



**A workshop organised by the EU-funded
Collective Research on Aquaculture Biofouling**

Held on May 10, 2006 at the occasion of



in Florence, Italy

www.crabproject.com



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Summary

AQUA2006 – the combined meeting of the European Aquaculture Society and the World Aquaculture Society - brought together 3.250 participants from 86 countries in a scientific conference, a trade exhibition and several science-industry events. The European Commission, apart from having a pavilion in the exhibition, used AQUA2006 as a showcase for several EU-funded initiatives.

The CRAB project (Collective Research in Aquaculture Biofouling) is one of those initiatives focused on during AQUA2006. Apart from the workshop summarised in this document, members of the CRAB consortium also presented papers in the scientific conference and a CRAB stand in the exhibition provided a source of more detailed information to AQUA2006 participants.

34 participants from 19 countries attended the workshop. Analysis of organisation name showed that attendance was split 44% from industry (including industry associations), 44% from science and education and 12% from government institutions.

The full workshop presentations are available in PDF format on the [CRAB](#) web site.

The workshop was split into two major sessions, preceded by a general introduction to biofouling and the CRAB initiative, and followed by a presentation of the dissemination and training aspects of the project. The first session addressed the impact of biofouling on infrastructure – notably net cages, platforms, ropes, buoys and all other equipment in contact with water. The second focused on fouling of the stock species, especially shellfish and the different set of problems that this poses. Each session was comprised of a presentation by one of the RTD partners in CRAB on the status of the research being carried out, followed by a presentation from one of the SME partners on the aspects that are important to industry. The floor was then open to participants for discussion on the CRAB approach and to compare the issues in other countries.

While net drying and cleaning remain the current strategy in many countries, others are experimenting with rigid and semi-rigid netting that is cleaned underwater and provides a barrier for predation and for escapes. Copper-based treatments are still allowed and used in many countries, but environmental sustainability must be a factor in the development of non-toxic treatments.

The time and costs spent cleaning shellfish account in some cases of up to 80% of production cost. At present, techniques such as cool rooms and immersion techniques (particularly immersion in hot water – approx. 60°C) are used to kill fouling on shellfish that can then be more easily removed.

The high number of countries represented in the workshop showed the level of international interest in the CRAB initiative. Sharing experiences and the challenges that the CRAB consortium faces in terms of the success of the initiative, show that European initiatives such as CRAB are useful as a model for cooperation in other countries and regions.

About CRAB

The Biofouling problem

Biofouling is a complex and recurring problem in all sectors of the European aquaculture industry. Problem areas include biofouling on INFRASTRUCTURE (Immersed structures such as cages, netting and pontoons; equipment and structures such as pipelines, pumps, filters and holding tanks) and FARMED SPECIES (mussels, scallops, oysters etc). In the next 10 years the choice and availability of biocides for use as antifoulants will become much more restrictive within Europe with the application of the Biocides Products Directive EC 98/8/EC. Better knowledge within the sector will allow farmers to make informed choices and seek sustainable alternatives to current toxins that can cause pollution problems.

European Collective Research

Collective research is a new tool within the EC 6th Framework Research and Technological Development (RTD) Programme. Within each project, **R&D performers** carry out work for **industrial associations and groupings** representing **SMEs** in order to improve the overall competitiveness of large communities of SMEs and SME intensive sectors.

Collective research projects typically run from two to three years and cost between €2 and €5 million each. As Europe-wide initiatives, these projects aim to:

- Reinforce the technological basis of sectors;
- Develop 'technological tools', such as diagnosis methods, safety equipment, etc.
- Find solutions to common challenges such as fulfilling environmental performance criteria, meeting regulatory requirements, achieving workplace safety standards; and
- Carry out pre-normative research to help set European norms and standards.

More information is available from the [CORDIS](#) web site.

Assessing strategies

CRAB (Collective Research on Aquaculture Biofouling) is a pan-European initiative that is developing effective biofouling management strategies for the aquaculture industry. It is reviewing current fouling control techniques and technologies and selecting (and optimising) suitable strategies to combat biofouling in aquaculture. These include biological control (using natural grazers); new materials such as non-toxic antifouling coatings; electrical methods (generating biocides (Cl-) or pH shifts) and new shellfish handling and immersion techniques.

Outcomes

Key deliverables of the CRAB initiative include best practice guidelines; training courses and materials for industry workers on biofouling and suitable control techniques, sustainable antifouling strategy management and decision support tools.

A key ambition is to increase the knowledge base of the European aquaculture community. Informing aquaculture producers about the importance and extent of biofouling at a local and regional level, combined with effective training in management tools, will give them the knowledge to make informed appropriate choices for their farming situation.

The CRAB initiative, biofouling species in European aquaculture and associated problems.

Peter Willemsen

Netherlands Organisation for Applied Scientific Research (TNO)
CRAB coordinator, The Netherlands.

Peter presented the general issues concerning biofouling and its effects on the European coastal aquaculture industry. This includes the general process, the biofouling organisms frequently encountered, the problem areas and estimations of the cost effects on the sector.



The effects of biofouling on infrastructure and on stock species are the two main pillars of the CRAB project.

Improving management practice and the possibility to predict biofouling will have advantages in the following production areas:

- Improving flow rates in cages and hence the growth rate of the fish
- Decreasing the frequency of net replacement and application of fouling products (coatings etc.)
- Reducing the stress on fish from net manipulation
- Reducing labour costs in shellfish cleaning

Especially this last point was raised for many SMEs in the shellfish sector. This cost can be the difference between profitability and failure for many small, often family-run businesses. But even for larger companies, the annual cost in net replacement and treatment for a medium sized salmon farm is estimated at €120k¹.

In presenting the CRAB initiative, Peter Willemsen pointed out that there is no "one size fits all" solution to biofouling. CRAB will contribute to the knowledge base by bringing together information that in the past has remained fragmented and rather inaccessible. He emphasized the importance of learning what may be useful from developments in

¹ Own estimation by CRAB SME partners

other sectors (notably the shipping and pleasure boat sectors) for cost-effective application in aquaculture.

Antifouling strategies in CRAB

1. Biological control
2. Materials
3. Cleaning treatments (*Enzymatic cleaning*)
4. Husbandry practice (*Handling and avoidance measures*)
5. Cleaning practices
6. Electrochemical



Introduction to Biofouling in Aquaculture, Aqua2006

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CRAB is assessing the usefulness of various antifouling strategies

CRAB will evaluate the practicability and cost-benefit of the most promising strategies, and look at how strategies can be combined in the most effective way. A European biofouling baseline of farm types and site characteristics is being developed in CRAB that will allow predictability of the effectiveness of the various strategies.

He concluded by stating that more effective control and management of the biofouling problem will benefit the industry, with potential savings being 5-10% of the production value. The results from CRAB will be provided to the sector in the form of various tools that should be integrated in the overall production management protocols.

Reducing biofouling on infrastructure and equipment

Simone Dürr

University of Newcastle Upon Tyne, UK

and **Donald Fowler**

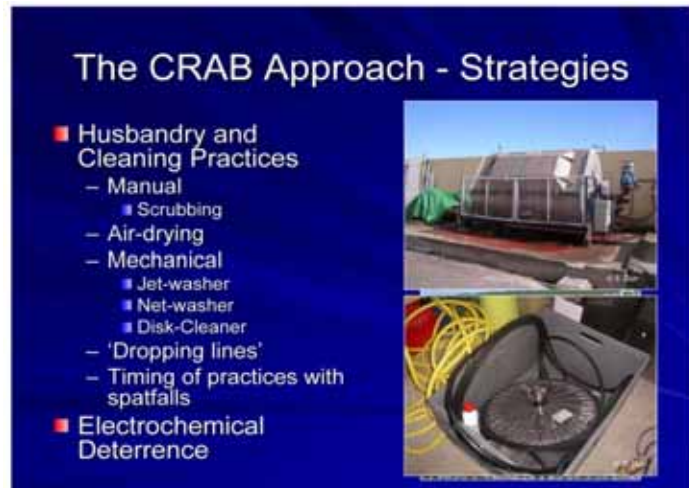
Boris Net Company Ltd, UK

Simone and Donald co-presented a more detailed review of the CRAB strategies related to infrastructure, especially focussing on nets, and the possibilities offered by the use of slow-release anti-fouling coatings.

The three main biofouling principles are to combat settlement in the first place, to prevent fouling from developing and/or to remove the biofouling (by cleaning or reducing the adhesion forces).

Net cleaning, through various methods, is the most widely used strategy in many finfish producing countries, and may be done by the company itself, or, as in the case in Norway, by specifically trained companies contracted by producers.

The cleaning may be done underwater, or on land, after drying of the nets to kill the biofouling organisms.



Various strategies are used for controlling biofouling on aquaculture nets



Non-toxic fouling release coatings may show promise for the finfish sector in Europe

Net cleaning is one thing, but net coatings are also important, especially new developments in non-toxic fouling release coatings. CRAB is testing some of these in "real-situation" farms.

However, the most important factor in managing biofouling remains the same in all locations. It is the possibility to accurately predict the occurrence of fouling episodes, especially mussel spat fall.

The discussion in this part of the workshop allowed the possibility for the CRAB partners present to exchange information with participants from European and non-European countries on the fouling problem and how to reduce fouling on infrastructure and equipment. The non-European contribution is summarised as follows:

In Chile, fouling problems are mainly caused by tunicates, mussels and algae. The fouling problem is much more severe than in other countries due to the high productivity providing ideal bio-fouling conditions. In Chilean finfish farming, standard practice is to use Copper-oxide anti fouling treated nets, which are then removed from the cages and washed on-shore in industrial net washers. Recently, rigid and semi-rigid nettings for cages are being introduced into Chile; nettings such as 'Aquagrid' and metal mesh nettings, these do not currently require antifoulants. The main reason for their introduction is better predation deterrence. They are cleaned *in situ* as they are heavy and more difficult to handle, compared to conventional nylon netting. However, fish welfare may be improved due to the anti-predator properties of these nettings, possibly creating less stress. Furthermore, (salmon) escapes are a big issue in Chile (as in other salmon-producing countries, and nets that can prevent escapes are being tested. In Norway, the increase in cod production is accompanied by important efforts to reduce escapes, which cod seem particularly adept at doing. Cod eat their way through nylon mesh (as do sea bream in the Mediterranean) netting, particularly at the base of nets. The use of polyester or 'dyneema' mesh can help eliminate this issue.

The preferred cleaning method for 'Aquagrid' is the underwater disk-cleaner. Cleaning has to be carried out on a regular 3-4 week cycle otherwise nets become badly fouled. Cleaning also provides improved welfare conditions. Labour costs for cleaning could be an issue in higher wage economies. In addition, these new nettings are much more expensive. Cost/benefit is therefore an important issue in appraising their efficiency.

In Canada (as in Chile) the major fouling organisms suggested as the main biofouling problem species in Canada are tunicates (*Ciona intestinalis*), algae, mussels and barnacles. The usual approach in fish farming is to use copper treated netting as antifoulant (as in Chile). The allowed copper incorporation rate is 20% higher than the levels used in European aquaculture. Air drying of nets is also used. Poly-culture techniques are currently being investigated. Research is showing that mussel culture introduced close to finfish farms may help to reduce settlement of tunicates.

From **Brazil** (from a shrimp farmer - this farm type is not included in the CRAB project). Participants indicated fouling in shrimp pools are mainly on the aeration paddle wheel, and this problem is solved by air drying and cleaning. In **Australia**-shrimp farming: participants indicated fouling on the paddle wheels was an issue primarily caused by barnacles and *Ulva* species.

In **New Zealand**, the fouling problems are caused by tunicates. The participant feels that invasive species will become more important in the near future.

In conclusion, the CRAB findings so far have been shown to be valid also for other countries. Similar solutions in finfish farming are being tried in Canada and Chile. Major fouling organisms seem to be tunicates, mussels and algae. Approaches against the problem are various and seem to be country/region and equipment specific.

Reducing biofouling in shellfish cultivation

Douglas Watson

University College Cork, Ireland
and **John Icely**,
Sagres, Portugal.

Douglas presented the status of CRAB work on shellfish biofouling. Antifouling measures are based on husbandry and cleaning methods and involve manual or mechanical cleaning, facilitated by dipping (for example in hot water) and air drying. There is of course a crossover between the fouling on the shellfish themselves, and the fouling of infrastructure, buoys, lines, trays, lantern nets etc. mentioned in the previous section. Once again, the timing of any treatment is of primary importance.



However, CRAB is also assessing other strategies, including the use of grazers such as sea urchins (*Paracentrotus lividus*) and sea snails (*Monodonta lineata*) – shown on left – in shellfish trays.

The possibility of allowing tunicates to foul shellfish is also being explored. The tunicates would prevent other fouling organisms taking hold, and are easy and therefore cheap to remove.

Furthermore, special shellfish coatings are being looked into for their efficacy.

John Icely, an oyster producer based on the Algarve coast in Portugal, summed up in simple words the costs and benefits of being involved in CRAB. He presented some basic data on the time (personnel cost) that is spent in cleaning oysters prior to being sold, or being re-stocked.

When management fails, one day's labour can easily become 6 times the effort. This translates into one person day at €35 becoming €210. For John and many other family-owned shellfish producers across Europe, the potential is high and may even represent actual economic viability in the sector.

What happens when management fails?



Time to process nets increases
Time to prepare shellfish for sale increases
Time to clean lantern nets increases

1 days labour >>> 6 days labour
One person day at 35 Euros >> 210 Euros

Biofouling is effectively a management issue



The involvement of Sagremarisco Lda (Portugal) in CRAB is to look for effective ways to reduce labour cost in shellfish cleaning

The exchange between workshop participants from the shellfish sector gave rise to the following observations:

In **Australia** (one Pacific Oyster [*Crassostrea gigas*] farmer was present) the problem is not a particularly important one. Most of the farming of oyster there is carried out at intertidal sites and, due to the weather and the frequent turning of bags/infrastructure, the fouling on the shells and the material infrastructure does not appear to become pronounced. These conditions separate it from other parts of the world as they provide conditions, which are not ideal for extensive fouling. Any fouling on the equipment could easily be removed while the structures are being handled.

In addition to the intertidal nature of the farms contributing to reduced fouling, these sites also employ techniques such as cool rooms and immersion techniques to control fouling on the shellfish. Such techniques (particularly immersion techniques in warmer water – approx. 60°C) are also employed by CRAB SME partners, such as Sagres in Portugal.

In **Mexico** most shellfish cultivation occurs in the North East and North West of the country. No further details of the actual types of production or the problems facing the industry in this area were given by those who participated in the workshop. However, due to its proximity to the U.S.A. it is likely that production species and problems will be similar.

Sandra Shumway (an expert in bivalves and their biology, ecology, physiology and cultivation) was present at the meeting. She was able to give some insights into the financial issues facing the **North American** sector. She stated that fouling on the shellfish can be attributed to as much as 80% of the production costs within the industry. This is a huge figure, but is in fact likely to be comparable to other areas of the world, when the analysis is made. North America is primarily a site for the production of Pacific Oyster (*Crassostrea gigas*) and King Scallop (*Pecten maximus*).

European best practice guidelines and training activities

Alistair Lane

European Aquaculture Society

Alistair Lane presented the activities of the European Aquaculture Society ([EAS](#)) and the European Network for Training and Technology Transfer in Aquaculture ([AquaTT](#)) in the dissemination and training tasks of CRAB. At the outset, it was decided that dissemination activities should start as early as possible in the project. Now, some 20 months in the project, the first results are being presented in AQUA2006, based on one full fouling season, with the second ongoing at the time of the workshop. The project design called for a minimum of two fouling seasons upon which to base its findings.

EAS is responsible for dissemination and will (with the other Association partners) build the Best Practice Guidelines based on findings of the work packages within CRAB, which will enable producers to select the most suitable strategy for their farming conditions.

AquaTT is responsible for building the training elements of CRAB. These include a biofouling manual and an online version of the Best Practice Guidelines. The combination of the two will allow a producer to consult regional information that will help in the prediction of biofouling events. This builds on AquaTT's experience in providing training tools, such as used in Aqualabs training courses; in [Pisces](#), and in other initiatives.

The training tools will be developed during the Spring of 2007 and will be disseminated throughout European aquaculture operations soon after. The will of course be posted on the CRAB web site (www.crabproject.com).

Concluding comments

While attendance was limited in numbers, it was certainly not in terms of the number of countries represented. This gave a unique opportunity to exchange information with other regions and countries and to provide feedback on the success of various strategies.

The workshop clearly indicated a selection of strategies clearly linked to national legislation. In the European context, the EU Directives are of course translated into Member State legislation. Different countries therefore have the possibility to select antifouling strategies (and compounds) that other countries do not have access to.

The workshop also gave the possibility for the Collective Research tool itself to be presented. There is a need (and a desire) for European RTD to move beyond Europe, but at the same time, Collective Research is targeted towards improving European competitiveness. The structure of CRAB, and the challenges that the CRAB consortium faces in terms of the success of the initiative, show that European initiatives such as CRAB are useful as a model for cooperation in other countries and regions.

The CRAB consortium

Associations

European Aquaculture Society
Federation of European Aquaculture Producers
Irish Salmon Growers Association
Norwegian Seafood Federation – Aquaculture Division

RTD Providers

TNO Science and Industry (NL)*
University College Cork (IRE)
University of Newcastle upon Tyne (UK)
Universidad Politécnica de Madrid (ES)

SMEs

Alevines Y Doradas SA (ES)
AquaTT UETP Ltd (IRE)
Bømlo Skjell AS (NO)
Boris Net Company Ltd. (UK)
James Newman - Crookhaven Fisherman's Association (IRE)
Curryglass Enterprises Ltd (IRE)
Fastnet Mussels (IRE)
Lakeland Marine Farms Ltd. (UK)
Materials Innovation Centre (NL)
Promociones Marsan SL (ES)
Quinta Formosa, Produções Aquícolas, Lda (PT)
Sagremarisco Lda (PT)
Val Akva (NO)
Viveiros Ana Manjua Unipessoal Lda (PT)

* *CRAB Coordinator*

