Name	**Sulphide/Oxygen probe**
DPSIR class	Response
ECASA sub-group	Sediment
ECASA code	SULPROBE
Proposed by participant	1 - SAMS
Definition, computation,	Established relationship between organic enrichment processes and concentration of sulphide within the sediment pore water (Wildish *et al.* 2004). Wide range of sulphide concentrations which cause impact. There is some information in the literature regarding the level of sulphide concentration toxic to specific organisms (Bagarinao 1993, Gamenick et al. 1998, Hentschel et al. 1999, Wang et al. 1999).
Data required	Combined sulphide/oxygen probe required
Summary, scientific meaning, implementation	Marine sediments may become anoxic as a result of insufficient dissolved oxygen to maintain aerobic respiration of deposited material arising from the aquaculture operation. Under these conditions, sulphide is produced using sulphate as the terminal electron acceptor in the degradation of organic material. Sulphide is toxic to many marine organisms and can be used as an indicator of adverse impact. Several examples of measurement of sedimentary sulphide using combined electrodes (Blackburn and Kleiber, 1975; de Wit et al. 1989; Visscher et al., 1991; Heijs et al., 1999). Brooks and Mahnken (2003) give examples in the literature of this technology being used in assessment of aquaculture impacts, although many are unpublished reports.
Range of validity	Correlations exist in the literature between organic enrichment and free sulphide concentrations
Species concerned (fishes/molluscs)	
Related type of aquaculture	All
Relevant environments for this indicator	All
Geographic scale	local
Direct relevance to objectives	B – Useful in that it can be used in-situ and instant measurements are obtained. This technology could be used in the field in monitoring surveys to give information on the zone of impact of the aquaculture operation. By obtaining this information quickly, sampling stations for macrofauna could then be appropriately placed on a site specific basis, rather than using a non-site specific spacing between stations. This is particularly relevant in determining the boundary of the zone of impact which may not be known until some preliminary samples are taken (see section 9 in Annotated sheet – Macrofauna univariates for more information on sampling station positioning).
Clarity in design.	B – Clear definition of what is being measured

Realistic collection or development costs	B - There is a cost associated in obtaining the technology and in training personnel in its use.
High quality and reliability	B – Further testing of probes for use in assessing aquaculture impacts is required.
Appropriate spatial and temporal scale	B – Indictor appropriate for measuring spatial differences between stations but temporal comparisons may be influenced by environmental effects such as season. In addition, such a biochemical indicator is likely to fluctuate more on a short term basis than biological indicators such as macrofauna univariate indices.
Obvious significance	C – Careful explanation of this indicator to stakeholders will be required.
advantages	Advantages in testing and validating such a biochemical indicator relate to current trends in modelling. Many aquaculture impact models link the physics (e.g. sedimentation flux) to biology (benthic fauna response) but lack a biochemical component. Biochemical components of aquaculture models are currently being developed and having an indicator such as sulphide for validating these models will be highly useful. This may lead to a biochemical indicator which can be measured and modelled for assessing aquaculture impact alongside benthic faunal indicators.
disadvantages	Meaning needs to be explained to the end-users
references	Bagarinao, T. 1992. Sulfide as an environmental-factor and toxicant - tolerance and adaptations in aquatic organisms. Aquatic Toxicology 24, 21-62. Blackburn, T.H. and Kleiber, P. 1975. Photosynthetic sulphide oxidation in marine sediments. OIKOS 26, 103-108. Brooks, K.M. and Mahnken, C.V.W., 2003. Interactions of Atlantic Salmon in the Pacific northwest environment II. Organic wastes. Fisheries Research 62, 255-293. Gamenick, I., Vismann, B., Grieshaber, M.K., Giere, O.1998. Ecophysiological differentiation of Capitella capitata (Polychaeta): sibling species from different sulfidic habitats. Mar. Ecol. Prog. Ser. 17, 155–166. Heijs, S.K., Jonkers, H.M., van Gemerden, H., Schaub, B.E.M., Stal, L.J. 1999. The buffering capacity towards free sulphide in sediments of a coastal lagoon (Bassin d'Arcachon, France) – the relative importance of chemical and biological processes. Estuarine, Coastal and Shelf Science 49, 21-35. Hentschel, U., Berger, E.C., Bright, M., Felbeck, H., Ott, J.A. 1999. Metabolism of nitrogen and sulfur in ecosymbiotic bacteria of marine nematodes (Nematoda, Stilbonematinae). Mar. Ecol. Prog. Ser. 182, 149–158. Van Gemerden, H., Tughan, C.S., De Wit, R. and Herbert, R.A. 1989. Laminated microbial ecosystems on sheltered beaches in Scapa Flow, Orkney Islands. FEMS Microbiology Ecology 62, 87-102.

references	Visscher, P.T., Beukema, J. and van Gemerden, H. 1991. In situ characterisation of sediments: Measurements of oxygen and sulphide profiles with a novel combined needle electrode. Limnology Oceanography 36, 1476-1480. Wang, F., Chapman, P.M., 1999. Biological implications of sulphide in sediment: a review focusing on sediment toxicity. Environ. Toxicol. Chem. 18, 2526–2532. Wildish D.J., D. Dowd, T.F, Sutherland and C.D. Levings, 2004. A scientific review of the potential environmental effects of aquaculture in aquatic ecosystems. Volume III Near-field organic enrichment from marine finfish aquaculture, Can. Tech. Rep. Fish. Aquat. Sci. 2450, 117pp. de Wit, R., Jonkers, H.M., van den Ende, F.P and van Gemerden, H. 1989. In situ fluctuations of oxygen and sulphide in marine microbial sediment ecosystems. Netherlands Journal of Sea Research 23, 271-281.
State of validation	Further testing of probes for use in assessing aquaculture impacts is required.
recommendations	