Size at Onset of Maturity in the American lobster *(Homarus americanus)* Along the Maine Coast

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Abstract

From 1994 through 1998, male and female American lobsters were collected from three geographical regions along the Maine coast to determine size at onset of maturity. Physiological maturity (presence of spermatophores) in males occurred at approximately 43.5 and 45 mm CL in the central (Pratts Is./ Bailey Is.) and eastern (Winter Harbor) regions, respectively. Propodite volume of the crusher cheliped increased to a greater rate of allometric growth when the male lobster reached maturity. The inflection occurred at approximately 80 mm CL for western (Cape Porpoise) and Downeast males and 90 mm CL for central (Boothbay Harbor) males.

Immature ovaries occurred in females less than 75 mm CL from Cape Porpoise, 85 mm CL from Boothbay Harbor, and 91 mm CL from Downeast. Based on logistic curves sizes at 50% maturity were approximately 87, 89 and 94 mm CL for Cape Porpoise, Boothbay Harbor, and Downeast respectively.

Introduction

A study to determine the size at onset of maturity of both sexes of the American lobster (*Homarus americanus*) along the coast of Maine began in 1994-1995 in the mid-coast region (Boothbay Harbor and Bailey Is.), continuing during 1995-1996 in the western region (Cape Porpoise), and concluding during 1997-1998 in the eastern region (Stonington, Sorrento and Winter Harbor) (Figure 1). A similar study by Krouse (1973) was limited to the Boothbay Harbor area. The objectives of this study were to determine the size at which they become sexually mature based on specific criteria including 1) cheliped dimensions in the males and 2) ovary color, ova size, abdominal width to carapace length ratio, and presence or absence of spermatophores in the seminal receptacle in the females.

Methods

Two hundred fifteen nonovigerous females ranging in size from 60-101 mm CL and 162 males ranging in size from 44-111 mm CL were collected with four-foot commercial traps from the Cape Porpoise lobster boat participating in the sea sampling program. In the Boothbay Harbor area 227 nonovigerous females ranging in size from 65 to 105 mm CL and 252 males ranging in size from 43 to 121 mm CL were collected with three-foot research traps. In the downeast region 247 nonovigerous females ranging in size from 65-111 mm CL and 184 males ranging from 45-100 mm CL were collected from Stonington and Sorrento commercial lobster pounds. All "old" hard shell samples were collected from spring through early fall, west to east respectively, and subsequently examined within two weeks.

To determine maturity in nonovigerous females I used the methodology of Krouse (1973). The presence or absence of sperm cells in the seminal receptacle was determined by extracting material from within the seminal receptacle with a 20 gauge blunt-tipped hypodermic needle, smearing on a glass slide and examining with a Zeiss compound microscope at 640x.

Methodology to determine maturity in males is described by Aiken and Waddy (1989) in which the crusher cheliped length, width and thickness were measured to the nearest millimeter. The volume was also determined by volumetric displacement in which the cheliped was submerged in a graduated cylinder and the displaced water was measured to the nearest milliliter.

The testes of 70 males ranging in size from 36-52 mm CL were collected intertidally at Bailey Island, Pratts Island, and Winter Harbor, and examined for the presence or absence of spermatophores (physiological maturity) using the extraction technique described by Krouse (1973). Sperm cells were identified with a Zeiss compound microscope at 640x.

Results and Discussion

Male maturity

In this study male maturity was based upon the presence or absence of sperm cells and crusher cheliped criteria developed by Aiken and Waddy (1989). I examined the testes of 31 males from the Boothbay Harbor area and determined that all of the males from 50 to 80 mm CL (one male examined at each 1 mm increment) were mature. Since Krouse (1973) determined the 50% maturity level at about 44 mm CL, I examined 34 males hand collected at Bailey and Pratts Islands ranging from 36-50 mm CL to fine tune this critical size. Figure 2 indicates that 50% of these lobsters mature at approximately 43.5 mm CL. The Cape Porpoise 40-50 mm CL sample was too small (n=12) to accurately determine the 50% maturity level, however, the smallest mature male was 42 mm CL. I also examined 36 males ranging from 40-52 mm CL collected at Sand Cove in Winter Harbor and determined 50% maturity to be approximately 45 mm CL.

Templeman (1934) observed that males were unable to mate with considerably larger females. Since most females in all areas mature above the minimum legal size (82.55 mm CL) as discussed in the "female maturity" section, it would be

reasonable to assume that pre-recruit males do not significantly contribute reproductively to the natural population.

Several investigators demonstrated an inflection between mature and immature male lobsters by noting relationships between cheliped propodite length against total length (Templeman 1935), crusher cheliped weight against carapace length (Squires 1970), and crusher cheliped weight/ whole weight ratio against carapace length (Ennis 1980). Two major drawbacks to Squires' and Ennis' methodology used as field techniques were 1) a valuable part of the lobster must be removed and 2) some sample weights were determined on small, potentially unstable fishing vessels. Realizing that weight is approximately proportional to volume, Aiken and Waddy (1989) estimated cheliped volume from the length, width, and thickness of the propodite. I compared their methodology to volumetric displacement, an appropriate methodology in the laboratory. Figures 3 and 4 indicate a high correlation between the two methods for both Cape Porpoise and Boothbay Harbor samples. The bustling activity at the Downeast lobster pounds were not favorable environments for the volumetric displacement methodology.

The "crusher propodite volume", or CPV, was divided by the cube of the carapace length to produce a straight horizontal line when plotted against carapace length. Aiken and Waddy's (1989) formula $100(CPV)/(CL)^3$ was used as a male maturity index which they term the CPI, "Crusher Propodite Index." CPI values greater than 22-24 are indicative of greater allometric crusher growth, thus a male maturity indicator. Their data indicated the onset of male maturation at approximately 68 mm CL from the warm waters of the Gulf of St. Lawrence compared to 110 mm CL in the Bay of Fundy. Figure 5 indicates inflection points, which indicate the onset of maturity, at approximately 80 mm CL from Cape Porpoise and Downeast, and 90 mm CL from Boothbay Harbor. The extreme inflection at 105 mm CL (Boothbay Harbor) may be due to an inadequate sample size. The number of males ranging from 101 mm to 121 mm CL (n=8) was only 3.2% of the total sample. The Downeast sample size extends only to 100 mm CL due to a

malfunction in the sea water intake system, thus destroying several dozen large males >100 mm CL.

Female maturity

Size frequency histograms of the three ovarian stages of development from Cape Porpoise, Boothbay Harbor, and Downeast (Figures 6a-c) indicated the following:

	CL Size Range (mm) (Percentages)		
	Immature	Developing	Mature
Cape Porpoise	60-85 (46.6)	65-92 (22.7)	68-101 (30.7)
Boothbay Harbor	65-82 (33.9)	70-94 (44.4)	79-105 (21.7)
Downeast	65-91 (29.9)	77-99 (34.6)	79-110 (35.5)

Although there was considerable overlap in the size ranges of the ovarian stages, immature ovaries were predominantly in females less than 75 mm CL from Boothbay Harbor, less than 85 mm CL and 91 mm CL from Cape Porpoise and Downeast, respectively. Females with developing ovaries generally ranged from 70-99 mm CL, with one Cape Porpoise female measuring 65 mm CL.

For the most part, Cape Porpoise females >76 mm CL had mature ovaries, although there was one fully mature female (possessed a mature ovary along with the presence of spermatophores in her seminal receptacle) at 68 mm CL. The smallest fully mature female from BBH was 79 mm CL. In 1993, the Boothbay Harbor research traps captured an ovigerous female that measured 77 mm CL. Boothbay Harbor females had mature ovaries gradually increasing in frequency greater than 85 mm CL, similar to observations by Krouse (1973). Mature ovaries from the Downeast samples were predominantly in females larger than 90 mm CL.

Spermatophores, another criterion for maturity, were observed more frequently in seminal receptacles of mature females (typically >89 mm CL) from all areas (see Figures 6a-c). From the Cape Porpoise samples I detected spermatophores in four females (4.6%) that were <75 mm CL, while only 2 (1.7%) females

of similar size from Boothbay Harbor and one female (<1%) from Downeast possessed spermatophores. All of the Boothbay Harbor females >89 mm CL had spermatophores, while 11 of 14 (78.6%) and 28 of 34 (82.4%) females from Cape Porpoise and Downeast, respectively, possessed sperm cells.

Females mate in the soft-shelled condition (Templeman, 1934), thus several females that I examined without spermatophores would be incapable of spawning although their ovaries were classified as developing or mature. Krouse (1973) observed that only 5 of 84 (6%) Boothbay Harbor females in the 80-90 mm CL size range were considered fully mature. All 24 of the Boothbay Harbor females in this size range that I examined were considered fully mature. Twenty of 22 (90.9%) Cape Porpoise females were fully mature, whereas the remaining two lobsters (82, 90 mm CL) would not spawn until they shed to 93 and 103 mm CL, respectively, assuming a 14% growth increment. From the Downeast samples only 3 of 38 (7.9%) females measured between 80-90 mm CL, and of those only 2 were fully mature. Six of 34 (17.6%) females >90 mm CL would have to undergo another molt and successfully mate with a male to ensure full maturity.

Templeman (1935) observed that the female lobster's abdomen widens significantly as she matures. Figure 7 shows the ratio of abdominal width to carapace length plotted against carapace length grouped by 5-mm. Inflection points, indicating the commencing of maturity, occurred at approximately 70 mm CL for all areas. Krouse's (1973) Boothbay Harbor data showed an inflection point at approximately 80 mm CL. Aiken and Waddy (1980) demonstrated that the increase in relative width of the abdomen begins three or more molts before the first egg extrusion. However, we have observed, during sea sampling trips since 1985, sublegal ovigerous females at or below this inflection point. In many graphs of abdominal width/carapace length ratios that are described by Ennis (1980), he points out that inflections and asymptotes are not very distinct, possibly due to sample size or maturation occurring over a wide range of sizes.

Physiological size-maturity relationships, based on ova diameter, were derived for each area (Figure 8). I also included the Canadian Gulf of Maine data, from southwest Nova Scotia sea sampling, for comparison. The graph was composed by Robert Glenn of the Massachusetts Division of Marine Fisheries using a logistic equation incorporated into the ASMFC lobster stock assessment. Sizes at 50% physiological maturity were approximately 87, 89, and 94 mm CL for Cape Porpoise, Boothbay Harbor, and Downeast, respectively.

Acknowledgments

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Figure 1. Maturity sites at three geographic regions along the coast.

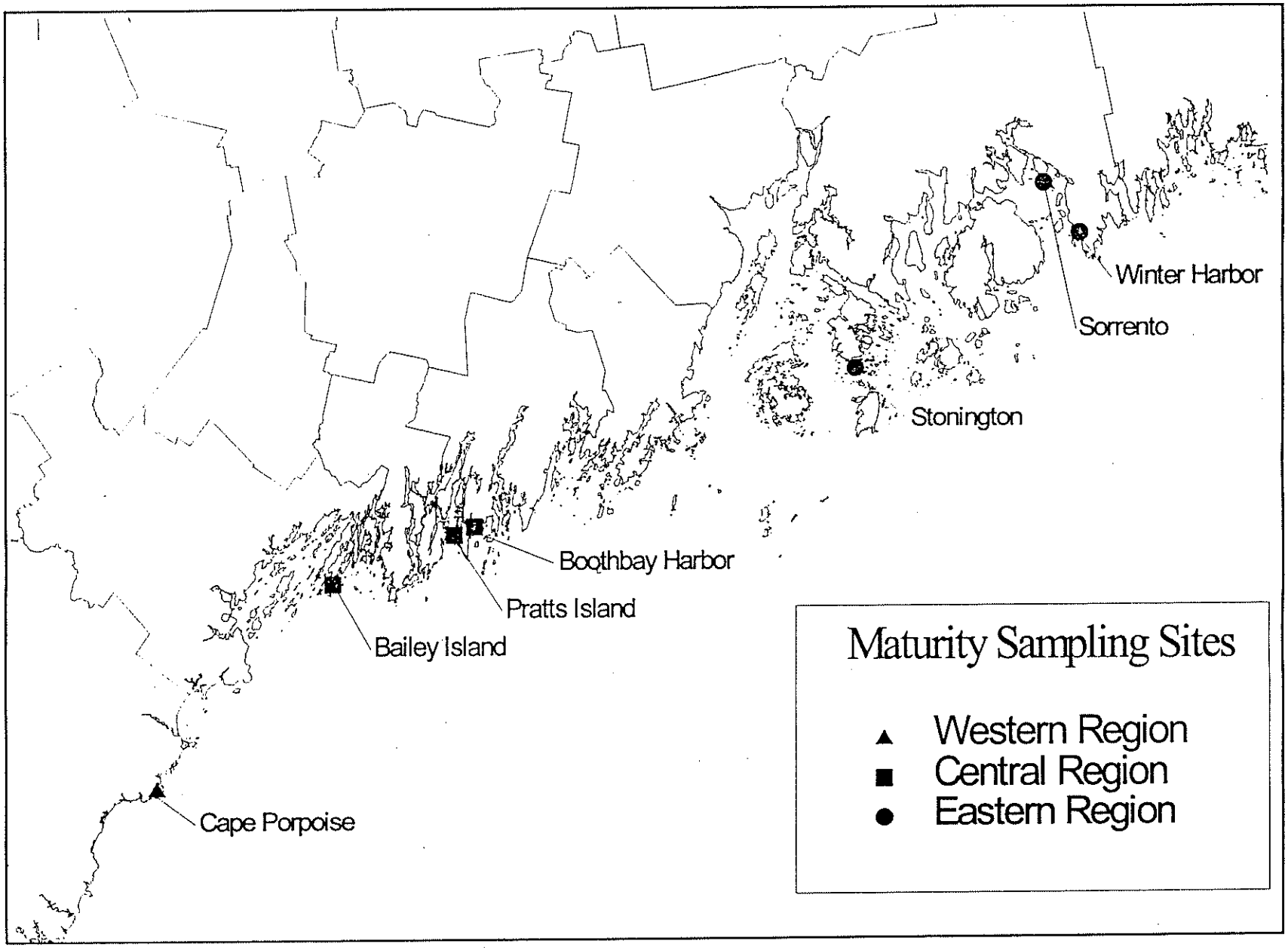

Figure 2. Percent frequency of physiologically mature male lobsters collected intertidally by hand at Pratts Island/Bailey Island and at Winter Harbor.

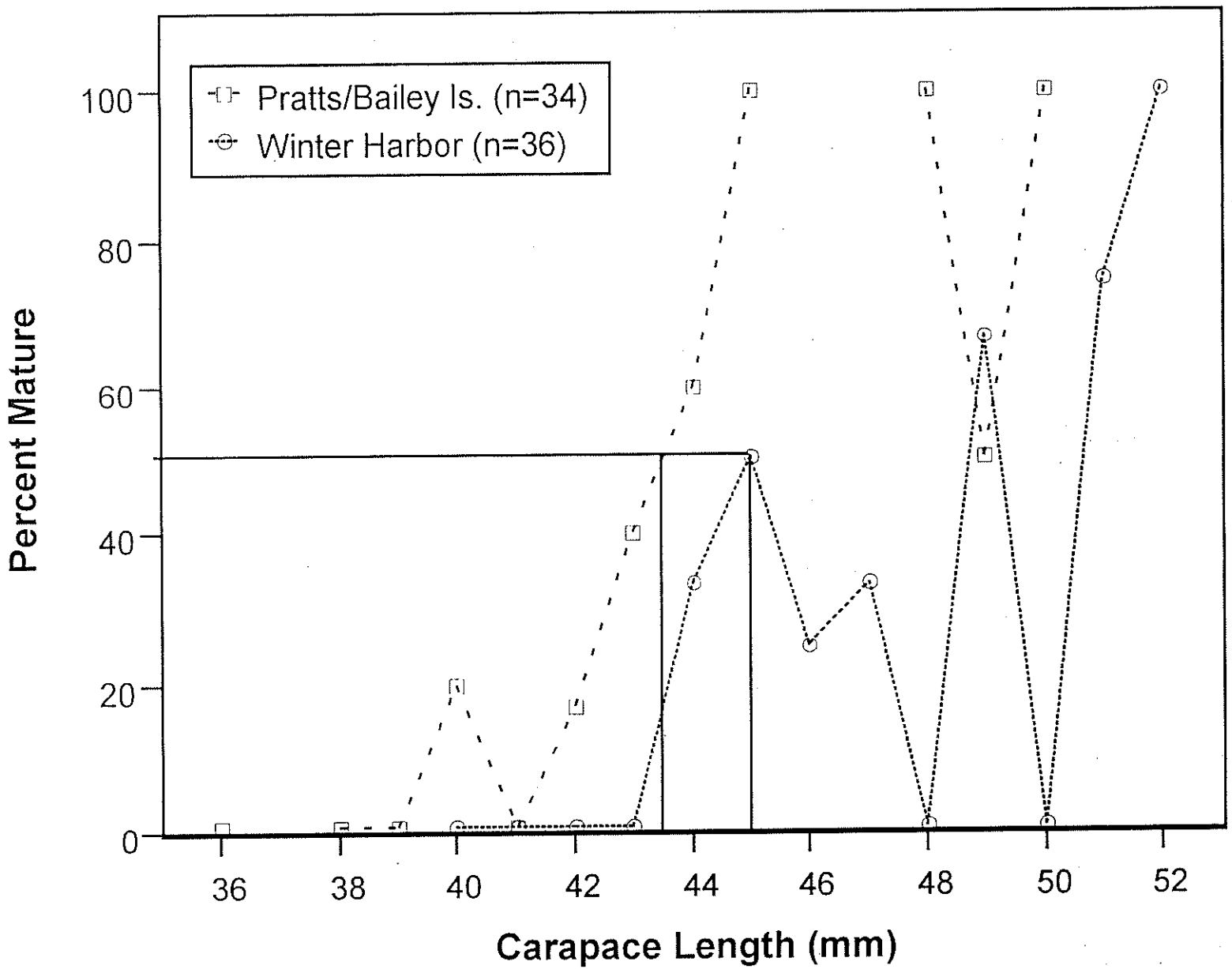

Figure 3. Relation of crusher propodite volume to crusher displacement for male lobsters collected at Cape Porpoise.

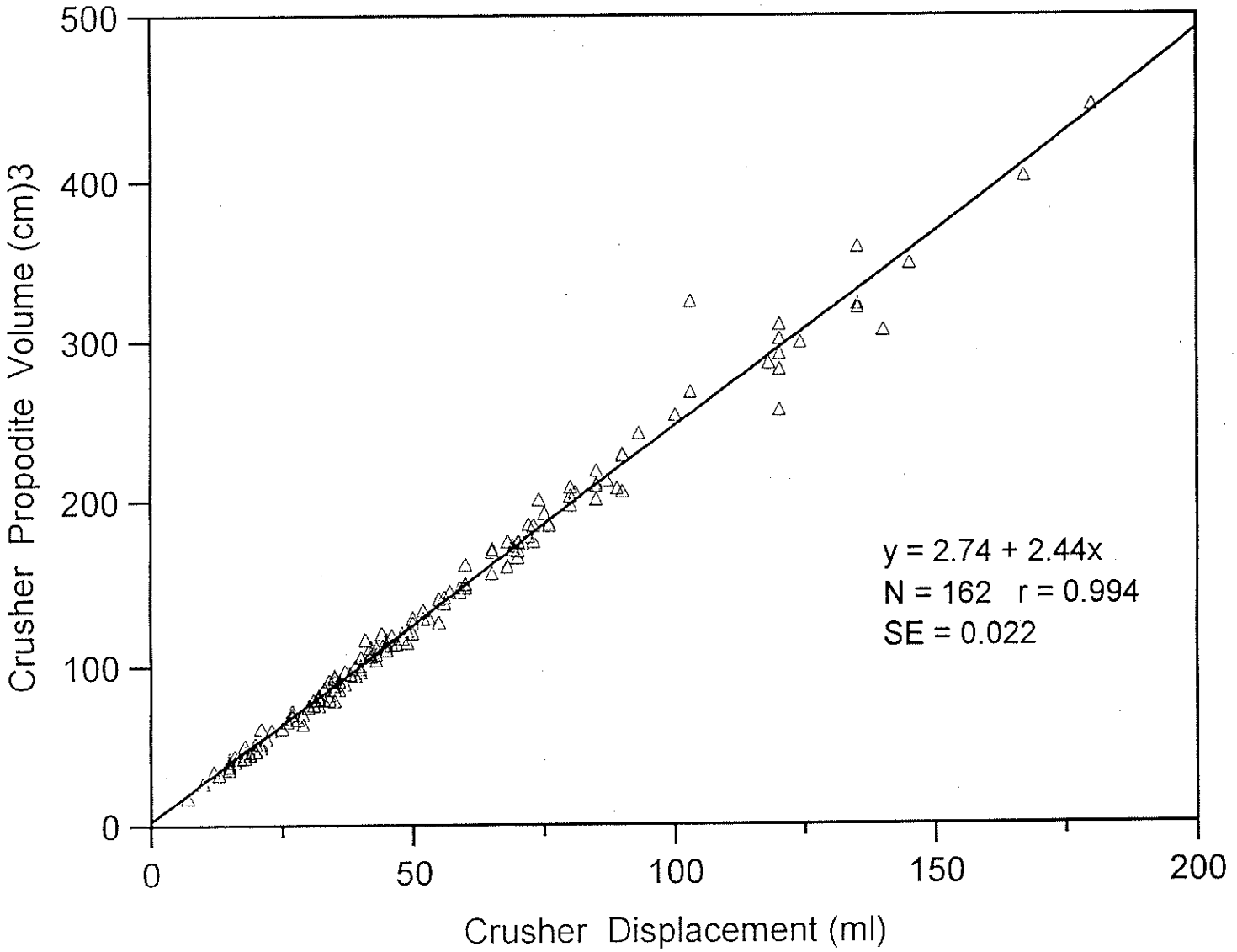

Figure 4. Relation of crusher propodite volume to crusher displacement for male lobsters collected at Boothbay Harbor.

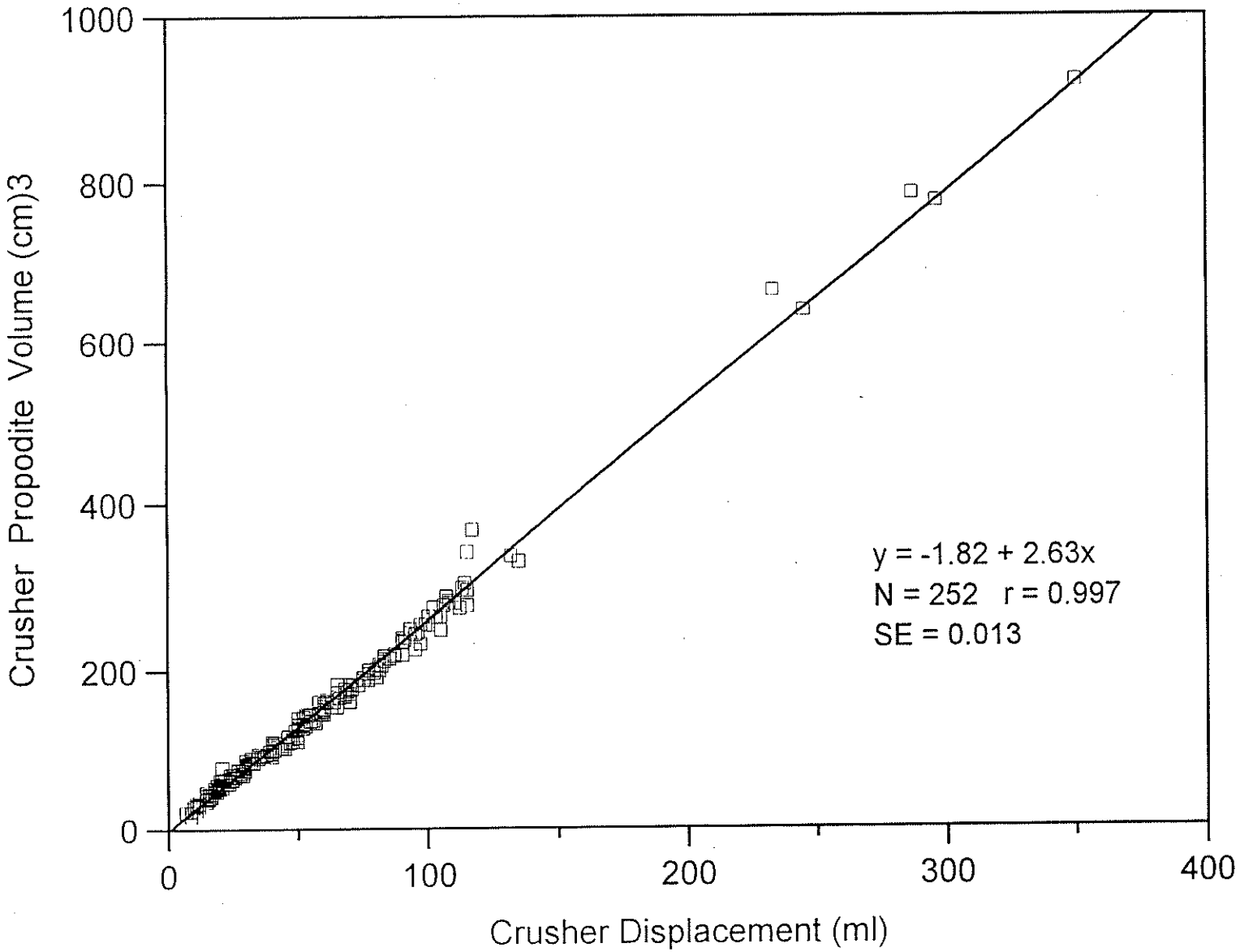

Figure 5. Growth of male crusher cheliped by plotting crusher propodite index against carapace length by 5-mm size classes.

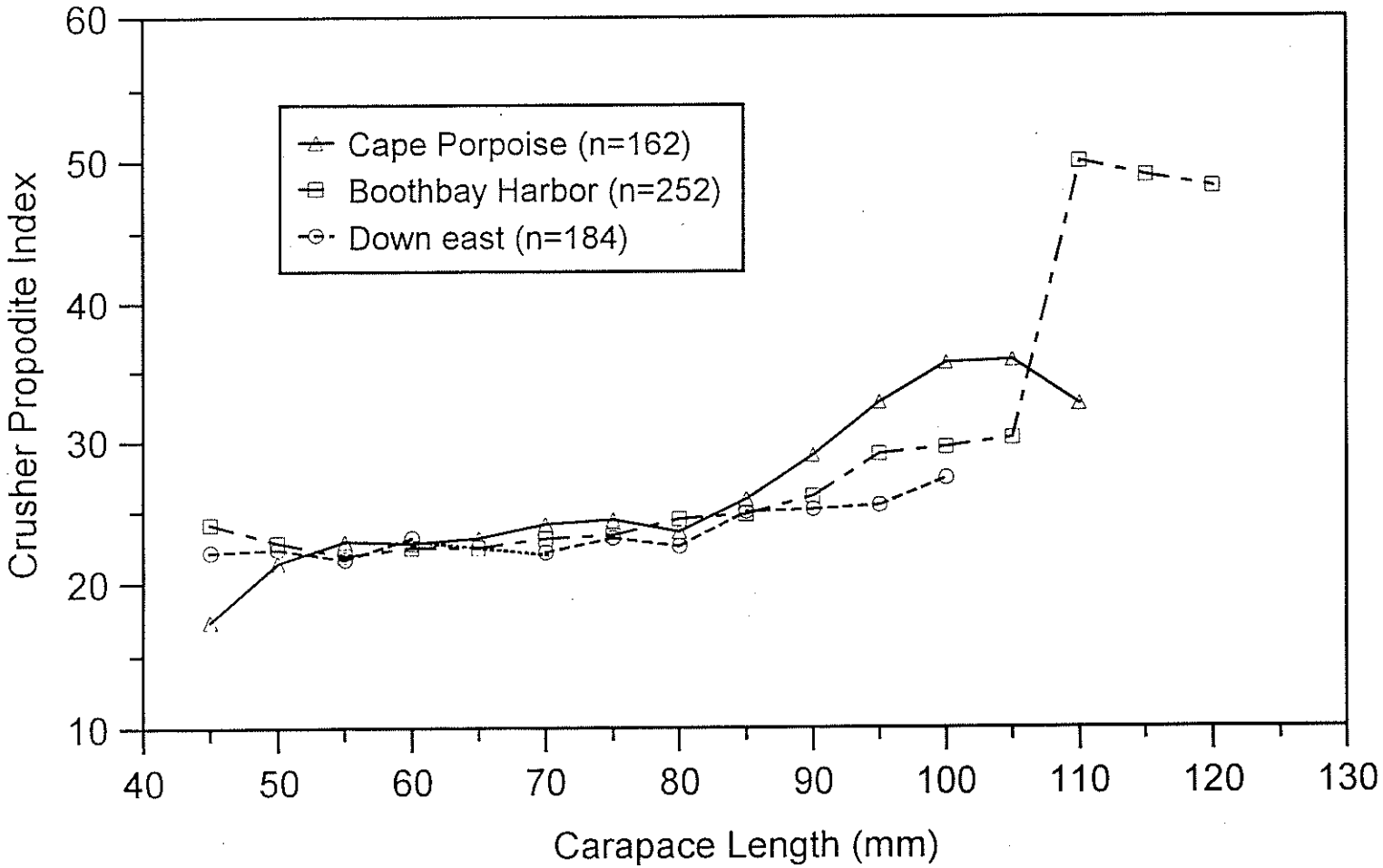

Figure 6a. Percent frequency of the ovarian stages of development and the occurrence of spermatophores in the seminal receptacles of females collected at Cape Porpoise.

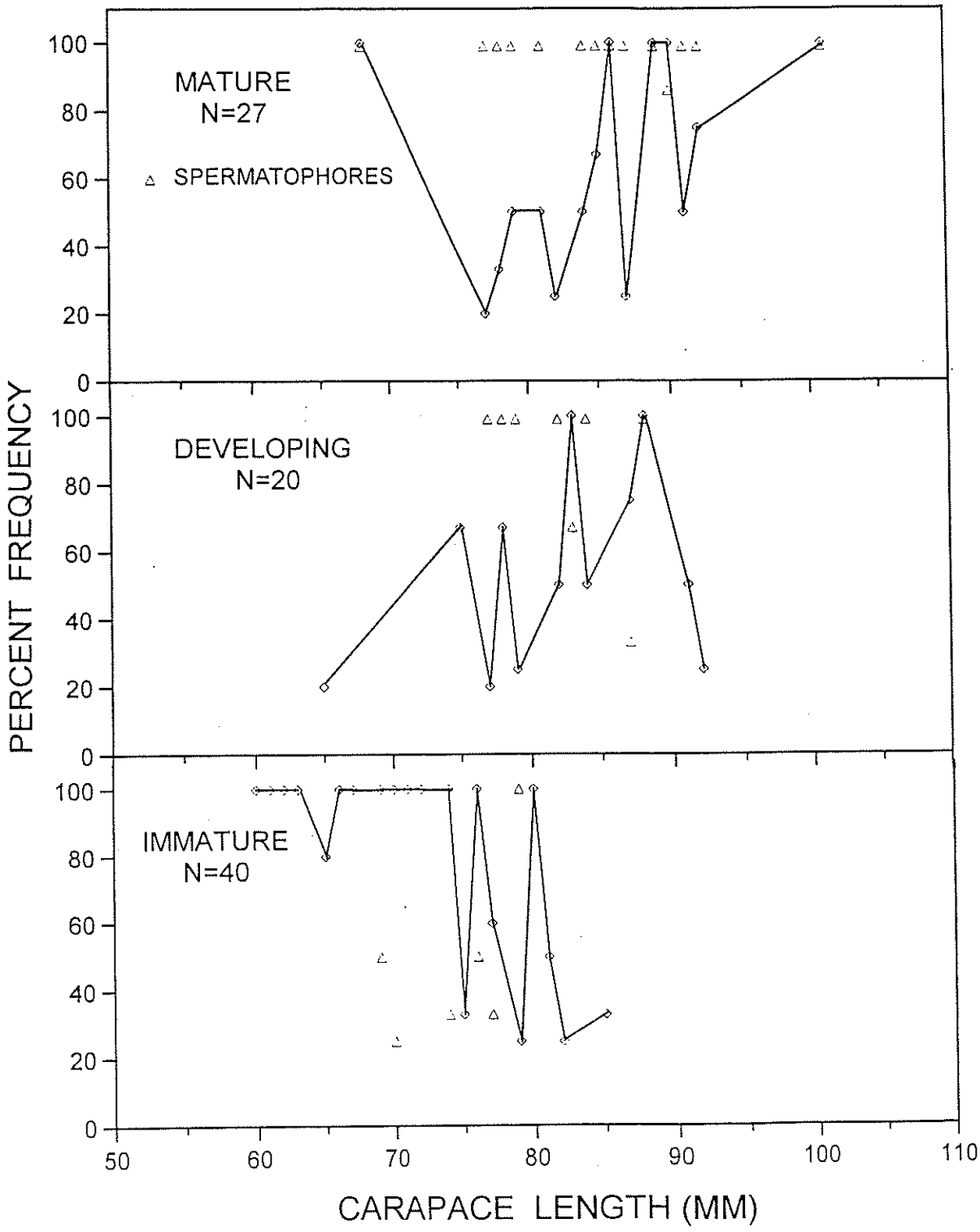

Figure 6b. Percent frequency of the ovarian stages of development and the occurrence of spermatophores in the seminal receptacles of females collected at Boothbay Harbor.

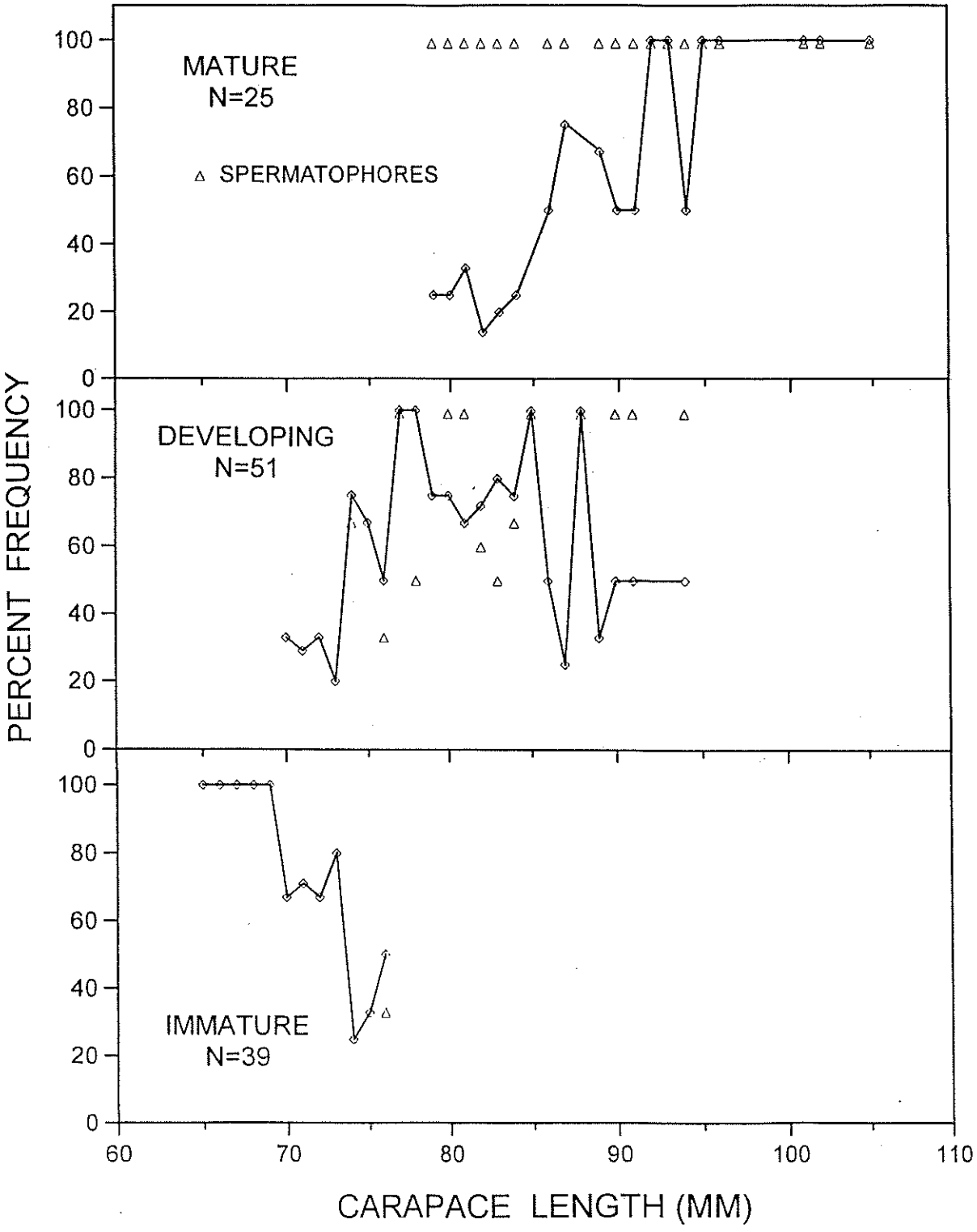

Figure 6c. Percent frequency of the ovarian stages of development and the occurrence of spermatophores in the seminal receptacles of females collected at Stonington and Sorrento.

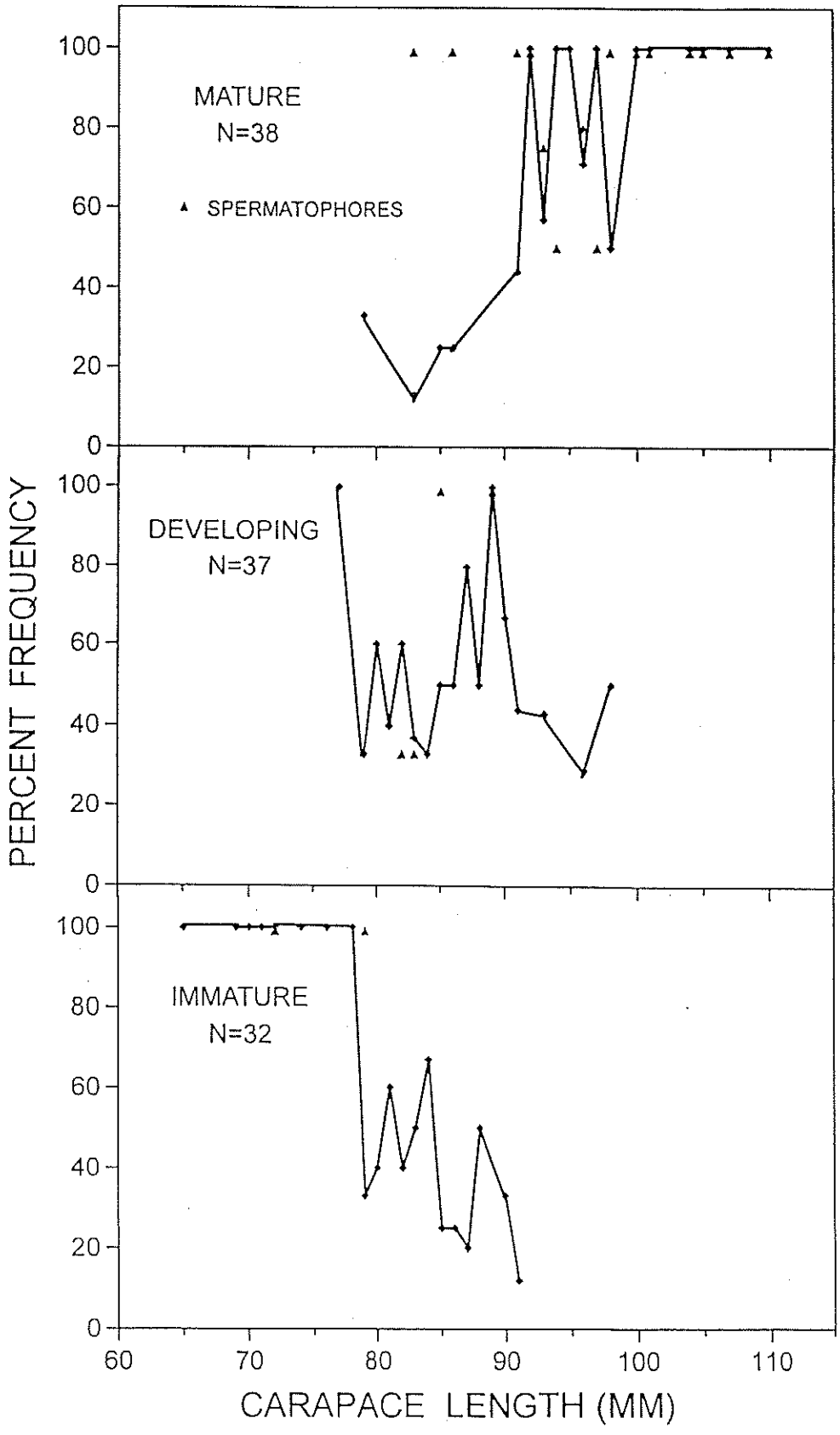

Figure 7. Relation of abdominal width:carapace length ratio to carapace length for female lobsters by 5-mm size classes.

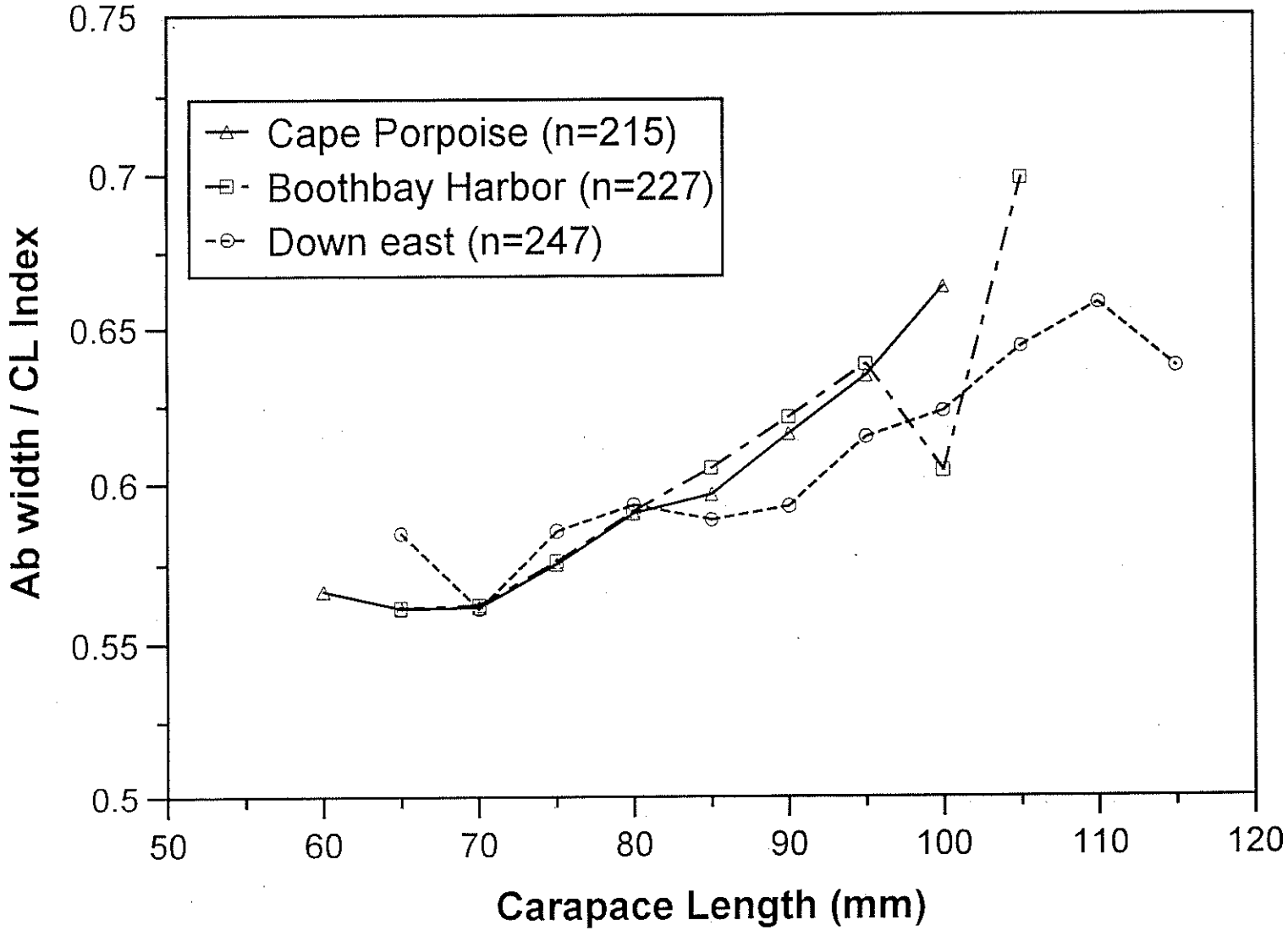

Figure 8. Physiological size-maturity relationships for female lobsters from three geographical regions along the Maine coast and SW Nova Scotia.