



# aquaculture europe

VOL. 34 (1) MARCH 2009

## Seaweed culture has interesting prospects in Turkey



**The future of Sole farming**  
**Future aquaculture and fisheries research**  
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# Sole farming: nearly there but not quite?!

*A report of the 4<sup>th</sup> Workshop on the Cultivation of Soles*



High density juveniles in a shallow raceway at a farm (A. Coelho & Castro) in northern Portugal (photos above and below: Victor Øiestad)

BY BARI HOWELL, LUIS CONCEIÇÃO, RICHARD PRICKETT, PEDRO CAÑAVATE AND EVARISTO MAÑANOS

## INTRODUCTION

Progress towards the long-awaited commercialisation of sole farming continues but, it has to be said, at a gentle pace and not without some fingers being burned!

That seems to have been the reality of the last few years, but this rather depressing scenario does have to be tempered with the optimism that we will get there in the end! At least that seemed to be the mood of the most recent (the fourth) Workshop on the Cultivation of Soles that was hosted by the CCMAR of the University of the Algarve in Faro from 11-13 November last year. An article summarising the results of the first three workshops was published in *Aquaculture Europe* in September 2006.

CCMAR is one of the principal research centres which has pioneered the development of rearing techniques for the Senegalese sole, *Solea senegalensis* and so it was entirely appropriate that they should have hosted this latest Workshop. Since the last Workshop the level of commercial interest in sole farming has been maintained (though not without some changes in the participants!) against a background of increasing research effort seeking to support and underpin these as yet tentative commercial developments.

The Workshop aimed to bring researchers and operators together to *evaluate the current status and future needs of the sole farming industry* while providing an opportunity for the exchange of information and discussion of major issues.

More than 80 people participated, about 25% of whom were from industry. The Iberian Peninsula remains the



A trial version of a shallow raceway systems at a farm (A. Coelho & Castro) in northern Portugal.

focus of activities with these species with almost 80% of the participants coming from Spain or Portugal. Five other European countries (Norway, the Netherlands, UK, Greece and Italy) were also represented.

Three participants even undertook the journey from China where marine aquaculture has developed considerably during the last 20 years. Having established a 50,000 tpa industry farming the European turbot, as well as a range of other species, their attention has now turned to soles with an active interest in both the Senegal sole (*Solea senegalensis*) as well as their indigenous species, the tongue sole (*Cynoglossus semilaevis*).

In Europe, the dominant species of interest is the Senegal sole but there is still some commercial and research interest in the Dover sole (*S. solea*), particularly in more northern countries, notably the Netherlands and the UK. There is a high degree of commonality between these species and so no attempt to separate them was made in structuring the programme.



The workshop began with a session that aimed to establish the current status of the industry with the help of a questionnaire that had been previously distributed to commercial operators, a summary of which was presented alongside reports from both commercial operators and researchers.

The remainder of the Workshop focused on three key areas of central importance to the development of the industry, namely disease, reproduction and nutrition. These are not of course mutually exclusive, the latter in particular being an important element of disease susceptibility and reproductive performance as well as of course being a major determinant of flesh quality and growth rate. The latter is an aspect of performance of increasing concern to producers but was not dealt with specifically at this meeting.

This article provides a brief summary of the current status of the industry and its problems as well as the key areas around which the discussions were centred.

### STATUS OF THE INDUSTRY

The current production in Europe for each species is:

	Senegal sole	Dover sole
Juveniles('000s)	600	330
Market size (tonnes)	110	28



Granulomas in the spleen; a symptom of Pasteurellosis (photo: Carlos Zarza)

The industry has not grown as expected since the last meeting and several producers on the Mediterranean coast have been forced to close due to disease problems, particularly Pasteurellosis. Thus, the vast majority of producers are now based on the Atlantic coast of Spain and Portugal with one producer in the Canary Islands and one producing only Dover sole in Holland.

Most production is from on-shore tank systems, either shallow raceways or conventional tanks, often in conjunction with recirculation systems.

Most companies reported problems of poor growth, disease in the nursery and on-growing stages, and spawning of F1 & F2 stocks. Feed formulation and management of production systems were also reported as problem areas.



Skeletal abnormalities in sole (Photo: Paulo Gavaia)

With regard to growth rate, stocking density emerged as a key issue not least because it is a major determinant of economic viability in intensive systems but is a particular concern with soles because several studies (on Dover sole) have demonstrated a marked negative effect on growth with increasing stocking density. This is in contrast to some other farmed species such as the turbot.

While poor growth and high size variation in culture systems is of general concern, high growth rates of Senegal sole reported in shallow raceway systems at relatively high densities (up to 60 kg.m<sup>-2</sup>) were encouraging. It is unclear why this should be the case, though the relative lack of a density effect may be due to several factors including improved water quality in the micro-environment surrounding the fish, food distribution patterns that prevent dominance of the food supply by larger fish and reduced interaction between individuals forced to orientate and maintain position against a current.

However, optimism perhaps should be tempered since a report of one experiment showed that although high density did not measurably depress growth rate, there was a detectable suppression of the immune system which would render the fish more susceptible to disease. In a separate paper, evidence was also presented that the stress of crowding brought changes in plasma concentrations and free amino acids. This led to the positive suggestion that dietary provision of certain amino acids might be a way of alleviating the effects of stress (see Disease section).

Other points raised during the discussion were:

- Economic studies show that sole farming is still a marginal business with costs of production of around €8-9/kg before interest, administration and sales costs. The minimum viable capacity for a production unit is >100t/yr which is still not proving to be attractive to investors considering the risks involved.
- Discussion of the technical merits of shallow raceways versus other tank systems was not conclusive but



Stripping eggs from Senegal sole in China (photo: Liu Xinfu & Lei Jilin)



HCG-induced spermiation (photo: Evaristo Mañanos)

both systems had proved successful in commercial experiences.

- Several producers reported that culling of up to 50% of stocks was necessary due to slow and uneven growth even though there was some evidence of compensatory growth in slow growers after grading. Poor juvenile quality was a likely cause of this and is probably a significant limiting factor to the development of the industry.
- Juvenile production is now based on orders only and therefore current costs are high (1€/5g fish – up to 30% of production costs). However, this should improve when quality issues are resolved and demand increases.
- Stability of water temperature (and quality) was considered vital for production. This would favour the use of recirculation systems or boreholes.
- Selection of components for recirculation systems to suit sole production in shallow raceways and other tank systems was discussed. It is of some concern that such systems are still not profitable for more established flatfish species such as turbot.

## KEY ISSUES

### Disease

Disease continues to be the major obstacle to commercialisation of these species. As stated above, on the Mediterranean (and south Iberian) coast losses from Pasteurellosis have brought about the closure of almost all farms. On the Atlantic coast the dominant diseases are BPN/Tail rot (*Tenacibaculum sp.*) and vibriosis. While losses from these diseases can be severe they have not been quite as crippling as those from Pasteurellosis. It is also encouraging that some progress has been made towards the development of vaccines to combat *Tenacibaculum*, although much more needs to be known about the immune system before effective vaccines and vaccination programmes can be realised.

There is still a lack of information on the susceptibility of soles to viruses or the possible existence of fish that are infected by virus but do not show clinical signs (for example Viral Nervous Necrosis). VNN, however, has been isolated from Dover sole in the UK and possibly from Senegal sole in Italy

Further progress was reported on the use of probiotics as a disease management option. The application of a probiotic (pdp11) during the larval stages has been shown to significantly improve larval and post-larval performance. Work was also reported of a possible immuno-stimulant effect of amino acids (AAs). Stress events (crowding, handling) have been observed to bring about changes in the AA pool and may result in an increased requirement for indispensable amino acids (IAAs). Supplementation of diets with certain IAAs, or other nutrients yet to be studied, may therefore provide a means of minimizing the harmful effects of stress.

Enhancing the immuno-competence of the fish by such means will undoubtedly play a major part in combating disease. It was also considered, however, that there was still considerable scope for improvement through reducing stress levels by more closely matching system design and rearing protocols to the biological needs of the fish.

Skeletal deformity can be a highly visible manifestation of inadequate rearing conditions, although it is not exclusively the result of the captive environment. It was reported to be a serious problem in at least some hatcheries, though not at a level that would compromise commercial viability. These, and other physical abnormalities such as pigmentation, could perhaps be used as an indicator of juvenile quality or 'fitness' and contribute to the development of a more consistently viable product.

### Reproduction

Protocols have now been defined which allow the acquisition of naturally fertilised eggs from captive stocks of soles. However, while this is the case for stocks of wild-caught fish, performance of F1 fish remains problematic. Research programmes are underway to try and link such reproductive dysfunction with environmental/husbandry factors during early development. Interestingly, mating behaviour was not detected in F1 breeders even after hormonal therapy and artificial fertilization of eggs from these fish was therefore necessary. Other observations suggest the lack of mating behaviour may be attributable to inadequate pheromone production that in turn may be linked to observed differences in fatty acid ratios (ARA/EPA/DHA) between the ovaries of wild and F1 breeders.



are as yet unsubstantiated hypotheses, but it is clear that systematic research being undertaken on the reproduction of these species will eventually lead to a resolution of these anomalies. In the meantime, progress on hormone therapies is enabling the achievement of artificial fertilization. In China, a notable achievement has been the application of such techniques on a commercial scale.

Other research is also contributing to our understanding of how a regular supply of good quality eggs might be secured. A number of examples were reported and included:

- Seasonal variations in sperm quality have been revealed using recently development techniques that enable more accurate evaluation of sperm quality.
- A marked spawning rhythm with egg release after sunset has been described, no doubt linked with the production of melatonin during darkness.
- Parental analysis of offspring from Dover sole breeding tanks revealed a similar skewed pattern to that found for Senegal sole and other group spawners with the consequent high risk of inbreeding.

Presentations concerned primarily with development reported that:

- Pineal photoreception and melatonin synthesizing capacity appear at early developmental stages suggesting that the control of environmental factors could represent an important issue during ontogeny.
- Contrary to other fish species, isosmotic salinities appear to be suboptimal for *S. senegalensis* growth.
- The development of feeding behaviour of the tongue sole parallels that of European soles. Larvae are predominantly diurnal feeders but become predominantly nocturnal after metamorphosis. This change is reflected in the sensory mechanisms involved in food detection and capture.

### Nutrition

At this stage there is still much to learn of the specific nutritional needs of soles despite the long history of interest in their cultivation. Advances have been made, but, for example, estimates of dietary requirements between studies remain variable, especially for lipid levels, and need to be validated for various large-scale commercial systems. On a positive note, Senegal sole do seem to utilise plant proteins very well and so offer good prospects for high levels of fish meal replacement.

The nutrition of the larval stages is of particular importance because of the long lasting effects that deficiencies may have. In this respect, the availability of radioactive and stable isotope techniques for fast-track studies of nutritional requirements and feeding strategies for sole larvae and juveniles is particularly important and will accelerate our understanding of requirements. With regard to specific requirements of larvae, evidence was presented that supported the role of Vitamins A & K in the modulation of the prevalence of skeletal deformities.



Sole pellets (photo: Jorge Dias)

It was reported that natural foods, such as worms and mussel-based diets, still outperform dry diets with respect to growth and food conversion efficiency. These nocturnal species adapt well, however, to diurnal feeding regimes at least as far as growth is concerned.

Commercial interests emphasised that the absence of feeding tables for sole is a serious obstacle to effective husbandry. These should be constructed and validated for different production systems, recognizing that they will also depend on dietary energy levels.

The need for a reference diet (golden standard) for sole was also highlighted. Such a diet, which does not need to be commercially acceptable as far as costs are concerned, may be used to verify nutritional and zoo-technical improvements.

### CONCLUSIONS

It is clear that the development of commercial sole farming still has many challenges to face. It is also evident, however, that the research capability that has become established in the key problem areas equips us well to overcome the difficulties.

Stabilising production for both species of sole is still limiting the development of the industry. From a commercial perspective, immediate priorities should therefore focus on key issues limiting production and are seen to be as follows:

- Improve egg and larval quality particularly with respect to hatchery reared (F1) stocks.
- Evaluate stripping techniques as a commercial method for egg production.
- Improve larval quality and establishing bench marks to compare relative fitness/growth performance/levels of deformity
- Develop vaccines and therapies to reduce the incidence of disease, particularly Pasteurellosis and Tenacibaculosis.
- Improve the formulation of feeds for use in open and recirculation systems