

Biol. Mar. Medit. (2000), 7 (2): 361 -364

Mark Dimech, Joseph A. Borg and Patrick J. Schembri
Department of Biology, University of Malta, Msida, Malta

STRUCTURAL CHANGES IN A *POSIDONIA OCEANICA* MEADOW EXPOSED TO A POLLUTION GRADIENT FROM A MARINE FISH-FARM IN MALTA (CENTRAL MEDITERRANEAN) .

Abstract

Posidonia oceanica morphological parameters were measured at increasing distance from a marine fish-farm that has been operational for 7 years. Most parameters changed significantly with increasing distance from the cages, the greatest change occurring in the first 50 m.

Key-Words: Fish-farms, Mediterranean, Pollution, *Posidonia oceanica*.

Introduction

Marine fish-farms generate large amounts of waste organic matter, most of which settles in the vicinity of the cages (Hevia et al., 1996). The deposition of particulate organic matter on beds of *Posidonia oceanica* (L.) Delile in low energy environments (weak currents) can bury the seagrass (Boudouresque et al., 1984) and completely degraded areas with only dead rhizomes have been reported under fish-farm cages (Mendez et al., 1997). High inputs of fish-farm waste also lead to increased turbidity in the water column, which diminishes the light intensity and may reduce photosynthesis (Mendez et al., 1997). In turn, this may cause death of the below-ground organs of the plant due to a reduced flux of oxygen from the leaves (Hemminga, 1998). Additionally, in nutrient rich waters, phytoplankton in the water column and epiphytes on the *P. oceanica* leaves, bloom, further reducing the light intensity reaching the plant (Mendez et al., 1997). High epiphytic cover may also cause detachment of the leaves due to drag (Boudouresque et al., 1984), as well as reduce the uptake of nutrients by the leaves (Sand-Jensen, 1977).

This study investigates the morphological changes in a *P. oceanica* meadow on the NW coast of Malta, resulting from inputs of waste from a marine fish-farm.

Materials and methods

The study area was located in St Paul's Bay on the northwest coast of the island of Malta (Central Mediterranean) , where a fish-farm has been producing *Sparus aurata* since 1991. The farm consists of eight cages linked together to form a single unit approximately 30m long by 15m. The cages are located in waters 12-16m deep. No *P. oceanica* is now present directly below the cages, but meadows start some 10m from the farm.

Sampling stations were located at the same depth but at increasing distances from the cages as follows: 10m, 30m, 50m, 90m, 170m, 330m . In August 1998, twelve shoots were randomly collected from each station by SCUBA diving. Shoot density was estimated by counting the number of shoots in a 35cm X 35cm quadrat (five replicates per station). In the laboratory each leaf was separated from the rhizomes and classified as 'adult', 'intermediate' or 'juvenile' according to Giraud's (1979) scheme.

For each station the mean number of leaves of each class was estimated. Leaf length was measured to the nearest millimetre for all adult and intermediate leaves longer than 5cm, since only such leaves contribute significantly to meadow leaf density. The epiphytic load was determined by scraping off the epiphytes from the adult and intermediate leaves (the only types that supported epiphytes) using a flat blade, and weighing them. The scraped leaves were then dried in an oven and the mean shoot biomass for each station was determined.

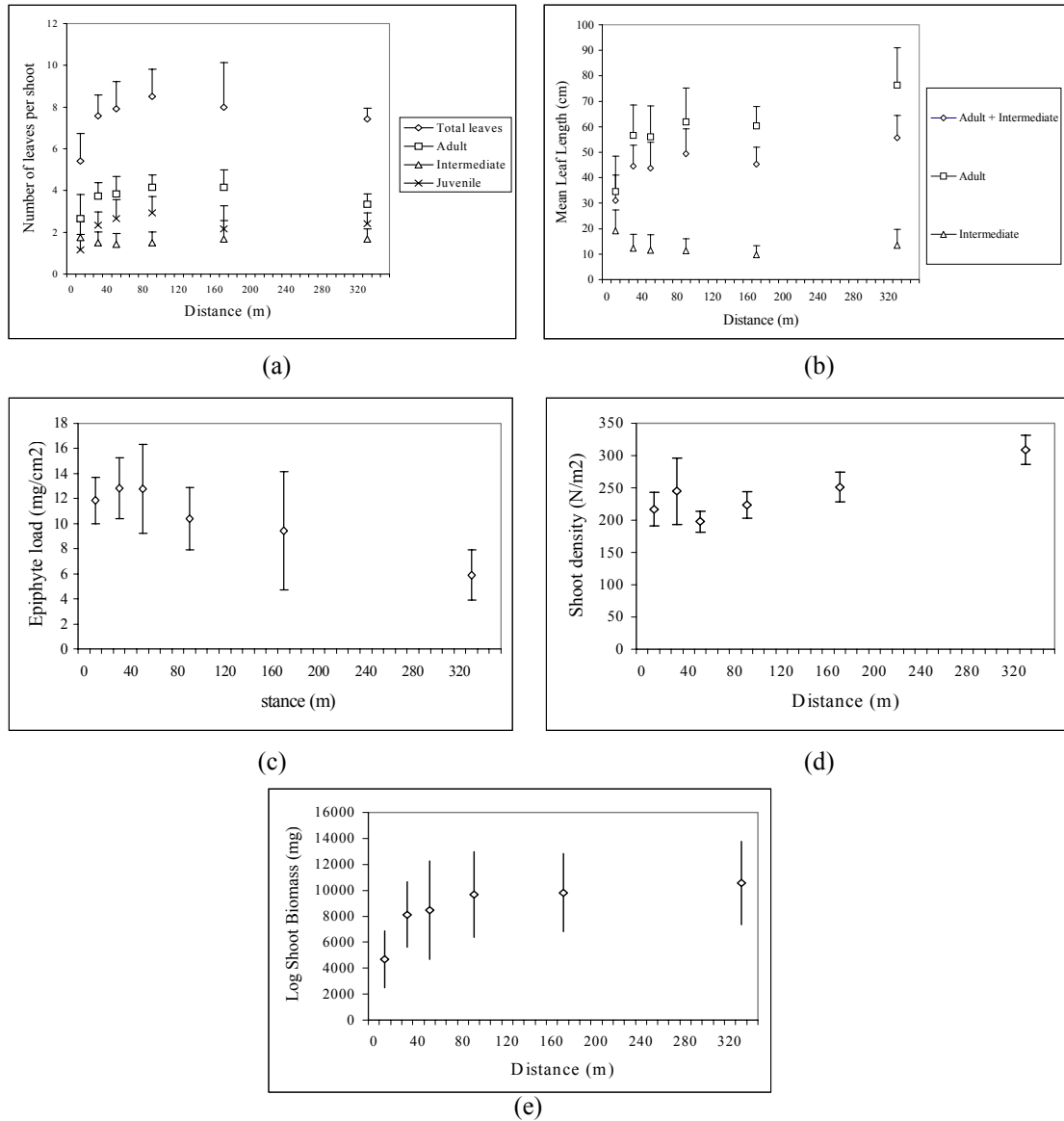


Fig 1 Changes in morphology of *Posidonia oceanica* with increasing distance from the fish-farm cages (a) mean number of total, adult, intermediate and juvenile leaves; (b) mean leaf length of adult + intermediate, adult and intermediate leaves; (c) epiphyte load; (d) mean log shoot biomass; and (e) shoot density. Bars represent standard deviations.

Results

The mean number of leaves per shoot showed no overall significant variation with distance from the cages (Kruskal-Wallis $P < 0.01$), however, the number of adult leaves at the 10m station was significantly different from that at the other stations (Kruskal-

Wallis $P < 0.05$) (Fig. 1a). There was also a significant trend of increasing mean leaf length (adult + intermediate), and of increasing adult leaf length, with distance from the cages (ANOVA $P < 0.05$) (Fig. 1b). A significantly higher value for intermediate leaf length was obtained for Station A (ANOVA $P < 0.05$). In general, epiphytic load decreased with increasing distance from the cages, however the maximum value for this parameter was reached at stations B and C (Fig. 1c). Shoot biomass and shoot density increased with distance from the cages (Fig. 1d and 1e).

Discussion

The structure of the *P. oceanica* meadow was considerably altered in the vicinity of the cages. Although the mean total number of leaves per shoot was fairly homogenous in all stations (Fig 1a), the number of adult leaves per shoot was lowest for station A (the closest to the cages). The reason may be that here adult leaves are being shed earlier.

Near the cages (station A) the total leaf and adult leaf lengths were greatly reduced, being nearly half those in station F (~30cm as opposed to 55cm for adult leaf length; see Fig. 1b) while intermediate leaf length was higher than for the other stations.

Near the cages, the elevated nutrient levels and high sedimentation rates (Cassar, 1994), and the high epiphytic cover of the leaves (Fig 1c) may cause a reduction in the light intensity reaching the photosynthetic tissues, possibly limiting photosynthesis and potentially causing death of the plant due to a reduced oxygen flux from the leaves to the below-ground organs (Hemminga, 1998).

Working in Corsica and Sardinia, Mendez *et al.*, (1997) obtained different results in that leaf length decreased with distance from the cages; they attribute this to the fertilisation effects of the nutrient inputs from the cages. The discrepancy between this and the present study could be due to the difference in the sampling seasons: summer in the present study, and spring for Mendez *et al.*, (1997). In spring, epiphytic cover is generally low but it then reaches a maximum in summer (Mazzella *et al.*, 1992). Shading effects, with all the attendant negative consequences, will therefore be more pronounced in summer as already discussed.

Only small changes in adult leaf length were recorded from a distance of 30m to 170m from the cages (Fig. 1b) but values increased again in station F, which was well away from the influence of the cages (330m). This suggests three conditions: (i) extreme stress near the cages; (ii) lower stress at intermediate distances and; (iii) unstressed conditions beyond a distance of 330m.

Shoot biomass was relatively low near the cages (station A) but was higher and relatively constant at the other stations. This indicates that, although stations B, C, D and E had lower leaf length values than station F, primary productivity at these intermediate stations was not affected. Shoot density increased with distance from the cages. The low values near the cages were due to death of the shoots which then break off from the rhizomes. Low values for shoot density were also obtained by Mendez *et al.*, (1997).

From these results the overall trend appears to be that dense epiphyte growth, high suspended organic matter and increased phytoplankton production, affect the light penetration and consequently the photosynthetic capacity of the seagrass. This, in turn, is reflected

in the leaf length. Near the cages, the combined effect of the three factors results in relatively low leaf length values. From distances of 30m to 170m the suspended organic matter and phytoplankton production is relatively lower but epiphytic load is still high resulting in an overall increase in leaf length. At a distance of 330m the three factors are low, with the result that further increase in leaf length occurs.

Acknowledgements

We are grateful to Ms Miraine Rizzo for her assistance. This study was funded by research grants from the University of Malta.

Bibliography

BOUDOURESQUE C.F., JEUDY DE GRISSAC A., MEINESZ A. (1984) - Relations entre le sedimentation et l'allongement des rhizomes orthotropes de *Posidonia oceanica* dans la Baie d'Elbu (Corse). In: Boudouresque C.F., Jeudy de Grissac A., Oliver J. (eds.) *International workshop on Posidonia oceanica beds 1*, GIS Posidonie Publ., France: 185-191.

CASSAR M. (1994) - *An investigation of the environmental impact of a marine cage fish-farm in Malta*. Unpublished, M.Sc. dissertation, Faculty of Science, University of Malta.

CLARKE K.R., WARWICK R.M. (1994) - Similarity-based testing for community pattern: the two-way layout with no replication. *Mar. Biol.* 118: 167-176.

GIRAUD G. (1979) - Polygone de frequence de longueur des feuilles de *Posidonia oceanica* (Linnaeus) Delile. *Rapp. Comm. Int. Mer Medit.* 25/26 (4), 215-217.

HEMMINGA, M.A. (1998) The root/rhizome system of seagrasses: an asset and a burden. *J. Sea Res.* 39: 183-196.

HEVIA M., ROSENTHAL H., GOWEN R.J. (1996) Modelling benthic deposition under fish cages. *J. Appl. Ichthyol.* 12: 71-74.

MAZZELLA L., BUIA M.C., GAMBI M.C., LORENTI M., RUSSO G.F., SCIPIONE M.B., ZUPO V. (1992) - Plant-animal trophic relationships in the *Posidonia oceanica* ecosystem of the Mediterranean Sea: a review. In: John D.M., Hawkins S.J., Price J.H. (eds.), *Plant-Animal interactions in the marine benthos*. [Systematics Association Special Volume No 46], Clarendon Press, Oxford: 165-187.

MENDEZ A., PERGENT G., PERGENT-MARTINI C. (1997) - Impact of fish-farming facilities on coastal ecosystems. In: Ozhan, E. (ed.), *Proceedings of the third International Conference on the Mediterranean Coastal Environment. MEDCOAST 97, Qawra, Malta*. Middle East Technical University, Ankara, Turkey: 197-211.

SAND-JENSEN K. (1977) - Effects of epiphytes on eelgrass photosynthesis. *Aquatic Botany* 3, 55-63.