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# Abdomen Width and Carapace Length, a Maturity Index for Female Lobsters, *Homarus americanus*.

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## Abstract

Templeman (1944) suggested that relative abdomen width could be used to determine size at which female lobsters mature. Although there is considerable evidence in support of this concept, no one has previously defined the exact relationship between abdominal width and maturity. Abdomen width expressed as a percentage of carapace length (AWI) is used as a Female Maturity Index. Through the correlation of abdomen width index (AWI) and stage of ovary development, we have been able to show that 50% of females with an AWI of 65 are potentially mature (capable of extruding eggs in the current season). Of those with an AWI of 67, 97% are potentially mature, and at an AWI of 68 or greater, virtually all are mature.

Data from mature females from areas as diverse as Grand Manan (Bay of Fundy) and the southern Gulf of St. Lawrence indicate the above relationships are consistent throughout the range. Accuracy in measuring abdomen width is critical as the pleura of the second abdominal segment are flexible and easily compressed during measurement of the maximum outside width. On a female of 95 mm CL, lateral compression of only 1.0 mm in abdomen width can decrease the AWI from 67 (97% expected maturity) to 65 (only 50% expected maturity). This emphasizes the need for careful and precise measurements when making AWI determinations. When such care is exercised, AWI information will permit quick and easy estimation of female maturity in a stock of lobsters without the necessity for measuring large numbers of berried females.

## Résumé

Selon Templeman (1944), on peut utiliser la largeur relative de l'abdomen pour déterminer la taille à laquelle les homards femelles atteignent la maturité. Bien que bon nombre d'indices viennent appuyer ce concept, personne n'avait encore défini la relation exacte entre la largeur de l'abdomen et la maturité. Comme indice de maturité des femelles, nous faisons ici appel à la largeur de l'abdomen en pourcentage de la longueur de la carapace (AWI). Grâce à la corrélation de l'indice de largeur de l'abdomen (AWI) et le stade de développement ovarien, nous avons pu démontrer que 50% des femelles ayant un AWI de 65 sont potentiellement matures (capables d'expulser des oeufs dans la saison en cours). Parmi les sujets à AWI de 67, 97% sont potentiellement matures, et avec un AWI de 68 ou plus, pratiquement toutes les femelles sont matures.

Les relations mentionnées ci-dessus tiennent dans toutes l'aire de distribution, comme le démontrent des données prélevées sur des femelles matures provenant de régions aussi diverses que Grand Manan (baie de Fundy) et le golfe du Saint-Laurent méridional. Une mesure critique est celle de la largeur de l'abdomen, que doit être très précise: les pleura du deuxième segment abdominal sont flexibles et peuvent être facilement comprimés quand on mesure la largeur externe maximale. Sur une femelle de 95 mm de longueur de carapace, une compression latérale de seulement 1,0 mm de l'abdomen peut entraîner une diminution de AWI et le faire passer de 67 (97% de maturité anticipée) à 65 (seulement 50% de maturité anticipée). Comme on le voit, toutes les déterminations de AWI doivent être fondées sur des mensurations précises, faites avec beaucoup de soin. Une fois ces conditions remplies, AWI permettra une estimation rapide et facile de la maturité des femelles dans un stock de homards, sans qu'on ait à mesurer un grand nombre de femelles oeuvées.

## Introduction

Size at onset of maturity in female lobsters can be determined from sizes of egg-bearing females in the population, and such a determination can be based on actual size of the smallest ovigerous females or on a mathematical treatment of size distribution of ovigerous females. However, this method does not include those females considered mature when capable of extruding eggs. Such females account for a large proportion of the mature female population at any one time and maturity estimates of these can be made from the appearance of a secondary sex character - the rapid change in relative abdomen width.

More than forty years ago Templeman (1935) observed that the relative width of the second abdominal segment of female lobsters increased with the approach of sexual maturity. As a result, he suggested (1944) that relative abdomen width could be used for determining the size at which female lobsters mature.

Simpson (1961), with Homarus gammarus, first expressed abdomen width as a percentage of carapace length and in this form the AWCL relationship (AWI) is referred to as a 'Maturity Index'. This relationship has been often used as an indicator of maturity (Aiken and Waddy 1980a, b; Briggs 1976; Briggs and Mushacke 1979, 1980; Ennis 1971, 1980; Krouse 1973; Perkins and Skud 1966; Skud and Perkins 1969; Squires 1970; Van Engel 1980) and, although most of these authors recognized a correlation between increased abdominal width and mature ovarian eggs, the exact relationship has not been defined. It is well accepted that the asymtote at an AWI of about 70 is the point where most females can be considered mature (Briggs and Mushacke 1979, 1980; Ennis 1980; Squires 1970; Van Engel 1980). Squires (1970) found that egg-laying often preceded the onset of increase in relative abdomen width and therefore questioned the usefulness of the abdomen width as an index of maturity in any locality. He felt that comparisons between geographic localities should be based on the smallest size where acceleration in relative abdomen width occurs rather than on a fixed percentage of AWCL. Ennis (1980) also found that egg-laying preceded the onset of relative AW increase in certain areas and advised caution on the use of relative AW as an index. We have found that oviposition never precedes the onset of increase in relative abdomen width which, in fact, begins 2-3 molts prior to first oviposition (Aiken and Waddy 1980a, b). Krouse's data (1973) indicated this early digression from the male AW baseline and our laboratory work on cultured juveniles has substantiated this (Aiken and Waddy 1980 a,b). Some authors (Ennis 1980; Perkins and Skud 1966; Van Engel 1980) have noted that the size of the smallest berried female is very close to the carapace length at which the first inflection occurs.

Briggs (1976) and Briggs and Mushacke (1979, 1980) altered the methodology of Templeman (1935) by measuring the maximum outside width of the second abdominal segment rather than the maximum inside width. Thus, Briggs' AW/CL ratios are slightly larger than those based on Templeman's procedure (i.e. Krouse 1973; Perkins and Skud 1966; Skud and Perkins 1969; Squires 1970). Independently from Briggs, we also adopted the outside measurement because we find it more rapid and accurate under field conditions. Although Ennis (1971, 1980) does not state which measurement he used, his was also an outside measurement (Ennis, pers. comm.).

Although the data presented by these various authors substantiate Templeman's suggestion that AW/CL and the relationship of AW/CL to CL can be used as an indicator of maturity for lobsters within a specified geographic area, and could also be used to compare size at maturity in different areas, the exact relationship between ovary development and abdomen width has not been defined. In this report, the correlation will be applied to females from areas as diverse as southern Gulf of St. Lawrence and Grand Manan (Bay of Fundy). These areas represent the two temperature extremes in Canadian waters and produce the extremes in size at onset of maturity .

## Methods

The correlation between ovarian development and AWI ratio was determined in four areas using females caught by commercial lobster trap. The areas examined were: North Rustico on the Gulf side of Prince Edward Island (238 females during May and June of 1978 and 1979); Miminegash, on the Northumberland Strait of P.E.I. (108 females during August, September and October of 1977 and 1978); Newcastle, N. B. (44 females on 4 July, 1977); and Grand Manan (101 females between 4 July and 6 October, 1978). All lobsters were dissected after measuring carapace length and abdomen width. Ovaries were weighed and ova size measured. Ovary factors were calculated by relating ovary weight to carapace length (Aiken and Waddy 1980 a,b). On the basis of the criteria given in Table 8, ovary stages were assigned.

## Results

Through hundreds of dissections, we have related ovary category (Table 8) to AWI. The largest sample was at North Rustico just prior to the beginning of the egg-laying season. The percentage found mature at each AWI are given in Table 1. Those listed as having developing ovaries will not extrude eggs until the following year while extrusion is within the current season in the mature category. In this area, 50% of those females with an AWI of 65 are potentially mature while 97% of those with an AWI of 67 are potentially mature. This assessment was made during the spring fishing season just prior to the time of egg-laying. Almost all of those examined (more than 99%) were on their first cycle of ovarian development as judged by oviduct color (Aiken and Waddy 1980a,b) and thus had been caught just before extruding for the first time.

The same correlation was determined at Miminegash in late summer - early fall, following the egg-laying season. Because of the time of year, no mature ovaries were present in the sample. Those in the developing category would have extruded the following year without molting. A few of those (with large stage 2 ovaries) classed as immature would also probably have extruded eggs the next year, following an early molt. The others in the immature group would have molted at least once and more likely twice before becoming ovigerous. Because of the difficulty in assessing ovaries that far in advance, the percentage predicted to be potentially mature at an AWI of 67 was less than that at North Rustico.

Table 3 defines the relationship obtained from Newcastle area females on 4 July, 1977. The value of only 87% mature at an AWI of 67 reflects the fact the sample was taken during the hatching/egg-laying season and may have

included a few females that had finished hatching and thus had smaller than expected ovaries.

Grand Manan females (Table 4) show results very similar to those of the other groups.

Measurements from 375 sub-legal female lobsters (52.0-63.4 mm CL) at North Rustico (Table 5) indicate that only 1% of females in this size group are potentially mature (AWI of 67 or greater).

Data from ovigerous females from several areas, Richibucto Cape, N.B.; S.W. Nova Scotia; Pleasant Bay, N. S.; Beech Point, P.E.I and Grand Manan (Table 6 ) indicate that between 76 and 85% of berried females have an AWI of 67 or greater.

Using the percentages known to be mature at each AWI from North Rustico and Miminegash (Tables 1 and 2) and the distribution of these AWI's (Table 7), the numbers of potentially mature females can be calculated. At North Rustico, 27% of canners (63.5-80.9 mm CL) are potentially mature. If the minimum legal size were increased to 76.0 mm (3 inches), the percentage of mature canner lobsters increases to 71%. As can be seen from the Table, the values for Miminegash are comparable. This means the increase in minimum size would decrease the pre-ovigerous kill rate from the present 98% to about 45% in the North Rustico area.

## Discussion

This paper clearly demonstrates the potential of the Maturity Index (AWI) as a means of identifying numbers of mature females in the population and size at maturity. From the presented data, it is obvious that the relationship between potential maturity and AWI is similar for all areas examined, with differences being due to time of year that sampling was done. The process of establishing the relationship in an area, which was done previously through autopsy, has now been simplified by defining the correlation between cement gland development and ovary condition so that it is no longer necessary to perform dissections to assess maturity (Waddy and Aiken 1980). By examining the population for cement glands just prior to the egg-laying season, the relationship to AWI can be established. Once that is done, measurements of abdominal width at any time of the year will give numbers and size distributions of mature females. From the data presented here, it seems likely that the rule of 50% mature at AWI of 65, and 97% at 67, will hold true. It is critcal that accurate measurements are taken as the pleura of the second abdominal segment are flexible and easily compressed during measurement of the maximum outside width. On a female of 95 mm CL, lateral compression of only 1.0 mm in abdomen width can decrease the AWI ratio from 67 (97% expected maturity) to 65 (only 50% expected maturity).

As stated by Ennis (1980) inflection points from many areas are not very distinct and caution must be exercised when interpreting such data. Because the increase in relative abdomen width is a secondary sexual characteristic, it begins to develop with the first presence of female hormones, and takes several molts to change from complete immaturity (AWI 54-57) to full maturity (AWI 67). Because all females in any one area do

not begin to mature at exactly the same size, inflection points may not be well defined. At the first inflection of AWI 58-59, mature females will be very rare. It will take another 2 molts before there is a significant number of mature females. As well, the asymtote at 70 generally regarded as the point where all are mature is about one molt above full maturity (AWI 67-68).

The method presented here of using numbers of females at each AWI to determine size at maturity is much more accurate than previously described methods of interpreting AWI data and is very easy to perform under field conditions.

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Table 1. Relationship between ovary category and AWI for North Rustico females during May and June (N = 238).

| AWI | Ovary category Immature[1] | Developing[2] | Mature[3] |
|---|---|---|---|
| ≤58 | 100% | - | - |
| 59 | 35% | 58% | 8% |
| 60-62 | 13% | 70% | 17% |
| 63-64 | 3% | 54% | 42% |
| 65 | - | 50% | 50% |
| 66 | - | 14% | 86% |
| 67 | - | 3 | 97% |
| ≥68 | - | - | 100% |

[1]Immature; no ovarian development (stage 1 ovary).
[2]Developing, one year from extrusion (stage 2,3 ovary).
[3]Mature; extrusion within the current season (stage 4,5,6 ovaries).

Table 2. Relationship between ovary category and AWI for Miminegash females during August-October (N = 108).

| AWI | Ovary category Immature[1] | Developing[2] | Mature |
|---|---|---|---|
| ≤58 | 100% | - | - |
| 59 | 100% | - | - |
| 60-62 | 100% | - | - |
| 63-64 | 75% | 25% | - |
| 65-66 | 50% | 50% | - |
| 67 | 15% | 85% | - |
| ≥68 | - | 100% | - |

[1]Immature; will not extrude for two seasons (ovary stages 1,2).
[2]Developing; will extrude next season (ovary stages 3,4,5).

Table 3. Relationship between ovary category and AWI for Newcastle females during July (N=44).

| AWI | Ovary category Immature[1] | Developing[2] | Mature[3] |
|---|---|---|---|
| ≤58 | 100% | - | - |
| 59 | 20% | 80% | - |
| 60-62 | 40% | 60% | - |
| 63-64 | 12% | 50% | 38% |
| 65-66 | - | 67% | 33% |
| 67 | - | 13% | 87% |
| ≥67 | - | - | 100% |

[1]Immature; no development (ovary stage 1).
[2]Developing; will extrude next year (ovary stages 2,3).
[3]Mature; will extrude during the present season (ovary stages 4,5,6).

Table 4. Relationship between ovary category and AWI for Grand Manan females during July through October (N=101).

| AWI | Ovary category Immature[1] | Developing[2] | Mature[3] |
|---|---|---|---|
| ≤58 | 100% | - | - |
| 59 | 49% | 51% | - |
| 60-62 | 17% | 74% | 9% |
| 63-64 | - | 100% | - |
| 65-66 | - | 50% | 50% |
| 67 | 15% | 10% | 90% |
| ≥67 | - | - | 100% |

[1]Immature; no development (ovary stage 1).
[2]Developing; extrusion will occur next season (ovary stages 2,3).
[3]Mature extrusion will occur this season (ovary stages 4,5,6).

Table 5. AWI distribution among sublegal female lobsters (52-63.5 mm CL) at North Rustico (N = 375).

| AWI | N | % | Mature[1] N | % |
|---|---|---|---|---|
| 50-59 | 319 | 85 | - | - |
| 60-62 | 45 | 12 | - | - |
| 63-64 | 5 | 1 | - | - |
| 65-66 | 2 | 0.5 | 1 | - |
| ≥67 | 4 | 1 | 4 | 1 |

[1]Estimated from known relationship of AWI to ovary condition.

Table 6. AWI of ovigerous females.[1]

| AWI | Richibucto Cape, N.B. N=44 | Beech Point, P.E.I. N=62 | Grand Manan N=62 |
|---|---|---|---|
| ≤59 | - | - | - |
| 60-62 | - | 2% | - |
| 63-64 | 2% | 13% | 3% |
| 65-66 | 18% | 9% | 12% |
| ≥67 | 80% | 76% | 85% |

[1]Data from Robinson (unpublished).

Table 7. Percent of potentially mature females in the landed catch from two areas in the southern Gulf of St. Lawrence[1]. Sample size given in brackets (N).

| | North Rustico | Miminegash |
|---|---|---|
| Canners, CL 63.5-80.9 mm | 27% (244) | 21% (87) |
| Large canners, CL 76.0-80.9 mm | 71% (48) | 74% (21) |
| Markets, CL 81.0-89.9 mm | 82% (92) | 80% (58) |

[1]Estimates based on AWI. See text for explanation.

Table 8. Stages and morphological criteria used to classify ovary development in the American lobster *Homarus americanus*[1].

| |
|---|
| *Stage 1: Immature* |
| Ovary white |
| Oocytes <0.5 mm |
| $O_f$ <100 |
| *Stage 2: Immature Developing* |
| Yellow, beige, pale green |
| Oocytes <0.8 mm |
| $O_f$ <100 |
| *Stage 3: Developing* |
| Light to medium green |
| Oocytes <1.0 mm |
| $O_f$ <200 |
| *Stage 4: Developing* |
| Medium to dark green |
| Ooctyes 0.1-1.6 mm |
| $O_f$ <325 |
| *Stage 5: Developing* |
| Dark green |
| Oocytes 1.0-1.6 mm |
| $O_f$ >325 |
| *Stage 6: Ripe* |
| Dark green |
| Oocytes 1.4-1.6 mm |
| $O_f$ >400 |
| *Stage 6A: Oocytes free* |
| *Spent or Reabsorbing* |
| White or yellow with |
| dark green residual ova |
| Flaccid in early stages |

[1]From Aiken and Waddy (1980a).