Mariculture Committee

ICES CM 1995/F:4

REPORT OF THE
WORKING GROUP ON MASS REARING OF JUVENILE MARINE FISH

Conwy, United Kingdom
22–24 June 1995

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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TABLE OF CONTENTS

1. PARTICIPANTS

The Working Group convened its sixth meeting in Conwy, U.K. on 22-24th June, 1995. The following representatives of ICES member countries participated in the meeting:

Belgium:	P. Coutteau, P. Lavens
Denmark:	J. Støttrup
Canada:	K. Waiwood
Finland:	A. Soivo
France:	J. Robin
Holland	J. Verreth
Norway:	E. Kjørsvik, A. Mangor-Jensen, T. Harboe, K. Naas, V. Öiestad, Y. Olsen, G. Rosenlund.
Spain:	A. Alcazar, J. Iglesias, J. Peleterio
Sweden:	P. Larsson
U.K.:	S. Baynes, T. Beard, N. Bromage, N. Brown, B. Howell, R. Johnstone, R. Shields

The meeting was chaired by B. Howell (UK) and R. Johnstone (UK) acted as rapporteur with assistance from J. Støttrup.

2. TERMS OF REFERENCE

The following terms of reference were approved by the Council (C. Res. 1994/2:26) during the 1994 Statutory Meeting in St. John's, Canada:

a) report on current trends, problems, and prospects for juvenile marine fish production in ICES Member countries;

b) report on an inter-laboratory investigation of the potential use of cell symmetry as a predictive indicator of egg quality;

c) report on an inter-laboratory evaluation of the effects of different DHA/EPA profiles in food on production success;

d) report on an inter-laboratory investigation on the effects of selected weaning diets;

e) evaluate progress on the establishment of a data base of environmental conditions under which fish are reared;

f) determine the potential for quality assessment criteria for juvenile animals.

g) develop and co-ordinate plans for the Mariculture Special topic on "Advances in Marine Fish Culture" at the 1995 Annual Science Conference.

3. AGENDA

The meeting was hosted by the Fisheries Laboratory, Conwy, UK but convened in the Imperial Hotel in the nearby town of Llandudno from 22-24 June, 1995. Presentations and discussions related to the topics identified in the Terms of Reference occupied the first two days with some relief provided by a tour of the facilities at the Fisheries Laboratory, Conwy during the second afternoon. In addition, Dr Peter Coutteau presented the final conclusions of the HUFA intercalibration exercise. The third morning of the meeting was dedicated to amending a draft report of the meeting which had been prepared and distributed to participants the previous evening, and with a discussion of the future activities of the Working Group.

4. HUFA INTERCALIBRATION EXERCISE

Dr Peter Coutteau presented the final results of the above exercise which will be published by ICES in the Cooperative Report series (C. Res. 1994/1:6). The approach adopted had allowed comparisons of analyses done by laboratories' preferred techniques as well as by a recommended protocol. The exercise was summarised as follows:

1. An international inter-calibration exercise was conducted to evaluate the accuracy of the ICES Standard Methodology for fatty acid analysis in a sample of *Artemia* and a formulated dry feed. Results were received from 11 of the 20 laboratories to which samples were sent. Five participants followed the Standard Method, five their own in-house method, and one laboratory compared their own in-house method with the Standard Method. Total lipid content was reported by eight participants.

2. The average intra-laboratory variation in the determination of total lipid content was only 3.6% (CV) for the dry feed and 4.0% for the *Artemia* nauplii. The inter-laboratory variation was somewhat higher being 5.2% for the dry feed and 8.7% for nauplii. In addition, significant differences were found between lipid content reported by the different laboratories. Nevertheless, the inter-laboratory variation obtained in this study was considerably lower than that reported in a previous inter-calibration exercise Léger *et al.* (1989). It is suggested that this may have been because precise procedures were prescribed for both hatching the cysts and lipid extraction.

3. Intra- and inter-laboratory variability in the determination of fatty acid composition was on average twice as high for quantitative data as it was for qualitative data. The intra-laboratory variation, averaged for all the laboratories for the feed and *Artemia* respectively, was as low as 3.3% and 2.7% for qualitative data, and 6.9% and 6.3% for quantitative data. In comparison, the average inter-laboratory variation for the major fatty acids in the feed and *Artemia* respectively, was 13.7% and 7.3% for qualitative data, and 24.5% and 11.5% for quantitative data. The higher variability in the quantitative, as well as qualitative data, for the dry feed may have been due to a higher variability in the extraction and/or methylation of the fatty acids from the extruded matrix of the diet compared to brine shrimp tissue.

4. The laboratories using the Standard Method exhibited a somewhat lower intra-laboratory and inter-laboratory variation for the qualitative values than the laboratories applying their own in-house method. In contrast, the quantitative analyses revealed, particularly for the dry feed, a slightly higher variability for the laboratories following the Standard Method.

5. The overall variability in the present exercise, both on the intra-laboratory as well as inter-laboratory level, was significantly lower than that reported by Léger *et al.* (1989). The better accuracy obtained in the present exercise for the determination of fatty acid composition in *Artemia* nauplii is at least partially due to the stipulation of a standard procedure for hatching and analysis of the cyst sample in the instructions to the participants.

6. Although it is more elaborate and solvent consuming than many current methods for fatty acid analysis in routine use, the ICES Standard Method may be used to inter-calibrate the analytical procedures adopted by different laboratories to analyse fatty acids in *Artemia* and marine samples.

A number of points of methodological detail were subsequently discussed. In conclusion, it was agreed that there was now an acceptably low level of qualitative and quantitative variability in the analysis of HUFA levels between different laboratories. There was also a satisfactory degree of understanding of the major causative factors underlying this variation. This information would be of critical importance in interpreting and comparing the results of studies done in different centres enabling, in turn, the more straightforward separation of the relative importance of, for example, different environmental variables and different dietary components on growth performance.

5. MARINE FISH PRODUCTION IN 1994 (Terms of Reference, item a)

The following comments are based on data submitted by members of the Working Group and were collated by the Chairman. They may be subject to the inaccuracies common to all data of this type. Nevertheless, it is considered that the trends evident in the data adequately reflect the real situation.

5.1. Production of juveniles

Data is shown for those species predominantly used for cultivation and those predominantly for stock enhancement in (Tables 1 and 2 respectively). As observed in the 1994 report of this Working Group (ICES, 1994), there is very little overlap between these two groups reflecting the different criteria used in the selection of species for these contrasting activities. Although the demand for juveniles for enhancing natural stocks is potentially much greater than that for cultivation, at present less than 5% of the total production of juveniles is currently used for that purpose. Future demand clearly depends on the final evaluation of the enhancement exercises currently being conducted.

The total production of juveniles in 1994 exceeded 80 million, an increase on the previous year of almost 50%. Over 95% of this total was produced in France, Spain and Portugal and consisted predominantly of sea bass and sea bream, each of which accounted for over 45% of the total. Production of each of these two species, which supports a now well established industry, continues to increase at an appreciable rate (Table 1). This contrasts with the turbot, the only other species for which commercial farming is reasonably well established. Production of this species has stabilised reflecting a hiatus in the development of the on-growing sector of the industry. These data compare with an estimated production for the Mediterranean of 165 million juveniles, 50-55 million of which was produced in Greece. Approximately 50% of the French and Spanish

production of sea bass and sea bream is exported to farms in other Mediterranean countries.

An encouraging aspect of the data is the marked increase in the production of juveniles for species which are not yet well established commercially. The considerable increase in the number of halibut reared in Norway reflects the continuing progress in solving the problems of rearing the larvae of this challenging species and suggests that commercial farming is imminent. There has also been a considerable increase in the production of juvenile sole (*Solea senegalensis*) in Spain but the problem of feeding the juvenile stages will need to be overcome before significant production of marketable fish will be attained. Nevertheless, recent research on a closely related species (*Solea solea*) has indicated that this problem can be solved. In addition to halibut and sole, small quantities of bream (*Pagrus pagrus*) and the striped bass (*Morone saxatilis*) were produced in France and Canada respectively.

The provision of adequate nutrition continues to be the greatest obstacle to the successful rearing of marine fish larvae. This seems particularly to be case for halibut larvae for which a diet of copepods still appears to be the most effective option. Similar survival rates can be obtained occasionally on a diet consisting only of *Artemia* but a high proportion of such fish are usually malpigmented and may even be physically deformed. Morphological abnormalities are a lesser problem with other species but do persist in being an undesirable feature. Techniques for the earlier identification of deformity problems which would allow the earlier culling of affected fish would allow scarce live feed resources to be better targeted. The dietary requirements of some species were still in need of clarification.

5.2. Production of market-sized fish

The total production of market-sized fish in 1994 was about 20% higher than that in 1993 reaching a level of about 10,000 t (Table 3). The production of all three commercially established species (sea bass, sea bream and turbot) showed significant increases, although as the juvenile production data indicates, this may not be sustained for turbot over the next few years. Although still at a low level, increasing quantities of halibut are now being marketed in Norway and Iceland reflecting the increase in the availability of juveniles. It is projected, for example, that the Norwegian production of halibut will reach 100 t in 1995. Much of the cod production in Iceland and Norway is based on wild-caught juveniles, though an attempt is being made to meet the demand with hatchery-reared fish. The small production of sole in Portugal and Spain is from semi-extensive systems.

Continued expansion in production is anticipated with juvenile supply only limiting commercial development for selected species. In many countries, such as Denmark, Holland, Belgium and France the availability of suitable sites appears to be the principal constraint on the expansion of the industry. In this respect, it is interesting to note the extension of recycling technology to marine fish, a development which would alleviate not only site availability but the limitation on the range of species cultured.

5.3. New species

Diversification in the number of species cultured is a widespread trend throughout ICES countries. This includes the development of culture techniques for species for which

techniques have not previously been established as well as the spread of species already being reared to other countries. Some of this diversification has been enabled by the use in northern countries of recycling systems. It was considered that this trend might continue as the systems technology performance and costs became better known as a result of their being 'tested' in the culture of salmonids and other species.

The subsequent discussion concentrated on the constraints on the potential for marine larval culture that might be occasioned by interruptions to future *Artemia* supply. Presently, over 90% of world *Artemia* supply comes from a single source, the Great Salt Lake, which has recently suffered declines in rates of production. The factors causing this were not sufficiently well known but it was thought it was less likely to be due to over-harvesting and more likely associated with changes in primary productivity and/or predation.

The constraints that this might cause could be both short and long term in nature. In the short term, the shortage of supply had driven costs up and this would necessarily impact on future production costs. Despite their small demand, in the face of the competition for the available supply, some researchers had reported difficulties in ensuring satisfactory supplies for their research. In the longer term any natural resource was prone to natural variability and was ultimately of limited production. These facts pointed towards the necessity to adopt future strategies in order to avoid, if possible, the worst consequences of a continuing shortfall from this source.

Important among these would be the identification of other *Artemia* sources of suitable quality and quantity. Further research into the nutritional requirements of different larval fish and of alternatives to live foods would also be important. The former would allow culturists to identify their minimum *Artemia* requirements, the latter would enable them to substitute satisfactory cost effective alternatives.

In most species there is still great variability in survival and growth rates. Because these factors have a major influence on the efficiency of the production process, rearing costs could not yet be exactly predicted with any confidence. The identification of the factors which contribute to this variability would allow the most efficient practices to be introduced which in turn should lead to a lowering of costs and a reduction in rates of production.

There was an emerging concern over the unequal sex ratios that were being observed in some cultured species (sea bass and sole). This took the form of an over abundance of males, the least preferred sex, since males commonly mature at an earlier age and at a smaller size. The implications of this concern within enhancement programmes was noted. Here, the potential for reducing genetic variability was already of some concern.

Recommendations:
The WG recommends that future research is directed towards:

- a further quantification of the nutritional requirements of fish larvae
- improving the consistency of production of live foods (*Artemia*, rotifers and copepods)

- the identification of alternatives to live feeds for larval marine fish so as to reduce the reliance on their use
- the development of more effective weaning diets for the less-established species
- a better understanding of the factors of importance in determining sex ratios in cultivated stocks
- identifying causes of variability with a view to reducing production cost
- understanding the implications to enhancement programmes of reduced genetic variability in stocks which destined for release to the wild.

6. ENVIRONMENTAL VARIABLES (Terms of Reference, item e)

Dr Verreth described the progress made towards a database of environmental parameters and their effects on rearing success. A consideration of the practicalities of such a scheme had suggested that it was an overly ambitious proposition. To be of real use, careful thought would have to be given to the nature of its construction such that sensible collation of the entries was possible. Construction, collection and collation were all very large and demanding tasks and beyond the present resources of the group. There was also some resistance from commercial operatives to providing information since the desirability of the end product (an ability to identify between species requirements and differences) was not apparent. An exercise confined to researchers might be possible but the same result would flow from reports of carefully targeted research programmes.

It was concluded that, notwithstanding that an understanding of the effects of environmental variables on performance was vital in early marine fish larval rearing, it did not presently make sense to erect a database of the sort envisaged.

Nevertheless, it was generally thought that a better understanding of the effects of environmental conditions was vital to rearing success. In particular, although microbiological development and the degree of interaction between biotic and abiotic parameters during larval rearing are poorly understood, their proper control is probable critical. In addition, it was noted that some laboratories are currently investigating the usefulness of probiotic techniques.

Recommendation:
The WG recommends that further research is directed towards:

- a better understanding of the interaction between larvae and their environment; this should include improving methods for monitoring and controlling microbial development.

7. REFERENCE WEANING DIETS (Terms of Reference, item d)

Dr Coutteau reviewed the progress made on the preparation of reference weaning diets via a coating of an extruded basal diet which allowed the modification of the composition of the lipophilic fraction (phospholipids, essential fatty acids, fat/soluble vitamins). The value of reference diets in enabling sensible inter-species and inter-laboratory comparability was discussed. They would allow the identification of the effects of

different dietary constituents on performance which would in turn allow better diets to be prepared. It should be stressed that such reference diets would be reformulated with increasing knowledge of nutritional requirements.

Recommendation:
The WG recommends that:

- reference diets be included in weaning experiments to enable better inter-species and inter-laboratory comparability.

8. DHA/EPA PROFILES IN ENRICHED *ARTEMIA* (Terms of Reference, item c)

Dr Lavens presented the results of a study on the sources of variability in HUFA enrichment of *Artemia* nauplii. Significant quantitative and qualitative variability exists in the HUFA levels resulting even from standardised protocols performed by the same operator. This intrinsic variability, coupled with the knowledge that harvest timing has a critical effect on levels, since DHA/EPA ratios are highly temperature and aeration sensitive, makes it essential that investigators have an accurate understanding of its consequences in their own studies. Levels might be measured at frequent intervals or their value predicted using modelling based on previous comprehensive tests. Reference enrichment emulsions for nutrition research are now available. There was some concern whether recommended enrichment practices were the most appropriate under commercial conditions.

Recommendation:
The WG recommends that:

- researchers consider and, whenever appropriate, report the effects of the intrinsic variability in live food enrichment programmes during the interpretation of nutritional experiments.
- research on the nutritional requirements of fish larvae using these reference diets should be conducted.

9. THE QUALITY OF REARED JUVENILES (Terms of Reference, item f)

The Chairman opened the discussion by outlining how alterations to rearing conditions might cause morphological, behavioural or physiological changes. A better understanding of the factors affecting subsequent quality and ways of assessing quality would be vital. Separate presentations were then made on the effects of rearing practice on opercular deformities in bass and resistance to thermal shock in sole. Another study using halibut and cod showed that tests of swimming performance correlated well with subsequent first feeding success. The generally low level of feeding success observed in these trials, however, made repetition under more optimal first feeding protocols desirable. Further discussion revealed that 'stress' tests were not routinely used - assessments of quality were still in their infancy. In particular, there was currently no knowledge of correlations of test results with subsequent performance. Despite the general agreement that appropriate tests

of juvenile quality would be highly desirable, the WG thought standardisation would be difficult.

Recommendation:
The WG recommends that:

- researchers should continue to attempt to erect and assess the usefulness of tests of juvenile quality as performance indicators.

10. EGG QUALITY (Terms of Reference, item b)

Dr Shields described the results of a collaborative study into the use of cell symmetry as an indicator of egg quality. The study used a protocol based on microtitre plate incubation of eggs. Egg incubation in this system is generally associated with high hatch rates for halibut, cod and sea bream. It has thus become a useful tool for investigating egg viability.

In the collaborative study, problems had been encountered in distinguishing different egg categories from within a single batch. Nonetheless, trials had been completed on Atlantic halibut, sea bream and turbot using the agreed experimental design. Poor hatch success of asymmetrical eggs had been recorded for all species, mostly in association with other abnormal blastomere features. In halibut and sea bream these low viability eggs were encountered towards the end of the spawning season. Halibut showed a correlation between batch fertilisation characteristics and hatch rate within the asymmetrical class.

In 1994, asymmetry in turbot eggs correlated well with poorer performance. In 1995 more rigorous assessments of turbot asymmetry were instituted that excluded abnormal blastomeres. This, combined with a greater degree of intra-batch variability resulted in no significant differences in performance to hatch. Swedish cod results (1994) were confounded by the generally poor viability of the Baltic stock, but there was no evidence that asymmetrical batches were ever better than eggs of more normal appearance.

It was concluded from the study that symmetry characteristics alone are not a powerful predictor of egg viability. However, when used in conjunction with other blastomere abnormalities a useful predictive tool seems likely to emerge. Tests are underway to identify which of the assorted blastomere features will prove most useful.

Discussion followed on those maternal and egg husbandry factors that have been shown to influence blastomere characteristics and egg viability. Although alterations to temperature and salinity during the halibut incubation phase increased asymmetry in eggs at the 8 cell stage, this effect was not permanent, since morula stage embryos reverted to normal appearance. In cod, a serial spawner, spawning stage was critical in determining egg quality, late egg batches being poorer. Hatching rate correlated positively with the percentage of normal eggs. Overripening processes were also important. Eggs retained for longer than ca 8 h in ovarian fluid, as a mimic of over-ripening, experienced lower fertilisation and hatching rates. Rates of abnormalities (pigmentation, mouthparts and skeletal deformities) were greater in those eggs that did hatch. Retained eggs also

performed less well in salinity stress tests and these data correlated well with survival to day 6. ATP levels in retained eggs also declined with time, suggesting that energy levels may be a useful indicator of subsequent performance. Routine measurement of this variable, however, may be problematic.

There was general agreement on the need for further work on the required husbandry, environmental and nutritional requirements of broodstock.

Recommendations:
The WG recommends that:

- in recognition of the different recording practices adopted between research groups, it was reiterated that procedures for measuring fertilisation and hatching rates should be described when reporting
- future egg studies using the microtitre method should involve random stocking of eggs in order to generate hatch data that is applicable to the whole egg batch
- blastomere abnormalities should be recorded in more detail using a scoring system (see suggested parameters in Appendix 5). An illustrative key of appropriate features should be compiled for individual species for ease of transfer of this information to industry.

11. 1995 ANNUAL SCIENCE CONFERENCE (Terms of Reference, item g)

Contributions to the Mariculture Session on 'Advances in Marine Fish Cultivation' were canvassed from the membership of the Working Group by correspondence because the deadline for receipt of titles was before the scheduled date of the Working Group meeting. The response to this call for papers had been disappointingly low and the reasons for this were briefly discussed. The view was widely held that, although scientific contributions to committee sessions did provide an early opportunity to informally discuss recent scientific developments peers, this benefit did not compensate for the limited circulation and lack of status of the reports. Under the current conditions of increasingly limited funding for travel there was a strong inclination to select those conferences which published peer-reviewed papers in preference to the ICES Annual Science Conference.

12. FUTURE ACTIVITIES OF THE WORKING GROUP

This was the sixth meeting of the Working Group since its inception nine years ago. During that time it has dedicated its efforts to the analysis of critical aspects of the production of juvenile marine fish, providing an almost unique opportunity for practising scientists to engage in informal discussions of key issues. These have often acted as a catalyst for collaboration between participants, as well as having led to the organisation of formalised inter-laboratory exercises to resolve methodological problems or facilitate intra- and inter-specific comparisons. The HUFA inter-calibration exercise, shortly to be published as an ICES Cooperation Research Report and the more recent inter-laboratory evaluation of cell symmetry as a predictor of egg quality, both reported on in this report, proved to be particularly valuable exercises. An additional role recognised to be of some

importance has been the identification of research priorities which provides both national and international funding agencies with guidance in setting their priorities.

During the life of this Working Group, there have been significant commercial developments in marine fish farming production in ICES countries in 1994 having reached 10 000 tpa, an increase of 25% on the previous year. Although appreciable problems remain, juvenile production has, for many species, ceased to be a major constraint on expansion while other phases have become of increasing importance in determining the future development and sustainability of what is already in some areas a significant economic activity.

For these reasons, there was a consensus that the Working Group should not only have a continuing role but that its activities should be extended to include the whole of the production cycle. In accordance with this proposal, it is recommended that the Working Group should be renamed the *Working Group on Marine Fish Culture*.

It is proposed that the Working Group should continue to monitor the status of the industry and identify those factors likely to constrain its future development and sustainability. This would provide a sound basis for identifying key issues which should form part of the agenda of future activities of the Working Group. In addition, the Working Group identified the following specific areas as important to the immediate development of the industry and should be subjected to critical review at its next meeting:

1 The assessment of the quality of reared fish
2 The availability of food for larval marine fish
3 The development of alternative rearing systems
4 The importance of the abiotic and biotic environment in larval rearing systems
5 The impact of fish welfare issues on the development of fish cultivation practices

13. REFERENCES

ICES 1994. Report of the Working Group on Mass Rearing of Juvenile Marine Fish to the Mariculture Committee of ICES. ICES CM 1994/F:6.

Léger, Ph., Bengston, D.A., and Sorgeloos P. 1989. Analytical variation in the determination of the fatty acid composition of standard preparations of brine shrimp Artemia: an interlaboratory exercise: 413-423. In: Aquatic toxicology and Hazard assessment: 12th volume, ASTM STP 1027. Cowgill U.M. and L.R. Williams (Eds.). American Society for Testing and Materials, Philadelphia, USA.

14. RECOMMENDATIONS

The Working Group on the Mass Rearing of Juvenile Marine Fish recommends that it be renamed the Working Group on Marine Fish Culture, to reflect an extended remit to include all phases of the production cycle, and that this new Working Group works by

correspondence in 1996 in preparation for its first meeting in Murcia, Spain from 23-25 June, 1997 with Dr. B. R. Howell as Chairman to:

a) report on the current status of marine fish cultivation in ICES countries and on the factors which are likely to constrain the further development and sustainability of the industry
b) report on research into the characteristics of reared fish and reappraise the potential for establishing quality assessment criteria
c) report on the current and continuing availability of live foods for larval marine fish and review the prospects for their replacement with formulated feeds
d) assess the impact of recent advances in the development of alternative on-growing systems for marine fish
e) evaluate the effects on larval performance of alterations to biotic and abiotic environmental variables
f) report on developments in fish welfare issues and assess their impact on marine fish cultivation practices

A progress report on the intersessional activities of the Working Group will be submitted to the 1996 Annual Science Conference.

Table 1. Production ('000s) of juvenile marine fish in ICES countries in 1994: species primarily, though not exclusively, used for intensive cultivation. Data for 1993 are given in parenthesis.

COUNTRY	HALIBUT *Hippoglossus hippoglossus*	TURBOT *Scophthalmus maximus*	SEA BASS *Dicentrarchus labrax*	SEA BREAM *Sparus aurata*	BREAM *Pagrus pagrus*	SOLE *Solea senegalensis*	STR'D BASS *Morone saxatilis*	TOTALS
ICELAND	5 (1)							5 (1)
NORWAY	400 (172)	411 (350)	0 (1000)					811 (1522)
SWEDEN		0 (1)						0 (1)
DENMARK		502 (810)	500 (0)	220 (0)				1222 (810)
UK	2 (0)	250 (325)						252 (325)
PORTUGAL			9063 (6750)	6597 (7200)				15660 (13950)
NETHERLANDS								0 (0)
FRANCE		1200 (1250)	23800 (13650)	13350 (5020)	70 (0)			38420 (19920)
SPAIN		1028 (1012)	4035 (2370)	17675 (15660)		699 (100)		23437 (19142)
CANADA							7 (12)	7 (0)
TOTALS	407 (173)	3391 (3748)	37398 (23770)	37842 (27880)	70 (0)	699 (100)	7 (12)	79814 (55683)
% CHANGE	135	-10	57	36		599	-42	43

Table 2. Production ('000s) of juvenile marine fish in ICES countries in 1994: species primarily, though not exclusively, used for stock enhancement exercises. Data for 1993 are given in parenthesis.

COUNTRY	COD *Gadus morhua*	FLOUNDER *Pleuronectes flesus*	PLAICE *Pleuronectes platessa*	LUMPFISH *Cyclopterus lumpus*	WHITEFISH *Coregonus lamaretus*	TOTALS
ICELAND	1 (0)					1 (0)
NORWAY	380 (270)					380 (270)
FINLAND					65 (49)	65 (49)
SWEDEN	(2)		1			1 (2)
POLAND					(56)	
DENMARK	11 (11)	0 (7)	40 (18)			51 (36)
CANADA	1 (0)			2000 (2000)		2001 (2000)
TOTAL	393 (283)	0 (7)	(41) (18)	(2000) (2000)	(65) (105)	2499 (2413)
% CHANGE	39	-100	128	0	-38	4

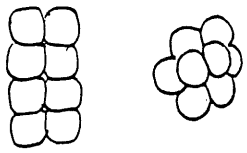
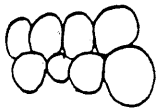
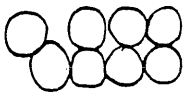
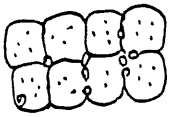
Table 3. Production (tonnes) of farmed marine fish in ICES countries in 1994. Data for 1993 are given in parenthesis.

COUNTRY	COD *Gadus morhua*	HALIBUT *Hippoglossus hippoglossus*	TURBOT *Scophthalmus maximus*	SEA BASS *Dicentrarchus labrax*	SEA BREAM *Sparus aurata*	SOLES *Solea spp.*	TOTALS
ICELAND	70 (10)	20 (10)					90 (20)
NORWAY		30 (10)	40 (10)	0 (50)			70 (70)
DENMARK			30 (28)	144 (250)	45 (0)		219 (278)
HOLLAND			10 (0)				
UK			20 (5)				20 (5)
IRELAND			3 (4)				3 (4)
PORTUGAL				342 (249)	1179 (867)	3 (12)	1524 (1128)
FRANCE			600 (440)	2510 (1952)	715 (382)		3825 (2774)
SPAIN			1809 (1584)	351 (371)	2094 (2014)	12 (12)	4266 (3981)
TOTALS	70 (10)	50 (20)	2512 (2071)	3347 (2872)	4033 (3263)	15 (24)	10027 (8260)
% CHANGE	600	150	21	17	24	-38	21

Zero returns for Sweden, Finland, Belgium, Poland and Canada

APPENDIX 1.

Table showing suggested morphological characteristics of egg blastomeres which may be used as criteria for a predictive indicator of viability. These characteristics were observed at the 8-cell stage eggs in the halibut study, 1995 and used in a scoring system (individual eggs assigned a score of 1-4 for each category marked *).

Characteristic	**Explanation**	**Diagram**
*Symmetry	Symmetry of arrangement of cells about a central axis	
*Uniformity	Uniformity of cell size	
*Cell Adhesion	The degree of cell to cell adhesion	
*Cell Margins	Distinctiveness of cell separation and cell walls	
*Clarity	Cleanness of blastomeres, i.e the presence/absence of droplets and the clarity of the cell cytoplasm etc	
Cell Number	Number of cells, normally 8 but some eggs may be advanced to 16, delayed at 4 or others may deviate from expected numbers e.g 6,7