Journal of
Fisheries and Aquatic Science

ISSN 1816-4927

Academic
Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 2 (3): 235-242, 2007
ISSN 1816-4927

Fishing Impact on *Mugil curema* Stock of Multi-Species Gill Net Fishery in a Tropical Lagoon, Colima, México

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Abstract: Total mortality rate of *Mugil curema* was estimated through the catch curve and the value was Z = 0.80. Natural mortality was calculated with Taylor's method, M = 0.20 and fishing mortality was F = 0.60. Survival rate was S = 0.449; this means that 55% of the population dies every year. Mortalities by sex had significant differences. Selectivity for the most used gill gear was l_c = 26.17 cm (mesh size of the gill net 5.71 cm) and l_c = 29.08 cm (mesh size of the gill net 6.35 cm). Exploitation rate is E = 0.750 owing to a very high mortality. A greater fishing yield could be obtained decreasing the fishing effort and increasing the mesh size of the gill net to 6.98 and 7.62 cm which would capture individuals from 32.11 to 35.05 cm of total length. The present yield per recruit is 128 g and the fishery impact occurs on the individuals 4 and 5 years of age who have reproduced at least once.

Key words: Mortality, selectivity, exploitation rate, yield per recruit, *Mugil curema*

INTRODUCTION

Mugil curema (Valenciennes, 1836) is an American species found on the Atlantic and Pacific Oceans, very appreciated by local fishermen. The analysis of its population parameters is necessary to protect the young individuals.

The total mortality analysis, considering both components i.e., natural and fishing mortality, are of great importance to understand the decrease in number of organisms from a population. The models that consider the yield of the population are based on the balance between the addictive factors (growth and recruitment) and the substractive factors (fishing and natural mortality), to insure that the population continues existing in time and space (Stein *et al*., 1975; Gobert, 1994; Gray, 2002; Albaret and Laë, 2003; Gray *et al*., 2005; Clavero *et al*., 2006). Therefore formulas that quantify total mortality by means of the catch curves have been developed and Taylor's (1958, 1959, 1960 and 1962) methods for the analysis of the natural mortality due to predation, sickness and senescence.

The study of the selectivity of the fishing methods are used to analyze fishing impact on populations; it is oriented to regulate a mesh size that permits the exclusion of organisms that have not reproduced at least once, thereby allowing the reproduction population recovers to replace organisms that die by fishing or from natural causes (Clavero *et al*., 2006; Rotherham *et al*., 2006).

Commercial catch of white mullet in the Mexican Pacific coast reaches 219 tons, of which 98 tons are from Colima (SEMARNAP, 2000). According to Cabral-Solís (1999) Cuyutlan Lagoon *M. curema*

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is the second most important fishery (after shrimp), giving employment to more than 400 fishermen, albeit at a very low price (2 to 3 Mexican pesos per kg, the equivalent to 10 cents a pound). This present research is to show an analysis on mortality and selectivity and their influence in the exploitation rate in *M. curema*'s fishery in the Cuyutlan Lagoon, that will give a background for a better assessment and management of the fishery and the ecosystem.

MATERIALS AND METHODS

Specimens were obtained from the commercial fishery in the Cuyutlan Lagoon (103°57' and 104°19' W; 18°57' and 19°50' N), in monthly sampling from March 1997 to February 1998. Total length for 4,482 organisms was registered, 60.28% of which were females and 37.82% males.

For growth study, the scales of 548 organisms were studied. This analysis allowed the identification of six age groups: Age 0: 106.60 mm, age 1: 153.20 mm, age 2: 197.50 mm, age 3:231.30 mm, age 4: 258.20 mm and age 5: 276.00 mm (Espino-Barr *et al*., 2005). The mean length was used to calculate the von Bertalanffy (1938) growth equation. $L\infty$, K and t_o were obtained combining the following methods: (1) Ford (1933), Walford (1946) and Gulland (1964) (2) Tomlinson and Abramson (1961) (3) Allen (1966) (4) Prager (1987) and (5) Beverton (1954). Growth was also calculated for each sex and curves were obtained for each method and the goodness of fit evaluated with the sum of the square difference (Σe_i^2). Hotelling's T^2 test (Bernard, 1981) was used to compare growth curves of the two sexes. Longevity was obtained by Taylor (1958, 1959, 1960 and 1962) methods. Growth parameters were $L\infty$ = 364.7 mm, $W\infty$ = 456.61 g, K = 0.219, t_o = -1.557, ($A_{0.95}$) = 15 years. Growth rate between sexes were: Females: $L\infty$ = 365.8 mm, K = 0.221, t_o = -0.505; $A_{0.95}$ = 14 years; males: $L\infty$ = 322.0 mm, K = 0.251, t_o = -0.441, $A_{0.95}$ = 12 years (Gallardo-Cabello *et al*., 2005).

The method of the linealized catch curve was used to estimate the total mortality coefficient (Z) by plotting age groups versus the natural logarithm of the relative abundance of each group (Sparre and Venema, 1995). Survival rate was obtained by the equation: $S = e^{-Z}$ (Ricker, 1948; Ehrhardt, 1981; Sparre and Venema, 1995). Natural mortality (M) was estimated by using Taylor's (1960) method: M = -Ln (1-0.95)/A0.95, where A0.95 is longevity, which is based on the von Bartalanffy (1983) growth parameters.

The more common mesh size of gill net gear in the commercial catch of *M. curema* was 2¼ (5.71 cm) and of mesh size 2½ (6.35 cm). Selectivity was determined applying the selection curves proposed by Sparre and Venema (1995).

The exploitation rate was determined as E = F/Z (Sparre and Venema, 1995) and the yield per recruit (Beverton and Holt, 1957) with the equation:

$$y/r = F * e^{-Mr'} * W_\infty \left(\frac{1}{Z} - \frac{3e^{-Kr'}}{Z+K} + \frac{3e^{-2Kr'}}{Z+2K} - \frac{e^{-3Kr'}}{Z+3K}\right)$$

where,

y = Catch or yield
r = Recruit
F = Fishing mortality
M = Natural mortality
r' = $t_R - t_0$, time between recruitment and the hypothetic t_0
$W\infty$ = Corresponding weight to asymptotic length $L\infty$
Z = Total mortality
K = Growth coefficient

RESULTS AND DISCUSSION

Total Mortality

The catch curve for *M. curema* showed an ascendant slope for ages 0 and 1 years. On the right side, the descendant part corresponds to the ages whose recruitment to the net was complete and the total mortality value for the age groups 2 to 5 years was obtained by interpolation.

The regression line obtained for the calculation of the slope of the curve is given by the following equation:

$$y = 8.463 - 0.80\ x,\ R^2 = 0.807;\ F_{(0.05,\ 4,\ 0.038)} = 12.542,\ n = 5,$$

where x corresponds to the age groups and y to the natural logarithm of the relative abundance for each age group.

Total mortality value obtained for *M. curema* for ages 2 to 5 years is Z = 0.80 and the survival rate is S = 0.449 (Table 1).

Ibáñez-Aguirre and Gallardo-Cabello (1996) obtained a similar value of Z (0.85) for *M. curema* in the Tamiahua Lagoon, Veracruz in the Atlantic Ocean.

Mortality value for *M. curema* could be reduced by decreasing the fishing intensity, thereby protecting the population from overexploitation and increasing the fishery yield, since growth and recruitment will increase the biomass of the population, through greater lengths and weights for each age group.

Natural Mortality

Natural mortality rate of *M. curema* is M = 0.20; it also shows natural mortality rate for sexes: Males show a higher growth rate, a lower longevity value and a higher natural mortality rate than females (Table 1).

Similar results were obtained by Ibáñez-Aguirre and Gallardo-Cabello (1996), for *M. curema* in the Tamiahua Lagoon, Veracruz in the Atlantic Ocean: M = 0.16 for the species, M = 0.156 for females and M = 0.213 for males.

These values of mortality rates for the population of the white mullet in the Cuyutlan Lagoon mean that in a year 55.07% die (75% by fishing and 25% naturally) and 44.93% survive.

Selectivity

In the studied area two kinds of nets are employed for the catch of *M. curema*: The gill net and the cast net. Gill nets are the most used and efficient for the capture of the *M. curema*; the cast net are employed mainly for self consumption.

Gill nets also capture other commercial fish species, the most important owing to their high proportion are: *Gerres cinereus* (32.89%), *Mugil cephalus* (23.87%), *Eucinostomus argenteus* (10.56%), *Diapterus peruvianus* (6.66%), *Opisthonema libertate* (5.39%), *Caranx caninus* (3.85%), *Oligoplites altus* (3.36%) and *Arius seemanni* (2.59%) (Cabral-Solís and Espino-Barr, 2004). Therefore

Table 1: Growth and mortality parameters for *M. curema*

Parameters	Species	Males	Females
L_∞	364.7	322	365.8
K	0.219	0.251	0.221
To	1.557	0.441	0.505
Z	0.800	0.6000	0.890
M	0.200	0.242	0.213
F	0.600	0.358	0.677
S	0.449	0.549	0.411
Longevity	15	12	14

this fishery is considered as multiespecific and selectivity studies should be done for each one of the captured species. Application of a particular mesh size in a fishery regulation is easier and more efficient when applied for a monoespecific population, since only one selectivity value has to be applied (Gallardo-Cabello, 1984). However, in the studied area, fishery exploitation occurs simultaneously on several species with different growth rates and consequently different selectivity values. For this reason it would be necessary to regulate mesh size to capture the fish of highest commercial value, in this case, *M. curema*, *Gerres cinereus* and *Diapterus peruvianus*.

Selectivity curves obtained in this study for *M. curema* are shown in the Fig. 1. Table 2 shows the average selection length (l_c = length at which 50% of individuals are captured by the net) is 26.17 for 5.71 cm (2¼ inches) mesh size and 29.08 for 6.35 cm (2½ inches) mesh size which correspond to age groups 4 and 5 years, respectively. Length of the first sexual maturity for *M. curema* is: Females 20.0 cm (2 year) and males 18.6 cm (2 years) (Cabral-Solís, 1999). Therefore 30 mm mesh size of gill nets for *M. curema* captures individuals who have spawned once, this may be the reason this fishery has not completely disappeared although their volumes of capture decrease each year.

An increment in the mesh size from 2 ¾ to 3 inches would capture organisms with an average selection length of 32.11 to 35.05 cm of total length, considering a selection factor of 4.6, a closely approximated value (Table 3).

Exploitation Rate

According to Gulland (1964) the exploitation rate E = 0.5 means that 50% of the biomass is being fished, the optimum exploitation rate is E = 0.33, where F = M. therefore the value of the exploitation

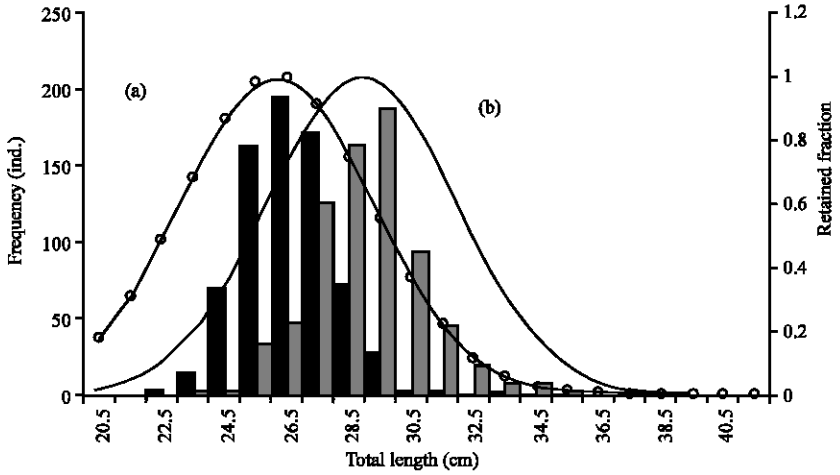

Fig. 1: Selectivity curve for *M. curema*: (a) gill net of 5.71 cm mesh size (2¼ inch) and (b) gill net of 6.35 cm (2 ½ inch)

Table 2: Average selection size and selection factor of different mesh size for *Mugil curema*

Mesh size (cm-inch)	Average selection size (Lc, weight and age)	Selection factor
5.71 (2 1/4)	26.17 cm-184 g-4.25 years	4.583
6.35 (2 1/2)	29.08 cm-252 g-5.75 years	4.579

Table 3: Average selection size for different selection factor and mesh size values

	Mesh size			
Selection factor (FS)	5.71 cm (2 ¼ in)	6.35 cm (2 ½ in)	6.98 cm (2 ¾ in)	7.62 cm (3 in)
3.6	20.56	22.86	25.12	27.43
4.6	26.26	29.21	32.11	35.05
5.6	31.97	35.56	39.10	42.67

rate obtained in this study E = 0.75 is considered high and represents the extraction of a great number of fish in reproductive age which are the recruitment providers of the organisms of the following year. Therefore it is necessary to decrease the fishing effort and increase the mesh size of gill nets to 6.98 and 7.62 cm (2 ¾ and 3 inches).

Yield per Recruit

The input data for the yield per recruit model are shown in Table 4. Beverton and Holt's (1957) model shows that the present yield per recruit (y/r) is 128 g. With the same size of gill net mesh and changing the fishing effort (as F), the maximum obtainable y/r, increasing F to 1.7 is 132.9 g (Fig. 2). Figure 3 shows the simulations of the model by changing the age of first capture (T_C), by modifying r'. It shows that reducing the age of first capture, the y/r decreases dramatically.

Fishery capture impacts mainly on age groups 4 and 5 years (25.67 and 27.79 cm length) which have already reproduced at least once. Older individuals cannot be obtained since they migrate to the sea to reproduce (catadromous). Lagoons are a nursery area which provides protection and feeding grounds for fingerling and juveniles fish. Therefore is very important that the mesh size of gill nets remains at least at 2 ¾ inches, which is mentioned in the regulation, in order to protect smaller organisms.

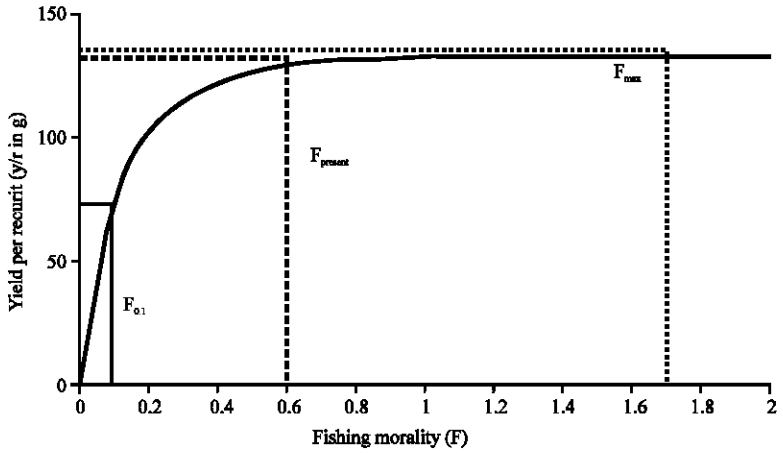

Fig. 2: Yield per recruit of *M. curema* for different fishing mortalities without changing the net size

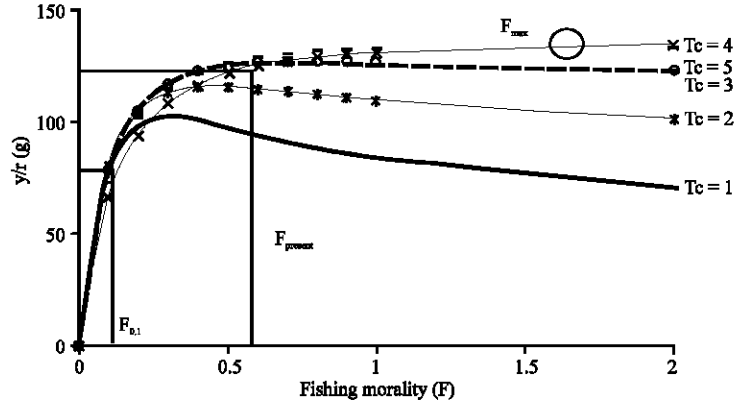

Fig. 3: Simulation of the y/r of *M. curema* changing F and T_C (age of first capture)

Table 4: Input parameters for the yield per recruit model

Parameters	Value	Unit	Size	Weight
Asymptotic length (L_∞)	36.47	cm		
Growth rate (K)	0.219			
Correction to the ordenate origin (t_o)	-1.557			
Asymptotic weight (W)	495	g		
First capture age (T_C)	4.01	years	25.70 cm	174 g
Recruitment age (Tr)	2.99	years	23.00 cm	125 g
Total mortality (Z)	0.8			
Natural mortality (M)	0.2			
Fishing mortality (F)	0.6			
Survival rate (S)	0.449			
Exploitation rate (E)	0.75			
Selectivity (lc)	26.17	mesh	5.71 cm	
(lc)	29.08	mesh	6.35 cm	
Length-weight relation (a)	0.000011			
(b)	2.979			

CONCLUSIONS

Total mortality coefficient (Z) of *M. curema* for age groups 2 to 5 years is 0.80 and survival rate is 0.449; in a year 55.07% of the organisms die (75% by fishing and 25% naturally) and 44.93% survive. Natural mortality rate (M) is: 0.20. Natural mortality rates (M) for sexes of *M. curema* are: 0.213 for females and 0.242 for males. The average selection length for *M. curema* is 26.17 cm employing a gill net of 5.71cm of mesh size, with a selection factor of 4.583. The average selection length for *M. curema* is 29.08 cm. employing a gill net of 6.35 cm of mesh size, with a selection factor of 4.579. Fishing mortality is F = 0.60. The exploitation rate is E = 0.75. The present yield per recruit (y/r) is of 128 g. The maximum increment of F (1.7) reaches 132 g. The fisheries impact occurs on individuals of 4 and 5 years old, who have spawned once. A greater yield is obtained decreasing the fishing effort and increasing the mesh size of the gill nets to 6.98 cm (2 ¾ inch) and 7.62 cm (3 inch).

ACKNOWLEDGMENTS

We would like to thank the fishermen of the Cuyultan Lagoon, who allowed us to sample their fish. Also our coworkers in the National Institute of Fisheries and specially Daniel Hernámdez-Montaño who designed a spreadsheet with the Beverton and Holt model analysis.

REFERENCES

Albaret, J.J. and R. Laë, 2003. Impact of fishing on fish assemblages in tropical lagoons: The example of the Ebrie lagoon, West Africa. Aq. Living Resour., 16: 1-9.

Allen, K.R., 1966. A method of fitting growth curves of the von Bertalanffy type to observed data. J. Fish. Res. Board Canada, 23: 163-277.

Bernard, D.R., 1981. Multivariate analysis as a means of comparing growth in fish. J. Fish. Aquat. Sci., 38: 233-236.

Beverton, R.J.H., 1954. Notes on the use of theoretical models in the study of the dynamics of exploited fish populations. United States Fisheries Wildlife Service, Fisheries Laboratory, Beaufort, Misc. Contribution, 2: 181.

Beverton, R.J.H. and S.J. Holt, 1957. On the Dynamics of exploited fish population. Fish. Invest. Minist. Agric. Fish. Food, 2-19: G.B. 533.

Cabral-Solís, E.G., 1999. Study on the growth and reproductive aspects of the white mullet *Mugil curema* Cuvier y Valenciennes, 1836, in the Cuyutlan Lagoon, Colima (Estudio sobre el crecimiento y aspectos reproductivos de la lebrancha *Mugil curema* Cuvier y Valenciennes, 1836, en la laguna de Cuyutlán, Colima.) Tesis de Maestría, Universidad de Colima, pp: 91.

Cabral-Solís, E.G. and E. Espino-Barr, 2004. Spatial and temporal distribution and abundance of the fish in the Cuyutlan Lagoon, Colima, Mexico (Distribución y abundancia espacio-temporal de los peces en la Laguna de Cuyutlán, Colima, México). Oceánides, 19: 19-27.

Clavero, M., F. Blanco-Garrido and J. Prenda, 2006. Monitoring small fish populations in streams: A comparison of four passive methods. Fish. Res., 78: 243-251.

Ehrhardt, N., 1981. Course on population dynamics methods. 1st Part. Population parameters estimation (Curso sobre métodos en dinámica de poblaciones. 1a. Parte. Estimación de parámetros poblacionales). México DF., pp: 150.

Espino-Barr, E., E.G. Cabral-Solís, M. Gallardo-Cabello and A.L. Ibáñez-Aguirre, 2005. Age determination of *Mugil curema* Valenciennes, 1836 (Pisces: Mugilidae) in the Cuyutlan Lagoon, Colima, Mexico. Int. J. Zool. Res., 1: 21-25.

Ford, E., 1933. An account of the herring investigations conducted at plymouth during the years from 1924 to 1933. J. Mar. Biol. Assoc., 19: 305-384.

Gallardo-Cabello, M., 1984. Total mortality analysis, selectivity and recruitment of the Great Forkbeard *Phycis blennoides* (Brünnich, 1768) in the occidental Mediterranean (Pisces: Gadidae). Análisis de la mortalidad total, selectividad y reclutamiento de la brótola, *Phycis blennoides* (Brünnich, 1768) en el mediterráneo occidental (Pisces: Gadidae). Anales del Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, 11: 217-224.

Gallardo-Cabello, M., E.G. Cabral-Solís, E. Espino-Barr and A.L. Ibáñez-Aguirre, 2005. Growth analysis of white mullet *Mugil curema* (Valenciennes, 1836) (Pisces: Mugilidae) in the Cuyutlán Lagoon, Colima, México. Hidrobiológica, 15: 321-325.

Gobert, B., 1994. Size structures of demersal catches in a multispecies multigear tropical fishery. Fish. Res., 19: 87-104.

Gray, C.A., 2002. Management implications of discarding in an estuarine multi-species gill net fishery. Fish. Res., 56: 177-192.

Gray, C.A., D.D. Johnson, M.K. Broadhurst and D.J. Young, 2005. Seasonal, spatial and gear-related influences on relationships between retained and discarded catches in a multi-species gillnet fishery. Fish. Res., 75: 56-72.

Gulland, J.A., 1964. Manual of methods of fish population analysis. FAO Fisheries Technical Paper 40, pp: 60.

Ibáñez-Aguirre, A.L. and M. Gallardo-Cabello, 1996. Total and natural mortality of *Mugil cephalus* and *M. curema* (Pisces: Mugilidae), in Tamiahua Lagoon, Veracruz. I. Selectivity. Hidrobiológica, 6: 9-16.

Prager, M.H., 1987. Nonlinear Parameter Estimation for Fisheries (Fishparm). Version 2.1S. Elsevier Scientific Publications Co., Bronxville, New Yourk.

Ricker, W.E., 1948. Methods of Estimating Vital Statistics of Fish Population. Science Ser. 15. Ind. Un. Publ., USA., pp: 101.

Rotherham, D., C.A. Gray, M.K. Broadhurst, D.D. Johnson, L.M. Barnes and M.V. Jones, 2006. Sampling estuarine fish using multi-mesh gill nets: Effects of panel length and soak and setting times. J. Exp. Mar. Biol. Ecol., 331: 226-239.

SEMARNAP, 2000. Fishing statistics year book 1999 (Anuario estadístico de pesca 1999). Secretaría de Medio Ambiente, Recursos Naturales y Pesca, pp: 271.

Sparre, P. and S.C. Venema, 1995. Introduction to the evaluation of tropical fihery resources. Part 1. Manual (Introducción a la evaluación de recursos pesqueros tropicales. Parte 1-Manual.) FAO Doc. Tec. de Pesca 306/1, Roma, pp: 420.

Stein, R.A., J.O. Mecom and B. Ivanovic, 1975. Commercial exploitation of fish stocks in Skadar Lake, Yugoslavia, 1947-1973. Biol. Conserv., 8: 1-18.

Taylor, C.C., 1958. Cod growth and temperature. J. Conseil, 23: 366-370.

Taylor, C.C., 1959. Temperature and growth. The Pacific razor clam. J. Conseil, 25: 93-101.

Taylor, C.C., 1960. Temperature, growth and mortality the Pacific cockle. J. Conseil, 26: 117-124.

Taylor, C.C., 1962. Growth equations with metabolic parameters. J. Conseil, 27: 270-286.

Tomlinson, P.K. and N.J. Abramson, 1961. Fitting a von Bertalanffy growth curve by least squares. Fish. Bull., 116: 3-69.

Von Bertalanffy, L., 1938. A quantitative theory of organic growth (inquiries on growth laws. II). Hum. Biol., 10: 181-213.

Walford, L.A., 1946. A new graphic method of describing the growth of animals. Biol. Bull., 90:141-147.