

Appendix 2 – Biology: sub-lethal responses

The figures of this Appendix present nearly all of the workshop biological data on sub-lethal changes, giving an overview of the range of responses to the same contaminant gradients. The plots cover the field sampling from Sites 1 to 4 in Langesundfjord (see Fig. 2 of Follum & Moe 1988) and the 4 exposure conditions C, L, M and H in the mesocosm experiment at Solbergstrand (Bakke et al. 1988). Benthic community responses are not covered here; raw data for these are given in the following Appendix and graphical presentations of the results are to be found in the papers on Community Studies.

Figures are presented in the order of the sections in this MEPS SPECIAL, with biochemical, cellular and physiological studies covered in Figs. 1, 2 and 3. Field and mesocosm plots for the same variables are placed adjacent to each other, and use common units of measurement and common axis scaling. The plots have been compiled by K. R. Clarke, M. R. Carr and H. Archer (Plymouth Marine Laboratory, U.K.).

Each response variable (or group of similar response variables) was examined for evidence of heterogeneity of variance, and then subjected to an appropriate variance-stabilizing transformation (see discussion in

Clarke & Green 1988). In nearly all cases, a \log_e transformation was appropriate. One-way ANOVAs were carried out on the transformed scales and 95 % confidence intervals constructed under the assumption of common variance across the 4 (or 5) conditions for each variable. Plot axes are of transformed scales, as indicated.

In all cases, field data (designated a, b, ...) are from the same paper as the corresponding mesocosm data (designated a', b', ...); all papers cited above, and in the figure legends, are from this MEPS SPECIAL. Field results all relate to animals sampled from 12 to 15 August, and mesocosm results to samples taken on 11 and 18 to 21 August 1986, after a 3 to 4 mo dosing period. Exceptions were the H dose mussels and control CH mussels, which were in the basins for only 3 wk; see Bakke et al. (1988) and Appendix 1 for dosing levels and tissue contaminant concentrations.

Abbreviations used throughout figure titles are: *M. e.* *Mytilus edulis*, *C. m.* *Carcinus maenas*, *L. l.* *Littorina littorea*, *P. f.* *Platichthys flesus*, *N. t.* *Nucula tenuis*; *Hep. pancreas* Hepato-pancreas, *D. Gland* Digestive gland, *Whole* Whole tissues, *Intest* Intestine.

BIOCHEMISTRY

FIELD

MESOCOSM

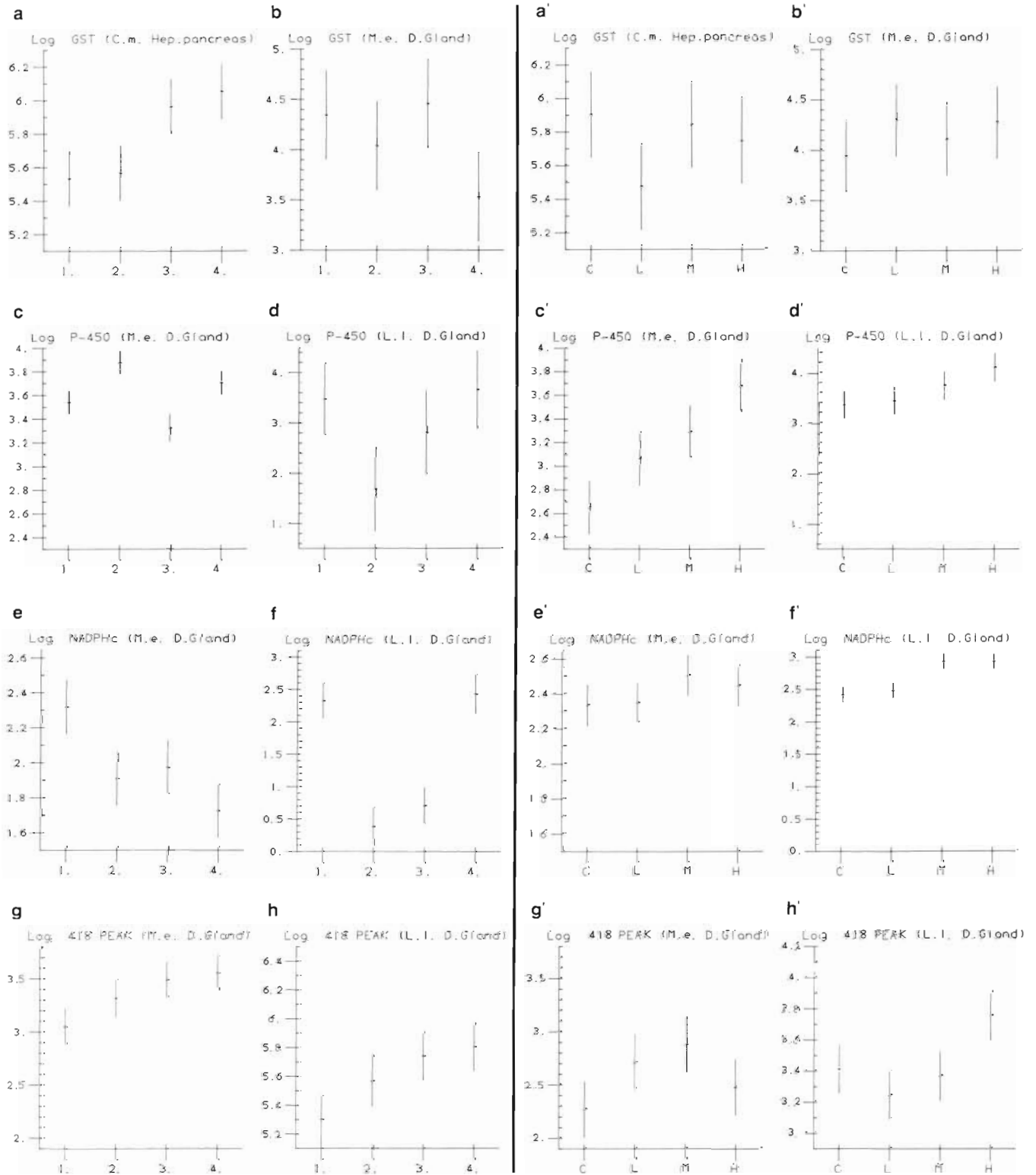


Fig. 1. *Biochemical responses.* (a), (b) Glutathione S-transferase (GST) activity; (c), (d) cytochrome P-450 content (P-450); (e), (f) NADPH-cytochrome c reductase activity; (g), (h) '418' peak. Units: (a), (b), (e), (f) $\text{nmol min}^{-1} \text{mg}^{-1}$; (c), (d) pmol mg^{-1} ; (g), (h) arbitrary. Source: (a), (b) Lee (1988); (c) to (h) Livingstone (1988)

BIOCHEMISTRY

FIELD

MESOCOSM

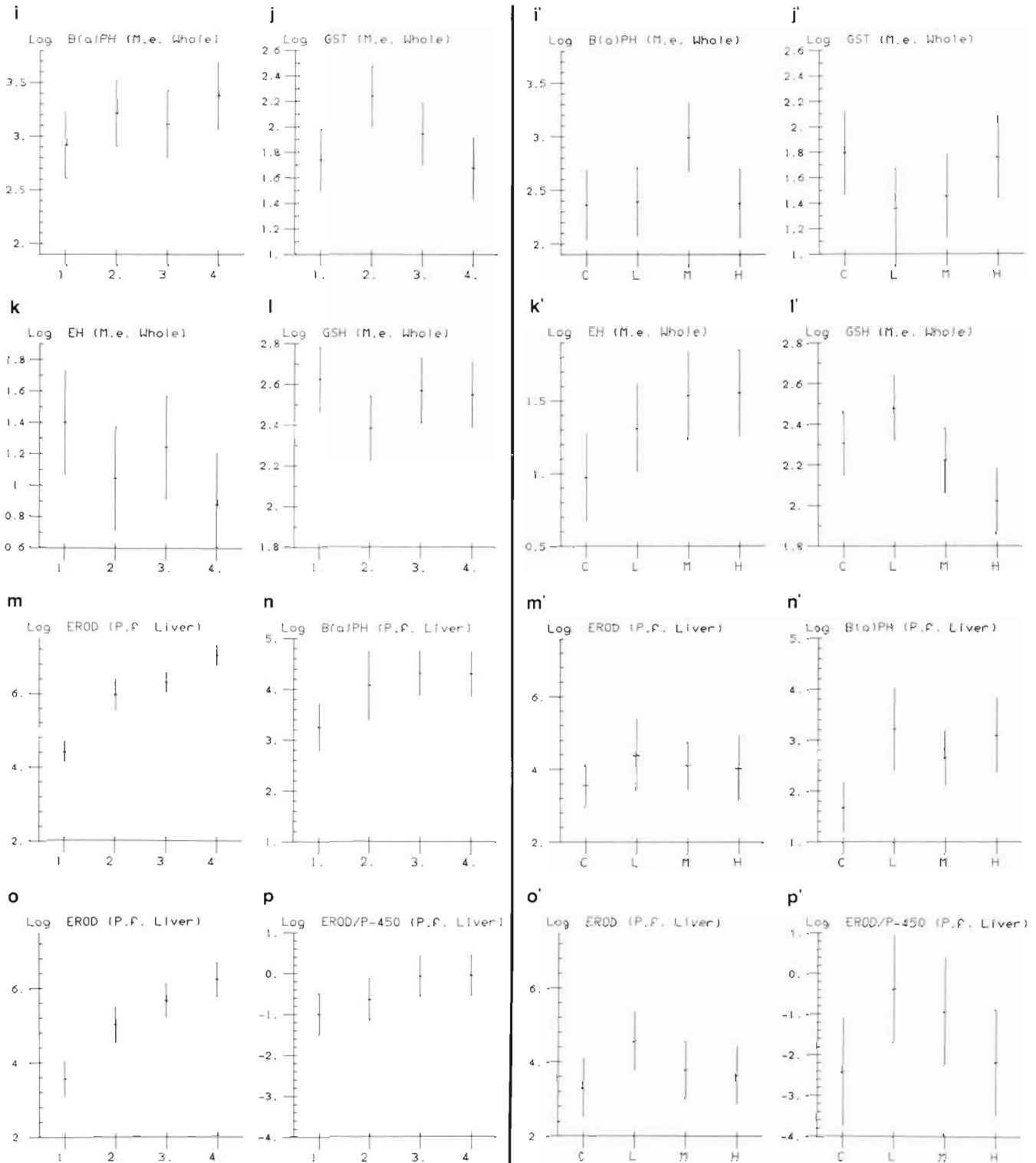


Fig. 1 (continued). *Biochemical responses.* (i), (n) Benzo(a)pyrene hydroxylase activity; (j) GST activity; (k) epoxide hydrolase activity; (l) glutathione content; (m), (o) ethoxyresorufin O-de-ethylase (EROD); (p) EROD per unit P-450. *Units:* (i), (n), (m), (o) $\text{pmol min}^{-1} \text{mg}^{-1}$; (j), (k) $\text{nmol min}^{-1} \text{mg}^{-1}$; (l) nmol mg^{-1} ; (p) $\text{nmol min}^{-1} \text{nmol P-450}^{-1}$. *Source:* (i) to (l) Suteau et al. (1988); (m), (n) Addison & Edwards (1988); (o), (p) Stegeman et al. (1988)

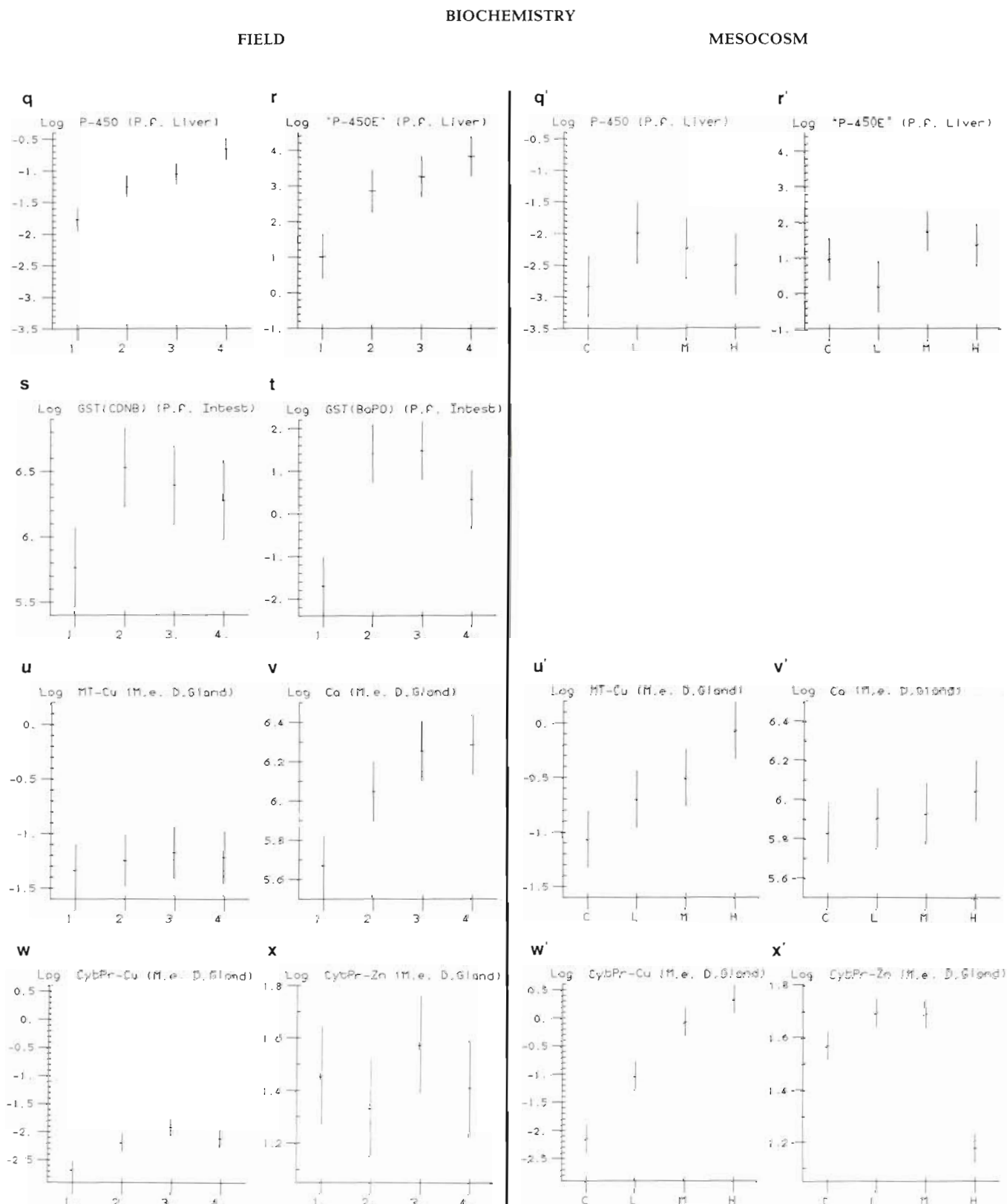


Fig. 1 (continued). *Biochemical responses.* (q) P-450 content; (r) anti-scorp P-450E content; (s), (t) GST activity (CDNB and BaPO as substrates); (u) Cu bound to thioneins; (v) Ca; (w), (x) Cu and Zn bound to cytosolic proteins. *Units:* (q) nmol mg^{-1} ; (r) pmol mg^{-1} ; (s), (t) $\text{nmol min}^{-1} \text{mg}^{-1}$; (u) to (x) $\mu\text{g g}^{-1}$ wet wt. *Source:* (q), (r) Stegeman et al. (1988); (s), (t) Van Veld & Lee (1988); (u) to (x) Viarengo et al. (1988)

BIOCHEMISTRY

FIELD

MESOCOSM

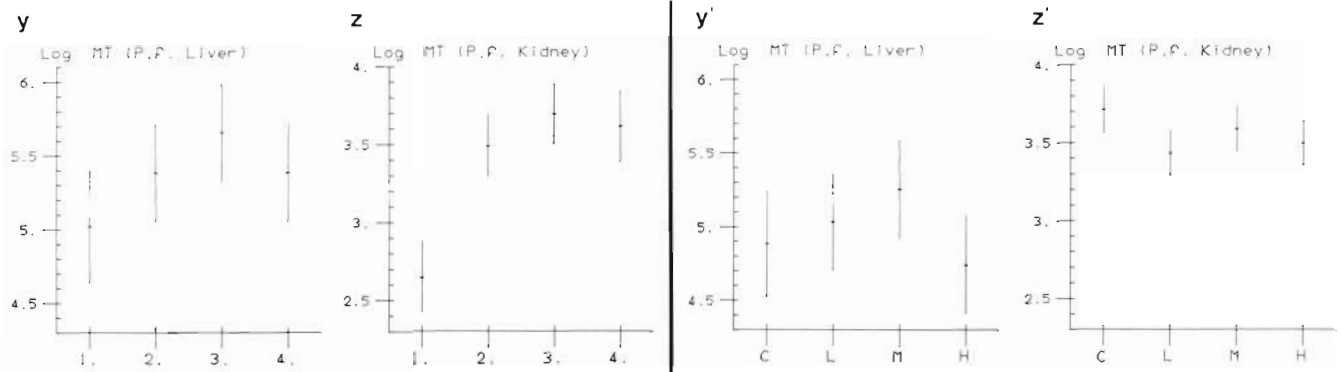


Fig. 1 (continued). *Biochemical responses.* (y), (z) Metallothionein concentration. Units: (y), (z) $\mu\text{g g}^{-1}$ wet wt. Source: (y), (z) Overnell & Abdullah (1988)

CELLULAR- AND HISTOPATHOLOGY

FIELD

MESOCOSM

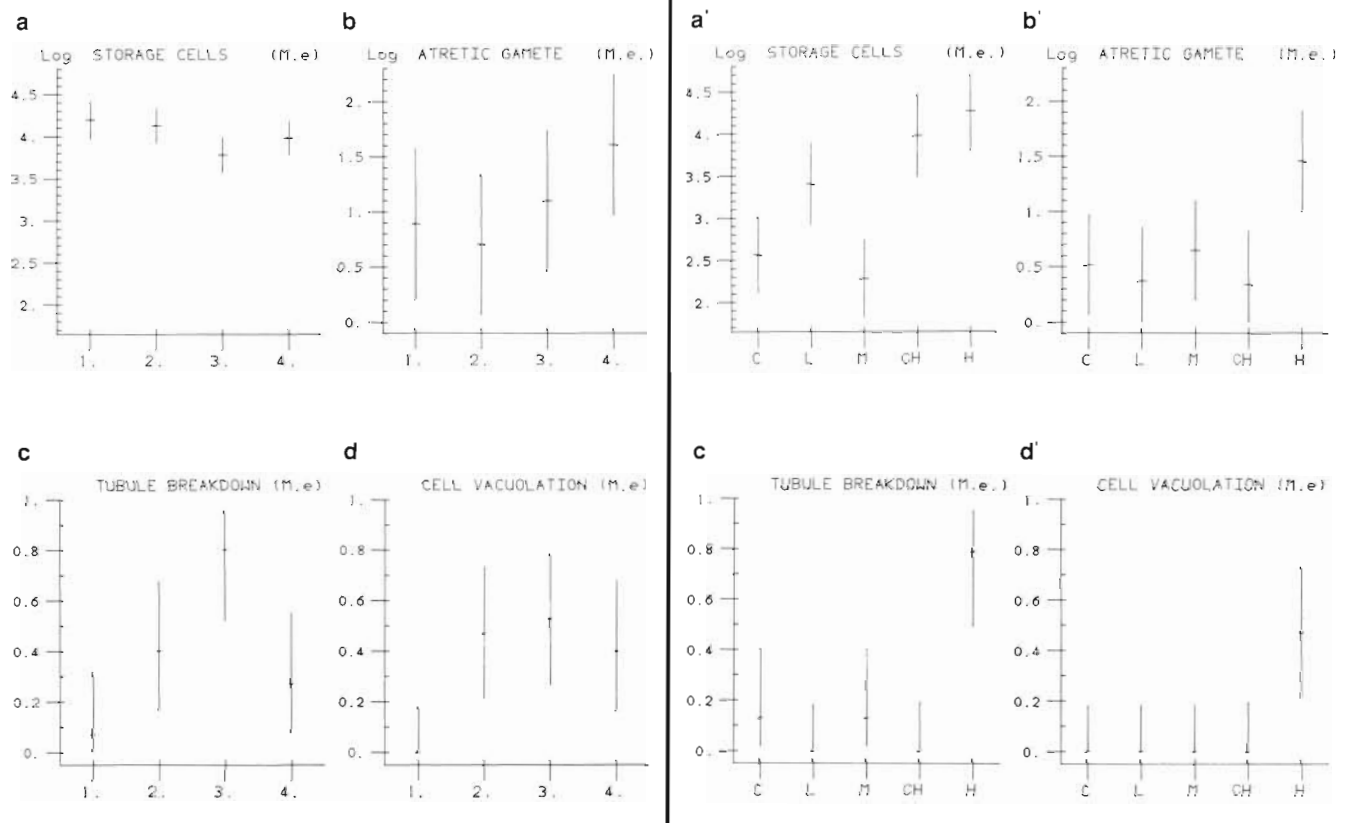


Fig. 2. *Cellular responses.* (a), (b) Storage and atretic gamete fraction in mantle tissues of *Mytilus edulis*; (c), (d) incidence of digestive epithelial cell breakdown and pyramidal cell vacuolation. Units: (a), (b) % volume; (c), (d) proportion. Source: (a) to (d) Lowe (1988)

CELLULAR- AND HISTOPATHOLOGY

FIELD

MESOCOSM

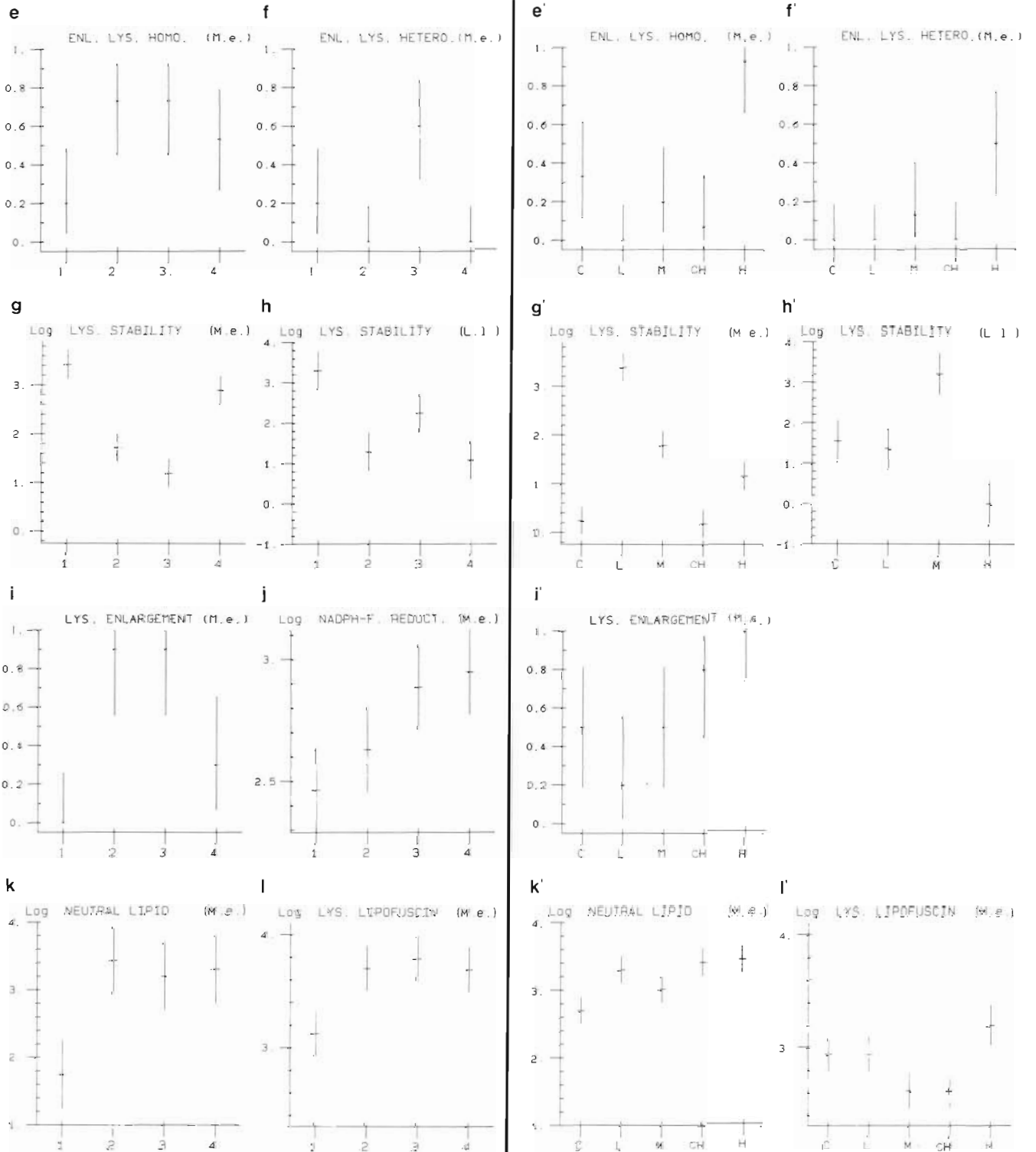


Fig. 2 (continued). Cellular responses. (e), (f) Incidence of homogeneous and heterogeneous enlarged secondary lysosomes; (g), (h) lysosome membrane stability (labilization period); (i) incidence of lysosomal enlargement; (j) NADPH-ferrohemoprotein reductase; (k) cytoplasmic unsaturated neutral lipid; (l) lysosomal content of lipofuscin. Units: (e), (f), (i) proportion; (g), (h) min; (j), (k), (l) integrated extinction. Source: (e), (f) Lowe (1988); (g) to (l) Moore (1988)

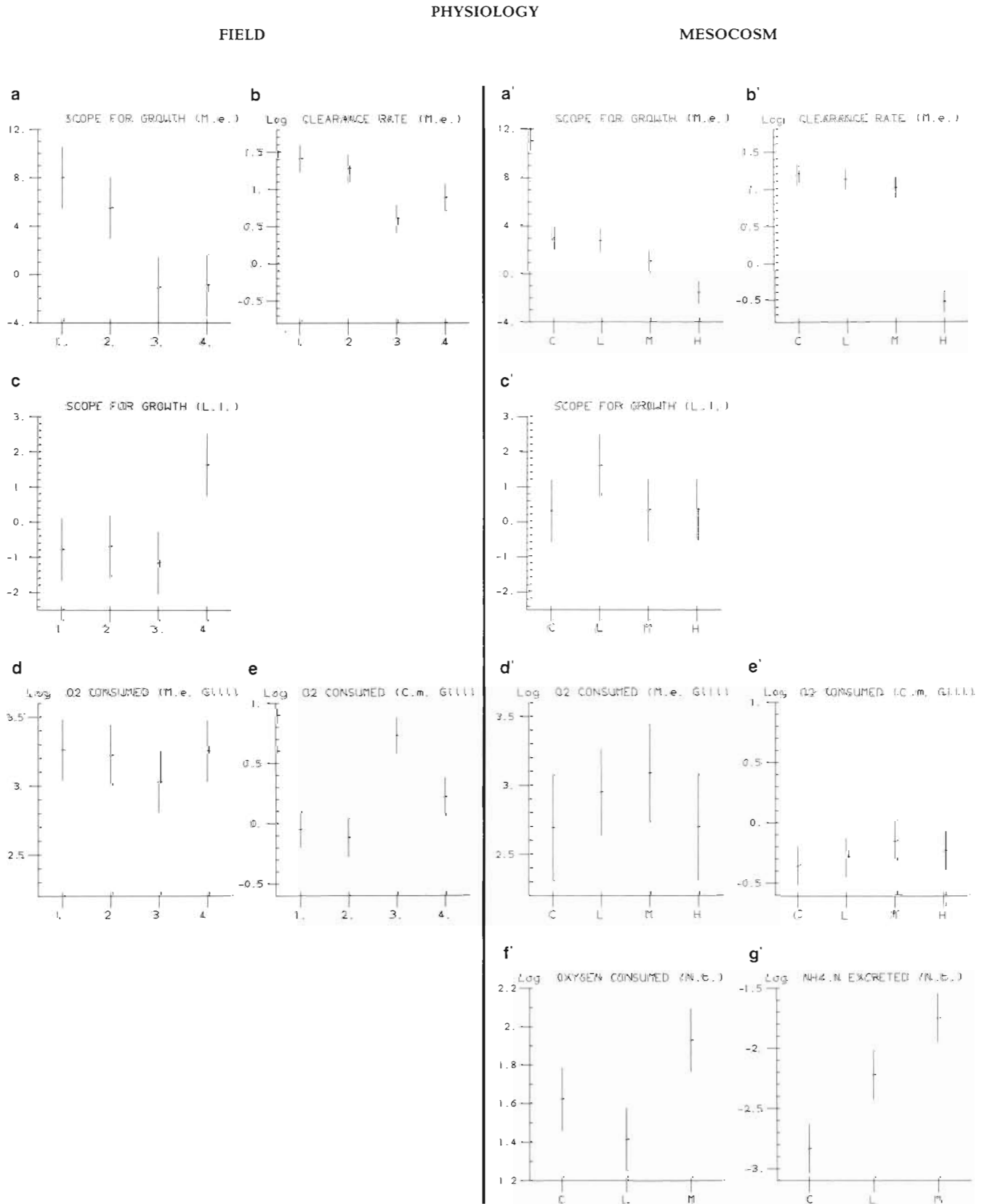


Fig. 3. *Physiological responses.* (a), (c) Scope for growth; (b) clearance rate; (d), (e), (f) oxygen consumption rate; (g) ammonia-nitrogen excretion rate. *Units:* (a) $\text{J g}^{-1} \text{h}^{-1}$; (b) $\text{l g}^{-1} \text{h}^{-1}$; (c) J d^{-1} ; (d), (e), (f) $\mu\text{l h}^{-1}$; (g) $\mu\text{g h}^{-1}$. *Source:* (a), (b) Widdows & Johnson (1988); (c) Bakke (1988); (d) to (g) Bayne & Thurberg (1988)

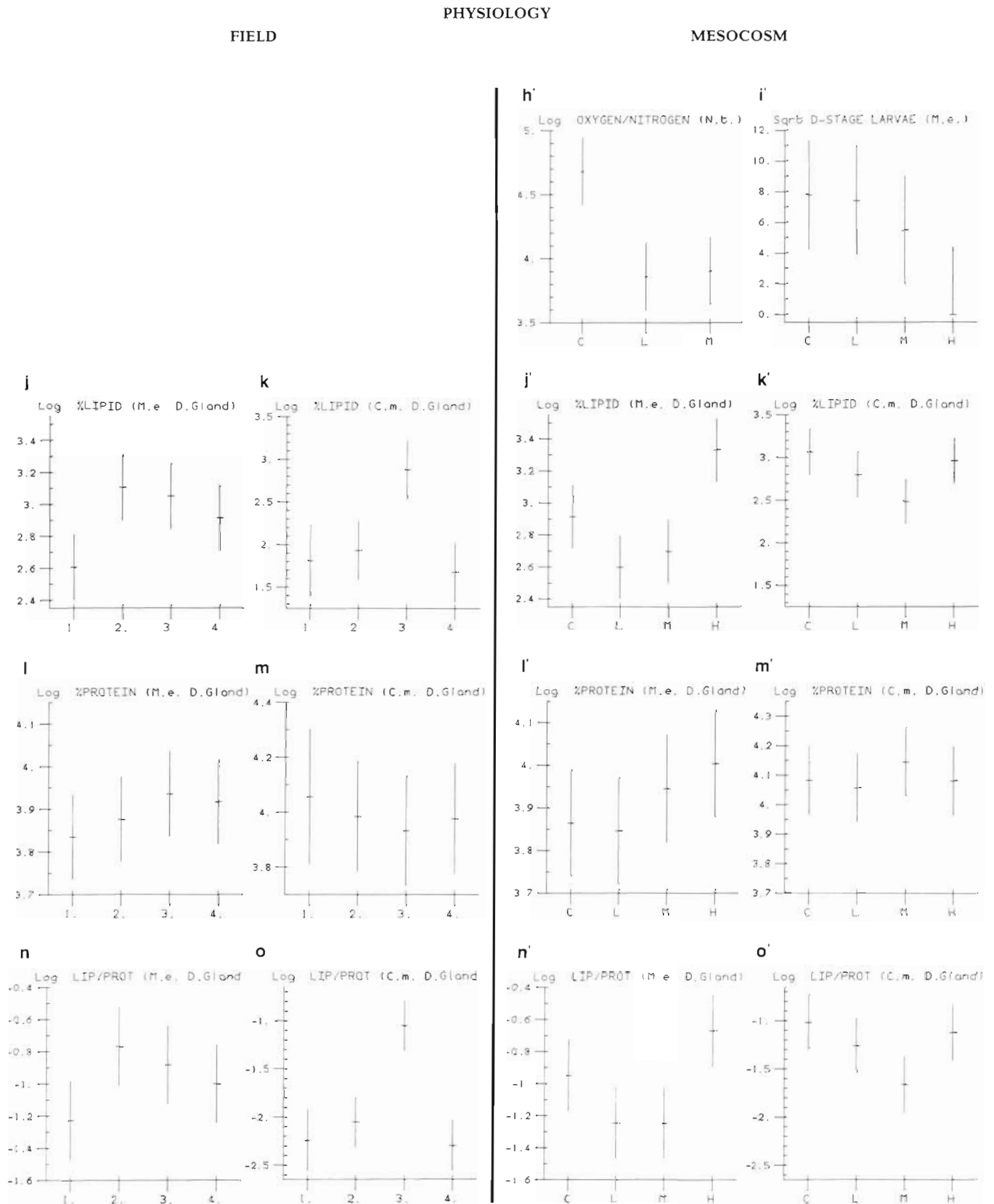


Fig. 3 (continued). *Physiological responses.* (h) Oxygen to nitrogen ratio; (i) numbers of larvae at 'D-stage'; (j), (k) lipid content; (l), (m) protein content; (n), (o) lipid to protein ratio. *Units:* (h) $\mu\text{l } \mu\text{g}^{-1}$; (j) to (m) %. *Source:* (h) Bayne & Thurberg (1988); (i) Johnson (1988); (j) to (o) Capuzzo & Leavitt (1988)