International Council for the
Exploration of the Sea

C.M.1981/F:46
Mariculture Committee
Ref: Anadromous &
Catadromous Cttee

REPORT OF THE WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

Sète, France, 5-8 May 1981

[*)] General Secretary,
ICES
Palægade 2-4,
DK-1261 Copenhagen K,
COPENHAGEN

CONTENTS

- o - o -

WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

Report of a Meeting held May 5-8, 1981 at Sète, France

The 1981 meeting of the ICES Working Group on Introductions and Transfers of Marine Organisms was held at the ISTPM Laboratory in Sète, France, May 5-8, with eighteen participants representing nine member countries (see Appendix I for list of participants).

The members of the group were welcomed by the Director of the Sète laboratory who outlined practical details for the running of the meeting. The agenda was then considered and accepted, with the addition of a requirement for a recommendation to ACFM regarding the Norwegian request to introduce Pacific salmon.

The chairman commented that a major priority of the group should be the completion of the Cooperative Research Report updating the information on introductions to the ICES area and producing the guidelines for implementation of the Introductions Code of Practice. The second important task was advice to ICES on the Norwegian and French proposals regarding coho salmon and the third was to develop and prepare protocols for examinations, communication procedures and requirements for diagnostic laboratories.

The Working Group first considered the responses to the request that copies of the laws and regulations for the various ICES countries be sent to the chairman. The response had been rather patchy, but the chairman already had an exceedingly thick file of documents. It was decided that copies of

the various laws should be kept at ICES headquarters only and the Working Group should produce a document from the summaries produced by the various countries. The titles of the laws would be in English plus the original language. This would be an information paper only and not a legal summary of the various documents. The chairman will distribute the summaries to the members of the Working Group, who will check with their various legal departments, with a view to possibly producing a paper for the 1982 Statutory ICES meeting.

NATIONAL SUMMARIES

An update of the situation regarding introductions was given by the representatives of the various countries present.

I. Relevant Laws

In Canada, new regulations are being developed to replace existing Maritime regulations which are considered inadequate. These, however, are regarded as having low priority and are unlikely to be approved for some time. Guidelines have been developed for the handling of rainbow trout transfers within the Maritimes Region. In British Columbia, new regulations have been drafted to prevent and control the importation of ornamental fish.

France has introduced a new regulation forbidding the transfer of oysters from areas affected by the new serious disease caused by the pathogen Bonamia ostreae.

Federal Republic of Germany has a new regulation covering resources in coastal waters which also includes introductions.

Spain has introduced legislation forbidding the import of O. edulis from France; a decision has still to be made on the introduction of C. gigas.

In the UK, the Import of Live Fish (England and Wales) Act 1980 now gives the power to ban or license imports of any non-native fish or shellfish on ecological grounds. In the UK as a whole, consideration is being given to the suitability of extending existing import regulations to cover all shellfish species.

II. Other Procedures

The Netherlands has taken steps to combat the spread of oyster disease from the East Scheldt area by clearing oysters from affected beds.

III. Deliberate Introductions

In Canada, pink salmon (O. gorbuscha) experiments have continued in New Brunswick to test the feasibility of ocean ranching, though no further introductions are planned. Experiments in Newfoundland have been discontinued, with remaining animals and eggs destroyed. Escapes have been reported from both areas prior to 1980. Small commercial introductions have been made to British Columbia waters of C. gigas and V. japonica seed from a California hatchery and juvenile Panope generosa (geoducks) for research purposes from a Washington hatchery. In 1980, imports of horseshoe crabs and sea urchins were permitted to quarantine systems for research purposes and then destroyed.

In France, the distribution of Ruditapes semidecussatus from French hatcheries now approaches commercial levels. R. decussatus seed has been imported from a Guernsey hatchery. Rainbow trout eggs have been imported from Denmark, USA, Australia and New Zealand; coho salmon eggs have been imported from the USA. It is possible that an unofficial introduction experiment occurred with chinook and coho smolts from a hatchery in the Alpes-Maritime region to waters near Toulon.

Federal Republic of Germany is still interested in developing C. gigas culture, with certified seed being relaid from German and Scottish hatcheries.

Norway has restricted imports of O. edulis and C. gigas seed from a Scottish hatchery, although requests have also been made to import from Ireland and the USA. The import of Canadian lobsters has been refused.

In the Netherlands, it has been found that introduced C. gigas can breed in most years and this species is now removed from O. edulis beds to prevent interference with the culture of the latter.

Spain has imported V. japonica seed from French and English hatcheries, lobsters from Ireland, and spiny lobsters from Northwest Africa.

In the UK, rainbow trout eggs continue to be imported from Denmark and the USA, and Atlantic salmon eggs from Norway. The F_1 progeny from the original coho import is contained, as before, by law.

In the USA, considerable interest is being shown in introducing Penaeus stylirostris from Mexican to Atlantic waters for induced breeding experiments. Several Tilapia species (Tilapia aurea, T. mossambica, and T. melanotheron, all from Africa) have colonized marine and brackish waters in Florida and California.

IV. Species Introduced Accidentally With Deliberate Introductions

Federal Republic of Germany reported that one coho salmon was caught in the Baltic.

A new disease organism (Bonamia ostreae) has been reported in the Brittany area of France and the East Scheldt area of the Netherlands. In the latter region, oysters imported from France have suffered a mortality of 60%. In the Netherlands, only one case of Marteilia refringens was noted in 1980; in addition, a fair percentage of oysters imported from Greece contained coccidia-like parasites, but this organism does not seem to have become established in Dutch waters.

In the UK, no new species have been reported. With regard to the copepod parasite Mytilicola intestinalis, licenses are now granted for the relaying of hatchery seed oysters from infected to free areas, provided the molluscs do not exceed 12 mm (O. edulis) or 25 mm (C. gigas). The possibility of importing the blood disease Gaffkemia with North American lobsters is causing concern in the UK.

V. Completely Accidental Introductions

The immigrant Japanese seaweed Sargassum muticum has continued to spread in the UK and France and attached populations have now been found in the Netherlands. The effect of this introduction is not yet known. Biological control experiments are being attempted in the UK. Sargassum muticum is now present off the Mediterranean coast of France.

In Scotland, the alga Gyrodinium aureolum has caused red tides. It is felt that this algae may be a fairly recent introduction.

A new phytoplankton organism Pleurosigma planctonicum was reported by the Netherlands.

VI. Species Introduced For Hatchery Rearing

In Canada, the bay scallop (Argopecten irradians) remains in quarantine conditions. The F_2 generations produced in 1980 were not released, due to inclusions being found in the digestive diverticula. No further imports are planned. The F_1 progeny of O. edulis (from Maine and Wales brood stocks) are also still held in quarantine conditions (though no pathogens have been found) until a release permit is granted.

In the UK, imports to the Conwy hatchery have included Crassostrea rhizophorae from Brazil, Venerupis semidecussata from the USA, Penaeus monodon from Tahiti and Thailand, and Homarus americanus from the USA.

VII. Future Introductions

In Canada, consideration is being given to the importation to quarantine hatchery facilities in Nova Scotia of striped bass (Morone saxatilis) eggs from New York hatchery facilities.

France intends introducing, to a hatchery, the Chilean oyster Ostrea chilensis. No official action has yet been taken regarding the request to carry out the experimental introduction of Macrocystis pyrifera.

Norway is considering the introduction of Pacific salmon (Oncorhynchus) species.

In the UK, the Tasmanian crayfish (Parastacoides tasmanicus) is to be imported for university studies. Consideration is being given to importing specimens of the Japanese scallop for comparative growth studies. The transplantation of Homarus gammarus x H. americanus crosses is also being considered.

RELEVANT PUBLICATIONS

Dr. Carlton of the United States has produced a list of over 28 papers which was much appreciated by the group. He has also produced a rough translation of the chapter titles of a book by Dr. Karpevich of the Soviet Union. This was of considerable interest to the Working Group, and a complete translation of the book will be obtained if possible.

Several papers were included in the Canadian and French national submissions. A complete reference list is included as Appendix VI.

GENERAL STATUS OF RECENT INTRODUCTIONS

(a) Molluscs

The situation in France was described. A number of oyster species had been tried after the O. edulis mortalities in the 1950's. C. angulata had been first imported from Portugal, but this had become expensive in the late 1960's and a small quantity of C. gigas had been imported from Japan. The numbers of these increased greatly after the onset of gill disease problems with C. angulata around 1970. Brood stock C. gigas were also imported from British Columbia; these had bred well in French Atlantic coastal waters (but not in the Mediterranean areas) so that home-produced seed supplies had been available for several years. C. rhizophorae (=guyensis?) had been imported from Guyana in 1976, but all had died. O. edulis had been imported from the USA (California hatchery) with variable results between 1976 and 1979. In 1979, an unidentified disease had occurred with these, resulting in 100% mortalities; further imports were therefore banned.

The new disease occurring in flat oysters in Brittany has resulted in a search for a replacement resistant species. Two have been looked at in detail -- O. chilensis from Chile and O. denseolamellosa from Korea. The former has been selected, and French scientists have brought back 80 kg of various sizes of oysters from Chile to quarantine conditions at the SATMAR hatchery. No parasites or diseases were apparent in the brood stock, and spat have already been produced. These will be used for growth experiments and tested for resistance to Bonamia ostrea. A few C. gigas seed are still being imported from Japan.

Clam species being introduced in France were Ruditapes decussatus from Guernsey and R. semidecussatus from the SATMAR hatchery (from USA brood stock which itself had come originally from Japan). Mercenaria mercenaria had been introduced from the USA in the mid-1960's but most appeared to have died.

The point was made that a number of scientists were concerned with the export and subsequent return of consignments of seed molluscs from the SATMAR hatchery to Senegal and Corsica. The French scientists reported that the molluscs were examined for pests and diseases before and after any growth experiments (none in fact had been returned to France from Senegal) to ensure no harmful effects occurred. One difficulty, however, was that no regulations existed limiting the import of molluscs (except for the recent ban on the movement of O. edulis), though this power was being sought.

The Netherlands reported that all O. edulis affected by Bonamia had been destroyed to try to prevent the spread of the disease. Stocks of isolated, unaffected O. edulis were available to build up new stocks. C. gigas imported from Japan and then France had been found to be able to breed during the most summers in Dutch waters. There are new fears that C. gigas will become a pest of the O. edulis fishery, and they are being weeded out and destroyed. No C. angulata remain alive in Dutch waters.

Mercenaria mercenaria were introduced in 1965, but had met with little commercial interest. A survey of Dutch waters in 1978 indicated that some of the original introduction were still alive, but no breeding had occurred.

Denmark reported that, like the Netherlands, their attempt to introduce C. gigas might prove too successful in that breeding had occurred in Danish waters and there was some concern that this species might become a pest of O. edulis culture. Denmark had introduced the new flat oyster disease Bonamia and was developing regulations requiring the inspection of further consignments of oysters to ensure freedom from disease.

(b) Algae

The Netherlands reported that Sargassum muticum had been found attached along 3 km of dyke and also in lagoon situations where growth would be expected to be very rapid.

The UK reported on the spread of Sargassum along the English Channel coast, on research on biological/amenity affects, and on attempts at control.

France also updated information on Sargassum, whose distribution is now from the Seine to Morlaix. There was some agreement with the UK finding of possible positive effects on fish/crustacea biomass. [Ref. J. Cosson et al. Bull. Soc. Linn. Normandie 1977, 105, p. 109-116].

France also indicated that there had been no progress with the proposed experimental introduction of Macrocystis, which had been first put forward in 1978. Authorization had not been received from the French Ministry of the Environment. If this is received, the proposal will go to the Introductions Working Group before any action is taken. It is possible that an unauthorized introduction could take place (as with any other species) since there is no regulation to prevent it, but Macrocystis is now so well known that it would be impossible for this not to be found out.

One possible result of introductions of Japanese oyster seed to France had been the associated introduction of several algal species to the L'Etang de Thau on the Mediterranean coast. Of special interest was Undaria pinnatifida which had first been found in 1973 and has flourished to such an extent that experiments are now underway to gauge commercial possibilities. Other species included Laminaria japonica, Porphyra tenera and Sargassum muticum. Sargassum had only been found in April 1981, and was possibly introduced by a boat from northern France.

(c) Salmon

The discussion of introduced Pacific salmon began with a general status report by Dr. Munro of Scotland. He pointed out a number of important aspects. Reproducing populations of members of the genus Oncorhynchus occur in Atlantic waters at present only in Canada, United States, Norway, and the USSR -- and the persistence of these populations is uncertain. Pink salmon introductions on the Kola Peninsula by the USSR have apparently ceased, and we know little about the success of the populations. Experiments with cage culture (and possibly ocean ranching) of chinook and pink salmon have been reported from DDR, Poland, and the Latvian/Estonian coasts. There are reports of coho culture in Spain and Italy, but coho ocean ranching activity is principally in the United States, except for experimental work in France and elsewhere. Additionally, steelhead (sea-run Salmo gairdneri) are being cultured in a number of countries.

Ecological aspects of Pacific salmon introductions were emphasized. Introduced diseases constitute a threat, although no problem has yet appeared. Interactions of introduced salmon with natives include estimation of the lengths of fresh water life, and the occupation, by preference, of different ecological niches. Information on interactions in marine waters is severely limited.

The gradual expansion of continuous cage culture of cohos will be accompanied by sporadic escapes. Any attempts at ocean ranching may be accompanied by establishment of runs, although this is not a necessary outcome in all locations.

Following the general status report, the Working Group addressed the two pressing issues of the moment -- the Norwegian proposal for sea farming of coho, and the CNEXO experiment concerned with ocean ranching.

Norway presented a desk study supporting the introduction of coho to establish a brood stock in strict quarantine conditions and to use F_1 progeny for sea cage trials. CNEXO (France) is continuing with controlled experiments in freshwater, but also wishes to expand the research program to include annual uncontrolled releases of coho smolts. These could not be the monosex individuals recommended by ICES, due to a ban in France on the use of hormones in food animals.

Following the general discussions, a subgroup on salmon was formed under Dr. Munro and this produced several documents for the full Working Group to consider. The Norwegian proposal proved the less contentious of the two and the following statement was developed and accepted by the Working Group:

NORWEGIAN REQUEST FOR ADVICE CONCERNING A PROPOSAL TO INTRODUCE COHO SALMON FOR STUDIES ON THEIR SUITABILITY FOR MARICULTURE

The request from Norway (copy attached as Appendix III) involves advice on a proposal for use of a disease-free stock of F_1 fish from a UK quarantine facility, or establishing a brood stock in quarantine for life and using the F_1 progeny for sea cage trials. Initial studies will involve relatively small numbers of fish.

The Working Group considered that this request would not pose a risk to the environment or to native salmonids, provided the Norwegian government representative endorsed the desk study statement (Appendix IV) supporting the proposal that escape of fish and any non-indigenous pathogens introduced with them could not occur from whatever facilities were used to contain the fish. With such an endorsement, it was recommended that Council accede to the request.

The Working Group assumes that the Norwegian authorities will ensure that the net pens or tanks holding the smolts will be maintained in conditions offering the best prospect for protection from the weather, and that the authorities are satisfied that the chances of escape are negligible during the lifetime of the original import and of the F_1 stock. Under such conditions, the Working Group sees no reason why the trial should not be conducted. If started with eggs in 1981, it will take 3 years to produce the F_1 stock and a further 3 years to evaluate the performance of the F_1 stock in seawater cages, making 6 years in all (a shorter period will be required if UK salmon are used as brood stock).

However, if the proposed experiment resulted in a recommendation for commercial aquaculture of coho salmon, the Norwegian authorities must recognize that a new situation might arise with some risk potential. Commercial development could not take place under the stringent "no escape" conditions of this proposal, and the virtual certainty of escapes raises the question of whether they posed a threat to native fish. The desk study acknowledged that such a threat might exist, yet made no reference to initiating research to settle this question. It was therefore strongly recommended that the Council point this out to the Norwegian authorities and advise them to use some of the F_1 stock to establish if interreactions between coho and native fish were significant and to the latter's detriment. All progress on the coho introduction should be reported to the Council.

CNEXO PROPOSAL FOR THE STUDY OF THE INTERACTIONS BETWEEN COHO SALMON AND NATIVE MIGRATORY SALMONIDS IN FRANCE

With regard to the CNEXO proposal concerning coho salmon introductions (copy attached as Appendix V), no initial agreement could be reached among members of the Working Group concerning releases to open waters.

The CNEXO position can be summarized by the following statement:

"The CNEXO proposal for experiments concerning interaction between coho salmon and native species presented at the last statury meeting (1980) was composed of two projects:

° introduction of coho and salmon juveniles in a freshwater stream controlled for downstream migration; this part was agreed by the Anacat Committee;

° release of 10,000 cohos from a site equipped with an upstream migration trap during three years. This part was "viewed with concern" by the Anacat Committee which decided that approval could not be given except if the population realized was monosex (use of steroids to build up male population).

After consultation with other French scientific institutes concerned with this problem, it was considered that:

° steroid treatment will probably not produce in excess of 80% of males in the population;

° French legislation prohibits the use of hormones in animal food. Moreover, this practice, even on a limited scale, may well have a dramatic impact on farmed salmon;

° due to the fact that the smolts which are proposed to be released are 0 age smolts (5 months old only) the deep endocrinal modifications induced by steroid treatment results in a high risk of altering smoltification, osmoregulation and migration behavior. The study would thus not bring results applicable to the present situation.

Considering these facts, steroid treatment to obtain a monosex population is not considered by the French scientists to be an acceptable solution.

To help minimize the risk of straying of adult salmon in other rivers, we propose to use chemical imprinting with morpholine which has been demonstrated to be efficient in reducing the straying of fish to other river systems.

Considering the present situation in France:

° Even if still limited to about 100 metric tons, coho salmon farming is now part of current commercial practice in France (1.6 million eggs introduced in 1981).

° Heterosexual populations are commonly escaping from hatcheries or commercial sea cages, generally not in great numbers, but escapes of several thousand fish are not uncommon.

° Uncontrolled intentional release of coho and chinook salmon have occurred since 1980 from at least two sites (one in the Mediterranean, the other on the Channel); the present French legislation is not appropriate to prevent this release directly in marine waters.

° The proposed releases within the experimental program are limited to 10,000 fish per year which is considered of the same magnitude as the potential risk existing in farms stocking sea cages with 5,000 to 10,000 fish/cage. They will be introduced in a site totally controlled, and downstream migration will be under the scrutiny of a French scientific committee.

The proposed program (freshwater introduction and seawater releases) will provide important scientific information which may help to determine an objective position on this very important subject. However, the release of 10,000 heterosexual smolts is still viewed with concern due to the non-negligible ecological risks they represent".

The reasons for considering rejection of releases of coho salmon into the Atlantic until more information is available from the freshwater studies were summarized as follows:

° "Results of the fresh-water phase of the experiment should be known and fully evaluated before the sea-release phase begins. Results from the fresh-water phase are crucial to any analysis and interpretation of straying.

° Fish returning not to the point of release but to other coastal rivers are unlikely to be observed. No other fish traps exist, and sport fishing activity likely to catch the fish is not significant. The number of spawning fish which might ascent other rivers, based on 10,000 smolts released/year, is variously estimated at from 2-400 in each of the 3 years. Any figure even remotely approaching the latter figure may offer a high risk of establishment of populations and threat to native fish.

° We already know that some coho will return to their point of release. Therefore, the results of the experimental releases can only be of quantitative significance, which seems more of commercial value than scientific merit.

° The migration routes at sea are most unlikely to be successfully determined. The numbers of fish are very small in relation to the potential area for migration. The methods of catching these fish at sea, namely gill nets and nearshore trawling, are not employed in local fisheries.

° No new science will result from this release; and it contains, as recorded previously by the Introductions Working Group and the Anacat Committee, an unacceptable element of risk. CNEXO might consider release in other coastal areas where native salmon are not at risk, or study of areas of accidental release near sea cages".

A number of relevant statements were made concerning coho salmon in France:

- ° A reproducing population of coho in Normandy may have developed following escapes of 15,000 fish from sea cages in 1976. The population may not exist today, however, since specimens have not been taken lately.
- ° There are no laws in France that would prevent direct release of coho into marine waters, so private farmers can rear salmon in fresh water and release into the sea.
- ° Some private farmers are doing this, and have been since 1971, in the Somme estuary and in the Mediterranean. The scale is unknown, since data are not given by those involved.
- ° ISTPM has given unfavorable advice on sea ranching to the French government, but there is no official French position relative to the matter.
- ° France has not officially requested an opinion or advice from ICES on the matter of sea ranching of salmon.

Following extensive remarks from all members of the Working Group, CNEXO therefore put forward an amended proposal which involved a single release of an adequate number of fish at the original experimental site, with increased electrofishing in adjacent rivers at spawning time and a statutory prohibition of other releases for three years following the experimental release. This experiment could not take place in 1981 for logistic reasons but would be planned for the following year.

In considering this amended proposal, the Working Group was made aware of both deliberate and accidental releases of coho salmon which were already taking place in French waters. The Working Group emphasized again its concern regarding the risks from the release of coho salmon into Atlantic waters. It was agreed that the proposed amended experiment was designed to provide scientific information to regulating authorities to assist them in making decisions regarding the ocean ranching of coho salmon in Atlantic waters. The experiment is not designed, however, to establish local spawning populations. Until this scientific information is available, any other releases must be prohibited.

A preliminary statement of the purpose of the new experiment would be:

° The experiment includes two approaches -- a study of freshwater interactions, and a detailed study of the effects of a single release into the sea.

° The experiment would assess potential risks to the environment of coho salmon escaping from sea pens and fresh-water rearing establishments, or from deliberate releases.

° The experiment is secondarily a feasibility study for ocean ranching.

° The experiment will provide information to regulatory bodies to be used in reaching decisions about future developments involving coho salmon.

° The experiment must include well planned and adequate scientific follow-up and monitoring.

The Working Group decided that a panel of experts under Dr. Munro should be formed which would provide advice and a report on the design of the revised CNEXO experiment (details to be provided by Dr. Harache). This advice would be sent to all members of the Working Group for their comments before submission to the parent Mariculture Committee prior to the 1981 Statutory Meeting.

A general statement describing a common understanding of the situation is as follows:

"The Working Group, with some exceptions, agreed in principle with the concept that carefully controlled tests of ocean ranching of coho could be undertaken, in view of accidental and deliberate releases that are occurring and have occurred. Experiments must be designed to produce maximum scientific benefit, and must be carried out without interference from other releases. A panel of experts under Dr. Munro will cooperate with CNEXO investigators. The releases will not occur in 1981, but a new detailed proposal and protocols will be prepared by CNEXO, involving a single release with provision for accumulating data on routes and rates, and a mechanism will be sought for prohibition of all other releases for 3 years".

FUTURE INITIATIVES FOR THE WORKING GROUP

During the discussions, a number of possible new initiatives were explored briefly. These were in some cases activities which are logical extensions of ongoing or completed projects, and in some cases new perceptions of the role of the Working Group:

(1) Preparation of a list of diagnostic and certifying laboratories in each country, for zoosanitary as well as public health aspects of importation of marine organisms.

(2) Improvement in international communications concerning planned or actual introductions and transfers of marine organisms. One aspect of this might be a newsletter, or association with an existing newsletter.

(3) Development of detailed reviews of the status of introduced species, with titles such as "Molluscs and molluscan diseases in France, 1968-1981", "Seaweed introductions into European waters 1970-1980", "Eel transfers and eel diseases". These reviews could form the basis for papers to be given at a proposed 1982 mini-symposium.

RECOMMENDATIONS

During the discussions, a number of recommendations to the parent Committee(s) were formulated by the Working Group on Introductions and Transfers of Marine Organisms. They are:

(1) Concerning the Norwegian proposal to introduce coho salmon for studies on their suitability for mariculture, the Working Group recommends that the following advice be offered:

The Working Group considered that this request would not pose a risk to the environment or to native salmonids, provided the Norwegian government representative endorsed the desk study statement (Appendix IV) supporting the proposal that escape of fish and any non-indigenous pathogens introduced with them could not occur from whatever facilities were used to contain the fish. With such an endorsement, it was recommended that Council accede to the request.

The Working Group assumes that the Norwegian authorities will ensure that the net pens or tanks holding the smolts will be maintained in conditions offering the best prospect for protection from the weather and that the authorities are satisfied that the chances of escape are negligible during the lifetime of the original import and of the F_1 stock. Under such conditions, the Working Group sees no reason why the trial should not be conducted. If started with eggs in 1981, it will take 3 years to produce the F_1 stock and a further 3 years to evaluate the performance of the F_1 stock in seawater cages, making 6 years in all (a shorter period will be required if UK salmon are used as brood stock).

However, if the proposed experiment resulted in a recommendation for commercial aquaculture of coho salmon, the Norwegian authorities must recognize that a new situation might arise with some risk potential. Commercial development could not take place under the stringent "no escape" conditions of this proposal, and the virtual certainty of escapes raised the question of whether they posed a threat to native fish. The desk study acknowledged that such a threat might exist, yet made no reference to initiating research to settle this question. It was therefore strongly recommended that the Council point this out to the Norwegian authorities and advise them to use some of the F_1 stock to establish if interactions between coho and native fish were significant and to the latter's detriment. All progress on the coho introduction should be reported to the Council

(2) Concerning the CNEXO proposal for the study of the interactions between coho salmon and native migratory salmonids in France, the Working Group recommends the following:

(a) That CNEXO scientists prepare a detailed revision of their experiment in accord with discussions at the 1981 Working Group meeting, and that advice of a Panel of Experts under Dr. Munro of Scotland be sought.

(b) That CNEXO proceed with a modified experiment involving study of fresh-water interactions, and a single release of coho salmon, after a carefully designed experiment is developed.

(c) That the status of the experiment be reviewed again at the 1982 meeting of the Working Group.

(3) Since the new information concerning introductions of non-indigenous species is now in final manuscript stage, the Council should publish the information as a Cooperative Research Report.

(4) A detailed response plan should be developed for queries to the Council from member countries considering introductions of non-indigenous species. The Council itself, possibly acting through the Consultative Committee, should determine the time schedule (since each situation is different), and the route to be followed in providing advice, since Working Groups do not communicate directly with member countries.

(5) National regulations concerning introductions of non-native species are still inadequate in some member countries. Every effort should be made by ICES to encourage development of adequate safeguards, since actions in one country may affect adjacent countries.

(6) An important book on introduced species "Theory and practice of acclimatization of aquatic organisms" has been published in the USSR by Dr. A. F. Karpevich. ICES should encourage translation of the work into other languages.

(7) Because of current interest in the status of a number of introduced species (Pacific salmon, oysters, exotic seaweeds, eels, etc.) ICES should convene a mini-symposium on the subject as part of its 1982 statutory meeting, supported jointly by the Mariculture and Marine Environmental Quality Committees. The mini-symposium should consist of summary invited papers.

(8) Protocols concerning inspection procedures, diagnostic procedures, and quarantine facilities and practices relating to introductions of non-indigenous species should be prepared and published by the Council as a further expansion of its Code of Practice.

(9) Summaries of national laws and regulations concerned with introduced species should be collated and published by the Council, with the complete national documents deposited and available at the offices of the Secretariat.

(10) Because of the need to continue its oversight on salmon, oyster, and seaweed introductions, and its preparation of protocols and advisory documents, the Working Group on Introductions and Transfers of Marine Organisms should meet at La Coruna, Spain, May 4-7, 1982.

APPENDIX I: LIST OF PARTICIPANTS -- ICES WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS -- SETE, FRANCE, 5-8 MAY, 1981

C. Sindermann	USA (Chairman)
A. Franklin	UK (Secretary)
T. W. Rowell	Canada
N. O. Christensen	Denmark
M. Comps	France
M. Bonnett	France
H. Grizel	France
Y. Harache	France
C. Maurin	France
A. Kiener	France
R. Rambault	France
D. Declerck	Belgium
R. Meixner	Federal Republic of Germany
H. Rosenthal	Federal Republic of Germany
P. van Banning	Netherlands
E. Egidius	Norway
H. Quiroga	Spain
A. L. S. Munro	UK

APPENDIX II

AGENDA

ICES WORKING GROUP ON INTRODUCTIONS AND

TRANSFERS OF MARINE ORGANISMS

Sète, France (ISTPM)

May 5-8, 1981

May 5, 1981

9:00 am — Convene

- Remarks by ISTPM officials
- Consideration of the agenda
- Comments by the Chairman
- Status of Working Group responses to resolutions approved at 1979 and 1980 Statutory Meetings
- Final review of Cooperative Research Report on Introduced Species (Update of Coop. Res. Rept. No. 32)
- Discussion of document containing collation and summary of national laws and regulations concerning introduced species
- Final review of draft document "Guidelines for implementation of the ICES Code of Practice concerning introductions and transfers of marine species
- National Summaries
- Relevant Publications

12-1:30 pm — Lunch

1:30 pm — Reconvene

- General review of status of salmon introductions and requests for advice -- Dr. Munro
- Develop plan of action concerning role of Working Group in advising ICES about salmon introductions, and protocols to be followed

6:00 pm — Adjourn

May 6, 1981

9:00 am — Reconvene

- General review of status of molluscs introductions
- Drafting sessions for subgroups to begin developing protocols for examination of fish, crustacea, molluscs, planned for introduction

11:30 am — Leave for field trip - oyster and Undaria growing areas

May 7, 1981

9:00 am — Reconvene

- General review of status of seaweed and other introductions
- Drafting session for subgroups to develop reporting and communications procedures for fish, crustacea, molluscs

12-1:30 pm — Lunch

1:30 pm — Reconvene

- Drafting sessions for subgroups to develop requirements for diagnostic and certifying laboratories

3:30 pm

- Working Group reassemble to consider results of drafting sessions
  - (1) protocols for examinations
  - (2) reporting and communication procedures
  - (3) requirements for diagnostic and certifying laboratories

6:00 pm — Adjourn

May 8, 1981

9:00 am — Reconvene

- Discussions of recommendations to ICES
- Discussions of actions to be taken by the Working Group in 1981
- Discussions of future Working Group activities and initiatives
- Discussions of documents to be prepared for the 1981 Statutory Meeting of ICES
- Consideration of the desirability of a Special Meeting on Introduced Species in 1982 and 1983

12-1:30 pm — Lunch

1:30 pm — Reconvene

- Drafting session on Working Group report to ICES
- Consider draft recommendations and draft report

5:30 pm — Adjourn

May 11-12 — Proposed field trip to coho salmon experimental site for those interested

APPENDIX III. REQUEST FOR ADVICE CONCERNING INTRODUCTION OF COHO SALMON FOR CAGE REARING IN NORWAY

NORDNESPARKEN 2
POSTBOKS 1870 – 5011 NORDNES (BERGEN)
TELEGRAMADRESSE: HAVFORSKING
TELEX 42 297 OCEAN N
BERGEN. NORWAY

BERGEN. 10.9.1980
SENTRALBORD 21 77 60

J. NR Akva 788/80 GS/DM/ASM
(BØR GJENGITT VED SVAR)

International Council for the
Exploration of the Sea
General Secretary
Palægade 2-4
DK-1261 København

Import of coho salmon

The Norwegian fish farming industry investigate the possibility to rear other salmonid fishes than the Atlantic salmon and rainbow trout.

A private firm, SEA FARM A/S, would like to import coho salmon in cooperation with the Norwegian authorities. Prior to any import, however, the Institute of Marine Research would like to listen to advice from the International Council for the Exploration of the Sea (ICES).

Knowing that this question has been discussed in the Working Group on the Introduction of Non-indigenous Marine Organisms and that one of the subjects in this year's meeting in Anadromous and Catadromous Fish Committee would be dealing with the status of Pacific salmon in the North Atlantic Area, we would like to ask ICES how to handle a possible import of coho salmon to Norway.

Gunnar Sætersdal

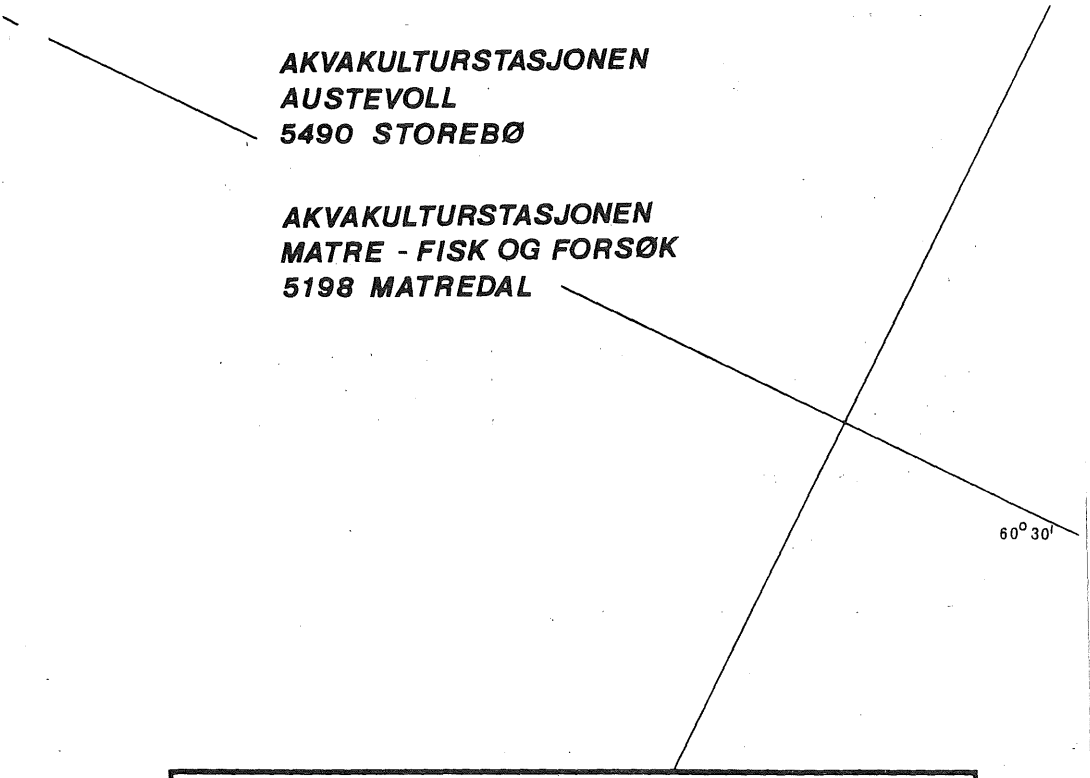
APPENDIX IV. DESK STUDY BY DR. E. EGIDIUS ON A PROPOSED INTRODUCTION OF THE PACIFIC SALMON TO NORWAY

FISKERIDIREKTORATETS
HAVFORSKNINGSINSTITUTT
5011 BERGEN - NORDNES

AVDELING FOR AKVAKULTUR

AKVAKULTURSTASJONEN
AUSTEVOLL
5490 STOREBØ

AKVAKULTURSTASJONEN
MATRE - FISK OG FORSØK
5198 MATREDAL



INTRODUCTION OF PACIFIC SALMON (ONCORHYNCUS SPECIES) TO NORWAY - DESK STUDY FOR THE CONSIDERATION OF THE ICES WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS AT ITS 1981 CONSULTATION

by

EMMY EGIDIUS
INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY

L.nr. 13/81

INTRODUCTION OF PACIFIC SALMON (ONCORHYNCHUS SPECIES) TO NORWAY - DESK STUDY FOR THE CONSIDERATION OF THE ICES WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS AT ITS 1981 CONSULTATION

INTRODUCTION

A considerable interest in the introduction of different species of Pacific salmon (Oncorhyncus) has been appearent in Europe the latter years. In Norway the interest in fish farming is steadily increasing. The species are Atlantic salmon (Salmo salar) and rainbow trout (Salmo gairdneri) both grown to the size of several kilos over a 1½ to 2 years period in sea water. Norwegian fish farmers wish to consider the inclusion of Oncorhyncus species for eventually filling niches in their marketing range of farmed salmon.

The opposition to such introductions for farming purpose is the concern to conservation and to sports-fishing interests. This concern is mostly linked to the uncertainty of the effect of possible escapes from the farms to native populations of Atlantic salmon and sea trout.

EARLY TRANSPLANTS

The salmonids always seem to have attracted man with a special fascination. First of all this is due to their interesting and complicated life cycle: their migration from the rivers to the sea as young fish, their rather obscur growing years in the sea, their abundant return and their ability to find the way back to their parent river to spawn with at least for the Pacific species a dramatic end. And secondly not to forget their long cherished value for sports-fishing and in later years market value.

There are records of early attempts to transplant members of the salmonid family from all over the world. Some examples: Mazeaud (1981) described the introduction of Quinnat or chinook (O.tshawytscha) to French rivers in 1880-ties. Pink (O.gorbuscha) was transplanted to the Great Lakes already in the nineteenth

century (Parsons, 1973) and according to Lear (1980) was attempted transferred to the New Foundland region around 1915. Joyner (1980) reports the early introduction attempts of both Oncorhynchus and Salmo species to South America and Waugh (1980) refers attempted transfers of Atlantic salmo to New Zealand a hundred years ago.

RECENT INTRODUCTIONS

Recent attempts of introductions are abundant and widespread and leave at least some reliable reports as to transferred numbers, mortalitiy, recatches etc. Nearly all of these transfers concern the Pacific species.

Pink salmon

The last twenty years the USSR has carried through intensive assays to acclimatize pink salmon to the Barent and White Sea releasing the fry at the Kola peninsula (Bakshtansky 1980). Some years have given good recaptures, but the climate of this region seems to be too hard for natural runs to become established. Some of the fish, however, have found their way to Norwegian rivers mainly in the Finnmark region were stray natural reproduction has been recorded (Bjerknes 1977). The USSR has recently stopped their efforts on stocking pink fry in the Kola region and if the Norwegian runs have developed to permanent ones, still remain to be seen.

Similar Canadian introductions of pink salmon to Newfoundland obviously have been unsuccessful (Lear 1980).

Rainbow trout

Steelhead or rainbow trout has been extensively transplanted to Europe for farming purpose. Since the early sixties the farming of rainbow trout in several European countries and on the North American Atlantic coast, has extended into sea water, in many cases resulting in large salmon like fish. Today rainbow trout as a candidate for introduction to European waters, would most probably have been prohibited due to its biology, ecology etc. being rather similar to that of the Atlantic salmon. But - with all the escapes sometimes of whole cage-loads - that have occurred along the Norwegian coast, wild, reproducing speciemens have never been reported.

Coho salmon

Coho (O.kisutch) is the main candidate for introductions to Europe today, and unfortunately, information from real large scale implantations are scarce. The implantations to South America of several trout species and a variety of landlocked Atlantic salmon readily adapted to their new environment. All efforts on transplantating seagoing populations, however, failed in the same region. Recently substantial effort is put into the release of coho in the Gulf of Ancud, Chile, the results of which remain to be seen.

Also in the New England States numerous introductions of coho have been attempted mainly for sports-fishing, but also for commercial fisheries. There is evidence of some natural spawning with low survival sustaining a small sports-fishery in some parts of the region (Solomon 1980).

BIOLOGY OF COHO AND ATLANTIC SALMON

As the interest of Norwegian fish farmers now is focused on the potential of coho, we have to compare its biology to that of the Atlantic salmon and sea trout.

Such a comparison of the biology, environmental requirements, food and feeding, stream behaviour etc. of the two species has been complied by Solomon (1979) in connection to introduction plans to the U.K. From his work the following can be summarized:

> The coho salmon has a rather similar biology to Atlantic salmon and sea trout. The young coho spend a year or two in fresh water before migrating to sea as smolts. They are aggressive and territorial, but the species differ somewhat in their microhabitat pattern, where Atlantic salmon keep to the streams, coho feed in pools and margin situations. In fast running water and during school-forming at higher densities the pattern of aggression is similar in coho and Atlantic salmon. The three species in fresh water feed on

available invertebrate drift. The sea trout returns from the sea to fresh water after a few months, the Atlantic salmon after one to several years and coho mostly returns after two years at sea. All coho die after spawning.

Also from Solomon the following can be summarized about inter-specific interactions:

Stream tank interaction studies on Atlantic salmon, coho and brook trout (Salvelinus fontinalis) showed that Atlantic salmon and brook trout were both more aggressive than coho, and brook trout more often displaced coho than did Atlantic salmon. The distribution and behaviour of coho was modified by the presence of the other species, where as the presence of coho had little effect on the distribution of Atlantic salmon and brook trout. The coho in this experiment however, came from hatcheries while the two other species originated from wild populations.

The interactions between coho and rainbow trout have been studied in the wild and interactive segregation between a 1 000 speciemens was noted in summer, the time of greatest potential competition. The survival of each species was found to be largely independent of the other species with the exception that high densities of rainbow may slightly depress the coho. Among the Pacific salmonides, the rainbow is suggested to have most ecological similarities to the Atlantic salmon.

Again from Solomons conclusions we can summarize:

It appears that all salmonid species considered have rather similar natural histories. Where two species occur together, the slight interspecific differences in behaviour become exaggerated and the two species occupy different, narrower niches. It is in the aspects of most similar habitat re-requirements that this interactive segregation takes place most markedly. A dynamic equilibrium is set up, with one species in one series of microhabitates and the second in another.

Although the productivity of each species is probably reduced by interactive segregation, it is likely that overall stream productivity will be increased as two or more species, with slightly different ranges of microhabitates that they can occupy will be more efficient at exploiding the whole stream habitat than one species alone.

In the case of Coho and Atlantic salmon where observations on interactions have indicated that they segregate spatically into different microhabitat types, it is unlikely that one species would exclude the other.

Taking the precaution that the evidence leading to the conclusions is sparse, fragmented and in some cases weak, circumstantial and even anecdotal, Solomon concludes that the accidental or intentional introduction of a spawning Stock of Coho salmon is unlikely to have a dramatic effect on native salmonids.

CONCLUSION

One can always argue that there is not sufficient knowledge about the biological interactions between the salmonid species. However, the rather extensive amount of reports on implantations of foreign species throughout the world, all point out the lack of success in creating natural sea-going runs. There is one exception: the Chinook implantation in New Zealand.

The intended introduction of Coho salmon to Norway is for farming purpose only, and not for release. Until more knowledge is gathered about this species under our conditions, special efforts will be made to avoid its escape. The risk of introducing a free-living coho population in competition with the native Atlantic salmon and sea trout seems negligible.

Pink salmon has been introduced to the rivers in Northern Norway without our cooperation, and also this species may be revived for fishfarming purposes.

The risk on introducing disease agents together with transfers of

new species are not taken into consideration in this study, as this point has been treated previously for the Working Group (Munro 1979, Munro et al. 1980). Eventual Norwegian imports will include certified diseasefree populations or will be kept under quaratine conditions for at least one generation.

We bring this case to the ICES for giving the organisation an opportunity to test the workability of the Code of practise to reduce adverse effects arising from introduction and transfer of marine species. However, we feel it necessary to emphasize that, from our point of view, this seems far to late. We have to accept that several of the Pacific salmon species, including Coho has already been introduced to European waters.

References:

Bakshtansky, E.L., 1980. Introduction of pink salmon into the Kola peninsula. In: Salmon Ranching. Editor J.E. Thorpe. Academic Press 1980. 245-260.

Bjerknes, V. 1977. Evidence of natural production of pink salmon fry (O. gorbuscha) in Finnmark, North Norway, Astarte 10, 5-7.

Joyner, T., 1980: Salmon ranching in South America. In: Salmon Ranching. Editor J.E. Thorpe. Academic Press 1980. 261-276.

Lear, W.H., 1980: The pink salmon transplant experiment in Newfoundland. In: Salmon Ranching. Editor J.E. Thorpe. Academic Press. 1980. 213-244.

Mazeaud, F., 1981. La societe nationale d'acclimatation et le saumon Californien au 19 eme siecle. Saunons (in press).

Munro, A.L.S., 1979: Introduction of Pacific salmon to Europe. ICES CM 1979/F:28, 1-6.

Munro, A.L.S., Elson, K.G.R., Needham, E.A., Nerris, R.J. and McGrath, E.J., 1980. The Quarantine of coho salmon for a whole life cyclus. ICES CM 1980/E:57. 20 pp.

Parsons, J.W., 1973. History of salmon in the Great Lakes, 1850-1970. Tech.Pop.Bur.Sport. Fish Wildl. U.S. 68, 80 pp.

Solomon, D.J., 1979. Coho-salmon in North-west Europe, possible effects on native salmonids. MAFF laboratory leaflet no. 49, Lowestoft. 21 pp.

Solomon, D.J. 1980: Pacific salmon in the North Atlantic: A history and assesment of current status. ICES CM 1980/M: 15 9 pp.

Wangh, G.D., 1980. Salmon in New Zealand. In: Salmon Ranching. Editor: J.E. Thorpe. Academic Press 1980, 277-304.

APPENDIX V. A PROPOSAL BY CNEXO CONCERNING STUDIES OF INTERACTIONS OF COHO AND NATIVE SALMON IN FRENCH WATERS, TOGETHER WITH A DETAILED EXPERIMENTAL PLAN

This report not to be cited without prior reference to the Council*

International Council for the Exploration of the Sea

C.M.1980/E:60
Supplement No. 1

A PROPOSAL CONCERNING STUDIES OF COHO AND NATIVE SALMON INTERACTIONS IN FRANCE, WITH COMMENTS FROM THE WORKING GROUP ON THE INTRODUCTION OF NON-INDIGENOUS MARINE ORGANISMS

*General Secretary
ICES,
Charlottenlund, 2920 Charlottenlund
Denmark

PREFACE

At the 1980 meeting of the Working Group on the Introduction of Non-Indigenous Marine Organisms, reference was made by French participants to a proposal being prepared to introduce young coho salmon or salmon eggs to a stream in Brittany in 1980 or 1981, to study their interactions with Atlantic salmon (CM1980/E:60, page 13).

Because of the possible ecological implications of the proposed action, members of the Working Group requested that the proposal, when formalized, be submitted to ICES, in accord with the ICES Code of Practice concerning introduced species.

On July 25, 1980, a copy of the proposal for the field experiments was received by several members of the Working Group and transmitted to all members of the Working Group. Comments on the proposal were prepared by members of the Working Group most familiar with salmon, and were reviewed, amended, and approved by the Working Group through correspondence.

This document, a supplement to the 1980 Report of the Working Group, consists of the French proposal, in French (I) and English (II), an explanation of the proposal from Dr. Harache (III), and comments from the Working Group (IV). The document should serve as a basis for discussion and possible action by the parent committees of the Working Group during the 1980 Statutory Meeting of ICES.

I. PROJET D'ETUDE DES INTERACTIONS SAUMON COHO-ESPECES INDIGENES, DANS LE CADRE DU PROGRAMME SEA-RANCHING DU C.N.E.X.O.

INTRODUCTION

Depuis 1970, plusieurs millions d'oeufs de saumon coho ont été introduits en France à des fins d'élevage en captivité, soit en pisciculture d'eau douce, soit pour la production d'animaux élevés en fermes marines pendant une partie de leur cycle. La production actuelle de coho d'aquaculture a atteint environ 100 tonnes en 1980 et les caractéristiques de l'espèce laissent envisager des possibilités de développement de la production non négligeables sur les côtes franciases.

Un certain nombre de fuites accidentelles, généralement limitées, sont intervenues en plusieurs points du littoral sans qu'il soit possible de bien cerner les conséquences de l'introduction de cette nouvelle espece dans le milieu naturel.

Il existe très peu de références bibliographiques permettant d'apprécier les risques éventuels représentés par le coho pour les espèces indigènes et nous pensons qu'il est nécessaire de mettre en oeuvre un effort de recherche permettant de préciser le degré d'intéraction entre coho d'une part et saumon atlantique-truite de mer d'autre part, dans les zones où le risque de trouver ces 3 espèces dans le même type d'environnement existe. Cette proposition va dans le sens de la recommandation du groupe de travail sur"l'introduction des espèces non indigènes" du "Conseil International pour l'Exploration de la Mer" (Nantes 22-26 avril 1980) (cf. annexe 1).

LE PROJET "SEA RANCHING" DU CNEXO.

Le CNEXO a entrepris en 1980 un programme de recherche sur la technique du "Sea Ranching" en salmonidés migrateurs, consistant à tester les performances des espèces indigènes (saumon atlantique et truite de mer) dont les juvéniles produits en écloserie seront relachés dans un étang a marée apres conditionnement ou non (technique Hasler).

Le site retenu, étangs d Trébabu pres du Conquet (cf. annexe 2), sera équipé d'une petite pisciculture (fonctionnement partiel fin juillet 1980) permettant d'élever les juvéniles de migrateurs, et d'un dispositif de recapture des adultes lorsde leur éventuel retour au site de lâcher.

Les caractéristiques du site et son équipement dans le cadre du projet "Sea Ranching" pourraient être mises a profit pour tenter de préciser la nature des intéractions entre saumon coho et especes indigènes.

PROJECT D'ETUDE INTERACTION COHO-ESPECES INDIGENES.

1. Compétition en milieu lotique (ruisseau).

   1.1 Caractérisation des secteurs d'immersion compris entre le 3ème étang d'eau douce (le plus en amont) et la pisciculture:
   - largeur, profondeur (3 mesures sur 1 transert) tous les 15 m;
   - pente (niveau de géomètre);
   - vitesse du courant (moulinet OTT);
   - granulométrie superficielle.

   1.2 Immersion, en juillet 1980, de 500 coho et 500 salar de taille comparable mais d'age différent, sur des secteurs préalablement définis, avec marquage différentiel par secteur (tableau 3).

1.3 Pêches électriques de contrôle fin septembre 1980 pour évaluer les paramètres croissance mortalité et dispersion. Etude des dévalaisons sur une année au niveau de la pisciculture dans un piège de contrôle.

1.4 Pêche électrique de contrôle en février 1981 pour effectuer un deuxième inventaire piscicole (croissance, mortalité, dispersion).

1.5 Etude de la dévalaison des smolts printemps 1981 par piégeage aval.

2. Compétition en milieu lentique (étang).

2.1 Choix de 2 étangs de même superficie isolés par des grilles amont et aval.

2.2 Immersion en septembre 1980 de:

- étang amont : 3 000 parrs de S. salar
- étang aval : 1 500 parrs de S. salar + 1 500 parrs de coho.

2.3 Contrôle en mars-avril 1981 des paramètres croissance-mortalité et pourcentage de smoltification puis marquage.

3. Etude de la migration marine du saumon coho.

Objectif: apporter des éléments de réponse aux questions suivantes:

+ Le coho revient-il à son point de lâcher, dans quelles proportions et avec quelle fiabilité (pourcentage de divagation)?

+ Où passe-t-il sa phase marine estuaire, zone côtière, migration courte ou longue, etc...?

Moyens:

+ Lâcher pendant 3 années consécutives d'environ 10 000 smolts de coho produits sur le site sous contrôle sanitaire dont 3 000 porteurs de marques étiquettes permettant de localiser les points le recapture en mer.

+ Piégeage des adultes lors du retour éventuel au site de lâcher.

CONCLUSION.

Le passage par une phase de recherche sur l'impact éventuel des saumons du Pacifique sur les espèces indigènes nous semble indispensable pour définir une position objective et éventuellement des mesures réglementaires, devant la pression croissante des projets de "Sea Ranching" privé ou collectif a partir d'espèces pacifiques.

Un tel programme pourrait se développer en association avec divers organismes français de recherche et ses résultats soumis à l'examen d'un comité scientifique de contrôle.

P. PROUZET Y. HARACHE

PRESENTATION DU SITE EXPERIMENTAL.

Le site du Conquet (étangs de Kerjeau) se situe sur la côte Nord du Finistère. Il est constitué d'une rivière de 6 km de long entrecoupée par des étangs. La surface en eau exploitable comprend 14 hectares d'eau saumâtre (1er étang) (5‰ - 25‰) renouvelable par le jeu des marées, 2 hectares d'étangs d'eau douce (3 étangs) et 0,5 hectare de rivière dont la pente moyenne est de 1%.

Hydrologie (tableau 1)

Paramètres	Débit l/s	T °C	pH	O_2d' mg/l	O_2 %sat	DBO_5 mg/l	NH_4 mg/l-N	NO_3 mg/l-N	NO_2 mg/l-N	Ca mg/l	PO_4 mg/l-P
Valeurs mini	45	3	7	8,7	75	0,6	0,02	3,35	0,001	18	0,18
Valeurs maxi	330	23	9	11,9	120	6,44	0,25	12,48	0,05	26	0,88

Les fortes valeurs des sels nutritifs permettent d'expliquer les phénomènes d'eutrophisation rencontrés en milieu lentique.

ETUDES MENEES SUR LE SITE.

- Etude physico-chimique (Mémoire d'I.U.T., 1979).
- Etude des populations de truites (D.E.A., 1979 et Maîtrise de Sciences et Techniques, 1980).

Sommaires des résultats obtenus

La qualité hydrologique du site pourrait être améliorée par la mise hors circuit d'au moins un étang durant le période estivale et automnale de manière à limiter l'échauffement de l'eau et les zones d'eutrophisation.

La population de truites se caractérise par une faible densité mais par une forte croissance (analogue à celle des truites de la Nivelle) due en partie à la migration des truites en zone marine durant le période estivale.

◇ estuary ▽ brackish water ▼ freshwater ■ hatchery ✱ counting trap

E: 1/25000

II. (TRANSLATION) STUDY PROJECT ON THE COHO SALMON - INDIGENOUS SPECIES INTERACTIONS WITHIN THE FRAMEWORK OF THE SEA-RANCHING PROGRAM OF C.N.E.X.O.

INTRODUCTION

Since 1970 several million coho salmon eggs have been introduced into France with the intention of raising them in captivity either in fresh water or by using "marine farms" during a part of their life cycle. The actual production of coho from aquaculture was about 100 tons in 1980 and the characteristics of the species suggest the development of a not inconsiderable production along the French coasts.

Even though a certain number of accidental escapes, generally limited, have occurred at several places along the shore, it has not been possible to determine the consequences of the introduction of this species into the natural environment.

There are very few bibliographic references which could enable us to predict the eventual risks presented by the coho salmon towards indigenous species, and we think it advisable to design a project to discover the degree of interaction between the coho on the one hand and Atlantic salmon and sea trout on the other, in areas where there exists the chance of finding these three species in the same type of environment. This proposal is in accord with the recommendation of the I.C.E.S. working group on the "Introduction of Non-Indigenous Species" (Nantes, 22-26 April, 1980; cf. appendix 1).

"SEA-RANCHING" PROJECT/CNEXO.

This year (1980) CNEXO has undertaken a research program on the technique of "sea-ranching" of migratory salmonids. It consists of testing the performances of indigenous species (Atlantic salmon and sea trout) by releasing hatchery produced juveniles into tidal ponds with and without prior conditioning (Hasler technique).

The chosen site, the ponds of Trébabu near Conquet (cf. appendix 2) will have been equipped with a small fish culture facility (partially functional by the end of July, 1980) for raising the migratory juveniles, and a device for recapturing the adults at the time of their eventual return to the release site.

The characteristics of the site and its equipment in the framework of the "Sea-Ranching" project should be beneficial for the attempt at determining the nature of the interactions of coho salmon and indigenous species.

STUDY PROJECT OF COHO - INDIGENOUS SPECIES INTERACTION.

1. Competition during the fresh water (stream) phase.

   1.1 Characterization of the immersion areas included between the third fresh water pond (the farthest upstream) and the fish culture facility:
   - size, depth (3 measures along one transect) every 15 m;
   - slope (on the geometric level);
   - current velocity (OTT flow meter)
   - basic or simple sediment particle sizing.

   1.2 Immersion, in July, 1980, of 500 coho and 500 salar of comparable size but different ages, in the above described sections, with different marking according to section (table 3).

   1.3 Electrofishing at the end of September, 1980, to evaluate the parameters of growth, mortality and dispersion. Study of downstream migrations during a year by trapping in the area of the fish culture facility.

1.4 Electrofishing in February, 1981, for a second fishery inventory (growth, mortality, dispersion).

1.5 Downstream migration study of 1981 spring smolts by downstream trapping.

2. Competition in the pond phase.

2.1 Choice of two superficially similar ponds isolated by up stream and down stream grilles.

2.2 Immersion in September, 1980, in:

- the up stream pond: 3,000 S. salar parrs
- the down stream pond: 1,500 S. salar parrs and 1,500 coho parrs.

2.3 Sampling in March-April, 1981, for the parameters of growth, mortality and percentage of smoltification after marking.

3. Study of Coho Salmon marine migration.

Objective: Supply answers to the following questions:

+ Does the coho return to its point of release; in what proportions and with what reliability (percentage of them going astray)?
+ Where do they stay during the marine-estuary phase; the coastal area; is the migration short or long; etc. .....?

Methods:

+ The release, in three consecutive years, of about 10,000 coho smolts produced at the site under controlled sanitary conditions. 3,000 will have marking tags providing for the notation of the recapture areas in the sea.
+ Capture of adults at the time of their eventual return to the release site.

CONCLUSION.

The completion of a phase of research on the eventual impact of Pacific salmon on indigenous species seems, to us, indispensable in order to define an objective position and, eventually, regulatory measures, in the face of growing pressure for private or collective "Sea-Ranching" projects beginning with Pacific species.

Such a project could develop in connection with several different French research agencies and its results be examined by a scientific monitoring committee.

(signed:) P. Prouzet Y. Harache

APPENDIX

PRESENTATION OF THE EXPERIMENTAL SITE.

The Conquet site (Kerjean ponds) is located on the north coast of Finistère. It has a 6 km river interrupted by ponds. The surface area of exploitable water is 14 hectares of brackish water (the first pond) (5 o/oo - 25 o/oo) renewable by tidal action; 2 hectares of fresh water ponds (3 ponds) and 0.5 hectares of stream whose average slope is 1%.

Hydrology (Table 1)

Parameters:	Flow l/s	T °C	pH	O_2d' mg/l	O_2 %sat	BOD_5 mg/l	NH_4 mg/l-N	NO_3 mg/l-N	NO_2 mg/l-N	Ca mg/l	PO_4 mg/l-P
Min. values:	45	3	7	8.7	75	0.6	0.02	3.35	0.001	18	0.18
Max. Values:	330	23	9	11.9	120	6.44	0.25	12.48	0.05	26	0.88

The high values of nutrient salts explain the phenomena of eutrophication encountered in the pond environment.

STUDIES CONDUCTED AT THE SITE.

- Physico-chemical study (Mémoire d'I.U.T., 1979)
- Trout population study (D.E.A., 1979 and Maîtrise de Science et Techniques, 1980).

Summaries of results obtained

The hydrologic quality of the site could be improved by placing at least one of the ponds outside the circuit during the summer and autumn period so as to limit the heating of the water and eutrophication zones.

The trout population is characterized by low density but good growth (analogous to the trout at Nivelle) due in part to the migration of the trout to the marine zone during the summer time.

III. INTERACTION OF COHO SALMON WITH INDIGENOUS SPECIES --
PROPOSAL OF FIELD STUDIES IN BRITTANY.
(An explanation of the proposal by Dr. Harache)

BACKGROUND

CNEXO has undertaken in 1980 an experimental program on "Sea Ranching" with indigenous species (S. salar and S. trutta) on a site situated at the extreme west of Brittany:

- This projects includes the equipment of a small freshwater system and tidal lagoon with:
  . a hatchery for producing the smolts,
  . trapping facilities
- The objectives of this program will be:
  . assessing the results of release-recapture with local species,
  . assessing the possibilities of winter extensive production of parrs and presmolts in freshwater impoundments and a backish water pond.

Due to the characteristics of the site, the proximity of the research center (15 km west of COB) and the equipments being installed in 1980, it appeared interesting to add to this main program a side and limited experimentation for studying:

- The interactions between coho and local species fry and parrs in various freshwater types of environment.
- The migration pattern of coho salmon in the sea.

In spite of several major escapes from hatcheries or sea cage facilities, no information is available about the marine behavior of this species.

PROPOSED EXPERIMENTAL PROGRAM

1 - Site characteristics (see annex).

2 - Competition during the freshwater phase (O. kisutch - S. salar).

+ Introduction of 2 000 fingerlings of each species of comparable size (8-12 cm) but different age (0+ and 1+) in different sectors of the freshwater system, including ponds and stream. Every fish will be branded accorded with the sector of release. Investigation will be conducted by electrofishing (twice a year) and downstream trapping. The various informations will be used to characterize the specific niches of each species according with the habitat (slope, depth, water velocity, substrat, etc...) using the scientific approach developped by PROUZET (1979).

Starting in 1981 eggs and fry of both species will be introduced in the stream to test the competition at early stages.

+ A more fundamental study of interactions in the early stages between coho atlantic salmon and brown trout fry will be undertaken in 1981 at INRA (Institut National de la Recherche Agronomique - St-Pée-sur-Nivelle) in artificial laboratory streams.

3 - Migration routes at sea.

Release during the spring of 1981, 82 and 83 of 10 000 0-age coho smolts with polyethylene tags, together with groups of Atlantic salmon and sea trout. The releases will occur directly in the brackish water pond.

4 - Origin of the fish released.

- All fish used in these experiments will be issued from specifically selected stocks of coho among populations presenting a high resistance to kidney disease.

- All eggs will be treated with erythromycin at water hardening and with wescodyne before shipment and at arrival.

- All fish will be reared in a new hatchery under strict sanitary control by the Laboratoire de Pathologie des Animaux Aquatiques which will carry on routine examination for any pathogens.

The present study is proposed for a duration of 5 years, and its execution will be controlled by a French scientific committee of several experts from different research organisations. In addition to this program, close attention will be devoted to the sites where escapes are known to have occurred to gather as much informations about the behavior of cohos in the French environment.

IV. COMMENTS FROM THE INTRODUCTIONS WORKING GROUP ON THE FRENCH PROPOSAL CONCERNING STUDIES OF COHO AND NATIVE SALMON INTERACTIONS

A. BACKGROUND

1. France has imported annually since 1971 several hundred thousand coho eggs. Fish have undoubtedly escaped, but the consequences are uncertain. Some were deliberately released. In ecological time scales this is a short period and it may take both the fish and scientific observers time to establish a pattern of events. French agencies are currently engaged in limited monitoring.

2. The numbers of farmed coho are increasing. Research emphasis is being placed on establishing French brood stocks to ensure a supply of eggs for the future. If successful, the latter should reduce the disease risk associated with wild egg imports to zero. However, the increase in farming activity and escapes to be expected from it may favor unwanted ecological effects.

3. The farming activity is in Northwest Brittany and in the Bay of Cherbourg. This is close to Southwest England and the southern part of the Republic of Ireland, both centres of breeding populations of Salmo salar and Salmo trutta.

4. The current objective of the French industry is to culture coho to market size. No existing French law forbids this. There are French laws which prohibit or may regulate the release of coho into natural waters, fresh or salt. However, if ranching coho appeared attractive these laws might be altered to allow ranching.

B. LIMITATIONS OF PRESENT COMMENTS

1. No members of the Working Group have seen the area and in particular the stream where it is proposed to conduct most of the work.

2. As the French paper is of very recent origin (July 25, 1980), there has been no time to discuss and clarify with the French workers aspects of their proposals.

3. A desk evaluation of the project by French scientists as requested in the ICES Code of Practice has not been made available.

C. COMMENTS ON THE FRENCH PROPOSALS

1. With the growth of the French coho farming activity the Working Group welcomes this initiative in principle.

2. The proposals do not indicate if the projects will continue for long enough for observations to be meaningful. Reference to releases in 1983 imply that work will be ongoing until 1985 and perhaps later. Some of our subsequent reservations, if accepted, would extend the program over a longer period. A statement indicating in principle that the work must be conducted over several years would be helpful.

3. Releases of fish in the stream should satisfy the requirements that all or most will be caught by electric fishing and a downstream migrant trap. The value of releasing tank reared coho parr in this stream system is questioned.

4. It would be useful if more information describing the ecology, hydrology, geography, etc., of the stream and its watershed were forthcoming, including information on existing fish production and distribution, as well as a description of the program of research on the other species.

5. The annual release of 10,000 tank reared "0" coho smolts beginning in 1981 is viewed with apprehension. We estimate some 0.1-20 percent as the possible range of returns -- i.e., 10-2,000 spawning condition fish. If a figure of 20% is allowed for straying, some 2-400 mature fish will ascend other rivers in each of 3 successive years. Although we accept that such figures are notional, we consider they could be realistic, and that with the current state of limited knowledge, the risks associated with such numbers of spawning fish are too great. The rate of escape from each of the 3 coho sea cage sites probably does not equal this rate of release. In addition it is known that escapes from cages often stay in the vicinity of cages and are caught later.

We feel that such a deliberate release of coho smolts should not be contemplated until the results from freshwater are available and their interpretation agreed upon.

As an alternative we suggest the use of monosex coho for initial release experiments if it can be shown satisfactorily that a very high rate of efficiency of conversion of females to males can be achieved -- e.g., 98% or more. In 10,000 fish this would represent 100 females. Using a maximum of 20 percent for the rate of return and 20 percent straying, some 4 females might stray to other rivers -- a figure which is likely to be within the probability of events at the commercial sites.

Details of the upstream migrant trapping system should be made available.

6. The ICES Code of Practice on introductions calls for projects like this to be reviewed by ICES. However, although ICES has an Introductions Working Group, the Council has not formally determined how such submissions

should be dealt with internally. This should now be discussed; problem areas should be considered -- such as whether all such proposals will be considered from a desk review of the data, or whether field visits are necessary.

D. CONCLUSIONS

1. The stream tank experiments are wholly endorsed.
2. More information is required on the stream site -- e.g., ecology, fishery potential, and ability to catch released fish.
3. Releases of smolt populations with heterosexual potential should not be contemplated until results from freshwater are available and their interpretation agreed upon. Releases of monosex populations of smolts could be considered if evidence were available to show high efficiencies of conversion to one sex.
4. ICES should act promptly to establish an internal mechanism for reviewing proposals such as this.

ETUDE * DE LA COMPETITION ENTRE LE SAUMON COHO (*Oncorhynchus kisutch*) ET LE SAUMON ATLANTIQUE (*Salmo salar*) EN EAU DOUCE ET DU COMPORTEMENT DU SAUMON COHO LACHE DANS LES EAUX COTIERES FRANCAISES

INTRODUCTION

Depuis 1970, plusieurs millions d'oeufs de saumons coho ont été introduits en France à des fins d'élevage en captivité, soit en pisciculture d'eau douce, soit pour la production d'animaux élevés en fermes marines pendant une partie de leur cycle. La production actuelle de saumon d'aquaculture a atteint environ 100 tonnes en 1980. Le développement de cette production s'est accompagné d'un certain nombre de fuites accidentelles en plusieurs points du littoral sans qu'il soit possible de bien cerner le devenir des animaux échappés ni les conséquences de ces fuites sur les populations locales.

Parallèlement à cette filière intensive, des essais limités de production extensive de saumons ont été élaborés (principalement à partir de repeuplement en saumon atlantique). Le coho a été utilisé pour des essais limités de Sea Ranching en Méditerranée (Var), et des projets de Sea Ranching à partir de cette espèce sont envisagés sur la façade atlantique.

Si l'introduction de cohos dans nos eaux continentales est interdite par le Code Rural, rien n'est prévu pour le Domaine Public Maritime et aucun élément scientifique sérieux *** ne permet de prendre position sur de tels projets qui présentent des aspects séduisants, mais également des incertitudes en proportion non négligeable :

- Les *Oncorhynchus* présentent la caractéristique de pouvoir être élevés en grand nombre à un coût très inférieur à celui des smolts de saumon atlantique, et ceci sans recourir obligatoirement à des installations particulières (les pisciculture traditionnelles peuvent être utilisées).

- Rien ne permet à l'heure actuelle de garantir le comportement de cette espèce dans le milieu marin et en particulier leur survie et leur précision de retour au site de lacher. Il est en fait impossible d'affirmer actuellement que l'exploitation extensive de cette espèce constitue un choix prioritaire pour des opérations de Sea Ranching.

* Cette étude fait partie d'un projet plus général portant sur la production extensive de salmonidés migrateurs.

*** cf. chapitre suivant.

La nature des intéractions entre coho et espèces locales (Salmo salar) et Salmo trutta) ne peut, en l'état actuel des connaissances, être appréciée. Il existe, en effet, peu de travaux concernant les risques écologiques découlant de l'introduction de cette espèce hors de sa zone naturelle de répartition.

Compte-tenu de ce contexte, il nous semble important de mettre en oeuvre un ensemble d'expérimentations portant, d'une part sur les problèmes de compétition pouvant exister en eau douce entre les juvéniles de cohos et les juvéniles d'espèces indigènes, et d'autre part, sur le comportement du coho (migration, précision du homing) laché dans nos eaux territoriales.

I - ETAT SOMMAIRE DES CONNAISSANCES SUR LE COMPORTEMENT DU COHO EN EAU DOUCE ET MARINE DANS ET HORS DE SA ZONE DE REPARTITION NATURELLE

1.1 - Comportement et intéractions avec d'autres espèces de salmonidés

Le coho est une espèce dont le comportement territorial et agressif est semblable au comportement du saumon atlantique et de la truite commune (CHAPMAN 1962, HARTMAN 1968, DILL 1978). Le coho préfère les zones à courant faible (HOAR 1951, BUSTARD et NARVER 1975b), et selon RUGGLES (1966), la production en smolts de coho semble favorisée par une intensité de courant modérée. Il affectionne comme abri les sous berges (BUSTARD et NARVER 1975a) et se trouve souvent dans des zones de "pool" (surtout quand la température est basse) (BUSTARD et NARVER 1975b).

Son aire de répartition naturelle (allant sur la côte américaine de la Californie à l'Alaska) le conduit généralement à subir en eau douce des températures basses (inférieure à 5° C) durant l'hiver. Selon MONZER et al (1965), son préférendum thermique en mer se situerait entre 7 et 12° C et il supporterait en moyenne des températures comprises entre 5 et 15 ° C (tolerable range).

Il existe à l'heure actuelle de nombreux documents concernant des expériences portant sur les intéractions entre les diverses espèces de salmonidés, mais peu ont trait aux intéractions entre saumon atlantique et saumon du Pacifique. Parmi ceux-ci, l'on peut mentionner :

- les travaux de GIBSON (1977) sur les intéractions entre le coho (*Oncorhynchus kisutch*), le saumon atlantique (*Salmo salar*) et l'omble de fontaine (*Salvelinus fontinalis*). Ces études menées en milieu confiné (grand aquarium) montrent :

= d'une part, que la répartition des saumons coho et des saumons atlantique est différente : le saumon atlantique occupe des zones peu profondes à courant rapide, le coho occupe des zones plus profondes où le courant est plus lent.

= d'autre part, que l'omble et le saumon atlantique sont plus agressifs que le coho qui est plus facilement déplacé de ses territoires par les deux autres espèces.

GIBSON conclut que le saumon atlantique et le coho seraient écologiquement compatibles. Cependant, les résultats découlant de ces travaux peuvent être biaisés du fait que GIBSON a utilisé des cohos d'élevage et des saumons atlantique et ombles de fontaine sauvages.

- les travaux de SYMONS et MARTIN (1978) qui décrivent les répartitions respectives en rivière de trois espèces de salmonidés (coho, omble de fontaine et saumon atlantique). Leurs observations montrent qu'en été le saumon atlantique occupe des zones à pente forte et à courant rapide, alors que le coho se tient dans des zones de "pool" où l'eau est plus calme. En hiver, il semble y avoir un rapprochement et une interpénétration plus grande des différentes zones de répartition (le saumon atlantique pouvant utiliser à cette période les zones de "pool").

Au vu des différents travaux effectués sur le comportement des différentes espèces de salmonidés de la zone Pacifique et de la zone Atlantique, SOLOMON (1979) conclut que la répartition des cohos en eau douce semble plus se rapprocher de celle de la truite commune que de celle du saumon atlantique. De plus, les intéractions entre le saumon atlantique, l'omble de fontaine, l'arc-en-ciel et la truite commune, devraient être, au vu des différentes études, plus fortes que celles observées entre le coho et le saumon atlantique.

Or, l'omble de fontaine et l'arc-en-ciel ont été largement introduits en Europe sans pour autant qu'il y ait eu un effet désastreux sur les espèces locales et en particulier sur la truite commune.

1.2 - Introduction du saumon du Pacifique hors de sa zone de répartition

RICKER (1954) pense que pour toute transplantation, deux conditions générales devraient être respectées si l'on ne veut pas aboutir à un échec :

- Au départ, les quantités introduites doivent être relativement importantes et être immergées sur un ou plusieurs sites de manière à ce qu'il y ait sélection d'une population non résiduelle possédant un pool de gènes suffisamment diversifié pour qu'il y ait une réelle acclimatation de l'espèce.

- Le stock d'origine doit être soigneusement sélectionné afin que les conditions d'environnement dulcaquicole et marin des sites d'origine et d'introduction soient les plus proches possibles.

C'est le non respect de ces conditions et en particulier de la deuxième qui, selon JOYNER (1973) explique l'insuccès de l'acclimatation du coho dans le Connecticutet le succès de celle-ci dans le New Hampshire (front thermique trop chaud au large du Connecticut empêchant le retour des cohos en début d'automne vers cette région). A l'heure actuelle, l'acclimatation du coho dans le New Hampshire est une réalité puisqu'en 3ème génération des taux de retour de 2,3 % ont été obtenus (Anonyme 1979).

En ce qui concerne la France, de nombreuses observations montrent que le coho se développe rapidement dans nos eaux continentales, soit en écloserie (croissance rapide permettant l'obtention de smolts de 6 mois), soit dans le milieu naturel (observation d'une production naturelle de coho dans la Varenne, (EUZENAT et FOURNEL 1977). Il semble s'adapter, au moins en partie, à l'environnement marin de la Manche et de la Mer du Nord, puisque 40 cohos adultes ont été recapturés sur un front de 50 kilomètres entre la CANCHE et la VARENNE (Haute-Normandie). Ce résultat confirmerait des observations antérieures faisant mention d'importantes captures de grands saumons d'espèces du Pacifique dans différents sites de lacher entre 1886 et 1905 (ARRIGNON 1973).

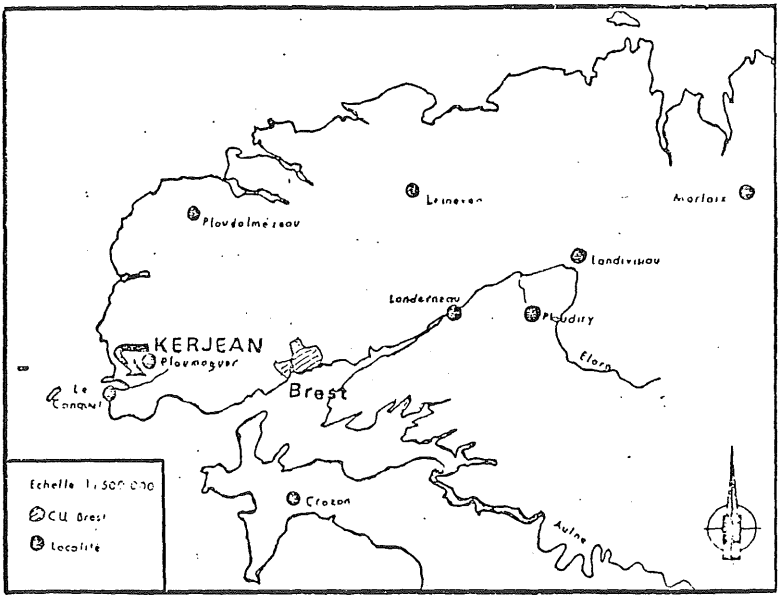
Il semblerait, cependant, si l'on prend la démonstration de JOYNER, que les conditions thermiques de l'environnement côtier français soient limites pour le coho, et en particulier en Bretagne (15° C au large de Brest jusqu'en octobre). L'existence d'un front thermique pourrait éventuellement bloquer le retour de cohos surtout si l'on utilise des souches de remontées précoces (fall-spawning), comme cela a été le cas jusqu'à présent en aquaculture. Les importantes mortalités observées en élevage marin durant la période estivale et les difficultés d'obtention d'oeufs viables à partir de géniteurs captifs vont dans le sens de l'hypothèse : existence de conditions estivales limites ou marginales le long de nos côtes pour cette espèce.

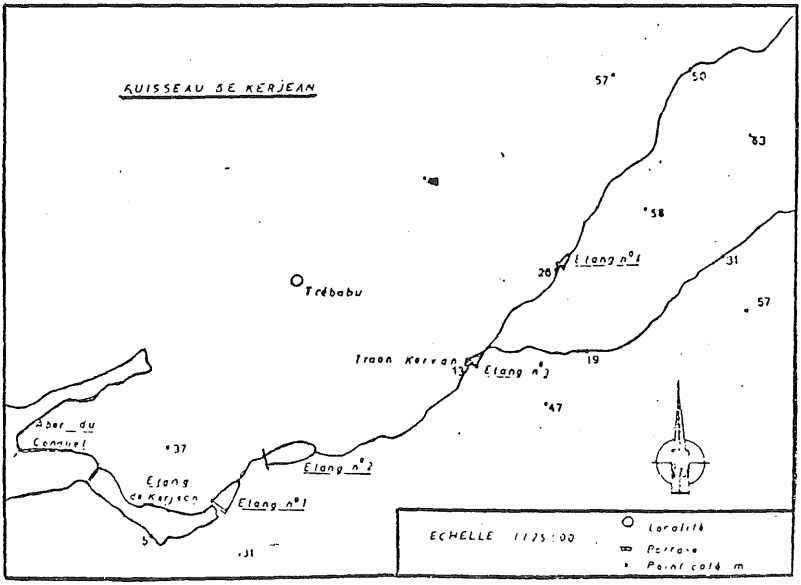
Au total, et en accord avec SOLOMON (1979), l'ensemble des observations que nous possédons ne nous permet pas d'avoir une opinion précise sur la nature et l'intensité des intéractions qui existent entre le coho (ou une autre espèce de saumon du Pacifique) et les espèces locales. Il est donc nécessaire de conduire un maximum d'expérimentations sur ce sujet d'étude. Nous pensons également qu'il faut entreprendre des expérimentations sur la phase marine, en prenant un certain nombre de précautions *, de manière à obtenir les informations complémentaires qui permettront d'avoir une idée réelle des possibilités d'acclimatation de l'espèce. Cette proposition va dans le sens de la recommandation du groupe de travail sur "l'introduction des espèces non indigènes" du CIEM (Nantes 22-26 avril 1980).

* détaillées ultérieurement

II - PRESENTATION DU SITE D'EXPERIENCES DU CONQUET

Le site du Conquet se situe sur la côte Nord du Finistère à 15 kilomètres de Brest (cf. carte 1).





Il est constitué par un ruisseau qui prend sa source à 3 kilomètres au Sud-Est de Ploumoguer et qui débouche dans l'Aber du Conquet après une course de 6 kilomètres.

Le ruisseau est entrecoupé par 4 étangs d'eau douce (trois étangs sont placés sur le site d'expériences) et un étang saumâtre dont la salinité varie de 5 ‰ à 25 ‰.

La surface en eau disponible pour les expérimentations comprend 14 hectares d'eau saumâtre renouvelable par le jeu des marées, 2 hectares d'étang d'eau douce et 0, 5 hectare de ruisseau.

2.1 - Caractéristiques physiques et hydrologiques

Le bassin versant occupe une superficie de 10,3 km^2. La pente moyenne du ruisseau est de 1,5 % (minimum 0,9 %, maximum 2,5 %) et la largeur moyenne est d'environ 1,7 m. La valeur du couple pente-largeur permet de classer ce ruisseau dans la zone à truite inférieure du diagramme de HUET (1949). Le débit varie de 45 à 330 l/s * et la qualité de l'eau (cf. tableau 1) peut être considérée comme moyenne, mais non compatible à la vie des salmonidés. Les fortes teneurs en sels nutritifs permettent d'expliquer les phénomènes d'eutrophisation observés en milieu lentique.

Tableau 1 Caractéristiques hydrologiques

DEBIT l/s 1970-1975	Variation annuelle de t°	PH	% d'O_2/ saturation	NO_3 mg/l-N	NO_2 mg/l-N	NH_4 mg/l-N	PO_4 mg/l-P	DBO_5	Ca mg/l	Indice biotique
45	3	7	75	3.4	0.001	0.02	0.18	0.6	18	7
à	à	à	à	à	à	à	à	à	à	à
330	23	9	120	12.5	0.05	0.25	0.88	6.4	36	9

2.2 - Caractéristiques piscicoles

Les espèces rencontrées originellement sur le site sont :

- Salmonidés : truite commune (*Salmo trutta*), variétés sédentaire et migratrice (en faible nombre).
- Anguillidés : anguille (*Anguilla anguilla*) forme la biomasse la plus importante.
- Cyprinidés : vairon (*Phoxinus phoxinus*).
- Cottidés : chabot (*Cottus gobio*).
- Cobitidés : loche franche (*Noemacheilus barbatulus*).

* Il s'agit d'un débit calculé à partir des débits spécifiques. Il ne tient pas compte des prélèvements par pompage qui, l'été, peuvent prendre une bonne partie du débit.

La population de truites communes se caractérise par une forte croissance(la taille légale de 23 cm est atteinte à 2 ans) due en partie à la migration des truites en zone marine en période estivale et par une faible densité (entre 320-580/hectare).

2.3 - Caractéristiques du site d'expérimentation (eau douce) voir plan

Il s'étend de la salmoniculture au moine du 3ème étang d'eau douce sur une longueur de 1 100 m. Sa superficie est de 1 900 m^2 et sa pente moyenne de 0,5 %. Il est entièrement clos (présence d'une trappe de capture à l'aval et d'une chute de 2,50 m à l'amont).

Le site a été tronçonné en secteurs de longueurs différentes (45 à 200 m), ce qui permet d'avoir à l'intérieur des secteurs des biotopes relativement homogènes et des biotopes différents si l'on considère les secteurs entre eux. (secteurs de pool, radiers, zones découvertes ou abritées ...). La largeur moyenne suivant les secteurs varie de 1,60 m à 2,50 m ; les profondeurs moyennes (mesurées en juillet) de 0,13 m à 0,27 m et la vitesse moyenne de 12 à 35 cm/s.

III - PROTOCOLES EXPERIMENTAUX

3.1 - Etude Compétition Coho-Salar en eau douce

- Immersion fin mai dans 7 secteurs (entre chaque secteur, il existe une zone vierge ne recevant pas de poissons) de 500 coho et de 500 salar (même densité par secteur), de taille identique en moyenne, mais d'âge différent. Les deux espèces sont marquées de la même manière pour un secteur (ablation de l'adipeuse et/ou cryotatouage), mais de manière différente suivant les secteurs.

- Contrôle en continu de la dévalaison grâce à une trappe de capture située à la pisciculture.

- Pêche électrique de contrôle durant l'été sur tout le site d'expérimentation pour l'évaluation des paramètres : croissance, mortalité et dispersion. Après l'inventaire, les poissons sont remis dans leur secteur de prélèvement (et non pas d'origine). Un échantillon de poissons par espèce est prélevé sur chaque secteur pour l'étude du bol alimentaire.

- Pêche électrique de contrôle en fin d'hiver sur tout le site d'expérimentation pour l'évaluation des paramètres précédemment cités. L'étude des résultats obtenus au cours des deux inventaires permettra de faire la comparaison entre les dispersions estivale et hivernale .

3.2 - Etude du comportement du coho lâché dans les eaux côtières

C'est ce point de l'expérimentation qui apporte le plus grand risque d'extension de l'espèce hors du site de lacher et de recapture. Il importe donc de prendre le maximum de précautions afin de minimiser les risques d'acclimatation de l'espèce en dehors du site de lacher initial.

Pour cela, deux types de solution peuvent être envisagés :

3.2.1 - Solution préconisée par le groupe de travail sur "l'Introduction d'espèces non indigènes" (C.I.E.M.) : traitement aux hormones mâles pour l'obtention d'une population unisexe.

- Avantage : selon les Anglais, possibilité d'obtenir à 95 % une population mâle.

- Inconvénient : utilisation d'hormones dans l'aliment (avec tous les problèmes législatifs que cela comporte). Selon CHEVASSUS et JALABERT (communications personnelles), on arriverait au mieux à produire 80 % de mâles et l'on ne sait rien sur l'impact de ce traitement sur le "homing" des sujets traités et les 20 % de sujets "normaux" pourraient à ce moment coloniser les rivières environnantes.

3.2.2 - Solution préconisée par le Centre Océanologique de Bretagne

Imprégnation par morpholine des saumons coho lâchés dans le milieu marin pour renforcer leur homing et minimiser ainsi le pourcentage de divagation. Selon les expériences faites par le Professeur HASSLER (voir tableau 2), ce taux de divagation serait de l'ordre de 5 %.

Tableau 2 Principaux résultats obtenus avec des expériences d'imprégnation Morpholine Phénétyl-alcool sur le coho (d'après SCHOLZ et al 1975)

Groupes Expérimentaux	Nombre de poissons lâchés en mai 1973	Nombre de poissons recpaturés		
		Site (morpholine)	Site (Phénétyl-alcool)	Autres sites
Traitement morpholine	5 000	207 (94,1 %)	5 (2,3 %)	8 (3,6 %)
Traitement Phénétyl-alcool	5 000	6 (4,1 %)	132 (90,5 %)	8 (5,4 %)
Non traité	5 000	24 (19,4 %)	21 (16,9 %)	79 (63,7 %)

- Avantage : obtention de sujets non traités permettant de voir ce que donne réellement le "lacher-recapture" de coho dans nos conditions climatiques.

- Inconvénient : les 5 % de la population ne retournant pas au site de lacher peuvent se reproduire dans d'autres rivières environnantes, mais globalement, le risque semble être moins important que dans le cas de la première solution.

Compte-tenu de l'importance des installations de production (cf. annexe), il ne nous est pas possible de réaliser à la fois les deux solutions. Si nous prenons comme hypothèse de base l'acceptation de la deuxième solution, le protocole expérimental sera dans ses grandes lignes le suivant :

- Production à l'écloserie du Conquet d'environ 10 000 smolts de 6 mois.*

- Au moment de la smoltification imprégnation par morpholine de tous les cohos qui seront lâchés suivant le protocole défini par le Professeur HASSLER lors de ses expériences sur le lac Michigan.

- Marquage

= emploi des marques étiquettes pour l'observation des voies de migration des coho en milieu marin (entre 1 000 et 2 000 poissons).
= emploi du cryotatouage et du marquage magnétique pour l'évaluation du taux de retour au site de lacher (permet la comparaison de l'incidence des différents marquages sur le taux de retour).

- Imprégnation par morpholine du site de capture au moment des périodes de remontées pour renforcer l'effet attractif du site.

- Capture des géniteurs au moyen d'une trappe de capture pour l'évaluation de leurs caractéristiques et de leur taux de retour.

CONCLUSION

La réalisation de ce projet d'étude ne peut apporter à elle seule toutes les solutions ni toutes les réponses au problème soulevé par l'introduction du coho dans nos eaux continentales.

La configuration du site expérimental en eau douce, de par sa faible pente, n'est théoriquement pas en faveur de l'implantation optimale du saumon atlantique et serait, si l'on s'en tient à la bibliographie existante, plus favorable au coho. Il importe donc de mener sur d'autres sites et dans d'autres conditions des expériences complémentaires et en particulier des études en milieu confiné telles que celles effectuées sur la truite commune ou sur le saumon atlantique par l'INRA Biarritz. La poursuite de l'expérimentation en milieu marin permet de récolter des données concrètes sur le comportement du coho et surtout d'estimer l'importance des problèmes que pourrait engendrer l'introduction de cette espèce sur le développement des espèces locales.

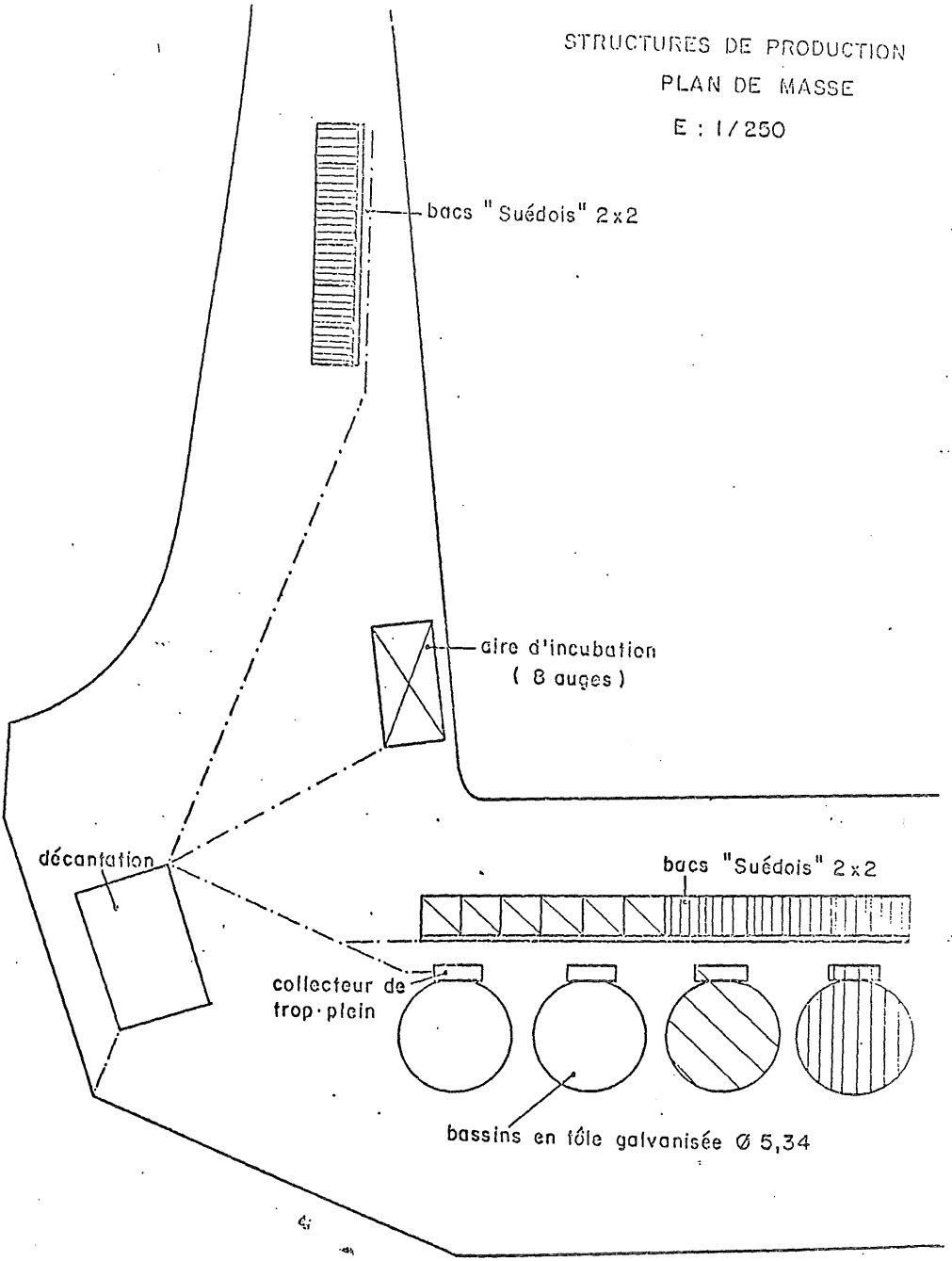
L'ensemble des données recueillies permettra, en fait, d'avoir un peu plus de recul pour juger sur l'opportunité de développer la technique du Sea Ranching à partir de cette espèce non indigène (bilan économique et bilan écologique).

* Il s'agit pour nous d'un chiffre minimum si l'on veut obtenir des résultats tangibles et des informations suffisantes sur les possibilités d'acclimatation de l'espèce.

STRUCTURES DE PRODUCTION

PLAN DE MASSE

E : 1/250



ANNEXE : Plan de l'écloserie du Conquet

Les structures de production ont été choisies en fonction de l'espèce la plus exigeante, c'est-à-dire le saumon atlantique.

Elles sont classiques pour cette espèce et comprennent essentiellement deux types de bassins :

- des bacs types "Ewos " de 2 mètres de diamètre pour l'alevinage ;

- des bassins circulaires en tôle ondulée de 5 mètres de diamètre, utilisés normalement pour le stockage du lisier, pour la finition.

L'alimentation en eau se fait à partir de 2 ruisseaux. L'eau est filtrée à 0,5 mm et les bassins sont desservis par des tuyauteries PVC et vannes.

La capacité de production est d'environ 25 000 pré-smolts ou 10 000 smolts des 3 espèces (saumon atlantique, truite de mer, coho).

BIBLIOGRAPHIE

ANONYME, 1979. Annual Report Division of Ireland and Marine fisheries New Hampshire Fish and Game department. 107 p.

ARRIGNON J., 1977. Saumons coho fugitifs dans les eaux françaises. Salmon and Trout Association. 4 pages.

BUSTARD D.R., and NARVER D.W., 1975a. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and Steelhead trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 32 : 667-680.

1975b. Preferences of juvenile coho salmon (*Oncorhynchus kisutch*) and Cutthroat Trout (*Salmo clarki*) relative to simulated alteration of winter habitat. J. Fish. Res. Board Can. 32 : 681-687.

CHAPMAN D.W., 1962. Agressive behavior in juvenile coho salmon as a cause of emigration. J. Fish. Res. Board Can. 19 : 1047-1080.

DILL L.M., 1978. Agressive distance in juvenile coho salmon (*Oncorhynchus kisutch*). Can. J. Zool. 56 : 1441-1446.

FOURNEL F. et EUZENAT G., 1977. Etude des salmonidés migrateurs du Bassin de l'Arques (Seine Maritime). Rapport M.Q.V. et CSP. 53 pages.

GIBSON R.J., 1977. Behavioural Interactions between juvenile coho salmon *(Oncorhynchus kisutch)*, and juvenile Atlantic salmon (*Salmo salar)* and Brook Trout (*Salvelinus fontinalis*). I.C.E.S. CM 1977/M : 23. 18 pages.

HARTMAN G.F., 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 22 : 1035-1081.

HOAR W.S., 1951. The behaviour of chum, pink and coho salmon in relation to their seaward migration. J. Fish. Res. Bd. Canada, 8 : 241-263.

HUET M., 1949. Appréciation de la valeur piscicole des eaux douces. Trav. Stat. Rech. Eaux, Forêts, Groenendaal, sér. D, 10 : 55 p.

JOYNER T., 1973. Part II : Effect of the Ocean Environment on the high seas distribution of salmon. Marine Fisheries Review, Vol. 35, 10 : 4-8.

MANZER J.I., ISHIDA T., PETERSON A.E. and HANAVAN M.G., 1955. Salmon of the North Pacific Ocean. Part. V. Offshore distribution of salmon. Int. North Pac. Fish. Comm., Bull. 15, 452 p.

RICKER W.E., 1954. Pacific salmons for atlantic waters ? Can. Fish. Cult., 16 : 6-14.

SOLOMON D.J., 1979. Coho salmon in North-West Europe. Possible effects on native salmonids. Report N° 49. Laboratory Leaflet. Lowestoft. 21 p.

SYMONS P.E.K. and MARTIN J.D., 1978. Discovery of juvenile Pacific salmon (coho) in a small coastal stream of New Brunswick. Fishery Bull. Fish. Wild Serv. U.S., (76) : 487-489.

SCHOLZ A.T., HORRALL R.M., COOPER J.C., HASLER A.D., MADISON D.M., POFF R.J. and DALY R.I., 1975. Artificial Imprinting of salmon and trout in Lake Michigan. University of Wisconsin Sea Grant advisory Report N° 414, 45 pages

APPENDIX VI. RECENT PUBLICATIONS CONCERNING INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

Anonym. 1970. Essais d'acclimatation du Clam, Venus mercenaria, en milieu lagunaire méditerranéen. Science et Pêche, Bull. Inst. Pêches marit., No. 193.

Anonym. 1980. L'activité de l'Institut des Pêches en 1979. Principales actions en matière de cultures marines et d'environment marin. Science et Peche, Bull. Inst. Pêche marit., No. 306.

Audouin, J. et C. Maurin. 1958. Note sur la présence de poissons du genre Salmo dans le bassin occidental de la Méditerranée. Rev. Trav. Inst. Pêches Marit., 22(3): 337-343.

Bodoy, A., T. Maitre-Allain et A. Riva. 1980. Croissance comparée de la palourde Européenne (Ruditapes decussatus) et de la palourde Japonaise (Ruditapes philippinarum) dans un écosystème artificial Méditerranéen. Vie Marine (Ann. Fond. Océanog. Ricard), 2 (Sous presse).

Britton, J. C. (editor). 1979. Proceedings, First International Corbicula symposium. Texas Christian University Research Foundation Publications, Fort Worth, Texas, USA, 313 pp. (a 1977 symposium; 18 papers; introduced fresh- and brackish-water Asian clam).

Buizer, D. A. G. 1980. Explosive development of Styela clava Herdman, 1882, in the Netherlands after its introduction (Tunicata ascidiacea). Vol. 7, No. 18, pp. 181-185. (from Asia).

Cadwallader, P. L., G. N. Backhouse and R. Fallu. 1980. Occurrence of exotic tropical fish in the cooling pondage of a power station in temperate south-eastern Australia. Australian Journal of Marine and Freshwater Research, Vol. 31, pp. 541-546.

Cadwallader, P. L. et Eden. 1981. Food and growth of hatchery produced chinook salmon, Oncorhynchus tshawytscha (Walbaum), in land-locked Lake Purrumbete, Victoria, Australia. J. Fish. Biol., 18: 321-330.

Carlton, J. T. and E. W. Iverson. 1981. Biogeography and natural history of Sphaeroma walkeri Stebbing (Crustacea: Isopoda) and its introductions to San Diego Bay, California. Journal of Natural History, Vol. 15, pp. 31-48. (introduced marine isopod spread around the world by ships).

Caubère, J. L., R. Lafon, F. René, et C. Salès. 1976. Etude de la maturation et la ponte chez Penaeus japonicus en captivite. In Advances in Aquaculture-FAO Technical Conference on Aquaculture, Kyoto, 1976: 277-284.

Courtenay, W. R., Jr. 1978. The introduction of exotic organisms. Chapter 14, pp. 237-252. In Wildlife and America, Contributions to an Understanding of American Wildlife and its Conservation. H. P. Brokaw, ed. Council on Environmental Quality, Washington, D.C. (Availabl. from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 USA; $8.50 US) x + 532 pp.

Dempson, J. P. 1980. Present status of pink salmon (Oncorhynchus gorbuscha) in the Newfoundland Region. Cons. Int. Explor. Mer., C.M.1980/M:27.

Dresler, P. V. and R. L. Cory. 1980. The Asiatic clam, Corbicula fluminea (Müller) in the tidal Potomac River, Maryland. Estuaries, Vol. 3, pp.150-151.

Emery, A. R. and G. Teleki. 1978. European flounder (Platichthys flesus) captured in Lake Erie, Ontario. Canadian Field-Naturalist, Vol. 92, pp. 89-91.

Fabre, F., R. Jullien et A. Kiener. 1974. Capture d'une truite de mer aux Goudes, près de Marseille (B. du RH.). Bull. Mus. Hist. Nat. Marseille, 34: 297-303.

Fage, L. 1912. Essais d'acclimatation du saumon dans le Bassin de la Méditerrandée. Bull. Inst. Oceanogr., 225: 14 pp.

Fletcher, R. L. 1980. Studies on the recently introduced brown alga Sargassum muticum (Yendo) Fensholt. III. Periodicity in gamete release and 'incubation' of early gernling stages. Botanica Marina, Vol. 23, pp. 425-432. (England).

Foster, B. A. and R. C. Willan. 1979. Foreign barnacles transported to New Zealand on an oil platform. New Zealand Journal of Marine and Freshwater Research, Vol. 13, pp. 143-149.

Haaker, P. L. 1979. Two Asiatic gobiid fishes, Tridentiger trigonocephalus and Acanthogobius flavimanus, in southern California. Bulletin of the Southern California Academy of Sciences, Vol. 78, pp. 56-61.

Hedgpeth, J. W. 1980. The problem of introduced species in management and mitigation. Helgoländer Meeresuntersuchungen, Vol. 33, pp. 662-673. (14th European Marine Biology Symposium: Protection of Life in the Sea).

Heggberget, T. G. and T. Hesthagen. 1981. Effect of introducing fry of Atlantic salmon in two small streams in northern Norway. Progressive Fish-Culturist, Vol. 43, pp. 22-.

Hendrick, M. E. 1980. Range extensions of three species of Teredinidae (Mollusca: Bivalvia) along the Pacific coast of America. Veliger, Vol. 23, pp. 93-94. (Caribbean spp. passing through Panama Canal).

Hoagland, K. E. and R. D. Turner. 1980. Range extensions of teredinids (shipworms) and polychaetes in the vicinity of a temperate-zone nuclear generating station. Marine Biology, Vol. 58, pp. 55-64. (New Jersey, USA: shipworms and serpulid polychaetes introduced by man).

Ishak, M. M., A. A. Alsayes and F. A. A. Razek. 1980. Bionomics of Penaeus kerathurus transplanted into Lake Quarun (Egypt). Aquaculture, Vol. 21, pp. 365-374.

Jenkins, R. J. and J. L. Meredyth-Young. 1979. Occurrence of the Pacific oyster, Crassostrea gigas, off the south island of New Zealand. New Zealand Journal of Marine and Freshwater Research, Vol. 13, pp. 173-174.

Kiener, A. et J. Ollier. 1970. Contribution a l'étude écologique et biologique de la rivière le Gapeau (Var). Hydrobiologia 36(2): 189-151.

Kraemer, L. R. 1979. Corbicula (Bivalvia: Sphaeriacea) vs. Indigenous mussels (Bivalvia: Unionacea) in U. S. rivers: a hard case for interspecific competition? American Zoologist, Vol. 19, pp. 1085-1096. (introduced Asian clam Corbicula).

Landrein, S. 1976. Adaptation des truites Salmo trutta fario et Salmo G. irideus à la vie marine. Thèse. Université Sci. et Techn. Languendoc. Doc. ronéo. 112 pp.

Larkin, P. 1980. Pacific salmon. Scenarios for the future. Donald L. McKernan Lectures in Marine Affairs. Washington Sea Grant Publication, University of Washington, Seattle, Washington 98195 (USA), 23 pp. ($3 US).

Laubier-Bonichon, A. et L. Laubier. 1976. Reproduction contrôlée chez la crevette Penaeus japonicus. In Advances in Aquaculture. FAO Technical Conference on Aquaculture, Kyoto, 1976: 273-277.

Leloup, E. 1980. Recherches sur l'ostreiculture dans le bassin de Chasse d'Ostende en 1972 et 1973. Bull. Inst. Roy. Sci. Nat. Belg. Vol. 42, No. 4.

Marteil, L. 1956. Acclimatation du clam (Venus mercenaria L.) en Britagne. Rev. Trav. Pèches marit., 20(2).

Marteil. L. 1979. La Conchyliculture Francaise. L'ostréiculture et la mytiliculture. Revue des Travaux de l'Institut des Peches Maritimes, Vol. 43, pp. 5-130. (La Mytiliculture par M.-J. Dardignac-Corbeil).

Maurin, C. 1963. Nouvelles captures de Salmonides en Méditerranée Occidentale, leur interprétation sur le plan biologique. Rev. Trav. Inst. Pêches Marit.: 27(2): 177-178.

Maurin, C. 1965. Premières observations sur l'acclimatation des truites en eau salée. Ext. Rapp. P.V. Comm. Intern. Explorat. Sci. Mer Medit., 18(3): 721-722.

Maurin, C. 1980. Introduction d'espèces non indigènes en France. Note ronéotypée présentée à la réunion du C.I.E.M. (Conseil int. Explor. Mer) a Nantes, avril 1980, 9 pp.

Maurin, C. et U. Harache. 1980. Introduction d'espèces non indigènes en France. Période 1973-1979.

Mazeaud, F. 1980. Les saumons du Pacifique. La Pêche maritime, Novembre: 7 pp. (en tiré a part).

Mazeaud, F. 1981. La Societe Nationale d'acclimation et le saumon Californien au 19 ème siècle. Rev. Assoc. Intern. Defense Saumon (A.I.D.S.A.), 35.

Morgan, M. D. 1980. Life history characteristics of two introduced populations of Mysis relicta. Ecology, Vol. 61, pp. 551-561. (mysid shrimp; USA).

Morrison, F. and G. Shum. 1981. Chlamydia-like organisms in the digestive diverticula of the bay scallop, Argopecten irradians. Submitted to the Journal of Fish Diseases.

Olsen, P. 1980. Population development of introduced Mysis relicta and impact on char and brown trout. Doctoral dissertation, Uppsala University (Acta Universitatis Upsaliensis: Abstracts of Uppsala Dissertations from the Faculty of Science, 570). 11 pp. (Abstract).

Pillay, T. V. R. and W. A. Dill, editors. 1979. Advances in aquaculture. FAO, Fishing News Books, Ltd., England. 653 pp. (includes: Chapter VIII, Artificial recruitment and transplantations, which includes papers by Jhingran and Natarajan, inland stocking of fishery resources; Glude, world review of oyster culture; Sindermann, oyster mortalities and their control)

Quayle, D. B. 1941. The Japanese "little neck" clam accidentally introduced into British Columbia waters. Pro. Rep. Fish. Res. Bd. Can., Pacific Coast Sta. 48: 17-18.

Reish, D. J. and J. L. Barnard. 1979. Amphipods (Arthropoda: Crustacea), Chapter 11, pp. 345-370, In C. W. Hart, Jr. and S. L. H. Fuller, editors, Pollution ecology of estuarine invertebrates. Academic Press, New York, USA (pp. 355-359: distribution of introduced amphipod species by man).

Rosenthal, H. 1980. Implications of transplantations to aquaculture and ecosystems. Marine Fisheries Review (U.S. Department of Commerce), Vol. 42, No. 5, pp. 1-14.

Solomon, D. J. 1979. Coho salmon in north-west Europe. Possible effects on native salmonids. Ministry of Agriculture Fisheries and Food (MAFF). Directorate of Fisheries Research, Laboratory Leaflet No. 49, 21 pp.

Stewart, L. 1980. A history of migratory salmon acclimatization experiments in parts of the southern hemisphere and the possible effects of oceanic currents and gyres upon their outcome. Advances in Marine Biology, Vol. 17, pp. 397-466.

Sumner, C. E. 1980. Growth of Pacific oysters, Crassostrea gigas, Thunberg, cultivated in Tasmania. I. Intertidal stick culture, Australian Journal of Marine and Freshwater Research, Vol. 31, pp. 129-135.

Sutterlin, A. M., E. B. Henderson, S. P. Merrill, R. L. Saunders and A. A. MacKay. 1981. Salmonid rearing trials at Deer Island, N.B., with some projections on economic viability. Can. Tech. Rep. Fish. Aquat. Sci. (in press).

Vibert, R. 1967. Importance et caracteristiques essentielles des migrations de reproduction chez les poissons. Bull. Inform. Conseil Sup. Pêche, 70: 35-43.

Vivier, P. 1951. Poissons et crustacés d'eau douce acclimatés en France en eaux libres depuis le déput du siècle. La Terre et la Vie, 98(2): 57-82.

Welcomme, R. L. 1979. Preliminary record of international transfers of fish species. F.A.O., Departement des pêches. Rome, Fisheries Circular No. 715.