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The monitoring and regulation of marine aquaculture in Europe (MARAQUA)[1]

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SUMMARY – The MARAQUA project aims to establish scientific guidelines for Best Environmental Practice for the regulation and monitoring of marine aquaculture throughout the European Union. This paper demonstrates how the MARAQUA Concerted Action is currently using several methods, including a comprehensive literature review and production of a computerised bibliography, establishment of a "register of experts" and a world wide web site, circulation of a newsletter and a series of workshops to achieve this objective. The progress relating to the objectives of this project is briefly outlined.

Key words: Monitoring, regulation, marine aquaculture.

RESUME – *"La surveillance et la règlementation de l'aquaculture marine en Europe (MARAQUA)". Le projet MARAQUA vise à établir les directives scientifiques pour une meilleure pratique environnementale moyennant la réglementation et la surveillance de l'aquaculture marine dans l'ensemble de l'union européenne. Cet article montre comment l'action concertée de MARAQUA utilise actuellement plusieurs méthodes, y compris une révision complète de la littérature et la production d'une bibliographie informatisée, l'établissement d'un "registre des experts" et d'un site de World Wide Web, la diffusion d'un bulletin ainsi qu'une série d'ateliers pour atteindre cet objectif. Le progrès concernant les objectifs de ce projet est brièvement présenté.*

Mots-clés : *Surveillance, réglementation, aquaculture marine.*

Introduction

Aquaculture is essentially an economic development within small and medium sized enterprises that has grown substantially in most European Union (EU) countries over recent years. This development has been particularly evident in e.g. Scotland, Norway and Ireland [salmon (*Salmo salar*)], the Mediterranean [seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*)] and Ireland, Greece, Spain and France [mussel (*Mytilus edulis*) farming by line or raft] (Read *et al.*, 2000). This trend has paralleled a general decline in catchable wild fish stocks and an increase in consumer demand for fin and shellfish resources (FAO, 1999). Aquaculture therefore provides opportunities to reduce the dependence on wild stocks, to meet increased consumer demand, and to alleviate the economic impact of wild stock decline on coastal communities through the creation of new jobs and businesses (FAO, 1999; MacAllister Elliot and Partners, 1999).

The competitive use of coastal resources has highlighted the importance of satisfactory control measures to protect the natural environment and to safeguard the developing aquaculture industry. In order to achieve sustainable development of the aquaculture sector, several countries introduced regulatory, control and monitoring measures, often without considering the relevance of such measures for the safeguard of the natural environment. Several organisations have documented this situation in several parts of the world and have also recommended procedures to minimise ecological impacts (e.g. FAR, 1993).

Key problems related to modern aquaculture were recognised and addressed in 1992 and there was a proposal to harmonise the previously recommended control procedures (FAR, 1993). The need for the harmonisation of regulatory, control and monitoring procedures has been reinforced in a number of recent reports (e.g. Cowey, 1995; GESAMP, 1996). However, little further progress has been made and in general, EU countries have continued to proceed independently. A recent Directive (Council Directive 97/11/EC of 3 March 1997) amending

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Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment (CEC, 1985), which includes aquaculture in Annex II, emphasises the need for certain projects to undergo compulsory Environmental Impact Assessment (EIA), depending on scale, intensity and local conditions (CEC, 1997).

The regulation of the aquaculture sector comes under the remit of the Common Fisheries Policy (CFP) which is particularly concerned with environmental issues. In 1991, the European Commission (EC) produced a review of fisheries activities, the so-called *"1991 Report"* (EC, 1991), and stated that *"the need for rational, responsible, and sustainable exploitation of fisheries, a more effective control of the whole fishing industry, and a broad sharing of responsibilities for managing the CFP"*. As a result, a new basic Regulation establishing a Community system for fisheries and aquaculture was adopted in 1992 [Council Regulation (EEC) No. 3760/92; CEC, 1992a], together with a new regulation the following year establishing a control system applicable to the CFP [Council Regulation (EEC) No. 2847/93; CEC, 1993a]. This Regulation strengthened the controls and extended monitoring beyond catching of fish to other aspects of the CFP, such as structures, fish marketing and aquaculture. It is specifically acknowledged in Regulation 2847/93 that *"… it is necessary to include rules for the monitoring of conservation and resource management …"* and in Article 25 it is stated that *"… each Member State shall adopt provisions to verify compliance with the objectives referred to in Article 24 (regular monitoring of activities). To that end, it shall carry out technical controls, particularly in the following areas: (e) development of the aquaculture industry in coastal areas …"*. The submission of statistics on aquaculture products is also a requirement at European level [Council Regulation (EC) No. 788/96; CEC, 1996] and this resulted from an acknowledgement that *"… the impact of aquaculture on regional development and on the environment results in an increasing demand for statistics to monitor the development of this sector …".*

Using the structural funds system, the Community has created a specific fund, known as the Financial Instrument for Fisheries Guidance (FIFG), which can contribute to measures such as the withdrawal of vessels, fleet renewal, development of coastal waters and aquaculture activities [Council Regulation (EC) No. 3699/93; CEC 1993b]. In general, there is an encouragement and financial support at Community level to transfer fishermen from capture fisheries to the aquaculture sector, since there is a requirement for the overall reduction of fishing effort (Council Decision 94/15/EC; CEC, 1994a), but for no reduction in the overall demand of marine produce, as acknowledged in Council Regulation (EC) No. 788/96 (CEC, 1996). Community operations have been carried out under FIFG since 1994. This has facilitated the development of remote regions of EU Member States (e.g. west of Ireland, west of Scotland, some areas in Greece). In addition, the PESCA Initiative (up to 1999) supplemented the structural aid available under the FIFG (Council Communication 94/C 180/01; CEC 1994b).

The potentially adverse impacts of aquaculture are widely documented in the literature (e.g. Ackefors and Enell, 1990; Gowen *et al.*, 1990; Braaten, 1991). However, the actual detectable impacts are not widespread and when present, tend to be localised. It has been agreed that such impacts would be minimised or negated by the adoption of appropriate environmental safeguards including regulatory, control and monitoring procedures (NCC, 1989; Codling *et al.*, 1995; GESAMP, 1996; FAO, 1997). In addition, the aquaculture industry has a vital interest in a clean environment and therefore, in the context of Coastal Zone Management (CZM), there is a definite need to safeguard the marine environment. In 1994 a PARCOM Recommendation was issued on BEP (Best Environmental Practice) for the reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use (OSPAR, 1994). The Recommendation includes: (i) national Codes of BEP; (ii) national action programmes incorporating review, development and promotion of BEP; and (iii) the exchange of information between countries on research and development results and experiences with regulatory tools. It does not, however, specifically address the issue of harmonisation. A Code of Practice for aquaculture purposes is also included in US fisheries policies (Boehlert and Schumacher, 1997). Although there are currently requirements to produce national statistics and monitor the environmental impact of aquaculture activities, there is no overall system of monitoring and control that is widely applicable throughout Europe. In relation to this there is much to be learned from the research and development experience in some European countries, and it is proposed here that this specialised experience and expertise is utilised to harmonise regulatory, control and monitoring efforts in EU countries through the production of scientific guidelines for BEP. It is essential that such safeguards are formulated from the best available experience and expertise using the best available science and technology.

MARAQUA project objectives

The regulation, control and monitoring of aquaculture has been established to the greatest extent in Canada, some states of the US, Australia, New Zealand, Norway and Scotland and, despite the different degrees of development within these countries, the strategies are remarkably similar (e.g. Pedersen *et al.*, 1988; Codling *et al.*, 1995). The MARAQUA (Monitoring and Regulation of Marine Aquaculture in Europe) Concerted Action was established to devise scientific guidelines for BEP. This was undertaken through a study of current strategies and a review of the scientific principles and current research in specific topical areas. MARAQUA was established with the following specific objectives: (i) to prepare a compilation of the nature and scale of marine aquaculture production in EU countries from existing statistics, e.g. FAO, ICES, EU and national sources; (ii) to prepare a critical review of current and proposed licensing, regulatory and monitoring guidelines and procedures with specific reference to changes since earlier reviews; effluent control; and monitoring strategies for the assessment of environmental impact which are being developed or have been adopted; and (iii) to define scientific guidelines for BEP for harmonised regulatory, control and monitoring strategies which would be widely applicable.

Communication and progress to date

Communication between partners and other experts in the aquaculture sector throughout the EU has been promoted through the establishment of a register of experts, an information page in the worldwide web <http://www.biol.napier.ac.uk/maraqua>, circulation of a newsletter (Miller *et al.*, 1999a, 2000), production of a computerised bibliography of relevant publications (BIMAQUE; Miller *et al.*, 1999b), and a series of European workshops (three over the two year period of the programme). The topics for the three workshops were: (i) current strategies for regulation, control and monitoring; (ii) implications of current and proposed international Directives and Conventions and national initiatives; and (iii) scientific guidelines for BEP. A transregional steering committee, comprising numerous members of the partnership, was convened for each workshop to co-ordinate the work programme, evaluate progress, identify needs in relation to the objectives, and consolidate progress reports and the outcomes of workshops.

The evaluation and review of the nature and scale of marine aquaculture production and of the current practices relating to the regulation, control and monitoring of marine aquaculture was achieved through a process of literature review, and consultation and networking with experts, regulatory authorities and the marine aquaculture industry in EU member states. This was undertaken by the MARAQUA partners for their own countries and for other EU countries not represented by the partnership through a process of collaboration, thereby extending the network. The reports were presented at the first MARAQUA workshop (held at the University of the Algarve, Faro, Portugal, 6-8 September 1999) and the proceedings were published in Read *et al.* (2000). The reports of current practices emanating from this process are currently being scrutinised by all partners for analysis and determination of a scientific basis for widely applicable BEP and the determination of scientific guidelines for BEP is being achieved through a process of consultation and discussion.

It was also important to consider the implications of current, new and proposed international aquaculture regulations (e.g. EU Directives and international Conventions) for environmental safeguard of marine aquaculture. In particular, the Birds and Habitats Directives (CEC, 1979, 1992b), OSPARCOM Conventions, the Convention on Biological Diversity, ICES codes, Bern Convention, Coastal Zone Management initiatives, EC regulations on "Maximum Residue Limits" in fish (CEC, 1990a) and the labelling of foodstuffs (CEC, 1990b) are considered of utmost importance. The increasing international interest in the regulation and management of human activities taking place on the coast, especially following designation as Special Protected Areas and Special Areas of Conservation under the auspices of some of the aforementioned Directives, will also have direct implications for the control and regulation of aquaculture activities. The MARAQUA project addressed the implications of Directives and Conventions at the second workshop (held at the Institute of Marine Biology (Crete) (IMBC), Heraklion, Crete, 20-22 March 2000) and the proceedings of this workshop are currently in preparation.

A sectoral approach was used to produce guidelines for BEP. Five topic groups were established: (i) genetic interactions between farmed, cultured and wild species; (ii) the use of

hydrodynamic and benthic models for the prediction of environmental impacts; (iii) control of chemicals used in aquaculture; (iv) the scientific principles underlying environmental monitoring; and (v) socio-economic and policy issues relevant to aquaculture. Working papers were produced for each workshop and progress was documented in Miller *et al.* (1999a,b; 2000) and on the MARAQUA web site. Summaries of the final topic group reports are outlined below. The final topic group reports, with recommendations for BEP, were presented at the final workshop (held at Napier University, Edinburgh, Scotland, 28-31 August 2000) and will be submitted to the Commission on completion of the MARAQUA project. The workshop proceedings will be published as peer-reviewed papers in a special forthcoming issue of the *Journal of Applied Ichthyology*.

Genetic interactions between farmed, cultured and wild species

Marine aquaculture species, like all others, are genetically variable with respect to traits linked to performance. When genetic exchange among reproductive populations is absent or curtailed, wild populations are expected to diverge genetically under any of a number of forces – natural selection, genetic drift and bottle-necking. Where genetic structuring exists, genetic variation within species can be partitioned at levels of reproductive organisation at the population level, or at higher levels, often on a geographical basis (Youngson *et al.*, in prep.).

The population genetics of Atlantic salmon (*Salmo salar*) are relatively well-studied and genetic interactions between farmed and wild Atlantic salmon have been explored in some detail. In considering the impacts of commercial aquaculture on the genetic architecture of wild members of the same species, the case of Atlantic salmon can be treated as an exemplar – as a relatively extreme case in which any interactive effects are likely to be most clearly defined, and from which a general theory of interaction can be constructed (Youngson *et al.*, in prep).

Youngson *et al.* (in prep.) address the potential for commercially farmed species to interact with wild fish populations by way of unplanned introductions of farmed fish to the wild. The same authors present a critical review of escapes from aquaculture units, the reproduction of these escapees and the ecological interactions of their progeny. Policy and legislation adopted by the North Atlantic Salmon Conservation Organisation (NASCO) and the International Council for the Exploration of the Sea (ICES) are also discussed as well as the issues surrounding genetically modified fish for aquaculture (Youngson *et al.*, in prep.).

The use of hydrodynamic and benthic models for the prediction of environmental impacts

The current role of models in the management of environmental impacts arising from aquaculture is a developing science with much research still under development. Although many hydrodynamic and benthic models are available and have been proposed, they are not widely applied in the management of aquaculture impacts. There is also a need to improve the understanding of the wider environmental impacts of aquaculture and include this information within models in such a way that a strategy for sustainability and environmental management can be developed (Henderson *et al.*, in prep.).

Despite these problems, models are currently successfully used to facilitate the environmental management of aquaculture since (i) they may provide indications (or warning signals) which can be used for adapting monitoring strategies; and (ii) they may be used for describing well understood physical processes, such as the settling of organic material around fish cages (Henderson *et al.*, in prep.). Modelling can also provide tools for planners, producers and regulators and is therefore seen as a means to help achieve BEP within the process of aquaculture development and its environmental management. In addition, models represent a cost-effective alternative to extensive field studies that may or may not be able to differentiate between anthropogenic impacts and the large variations that occur naturally (Henderson *et al.*, in prep.). Predictions from models can be obtained quickly and are contributing to the movement from reactive to proactive management (Strain *et al.*, 1995).

Henderson *et al.* (in prep.) critically review the different types of models, their possible application and the way they can be used to improve the management of aquaculture practices. The operational needs of growers and regulators and special considerations for model

development and application are also discussed.

Control of chemicals used in aquaculture

A range of authorised chemicals are used in European marine aquaculture to safeguard animal health and welfare. These chemicals can be categorised as anti-foulants, disinfectants and medicines. EU Directives and Regulations are the principle mechanisms for the control of chemicals used in marine aquaculture in Europe although the implementation of these international regulations through national legislation is difficult and varies between countries. In spite of this variability in implementation, similar principles are evident, namely the prevention of use of unauthorised chemicals, the use of alternative treatments, and the prudent non-prophylactic use of chemicals. Costello *et al.* (in prep.) suggest that scientific guidelines for BEP, relating to the control of chemicals in marine aquaculture should be targeted at European and national level rather than at the level of individual farms.

Costello *et al.* (in prep.) review public concern regarding the control of aquaculture chemicals in relation to residues in food. Public concern has been addressed by the provision of Maximum Residue Limits (MRL) (EC Council Regulation 2309/93) based on scientific, toxicological risk assessment and monitoring of food for chemical residues. The European agency for the Evaluation of Medicinal Products (EMEA) co-ordinates the designation and marketing authorisation of MRLs within the European Union.

Costello *et al.* (in prep.) also address the environmental impacts of chemicals. The evaluation of applications for marketing authorisations is a process that may be conducted through individual member states or by the EMEA Committee for Veterinary Medicinal Products (CVMP). Authorisation should include environmental risk assessment to a common EU or international standard. However, even with a marketing authorisation, the release of a chemical to the environment requires a licence from the national authority, reflecting the need for national authorities to consider local environmental conditions (e.g. other uses of the water, dilution and degradation rates) in permitting discharges of wastes to water.

The scientific principles underlying environmental monitoring

GESAMP (1996) has suggested a working definition of monitoring as "the regular collection, generally under regulatory mandate, of biological, chemical or physical data from pre-determined locations such that ecological changes attributable to aquaculture wastes can be quantified and evaluated". Traditionally, environmental monitoring has concentrated on a few key physical and chemical parameters and organisms. Nevertheless, the current approach is to consider whole-system environmental monitoring and assessment (e.g. the forthcoming Water Framework Directive, OSPAR, 1998). Eleftheriou *et al.* (in prep.) review the practical approaches to monitoring of marine aquaculture activities currently in place in Europe. Although the background legislative framework is mostly common to all countries (European Directives and International Conventions) the procedures in place are diverse. Eleftheriou *et al.* (in prep.) acknowledge that there is a need to address the development of a monitoring approach of aquaculture operations in a stepwise manner. The same authors propose that the monitoring process should be adaptable to apply to different phases in the production cycle. In this respect they define three phases, namely, pre-operational, operational and post-operational.

In the first instance the authors suggest that as part of the pre-operational licensing process a baseline survey should be undertaken against which future monitoring can be conducted during the other two stages in the production lifecycle. In some instances an environmental statement should then be prepared and submitted as part of the licensing process. The role of modelling is considered to be essential at this stage as part of the prediction of future impacts (Eleftheriou *et al.*, in prep.). Alternative management proposals can also be derived at this stage.

The same authors suggest that a specific monitoring programme, applicable to the operational phase, should be derived after the pre-operational survey. The design and intensity of the programme prescribed should be adjusted according to the existing situation and proposed scale of operation: whether the suggested location has already been in operation; the site history (i.e. length of time it has been in operation, other uses), production volume, fish type, feeding

regimes; whether fallowed sites are intended for re-use or are permanently decommissioned, whether the area is of conservation importance (Eleftheriou *et al.*, in prep.). It is important that results from the operational monitoring programme provide warning signals regarding significant environmental impacts and inform the management system. Monitoring during the post-operational phase should be designed to provide information on the recovery of the environment after cessation of aquaculture operations (Eleftheriou *et al.*, in prep.).

Socio-economic and policy issues relevant to aquaculture

Aquaculture is a major development activity throughout the coastal regions of Europe. The social and economic benefits from these activities have helped to expand and diversify the economic bases of rural areas. The maintenance of a high quality environment for efficient aquaculture production depends on sustainable resource management and ecologically sound practices by all coastal resource users. The future success of the aquaculture industry depends on this and the improvement of public understanding of recent advances in aquaculture. The integration of aquaculture with other coastal activities will support the achievement of Integrated Coastal Zone Management (ICZM) goals which have been described as the principle means of achieving sustainable development of the coastal zone. However, a number of critical social and economic issues must be addressed before effective policies can be developed in order to support the development of sustainable aquaculture so that it can be effectively integrated with other coastal activities (Burbridge *et al.*, in prep.).

Burbridge *et al.* (in prep.) critically review current social, economic and policy issues relevant to marine aquaculture. In the context of social issues these authors discuss, changing social pressures, ownership and control of resources, rural development, public participation in aquaculture development, co-management issues and the integration of coastal resource users. The economic issues associated with aquaculture development include discussion of financial and economic analyses of aquaculture, property rights and environmental/economic impacts. Finally, Burbridge *et al.* (in prep.) discuss policy issues, namely the position of aquaculture in the coastal zone and the integration of coastal resource users and conclude with a proposal for an objective framework for the integration of social, economic and environmental parameters.

Conclusion

To summarise, by the end of the project (December, 2000), MARAQUA will have produced a review of the nature and scale of marine aquaculture in the EU and a critical review of current and proposed licensing, regulatory and monitoring guidelines and procedures with reference to the implications of national and international regulations. In addition, MARAQUA will have analysed and evaluated current practice and established scientific guidelines for BEP, using the reports from the five topic groups. A full report will be submitted to the EC upon completion of the project.

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