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CAFSAC Research Document 80/7

# Morphometrics, meristics and gonad development of Arctic cod from northern Labrador during September, 1978

by

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## INTRODUCTION

Arctic cod (*Boregadus saida*) were present in fairly large concentrations (up to 15 tons per 30-minute tow) on the coastal banks of northern Labrador (ICNAF Divisions 2G and 2H) during September, 1978 (Lear, 1979). Lear (1979) described the distribution by depth and temperature, size distributions by area, sex ratios and sexual maturity of Arctic cod in ICNAF Subareas 1 to 4 inclusive.

This paper presents additional data on the length-weight relationships, body proportions, meristics and gonad development of Arctic cod collected during September, 1978 from ICNAF Divisions 2G and 2H.

## METHODS AND MATERIALS

The Arctic cod described in this report were collected during a regular groundfish survey of the 80 m stern trawler "Gadus Atlantica" in ICNAF Divisions 2G and 2H during September 1978. The catches were obtained by a 164 Engels High Rise otter trawl in which the codend was lined with a 29 mm nylon mesh. The vertical opening of the net was 6.7 m while the horizontal opening was 13.9m.

Random samples of Arctic cod were collected during the cruise, frozen and brought back to the laboratory. They were thawed and were measured and examined as follows:

1. Fork length from tip of snout to deepest fork of the tail (mm).
2. Total length from tip of snout to tip of the longest caudal lobe (mm).
3. Whole weight (grams).

4. Gutted weight (grams). Gills <u>not</u> removed.
5. Sex and maturity stage.
6. Gonad weight (grans to the nearest tenth).
7. Egg diameters of females (tenth of a mm).
8. Otoliths.
9. X-Ray of vertebral column and fin rays.

## RESULTS AND DISCUSSION

### Morphometrics

#### Total length versus fork length:

Total lengths were plotted against fork lengths in a least squares regression for 167 Arctic cod from ICNAF Divisions 2G and 2H. The relationship between total length and fork length was as follows:

$Y = 1.0731\ X - 3.7571$ ( $r=0.999$)
when $Y$ = total length (mm)
and $X$ = fork length (mm) (Fig.1).

#### Fork length versus total length

Fork lengths were plotted against total lengths in a least squares regression for 167 Arctic cod from ICNAF Divisions 2G and 2H. The relationship between fork length and total length was as follows:
$Y = 0.9306\ X + 3.7471$ ($r=0.999$)
when $Y$ = fork length (mm)
and $X$ = total length (mm). (Fig.2).

#### Whole weight versus fork length

The fork length-whole weight curve was obtained by using the equation $W = cL^b$ in which $W$ = weight (g), $L$ = length (mm) and c and b were constants. The least squares regression of the logarithmic transformation
$Y = a + bX$
in which $Y = \log_{10} W$; $a = \log_{10}$ and $X = \log_{10} L$ was used for estimating values of c and b. The fork length-whole weight curve based on 167 Arctic cod was $Y = 0.00001266\ X^{2.9321}$ ($r = 0.990$)
where $Y$ = whole wt (g) and $X$ = fork length (mm) (Fig.3).

#### Gutted weight versus fork length

The fork length-gutted weight curve was obtained in the same way as described above. The fork length - whole weight curve based on 158 Arctic cod was:

$Y = 0.00001024\ X^{2.9124}$ ( r = 0.993)

where Y = gutted weight (g) and X = fork length (mm) (Fig.4).

Gutted weight versus whole weight

In an effort to obtain a conversion factor from whole weight to gutted weight, gutted weights were plotted against the whole weights of 164 Arctic cod in a linear least squares regression. The relationship was as follows:

Y = 0.7792 X -0.6044 (r=0.998).
where Y = gutted weight (grams)
and X = whole weight (grams). (Fig.5)

Ricker (1973) stated that a functional regression is more suitable in most situations than the ordinary predictive regression and especially for conversions from one length or weight to another. The functional regression of gutted weight versus whole weight was as follows:

Y = 0.7808 X -0.6954
which does not differ greatly from the predictive regression because of the high value (0.998) of the correlation coefficient (r).

Meristics

The vertebral columns of 163 Arctic cod collected during September, 1978 in ICNAF Divisions 2G and 2H were x-rayed and the vertebral counts (not including the urostylar half vertebra) were obtained by viewing the negatives over an illuminated X-ray viewer. The vertebral averages were grouped by the area in which they were caught (Table 1). An analysis of variance on the four groups indicated that the vertebral averages were not significantly different ($F(3,159) = 0.0957$). This suggested that the Arctic cod of ICNAF Divisions 2G and 2H are possibly the same stock. Further work will need to be done on vertebral averages and other meristic characters from other areas to determine if in fact the whole population of Arctic cod from Cape Chidley southwards is in fact one or several stocks and if it proves to be one stock, how far north this discrete stock extends. This may also have to involve the use of biochemical indicators as evidence of genetic diversity or similarity of the populations.

Gonad Development

The gonad weights were plotted against fork lengths of male and female Arctic cod in a log-log least squares regression. An analysis of covariance indicated that the regression of gonad weights versus fork lengths for males was significantly different (P .001) than that for females. The relationships between gonad weights and fork lengths for male and female Arctic cod are as follows:

Males: $Y = 0.000000000005153\ X^{5.1640}$ (Fig.6)

Females: $Y = 0.0000000008823\ X^{4.0537}$ (Fig.7)

where Y = gonad weight (gross) and X = fork length (mm). At a fork length of

200 mm, a male Arctic cod would have a gonad of 4g while the female would have one of 2g. At a fork length of 250 mm a male Arctic cod would have a gonad of 12.5g while a female of the same size would have gonad of about 4.5g. The male gonads were in a much more advanced development stage than females of the same size. Even in the larger females (250-300 mm fork length) the gonads were fairly small and seemed to be in an early stage of maturity and in some cases were in an immature condition (no eggs visible). Preliminary data from a groundfish cruise in 2G-H during August 1979 suggests that the larger females Artic cod were in an immature condition yet had evidence of a previous spawning (old eggs remaining in the ovary). Thus the determination of maturity stages during August-September is suspect in view of these preliminary observations since it is difficult to tell if a fish has spawned previously or if it is maturing for its first time. The maturity stages for the males at this time, can be determined with a greater degree of reliability. There may even exist the possibility, in view of the presence of large immature females among the large maturing females, of spawning in alternate years. This will have to be determined on the basis of further analysis.

The gonad weights versus whole weights of Arctic cod were also plotted in log-log least squares regressions for males and females seperately on the basis that an analysis of covariance indicated they were significantly different at the .001 level.

The relationships between gonad weights and whole weights were as follows:

Males: $Y = 0.002182\ X^{1.7726}$ (Fig.8)

$Y = 0.005609\ X^{1.3807}$ (Fig.9)

where Y = gonad weight (grams) and X = whole weight (grams).

The average gonad weights of maturing male and female Arctic cod from ICNAF Divisions 2G-H during September 1978 are shown in Table 2. The male gonads were about twice as large on the average as the females. The gonad weight expressed as a percent of body weight ranged from 4.0 to 14.7% in the males and from 2.0 to 7.7% in the females. The egg diameters of the maturing Arctic cod averaged 0.50 mm and ranged from 0.1 to 1.0 mm indicating clearly that they were in an early stage of maturity since at spawning time the egg diameters of fully mature Arctic cod were observed by Ross (1968) to range from 1.53 to 1.90 mm.

## REFERENCES


Lear, W.H. 1979. Distribution, size and sexual maturity of Arctic cod (*Boreogadus saida*) in the Northwest Atlantic during 1959-1978. CAFSAC Research Doc. 79/17, 40 pages.

Ross, T.S. 1968. Spawning and development of Polar cod. Rapp. et. P.-V. de Reun. Cons. Perm. Int. Explor. Mer., 158; 135-137.

Ricker, W.E. 1973. Linear regressions in fishery research. J. Fish. Res. Board Canada. 30: 409-434.

Table 1. Vertebral averages of Arctic cod from ICNAF Divisions 2G and 2H collected during September, 1978. Vertebral averages do not include the urostylar half-vertebra.

| DATE: | ICNAF DIV. | POSITION | DEPTH(M) | NO. EXAMINED | VERT. AVG. | STAN. DEV. | STAN. ERROR |
|---|---|---|---|---|---|---|---|
| 1978 | | | | | | | |
| Sept.26 | 2G | 60 04 N<br>61 42 W | 223 | 41 | 54.976 | 0.7241 | 0.1131 |
| 26 | 2G | 59 26 N<br>62 45 W | 143 | 80 | 55.038 | 0.8634 | 0.0965 |
| " 27 | 2G | 59 15 N<br>61 29 W | 169 | 9 | 55.111 | 0.6009 | 0.2003 |
| " 17 | 2H | 55 47 N<br>57 40 W | 224 | 33 | 55.030 | 0.7282 | 0.1268 |

Analysis of variance on 4 areas.

$F(3,159) = 0.0957$

∴ NOT SIGNIFICANTLY DIFFERENT.

Table 2. Gonad weights and egg diameters of maturing Arctic cod from ICNAF Divisions 2G and 2H collected during September, 1978.

| | GONAD WEIGHTS (g) MALES | FEMALES | EGG DIAMETER (MM) |
|---|---|---|---|
| No. examined | 61 | 103 | 102 |
| Average | 9.175 | 4.420 | 0.500 |
| Standard deviation | 2.969 | 1.222 | 0.199 |
| Standard error | 0.380 | 0.120 | 0.020 |
| Range | 3.8-17.8 | 2.0-7.7 | 0.1-1.0 |
| Gonad weight as a % of whole weight | 4.0-14.7 | 2.2-5.4 | - |

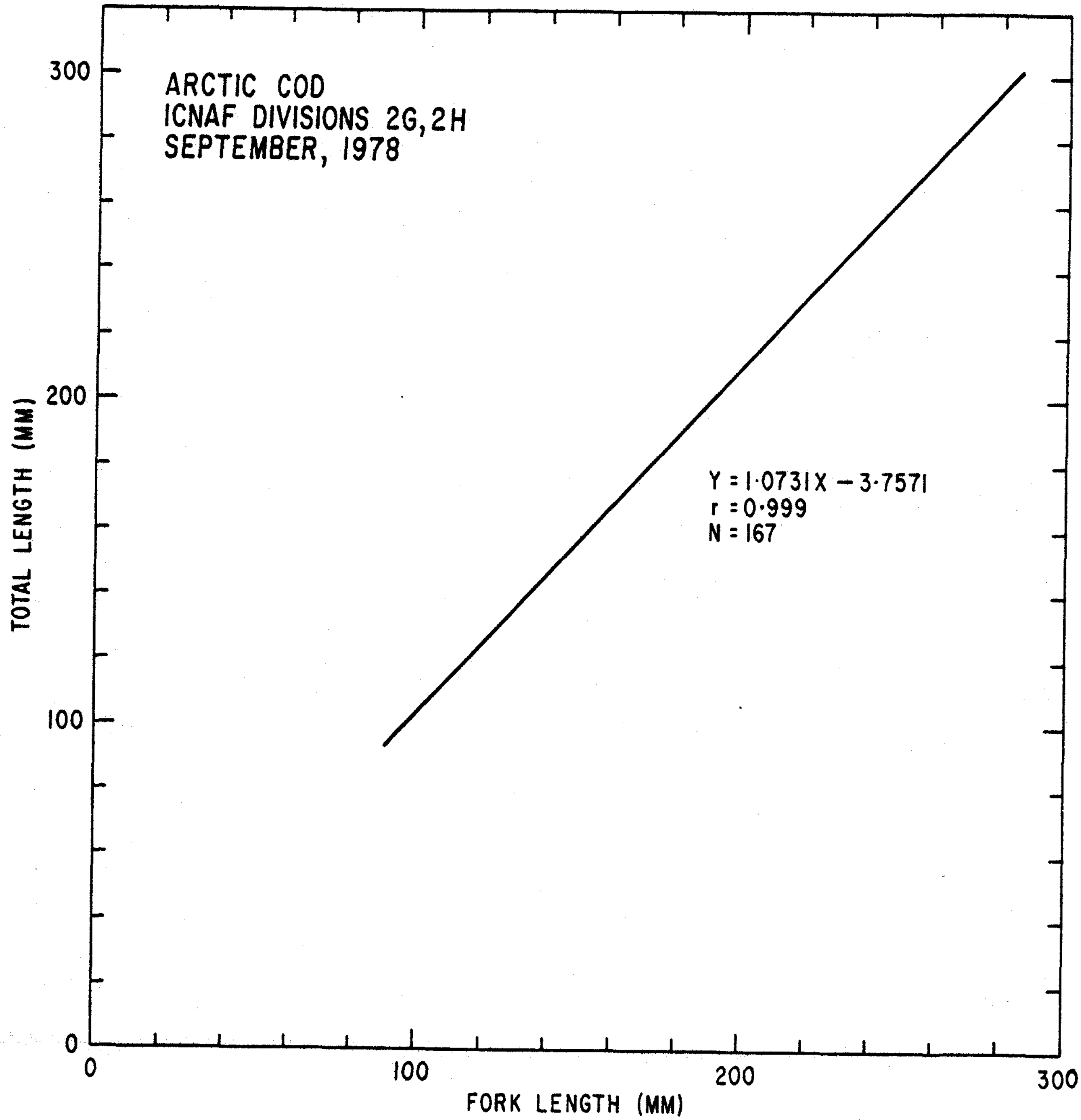


Figure 1. Weighted least squares regression of total length (mm) versus fork length (mm) for Arctic Cod.

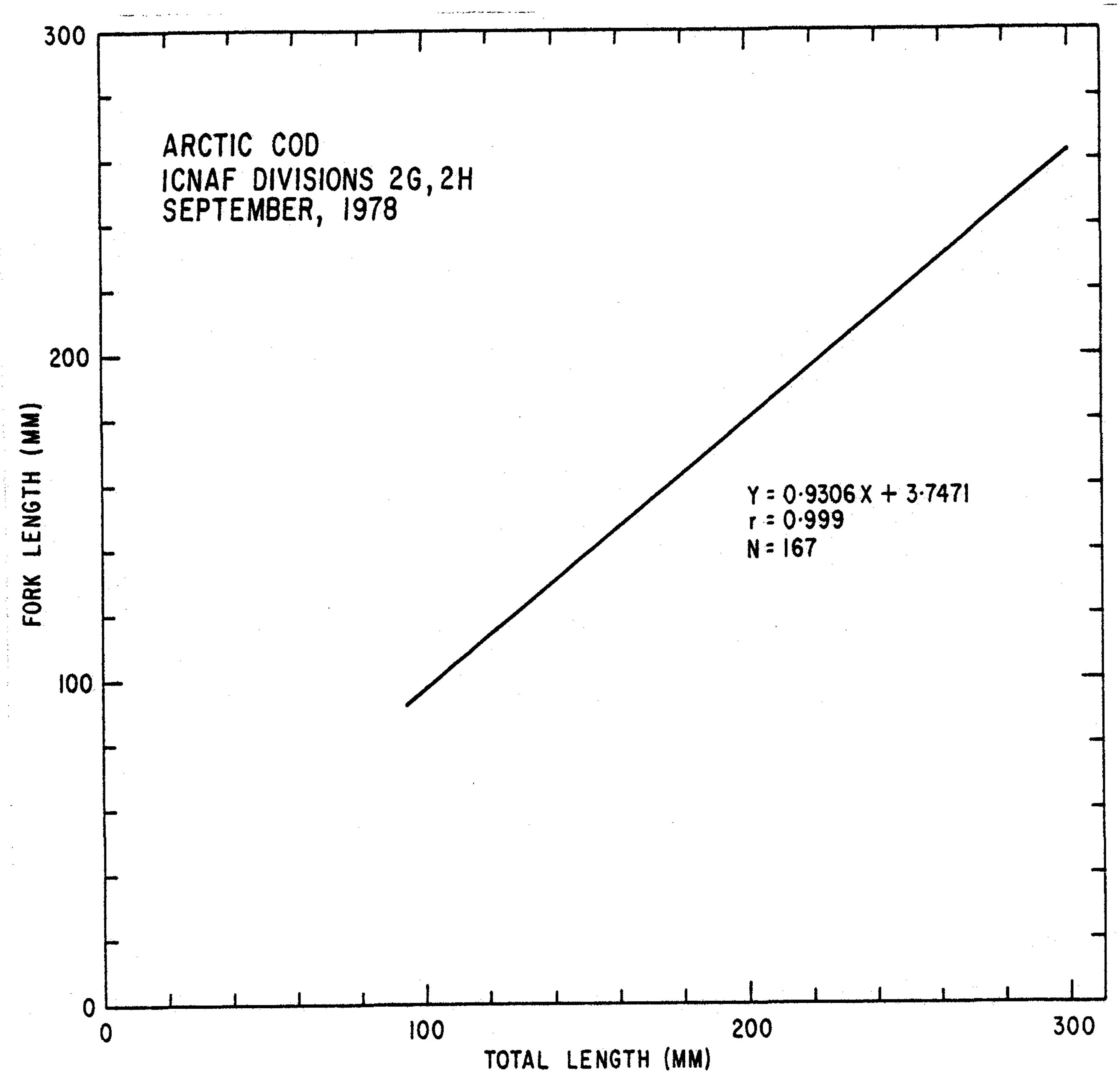


Figure 2. Weighted least squares regression of fork length (mm) versus total length (mm) for Arctic cod.

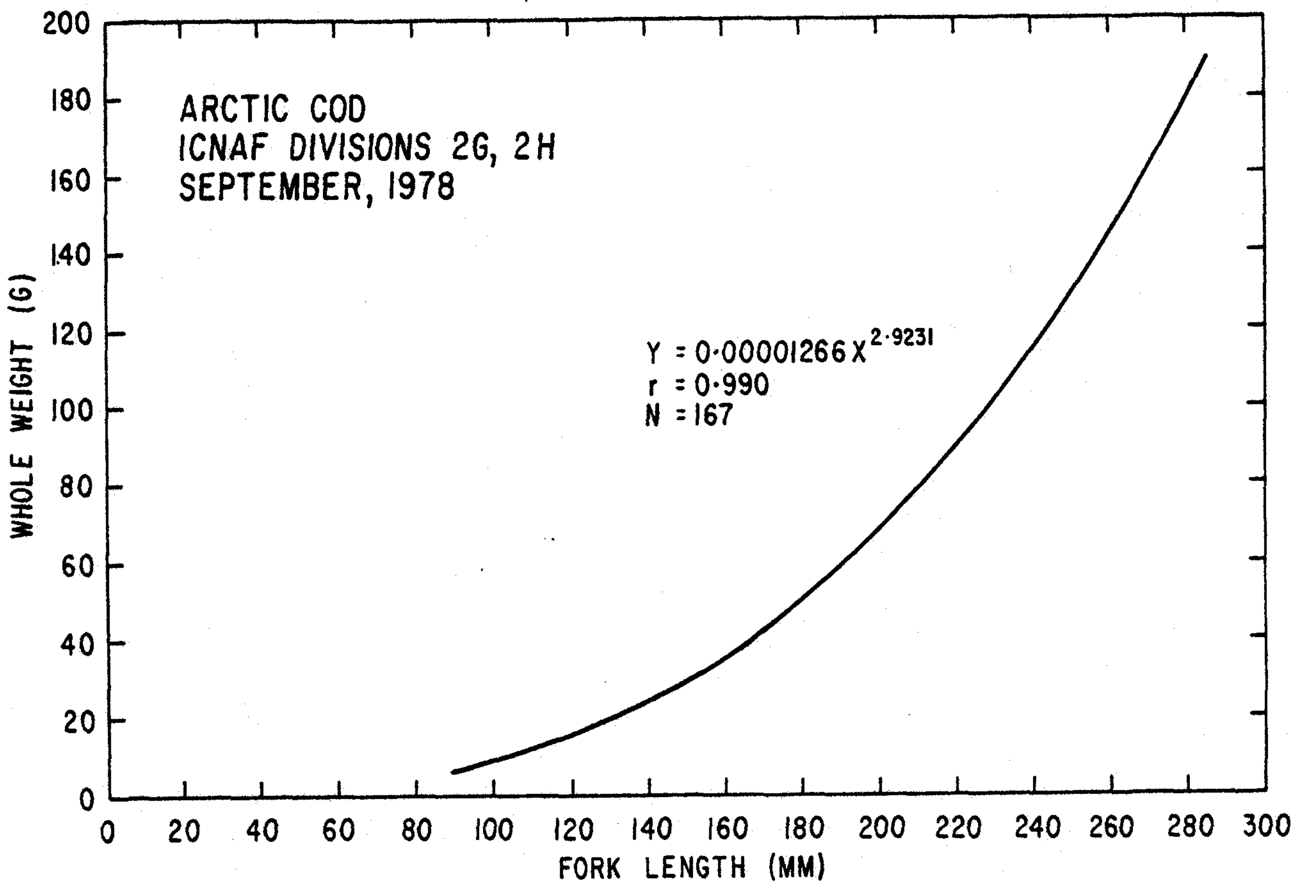


Figure 3 . Weighted least squares regression of whole weight (g) versus fork length (mm) for Arctic cod, derived from a double logarithmic transformation.

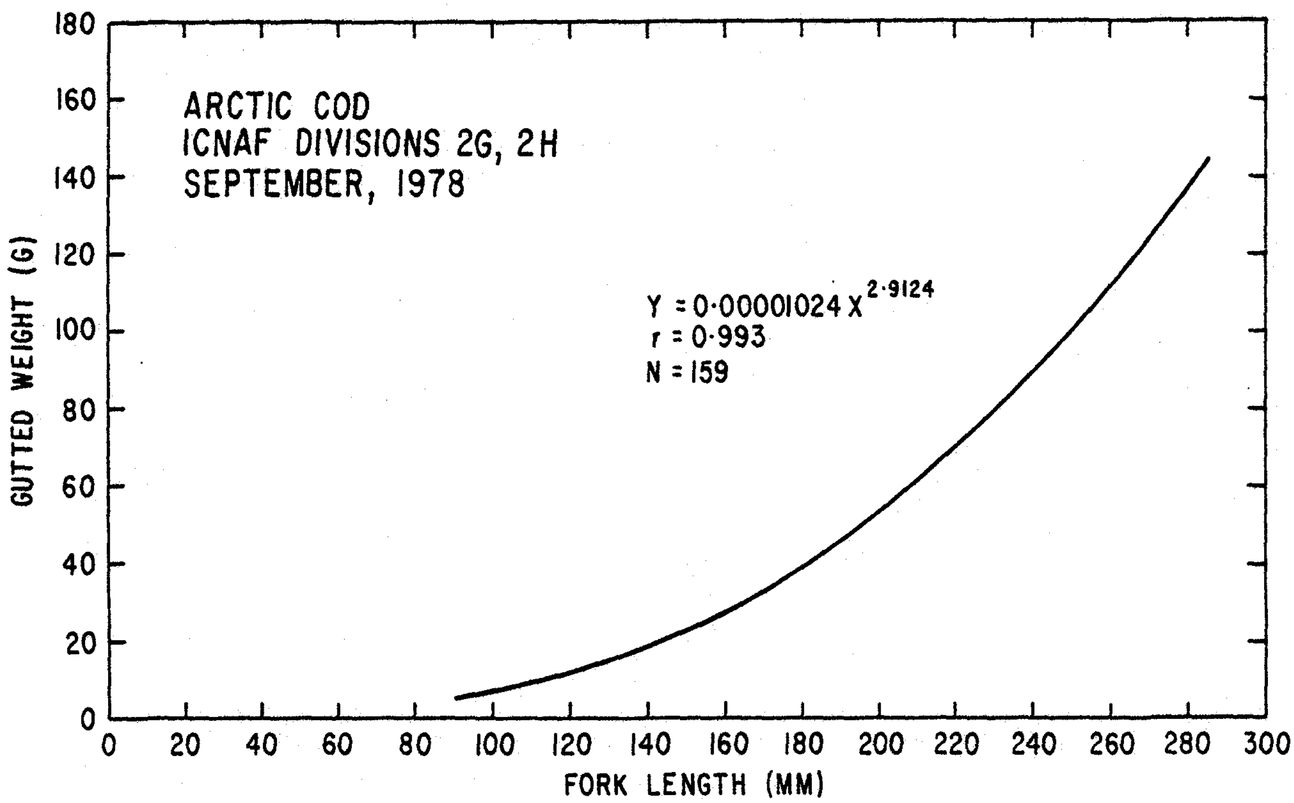


Figure 4. Weighted least squares regression of gutted weight (g) versus fork length (mm) for Arctic cod, derived from a double logarithmic transformation.

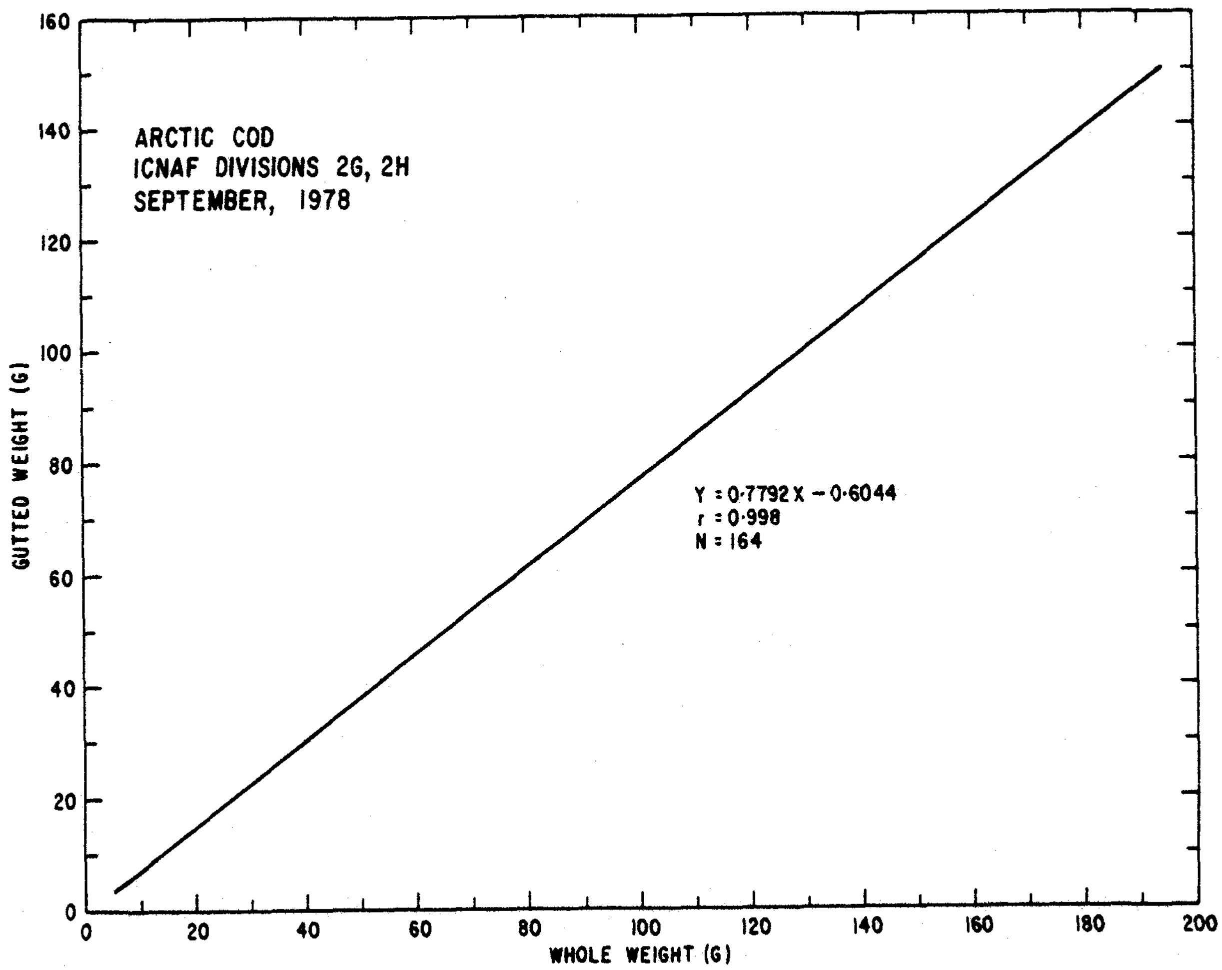


Figure 5. Weighted least squares regression of gutted weight (g) versus whole weight (g) for Arctic cod.

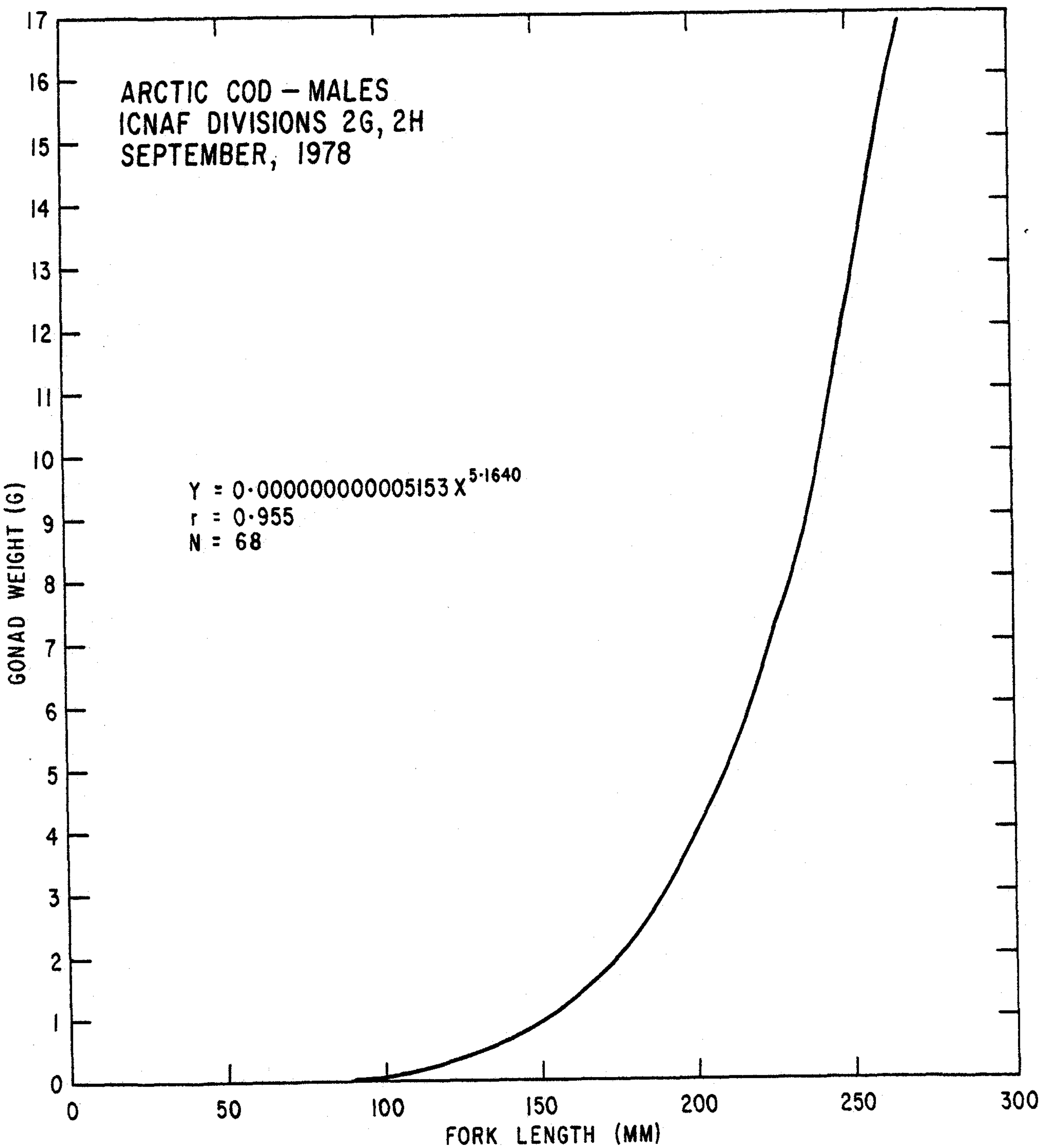


Figure 6. Weighted least squares regression of gonad weight (g) versus fork length (mm) for male Arctic cod, derived from a double logarithmic transformation.

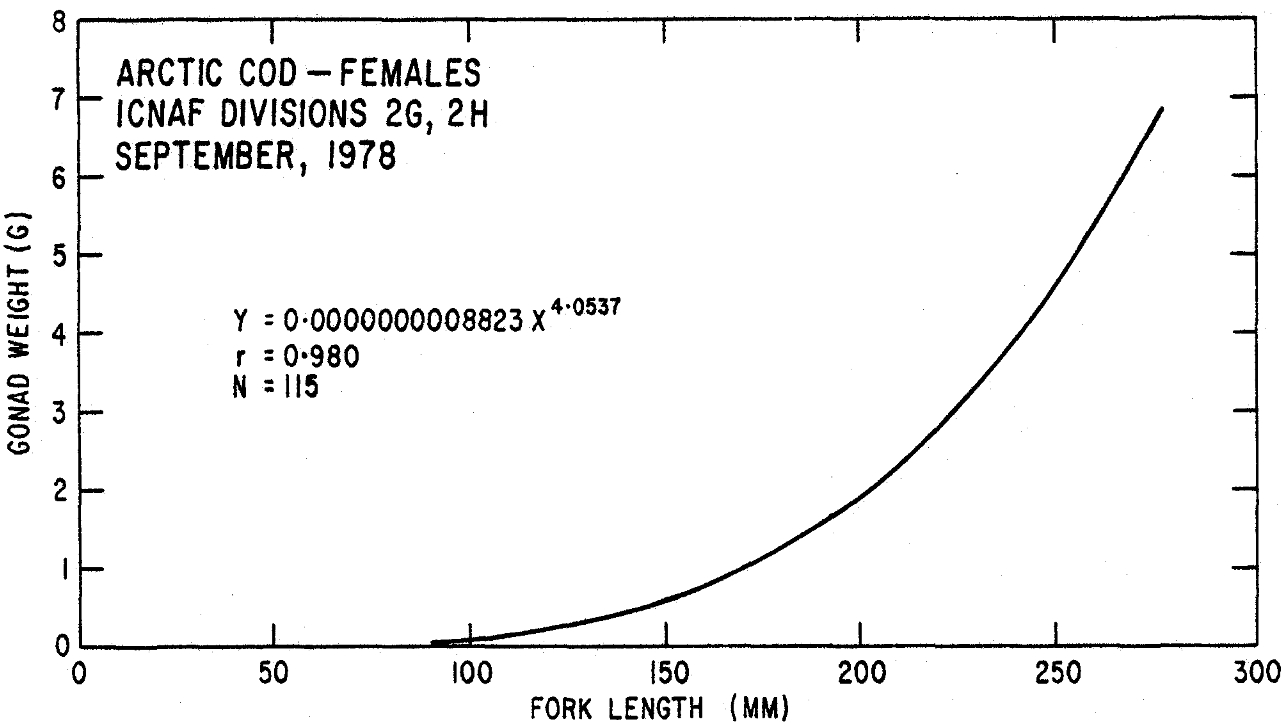


Figure 7. Weighted least squares regression of gonad weight (g) versus fork length (mm) for female Arctic cod, derived from a double logarithmic transformation.

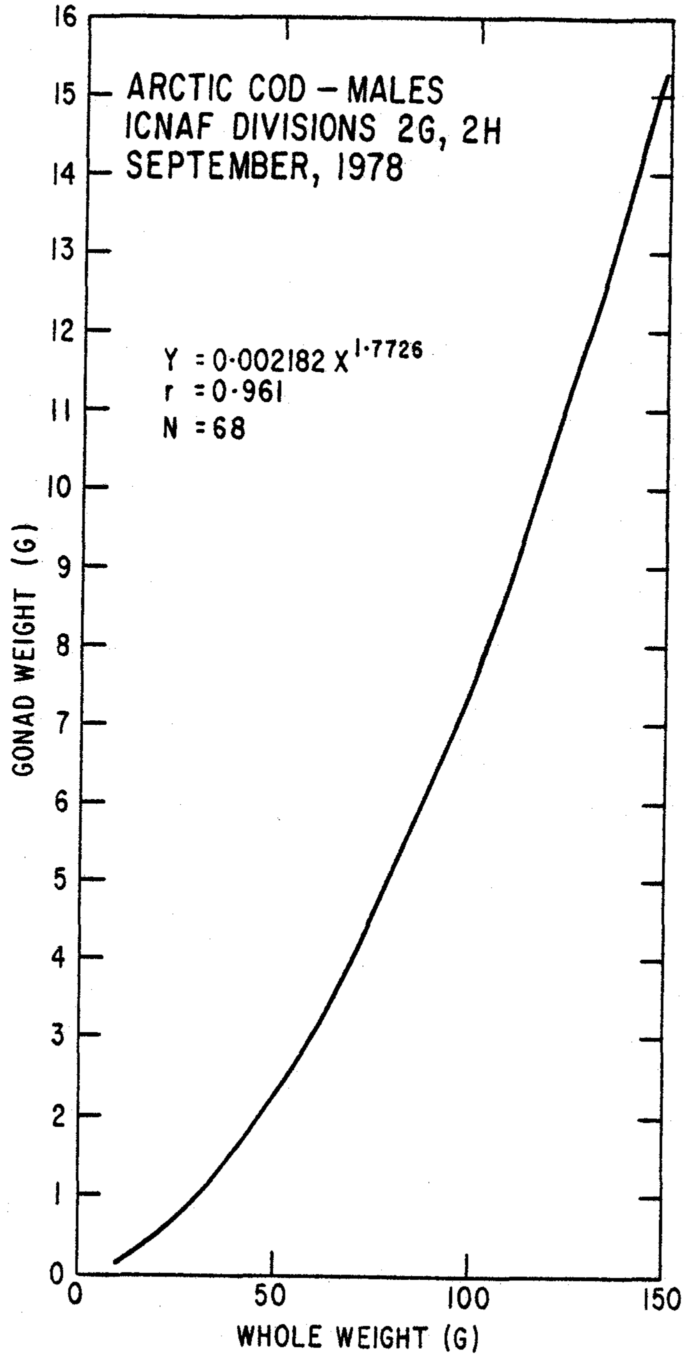


Figure 8. Weighted least squares regression of gonad weight (g) versus whole weight (g) for male Arctic cod, derived from a double logarithmic transformation.

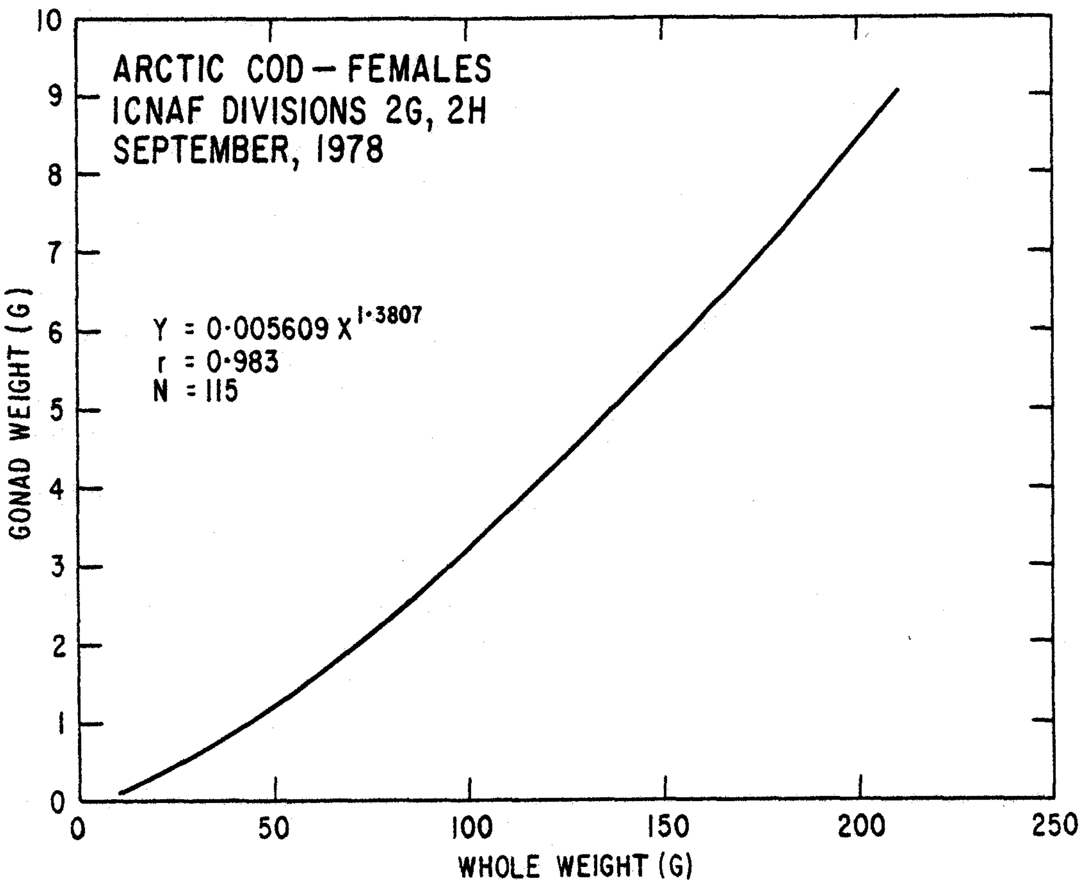


Figure 9. Weighted least squares regression of gonad weight (g) versus whole weight (g) for female Arctic cod, derived from a double logarithmic transformation.