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Illumination in first feeding tanks for marine fish larvae

by

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ABSTRACT

Illumination levels were measured in three artificially illuminated tanks: a black tank, a white tank and a tank with black sides and white bottom, in order to test how well normal tank illumination in different tank types corresponds to natural illumination conditions for first feeding of marine fish larvae. Measurements were made with clear water and with algae added ("green water").

The black tank had low wall and bottom illumination. The white tank had high wall and bottom illumination. The black walled white bottomed tank had low wall and high central and bottom illumination. Green water attenuated light substantially. The black tank seemed best suited to reproduce natural illumination conditions. The white tank was not suited. The black walled white bottomed tank had interesting properties, but species specific tests would have to be carried out to fine tune the reflective properties of the bottom. Green water seemed to be beneficial in all tests.

INTRODUCTION

Most marine fish larvae are visual feeders (Hunter 1981, Blaxter 1986). Acordingly, illumination in larval first feeding tanks is of primary importance. Also, the larval eye at first feeding is very simple, with no illumination adaptation capabilities (Blaxter & Staines 1970, Neave 1984). This makes the larvae very dependent on absolute illumination, as the larval eye functions as a light meter (Huse 1992). At first feeding, many marine fish larvae are also at a very primitive general development level as a minimum of energy is invested in each egg. The larvae thus posses a very limited reportoir of stereotypic behaviour patterns, as well as a very simple positioning algorithm (Huse 1992). This behavioural algorithm governs larval positioning in order to maximize feed uptake and minimize predation. The main input parameter to this algorithm seems to be illumination (Huse 1992), and a number of investigations have described positive and negative phototaxis in marine fish larvae (e.g.: Bulowsky & Meade 1983, Corassa & Nickum 1981, Naas & Mangor-Jensen 1990, Wales 1984). Accordingly, illumination preference in different marine fish larvae, both in relation to vertical positioning (e.g.: Blaxter 1973, Matthews 1984, Swenson and Matson 1976, Wales 1984) and first feeding (e.g.: Batty 1987, Batty et al. 1990, Ellertsen et al. 1980) is extensively investigated.

In the sea, the incoming light is either highly directive (sun, moon) or less directive (skylight, stars). In an indoor fish tank the incoming light is normally highly directive from one or a few sources. When light enters and travels through water, part of it is absorbed, and part is reflected and thus scatterd by particles. The rest retains its directivity and is eventually reflected or absorbed by surfaces surrounding the water body. In a shallow water body with few particles like a clearwater fish tank the scattering and absorption of light is insignificant compared to the direct propagation of directive light. The reflective properties of the tank walls and bottom therefore become very important. The addition of algae will increase both absorbtion and scattering of light, and thus transfer the point of equilibrium from direct light towards scattered light in addition to attenuating illumination with increasing depth by absorbtion. There is reason to believe that the behaviour of a fish larva in its search for food or escape from predators will be greatly influenced by variation in these parameters. The larva is programmed for natural conditions, and this should therefore also be a guideline in tank illumination design. In the sea the horisontal and downwards vertical visual background is dark, while prey and predators reflect light and appear lighter than the background, giving good contrast. Algae and other particles scatter and absorb light, and skylight will contribute to a diffuse light environment.

Little or no litterature is available on illumination conditions in first feeding tanks. The present investigation is a small initial contribution to remedy this, and the working hypothesis is: can a first feeding tank for marine fish larvae be illuminated and otherwise optically managed to give the larvae a light environment similar to natural conditions?

MATERIALS AND METHODS

The experiments were carried out in conical tanks with an upper diameter of 128cm, a lower diameter of 115cm, and a depth of 75cm. The tanks were illuminated by 3x2 120 cm daylight type fluorescent lamps (Phillips TLD 36W/54), one set of two placed centrally over the tank, and the two others parallell with the first over the tank margins. One tank was black, one was white, and one had black sides and white bottom. The bottoms of all tanks were slightly conical, draining towards a central bottom outlet. Each experiment was run separately with only the illuminating fluorescent tubes contributing light to the tanks.

"Green water" was provided by adding Isochrysis galbana to a final concentration of 125,000 cells/ml in the tanks. The tanks were kept aerated until the start of the light measurements in order to secure a thorough mixing of the algae in the tank water.

Light measurements were carried out with a Li-Cor LI 1000 light meter with a 180o LI-192SA Underwater Quantum Sensor (Cosine corrected). Measurements were taken at 10cm intervals vertically down- and upwards, and horisontally from one wall to the other, perpendicularly to the planes of the fluorescent tubes.

RESULTS

The illumination level at the surface of the tanks were 24 microEinstein at the center and 19 near the walls. All readings used to generate the figures were standardized according to corresponding surface readings in order to even out these differences. The results of the measurements in the white walled/bottomed tank are given in fig.1. The upwards and downwards readings are summed, and the sums are presented in the figures. Fig.1A shows that the clearwater white tank was most illuminated at the walls despite lowest surface illumination here. It was darkest in the central volume, with a least illuminated cone towards the central bottom, and a tendency towards illumination stratification parallell to the wall. With green water (Fig.1B) the tank had a gradually decreased illumination from upper wall to lower center. The tank was also substantially less illuminated than without algae, and there was a tendency towards a more surface parallell stratification than in the clear water situation. The horisontal measurements (Figs.1C and D) showed a global centrolateral volume of low illumination in both situations, but with substantially lower minimum readings with green water.

Fig. 2 shows the readings from the tank with black sides and white bottom. Illumination decreased towards the bottom, more pronounced along the sides than in the center in clear water (Fig. 2A), but more evenly in green water (Fig. 2B). Horisontal readings (Figs. 2B and C) decreased towards the wall, with higher horisontal illumination readings along the bottom and surface than in midwater. With clear water the highest readings were along the bottom, while with green water they were highest along the surface. General illumination was lower than in the white tank.

Fig. 3 shows the readings from the black tank. In the clear water (Fig. 3A) the illumination was higher centrally than laterally in the upper half, and reverse in the lower. In green water (Fig. 3B) the center was less illuminated throughout the water column. Both with clear and green water the light attenuation was much higher than in the other two tanks. Horisontal readings (Figs. 3C and D) decreased towards the wall and bottom, and was highest at the surface.

DISCUSSION

Generally the results show that reflections from surfaces in a tank are very important for the light distribution in the water body. White surfaces reflect much more light than black surfaces, causing a situation of increased illumination towards white surfaces. Towards black surfaces, however, this effect is hardly discernible. It is well known that many marine fish larvae have a tendency to collect at the tank walls. There may be several reasons for this, but one can be the well documented phototaxis of fish larvae, causing them to swim to the optimally illuminated part of the tank, which may well be a reflecting tank wall or bottom. If this argument holds, the white tank clear water situation is a perfect wall trap. Already adding algae improves the situation somewhat by increasing the vertical attenuation, but tank sides and tank bottom are still the most luminous parts of the water body.

Based on the working hypothesis, the black tank seems best suited of the systems tested to provide an illusion of natural conditions. With clear water there is increased illumination towards the center in the upper part, but the oposite in the lower part. This is probably due to decreased importance of direct compared to reflected light with increasing water depth. With green water, however, there is decreased illumination towards the center throughout the water column. This is to be expected, as direct light will be equally absorbed and scattered by algae all over the tank, but reflected light will contribute most along the walls. Variations are, however, small, and the horisontal and downwards vertical background will generally appear dark.

The black walled tank with white bottom is also interesting. The reason why this layout was considered at all is the optimal conditions for visual inspection in the tank. There is an increasing illumination gradient towards the center of the tank both in the clear and green water situation which potentially should bring the larvae away from the wall by phototaxis. There is, however, also a fairly strong positive gradient towards the bottom, especially in clear water, and only species specific experiments can elucidate eventual effects of this.

In conclusion, based on the working hypothesis, the white walled tank should be avoided. The black walled tank with a lighter bottom is an interesting alternative, but total illumination and reflective properties of the bottom would have to be fine tuned for each species, as bottom reflection might easily become a light trap. The all black tank is, however, the safest and best bid in providing natural illumination. Green water seems to be beneficial in all situations.

REFERENCES

Batty, R. S. 1987. Effect of light intensity on activity and food-searching of larval herring, Clupea harengus: a laboratory study. Mar. Biol. 94:323-327.

Batty, R. S., Blaxter, J. H. S., and Richard, J. M. 1990. Light intensity and the feeding behaviour of herring, Clupea harengus. Mar. Biol. 107: 383-388.

Blaxter, J. H. S. and Staines, M. 1970. Pure-cone retinae and retinomotor responses in larval teleosts. J. Mar.Biol. Ass. U.K. 50: 449-460.

Blaxter, J. H. S. 1973. Monitoring the vertical movements and light responses of herring and plaice larvae. J. Mar. Biol. Ass. U. K. 53: 635-647.

Blaxter, J. H. S. 1986. Development of sense organs and behaviour of teleost larvae with special reference to feeding and predator avoidance. Trans. Am. Fish. Soc. 115:98-114.

Bulowsky, L. & Meade, J. W. 1983. Changes in phototaxis during early development of walley. Trans.Am.Fish.Soc. 112: 445-447.

Corazza, L. & Nickum, J. C. 1981. Positive phototaxis during initial feeding stages of walleye larvae. Rapp.Proc.Verb.Reun.Cons.Int.Explor.Sea 178: 492-494.

Ellertsen, B., Solemdal, P., Strømme, T., Tilseth, S., & Westgård, T. 1980. Some biological aspects of cod larvae (Gadus morhua L.). Fisk.Dir. Skr. Ser. HavUnders., 17:29-47.

Hunter, J. R. 1981. Feeding ecology and predation of marine fish larvae. *In* R. Lasker (ed.). *Marine fish larvae. Morphology, ecology and relation to fisheries*. pp 33-77. University of Washington Press, Seattle.

Huse, Ingvar 1992. First feeding larval sensory perception and behavioural programming: implications for systems and procedures in culture. *In*: Proc. Fish larval development symp. Bergen 1990. In press.

Matthews, W. J. 1984. Influence of turbid inflows on vertical distribution of larval shad and freshwater drum. Trans. Am.Fish. Soc. 113: 1192-198.

Naas, K.E. & Mangor-Jensen, A. 1990. Positive phototaxis during late yolksacstage of Atlantic halibut *Hippoglossus hippoglossus* (L.). Sarsia 75: 243-246.

Neave, D. A. 1984. The development of visual acuity in larval plaice (*Pleuronectes platessa* L.) and turbot (*Scophthalmus maximus* L.). *J. Exp. Mar. Biol. Ecol*. 78: 167-175.

Swenson, W. A. & Matson, M. L. 1976. Influence of turbidity on survival, growth and distribution of larval lake herring (Coregonus artedii). Trans.Am.Fish.Soc. 105: 541-545.

Wales, W. 1984. Photic behaviour and vertical migration in herring larvae. Marine Behaviour and Physiology 11: 139-156.

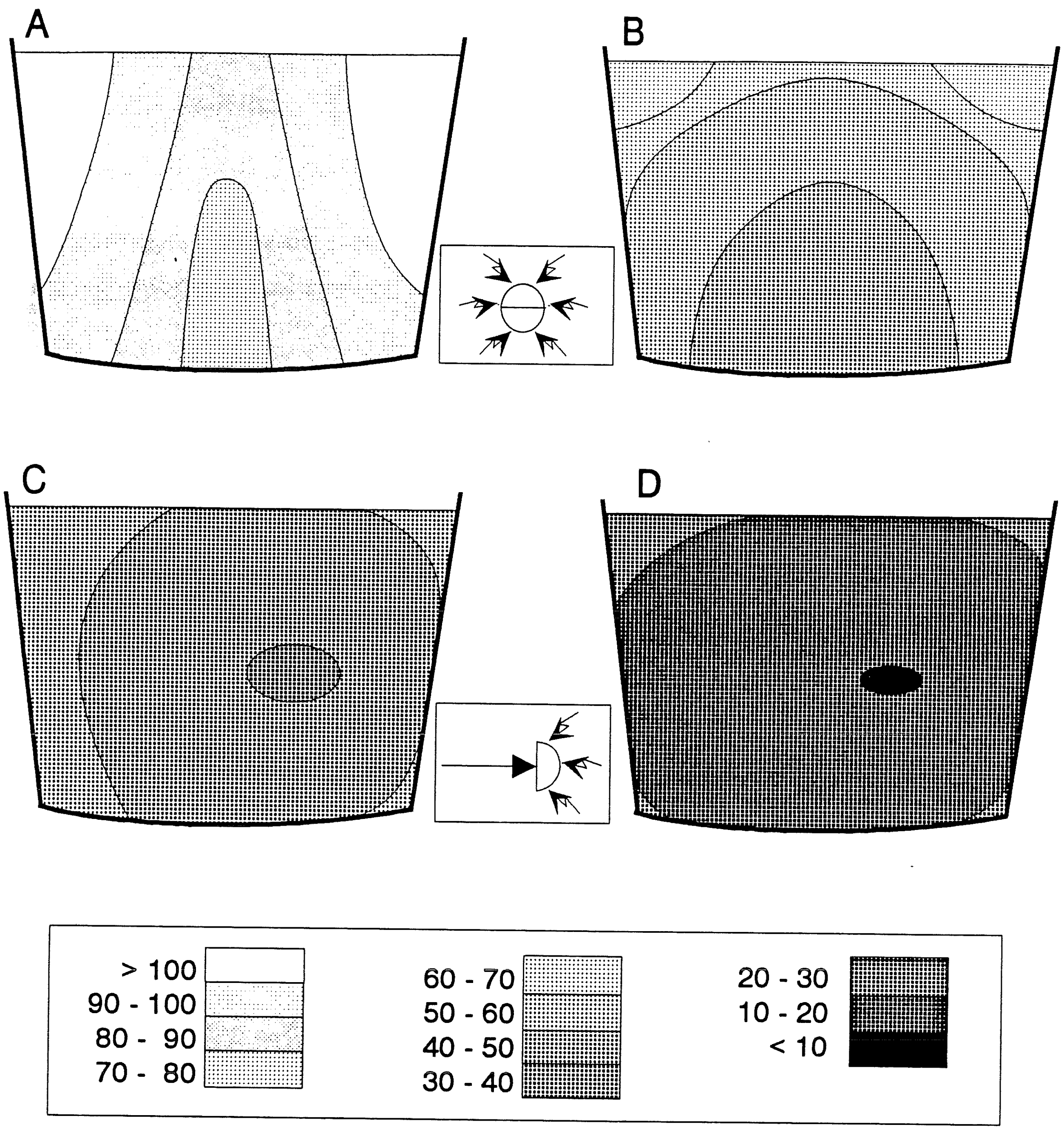

Fig. 1. Isolines of light intensities (relative values) measured in tanks with white walls and white bottom. **A**: clear water, 360°; **B**: green water, 360°; **C**: clear water, 180° (horisontal); **D**: green water, 180° (horisontal)

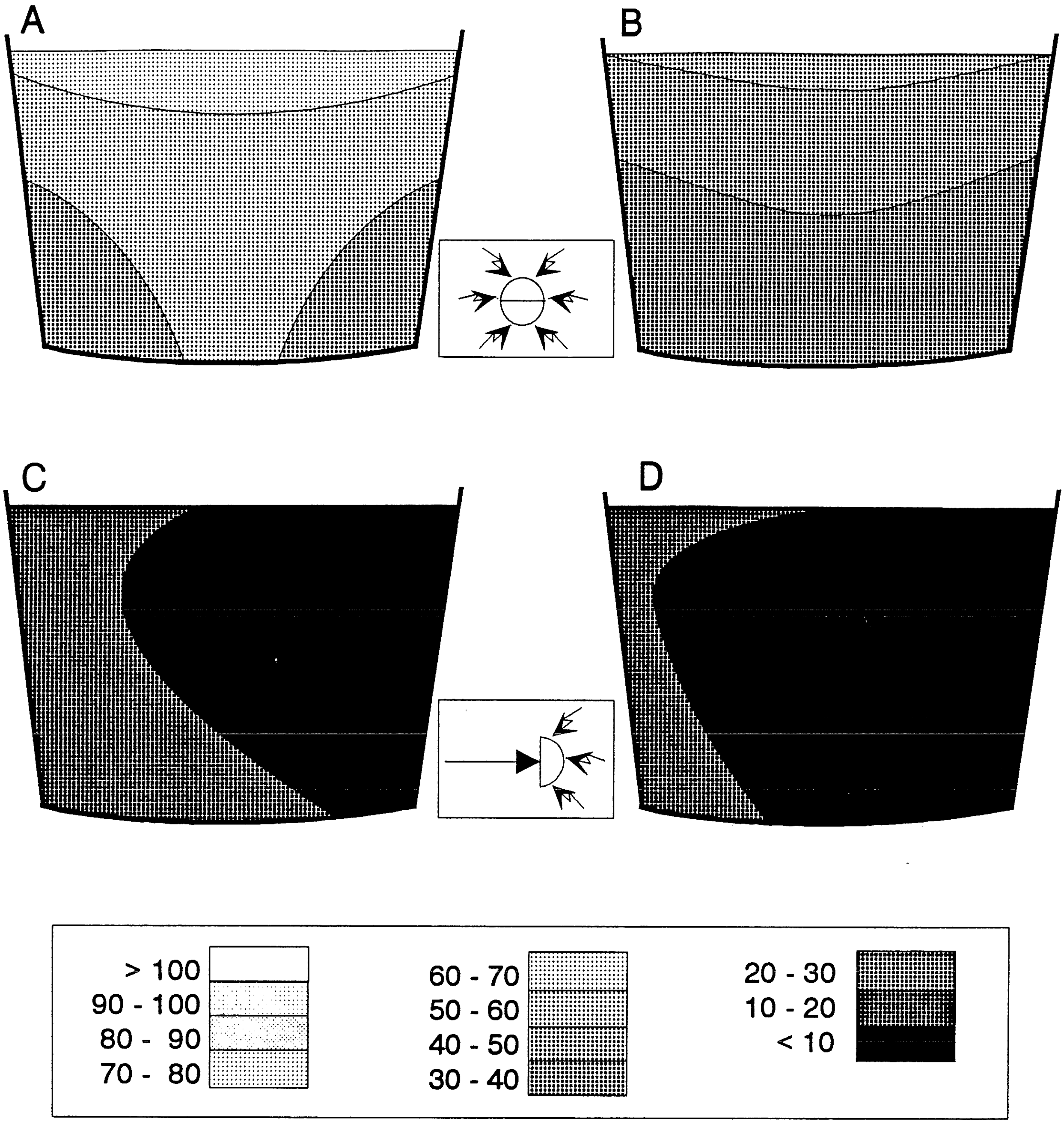

Fig. 2. Isolines of light intensities (relative values) measured in tanks with black walls and white bottom. **A**: clear water, 360°; **B**: green water, 360°; **C**: clear water, 180° (horisontal); **D**: green water, 180° (horisontal)

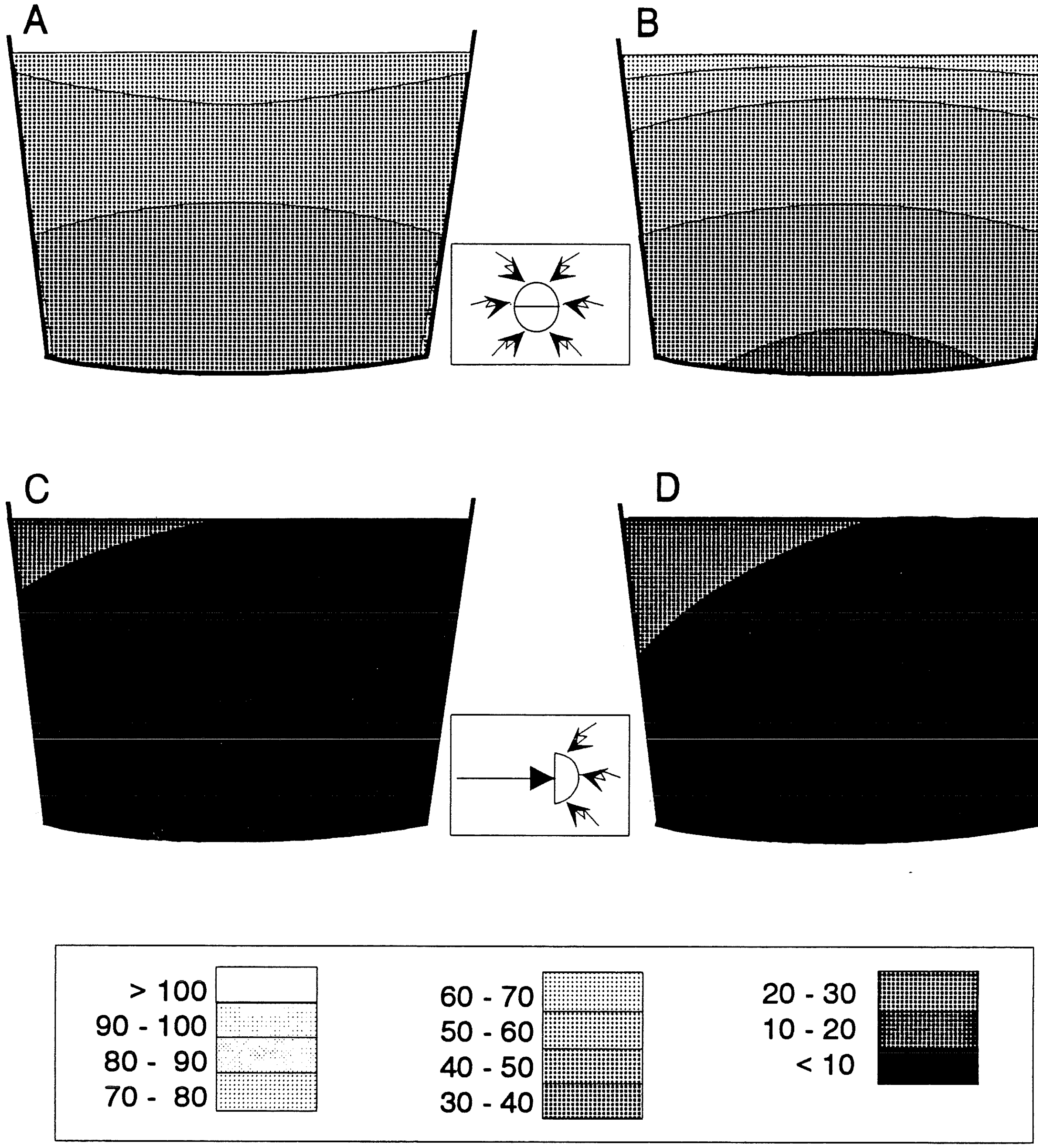

Fig. 3. Isolines of light intensities (relative values) measured in tanks with black walls and black bottom. **A**: clear water, 360°; **B**: green water, 360°; **C**: clear water, 180° (horisontal); **D**: green water, 180° (horisontal)