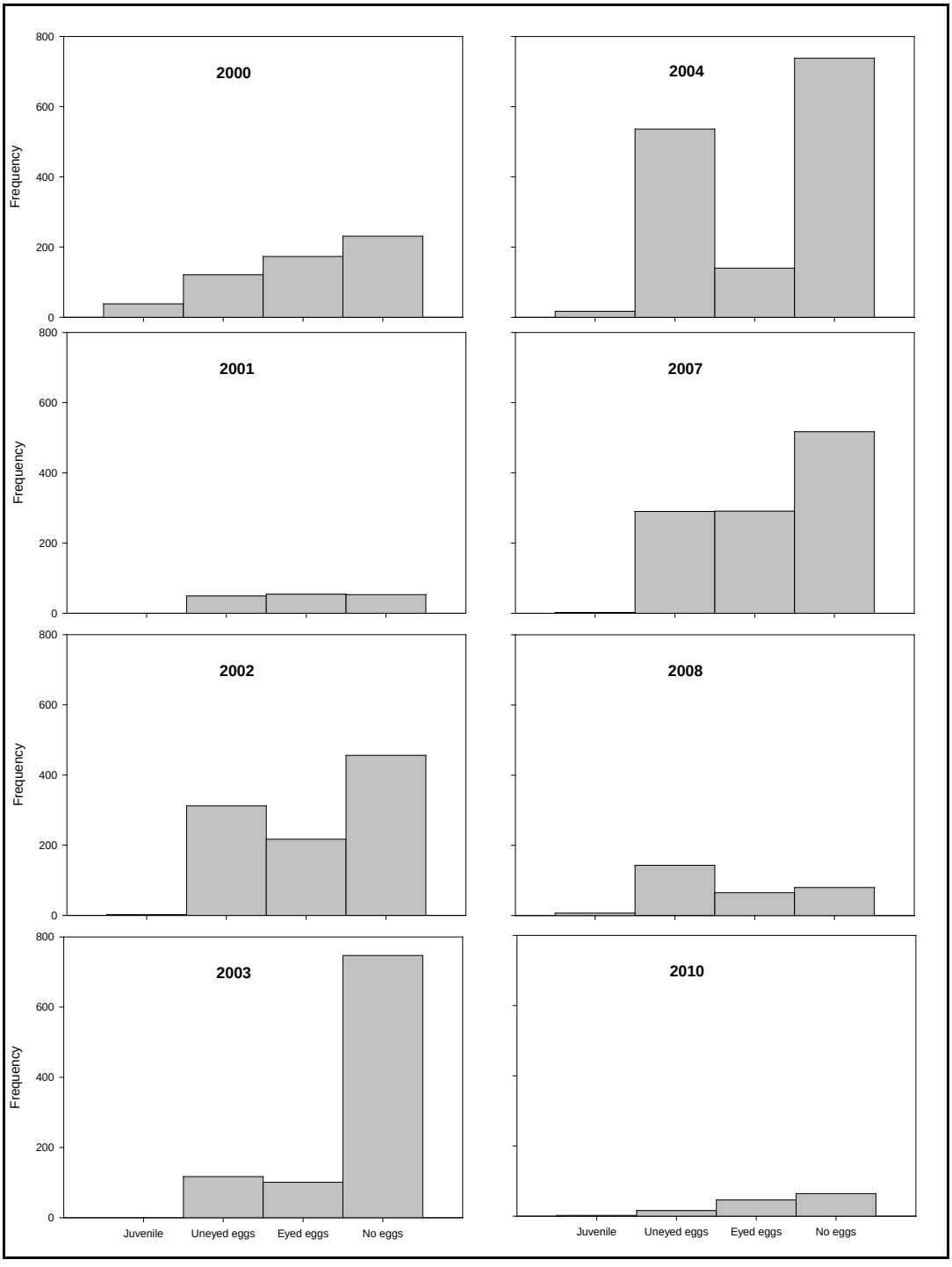

Figure 6.–Egg development stage of female golden king crab sampled from pots while observing onboard in the East Central management area during 2000 through 2010 seasons.

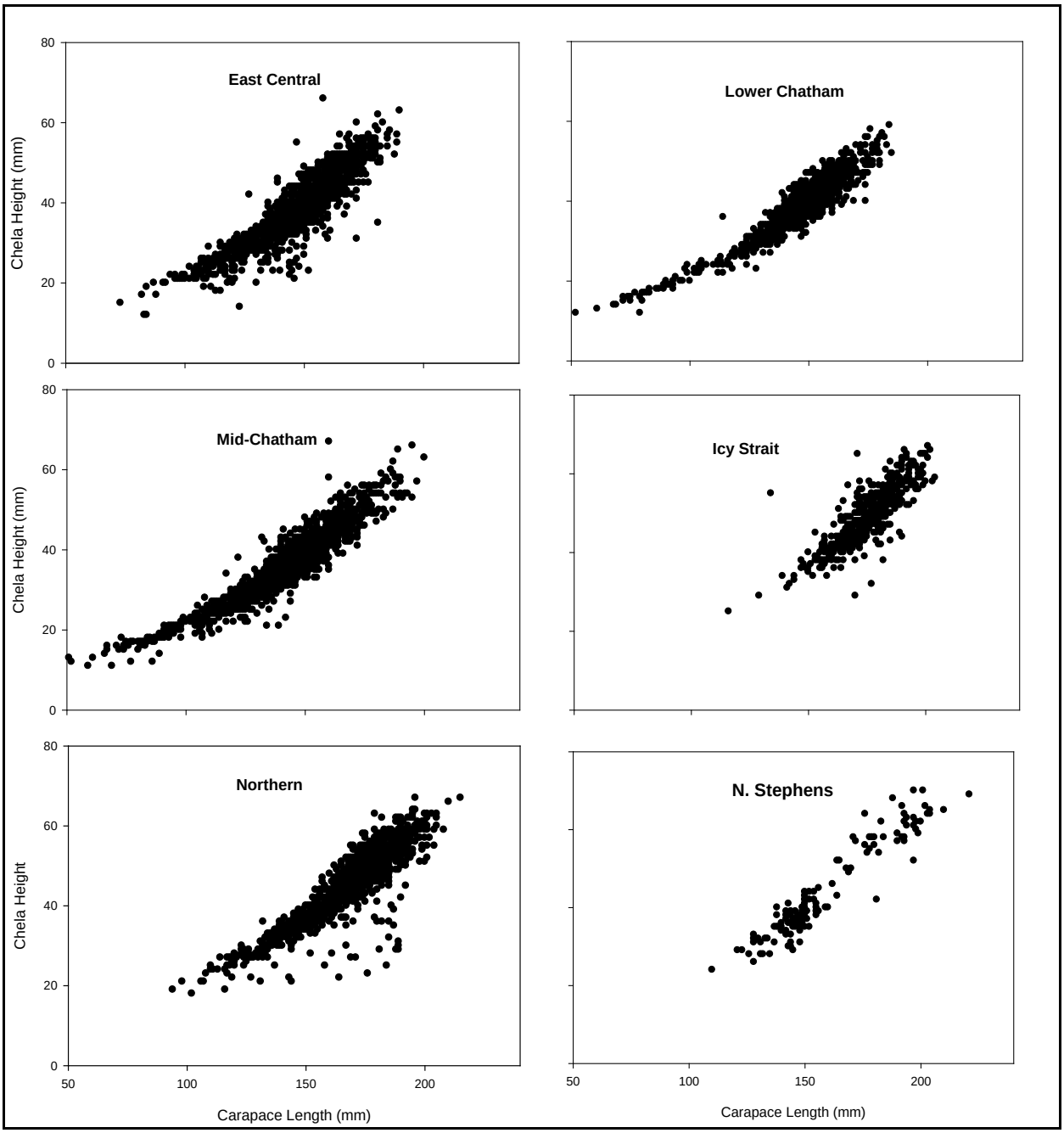

Figure 7. –Chela height versus carapace length of male golden king crab by management area for 2007 through 2010 seasons.

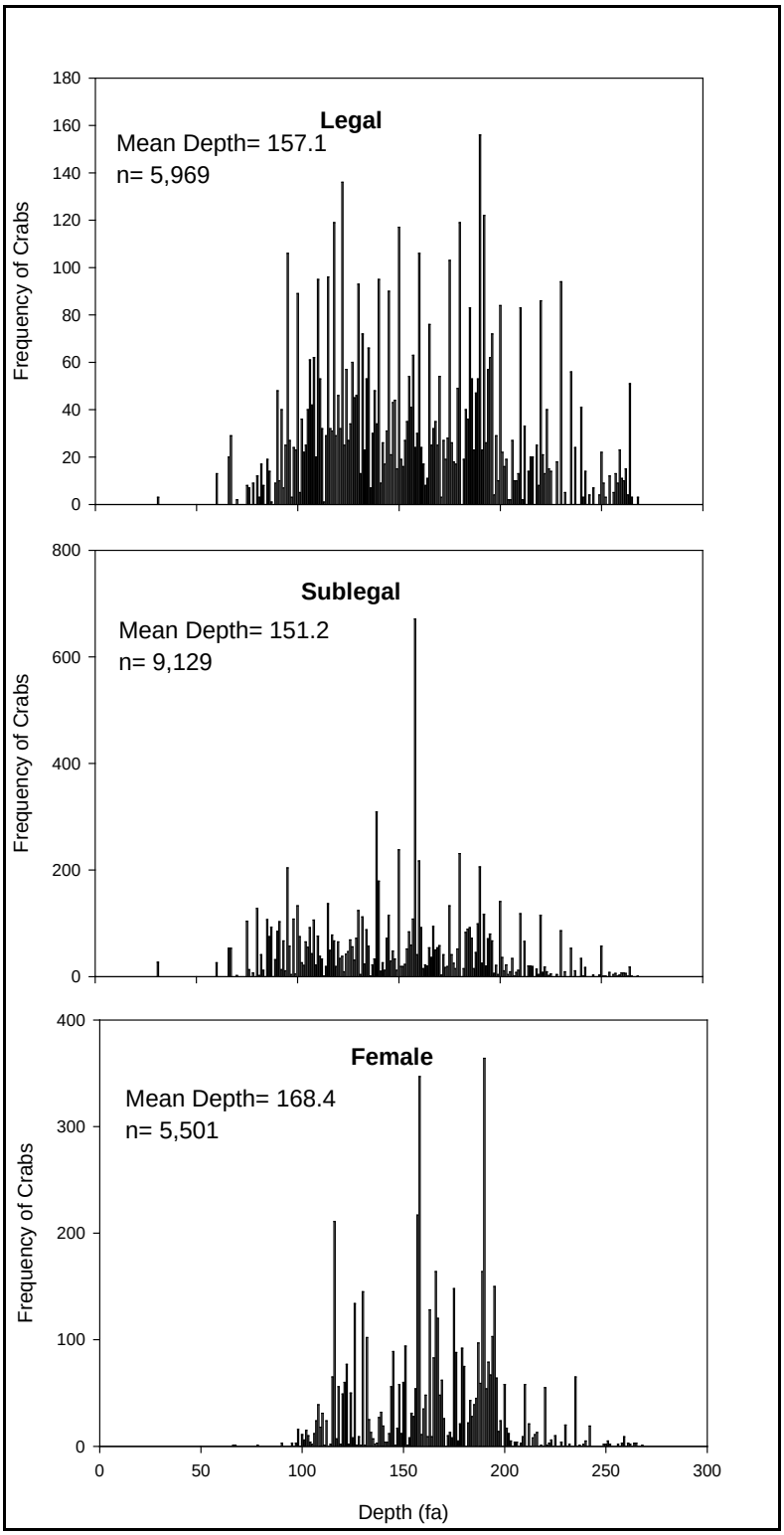

Figure 8.–Depth distribution of golden king crabs by sex and legal status in the East Central management area grouped for 2000 through 2004, 2007, 2008, and 2010 seasons.

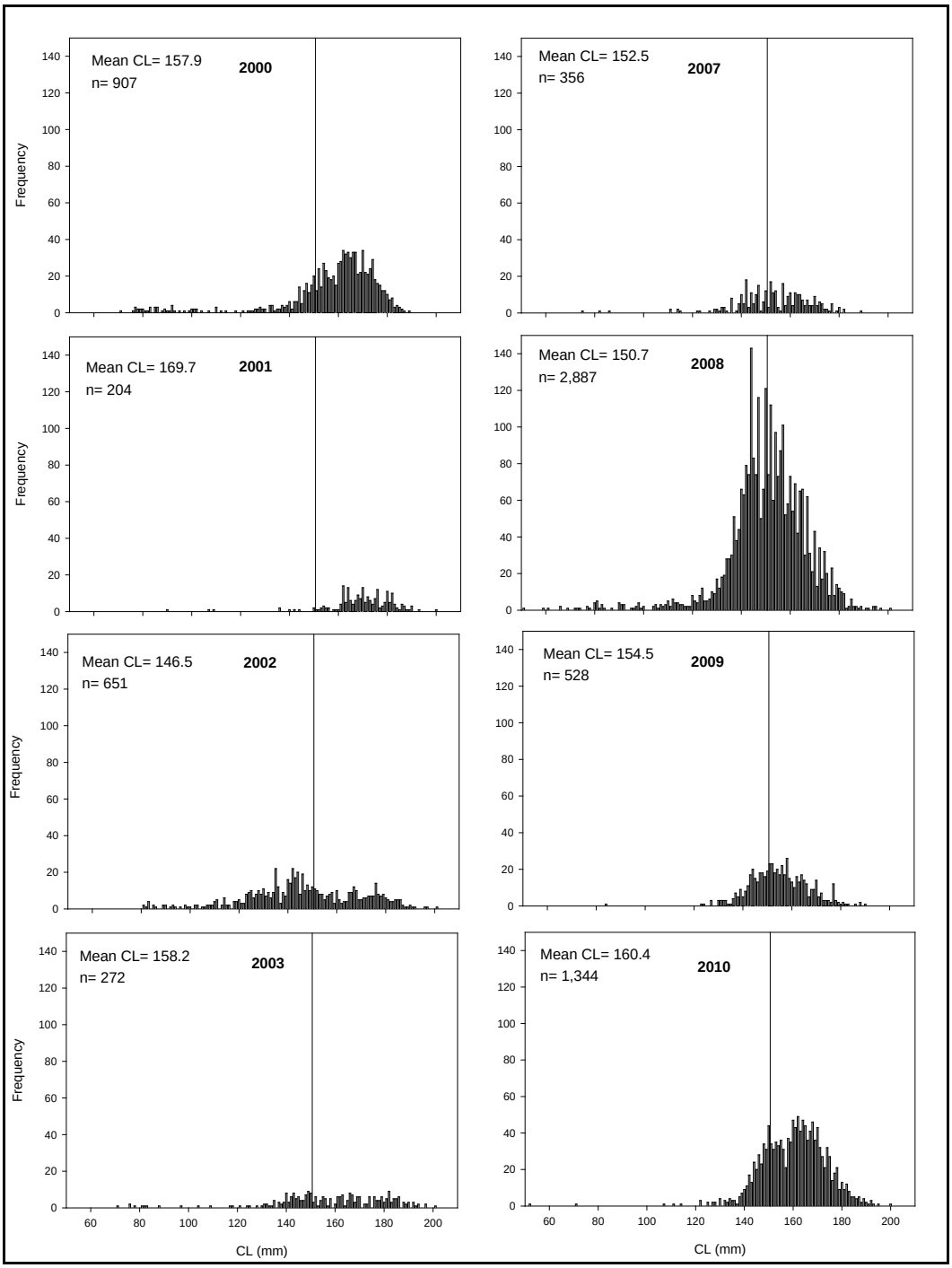

Figure 9.–Carapace length (CL) composition of male golden king crab sampled from pots with open escape rings while observing onboard in the Mid-Chatham management area during 2000 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

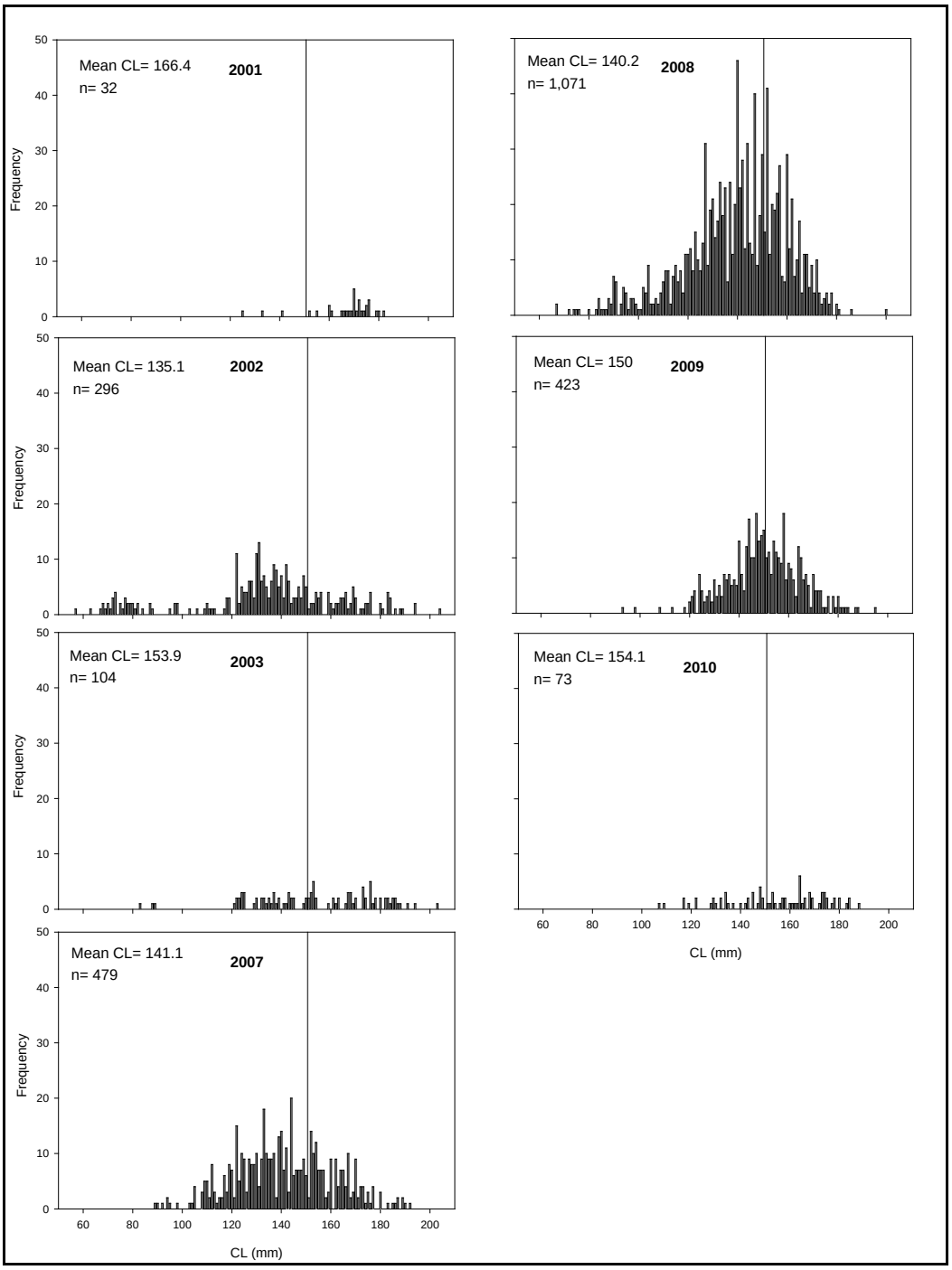

Figure 10.–Carapace length (CL) composition of male golden king crab sampled from pots with closed escape rings while observing onboard in the Mid-Chatham management area during 2001 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

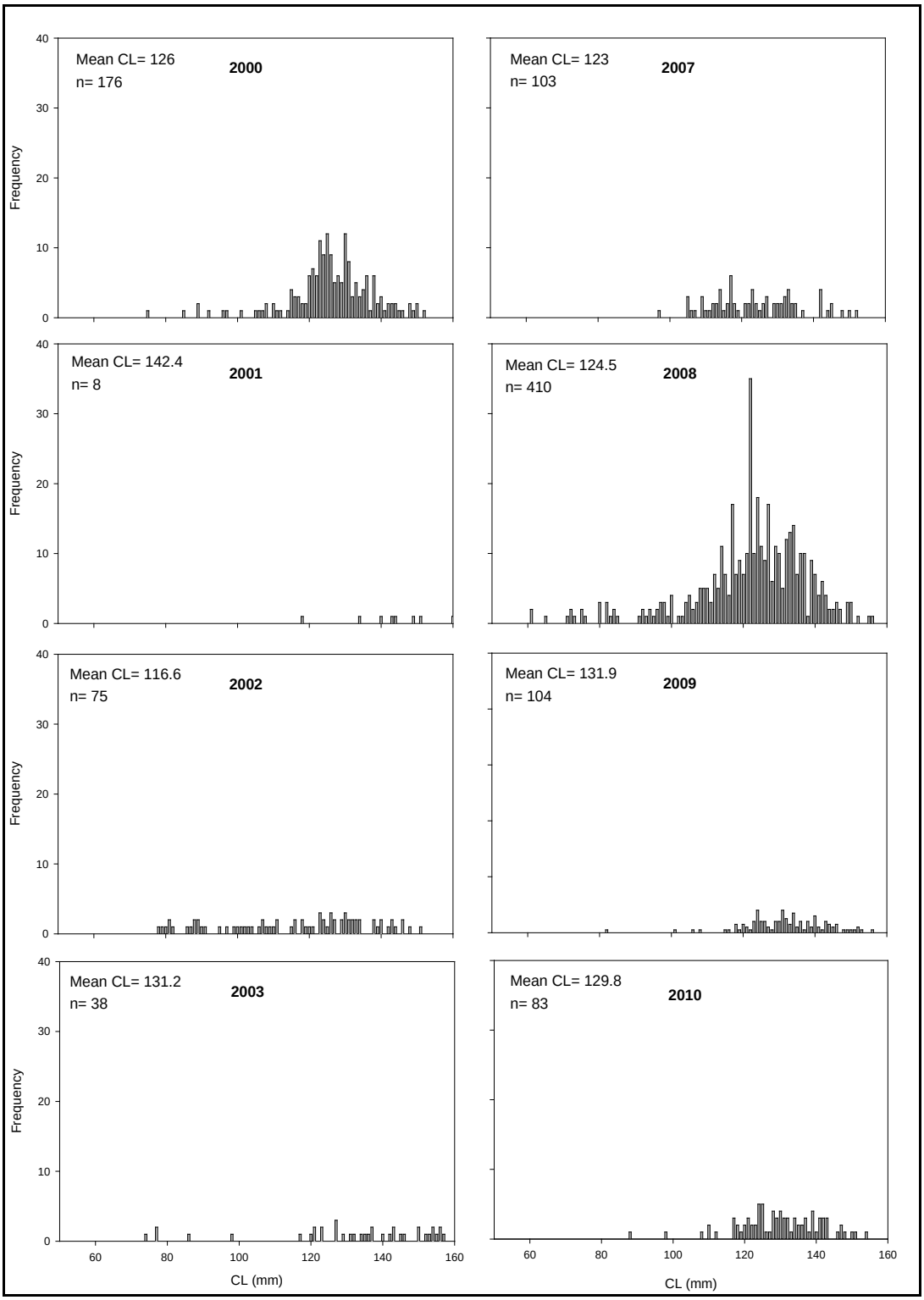

Figure 11.–Carapace length composition of female golden king crab sampled from pots with open escape rings while observing onboard in the Mid-Chatham management areas during 2000 through 2010 seasons.

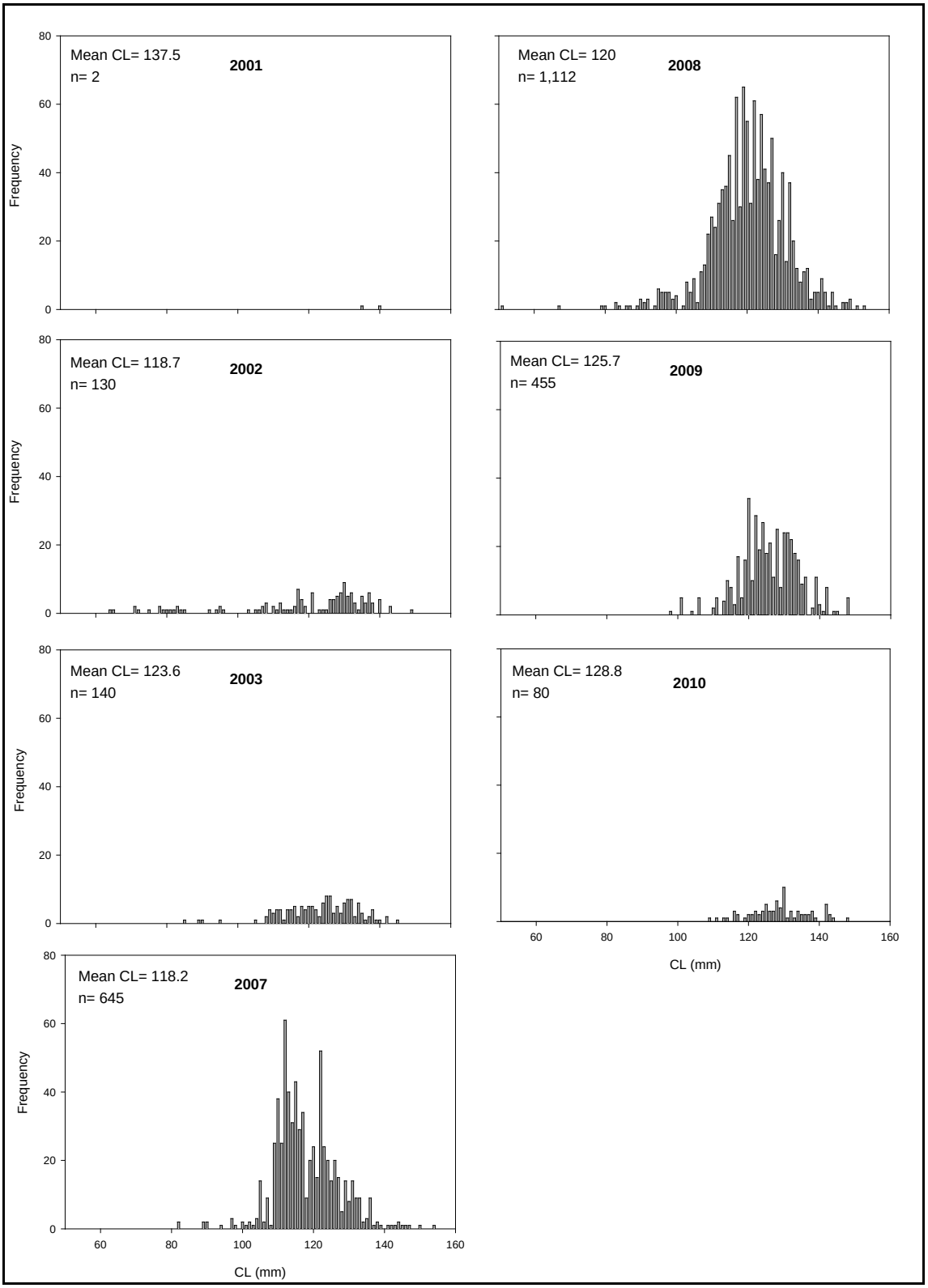

Figure 12.–Carapace length composition of female golden king crab sampled from pots with closed escape rings while observing onboard in the Mid-Chatham management area during 2001 through 2010 seasons.

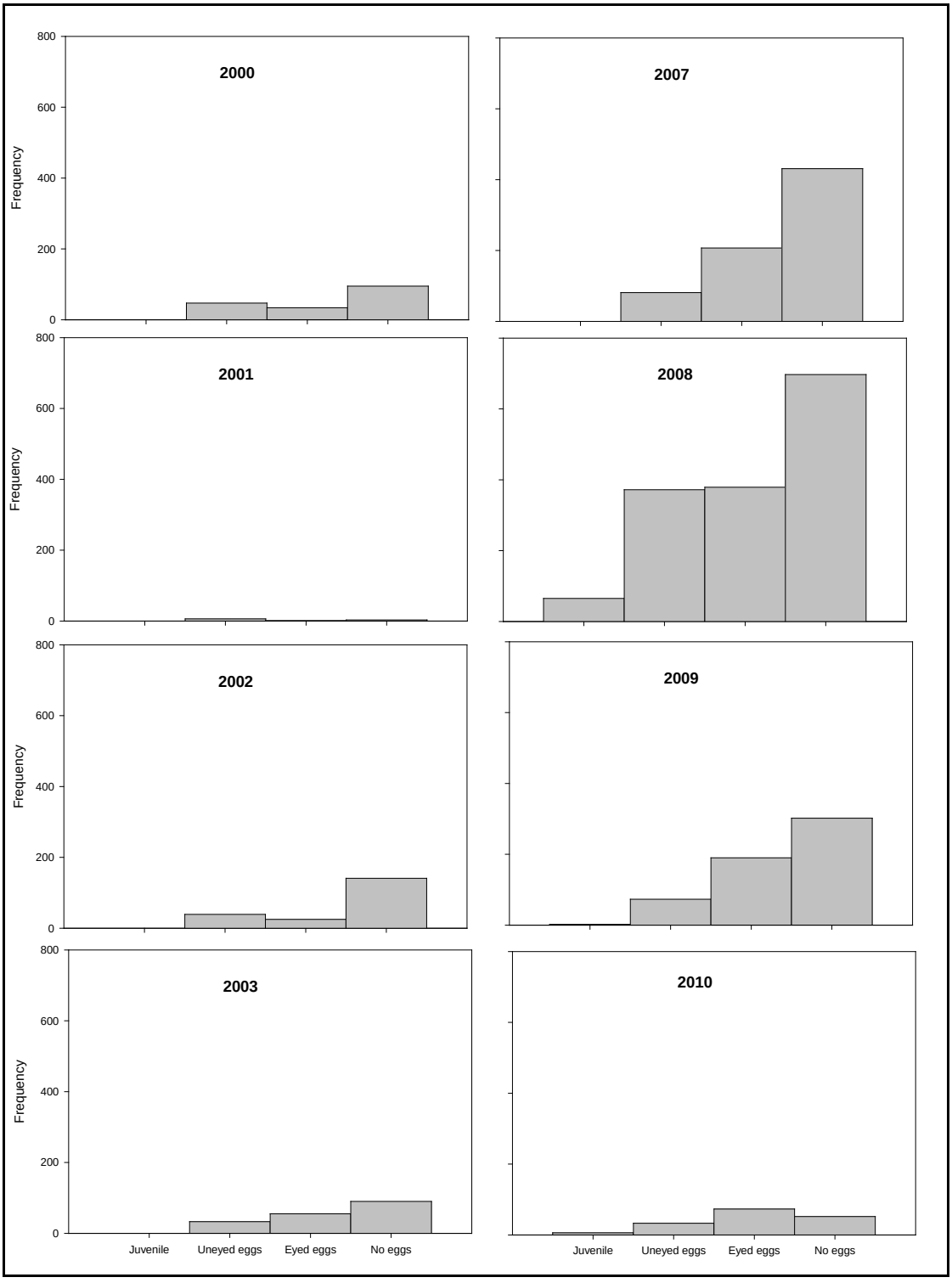

Figure 13.–Egg development stage of female golden king crab sampled from pots while observing onboard in the Mid-Chatham management area during 2000 through 2010 seasons.

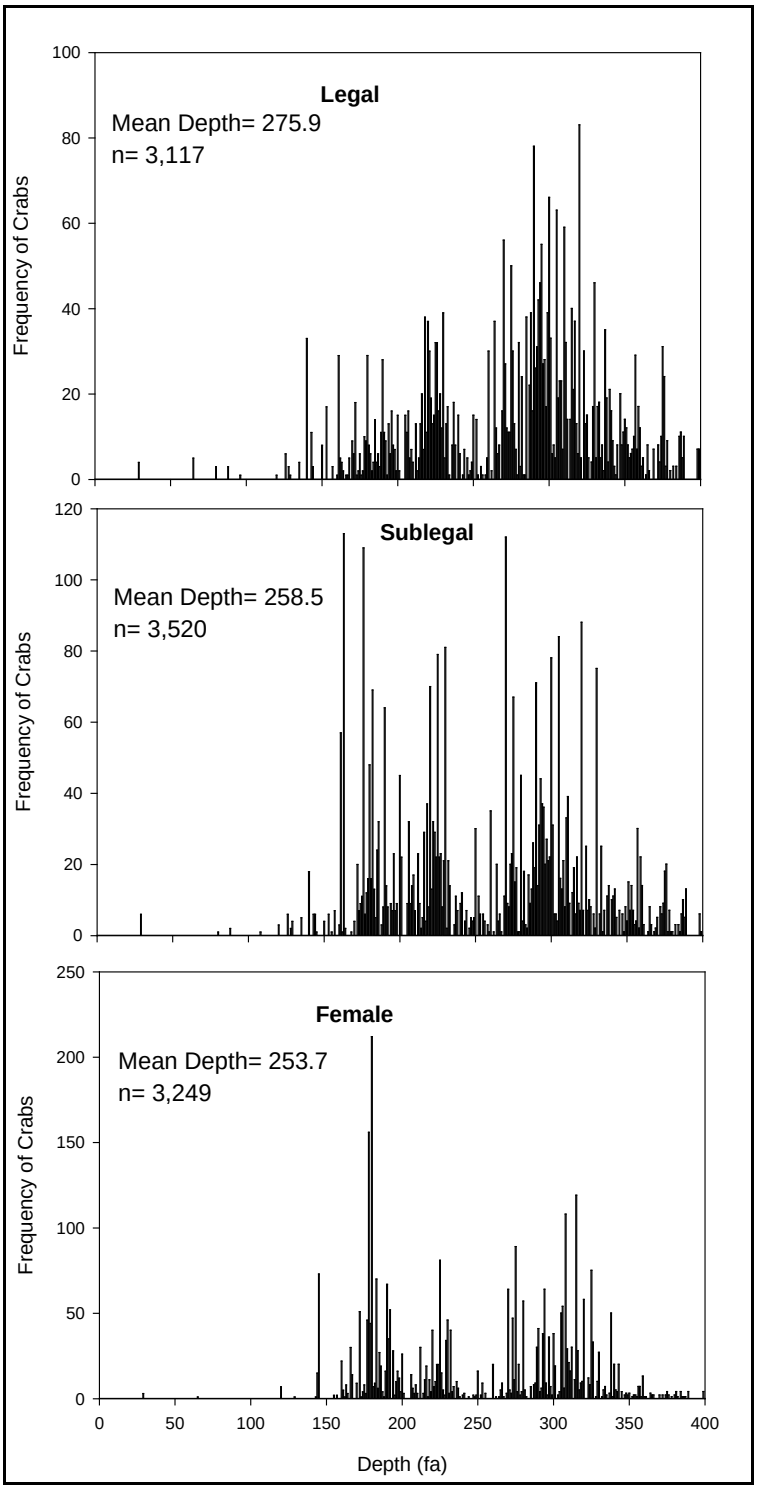

Figure 14.–Depth distribution of golden king crabs by sex and legal status in the Mid-Chatham management area grouped for 2000 through 2003 and 2007 through 2010 seasons.

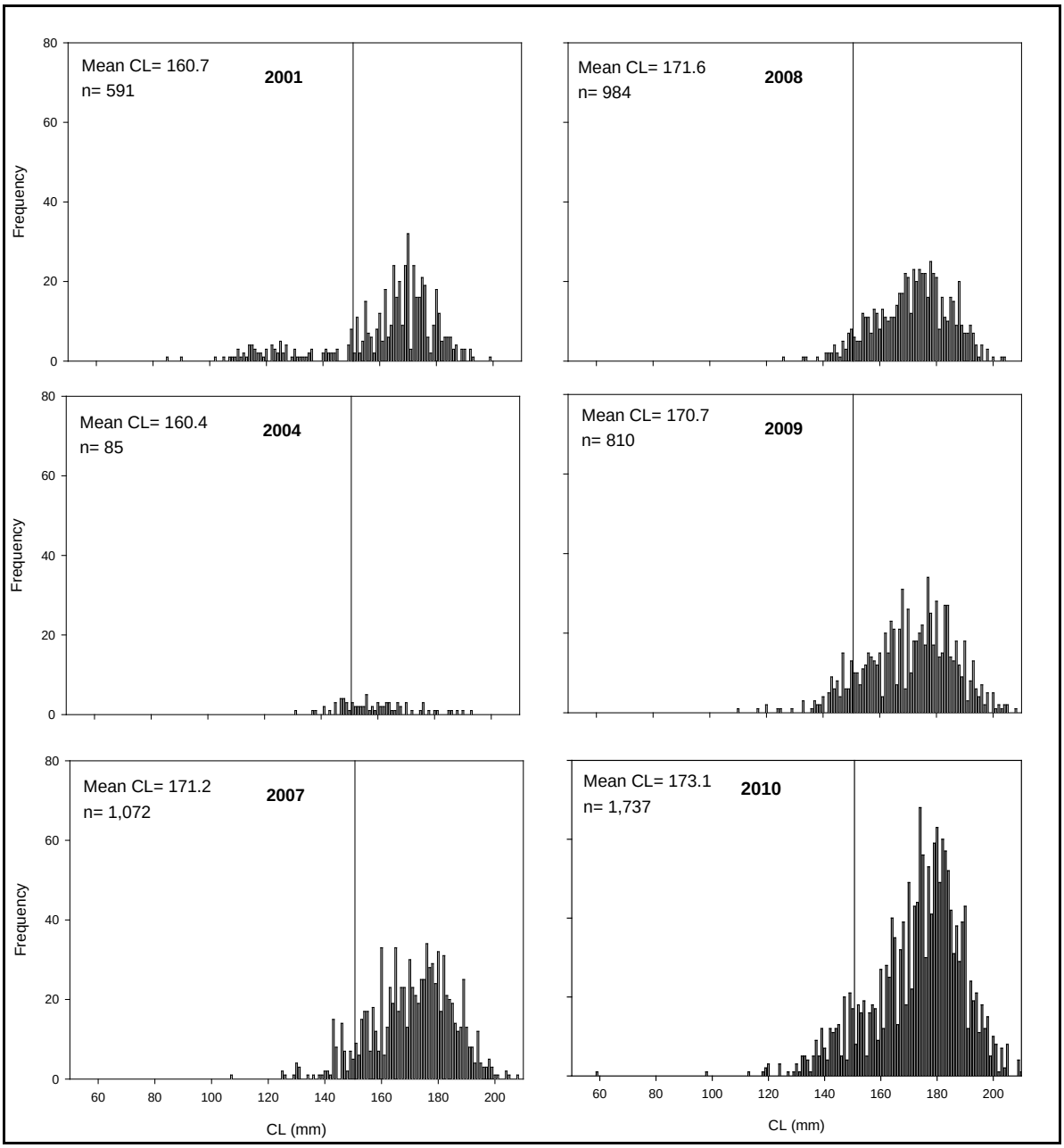

Figure 15.–Carapace length (CL) composition of male golden king crab sampled from pots with open escape rings while observing onboard in the Northern management area during 2001 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

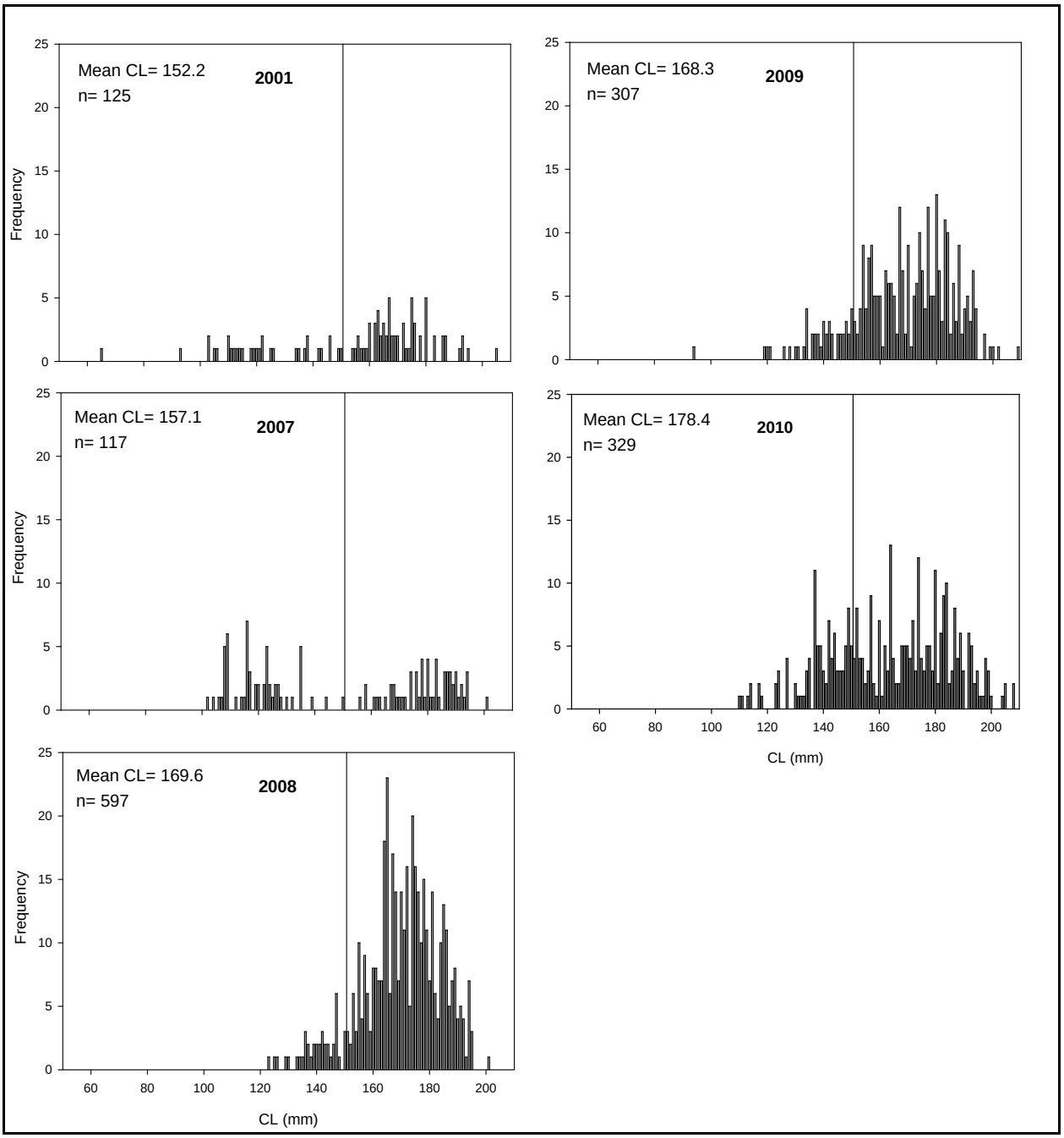

Figure 16.–Carapace length (CL) composition of male golden king crab sampled from pots with closed escape rings while observing onboard in the Northern management area during 2001 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

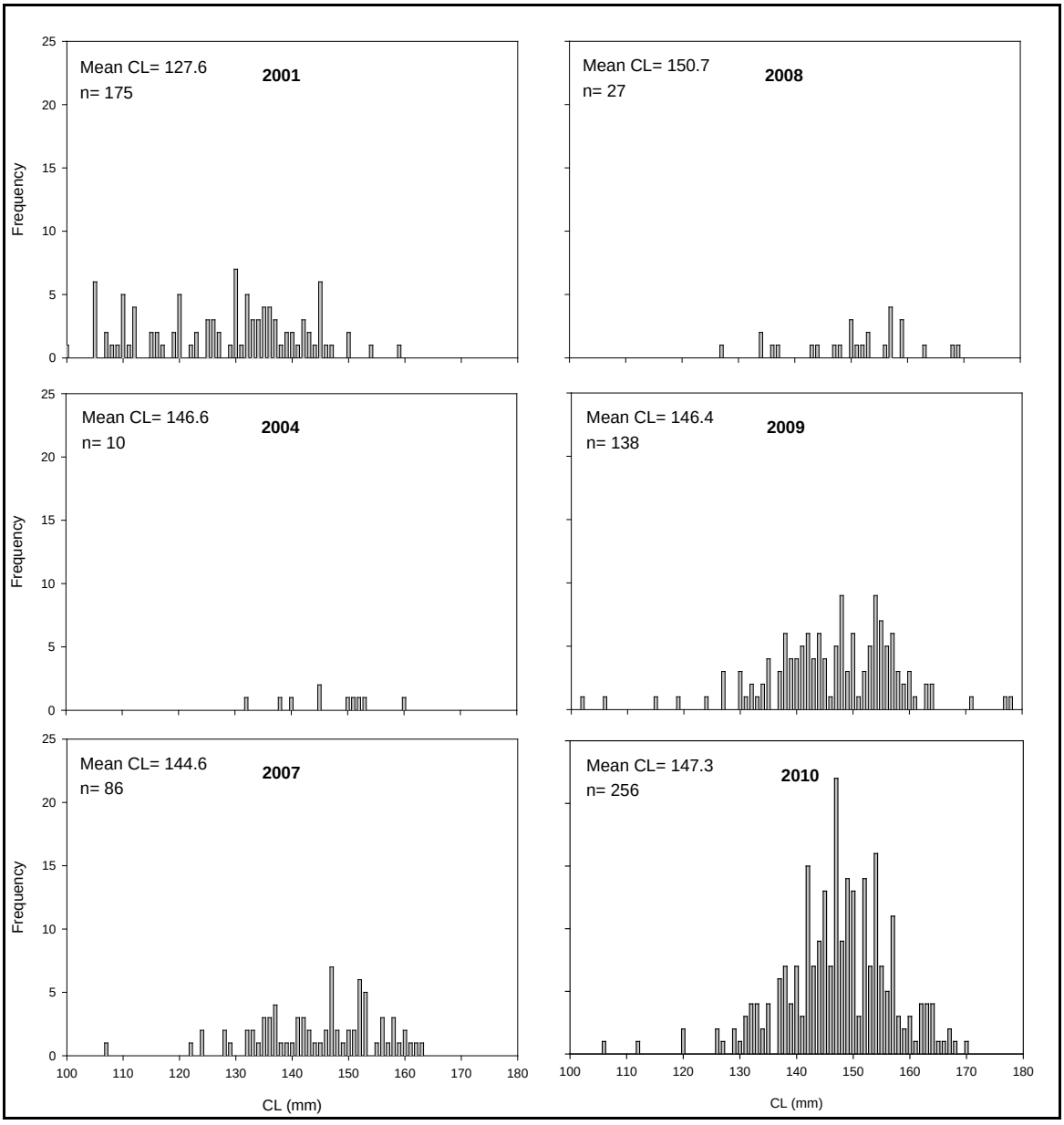

Figure 17.–Carapace length composition of female golden king crab sampled from pots with open escape rings while observing onboard in the Northern management area during 2001 through 2010 seasons.

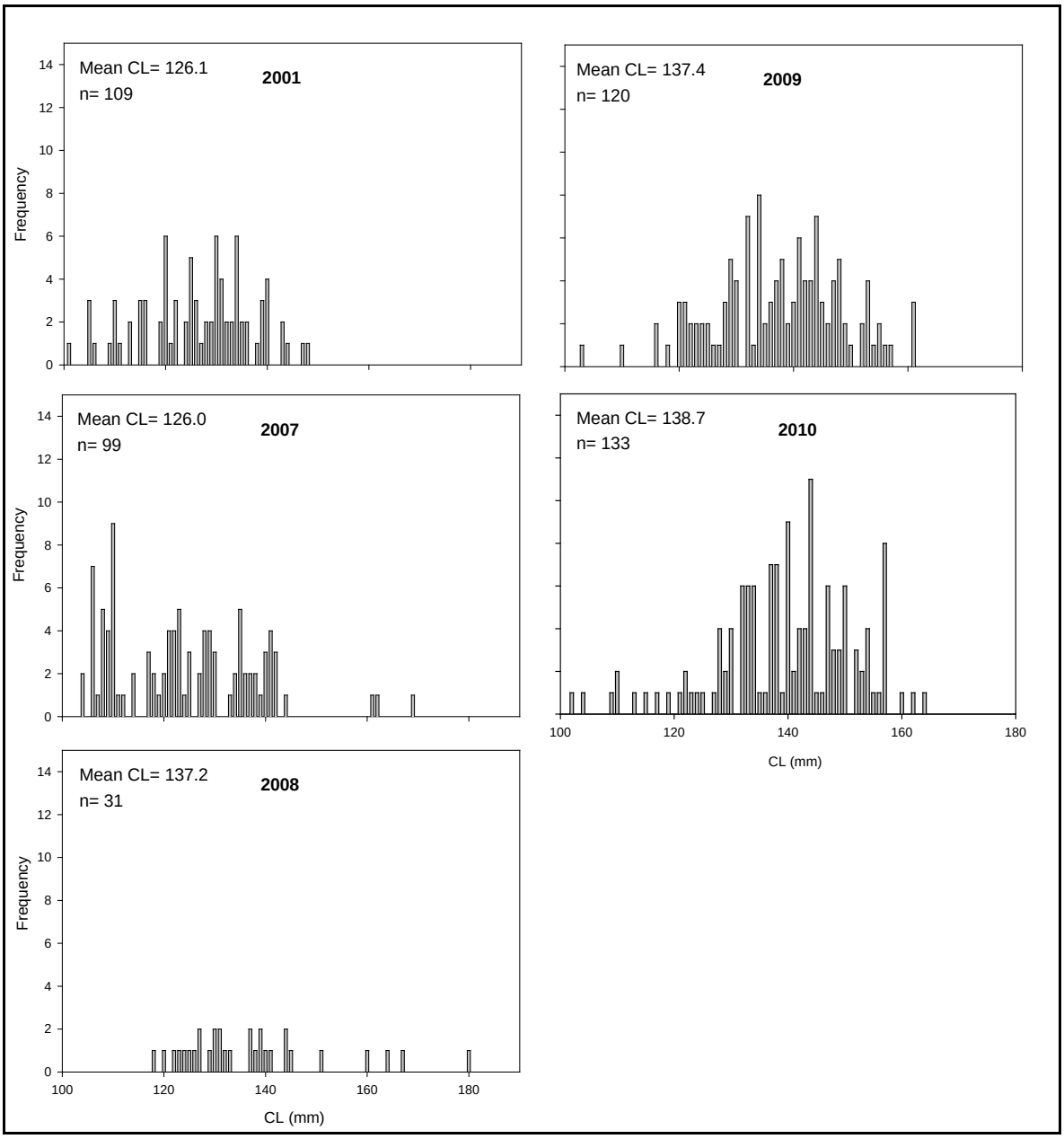

Figure 18.–Carapace length composition of female golden king crab sampled from pots with closed escape rings while observing onboard in the Northern management area during 2001 through 2010 seasons.

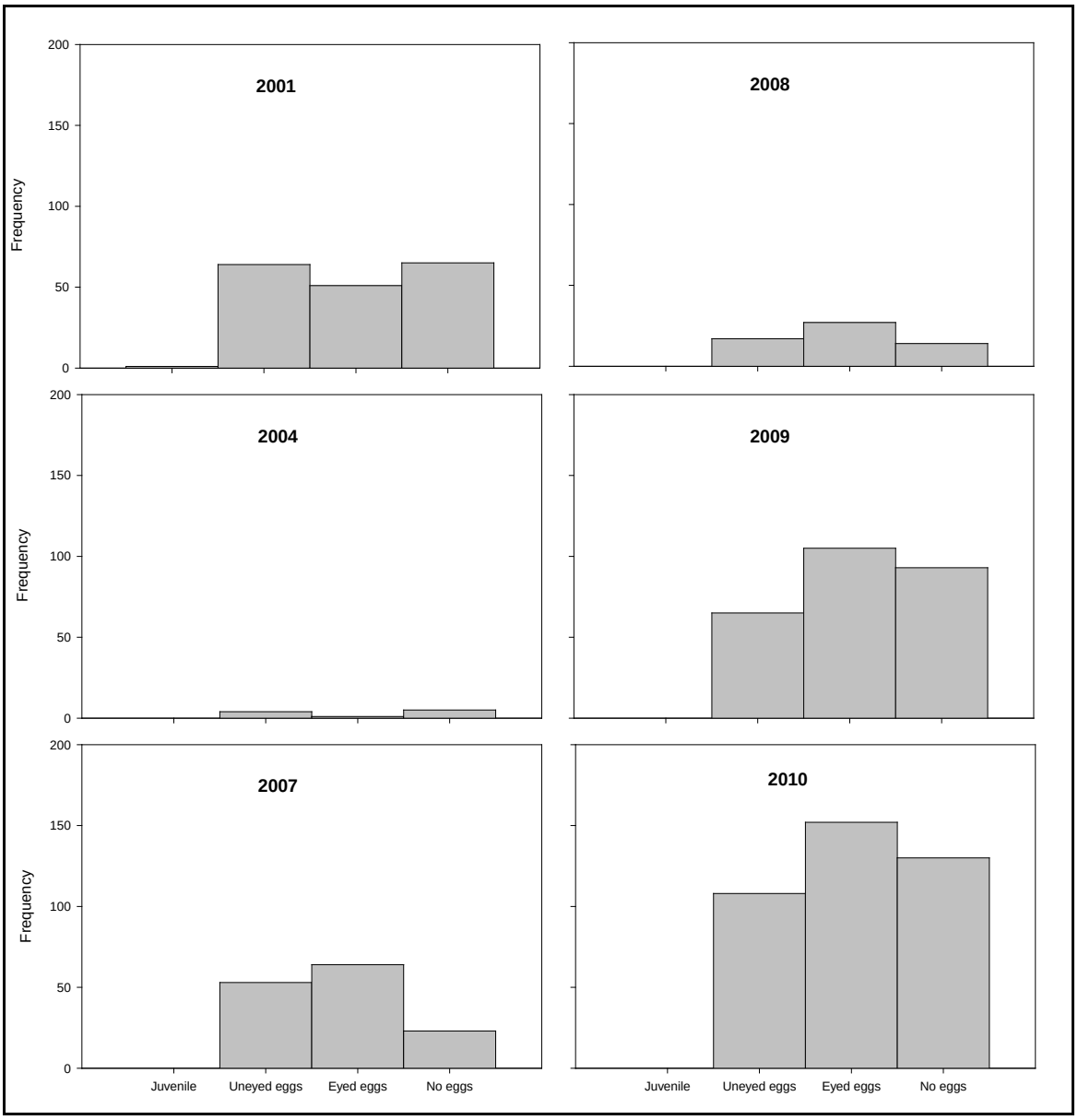

Figure 19.–Egg development stage of female golden king crab sampled from pots while observing onboard in the Northern management area during 2001 through 2010 seasons.

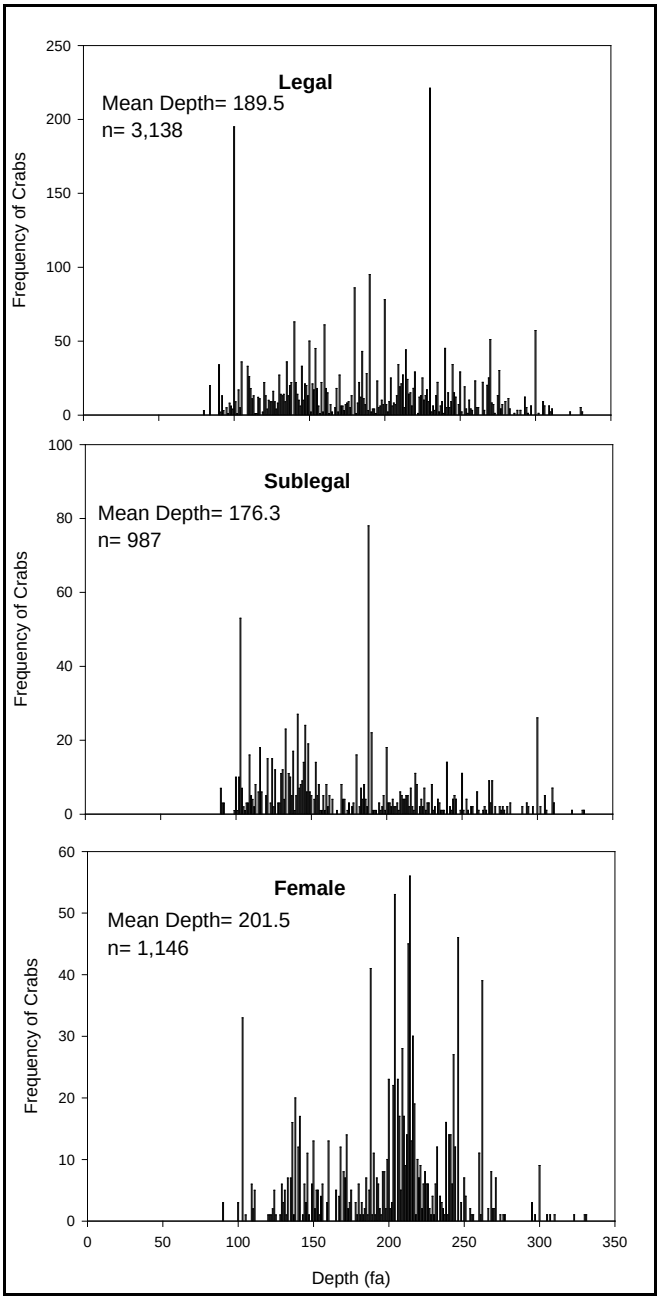

Figure 20.–Depth distribution of golden king crabs by sex and legal status in the Northern management area grouped for 2001, 2003, 2004, and 2007 through 2010 seasons.

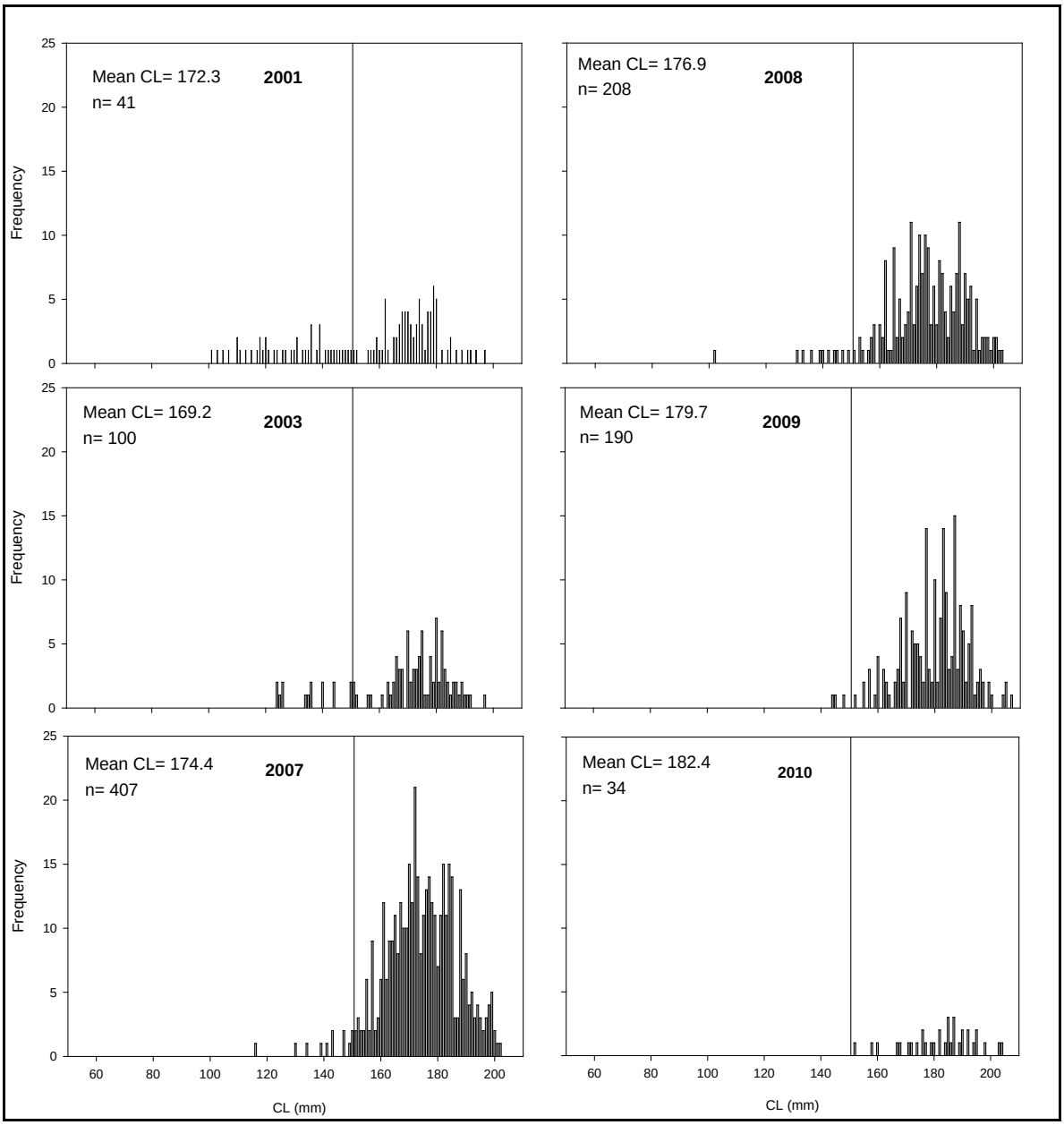

Figure 21.–Carapace length (CL) composition of male golden king crab sampled from pots with open escape rings while observing onboard in the Icy Strait management area during 2001 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

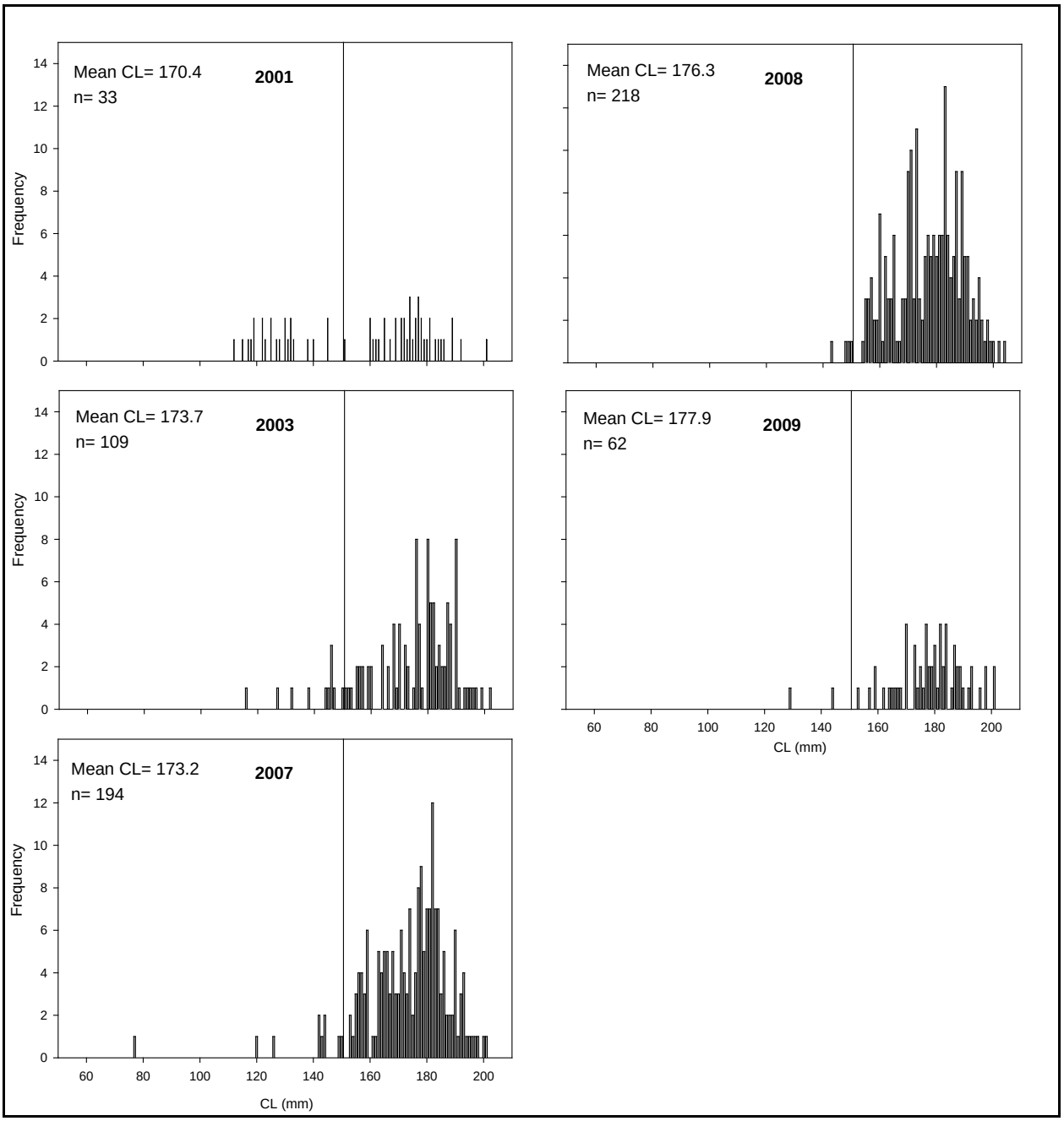

Figure 22.–Carapace length (CL) composition of male golden king crab sampled from pots with closed escape rings while observing onboard in the Icy Strait management area during 2001 through 2009 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

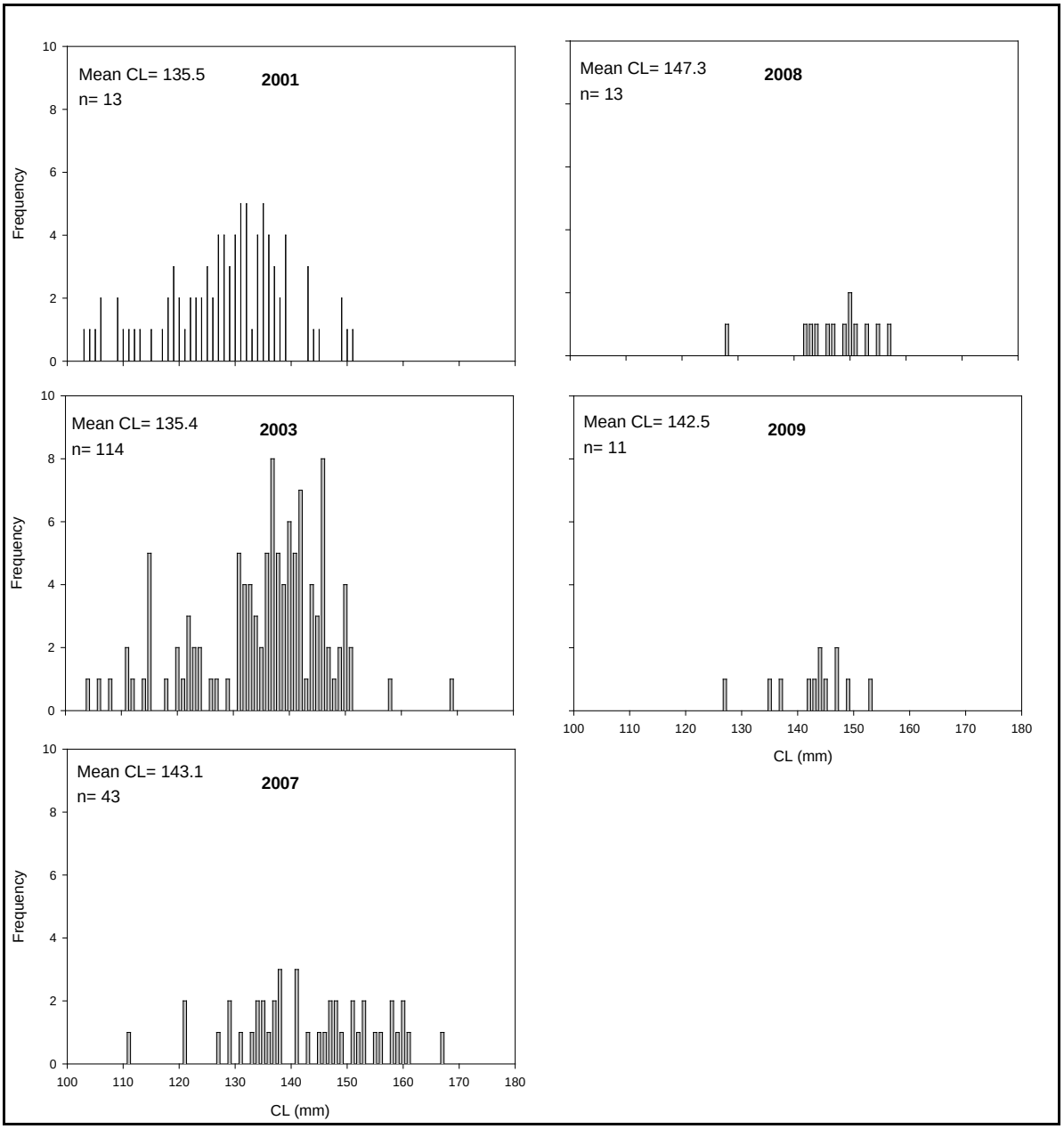

Figure 23.–Carapace length composition of female golden king crab sampled from pots with open escape rings while observing onboard in the Icy Strait management area during 2001 through 2009 seasons.

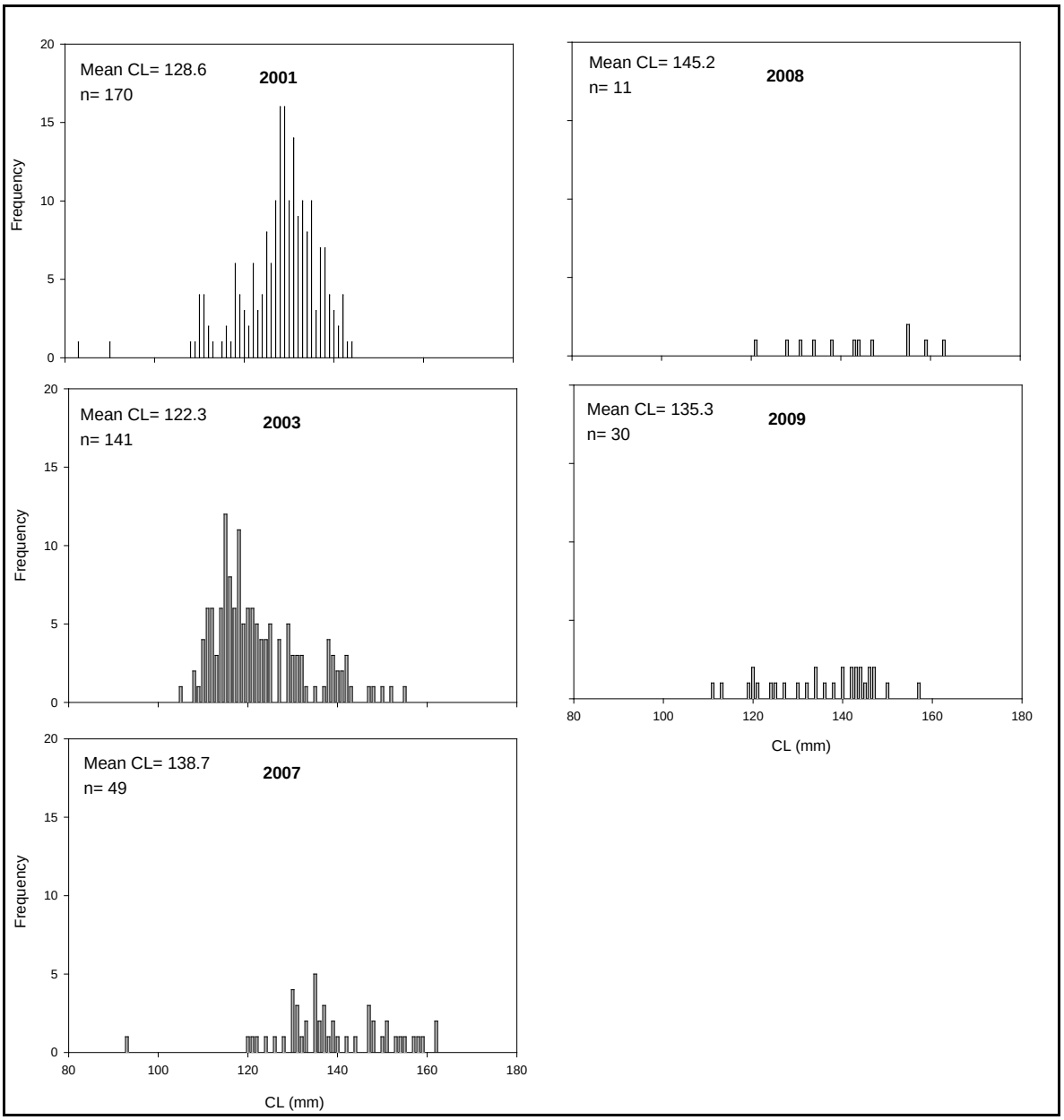

Figure 24.–Carapace length composition of female golden king crab sampled from pots with closed escape rings while observing onboard in the Icy Strait management area during 2001 through 2009 seasons.

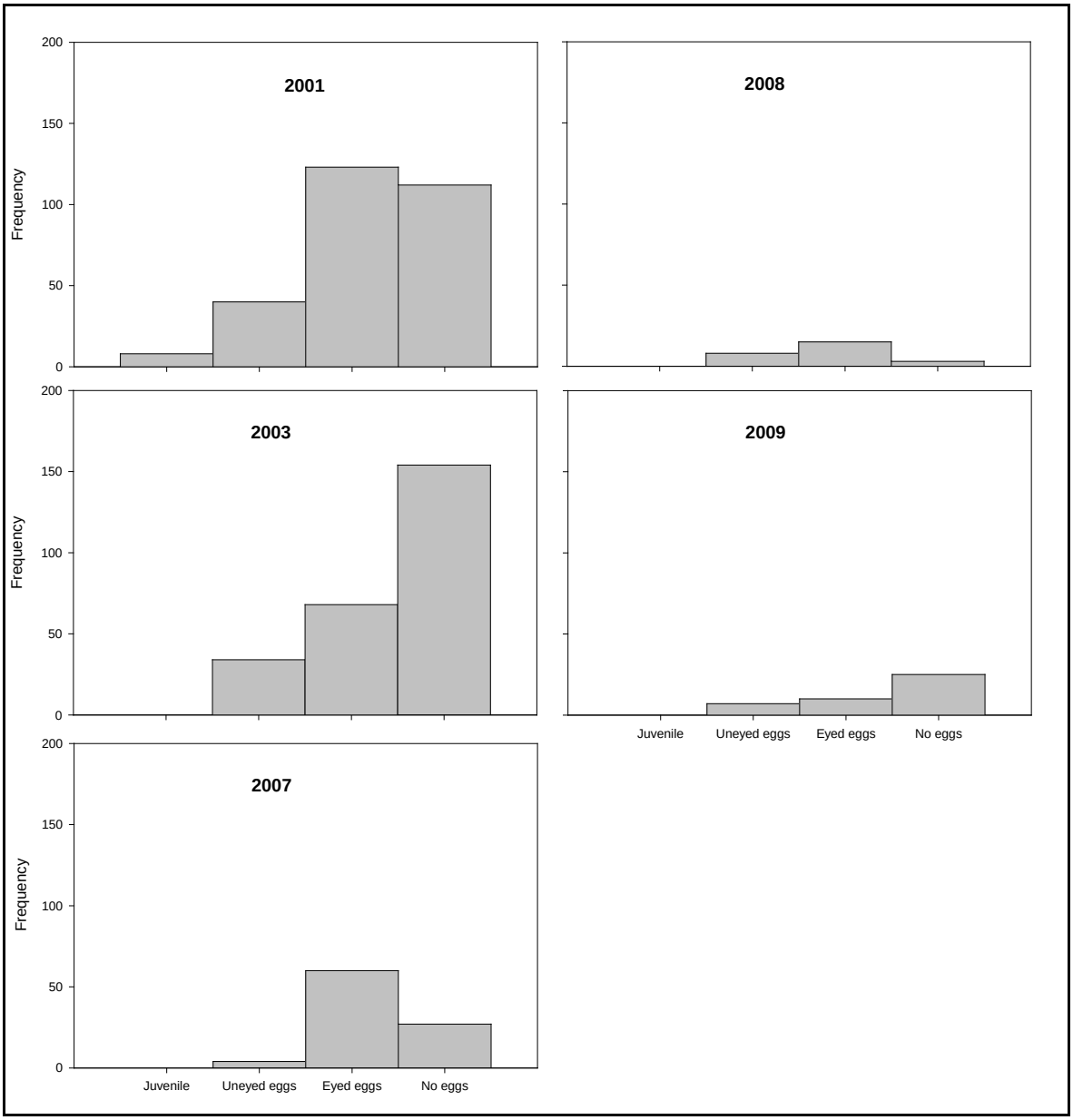

Figure 25.–Egg development stage of female golden king crab sampled from pots while observing onboard in the Icy Strait management area during 2001 through 2009 seasons.

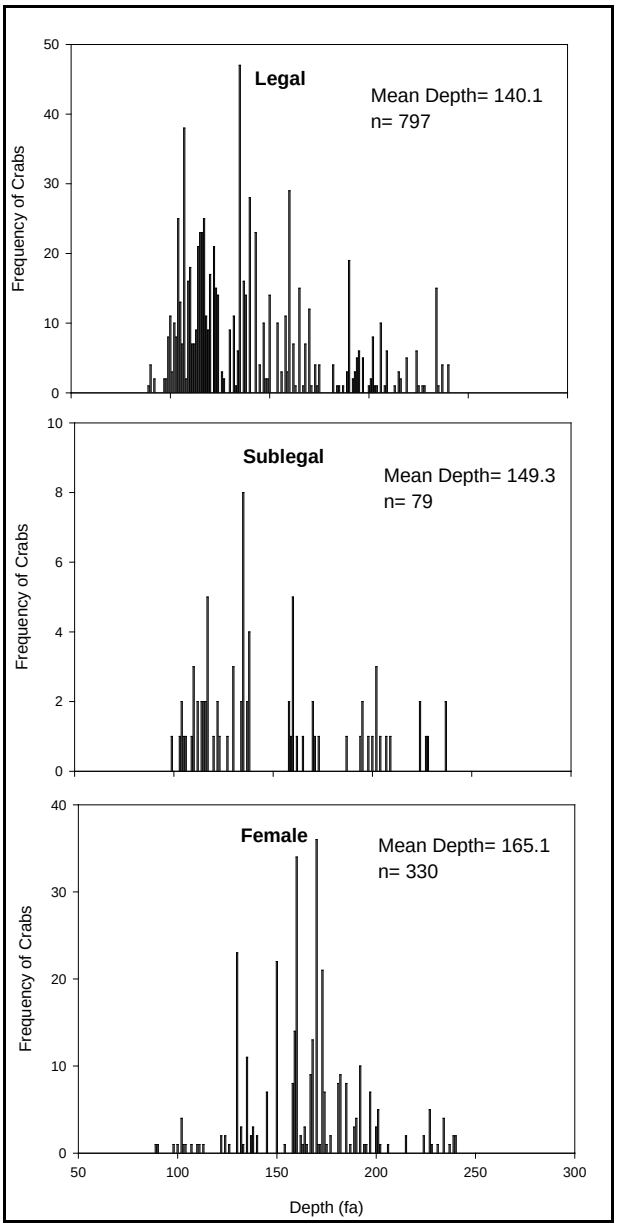

Figure 26.–Depth distribution of golden king crabs by sex and legal status in the Icy Strait management area grouped for 2001, 2003, and 2007 through 2010 seasons.

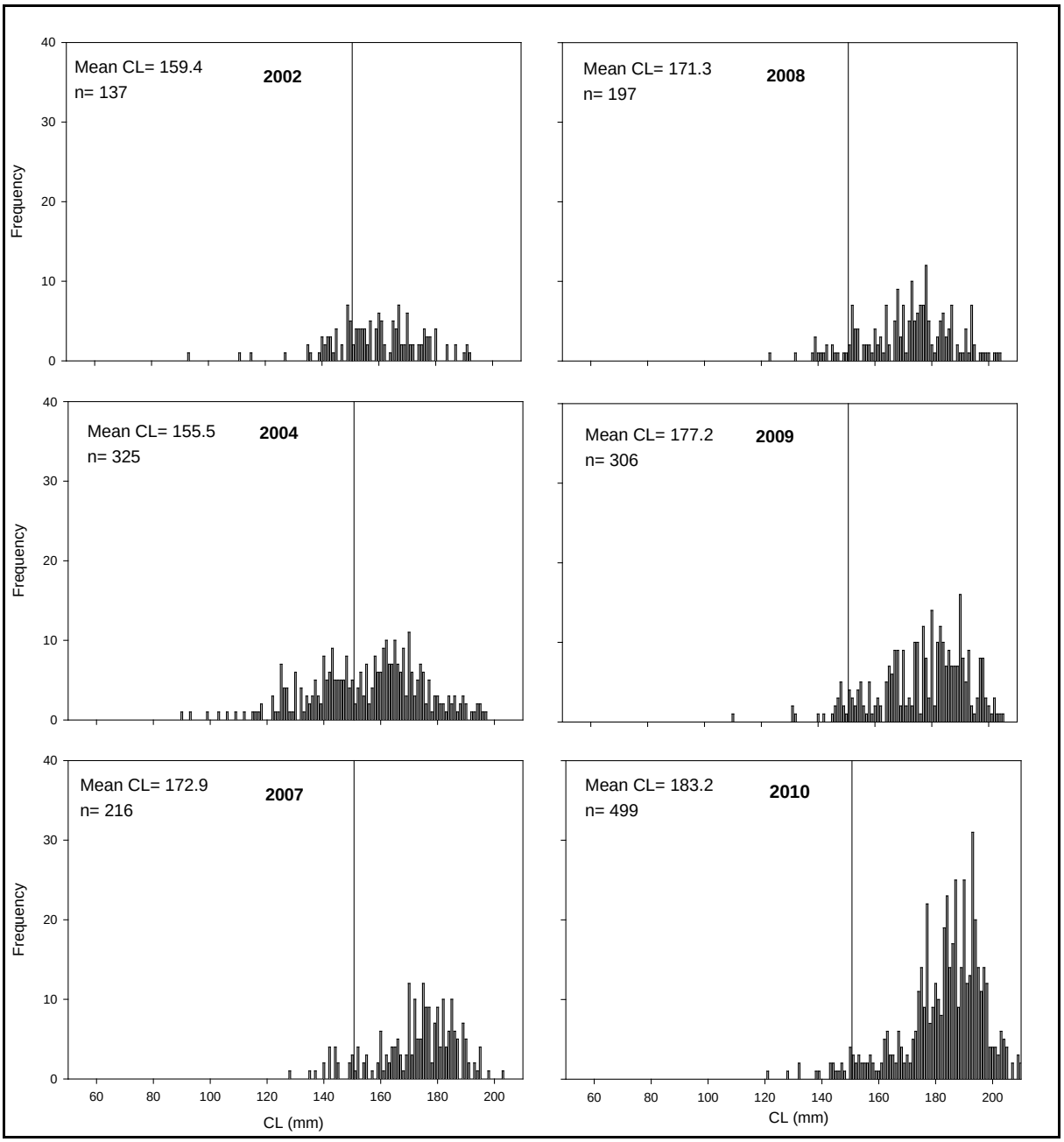

Figure 27.–Carapace length (CL) composition of male golden king crab sampled from pots with open escape rings while observing onboard in the North Stephens Passage management area during 2004 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

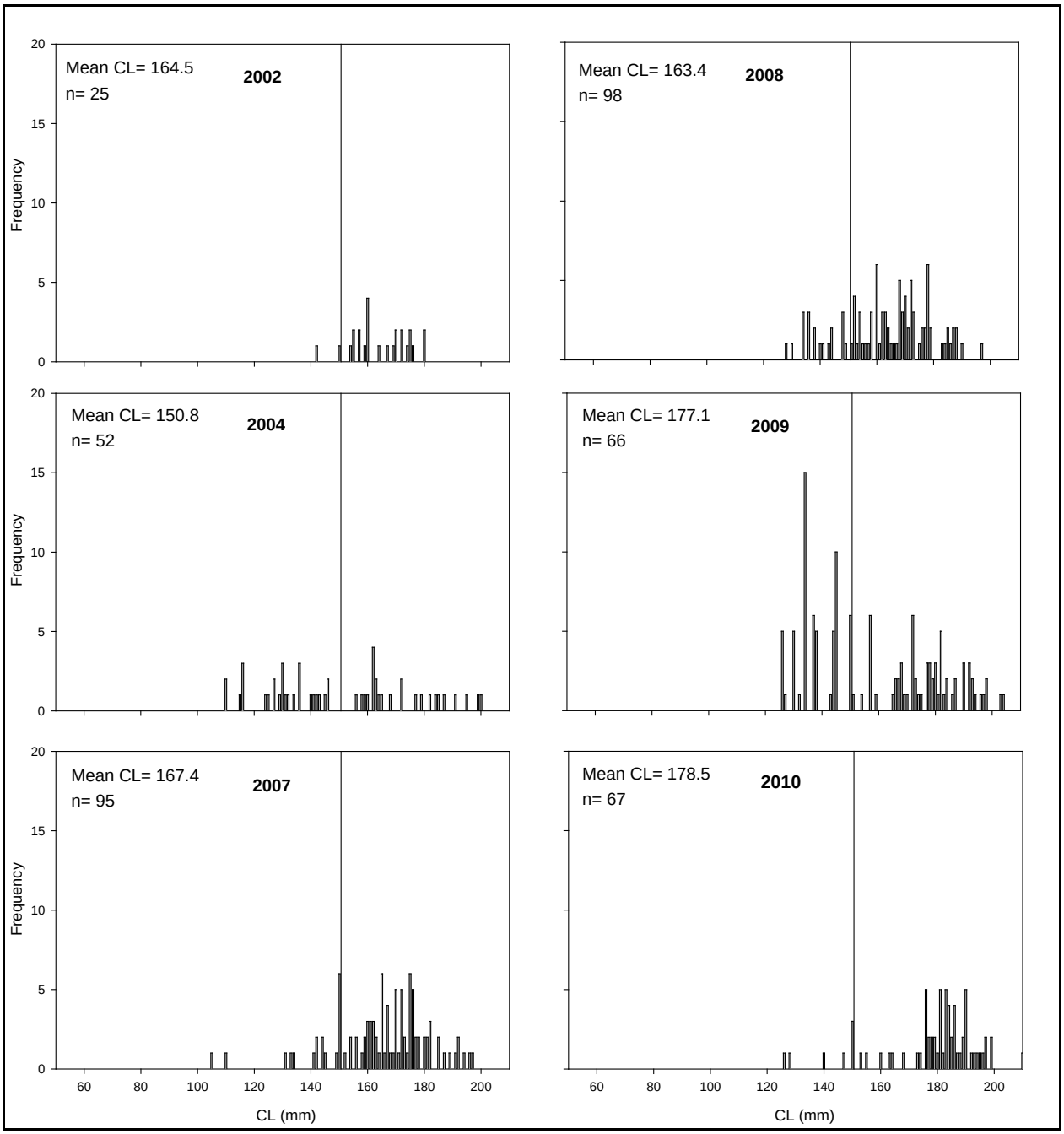

Figure 28.–Carapace length (CL) composition of male golden king crab sampled from pots with closed escape rings while observing onboard in the North Stephens Passage management area during 2002 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

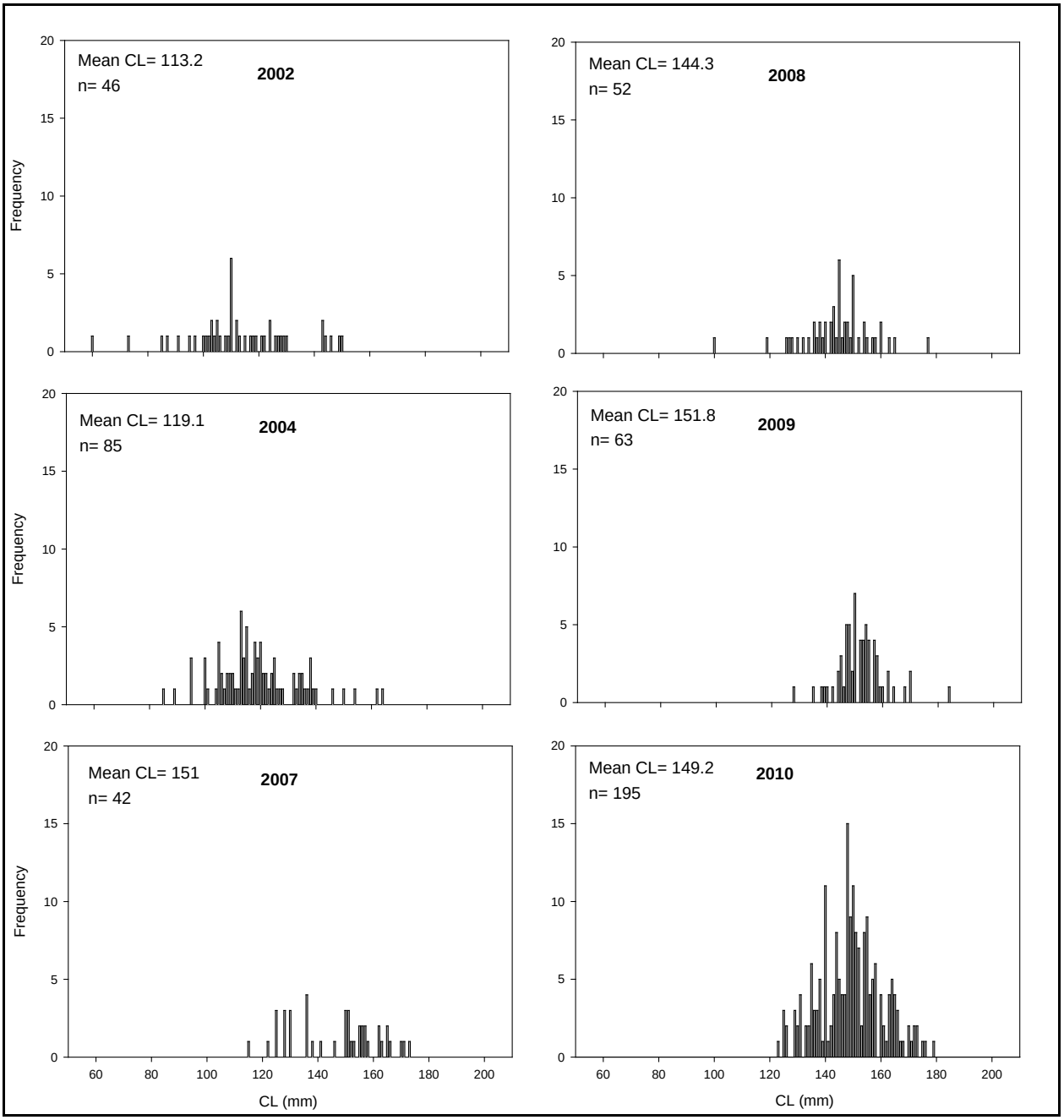

Figure 29.–Carapace length composition of female golden king crab sampled from pots with open escape rings while observing onboard in the North Stephens Passage management area during 2002 through 2010 seasons.

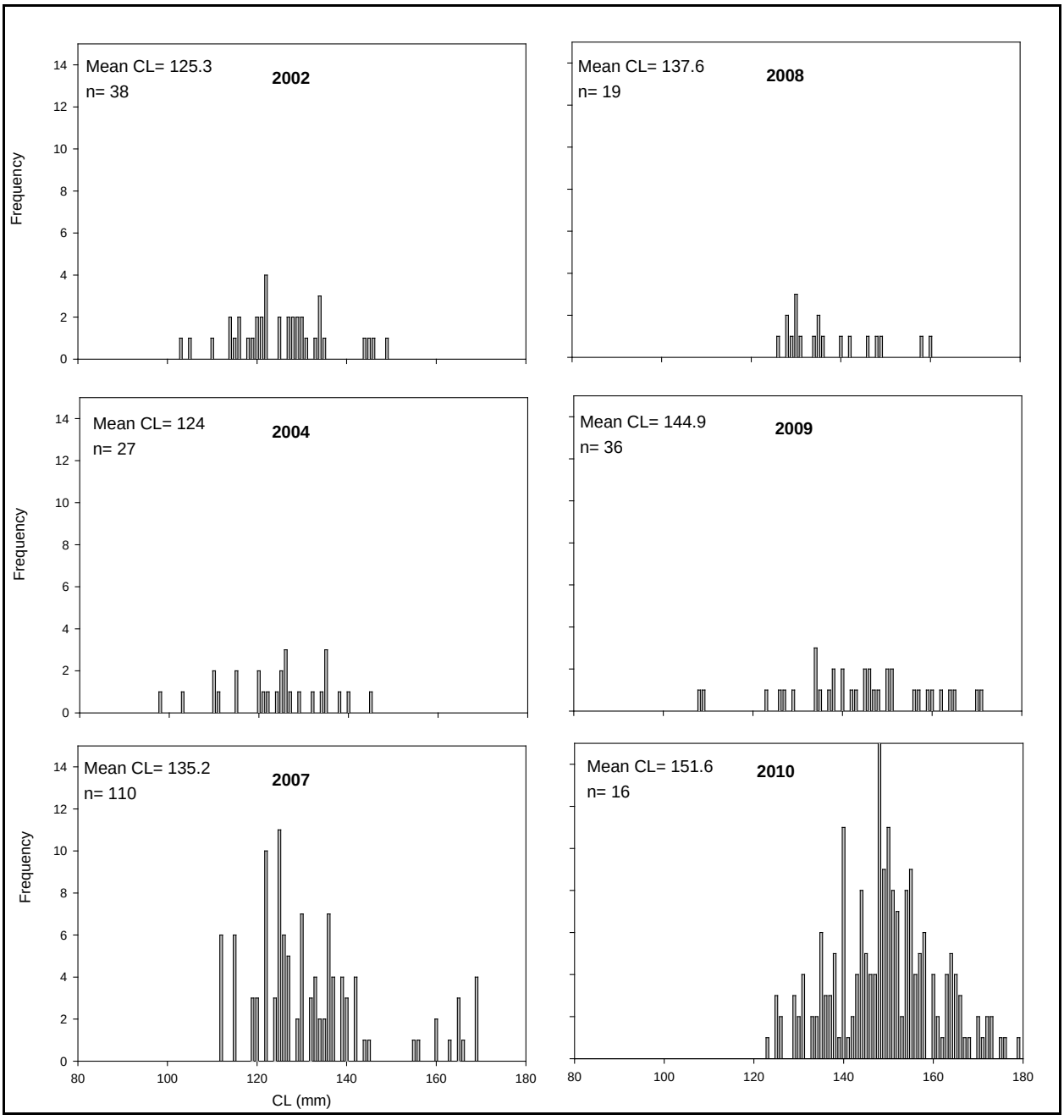

Figure 30.–Carapace length composition of female golden king crab sampled from pots with closed escape rings while observing onboard in the North Stephens Passage management area during 2002 through 2009 seasons.

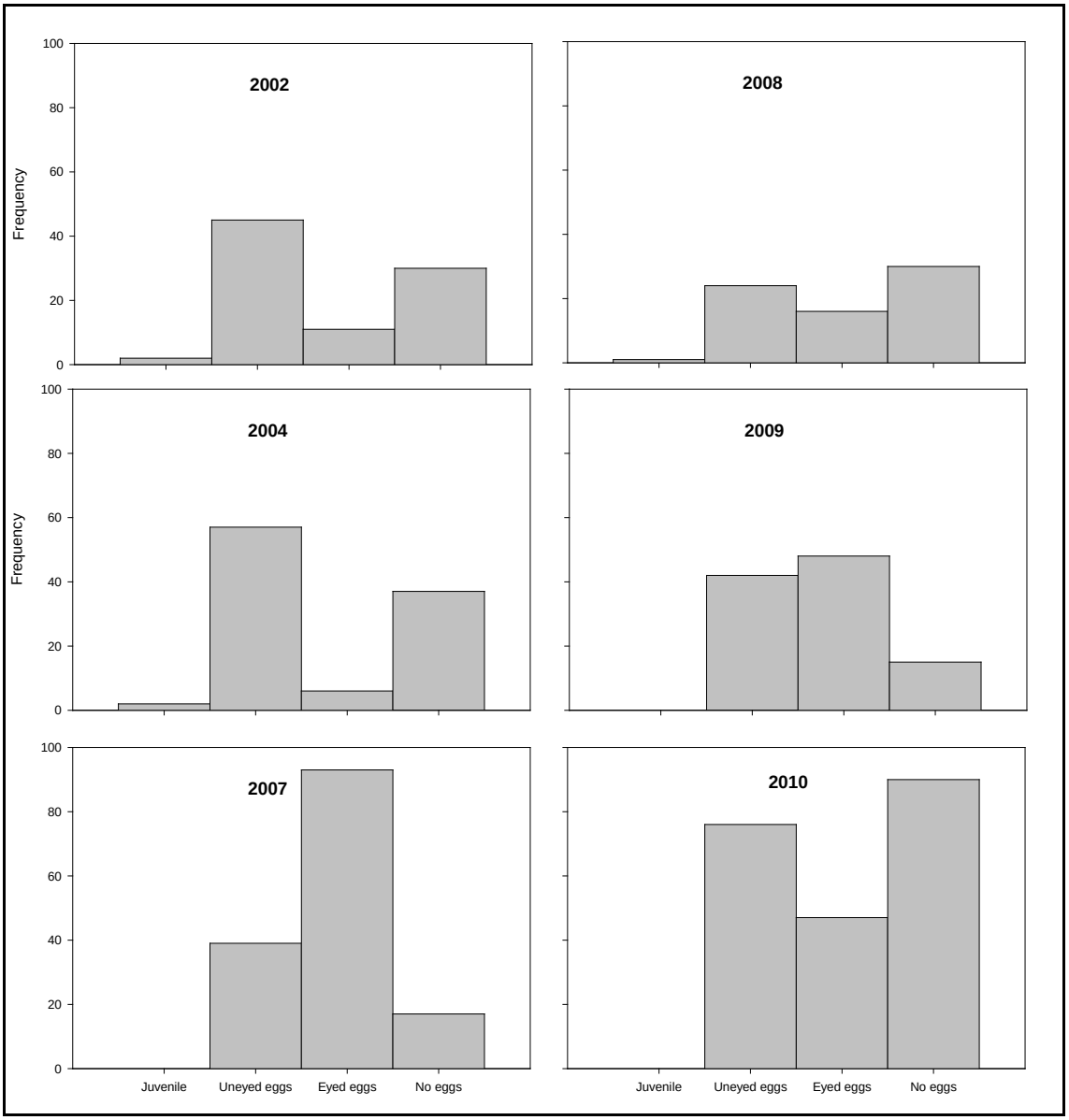

Figure 31.–Egg development stage of female golden king crab sampled from pots while observing onboard in the North Stephens Passage management area during 2002 through 2010 seasons.

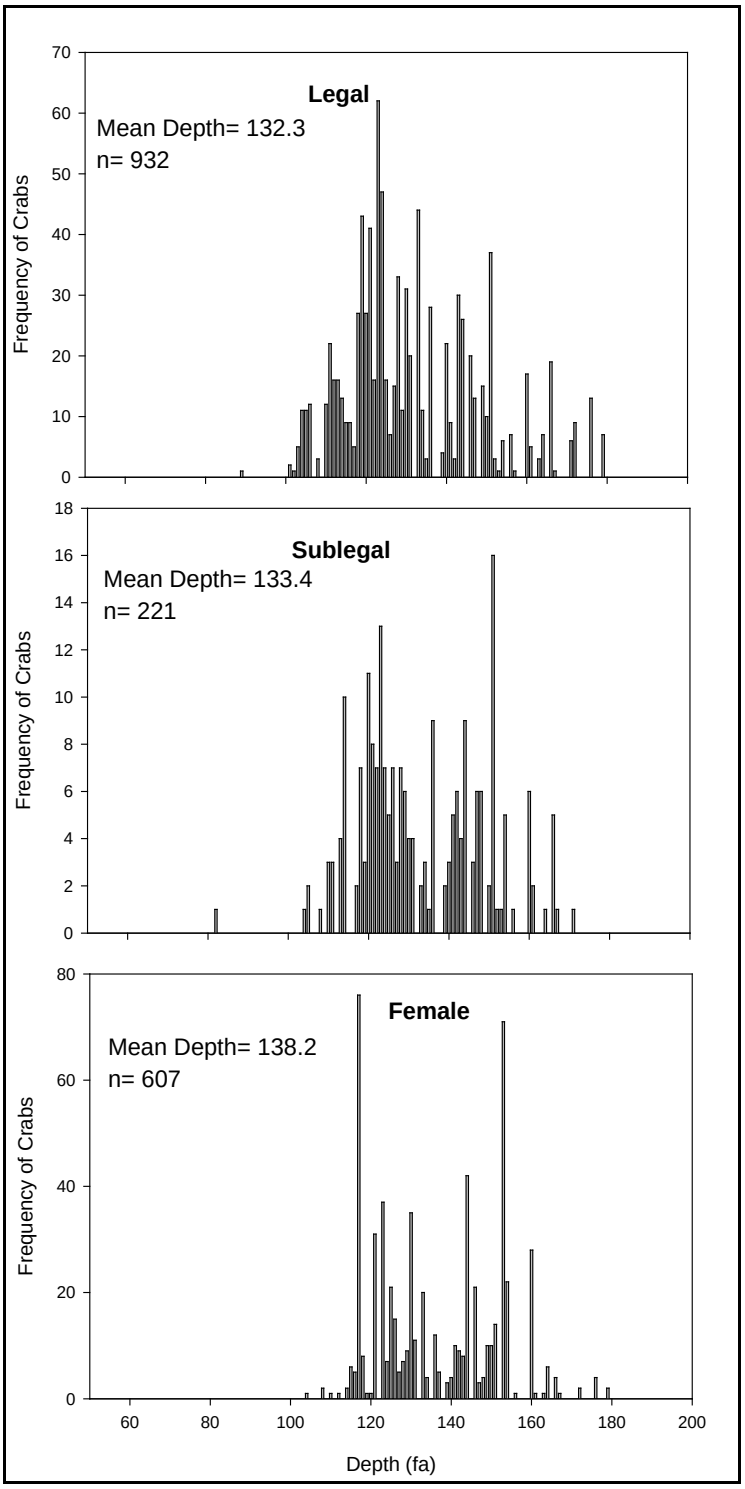

Figure 32.–Depth distribution of golden king crabs by sex and legal status in the North Stephens Passage management area grouped for 2002, 2004, and 2007 through 2010 seasons.

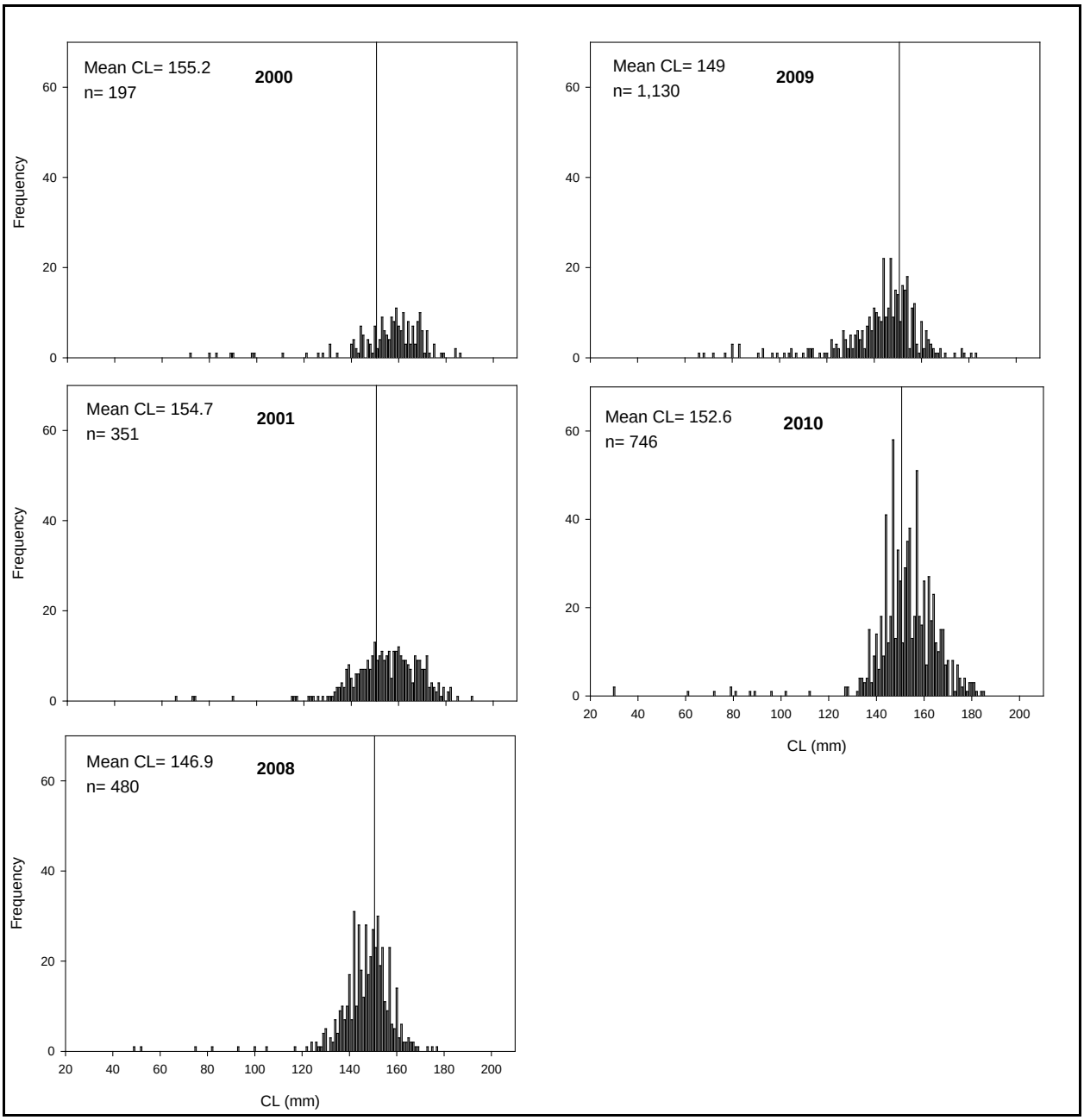

Figure 33.–Carapace length (CL) composition of male golden king crab sampled from pots with open escape rings while observing onboard in the Lower Chatham Strait management area during 2000 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

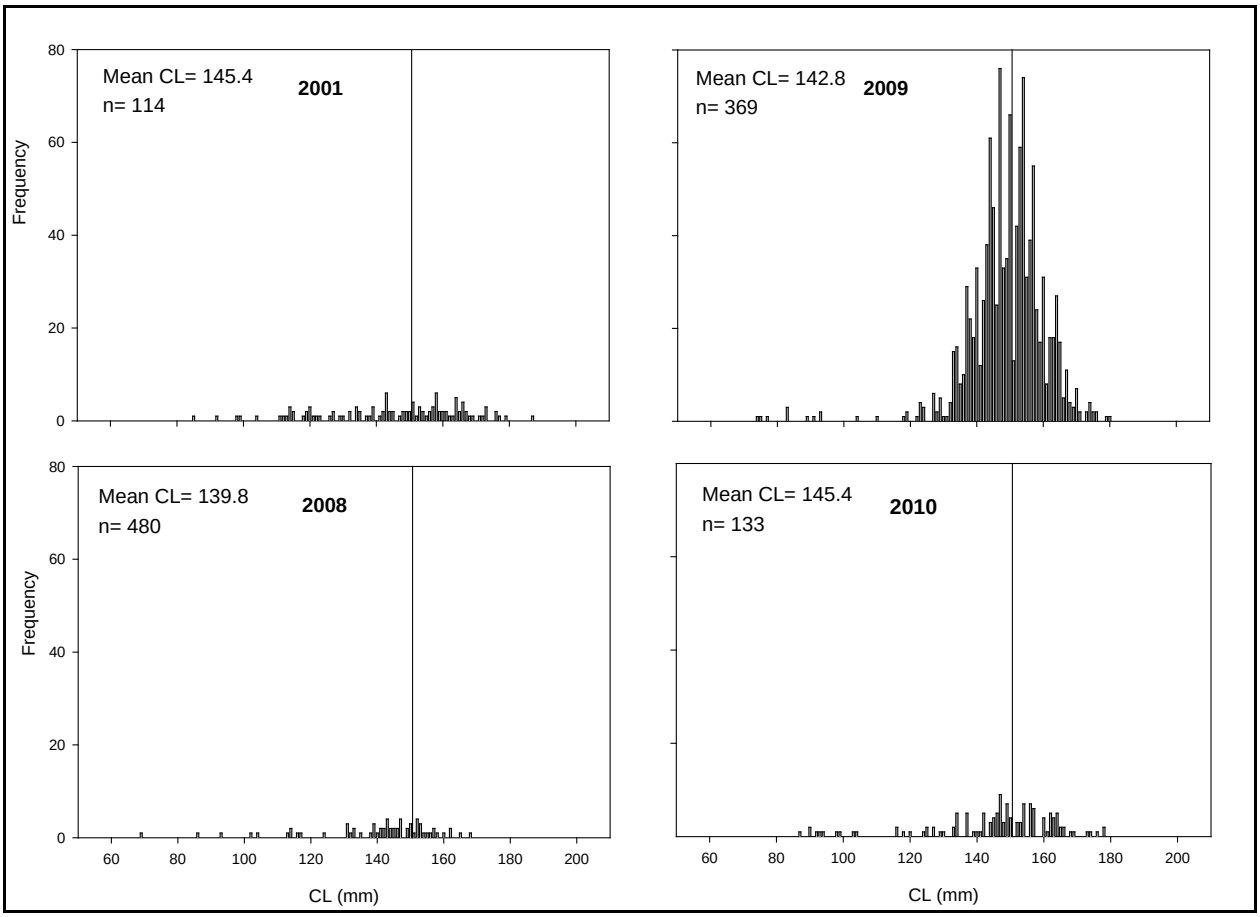

Figure 34.–Carapace length (CL) composition of male golden king crab sampled from pots with closed escape rings while observing onboard in the Lower Chatham Strait management areas during 2001 through 2010 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

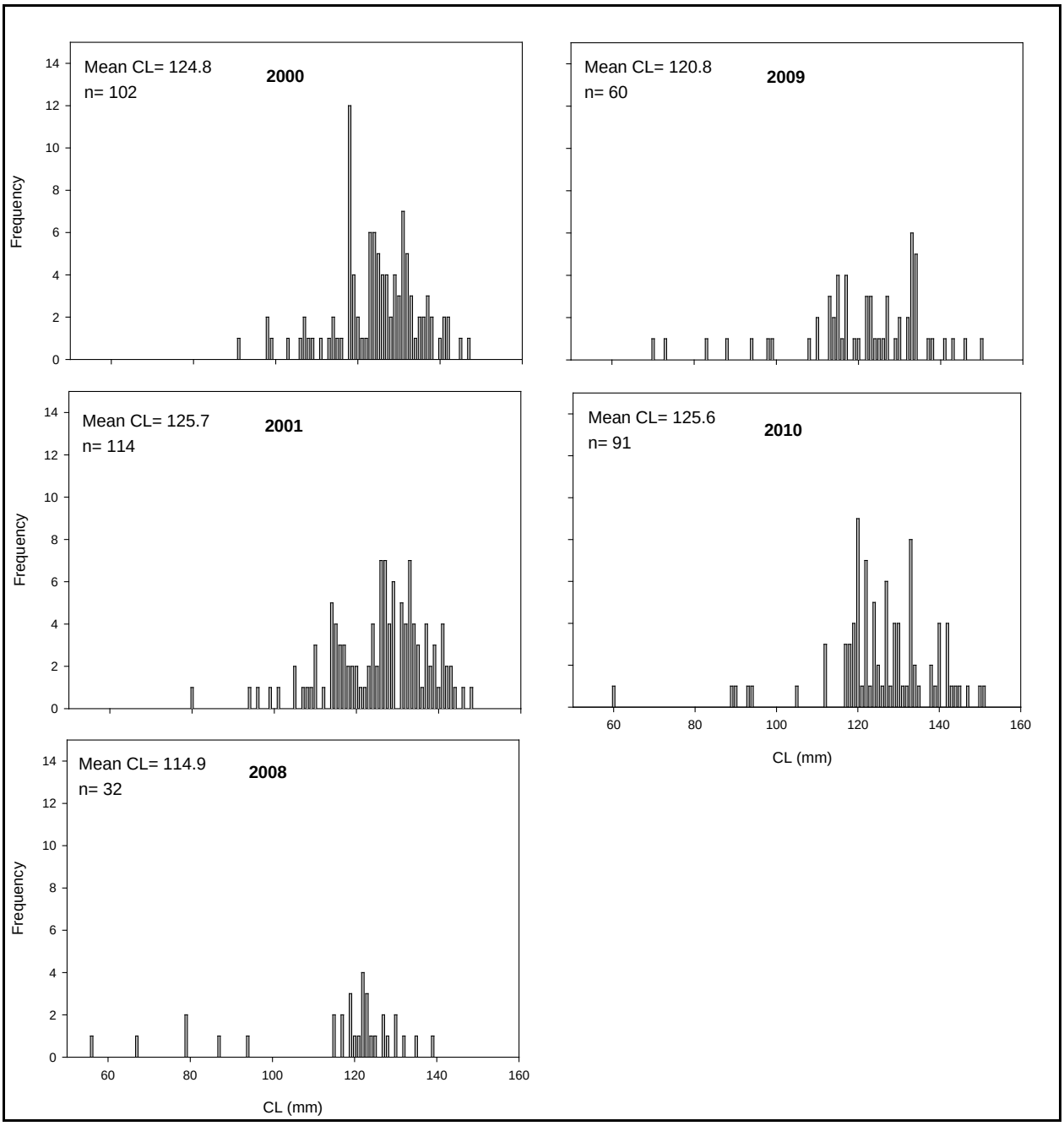

Figure 35.–Carapace length composition of female golden king crab sampled from pots with open escape rings while observing onboard in the Lower Chatham management area during 2000 through 2010 seasons.

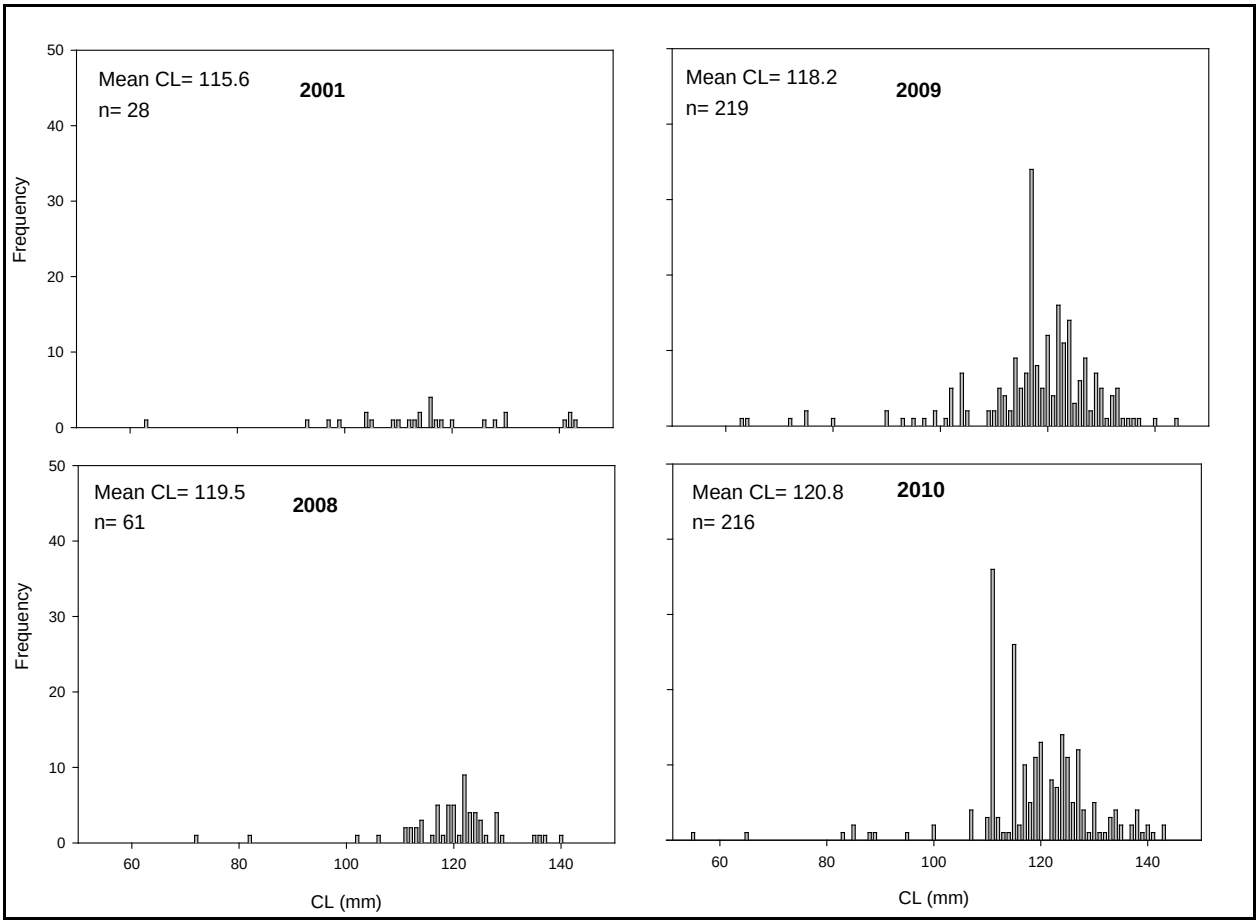

Figure 36.–Carapace length composition of female golden king crab sampled from pots with closed escape rings while observing onboard in the Lower Chatham management area during 2001 through 2010 seasons.

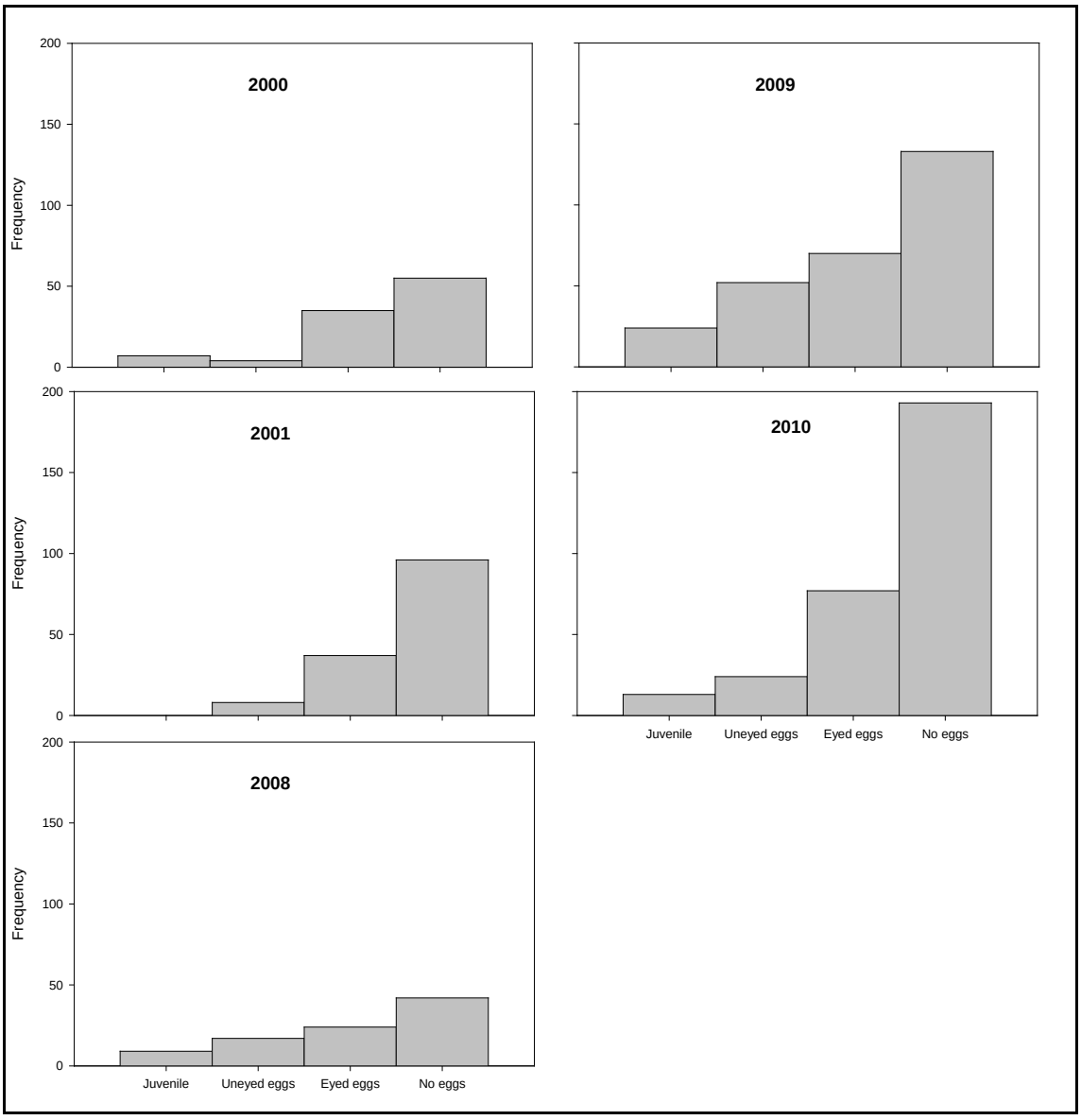

Figure 37.–Egg development stage of female golden king crab sampled from pots while observing onboard in the Lower Chatham management area during 2000 through 2010 seasons.

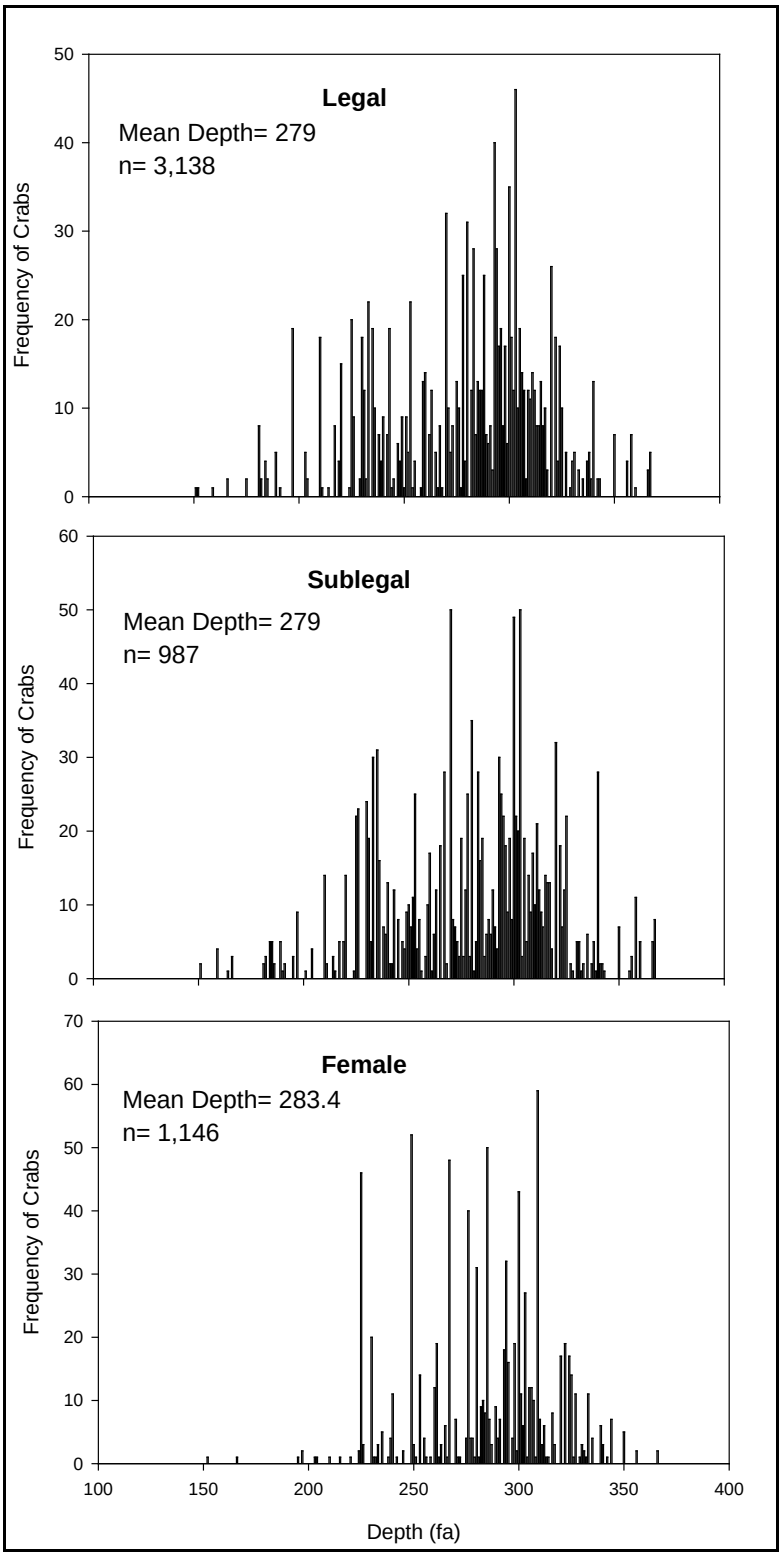

Figure 38.–Depth distribution of golden king crabs by sex and legal status in the Lower Chatham management area grouped for 2000, 2001, and 2008 through 2010 seasons.

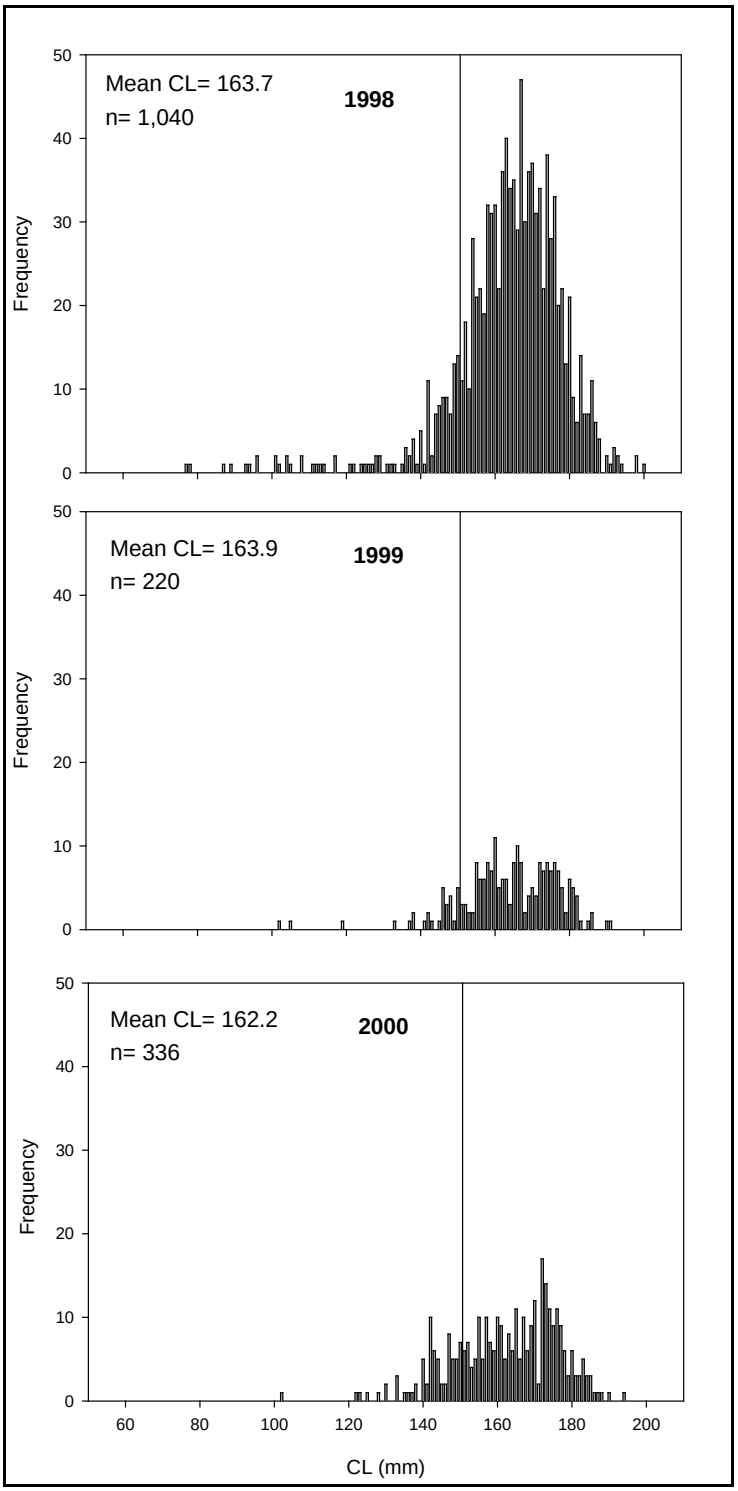

Figure 39.–Carapace length (CL) composition of male golden king crab sampled from pots with open escape rings while observing onboard in the Southern management area during 1998 through 2000 seasons. A vertical line at 150.6 mm CL represents the minimum legal CL, based on $CW = 44.336 + 0.8875CL$ (Koeneman and Buchanan 1985).

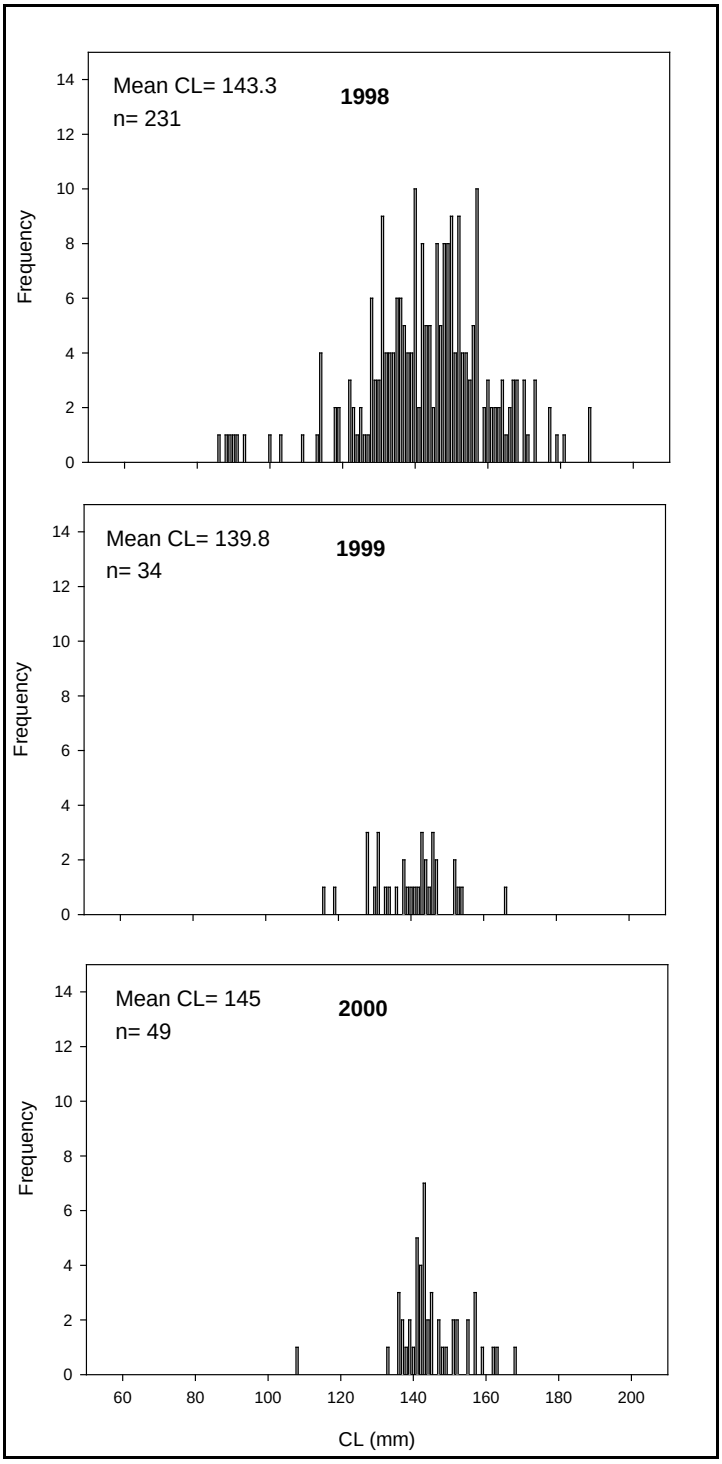

Figure 40.–Carapace length composition of female golden king crab sampled from pots with open escape rings while observing onboard in the Southern management area during 1998 through 2000 seasons.

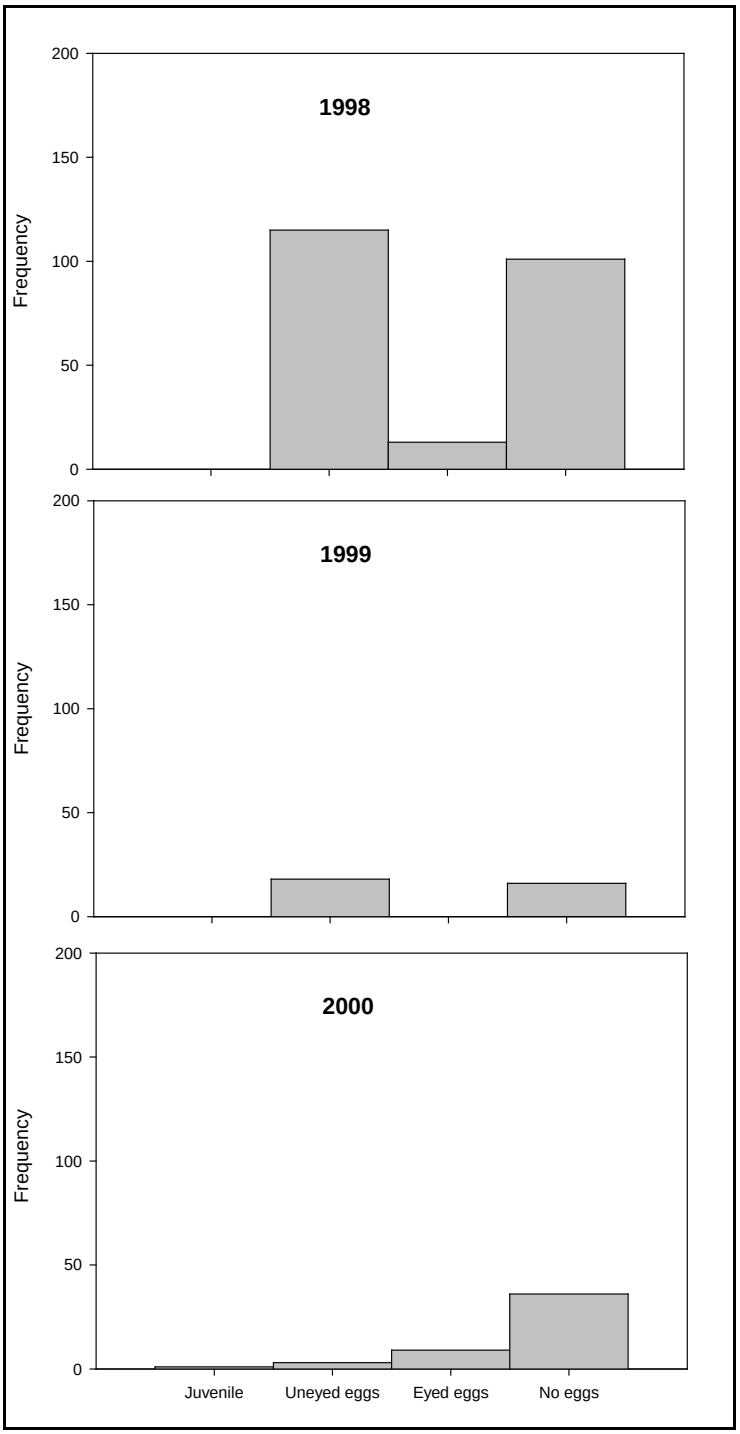

Figure 41.–Egg development stage of female golden king crab sampled from pots while observing onboard in the Southern management area during 1998 through 2000 seasons.

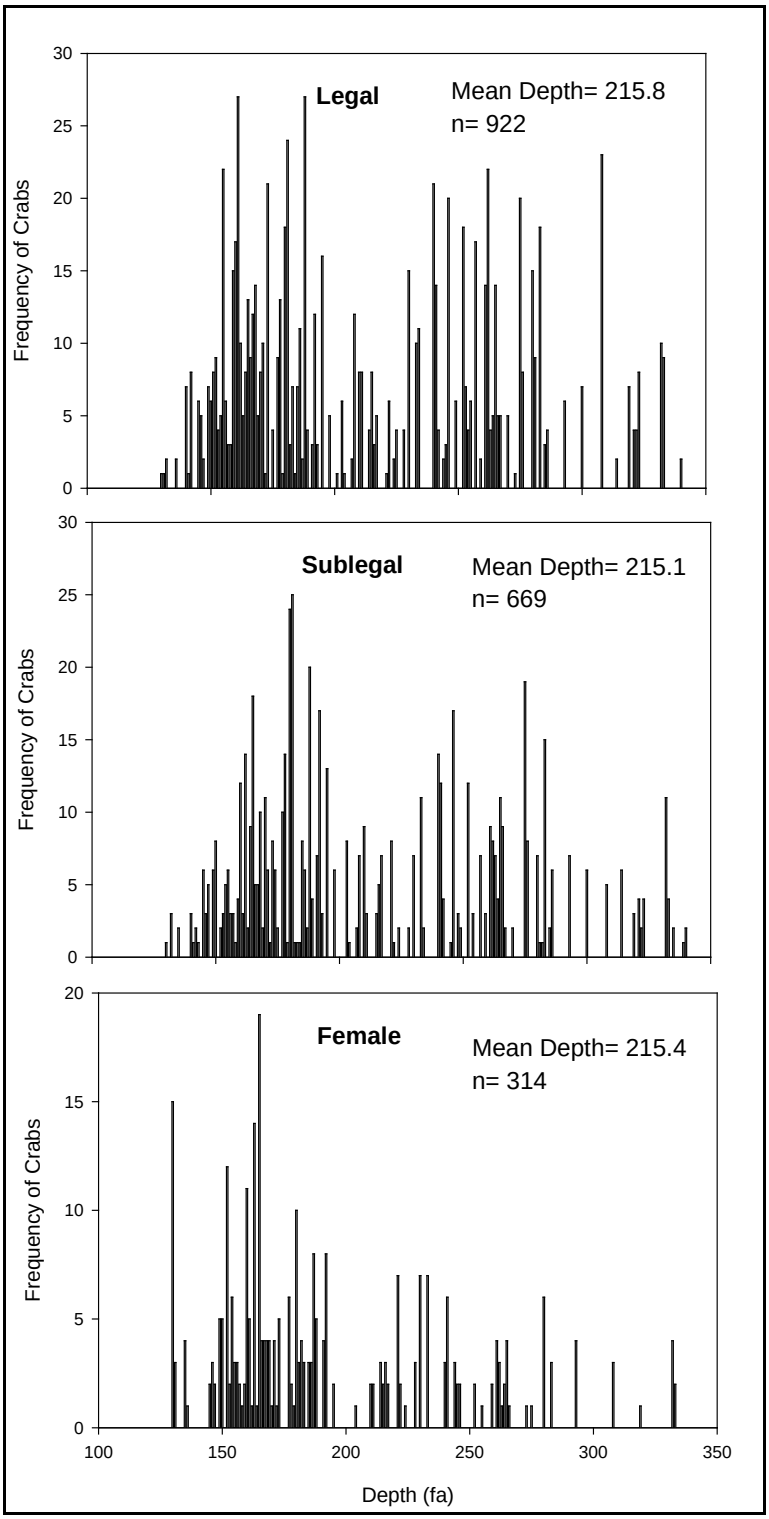

Figure 42.–Depth distribution of golden king crabs by sex and legal status in the Southern management area grouped for 1998, 1999, and 2000 seasons.

TABLES

Table 1.–Overview of effort during the golden king crab onboard observer program in the East Central management area, 2000 through 2004, and 2007, 2008, and 2010 seasons.

		Soak time		#Sampled pots		# Crab	
Season	# Trips	Mean (hr)	SE	Closed	Open	Sampled	Chela measured
2000	1	57.2	1.4	0	116	1,348	1
2001	2	43.6	2.7	19	26	561	0
2002	3	68.8	3.0	33	176	2,837	0
2003	1	165.3	7.1	36	55	2,380	0
2004	2	79.2	2.3	56	153	3,808	0
2007	2	89.9	3.4	71	232	6,728	1,281
2008	1	71.3	4.0	26	54	2,183	151
2010	1	41.4	0.7	25	116	1,820	131
TOTAL	13	77.1		266	928	21,665	1,564

Table 2.–Total contents of pots sampled during the onboard golden king crab observer program by management area, 1998 through 2010 seasons.

Common name	Species name	East Central	Icy Strait	Lower Chatham	Mid Chatham	North Stephens	Northern	Southern
Arrowtooth flounder	*Atheresthes stomias*	0	0	0	0	1	1	0
Barnacle spp.	Cirripedia	6	4	0	5	2	4	0
Basket star	*Gorgonocephalus eucnemis*	0	0	0	1	3	2	0
Blackfin sculpin	*Malacocottus kincaidi*	0	0	0	0	1	1	0
Brown box crab	*Lopholithodes foraminatus*	0	3	1	0	0	0	0
Brachiopod spp.	Brachiopoda	0	1	0	0	0	1	0
Brittle star spp.	Ophiuroidea	0	0	0	1	0	3	0
Buccinum spp.	Buccinidae	5	0	0	0	0	0	0
Buffalo sculpin	*Enophrys bison*	0	1	0	0	0	0	0
Coral spp.	Anthozoa	0	1	0	0	0	1	0
Hairy triton	*Fusitriton oregonensis*	11	0	1	0	0	3	0
Sculpin spp.	Cottidae	0	1	0	0	0	0	0
Giant pacific octopus	*Octopus dofleini*	4	1	0	1	17	1	2
Golden king crab (legal)	*Lithodes aequispinus*	6,034	1,193	1,215	3,462	1,164	3,248	922
Golden king crab (sublegal)	*L. aequispinus*	9,913	194	1,423	3,758	362	1,014	669
Golden king crab (female)	*L. aequispinus*	5,552	652	923	3,569	729	1,186	314
Green sea urchin	*Strongylocentrotus droebachiensis*	18	7	4	0	3	1	0
Groundfish spp.	Pleuronectiformes	0	0	0	1	1	0	0
Hermit crab spp.	Paguridae	1	0	0	3	0	0	0
Irish lord spp.	*Hemilepidotus*	1	0	0	0	0	0	0
Longhorn decorator crab	*Chorilia longipes*	1	0	0	3	0	3	0
Misc. species		259	74	3	0	0	29	0
Ribbed neptune	*Neptunea lyrata*	39	0	0	0	4	15	0
Rockfish spp.	Sebastes	21	1	0	1	0	0	0
Pacific cod	*Gadus macrocephalus*	65	0	0	2	0	110	0
Pacific halibut	*Hippoglossus stenolepis*	2	1	2	0	1	1	0
Red Irish lord	*Hemilepidotus hemilepidotus*	0	0	1	0	0	0	0
Red king crab (legal)	*Paralithodes camtschaticus*	4	1	0	0	10	1	3
Red king crab (sublegal)	*P. camtschaticus*	2	0	0	0	0	0	1
Red king crab (female)	*P. camtschaticus*	0	2	0	2	0	1	0

-continued-

Table 2.–Page 2 of 2.

Common name	Species name	East Central	Icy Strait	Lower Chatham	Mid Chatham	North Stephens	Northern	Southern
Redbanded rockfish	*Sebastes babcocki*	0	0	0	4	0	0	0
Redstripe rockfish	*S. proriger*	0	0	0	1	0	1	0
Sablefish	*Anoplopoma fimbria*	1	0	0	1	0	0	0
Scale crab	*Placetron wosnessenskii*	0	1	0	0	0	0	0
Sea urchin spp.	*Strongylocentrotus*	8	0	0	0	2	4	0
Skate spp.	Rajidae	1	0	0	0	0	0	0
Snail spp.	Gastropoda	2	1	0	1	2	0	0
Snailfish spp.	Liparidae	5	0	0	0	10	1	0
Sponge spp.	Demospongiae	0	0	0	1	0	0	0
Spot shrimp	*Pandalus platyceros*	1	0	0	0	0	0	1
Sea star spp.	Asteroidia	17	5	0	0	2	0	0
Sunflower sea star	*Pycnopodia helianthoides*	0	0	0	0	1	0	0
Tanner crab (legal)	*Chionoecetes bairdi*	5	9	0	1	847	140	0
Tanner crab (sublegal)	*C. bairdi*	11	88	0	0	801	136	4
Tanner crab (female)	*C. bairdi*	2	1	0	0	24	5	0
Walleye pollock	*Theragra chalcogramma*	0	0	2	1	0	0	43
Yelloweye rockfish	*S. ruberrimus*	1	0	7	0	2	1	1
Yellowfin sole	*Pleuronectes asper*	0	0	0	0	0	1	0

Table 3.–Overview of effort during the golden king crab onboard observer program in the Mid-Chatham management area, 2000 through 2003 and 2007 through 2010 seasons.

		Soak time		#Sampled pots		# Crab	
Season	# Trips	Mean (hr)	SE (hr)	Closed	Open	Sampled	Chela measured
2000	1	83.0	0.6	0	121	1,083	0
2001	1	121.3	5.1	5	53	250	0
2002	1	165.2	12.3	23	52	1,152	0
2003	1	156.0	12.6	20	45	555	0
2007	1	165.7	10.4	43	50	1,583	438
2008	3	130.2	7.3	84	228	5,501	603
2009	1	98.7	3.7	22	41	1,563	188
2010	1	123.7	3.2	18	161	1,586	628
TOTAL	10	130.5		215	751	13,273	1,857

Table 4.–Overview of effort during the golden king crab onboard observer program in the Northern management area, 2001, 2003, 2004 and 2007 through 2010 seasons.

		Soak time		#Sampled pots		# Crab	
Season	# Trips	Mean (hr)	SE (hr)	Closed	Open	Sampled	Chela measured
2001	3	124.8	5.2	24	121	1,009	0
2003	1	82.8	0.6	0	7	0	0
2004	1	44.8	0.4	0	20	95	0
2007	4	98.5	3.4	35	215	1,374	700
2008	2	90.6	15.5	58	94	1,639	41
2009	2	45.8	1.1	146	50	1,393	133
2010	2	47.9	0.5	44	309	2,455	600
TOTAL	15	76.5		307	816	7,965	1,474

Table 5.–Overview of effort during the golden king crab onboard observer program in the Icy Strait management area, 2001, 2003 and 2007 through 2010 seasons.

		Soak time		#Sampled pots		# Crab	
Season	# Trips	Mean (hr)	SE (hr)	Closed	Open	Sampled	Chela measured
2001	2	78.3	4.6	31	65	288	0
2003	1	84.2	0.4	30	43	464	0
2007	2	83.9	4.8	33	93	693	444
2008	2	N/A	N/A	37	40	450	11
2009	1	50.9	1.4	21	58	300	5
2010	1	46.1	0.4	0	17	34	31
TOTAL	9	68.7		152	316	2,229	491

Table 6.–Overview of effort during the golden king crab onboard observer program in the North Stephens Passage management area, 2002, 2004 and 2007 through 2010 seasons.

		Soak time		#Sampled pots		# Crab	
Season	**# Trips**	**Mean (hr)**	**SE (hr)**	**Closed**	**Open**	**Sampled**	**Chela measured**
2002	2	106.4	8.6	17	50	253	0
2004	3	51.1	2.8	20	99	489	0
2007	1	591.0	18.0	20	29	463	47
2008	1	157.9	13.8	7	31	366	24
2009	2	280.1	14.7	20	68	471	35
2010	2	563.2	5.2	17	109	782	42
TOTAL	11	291.6		101	386	2,824	148

Table 7.–Overview of effort during the golden king crab onboard observer program in the Lower Chatham management area, 2000, 2001 and 2008 through 2010 seasons.

		Soak time		#Sampled pots		# Crab	
Season	**# Trips**	**Mean (hr)**	**SE (hr)**	**Closed**	**Open**	**Sampled**	**Chela measured**
2000	1	145.2	0.4	0	28	299	0
2001	1	264.1	5.1	20	84	609	0
2008	1	198.3	9.6	17	107	638	415
2009	1	196.7	9.0	0	161	1,778	689
2010	1	167.7	5.3	20	124	1,186	422
TOTAL	5	194.4		57	504	4,510	1,526

Table 8.–Overview of effort during the golden king crab onboard observer program in the Southern management area, 1998 through 2000 seasons.

		Soak time		#Sampled pots		# Crab	
Season	**# Trips**	**Mean (hr)**	**SE (hr)**	**Closed**	**Open**	**Sampled**	**Chela measured**
1998	2	165.9	10.5	0	170	1,271	0
1999	1	N/A	N/A	0	44	254	0
2000	2	370.0	1.6	0	49	385	0
TOTAL	5	268		0	263	1,910	0