

**Biofiltration and Aquaculture:
an Evaluation of Hard Substrate Deployment
Performance within Mariculture Developments**

BIOFAQs

Part C

Description of contribution to EU policies, economic
development, management and participants

15 November 1999

Does this project belong to a cluster? ~~YES~~ NO

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C3 Management and Resources

Project Management

Dr Black Kenneth will be the administrative co-ordinator of the project. Dr Black has previously co-ordinated 2 successful EU FAR/AIR projects and is responsible for the management of several major research projects relating to the environmental impacts of mariculture. As administrative co-ordinator he will be responsible for progress control, reporting and quality assurance. He will be supported in this role by Dr Dror Angel (partner 2) and Dr Martin Sayer (partner 1). This Administrative Group will have monthly meetings by conference phone or video conference to monitor the timely delivery of Work Package outputs.

The scientific aspects of the project will be managed by a steering group (SG) which includes the principle investigators from each of the Principal Contractors and the leaders of each of the Work Packages. Explicitly this group will include:

- 1 Dr Martin Sayer, CCMS.DML, UK
- 2 Dr Dror Angel, IOLR, Israel
- 3 Prof Ehud Spanier, Haifa Univ., Israel
- 4 Prof Alenka Malej, MBS.NIB, Slovenia
- 5 Dr. Ioannis Karakassis, IMBC, Greece
- 6 Dr. Helen Pickering, CEMARE, UK
- 7 Dr Ken Collins, Southampton University, UK

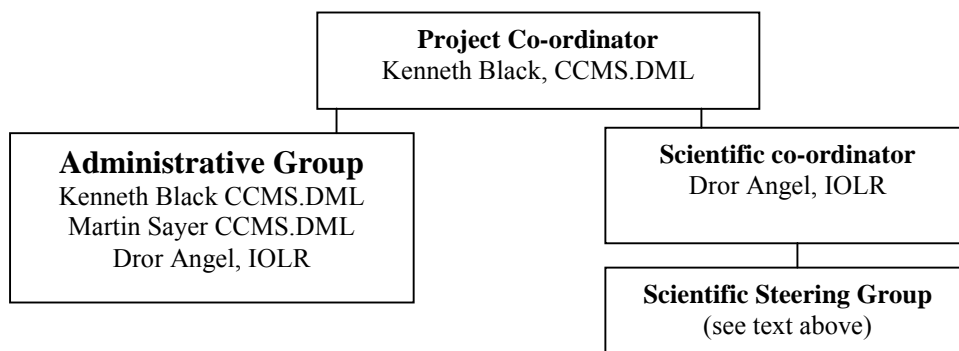
The project steering group will be chaired by the Scientific co-ordinator Dr Dror Angel from partner 2. The SG as a whole will be responsible for co-ordination of all field and laboratory science and provide a formal interface between Work Package leaders. The SG will formally meet 6 times during the project, together with other key project members, depending on the phase of the project. Of these 6 meetings three have already been provisionally arranged:

- 1 Technical workshop - beginning of year 1 to standardise research techniques and protocols across the programme, in Dunstaffnage, Oban Scotland.
- 2 Progress meeting - early/mid year 2, IMBC, Crete.
- 3 Final meeting focussed on research outputs- end of year 3, ILOR, Eilat, Israel.

The intention would be for these to be relatively short (1-2 days).

In addition to these face-to-face meetings, full use will be made of the video conference facilities of the partner institutions. The most important method of communication will, however, be emails. In addition to normal organisational intercourse, each partner will prepare a short description of progress and activities to be sent to the co-ordinator on a monthly basis. The co-ordinator will edit these together to provide a regular project newsletter not only for the information of the partners but also for use in publicising the project.

In accordance with the requirements of the Consortium agreement that will be produced for the project, a co-ordination committee (CC) will be set up. This will consist of a sub-set of the members of the SG such that all partners are represented and will meet at the same time as the project meetings. The CC will specifically deal with issues that relate to the progress, performance and allocation of responsibilities of each of the consortium partners.



<p>Work Package Leaders WP1 Martin Sayer CCMS.DML WP2 Kenneth Black CCMS.DML WP3 Ioannis Karakassis IMBC WP4 Dror Angel IOLR WP5 Helen Pickering CEMARE WP6 David Witmarsh CEMARE</p>
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Quality assurance aspects relate to methodology and research outputs. The initial project meeting will focus on establishing protocols for those methods that will be common to several sites. For example, where hard substrates are established in association with mariculture, local partners will be highly involved in maintaining basic environmental records and it vital that these are comparable between sites. For functions which are specific to one partner but will be applied across all sites, it is vital that each of the partners can trust data gathered by such specialists. It is, therefore, appropriate that each of the laboratories operate to the principles of good laboratory practice such that all data generated can be trusted as having originated from assured sources.

The key scientific outputs from the project will be peer reviewed and, therefore, have in-built quality screening. It is important that plans to produce papers for high quality international peer reviewed journals are prepared early in the project and that appropriate measures are taken to ensure that experimental design is statistically rigorous. It is recognised that it is of crucial importance that research be turned into high quality outputs. The management of this process will be a key function of the Administrative Group.

In addition to paper outputs, partners will be encouraged to present their work at important international meetings. Computer models produced or developed during the project will be made available to bone fide research users.

Regarding legal aspects; a key aspect of this project is an assessment of the legal and regulatory issues surrounding the use of hard substrates as bio-filters around fish farms. As far as is presently understood small-scale experimental use of such structures should present no significant problem for the project but the consortium is well aware of the potential legal and regulatory difficulties that might face commercial users, which will differ between countries. These will be fully explored within the project and in terms of the quality of the outputs, peer reviewed by academic, practitioner and governmental legal experts for each legal regime addressed. Intellectual Property Rights will be shared amongst the partners according to Box 8 of Part 1 of the Guide for Proposers. In addition, IPR issues will be fully discussed at the first project meeting and a formal IPR agreement signed between partners.

The Partnership

The programme partners have been identified both to utilize current expertise but also to be representative of the geographic, legal, environmental and cultured species differences in European mariculture. Each member of the consortium either offers general research capability in order to carry out the deployment and routine monitoring of the biofilter performance at one site, or has specialised skills applicable to each of the study sites or a combination of both aspects. The following table is illustrative of this but is not intended to be exhaustive.

Partner	General skills	Specialised skills
1	Biogeochemistry, experimental design and monitoring	Modelling, hydrodynamics
2	Biogeochemistry, reef deployment, biofiltration	Energy flow
3	Biological monitoring, substrate design and monitoring	Fish taxonomy & behavior
4	Biogeochemistry	Sediment trapping
5	Reef deployment, productivity assessments	Mesocosm experiments
6		Legal and regulatory comparison and analysis, economic analysis
7		Energy, oxygen and nutrient fluxes
8		Stable isotope geochemistry

Partner 1. Profile:**NERC, Centre for Coastal and Marine Sciences, Dunstaffnage Marine Laboratory (CCMS.DML) Oban, UK**

The Dunstaffnage Marine Laboratory is one of three sister laboratories that comprise the Natural Environment Research Council, Centre for Coastal and Marine Sciences. The laboratory is situated near Oban on the Scottish west coast and currently employs 104 staff. The laboratory has considerable experience in participation in international and UK multidisciplinary, multi-laboratory programmes. The laboratory has core scientific expertise in animal ecology, marine biogeochemistry and marine technology for which there is considerable infrastructure support including 2 coastal research vessels.

Dunstaffnage has a long history of research into environmental aspects of fish farming and has made major contributions at a national and international level. Current research is focussed on modelling the deposition of solids on the sea bed and consequences to infauna, the consequences of increased dissolved organic inputs to bacterial and nanoflagellate assemblages and the ecosystemic effects of the use of new sea lice treatment chemicals in the salmon culture industry.

Key personnel

Dr Kenneth Black has been involved in marine science for 8 years and has published 16 papers on a variety of topics ranging from organic chemistry to environmental impacts of aquaculture. He is currently deputy leader of the CCMS Core Strategic Research Programme on Restricted Exchange Environments which is focussed on the Scottish fjordic sea lochs. He has previously co-ordinated 2 EU projects concerning the impacts of aquaculture (AIR and FAIR). He currently supervises a Marie Curie Fellow working in this area and has considerable experience in aquaculture impacts in the Mediterranean. Dr Black has recently edited a major book in which he authored a review chapter on environmental interactions of farmed fish (Black, 1998).

Dr Martin Sayer has worked in the fields of marine science and animal ecophysiology for 15 years and has published 34 papers in the refereed primary literature and 39 technical reports. In addition he has edited a book on methods of biological control in fish farming. He is currently the deputy leader of the CCMS Core Strategic Research Programme on Impacts of Pollutants in the Marine Environment (incorporating a staff effort of approximately 200 man years over a 5 year period at an estimated cost of 19 million Euros). He currently supervises projects related to aquaculture, artificial reefs, and fish ecophysiology.

References

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- Cromey, C.J., Black, K.D.**, Edwards, A. and Jack I.A. (1998) Modelling the deposition and biological effects of organic carbon from marine sewage discharges. *Estuarine Coastal and Shelf Science*, **47**, 295-308.
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- Nickell, L.A. and **Sayer, M.D.J.** (1998) Occurrence and activity of mobile macrofauna on a sublittoral reef: diel and seasonal variation. *Journal of the Marine Biological Association of the United Kingdom* **78**, 1061-1082.

Partner 2 Profile

National Center for Mariculture, Israel Oceanographic & Limnological Research (IOLR), Eilat, ISRAEL

The National Center for Mariculture, IOLR, located at the northern end of the Gulf of Aqaba, (Eilat), was established to foster the development of marine aquaculture in Israel. Through its multidirectional research approach to domestication of marine organisms for mariculture and the development of modern technology in all aspects of mariculture, NCM has helped establish marine farming as a budding industry in Israel and the region. Mariculture also requires extensive development of innovative technology to make it economically and environmentally feasible in the modern world. NCM is busy developing such technology using basic and applied science in combination with state-of-the-art facilities in all of its areas of investigation. It plays an active role in the commercialization of its R&D through technology transfer and support to new mariculture enterprises. The Centre operates extensive sea water facilities, ranging from aquaria and fibreglass holding tanks of 250 - 8000 L up through raceways, concrete lined and earthen ponds of much larger volumes for experimental work. NCM maintains modern laboratories equipped with state-of-the-art instrumentation for research in the areas of molecular biology, biochemistry, physiology, nutrition, water chemistry and electron microscopy.

Key personnel

Dror Angel is the head of the Environmental Research group which studies various aspects of environmental impact associated with mariculture and means to reduce these impacts, i.e. to make fish farming a more sustainable activity. His research interests include marine microbial ecology and water quality issues related not only to sea-based, but also to terrestrial mariculture systems. D. Angel has been a project leader and participant in several national and international projects (Commission of EU, bi-lateral projects with France, Germany, Cyprus, USA). He has authored/co-authored many articles in internationally-refereed journals.

Noa Eden is a research scientist in the Environmental Research group. She has considerable experience in coral reef and seagrass ecology and has played an active part in the design and execution of several projects focused on understanding the impacts of fish farms on the benthic environment. Recently, her research has included the study of bacterial biofilters in recirculating mariculture systems. N. Eden is a certified skipper, and an experienced diver and underwater photographer. She will be involved in all aspects of the WP's specified for IOLR.

Relevant publications

- Angel, D. L.** and Spanier, E. 1999. Artificial reefs to reduce organic enrichment caused by net cage fish farming: preliminary results. - ICES Journal of Marine Science. (submitted).
- Angel, D.L.**, U. Fiedler, U., Eden, N., Kress, N., Adelung, D. and B. Herut. (1999). Catalase activity in macro and micro organisms as an indicator of biotic stress in coastal waters of the eastern Mediterranean Sea. *Helgolander Meeresuntersuchungen* (in press).
- Angel, D.L.**, Verghese, S., Lee, J.J., Saleh, A.M., Zuber, D., Lindell, D. and A. Symons. (1999). Impact of a net cage fish farm on the distribution of benthic foraminifera in the northern Gulf of Eilat (Aqaba, Red Sea). *Journal of Foraminiferal Research* (in press).
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- Angel, D.L.**, Eden, N. and L. Susel. (1995). The influence of environmental variables on *Halophila stipulacea* growth. *European Aquaculture Society* 25: 103-128.

Partner 3 Profile

Centre for Maritime Studies, Haifa University, Israel

The Leon Recanati Centre for Maritime Studies at the University of Haifa was established in 1972. Interdisciplinary in nature, the Centre conducts and promotes research projects, which encompass man's activities relating to the sea, bringing to light what was known in the past, man's involvement in the present and what man can accomplish by using in the future. The research group headed by **Prof. Ehud Spanier** has been involved in designing, construction and deployment of artificial reefs and ecological studies of these structures in the coastal waters of Israel since 1983. In the last two years they have been involved in a preliminary study, together with partner 2, of the use of specially designed artificial reefs as biofilters to reduce organic impact of net fish cages in the Northern Gulf of Aqaba. This has a complimentary aim of restoring biodiversity in the benthos of the impacted area. Key group skills include the design, construction and deployment of artificial reefs, ecological estimation of the effects of artificial reefs on recruitment and settlement of fish and macro-invertebrates to these structures and the behavioural-ecology of reef dwelling organisms. The Centre has the proper resources (diving and navigation gear, vehicles, etc.) and skilled manpower to perform long term and intensive underwater ecological studies.

Prof. Ehud Spanier, marine biologist: Biodiversity; Ecology and Behavior of fish and macro-invertebrates in the reefs (recruitment and habitat selection). Reef design, construction and deployment. Prof. Spanier is a member of ERRAN (European Artificial Reef Research Network) and the chairman of the Israel national artificial reefs committee. He was the president of the Israel Society for Ecology and Environmental Quality Sciences, the largest scientific society in Israel, in 1996-1998.

Stephen Breistein is a senior diving officer with wide experience of reef design, construction and deployment, SCUBA diving, underwater censuses and underwater still photography.

Amir Yurman is a diving officer and is experienced in SCUBA diving, underwater censuses and underwater video recordings.

Yossi Zilbiger is an MA Student in Maritime Studies at the University of Haifa. He has a broad biological and zoological knowledge. He is also very sophisticated in computerised analysis of video recording and in electronic literature survey.

Recent relevant publications

Spanier, E., M. Tom, S. Pisanty, and G. Almog-Shtayer, 1990. Artificial reefs in the low productive marine environment of the Southeastern Mediterranean. P.S.Z.N.I: *Marine Ecology*, **11(1)**: 61-75.

Spanier, E., 1991. Artificial reefs to ensure protection of the adult Mediterranean slipper lobster, *Scyllarides latus* (Latreille, 1803), In: *Les Espèces Marines à Protéger en Méditerranée* (C.F. Boudouresque, M. Avon and V. Gravez Eds.) GIS Posidonia Publ., Fr. 1991: 179-185.

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Spanier, E., 1994. What are the characteristics of a good artificial reef for lobsters? *Crustaceana*, **67(2)**:173-186.

Spanier, E., K.J. Collins and J. Morris, 1996. Environmental changes in an artificial reef in the southeastern Mediterranean in the last decade. Preservation of our world in the wake of change - Proceedings of the 6th International Conference of the Israeli Society for Ecology and Environmental Quality Sciences, Jerusalem, Israel (ed., Y. Steinberger). Vol. VIB, 446-448. ISEEQS, Jerusalem.

Spanier, E. 1997. Assessment of habitat selection behavior in macro-organisms on artificial reefs European Artificial Reef Research - Proceedings of the 1st EARRN (European Artificial Reef Research Network), Ancona, Italy, March 1996 (ed., A.C. Jensen), 323-336., Southampton Oceanographic Centre, UK.

Spanier, E. (1999, in press) Artificial reefs off the Mediterranean coast of Israel. Chapter 1 In: *Artificial Reefs in European Seas* (A. Jensen, K. Collins & A. Lockwood, eds.). Kluwer Academic Publishers, Hampshire, pp. 1-19.

Partner 4 Profile

Marine Biological Station, National Institute of Biology, Piran (NIB), Slovenia - Institutional profile

Marine Biological Station (MBS) located in Piran is affiliated to the National Institute of Biology in Ljubljana. The main research activities of the MBS are focused on characteristics and problems of coastal waters especially on the impact of pollution from land-based sources, coastal-dynamics, biogeochemical processes and cycling of substances, ecology of plankton and benthos. MBS has been involved in interdisciplinary projects concerning primary and secondary pelagic production, plankton dynamics, and pelagic-benthic coupling in coastal waters. Particular attention has been given to eutrophication problems (phytoplankton blooms, mucous aggregation, bottom-layer hypoxia/anoxia) in relation to freshwater inputs and hydrographic conditions. Important part of MBS activity comprises monitoring including assessment of the state of marine environment and conservation of coastal areas. MBS has taken part in a number of international projects: the environmental programme of the Alps-Adria working community, UNEP Regional Seas Programme (Mediterranean Action Plan), programmes of the Intergovernmental Oceanographic Commission, as well as EU funded programmes (project PALOMA within the Environment programme, Slovenia Coastal Zone Management Project and Coastal Oceanographic Station within Phare, TEMPUS Joint European Project).

Key personnel

Alenka Malej has a position of Associate Professor/Head of Marine Biological Station Piran at the NIB. Her main scientific interests are in plankton ecology and pollution and she has been project leader/responsible scientist in many national and international projects (UNEP MED POL, IAEA and FAO projects, Commission of EU, Alps Adria, bi-lateral projects with France, Italy, UK, USA). She has authored/co-authored over 60 articles in internationally refereed journals and over 30 in Slovenian language. A. Malej is chairperson of the National Committee for the Intergovernmental Oceanographic Commission, and a member of the tri-lateral Commission for the protection of the Adriatic Sea; she acts as National Coordinator for the Programme for Monitoring and Research of Pollution of the Mediterranean Sea.

Nives Kovaè research interests are in study of sources, fluxes and composition of suspended particulate matter in coastal waters. specifically of photochemical degradation and transformation of organic matter.

Vlado Malaèiè is Research Associate at MBS and Assistant Professor at Faculty of Maritime Studies of University of Ljubljana. He is engaged in the study of coastal water dynamics and is leading a project on sewage dispersion from submarine outfalls. In collaboration with Italian group (OGS, Trieste) he is investigating tidal dynamics of the northern Adriatic. He is member of the National Committee for the Intergovernmental Oceanographic Commission and member of Executive Board of the Slovenian Union of Geodesy and Geophysics.

Valentina Turk completed her PhD. in Marine Microbiology and has a position of Research Associate at MBS. Her research focuses on microbial foodweb dynamics in the coastal sea. She is also engaged in the national and international monitoring programmes being project leader of the monitoring programme within UNEP/WHO supported "Long-Term Pollution and Monitoring of the Mediterranean Sea".

Relevant references

- Covelli S., J. **Faganeli**, M. Horvat, A. Brambati. 1999. Porewater distribution and benthic flux measurements of mercury and methylmercury in the Gulf of Trieste (Northern Adriatic sea). *Estuar. Coastl. Shelf Sci.* 48: 415-428
- Kovaè N., **Faganeli J.**, Šket B., Bajt O. 1998. Characterization of macroaggregates and photodegradation of their water soluble fraction. *Org. Geochem.* 29: 1623-1634
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- Malej A.**, P. Mozetiè, **V. Malaèiè**, S. Terziæ, M. Ahel. 1995. Phytoplankton responses to freshwater inputs in a small semi-enclosed gulf (Gulf of Trieste, Adriatic Sea). *Mar. Ecol. Prog. Ser.* 120: 111-121
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Partner 5 Profile

Institute of Marine Biology of Crete (IMBC) , Greece

IMBC, established in 1987 by the Greek Ministry of Industry, Energy and Technology, is a research organisation focusing on the study of the oligotrophic marine environment in the Eastern Mediterranean, the anthropogenic impacts on the coastal zone, fish stock assessment, research on fish farming and genetics of marine organisms. The marine ecology research group involved in this project has a long experience on the taxonomy of marine benthic fauna, on integrated continental shelf and coastal ecosystems studies, on innovative statistical analyses regarding ecological data and on the use of underwater technology and an international expertise in the interactions of Aquaculture and the marine environment, gained through a large scale national (GR) project, as well as through participation in international working groups particularly addressing this issue (ICES, MAP, EU concerted action MARAQUA etc.)

Key Personnel

Ioannis Karakassis Since 1993 team leader on ecology of coastal ecosystems and biodiversity, responsible for the Reference Centre on the marine environment in Greece associated with the European Environment Agency (EEA). Coordinator of a national research project (OPRT 565) on the environmental impacts of Aquaculture and project manager for 10 other national RTD projects; participant in the MARAQUA concerted action (FAIR DG XII), participant in and member of the steering committee of ERMS project (MAST-III). Member of the national committee for establishing criteria on site selection for marine fish farming. FAO expert for assessing the strategic plan for the expansion of fish farming in Cyprus. Author and co-author in more than 20 reviewed publications.

Panos Drakopoulos: Senior Scientist in Physical Oceanography at IMBC. His scientific interests among others include numerical simulation of coastal and open ocean dynamics, data assimilation techniques, analysis of in situ and remotely sensed data. Author and co-author of more than 20 refereed publications.

Chris J. Smith: working on eastern Mediterranean sedimentary ecosystems for over 10 years. He is responsible for IMBC remote imaging systems (ROV's, video sled, side scan sonar and REMOTS). He has been the coordinator or principal IMBC researcher for a NATO SFS (Food chains in the Aegean), 2 MAST III, 2 DG14 on *Nephrops norvegicus*, one NATO SFS on "Trawling effects on the environment" and two DG14 projects on studies of environmental impacts of fishing gear.

Recent relevant publications:

Drakopoulos P.G. and A. Lascaratos (1998) A preliminary study on the internal tides in the Gulfs of Patras and Korinthos, Greece, *Continental Shelf Res.*, **18**:1517-1529

Drakopoulos P.G. and A. Lascaratos (1999) Modelling the Mediterranean Sea. Seasonal Forcing, *J. Mar. Systems*, **20**:157-173.

Karakassis I., Hatziyanni E., Tsapakis M. & Plaiti W. (1999) Benthic recovery following cessation of fish farming: a series of successes and catastrophes. *Marine Ecology Progress Series*, **184**:205-218.

Karakassis I., Tsapakis M. & **Hatziyanni E.** (1998) Seasonal variability in sediment profiles beneath fish farm cages in the Mediterranean. *Marine Ecology Progress Series*, **162**:243-252.

Karakassis I., Tsapakis M., **Hatziyanni E., Papadopoulou K.-N.** & Plaiti W. (1999) Impact of fish farming on the seabed in three Mediterranean coastal areas. *ICES Journal of Marine Science*, (in press)

Paspatis M., Batarias C., Tiangos P. & Kentouri M. (1999) Feeding and growth responses of sea bass (*Dicentrarchus labrax*) reared by four feeding methods. *Aquaculture* **175**:293-305.

Paspatis M., Boujard T., Maragoudaki D. & Kentouri, M. (1999) European sea bass growth and N and P loss under different feeding practices. *Aquaculture (in press)*.

Pitta P., & Giannakourou A. (1999) Planktonic ciliates in the oligotrophic Eastern Mediterranean: vertical, spatial distribution and mixotrophy. *Marine Ecology Progress Series (in press)*.

Pitta P., Karakassis I., Tsapakis M. & Zivanovic S. (1999) Natural vs. mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. *Hydrobiologia*, **391**:181-194.

Smith C.J., Papadopoulou K.-N. & Diliberto S. (1999) Impact of otter trawling on an Eastern Mediterranean commercial trawl fishing ground. *ICES Journal of Marine Science*, (in press).

Smith C.J., Papadopoulou K.-N., Labropoulou M. and Tselepides A. (1999) Megabenthic community structure and dynamics over the continental margin of north Crete. In: Tselepides & Polychronaki (eds) "Pelagic-benthic coupling in the oligotrophic Cretan Sea". Special issue *Progress in Oceanography*, (in press).

Partner 6 Profile

Centre for the Economics and Management of Aquatic Resources (CEMARE), University of Portsmouth, Southsea UK

CEMARE is a specialist research group within the Department of Economics at the University of Portsmouth. It was established in the early 1970s to promote multi-disciplinary research into marine resources, with an emphasis on the analysis of fisheries. Since then it has developed into a substantial Centre for training, advanced studies, research and consultancy, particularly in fisheries economics and management. The Centre has its own library with an extensive collection of fisheries books and journals and a specialist computer database, with on-line access to external databases. In addition, the main library of the University is a European Documentation Centre. The team within CEMARE will consist of Dr. Helen Pickering, Dr. David Whitmarsh, Carl James (Project Officer), Lorna Cromar and Dr Premachandra Wattage. Each of the individuals named have undertaken a number of research contracts and published refereed articles on aspects of this project. Their expertise will be used in both the economic cost – benefit, and the legal aspects of using artificial reefs in a biofiltration role, associated with aquaculture. Only the Project Officer and Dr. Wattage are costed.

Key personnel

Dr. Helen Pickering, BSc PhD ARICS (Professional Associate of the Royal Institution of Chartered Surveyors, Marine Resource Management Branch) - as Manager of the Centre for Coastal Zone Management and, subsequently, as Senior Research Fellow, CEMARE, has undertaken research on integrated coastal zone management, marine resource exploitation and maritime management and law. Her particular foci lie with conservation areas, marine ranching, stock enhancement, artificial reefs and institutional analysis of various maritime activities.

Dr. David Whitmarsh, BA MA PhD – is a Principal Lecturer in marine resource economics and coastal resource valuation. He has particular expertise in relation to the economic valuation of marine resource interactions and marine aquaculture.

Dr Premachandra Wattage, BA MS PhD – is a research fellow in Environmental economics, his primary research interest is in the valuation of water resources, both marketed and non-market elements.

Carl James, BSc MSc – is a Research Associate with particular interest in marine reserves and conservation areas. He has a multidisciplinary background, including marine biology, ecology, fisheries and economics.

Ms. Lorna Cromar is a legal expert with an L.L.B/DLP (Diploma in Legal Practice) and L.L.M. in European Legal Studies and specialisms in European law and Comparative law.

Indicative relevant recent publications:

Collins, A., Stapleton, M. and **Whitmarsh, D.** (1998) Fishery-pollution interactions: a modelling approach to explore the nature and incidence of economic damages. *Marine Pollution Bulletin* 36(3): pp 211-221

Milon, J.M, Holland, S.M. and **Whitmarsh, D.** (1999: in press) Social and economic evaluation methods. In Seaman, W. (ed.) *Evaluating Artificial Reefs and Related Aquatic Habitats*. CRC Press .

Pickering, H. (1999) Marine Ranching: A Legal Perspective. *Ocean Development and International Law*. Vol.30(2) . A development of a paper commissioned for the European Parliament Scientific and Technical Options Assessment Unit (STOA) workshop *Free Fish Farming at Sea* 1998.

Pickering, H. (1996) Artificial Reefs of Bulk Waste Materials: A Scientific and Legal Review of the Suitability of Using the Cement Stabilised By-Products of Coal-Fired Power Stations. *Marine Policy*. 20(6): pp.483-497.

Pickering, H. and Whitmarsh, D. (1997).Artificial Reefs and Fisheries Exploitation: A Review of the 'Attraction verses production' Debate, The Influence of Design and its Significance for Policy. *Fisheries Research*. 31: pp.39-59.

Soley, N. Nieland, A. and Nowell, D. (1994) An economic approach to pollution control in aquaculture. *Marine Pollution Bulletin* 28(3): pp 170-177

Wattage, P. (2000) New approach of incorporating environmental valuation and externalities in project evaluation: The case of water projects in Bangladesh. Paper submitted to *Journal of Environment and Planning A*.

Partner 7 Profile

University of Southampton(USOU), School of Ocean and Earth Science, UK

The School of Ocean and Earth Science (SOES) is the result of a merger between the Departments of Oceanography and Geology and is the largest component of the Southampton Oceanography Centre (SOC), a major international centre for marine and earth sciences. The Reef Group, lead by **Dr Ken Collins**, was formed in 1988 initially to study the feasibility of using cement stabilised coal ash as an artificial material and for the first time in the UK, investigate the fishery enhancement potential of an artificial reefs. The experimental reef in Poole Pay was rapidly colonised by lobsters. The behaviour of lobsters on the artificial and local natural reefs has been studied in great detail over the past 10 years, linking with MAFF fishery management requirements and research, advancing the cause of commercial lobster stock enhancement and aquaculture or ranching. A second phase of reef construction was undertaken in 1998 installing concrete and scrap tyre units to study the environmental impact of tyres in the sea. Work on the artificial reef has been wide ranging, chemical leaching and bioaccumulation studies, epibiota, macrofauna, fish, crustacea as well as the surrounding seabed infauna. In a recent collaboration with engineers, MAFF fishery scientists and mathematical modellers design criteria have been produced for enhancing the fishery potential of coastal marine structures.

Dr Phil Smith has experience in salmon fisheries and aquaculture. An investigation of feeding behaviour of farmed Atlantic Salmon in sea cages, (Dunstaffnage/Glasgow, 1990–91) aimed to assess the scope for using behavioural techniques to design feeding schedules to minimise food wastage and variability in growth rates. Underwater video was used to study the feeding behaviour of salmon in marine net pens. Seasonal and daily changes in appetite were monitored by observing the responses of fish to a standardized food presentation. Individually marked fish were used to investigate the importance of competition between fish on feed distribution. The influence of size and shape of food pellets on feeding efficiency was investigated by filming responses of fish to pellets in which length and width were varied systematically.

The group has also been involved in local environmental impact and fishery studies, for oil companies, harbour authorities and government nature conservation organisations. **Dr Antony Jensen** has a long interest in bivalve culture and is a member of the Southern Seas Fishery District committee. Active links have been forged with artificial reef workers in Italy, India and Hong Kong. Dr Jensen has successfully managed the European Artificial reef Research Network concerted action (AIR3-CT94-2144) which had 51 members and is still active following the completion of the AIR3 contract, and largely responsible for the Seventh International Artificial Reef Conference, 7-11 Oct.99, San Remo, Italy.

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Partner 8 Profile

The Jozef Stefan Institute (JSI), Ljubljana, Slovenia

The “Jozef Stefan” Institute founded 1949) is a research organisation for pure and applied research in the natural sciences and technology. Both partner 4 (NIB) and IJS are closely interconnected in research departments composed of different task teams: *IJS will act as associate contractor to partner 4*. Emphasis in basic research is given to the growth and education of young scientists, while applied research and development serve for the transfer of advanced knowledge, contributing to the development of the national economy and society in general. In view of its activities and status, Institute “Jozef Stefan” plays the role of a kind of national Institute, complementing the role of the universities and bridging the gap between science and application. The activities include research and education in the natural sciences, technology, and related fields including: Physics, Chemistry and Biochemistry, Electronics and Information Technology, Reactor Technics and Energetics, Reactor Engineering, Environmental Sciences, Protection and Ecology.

Key Personnel

Dr. Sonja Lojen

B.Sc.: Geology, University of Ljubljana, Faculty of Natural Sciences and engineering Department of Geology (June, 1988)

M. Sc.: Technical mineralogy, University of Ljubljana, Faculty of Natural Science and Engineering, Department of Geology (May, 1992)

Ph.D.: Geology, University of Ljubljana, Faculty of Natural Science and Engineering, Department of Geology (November, 1996)

Her research interests include materials science, transformation toughening of composite ceramics, processing of ceramic suspensions, stable isotope geochemistry of biogenic elements (C, N) and their biogeochemical cycling in lacustrine and marine environments

Dr. Nives Ogrinc

B.Sc., Physical Chemistry, Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia (November, 1989)

M.Sc., Physical Chemistry, University of Ljubljana, Slovenia (June, 1993)

Ph.D., Environmental Chemistry, University of Ljubljana, Slovenia (February, 1998)

Experience in stable isotope geochemistry of biogenic elements focussed on the study of carbon biogeochemical cycle in different aquatic environments (lacustrine, marine, peat), modelling of diagenetic processes. New fields of research include the control of the authenticity of food, and archaeological studies using stable isotope analysis. Collaboration with the group for Environmental Impact Assessment.

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C4. Community added value and contribution to EU policies

The project will provide community added value by the complementarity and coverage of the expertise and contacts of the partners and its contribution to EU policies (notably, Art.2 Council Regulation (EEC) No. 3760/92 of 20 Dec 92) in the ways noted below.

The project has the potential to address objectives and commitments under the CFP over the short, medium and long term. The project will address the medium and long term commitments under the common fisheries policy to mitigate the impacts of aquaculture in marine ecosystems. This will have a positive contribution to meeting the Community's objectives and international commitments on environmental protection, biodiversity and sustainability. There will be both direct and indirect benefits for the handling of waste and disease prevention within and around aquaculture operations and the potential for a secondary harvest. In terms of these benefits, positive results from the project and the subsequent adoption of artificial substrate as biofilters will assist to facilitate the continued maintenance and expansion of the sector and its contribution to fish supplies. These benefits will be felt within the industry as a whole, facilitating the Community's ability to make the most of its potential fish supplies, and by the operators of aquaculture units themselves.

The methodology used to assess pollution damage caused by intensive mariculture is of crucial importance, which is why the present research proposal will pay particular attention to establishing an appropriate valuation framework. The correct approach, we would contend, is to distinguish clearly between pollution damage costs (PDC) and pollution prevention costs (PPC), in the manner suggested by Smearman, D'Souza and Norton (1997) in their study of the external economic costs of trout farm waste water effluent in West Virginia, USA. PDC should then be assessed the techniques described above, i.e productivity-based methods and preference-based methods. Through scientific and socio-economic evaluation of the concept, both in terms of its own performance and in comparison with other potential solutions to the problem of environmental impact mitigation, the project will have a potentially significant contribution to make to the improvement of management advice in this context.

Within the area of legal research, the project will make a significant contribution to the provision of management advice through both in-depth and strategic reviews of the existing regimes and the identification of revisions necessary to ensure that the use of artificial substrate as biofilters are both feasible and appropriately managed. The production of a pan-European reference compendium in this context will extend in its relevance to associated legal and management regimes governing, inter alia, aquaculture, coastal management and planning, environmental management (including pollution mitigation), and artificial reef deployment. At the present time, national and regional legislation is not readily available in one place, particularly regional legislation. While the FAOLEX database, the various CDROMs and on-line bibliographic sources on European legislation and various national government web sites contain elements of this data, the production of a targeted reference source will prove a valuable tool for various audiences. The value-added contribution of the legal analysis within the project to the Community will also encompass the development of analytical frameworks within the field of comparative legal analysis, with particular relevance to marine and European issues. These will have benefit-transfer opportunities within Europe, along with the legal and management models identified during the review for the provision and management of the use of artificial substrate as biofilters.

In synergy the multi-disciplinary perspective adopted in the project will provide a comprehensive basis of information for use by decision-makers, at whom the outputs of the project will be aimed. By scientifically evaluating (including from the socio-economic perspective) the potential for biofiltration so far substantiated only by anecdotal evidence, and evaluating it against the alternative management strategies, this basis of information and resultant advice is strengthened. The resultant management advice may well contribute significantly to the future integration of the objectives of mitigating the impacts of farmed fish production on marine ecosystems to the objectives of the CFP to enhance fish supplies.

The project will also contribute to (on the basis of case studies in different European seas) development of methodology and tools for assessment of environmental capacity for coastal aquaculture and to EU policy concerning ecological quality of waters (Directive on the Ecological Quality of Water, (COM(93)680 final).

Smearman, S.C., D'Souza, G.E. and Norton, V.J. (1997) External costs of aquaculture production in West Virginia. Environmental and Resource Economics 10: 167-175

C5. Contribution to Community social objectives

As noted above, the project contributes to a number of the Community's social objectives. The project will address the medium and long run commitments under the common fisheries policy to mitigate the impacts of aquaculture in marine ecosystems. This will make a positive contribution to meeting objectives and international commitments on environmental protection, biodiversity and sustainability, for the benefit of local communities and society as a whole. It will facilitate the Community's ability to make the most of its potential fish supplies, and will benefit the operators of aquaculture units themselves through addressing the costs and implications of operationally induced water quality problems..

There will also be knock-on effects for other sectors of rural, coastal communities that are currently dependent on the fish industry and the local marine environment and for which other employment and income opportunities are limited. With the growing inclusion of the precautionary principle in coastal policy making and regulation, by addressing the environmental impacts of aquaculture, the future maintenance and development of aquaculture in coastal areas will be facilitated. In addition, activities dependent on water quality (notably recreation and tourism) will not be undermined.

Through scientific and socio-economic evaluation of the concept of using biofiltration, both in terms of its own performance and in comparison with other potential solutions to the problem of environmental impact mitigation, the project will have a potentially significant contribution to make to the improvement of management advice in this context.

The research will apply a methodology (MAUT) which has hitherto had only a limited application to problems of environmental valuation but which arguably has considerable potential in the present study. An excellent recent example of its application is in the elicitation of public preferences and economic values associated with environmental restoration of the Florida Everglades (Milon et al., 1999). MAUT provides an analytical framework in which the attributes of decision alternatives, and the trade-offs between them, can be evaluated. Implicit economic valuations can be inferred where one of the attributes is money. The major advantage of MAUT is that it enables comparisons to be made between different policy measures that have a diversity of environmental effects which are difficult to assess within the normal willingness to pay (WTP) framework of contingent valuation (CVM). Non-market environmental benefits from mitigating the pollution effects of mariculture that might be assessed using MAUT could include water quality improvement and biodiversity maintenance, both of which could be set alongside the costs of the different pollution mitigation schemes (including biofiltration).

C6. Economic development and scientific and technological prospects - Exploitation and dissemination plans

The results and methodology are to be disseminated through attendance at conferences, journal articles, reports and working papers. The project will be assigned an Internet homepage for this electronic publication and for wider dissemination of the other deliverables of the project and to encourage feedback and contributions from an international audience of academics and practitioners. All papers produced will be available as PDF files on the project's homepage subject to the authors' approval. Links will be established between the homepage, the partners institutions' websites and websites organised by relevant interested parties within Europe and beyond. Associated with this project will be several aquaculture SMEs who will be involved in discussions relating to dissemination of the project outcomes via trade associations and organisations at European and National level. Potential publications and dissemination activities deriving from each work package are outlined below:

WP1 Review of current knowledge base

The existing base of contacts with individuals and groups who are currently or have previously been involved in relevant research will be built on and invitations to attend the planned workshops will be made where appropriate to elicit the current state of knowledge and to obtain key information. On the basis of the review, reports will be produced, detailing the transferability and applicability of the findings of the research and methodologies used to the European context.

The deliverables given below will be aimed at the regulatory/ industrial community or at the research community as appropriate:

- Targeted summaries of the findings of the work package
- A report summarising the findings
- Academic papers for publication in refereed journals

WP2 Modelling

Models which accurately predict the effects of organic deposition from cage farms are now available in a user friendly state and are being widely taken up by the regulators across Europe but particularly in Scotland. The modelling work proposed in this programme will integrate existing models to new modules designed to encompass the range of environmental variables measured in the mesocosm and field workpackages. This integrated model will be made available with a similarly user-friendly interface by a licensing mechanism which protects the Intellectual Property rights of the owners i.e. at cost price to researchers and at a commercial rate to commercial users.

WP3 – Mesocosm Studies

While the deliverables of this project (below) are targetted mainly at Work packages 2 and 4, it is anticipated that the mesocosm work will lead to publishable outputs in its own right.

- Experimental data on design and performance that can be utilized in the modelling (WP02) and the field deployment (WP04) components of the project.
- Estimates of acceptable loading rates for each design will be obtained that will have direct relevance to farm husbandry practices.

A series of scientific papers will address the main questions answered through the mesocosm experiments such as:

- The fate of organic material settling beneath cage fish farms under different intensity of water renewal.
- The comparative analysis of the amount of settling organic material in different European regions
- The amount of chlorophyll and carbon produced by phytoplankton and attached macroalgae in different European regions and under different flushing rates
- The effect of reef design on biofiltration efficiency.

The results from this WP (as well those expected from other WPs) will also be presented in international and national conferences and symposia targeting different spectra of end users:

- EMBS, CIESM: scientific community
- ICES: Scientific community & policy makers
- EAS (European Aquaculture Society) conferences: scientists involved in Aquaculture and fish farm executives
- Hellenic Symposium of Oceanography & fisheries: scientific community, greek policy makers
- Greek federation for Mariculture annual conference: Scientists, fish farmers, politicians
- Mareamico conference (Italy): scientists, politicians, environmentalists

Results (published papers and major reports) will also become available to:

- European Environment Agency (EEA) and the associated European Topic Centre for Marine and Coastal Environment (ETC/MC)
- FAO officers in charge of Fisheries and Aquaculture
- UNEP/MAP and the associated EAM/PAP-RAC who have been active in developing recommendations for site selection for mariculture

A video report summarizing and visualizing the main achievements of the project will become available towards the end of the project.

WP4. Field Studies

Periodic reports of the findings of each of the participants carrying out field studies will be circulated among all other participants according to a preset schedule in order to enable fine-tuning of the mariculture-impact model and assessment of progress. Reports will also be made available to the immediate potential end-users; the fish farmers that provide access to the sites where field studies are carried out. These reports will serve as the basis for a number of publications and these will form the basis of the deliverables of the work package, *inter alia*:

- A report describing the function of biofilters as means to reduce the particulate and dissolved effluent load from intensive fish farms to the environment. This will focus on the generic application of this technology in a variety of different environmental conditions, as found in the coastal waters of Europe.
- Academic papers. A number of academic papers will be based on the reported summaries of the field data for publication in peer-reviewed journals, e.g. *Marine Ecology Progress Series*, *Aquaculture*.
- Technical reports. In addition to academic papers, findings will be summarized in technical reports, emphasizing the applied aspects of this innovative technology and providing easily accessible information and guidance to European fish farmers.

All outputs from this work package are destined for public dissemination and use by practitioners, regulators and academics, as both reference tools and for identification of solutions and strategies for development.

WP5. Legal Analysis and Recommendations

Targeted summaries of the findings of this work package will be produced to assist the project team in completing the other work packages of the project. These will be produced by each individual in the team for their respective allocated responsibilities and areas of expertise and co-ordinated by the coordinator of the work package. These will form the basis of the deliverables of the work package, *inter alia*:

- A report synthesising the frameworks of analysis, the existing case study and pan-European legal regimes, a typology of regimes, revisions desirable and the opportunities, constraints and caveats to their implementation - this will be by country and on a pan-European basis
- Bibliographic database of relevant literature and research in Europe and globally
- A compendium of legislation, implementation, institutional frameworks and legal sources
- Academic papers based on the targeted summaries for publication in respected refereed journals (e.g. *Ocean Development and International Law*, *Marine Policy*, *American Journal of Comparative Law*) in respect of the objectives of the work package, notably: legal models and potential for the future and methodological developments in comparative law. The themes and authorship of the papers will be decided during the initial project meeting. Electronic versions will be placed on the project's internet site.

All outputs from this work package are destined for public dissemination and use by practitioners, regulators and academics, as both reference tools and the identification of solutions and strategies for development.

WP6 Cost benefit economics

The principle mechanisms of dissemination of the results of this workpackage are inherent in the deliverables:

- A workshop report containing (i) a literature review (ii) summarising the methodology and results of the investigation
- Academic papers for publication in refereed journals
- Paper for presentation at the Annual Conference of the European Association of Fisheries Economists

The principle users of these dissemination activities will be policy makers at European, National and Regional level, the academic community and the aquaculture industry.

C7. Ethical aspects

This proposal does not overlap any of the specific ethical issues addressed in section II.7 of Part 1 of the Guide for Proposers.

C8. Safety provisions

This proposal has no particular safety requirements. Each laboratory will follow in-house safety procedures for best safe working practice. Where fieldwork involves 2 or more participants, joint protocols will be agreed prior to commencement of operations such that the safety standards of all participants are met or exceeded.

C9. Ongoing projects and previous proposals

This proposal, or a proposal similar to this, has not previously been submitted to the EU for consideration but this work follows on, as an identified research priority, from EARRN.

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