International Council for
the Exploration of the Sea

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Mariculture Committee

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

Dublin, Ireland; May 23-26, 1989

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WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS
Report of a meeting held May 23-26, 1989, at Dublin, Ireland

INTRODUCTION

The 1989 meeting of the ICES Working Group on Introductions and Transfers of Marine Organisms was held at the Department of the Marine, Dublin, Ireland, May 23-26, 1989. Twelve participants representing seven countries were present:

C. Sindermann	United States of America (Chairman)
R. Cutting	Canada (Rapporteur)
R. Porter	Canada (Canadian Co-chairman of the NASCO/NAC Scientific Working Group on Introduction and Transfer of Salmonids)
V. Jacobsen	Denmark
H. Grizel	France
Y. Harache	France
J. McArdle	Ireland
D. Minchin	Ireland
B. Dybern	Sweden
I. Wallentinus	Sweden
A. Munro	UK (Scotland)
S. Utting	UK (England and Wales)

The first day (May 23) was a joint meeting between NASCO and ICES representatives and other experts to consider "Genetic Threats to Wild Salmon posed by Salmon Aquaculture" in a program planned and led by Dr. Alan Youngson (Marine Laboratory, Aberdeen). Thirty-six scientists participated in the meeting and these included members of the ICES Genetics Working Group (App. I). Dr. Malcolm Windsor, Secretary of NASCO, welcomed the joint meeting participants, introduced the subject and charged the group with improved understanding of the subject matter.

On May 24, the participants in the ICES Working Group on Introductions and Transfers of Marine Organisms got underway with a welcome by the Irish host Ms. E. Twomey. The Chairman completed his opening remarks with round-the-table introductions. He then explained action he had taken to prepare a eulogy for Dr. Emmy Egidius whose untimely passing had occurred since the 1988 meeting (App. II. contains a text of the eulogy). Adjustments were made to the draft agenda (App. III) to accommodate discussion by participants and Genetics Working Group representation.

STATUS OF WORKING GROUP RECOMMENDATIONS FOR 1988

The Chairman reviewed the status of recommendations formulated at the last meeting of the Working Group in Edinburgh, Scotland, in May 1988 (1988 Report, CM 1988/F:20 pp. 33-35) submitted for consideration at the 76th Statutory Meeting of ICES in Copenhagen, Denmark, in October 1988.

Recommendation 1

That a one-day joint ICES/NASCO meeting be convened on May 23, 1989, to consider "Genetic Threats to Wild Salmon Posed by Salmon Aquaculture". >C. res. 1988/3: The Council passed the recommendation with a call for a joint report following the meeting. The joint meeting was convened as proposed.

Recommendation 2

That an international symposium, co-sponsored with FAO/EIFAC and the World Aquaculture Society (WAS), be convened for two days in separate sessions during the annual meeting of WAS in June 1990 at Halifax, Nova Scotia, Canada.

>C. Res. 1988/3: The Council approved the recommendation with the direction that Dr. C.J. Sindermann will be asked to serve as convener, together with Prof. K. Tiews (EIFAC) and a representative from WAS. Prof. Tiews has been replaced by Dr. Steinmetz, Netherlands, and planning for the meeting is well advanced.

Recommendation 3

That the Working Group on Introductions and Transfers of Marine Organisms (Chairman Dr. Sindermann) will meet in Dublin, Ireland, from May 23-26, 1989, especially to evaluate the effects of releases of introduced and transferred Atlantic salmon on wild stocks, to make further plans for the international symposium (See Recommendation 2), to prepare definitive advice and final recommendations relative to the Japanese brown alga, Undaria pinnatifida, on the Atlantic coast of France, to document further the national laws and regulations of ICES member countries, and to continue the overview of the status of ongoing and proposed introductions and transfers in and between ICES member countries.

>C. Res. 1988/3: The council approved the recommendation. The Dublin meeting has undertaken the prescribed duties.

NATIONAL SUMMARIES OF INTRODUCTIONS AND TRANSFERS

1. Relevant laws and regulations

Canada

Development of a nation-wide set of federal regulations to address import and export, inter-provincial, and intra-provincial introductions and transfers of all aquatic organisms having potential impacts including fish health, genetics or ecological effects is making slow progress.

In the Province of Manitoba a former moratorium on expansion of the live bait fish industry has been lifted. The change in policy will result in regulatory changes in 1989 which prohibit possession of live fish eggs or live fish unless holding a receipt indicating such items were purchased from a Commercial Live Bait Fish Dealer. Importation of live fish, crayfish, leeches, or salamanders, previously prohibited, is now possible under authority of a Live Fish Handling Permit.

Ireland

The importation of live fish into Ireland is prohibited except under license. A permit is necessary for movements of fish from one farm to another and for shellfish from one geographical area to another.

Sweden

Permission is needed from the National Board of Fisheries to introduce or stock fish, lobster Homarus, crayfish, Norway lobster Nephrops, prawns, crab Cancer, other crustaceans, cephalopods, oysters, pearl mussels, blue mussels and lampern within Sweden or the Swedish territorial borders. Without permission, fish are not allowed to move from one body of water to another or from one side of a dam to the other. The National Board of Fisheries examines the need and the biological risks, including fish disease and parasites, in main according to the ICES Code of Practice.

The National Board of Agriculture examines the risks of introducing disease and parasite if the above mentioned animals are imported. Special permission is then needed for import of live spawn or fish for farming and/or stocking. The prerequisites for the import can be revised from one time to another depending on changes in the disease situation. Conditions may also differ depending on how stable the disease situation is in each country of export. Import is permitted only if the farm or hatchery has passed a health control for at least the last three consecutive years. The delivery of the fish has to be accompanied by certificates of health and origin. The receiving farm or hatchery is considered being in quarantine for three months. No fish or spawn are allowed to be delivered during this time.

Distribution of fish for consumption purposes is allowed. Reloading or replacement of water is not permitted during the transport to the Swedish destination. Import from Finland is slightly less rigorous.

Import of eels (elvers) is associated with very rigorous conditions because they are captured in the wild. The eels are kept in official quarantines in Sweden. British eels may after this be used for stocking in natural waters, but French eels can only be kept in recirculating systems and then directly used for consumption.

If the diseases IPN or VHS are found in a fish farm a special law states that the fish has to be destroyed and the farm has to be cleaned up. The government pays the expenses.

Aquarium animals are not dealt with in these laws, and this is of great concern at least to the National Board of Fisheries. A poor consolation is that these animals mostly are of tropical origin and probably can not reproduce in natural Swedish conditions. Live crayfish can be transported, e.g., from an airport to the place of cooking.

2.0 Other procedures concerning introduced species

Canada

Canada and the United States of America are active with two bilateral organizations which are addressing introductions and transfers: the Great Lakes Fishery Commission and the NAC (North American Commission) (formerly Bilateral) Scientific Working Group on Salmonid Introductions and Transfers, under the North Atlantic Salmon Conservation Organization (NASCO). Both groups are in the late stages of preparing documentation for controlling introductions and transfers of fishes in the Great Lakes basin and of all salmonids in eastern North America.

In New Brunswick and Nova Scotia federal/provincial government and industry committees are actively planning and undertaking measures to provide broodstock to the Atlantic salmon aquaculture industry. Test movements of salmon eggs through quarantine facilities in the receiving provinces are yet small-scale until the efficacy and risks are better defined. Emphasis for the egg supplier is currently intra-provincial and is expected to remain so for the larger component of supply.

3.0 Deliberately introduced animal or plant species

3.1 Fish

Summaries of releases and transfers of eggs and juveniles of salmonid fishes are given in Tables 1 and 2, respectively, and in the footnotes therewith.

3.1.1 Fishery enhancement (establishment of a new breeding population)

Table 1
Introductions and Transfers of Salmonid Fish Eggs (Ova) in 1988.

Key: k=thousands; m=millions; n/a=not available

Species	From	To	Numbers
Atlantic salmon *Salmo salar*	Nova Scotia	Ontario(1)	60 k
	Scotland/Washington	British Columbia (2)	2.55 m
	New Brunswick	Manitoba (3)	50 k
	New Brunswick	Newfoundland (3)	120 k
	Maine	Nova Scotia (4)	25 k
	New Brunswick	Nova Scotia (3)	100 k
	Maine	Ontario (1)	75 k
	New Brunswick Norway, Iceland	Maine (3)	n/a
	Scotland	France (3)	1 m
	Scotland	Ireland (3)	several m
	Ireland	Chile, Spain, Greece (3)	several m
	Maine	Wales (2)	50 k

Table 1 (con't)

Species	From	To	Numbers
Rainbow trout *Oncorhynchus mykiss*	Ontario	Newfoundland (5)	155 k
	Ontario	Newfoundland (6)	10 k
	Ontario	Nova Scotia (5)	200 k
	Ontario	Nova Scotia (7)	280 k
	Ontario	Nova Scotia (3)	100 k
	Manitoba	Ontario (3)	25 k
	Ontario	Prince Edward Island (5)	25 k
	Ontario	Prince Edward Island (3)	125 k
	Washington	Prince Edward Island (3)	450 k
	Ontario	Québec (3)	600 k
	West Virginia	Nova Scotia (7)	250 k
	Indiana	Ontario (7)	56 k
	Washington	New Brunswick (3)	125 k
	Québec	New Brunswick (3)	100 k
	N. Ireland	Ireland	n/a
	Denmark	Scotland	
	Denmark	England and Wales (3)	13.8 m
	California	England and Wales (3)	16.6 m
	Australia	England and Wales (3)	5.0 m
	South Africa	England and Wales (3)	2.4 m
	Ireland	England and Wales (3 and 4)	150 k
Coho salmon *Oncorhynchus kisutch*	Unknown	France (8)	7 m
Arctic Charr *Salvelinus alpinus*	New Brunswick	Newfoundland (3)	35 k
	Manitoba	Newfoundland (3)	40 k
	Manitoba	New Brunswick (3)	3 k
	Manitoba	Ontario (3)	1 k
	Iceland	Ontario (6)	2 k
Brook trout *Salvelinus fontinalis*	Maine	Nova Scotia (7)	100 k

Table notes:
(1) Ontario has a five-year plan for establishing a breeding population for recreational purposes in two selected tributaries of Lake Ontario.
(2) Movements of eggs were in support of aquaculture and broodstock development; future movements will be only small numbers for broodstock development.
(3) Movement of eggs was for aquaculture and/or assessment purposes.
(4) Landlocked salmon stock is being tested for utility in aquaculture industry.
(5) Movement of eggs (Triploid F) was in support of aquaculture.
(6) Eggs were imported for research and/or teaching followed by incineration.
(7) Movement of eggs was in support of public stocking for recreational fisheries.
(8) About 700t of salmon were sold in France in 1988.

Table 2
Releases and Transfers of Juvenile Salmonid Fishes in 1988
(summarized from National Reports)

Key:
k=thousands; m=millions
sm=smolts; f=fry; fg=fingerlings; n/a=not available

Species	From	To	Numbers
Atlantic salmon *Salmo salar*	New Brunswick	Maine (2)	n/a
	New Brunswick	Prince Edward Island (2)	45 k f
	Norway	France (1)	60 k sm
	England	Scotland (2)	649 k sm
	Ireland	Spain (2)	n/a sm
Rainbow trout *Oncorhynchus mykiss*	Québec	Prince Edward Island (2)	50 k fg
	Prince Edward Island	Québec (2)	240 k fg
	Ontario	Newfoundland (3)	6 k f
	Ontario	Newfoundland (3)	1.65 k fg
	Ontario	Nova Scotia (3)	2 k fg
	Sweden	Finland (2)	n/a
Coho salmon *Oncorhynchus kisutch*	Lake Michigan	Massachusetts (4)	4.3 k f
	Lake Michigan	Massachusetts (4)	10.0 k fg
Arctic charr *Salvelinis alpinus*	New Brunswick	Prince Edward Island (2)	0.5 k fg

Table Notes:
(1) Smolts imported to France in October 1988 were placed for rearing at Antifer.
(2) Movement of fingerlings was for aquaculture purposes or assessment.
(3) Fish were moved into governmental or university facilities for use in research or biomonitoring and were subsequently destroyed after use.
(4) Massachusetts released coho salmon for open-ocean growout sport fishery purposes.

Canada

Eggs of the rainbow smelt, Osmerus mordax, were transferred within New Brunswick to eight lakes to establish forage populations for salmonids.

Denmark

Releases of rainbow trout, Oncorhychus mykiss, formerly Salmo gairdneri, took place in 1988 but the numbers have not yet been reported by the local associations. From 1989 this species will no longer be released into the sea and no subventions will be allocated to it.

Three hundred fifty kg glass eels, Anguilla anguilla, have been imported from the UK. Additionally, 2,546 kg (≈127,000 fish) from the UK, and 134 kg (≈ 6700 fish) from France meant for stocking have been released at various locations as part of a project to increase catches in the steadily falling eel fishery. Danish hatcheries are only using certified glass eels from the UK, and no glass eels collected in Denmark are added to the stocks in the hatcheries. In two hatcheries, Anguillicola has been detected; it is assumed that among the certified glass-eels some pigmented specimens, which have already fed upon infected copepods, may have introduced the parasite into the stocks. Anguillicola now can be found in silver eels all over Denmark with infection rates up to 85%. In the western Baltic Sea a mass appearance of the stickleback, Gasterosteus aculeatus, has been noted and, since this species acts as an intermediate host for Anguillicola, this distribution creates a threat to the wild population of eels in the Baltic area.

3.1.2 Mariculture (growth and fattening)

Sweden

Cod is indigenous in the Bothnian Sea, the northern part of the Baltic Sea, but reproduction is only successful in the mid and southern part of the Baltic main basin due to the low salinity (5-7 ppt) in the bottom water of the Bothnian Sea. The Bothnian Sea cod stock is normally of a size that is of no interest for trawl fishing, giving but a few hundred tons yearly in coastal gill-net fishing. Sometimes, e.g., three times so far during this century, an extremely large year-class or large year-classes in consecutive years increases the population dramatically. The growth of the cod is at least the same as in the Baltic proper and the quality of the fish is the same. With no predators on young cod, at least off shore, plenty of food available, and Baltic herring as the only competitor, the conditions seem to be good for a sea ranching operation with cod in the Bothnian Sea. A successful operation would be great help to the commercial fishery in the area suffering from decreasing stocks and marketing problems with some species contaminated by harmful substances. As a first step, a feasibility study is being done to determine whether cod stock from the main basin can be moved through the fish culture system to stock into the Bothnian Sea to support an annual commercial fishery (Fig. 1).

Elvers have recently been imported from England and Portugal. Due to the Anguillicola problem they can only be released along the Swedish west coast north of the Sound, where the parasite has not been found hitherto. Rigorous quarantine regulations are followed.

Fry and/or eggs of turbot have been imported from Denmark for growing purposes.

UK: England and Wales

During 1988, 52 licenses were issued for the import of 40.5 million salmonid ova from Denmark, USA, Australia, South Africa and Ireland (Table 1). The majority was for freshwater salmonid culture but small numbers may have been used for seawater farming of large trout.

3.1.3 Live storage prior to sale

Tropical fishes are imported into Canada for the aquarium trade, but no attempt has been made to determine the extent of the magnitude of the shipments.

UK: England and Wales

Import figures show that 1,542 tonnes of live fishes were imported, although the fate and storage of these fishes is unknown. This figure almost certainly includes large numbers of freshwater ornamental and tropical fish.

3.1.4 Recreational purposes

Canada

Splake, *Salvelinus namaycush* x *S. fontinalis*, were introduced to three New Brunswick lakes to determine value in recreational fisheries.

Charr-brook, *Salvelinus alpinus* x *S. fontinalis*, yearling fish were stocked into twelve New Brunswick lakes and ponds for recreational angling.

3.1.5 Captures of introductions originally made in neighbouring countries

U.S.A.

Muskellunge, *Esox masquinongy*, introduced to Québec waters several years ago were again noted in Saint John River headwaters in Maine, as well as at tidehead in New Brunswick. A near-border lake draining into Maine was reclaimed with piscicide in attempt to stop the spread into the U.S.A. of smallmouth bass (*Micropterus dolomieui*) and walleye, *Stizostedion sp.*, which had been introduced there.

3.1.6 Research purposes (excluding use in hatcheries)

Canada

Eggs of the whitefish, Coregonus lavaretus, weighing 150 g were imported from Finland for university research in Québec. Seven hundred fingerlings of the lake whitefish, Coregunus clupeaformis, were imported to Québec from Ontario for research in the university setting.

Sweden

Applications have been made for permission to import sea bass with the view of later cultivation of the species. The applications will probably be denied.

UK: England and Wales

Sea bream juveniles were imported from Greece for nutrition and disease trials.

A number of tilapia species is being held by universities for research purposes but details are difficult to obtain.

Seven Caiman crocodiles, Caiman crocodylus, were imported for research and are being held in re-circulation systems under strict quarantine.

3.2 Invertebrates

3.2.2 Mariculture (growth and fattening)

Canada

Thirty-six imports of oyster larvae, Crassostrea gigas, came from the states of Washington and California (USA) to British Columbia.

Imports of Manila seed clam, Tapes phillipinarum, were recorded from the states of Washington and California (USA) to British Columbia.

Denmark

15.000 Crassostrea gigas were imported from Northern Ireland and subsequently placed in the Danish Waddensea. A very rapid growth has been reported.

Ireland

Several million Pacific oysters, Crassostrea gigas, and Pacific clams, Ruditapes phillipinarum, were imported for ongrowing in Ireland.

Sweden

The import of oyster larvae from Norway has ceased.

3.2.3 Live storage prior to sale

UK: England and Wales

American lobsters, Homarus americanus, are imported under strict quarantine controls. The lobsters are for consumption in the UK and for export to Europe.

Large quantities of ragworm, Nereis virens,and lugworm, Arenicola marina, were imported from N. Ireland and Holland respectively and used by anglers as fishing bait.

Three thousand adult Pacific oysters, Crassostrea gigas, were imported from France and held in tanks at an inland site.

3.2.4 Improvement of food supplies for other species

UK: England and Wales

Dried brine shrimp, Artemia salina, eggs are imported in large quantities from several sources around the world to provide live food for fish in aquaculture and research systems.

3.2.5 Research purposes (excluding use in hatcheries)

Canada

Sea cucumbers, Thyone briareus, (600) were imported from the Woods Hole Marine Biology Lab, Massachusetts, for retention in enclosed aquaria for teaching and research purposes in New Brunswick.

Brittle stars, Amphipholis squamata, (360) were also imported to enclosed recirculation aquaria at a New Brunswick university for research and teaching purposes.

France

Rearing trial of Patinopecten yessoensis: Juvenile Patinopecten obtained during 1988 were placed for early rearing at a size of 3.6 mm. Forty thousand spat were transferred June 7, 1988, to the Mediterranean. In March 1989, survival rate was 32 percent and mean shell size was 32 mm. Ten thousand spat were placed at St. Anne du Portzec (Brest Road): the 60 percent survival is superior to that obtained in the Mediterranean but growth is inferior (20 to 30 mm). A third lot remains at Argenton. The epidemiological followup carried out on the three lots verified the presence of rickettsia, its prevalence and rates of infection were very variable, the more infected animals being in Brittany.

Rearing trial of Ostrea puelchana: In order to test their possible resistance toward two protozoans of the European flat oyster, O. edulis, 400 O. puelchana spawners from an Argentina source were introduced to France and placed in a quarantine facility of IFREMER (LPGIM). In view of the negative results from two controlled disease tests, the spawners were set for maturation. Different crosses produced 800,000 spat which are now in a nursery. Ultimately these spat will be set for rearing in Brittany and the Marennes - Oléron basin.

UK: England and Wales

Live adults and nauplii of Penaeus monodon were imported by research institutes. Animals were held in quarantine and rearing water was chlorinated before disposal. 110 broodstock adults were imported from Sri Lanka and Singapore; 30,000 nauplii were imported from Singapore and 240,000 nauplii from Singapore via Scotland.

A variety of molluscs was imported by research institutes and universities. Animals were held in quarantine, effluent water was chlorinated before discharge and at the end of the research period animals were destroyed. Species (and number) included:

Nassarius obsoletus (200) from Chesapeake Bay, USA.
Perna viridis (100) and P. indica (100 of 3 cm) from S.W. India.
Nacella concinna (80 of 2 cm) from South Georgia and Signy Island Antarctica.
Anadara senilis (1 kg of 5 cm) and Crassostrea tulipa (1 kg of 8 cm) from Ghana.
Saccostrea cucullata (1 kg of 5 cm) and Crassostrea iredalei (1 kg of 5 cm) from West Java, Indonesia.
Littorina littorea (50), Cerastoderma edule (50), Mytilus galloprovincialis (50) and Tapes (Venerupis) decussata (100) from the Algarve, Portugal.
Nucella lapillus (500 adults) from SW Brittany, France.

Tubeworms (species not specified) were imported from Ireland for experimental purposes. They were held in quarantine and destroyed at the end of the experiment.

3.3 Plants

Sweden
Kristineberg Marine Biological Station:

Small amounts of the brown alga, Ascophyllum nodosum ecad mackaii (Fucales), have been introduced from the U.S.A. for research purpose. The alga is kept in a green house, where it is always sterile. Also small amounts of the brown alga, Hormosira banksii (Fucales), have been introduced from southern Australia for research purpose. They are kept in complete laboratory conditions, the water being discharged into the urban freshwater discharge passing the sewage treatment plant.

University of Uppsala:

Small amounts of the red alga, Gracilaria secundata (Gigartinalcs), have been introduced from New Zealand for research purpose. The alga is kept in unialgal cultures in laboratory conditions and is also used for a pilot scale indoor tank aquaculture system.

4.0 Species introduced accidentally with deliberate introductions

Ireland

Oysters, Ostrea edulis, were noted to have wavy gill margins within some of the bays along the western and southern coasts of Ireland, into which transfers are known to have taken place. This condition was first noted in Kilkieran Bay, and oysters 2-15 cm dorso-ventral measurement could be affected. A copepod (Herminella sp.) was found within the mantle cavity of this species and may have been responsible for the gill damage. This species, although not described, is similar to a specimen recovered from the French coast some years previously.

The Chinese hat limpet, Calyptraea chinensis, is known from two bays from the western Irish coast. Established populations exist and are associated with oysters. Oysters in previous years had been introduced from the French coast prior to 1963 when it was first noticed.

An established population of the Pacific tunicate, Styela clava, exists in Cork Harbour, on the southern Irish coast. This species is found associated with oysters and is known to exist in this region since 1971. The tunicate when found among oysters and placed in a brine dip for 5 minutes and then exposed to the air, resulted in their total mortality.

Sweden

Anguillicola has been found sporadically along the Swedish east coast up to the town of Oskarshamn. Near this town there is an outflow of heated cooling water from the Simpevarp nuclear power station. Sampling of the eel population there during 1987 and 1988 revealed an increasing infection rate from 0 to 63%. Most infected eels harboured a single specimen but occasionally up to 15 worms were found. It is believed that the absence of Anguillicola from the Swedish west coast may depend on the considerably higher salinity.

The North American crayfish species, Procambrio clarkii, has been found in some lakes in southernmost Sweden after having been imported to the Limnological Institute at the University of Lund for research purposes.

U.S.A.

Viral Hemmorrhagic Septicemia (VHS), a fatal disease of salmonid fishes in Europe, was discovered in February 1989 on the Pacific coast of North America. It was found in an adult chinook salmon, Oncorhynchus tshawytscha, and an adult coho, Oncorhynchus kisutch, returning to two private hatcheries in the State of Washington, one on the Olympic Peninsula and the other on Orcas Island (near Puget Sound). As a result of this discovery, about 4 million eggs and fry of chinook, coho, chum Oncorhynchus keta, and steelhead were destroyed.

Dr. P.E.V. Jorgensen (Denmark) was brought in for expert consultation to advise on what was known about the virus and treatment programs. Isolates were from chinook and coho, and Dr. Jorgensen has returned to Denmark with these for confirmation and comparison with known European isolates. No mortalities have been observed, and coho salmon seemed refractory to the disease. VHS has not been found in rainbow trout or Atlantic salmon in Washington.

The mechanism by which VHS reached the Pacific coast of North America is not known. The two most probable means are: (1) importation of European rainbow trout or (2) ballast water discharge from ocean-going cargo vessels.

State of Washington fisheries authorities believe that importations of rainbow trout from Europe are not the most likely source of this virus. Rainbow trout have been brought from Finland and Norway (where VHS was introduced from Denmark about 10 years ago, but subsequently eradicated), not from more western or southern European locations where there are VHS "hot spots". All imports are certified virus-free. It remains possible, however, that there were illegal importations from Europe of which there would be no records.

Relative to the discharge of ballast water, Dr. Jorgensen apparently agreed that this mechanism is possible. Washington authorities have determined that at least two shipping lines have regular weekly service from Rotterdam to Seattle, a voyage of 2-3 weeks, with two stops in California. These are container ships, which do carry ballast water. Other direct European ship traffic to Puget Sound has not yet been investigated.

Washington officials are preparing to initiate studies in cooperation with the laboratory of Dr. J.T. Carlton (University of Oregon) on what living organisms, including viruses, may be arriving alive in ballast water from Europe into Washington.

5.0 Completely accidental introductions

Denmark

Sargassum muticum is still spreading in the Limfjord and at some locations (Nissum Bredning) it creates problems for smaller boats with outboard engines.

In 1988 one specimen of *Centrolabrus exoletus* (Rock cook, Petite vieille) was caught in the Isefjord. This species has not been recorded in Danish waters since 1901.

Sweden

On the occurrence of the Japanese brown alga, *Sargassum muticum*, in Sweden. The brown alga, *Sargassum muticum*, has for the last four years regularly been found on the Swedish west coast, mainly in the northern part. This brief report reviews the main events.

1985-1987

Drifting algae were first found in the summer of 1985. During the two following years, drift input continued. Reports cover the whole Swedish west coast, except for in the area south of Gothenburg to the city of Halmstad. In 1987, two attached populations were found in the Koster Archipelago in the northern part of the west coast. At the first locality (Burholmen) eleven individuals were found, and at the second one (Matkullen), one single specimen was found. All plants became fertile during the end of the summer. The plants grew at depths between 1-3m, and reached a maximum length of 180 cm before winter declination. Both populations found in 1987 survived the winter. In June 1988, the population consisting of 11 individuals the previous year had increased to 47, and the other had increased from 1 to 5 individuals.

1988

During 1988 two more localities were found. The most northern one, the island of Ramsokalven (the Koster Archipelago), was found in May and harboured a population of 3000-4000 plants. It must have been there for at least two years (probably longer), since old decaying plants covered the rock and because of the great amount. This means that the alga has survived the roughest winter on the Swedish west coast since the 1940s, with ice covering the Skagerrak for two months and water temperatures down to -1.4°C. The plants grew at depths between 0.5-7 m, and the majority of them became fertile.

The other locality found in 1988 is situated approximately 70 km south of the Koster Archipelago, at the island of Storön in the Vädcrö Archipelago. One attached plant was reported in the beginning of August.

In addition to the new records in 1988, a massive drift input occurred during the second half of July, especially in the northern part of the west coast. Aggregations of floating plants, 4-5 m^2 in diameter, were frequently found. It was not only the outermost skerries that were affected, even in the innermost sheltered areas around the Tjärnö Marine Biological Laboratory, Sargassum was seen almost every day during July-August.

1989

The winter 1988/89 has been extremely warm, with a water temperature not below 3.5°C. All populations previously found are thriving. In addition, two more localities with attached plants have been found this spring, again in the Koster Archipelago area. One is situated close to the small island Matkullen, where the species has previously been found, pointing to successive recruitment in the area. The other is situated at a skerry called Väskär, where plants are growing in a rock-pool. This is the only place found so far with this kind of growing habitat. Drift material was found in March close to the city of Lysekil.

UK: England and Wales

An accidental (?) release of the American lobster, Homarus americanus, has occurred. One adult was caught in a pot by fishermen working in the Solent area.

The survey planned for autumn 1988 to measure the level of infestation in eels by the nemotode parasite, Anguillicola sp., did not take place. Resources had to be diverted to work on spring Viraemia of carp (SVC) which has been positively identified in 40 sites (freshwater).

U.S.A.

Penaeus monodon Escape on Atlantic Coast

The large penaeid shrimp, Penaeus monodon, (also known in English by such common names as the giant tiger shrimp, black tiger shrimp, or grass prawn), was accidentally released from a mariculture facility along the south Atlantic coast of the United States in the summer of 1988. The giant tiger shrimp is native to Australia, India, and Southeast Asia.

The Waddell Mariculture Center, South Carolina (a state-operated research facility) brought in 100,000 postlarvae in the spring of 1988 from a hatchery in Hawaii for stocking and grow-out. At some point, some of these postlarvae appear to have been siphoned out through a drain pipe into a canal, which leads to a nearby river, and thus to the Atlantic Ocean. The holding ponds have since been replumbed, and no further escapes are thought possible.

The first reports of ocean-captured Penaeus monodon were in July 1988. Between July and October 1988 less than 500 (not 1,000 as reported in some press accounts) were captured from the open ocean over a range of 500 km (300 miles) extending from northern South Carolina (at Georgetown) to northern Florida (at St. Augustine). The largest specimen captured was about 125 gm (length > 220 mm (> 9 inches)), and was believed to be about 7 months old. No ovigerous females were found. No shrimp have been reported since October 1988.

Concern has been expressed about potential disease problems (although the larvae are certified disease-free by the Hawaiian hatchery), and, should they become established in more southern waters, possible competition with native shrimp species.

Introduction of European Aquatic Organisms into the Great Lakes of North America

Last year it was reported that the European river ruffe, Gymnocephalus cernua (Percidae), had dramatically appeared in the St. Louis River, in Duluth Harbour, in Lake Superior, Wisconsin. It was first found in 1987, at which time at least three year classes (1985, 1986, and 1987) were present. Several thousand fish have now been found as Gymnocephalus continues to expand its range in Lake Superior and associated stream drainages. In addition, the carnivorous European water flea (cladoceran), Bythotrephes cederstroemi, was also reported as having successfully colonized by 1987 all of the Great Lakes.

Both the ruffe and the water flea are thought to have been introduced by means of fresh or brackish water ballast discharged from inbound cargo ships arriving from western European ports. It now appears that yet a third species has invaded the Great Lakes: the freshwater zebra mussel, Dreissena polymorpha, which was discovered in Lake Erie in 1988. This species is also thought to have been introduced as larvae by means of ballast water. Dreissena, which grows to about 3 cm in length, has been a major economic nuisance in Europe, where it clogs water intake pipes and is an important fouling organism on boat bottoms. Great Lakes authorities are concerned that this new clam could add millions of dollars in maintenance costs to municipal and industrial water intakes as it spreads through Lake Erie, and into other lakes. They have already been found in densities up to 50 per square foot in some intake pipes. Dreissena has been found in "every drinking water intake" along western Lake Erie, the Detroit River, and Lake St. Clair as of March/April 1989.

The Great Lakes Fishery Commission has taken the lead in attempting to control the further release of exotic species in ballast water. As of May 1, 1989, the "Great Lakes Ballast Water Guidelines" went into effect, which calls for voluntary discharge of ballast water by vessels prior to their entering the Great Lakes (and replacing such water if necessary with open ocean water from off the Atlantic coast of the United States). This program has just begun and its effectiveness will not be known for some time. In addition, a bill has been submitted before the U.S. House of Representatives calling for a detailed study on the control of ballast water release in the Great Lakes. The matter of ballast water discharge involves two federal governments (Canada and the United States) and a large number of state and local agencies.

6.0 Species introduced for hatchery rearing

6.1 Stocks not subsequently planted outside the hatchery

Canada (Province of British Columbia)

A small shipment of giant tiger shrimp, *Penaeus monodon*, was imported from Hawaii to a contained laboratory.

One shipment of Japanese scallop, *Patinopecten yessoensis*, was imported from Japan for hatchery trial.

Two shipments of the blue mussel, *Mytilus edulis*, from Washington were contained in a bio-assay laboratory.

Small numbers of lamprey, *Lampetra tridentatus*, were imported from the western USA for research purposes.

U.S.A.

The eastern or Atlantic oyster, *Crassostrea virginica*, stocks of the Atlantic coast of the United States have been severely damaged in recent decades by two protozoan diseases. Some indication of resistance has been seen in survivors, but mortalities still occur.

According to a recent news report (February 1989), scientists at the Virginia Institute of Marine Sciences (VIMS), at Gloucester Point, Virginia, plan in 1989 to hybridize *Crassostrea virginica* with the Pacific, or Japanese, oyster, *Crassostrea gigas*. The hope is that the offspring will be resistant to the east coast diseases (the Pacific oyster seems to be resistant to a number of other diseases). The work will be done in quarantine at a hatchery on the York River. Concern has been expressed by other research institutions about possible escape from quarantine, and possible introduction of other disease organisms, which Pacific oysters are known to carry.

6.2 Stock relaid in small quantities under controlled experimental conditions

U.K.: England and Wales

Evaluations of the environmental impact of the Manila clam, *Tapes philippinarum*, and the culture potential of the American oyster, *Crassostrea virginica*, continue. Interest from commercial growers in American oysters has been minimal owing to its poor growth to date.

6.3 Stock supplied in larger quantities to the industry or to some other organization

Sweden

Elvers, *Anguilla anguilla*, are imported only from England (ceased ?) and Portugal.

UK: England and Wales

Commercial growers planted 1.7 million Manila clam seed during 1988 in mesh-protected plots. Seed were provided by commercial hatcheries in Britain and the Channel Islands.

7.0 Planned introductions

Canada

A professor at Mt. Allison University in New Brunswick has been authorized to import 50 sea urchins, Strongylocentrotus purpuratus, from the state of California and 250 sea stars, Asterina wega, from the Mediterranean and Red seas for teaching and research purposes. All animals will be destroyed.

8.0 Live exports for consumption

8.1 Molluscs

Canada

Species exported from British Columbia include Crassostrea gigas, Tapes philippinarum, Parrope abrupta, and Halistus kamtschaticana. Species exported from the five eastern provinces may include the following shellfishes:

Blue mussel	Mytilus edulis
Bay quahog	Mercenaria mercenaria
Ocean quahog	Artica islandica
Soft-shelled clam	Mya arenaria
Stimpson	Spisula polynyma
Surf clam	Spisula solidissima
American oyster	Crassostrea virginica
European oyster	Ostrea edulis
Periwinkle	Littorina littorea
Whelk	Buccinum undatum

France

Principal imports of shellfish destined for direct consumption in tonnes were:

	Species		
Country	Flat oyster	Mussel	Misc
Low countries	134	13,600	375
Ireland	229	460	290
United Kingdom	389	49	415
Spain	10	9,500	48
Italy	21	-	93

Ireland

Flat oysters, O. edulis, and Pacific oysters, C. gigas, are exported.

Scotland

Manila clams are exported live.

Sweden

Mussels, Mytilus edulis, are exported to France.

UK: England and Wales

Exports for consumption in 1988 were:

3,502 tonnes of mussels, *Mytilus edulis*
103 tonnes of oysters, *Ostrea edulis*
1,617 tonnes of scallops, *Pecten maximus*, and queens, *Chlamys*
16 tonnes of octopus
292 tonnes of squid and cuttlefish
7 tonnes of other live material

8.2 Crustaceans and sea urchins

Canada

Species in this group exported from British Columbia include *Strongylocentrotus droebachiensis*, *Pollicipens polymerus*, *Pandalus platyceros*, and *Cancer magister*. The American lobster, *Homarus americanus*, was exported live from all five eastern provinces (about 16,300 t in 1987).

Scotland

Lobsters and crabs are exported from Scotland for direct consumption.

UK: England and Wales

Exports in the species grouping include:
997 tonnes of lobster, *Homarus gammarus*
492 tonnes of Norway Lobster (*Nephrops norvegicus*).
6,401 tonnes of crabs, including green crab, spider crab, velvet crab.

8.3 Fish

Canada

Live fish exports in 1988 were: 437.8 t of the American eel, *Anguilla rostrata*, 15.9 t of trout, mainly *Salmo trutta* and *Oncorhynchus mykiss*, and 2.2 t of carp, *Cyprinus carpio*.

Scotland

Eels were exported from Scotland in 1988.

Sweden

Eels were exported to Denmark, West Germany and the Netherlands in 1988.

UK: England and Wales

About 1,100 tonnes of fish were exported mainly to EEC countries.

9.0 Live exports for purposes other than direct consumption

9.1 Molluscs

Scotland

Scotland exported Manila clams in 1988.

UK: England and Wales

Hatcheries in Britain and the Channel Islands exported around 12.5 million Pacific oyster, Crassostrea gigas, and 12 million Manila clam, Tapes philippinarum, seed of various sizes to on-growers in Ireland, Italy, Spain, and South Africa.

9.2 Crustaceans and fish

Scotland

Elvers and juvenile turbot were exported from Scotland in 1988.

UK: England and Wales

Around 30 tonnes of wild-caught elvers were exported to other European countries including Holland, Sweden and Germany for growing-on to market size.

90,000 hatchery-produced juvenile turbot were exported to Galicia, Spain for on-growing.

JOINT MEETING ON THE ICES WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS AND REPRESENTATIVES OF THE NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION (NASCO) AND OTHER EXPERTS

The WG met in joint session on May 23, 1989, at the offices of the Department of the Marine, Leeson Lane, Dublin, Ireland, with members of the ICES WG on Genetics, with representatives of the North Atlantic Salmon Conservation Organization (NASCO) and with other national experts for a program of papers and discussion on "Genetic threats to wild salmon posed by salmon aquaculture". The session was chaired by Dr. Alan Youngson, Aberdeen, Scotland, in the program outlined in Appendix IV. Five summary paper presentations were followed by an afternoon of general discussion and consideration of recommendations which are found in NASCO Paper CNL (89) 10 (Appendix V). Thirty-five experts and fishery scientists were present for the joint meeting (Appendix VI).

The WG reviewed the results of the one-day joint meeting and determined that information was insufficient to evaluate the degree of risk of adverse effects of Atlantic salmon which have escaped from cultivation and mixed with wild Atlantic salmon stocks. However, the large numbers of escapees observed in spawning escapements in rivers in Norway give cause for grave concern that the potential exists for serious effects on the productivity of wild stocks.

Dr. Wolfgang Villwock, Federal Republic of Germany, and Dr. Richard Saunders, Canada, current chairman and representative respectively from the ICES Genetics Working Group, were present for the review discussion and provided input as seen from the genetics perspective.

Wide-ranging discussion generated several pertinent points, including:

a. the symposium content lacked scientific information and the damage case is yet unproved;

b. ecological considerations require the close collaboration of geneticists and ecologists to fully assess impacts, i.e., a multi-disciplinary approach is needed;
c. the assessment effort is late getting started so a determined new thrust is urgently needed;
d. the longer the interval before genetic impact is understood the greater will be the genetic divergence of the farmed stocks, and
e. an improved scientific base is required as a justification if national laws need to be enacted.

The WG concluded that a conservative approach should be followed in development of Atlantic salmon aquaculture industries until the risk of adverse effects of wild Atlantic salmon stocks has been evaluated. Development of broodstock from stocks of local origin is recommended and encouraged. The Working Group noted that genetic, ecological and behaviourial research presently being undertaken is insufficient to evaluate the spectrum of effects of escapees on wild Atlantic salmon populations. The magnitude of the urgent research necessitates international cooperation and ICES should encourage and co-ordinate its early implementation.

Moreover, the WG concluded the urgent salmon stock impact problem calls for immediate documentation. National summaries of pertinent information could lay that required foundation. Multi-disciplinary science needs in ecological interactions, in physiology, and in behaviour can be addressed on a more timely basis than can those needs in genetics. A second meeting on this salmon aquaculture impact problem should be convened for review of that more-thorough science documentation in order to provide the basis for necessary national legislation.

With the increasing rate of research in gene transfers and genetic manipulation in marine organisms providing the potential for possible adverse affects and environmental impacts, the WG supports further work and collaboration to define this growing problem with greater precision.

CURRENT STATUS OF PROPOSED ACTUAL INTRODUCTIONS

The Introduction and Cultivation of the Japanese Brown Alga, *Undaria pinnatifida*, on the Atlantic coast of France.

Background

The history of this introduction and references to its consideration by the WG are found in the past two WG reports (C.M. 1987/F:35, p. 16-21 and C.M. 1988/F.20, p. 22-23). As well, the WG had the paper by Floc'h, Pajot, and Wallentinus (C.M. 1988/Mini No. 2, 16 p.) presented at the mini-symposium at the Statutory Meeting of ICES in Bergen, Norway, in October 1988. Dr. Wallentinus was present to provide additional information from the southern hemisphere and to lead the discussion.

Relevant new information

a) *Undaria pinnatifida* can survive and reproduce on the Atlantic coast of France.

b) Undaria appears to be a species with relatively low dominance - - it does not seem to overwhelm the smaller natural indigenous flora, nor has it dominated other laminarias.
c) Undaria has an annual cycle and is subject to grazing.
d) Based on observations to date, spread of Undaria seems inevitable, but it also seems slow and erratic.
e) Early experimental plantings were made in 1983 at two Atlantic coastal and one channel site; surviving populations occur at only one site (Isle d'Ouessant) where young sporophytes were set out repeatedly in the sea from the hatchery.
f) Massive imports of Pacific oyster spat were made in late 1960's and early 1970's on the French Atlantic coast, but no indication has been found of any successful accidental introduction of Undaria at that time.

Other considerations

a) Greater exploration should be made of native species of algae that could be used in culture.
b) The question of the anticipated spread of Undaria from production sites can be resolved only by long-term studies.
c) Undaria may become a fouling problem on submerged artificial structures.
d) Ecological competition for substrate by Undaria is still not fully studied (although some studies are in progress).
e) Scientific follow-up studies must be conducted.
f) Discussion applies only to Undaria pinnatifida and not to other algae.

WG Action in 1989

The WG concluded the following advice could go forward to the ICES Council:

1) Careful examination of available scientific evidence indicates that this introduction of Undaria pinnatifida to European Atlantic waters will not have major detrimental effects on the coastal ecosystems, although spread by natural and man-made means seems inevitable.
2) The Working Group does not oppose the continued development of Undaria pinnatifida culture in France, including commercial-scale projects.
3) No further introductions of Undaria pinnatifida from Pacific waters should be made unless the ICES Code of Practice is followed.
4) France should keep detailed annual records of locations, dates of initiation and extent of culture area for all projects. These records should be made available to ICES as part of the national report, with a summary, including ecological considerations and environmental impacts, to be presented to ICES in 1994.
5) ICES member countries should look actively for the occurrence of Undaria pinnatifida in their coastal waters.

The Introduction of the Japanese Scallop, *Patinopecten yessoensis*, to Ireland

Background

The Department of the Marine of the Republic of Ireland submitted to the ICES Secretary General a proposal for introduction of the Japanese scallop, *Patinopecten yessoensis*, for consideration by the Working Group on Introductions and Transfers of Marine Organisms. The WG was provided with information behind the proposal by staff of the Department of the Marine and by the commercial proponent. A major part of the justification relates to the low production capacity of local stocks and to their irregular spat production. The proposal options are to (1) import 500 adults to quarantine and release F_1 shellfish for rearing or (2) to import larval scallop to quarantine for disease assessment. The Japanese source was not yet identified, but Japanese technicians would accompany the adults and oversee the spawning. The introduction will be concentrated at a single location.

Summary

The WG discussion resulted in this summary of relative information and points of concern:

a) The introduction is being proposed principally because the native species are not as suitable as the proposed species for cultivation and local stocks are at low levels.

b) The introduced species is expected to establish viable populations in Ireland.

c) Small numbers of this species have been introduced to Denmark and to France on the Atlantic coast and on the Mediterranean coast, and the species is being used in laboratory studies in Newfoundland, Canada.

d) Available information on environmental data and on inter-specific competition with native species is inadequate to enable full evaluation of the proposal.

e) Greatest detrimental impact is likely to occur mainly in ecological interactions; pathological problems via unwanted disease movements are possible; and genetic risks through hybridization are expected to be low.

f) Late receipt of the proposal prevented consultative meetings within member countries.

g) Additional ecological and pathological information on this species in the native habitat is necessary, as required by the ICES Code of Practice.

Preliminary Advice

On the basis of the foregoing points of concern, the Working Group offers the following preliminary advice and comment:

1) The dominant issue is that of ecological impact, e.g., recruitment success in the British Isles is probable and spread of the species from Ireland would be expected and thus competition with valuable local species may occur.

2) Several disease problems with scallops are known, mass mortalities of unknown causes are frequent, and high losses of this species

occur in Japan; thus significant effort is required to prevent disease introduction to Ireland.

3) If Ireland wishes to establish a broodstock, adult scallops should be held in quarantine following the ICES Code of Practice. All scallops, including the F_1 generation, should be held in quarantine pending definitive advice.

4) The Working Group does not support the introduction of eyed scallop larvae unless they are destined only for use as broodstock and held in quarantine.

5) To improve international communication in the matter of introductions of Patinopecten yessoensis in ICES member countries, the Secretary General should query all member countries requesting summaries of past, present and future actions related to introduction and culture of Japanese scallops, to be provided by May 1990.

SYMPOSIA

The 1988 Mini-symposium on "Case Histories of Effects of Introductions and Transfers on Marine Ecosystems"

The mini-symposium was successfully held in October 1988 at the 76th Statutory Meeting of ICES in Bergen with Dr. C.J. Sindermann as Convenor. The chairman reported that all manuscripts have been edited and returned to authors for amendment per the editing comments.

The WG expressed a strong preference that publication of the papers take place as a single entity. Publication in a primary journal might result in a delay in publication if the editor should request further editing. The preferred journal is Journal du Conseil, but Jour., of Fisheries Science, Ocean & Shoreline Management, or Aquaculture might prove more responsive to our needs for publication as a unit.

The 1990 Symposium on "Case Histories of the Effects of Introductions and Transfers on Aquatic Resources and Ecosystems

An international symposium is planned for two days in June 1990 in Halifax adjunct to the World Aquaculture Society's (WAS) meeting, "Aquaculture: The Global Perspective". The symposium will be co-sponsored by ICES, EIFAC, and WAS with Dr. C.J. Sindermann (ICES), Dr. B. Steinmetz (EIFAC), and W. Hershberger (WAS) as co-convenor. Holding a joint meeting with EIFAC and adjunct to the WAS meeting presents a fine opportunity to pass information to aquaculturists, one of the target groups being affected by the deliberations of the WG.

The symposium will consist of a general session in the first half-day, followed by three thematic sessions over the next one and one-half days (Appendix VII). Three keynote papers are planned for the general session, addressing international movements of marine and aquatic organisms, laws and regulations governing these movements, and genetic engineering and introductions and transfers of genetically modified organisms. The theme sessions will be characterized by an overview paper followed by invited special case history papers for the themes of fish, invertebrates and plants. A one-quarter day session will be devoted to summary reports by the theme session co-chairman and to develop appropriate recommendations.

RECOMMENDATIONS

The Working Group formulated the following recommendations to the parent committee:

1) With reference to Atlantic salmon, particularly to the effects of cultured escapees on wild Atlantic salmon stocks, it is recommended that:
   a) studies on ecological and behaviorial interactions be continued and expanded.
   b) a study group be formed, under the chairmanship of Mr. Alan Youngson of Aberdeen, Scotland, to review, consolidate and report on the current status of techniques to detect genetic changes in Atlantic salmon stocks which could be caused through hybridization of wild and cultured populations; and to provide an experimental design for a research program to evaluate the possible effects of escapees of cultured Atlantic salmon on wild stocks. The research should address genetic consequences, ecological impacts, and behaviourial interactions as well as identification of appropriate locations for the research. Cost and duration should also be estimated for the research program. The proposed study group, reporting to both the Genetics Working Group and the Working Group on Introductions and Transfers of Marine Organisms, will consist of experts in the fields of genetics, ecology, behaviour, and population dynamics. These experts may be from the above ICES working groups, from the North Atlantic Salmon Working Group, or any other experts recommended by the Chairman of the study group in consultation with the ICES Delegates.
   It is proposed that the study group hold a meeting to coincide with the ICES Working Group on North Atlantic Salmon in March of 1990 to enable common members of both groups to participate in the study. A report from the study group should be available by the May 1990 meetings of the Introductions and Transfers and the Genetics working groups.
2) Despite substantial progress by ICES in developing and publicizing codes of practice and guidelines, continuing problems exist concerning introductions and transfers of marine organisms, and an updated status report (to replace Coop. Res. Rep. 116) should be prepared for review at the 1990 Statutory Meeting and published, after approval, as a Coop. Res. Rep. with the title "Status (1990) of Introductions of Non-Indigenous Marine Species to North Atlantic Waters."
3) Laws and regulations of member countries relative to introductions of non-indigenous species are evolving and changing; an updated summary of such laws and regulations (subsequent to the compendium prepared in 1980) should be prepared and deposited at Council headquarters by the date of the 1990 Statutory Meeting.

4) To improve international communication in the matter of introductions of <u>Patinopecten yessoensis</u> in ICES member countries, the Secretary General should query all member countries requesting summaries of past, present, and future actions related to introduction and culture of Japanese scallops, to be provided by May 1990.

5) With the increasing rate of research in gene transfers and genetic manipulation in marine organisms providing the potential for possible adverse affects and environmental impacts, the WG supports further work and collaboration with the objective of defining the growing problem with greater precision.

6) The ICES Working Group on Introductions and Transfers of Marine Organisms should meet for three days on June 6-8, 1990, in Halifax, Nova Scotia, Canada, immediately preceding the joint ICES/EIFAC/WAS International Symposium on "Case Histories of Effects of Introductions of Aquatic Organisms" which will be an integral part of the World Aquaculture Society (WAS) meeting, June 10-17, 1990. Working Group agenda items include:
   a) preparation of definitive advice and final recommendations relative to introduction of the Japanese scallop, <u>Patinopecten yessoensis</u>, to Ireland;
   b) receive and review national summaries which will form part of a report on the status of introductions of marine organisms -- to be published as a Coop. Res. Rep.;
   c) review and assemble national summaries of laws and regulations concerning introductions of marine organisms -- to be deposited as a bound volume at ICES headquarters;
   d) continue the overview of the status of proposed, new, and on-going introductions and transfers of marine organisms, and their biological and ecological effects in and between ICES member countries;
   e) review codes of practice concerning genetically modified organisms, with a view toward developing an extension of the ICES Code of Practice.

ACKNOWLEDGEMENTS

At the conclusion of its deliberations the Working Group extended its thanks; to Dr. Eileen Twomey and the staff of the Department of the Marine in Dublin for their gracious hospitality and invitation to the Working Group for its 1989 meeting, to NASCO Secretary Malcolm Windsor for the reception for the Working Group, and to Dr. John McArdle for hosting especially the field trip which provided an opportunity to appreciate the near-coastal history and beauty of Dublin.

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EMMY EGIDIUS

Marine Science is poorer today with the recent, untimely death of Dr. Emmy Egidius of the Institute of Marine Research, Bergen, Norway, and Professor of Aquaculture at the University of Bergen. Those of us in the ICES Working Groups on Marine Pathology and on Introductions and Transfers of Marine Organisms feel especially bereft, since both groups depended heavily on her professional expertise, good counsel, and perceptive leadership. Emmy represented that rare blend of outstanding professional competence and strength of personality so critical to successful participation in the best circles of international science.

Her professional competence was well-demonstrated by the critical role she assumed in the development of understanding of diseases affecting marine aquaculture in Norway -- especially the microbial infections that threatened an expanding salmon farming industry. Research accomplished by her pathology group contributed significantly to the continued viability and increased productivity of that industry, in particular by pioneering the use of the bath method of immunizing fish. Additionally, she participated actively in the development of fish disease regulations for Norway.

Dr. Egidius' scientific contributions were varied and substantive. She was an active member, beginning in the early 1970's of the ICES Working Group on Introduced Species, chaired originally by the late Dr. H. A. Cole. She had an important role in the emergence of the ICES Mariculture Committee, and of its predecessor, the Working Group on Mariculture, which was part of the former Fisheries Improvement Committee of the Council in the early 1970's. She was a founding member and later chairman of the ICES Working Group on Marine Pathology -- a group that, under her leadership, as well as that of her predecessor, Dr. Claude Maurin of France, has directed international attention to the critical role that diseases play in the survival of marine populations. She was instrumental in organizing major international meetings of marine pathologists, and in organizing disease-related activities of the North Sea Center. Dr. Egidius was at the time of her death the third president of the European Association of Fish Pathologists serving in that office after the term of Dr. Barry Hill of the United Kingdom, guiding that organization to a new maturity.

Emmy represented the ideal multilingual marine scientist; fluent in English, Dutch, and French, as well as in all the Nordic languages, she helped to provide essential communication among those of us less skillful. She had a wide circle of colleagues throughout Europe, and was a critical ingredient of the professional networks in marine pathology.

In addition to aquaculture pathology, Dr. Egidius was deeply concerned about diseases of wild stocks on the Norwegian coast, and about pollution-related diseases. To these ends, she maintained an active field research program, and organized several international cruises to examine diseases in high seas stocks.

Emmy's contributions to the ICES Introductions and Transfers Working Group were not limited to her specific interests in pathology, diseases, and parasites. Emmy participated willingly and with great energy in discussions of the purely ecological, economic, legal, and even social issues relative to exotic species, whether fish, clams, algae, or even ballast water, listening carefully to all issues and opinions, and then often summarizing the essence of the matter at hand. She brought a wealth of experience and insight to a great many matters.

Those of us in the ICES groups in which she participated can only say "Emmy, you were important to us and to the group efforts in which we are involved. We probably never told you this in explicit ways -- a common human failing -- but we will miss your contributions to the emergence of conceptual and practical aspects of marine science. More importantly, we will miss the warmth of your professional association with all of us. The world is somehow a less-perfect place without you."

APPENDIX III

DRAFT AGENDA

ICES WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

Dublin, Ireland
May 23-26, 1989

23 May 1989 Tuesday 9:00 a.m.	Joint NASCO/ICES Meeting on Genetic Threats to Wild Salmon, chaired by Alan Youngson, with joint participation of representatives of NASCO, ICES Working Group on Introductions, ICES Working Group on Genetics, and invited national experts (a separate agenda for this one-day meeting will be sent)

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24 May 1989 Wednesday 9:00 a.m.	Opening Session of Working Group Meeting Comments by representatives of the Fisheries Research Centre Comments by WG Chairman: Eulogy for Emmy Egidius Review of proposed agenda Status of recommendations from 1988 meeting and from previous meetings Review of joint meeting on genetic threats to wild salmon Review 1988 minisymposium on case histories of introductions National Reports
12:00 noon	Lunch
1:30-5:00 p.m.	Reconvene Continue national reports Status of: *Undaria pinnatifida* *Crassostrea gigas* *Sargassum muticum* Coho and other Pacific salmon Eel nematodes Other species
5:00 p.m.	Adjourn

<u>25 May 1989</u> Thursday 9:00 a.m.	Reconvene Final steps in preparation of revised document "National Laws and Regulations of ICES Member Countries Concerning Transfers and Introductions of Marine Organisms" Plans for 1990 World Symposium on Introductions and Transfers of Aquatic Organisms International response and comments on publication of "Code of Practice and Manual of Procedures" (Cooperative Res. Rept. No. 159) Discussion of the role of the WG in considerations of genetically engineered organisms
12:00 noon	Lunch
1:30-5:00 p.m.	Field Trip
<u>26 May 1989</u> Friday 9:00 a.m.	Reconvene Consideration of advice to the Council on the *Undaria* issue Discussion of decision procedures for introductions and transfers New Working Group initiatives
12:00 noon	Lunch
1:30-5:00 p.m.	Discussion of recommendations to parent committee Principal agenda items for 1990 WG Meeting (to be held in Halifax, Canada, in June, in conjunction with the joint international symposium on case histories of introduced species)
5:00 p.m.	Adjourn

NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION
ORGANISATION POUR LA CONSERVATION DU SAUMON DE L'ATLANTIQUE NORD

NASCO

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JOINT ~~NASCO/ICES MEETING~~ ON THE "GENETIC THREATS TO WILD SALMON POSED BY SALMON AQUACULTURE"

THE DEPARTMENT OF THE MARINE, LEESON LANE, DUBLIN 2 ON TUESDAY 23 MAY 1989

PROGRAMME

08.45	Registration
09.15	Opening Remarks - Dr Alan Youngson (Chairman)
09.20	Introduction - Dr Malcolm Windsor (Secretary of NASCO)
09.30	***"To what extent are farmed and wild salmon genetically distinct?"*** Dr Tom Cross, University of Cork, Ireland
10.05	***"Are differences in performance related traits likely to exist between farmed and wild fish and their crosses?"*** Dr John Bailey, Atlantic Salmon Federation, Canada
10.40	Coffee
11.00	***"Is the stage of life at which fish are released or escape a determinant of their subsequent performance?"*** Dr Lars Hansen, NINA, Norway
11.35	***"Can the factors likely to limit the crossing of wild fish and fish of farmed origin be identified?"*** Dr Alan Youngson, DAFS, Scotland
12.10	***"Is aquaculture likely to affect the genetic integrity of wild populations?"*** Dr Eric Verspoor, DAFS, Scotland
12.45	Lunch
14.00	General Discussion on the genetic threats to wild stocks. Formulation of Research and other needs and possible international collaboration.
16.00	Tea
16.15	Consideration of recommendations
17.00	Conclusion
18.30	Reception at the invitation of NASCO

NASCO

CNL8919

COUNCIL

PAPER CNL(89)19

REPORT OF DUBLIN MEETING ON GENETIC THREATS TO WILD STOCKS FROM SALMON AQUACULTURE

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CNL(89)19
REPORT OF THE DUBLIN MEETING ON GENETIC THREATS TO WILD STOCKS FROM SALMON AQUACULTURE

1. At its Fifth Annual Meeting the Council requested the Secretary, in consultation with the General Secretary of ICES, to convene a one-day meeting during the first half of 1989 to assemble what information was available on genetic threats to wild stocks.

2. In accordance with this decision a joint NASCO/ICES meeting was held at the Department of the Marine, Dublin on 23 May. The meeting was well attended by salmon geneticists, biologists and managers from throughout the North Atlantic countries and the report of this meeting is appended to this paper as Attachment 1.

3. The meeting consisted of five formal papers which were presented in the morning session and which served as a basis for an afternoon discussion session. The papers addressed the following questions:

   - To what extent are farmed and wild salmon genetically distinct?
   - Are difference in performance related traits likely to exist between farmed and wild fish and their crosses?
   - Is the stage of life at which fish are released or escape a determinant of their subsequent performance?
   - Can the factors likely to limit the crossing of wild fish and fish of farmed origin be identified?
   - Is aquaculture likely to affect the genetic integrity of wild populations?

4. A number of views on the impacts of farmed fish on the wild stocks was expressed. These ranged from no impact (or even benefits) to serious impacts. The only evidence presented, however, suggested that adverse effects were possible. There was general agreement that there were considerable gaps in our knowledge, and on the need for the necessary experimentation to assess the genetic impact. Such experimentation would be facilitated by the development of techniques to identify individual fish through genetic markers. The urgent need to support such research was recognised.

5. The meeting agreed a number of basic questions including:

   - what are natural straying rates?
   - where do escapees go?
   - to what extent are fish of farmed origin represented among spawners?
   - do wild and farmed fish interbreed?
   - do wild fish and fish of farmed origin interact ecologically?

   In addition the need to develop improved methods of identifying farmed fish in the wild was recognised.

6. In these circumstances where large numbers of farmed fish are occurring in the habitat of wild salmon and their impact is unknown, the meeting recognised the need for caution. The development of gene banks and of internationally agreed Codes of Practice or recommendations was agreed. Such codes or recommendations could include the following elements:

- cage security
- the use of sterile fish
- tagging of farmed fish and adequate reporting of escapes
- zones free of aquaculture
- emergency netting of severe escapes of farmed fish where legislation permits
- encouragement for the use of local stocks for farming purposes
- measures to maintain the vigour of existing natural stocks
- adoption of Codes of Practice for reducing genetic threats and the impacts of introductions and transfers in general.
- introduction and permanent scientific control of gene banks including sperm preservation as well as wild stock preservation.

7. The Council might like to consider if and how the development of genetic markers and research on impacts might be stimulated. The Council might wish to take note of the recommendation on the practical steps which might be taken in the meantime (such as the development of Codes of Practice or series of recommendations, and gene banks) as covered in other papers on these subjects CNL(89)21 and CNL(89)23.

Secretary
Edinburgh
26 May 1989

ATTACHMENT 1

JOINT NASCO/ICES MEETING ON

"THE GENETIC THREATS TO WILD SALMON POSED BY SALMON AQUACULTURE"
THE DEPARTMENT OF THE MARINE, LEESON LANE, DUBLIN 2
TUESDAY 23 MAY 1989

1. OPENING REMARKS

1.1 The Chairman Dr Alan Youngson opened the meeting, thanked the Irish Government for the arrangements which had been made for the meeting and welcomed all delegates.

2. INTRODUCTION

2.1 The Secretary of NASCO, Dr Malcolm Windsor, introduced the meeting by outlining the involvement of NASCO in the debate concerning the interactions of salmon aquaculture and the wild stocks (Annex 1).

3. PRESENTATION OF PAPERS

3.1 Dr Tom Cross of the University of Cork, Ireland, presented a paper entitled "To what extent are farmed and wild salmon genetically distinct?" (Annex 2).

3.2 Dr John Bailey of the Atlantic Salmon Federation, Canada, presented a paper entitled "Are differences in performance related traits likely to exist between farmed and wild fish and their crosses?" (Annex 3).

3.3 Mr Lars Hansen, of the Norwegian Institute for Nature Research, Norway, presented a paper entitled "Is the stage of life at which fish are released or escape a determinant of their subsequent performance?" (Annex 4).

3.4 Dr Alan Youngson of the Department of Agriculture and Fisheries for Scotland, presented a paper entitled "Can the factors likely to limit the crossing of wild fish and fish of farmed origin be identified?" (Annex 5).

3.5 Dr Eric Verspoor of the Department of Agriculture and Fisheries for Scotland, presented a paper entitled "Is aquaculture likely to affect the genetic integrity of wild populations?" (Annex 6).

4. GENERAL DISCUSSION ON THE GENETIC THREATS TO WILD STOCKS.

4.1 A list of objectives for possible future research was presented by the Chairman and discussed by the meeting. These objectives were:

1. To define genetic units in wild fish assessing gene flow between units.

2. To monitor strains in culture identifying genetic changes entrained by culture itself.

3. To find the means by which introgression of genetic material from farmed fish to wild fish may be studied in the field.

4. To determine the nature of any behavioural or physiological constraints to introgression.

5. To describe the dynamics of introgressed genetic material in wild populations.

6. To monitor the genetic condition of wild and domestic stocks and their performance and productivity.

7. To understand the genetic basis of performance.

4.2 The need to establish priorities for these issues was recognised. Some of these studies might be pursued with existing expertise and facilities. Others would be facilitated by accelerated development of emerging techniques.

4.3 The development of techniques for the analysis of variation in nuclear DNA was described by Dr Ferguson of Queens University, Belfast. Such markers would be very useful in establishing natural gene flow and in structuring experimental studies using neutral genetic tags. The technique is expensive to develop but once suitable probes have been developed it is quicker and screening costs are therefore lower than for mitochondrial DNA analysis. The development of these techniques might enable a biological impact experiment to be set up.

4.4 Present electrophoretic studies being conducted in Scotland, Ireland, England and Wales and Norway were described. In Norway 25% of fish ascending rivers were escapees from fish farms but there is not enough knowledge to predict what the genetic impact of these fish will be. A review of the literature was presented which suggested that some adverse effects were possible. However, in order to make better predictions experiments needed to be devised involving the use of genetic markers. One proposal was that a controlled experiment could be carried out in a monitored salmon stream by manipulation with a farmed stock.

4.5 The attention of delegates was drawn to a number of forthcoming meetings concerning the interactions between aquaculture and wild stocks. These include a meeting in Ireland in September 1989, a meeting in Norway in April or May 1990, a one day meeting of the World Aquaculture Society in Halifax, Nova Scotia in July 1990 and a meeting in Nanaimo, British Columbia in September 1990. It was agreed that there might also be a need for a further joint NASCO/ICES meeting on this subject in 1991.

5. CONSIDERATION OF RECOMMENDATIONS.

5.1 A range of views was expressed by the delegates concerning the genetic threats to the wild stocks posed by salmon aquaculture. These ranged from those who felt that there was unlikely to be any impact (or might even be benefits) to those who felt that there were potentially serious impacts.

5.2 The only evidence presented, however, suggested that some adverse effects were possible. There was general agreement that there were considerable gaps in our knowledge regarding the genetic impact of reared fish on wild stocks. There was also general agreement on the need for, and difficulty associated with, the necessary experimentation required to assess the genetic impact. The development of techniques for the analysis of variation in nuclear DNA would help to solve many of these and other open questions, including introgression, as a basic part of genetic impact and the meeting therefore urgently recommended that development work in this field should be supported.

5.3 The meeting agreed a number of basic questions which need to be answered in order to assess the genetic impact of farmed salmon on wild stocks. These were

- what are natural straying rates?
- where do escapees go?
- to what extent are fish of farmed origin represented among spawners?
- do wild fish and farmed fish interbreed?
- do wild fish and fish of farmed origin interact ecologically?

A number of these questions may be answered by applying or improving current methods. Some of these questions have been addressed by research presently being undertaken in Norway. Similar studies should be conducted in other countries. In addition the need to develop improved methods of identifying farmed fish in the wild was recognised.

5.4 The meeting approved the list of objectives presented by the Chairman as guidelines for future work (Paragraph 4.1). Much of this research was likely to be of a long term nature. The meeting recognised that in the absence of knowledge on impacts there is a need for caution in the meantime and endorsed a number of practical measures such as the development of gene banks and the development of Codes of Practice or Recommendations to minimise possible impacts. Such Codes or Recommendations might include the following elements:

- cage security
- the use of sterile fish
- tagging of farmed fish and adequate reporting of escapes
- zones free of aquaculture
- emergency netting of severe escapes of farmed fish where legislation permits
- encouragement for the use of local stocks for farming purposes
- measures to maintain the vigour of existing natural stocks
- adoption of Codes of Practice for reducing genetic threats and the impacts of introductions and transfers in general.
- introduction and permanent scientific control of gene banks including sperm preservation as well as wild stock preservation.

Dublin
24 May 1989

ANNEX 1

INTRODUCTION

by
Malcolm Windsor
Secretary
North Atlantic Salmon Conservation Organization
11 Rutland Square, Edinburgh EH1 2AS

Over the last 15 or 20 years we have seen the rise of a completely new industry - salmon farming. It did not exist in its present form before 1965. The growth of this industry has been so spectacular that we may have already reached the stage where there are more salmon in the sea in cages than there are in the wild. While there is much to admire in this new industry, and it may exert some protective influence on the wild stocks, at least economically, concerns have been expressed about the possible threats this industry poses to the wild stocks. There are a number of potential interactions between aquaculture and the wild stocks including interactions with the aquatic environment, interactions relating to diseases and parasites and, what we are here to discuss today, genetic interactions. We know that farmed salmon now occur in considerable numbers in the wild and these numbers are likely to increase if industry growth projections are accurate. However, little attention has been given to the question of the effects these fish have on the wild stocks. NASCO Council took the view that, as the international body charged with the conservation, restoration, enhancement and rational management of the salmon, we should try to assess the situation. To this end, at its Fifth Annual Meeting the Council recognised the serious nature of some of the threats posed by the aquaculture industry and agreed on a number of steps. These included the possibility of developing an internationally agreed Code of Practice to minimise the impacts on wild stocks, a review of the benefits of gene banks, a request to ICES for information available on the environmental threats, a review of legislation relating to introductions and transfers and, of course, convening this meeting to assess the genetic threats.

I think the basic question we need to address is "Are we now placing at risk 10,000 years of genetic selection and diversity, and if so is this a cause for concern?". I suspect that we shall find various points of view expressed in this room today.

ANNEX 2

TO WHAT EXTENT ARE FARMED AND WILD SALMON GENETICALLY DISTINCT?

by
Tom F Cross
Department of Zoology, University College, Cork, Ireland

Most studies comparing the genetic composition of reared strains and wild populations of Atlantic salmon (*Salmo salar*) have utilised enzyme electrophoresis. The method is briefly described and ways of calculating genetic composition (as gene frequencies at polymorphic loci) and extent of genetic variability (as mean heterozygosity) are demonstrated. Results of electrophoretic surveys, from Sweden, Norway, Finland, Ireland and Canada are summarised and other studies, as yet unpublished or in the planning stage, are mentioned. Published results fall into two categories: (i) where reared strains (and sometimes different year-classes of the same strain) are compared directly with the wild populations from which they were derived; and (ii) where a number of reared strains are compared with wild populations from the same general area, but not with their ancestral populations. The first category demonstrates that statistically significant differences in gene frequencies usually occur between reared strains and their wild progenitors. Furthermore, significant differences in allele frequency may occur between various year classes of a particular strain. Both categories show that some reared strains have lower genetic variability (measured as mean heterozygosity) than wild populations. One aspect of this loss of variability is that rare alleles present in the wild ancestral population may be lost in a reared strain.

Mitochondrial (mt) DNA analysis has also been applied to the comparison of reared strains and wild populations of Atlantic salmon. The methodology is described and it is noted that mt DNA, because it is haploid and inherited maternally, is more sensitive to factors which reduce genetic variability, than the nuclear DNA which is assayed indirectly by enzyme electrophoresis. One published investigation of Atlantic salmon from Sweden showed a profound reduction in variability in reared strains compared with wild populations.

It is argued that genetic differences between reared strains and neighbouring wild populations can be due to the origin and/or breeding regime of the reared salmon. If a reared strain originates from another geographic race than local wild populations, then genetic differences are likely to be very large. Three major races, detected electrophoretically, occur in Atlantic salmon. These occupy rivers: (1) in countries surrounding the Baltic; (2) in western Europe and Iceland; and (3) in eastern North America. Inter-racial transfers are not recommended, since for example, differences in disease occurrence or susceptibility have been demonstrated between races. Within races, significant allele frequency differences occur between nearly all wild populations assayed. Thus reared strains are likely to differ genetically from all wild populations except their ancestral population. There have been suggestions by managers and conservationists that reared strains should not be moved between countries. The present evidence from population genetics to support such a ban is ambiguous, with a positive relationship between genetic difference and geographic distance being reported in a few cases and not in most. In this context, it is noted, that the Scottish and Irish salmon farming industries rely heavily on strains of Norwegian origin. In the short term, it

would be difficult to replace these with native strains since the imported strains have been selected for fast growth and late maturity over several generations.
The other factor discussed which acts on genetic composition is breeding regime. Two aspects are of importance here: the number of adults used as broodstock and artificial selection. The use of inadequate numbers of parents (less than 50 of each sex equally represented) leads to a type of inbreeding which results in a loss of genetic variability and changes in gene frequencies at polymorphic loci. This form of inbreeding is progressive in each generation where small numbers of parents have been used. It can be halted by increasing parental number but not reversed except by outcrossing with suitable stock. Many authors have reported such inbreeding in Atlantic salmon and in other salmonid species.

The importance of changes in gene frequencies is not known. If a particular suite of gene frequencies is adaptive or marks adaptation to a certain river, then any change in genetic composition will reduce fitness. (In this context, it is noted that polymorphic gene frequencies of wild populations seem relatively constant over time.) It has been reported that various year classes of the same strain can have significantly different gene frequencies. If such frequency differences are indicative of fitness variations, then cohorts could vary in performance.

Such inbreeding can also result in reductions in variability. Some authors have shown in other salmonid species that such reductions can lead to a decline in overall performance. A reduction in variability can also lead to the loss of rare alleles at polymorphic loci. A loss of this type is permanent (unless outbreeding occurs) and reduces the adaptive potential of a strain. All of the sources of change listed above are potentially alterable. Directional selection as discussed below is less so.

Directional selection for fast growth and late maturity is widely applied in producing smolts for the farming industry. A typical selection programme, while improving the targeted traits, can lead to reduction in heterozygosity and to changes in gene frequencies at other polymorphic loci. It is noted that such a reduction in variability has been prevented in some reported cases by strain crossing, which artificially boosts variability before commencing selection. Such a practice, while suitable for producing smolts for captive rearing, may actually reduce the fitness of these fish in the wild.

In conclusion, it is noted that many more reared strains need to be assayed electrophoretically. It is also noted that reared fish may not only enter the wild through escapes from sea farms. Freshwater rearing facilities and enhancement and ranching programmes are also potential problem areas.

ANNEX 3

ARE DIFFERENCES IN PERFORMANCE RELATED TRAITS LIKELY TO EXIST BETWEEN FARMED AND WILD FISH AND THEIR CROSSES?

by
John K Bailey
Atlantic Salmon Federation, Canada

To my knowledge, there have been no studies where marked, domestic salmon have been wilfully released from aquaculture sites. However, there have been several studies, with brook trout (*Salvelinus fontinalis*) and wild rainbow trout (*Salmo gairdneri*) in natural and semi-natural environments that bear directly on this question. Although their results were not consistent, the above trials indicated that performance differences exist between domestic and wild trout and their hybrids. Similar differences should be anticipated between domestic and wild Atlantic salmon.

In Atlantic salmon, differences in performance have been found among wild stocks grown in a common environment, released from the same sea ranching facility, grown in cages, and stocked into the same stream for enhancement purposes. Similar results have been found among domestic strains reared in the same environment and within the same strain reared in different environments. In total, the above examples lead to one general conclusion. Quantitative genetic differences exist among salmon populations, whether they are wild or domestic, and genotype-environment interactions can be expected when stocks or strains are transferred from one environment to another. The question of real concern to salmon managers is whether escaped aquaculture fish are likely to have detrimental genetic effects on indigenous, wild salmon populations.

The homing habitat of Atlantic salmon has led to the differentiation of a large number of relatively discrete stocks that are generally assumed to be locally adaptive. However, it is inappropriate to think that all stock characteristics are necessarily adaptive. Examples exist that suggest some traits may result from a relaxation of selection pressure. Similarly, with respect to fitness, it is naive to suspect that there could only be one successful life history strategy for a given set of environmental conditions. In addition to the pressures of natural selection, gene pools can also be altered by mutation, migration and genetic drift. The latter three forces occur at random and are not predictable. Chance is also a genetic isolating mechanism.

In order to realise a genetic effect in a wild stock, its gene pool, and therefore, gene frequencies, must be permanently altered. However, because selection, mutation, migration and drift act in concert, at all times, the gene frequencies of wild stocks must be considered as dynamic and not static. Similarly, environments are also dynamic. A detrimental effect is more likely to be the result of too rapid change.

Where stable stocks exist in pristine habitats, the relative importance of these forces much achieve some form of equilibrium and remain balanced over protracted time intervals. Throughout their natural range, many salmon stocks are not stable. This may be symptomatic of an environment that is changing faster than new checks and balances can be re-established and natural selection cannot keep pace with the rate of environmental change.

Aquaculture has the potential to further upset this balance by making it possible for a significant increase in the immigration of domestic stocks into the wild. To have a genetic impact, the escapees' alleles and allele frequencies must differ from wild stocks and they must either add their genes to the gene pool or cause the loss of indigenous genes. A genetic impact can result from either introgression or displacement.

The introgression of new alleles from aquaculture escapees may provide additional raw material for natural selection. Escapees can be expected to increase the genetic variability within stocks at the expense of genetic variation between stocks. This may prove to be a benefit in rapidly changing habitats. With respect to fitness, there can be three possible effects. Fitness can remain unchanged, it may decrease or it may increase.

Few will argue that a decrease in natural fitness is not detrimental. However, if the alleles of the "initial gene packet" are not destroyed, this is unlikely. If the alleles contributed by escapees confer a selection disadvantage, the directional nature of natural selection will attempt to redefine the "historically established" gene frequencies. If they are neutral, allele frequencies may change, but fitness and stock characteristics should remain similar to that of the wild stocks. Should the novel alleles confer a selection advantage, fitness may actually increase. The nature and direction of such changes are only speculative.

The "historically established" gene and allele frequencies of proven fitness, cannot be re-established, if alleles from the "initial gene packet" are lost. Natural selection must then begin a new experiment to determine alternative successful combinations. Thus, displacement has the potential to be much more disruptive than introgression.

Among other animals, there are few examples where domestic strains both escape and successfully breed with wild stocks. The majority of domestic animals are unable to survive in the wild or compete successfully for wild mates. In the examples that do exist, there has been a broad range of responses. These include examples of minimal impact in the case of domestic dog (*Canis familiaris*) and coyote (*Canis latrans*) hybrids, successful introgression of domestic genes into a wild pig (*Sus scrofa*) stock, and the virtually complete displacement of European by African honeybees (different sub-species of *Apis mellifera*).

The second example, that of domestic and wild pigs may be of particular relevance in a discussion of the possible genetic effects of escaped salmon. Salmon, like pigs, are noted for their plasticity. They have adapted to inhabit a wide range of environmental conditions, both among stocks and within the same stock in different years. Perhaps the greatest effect of domestication is the simple relaxation of a variety of natural selection pressures which also may vary with environmental conditions.

In domestic environments, alleles that were adaptive in the wild may be unnecessary and therefore have a neutral effect, in terms of fitness. If broodstocks are large enough to minimize inbreeding and drift, null alleles can be maintained in the gene pool for many domestic generations. Should these fish escape they may be capable of a rapid return to the feral state.

While it is uncertain whether all of the conditions necessary to make a genetic impact even exist, it is prudent to assume that some changes will occur. The magnitude of any potential genetic impact will be influenced by the genetic differences between the populations involved. The long term consequences of changing the gene frequencies in wild stocks are unknown.

Nevertheless, in the absence of definitive evidence, the conservation of genetic diversity among stocks is a desirable objective. Preventing the escape of farmed fish is the only sure method of avoiding a genetic impact in wild stocks and husbandry techniques can be expected to improve in this respect. Practices designed to reduce the risk of detrimental genetic impacts should be encouraged.

Some will undoubtedly contend that any change is detrimental and should be prevented, at all costs. Such an inflexible stance is somewhat utopian and perhaps unrealistic. Evidence from other species suggests that, in the rare instances of hybridization between domestic strains and wild stocks, the long term genetic effects are usually of little consequence with respect to either fitness or behaviour. Both the gene pools and environments of wild stocks are dynamic and natural selection will continue to operate on any new gene pool.

ANNEX 4

IS THE STAGE AT WHICH FISH ARE RELEASED OR ESCAPE A DETERMINANT OF THEIR SUBSEQUENT PERFORMANCE?

by
Lars P Hansen
Norwegian Institute for Nature Research, Tungasletta 2,
7004 Trondheim, Norway

The development in farming and ocean ranching of Atlantic salmon has led to an increased proportion of reared fish in nature. Salmon may escape from fish farms at all life stages, while ranched fish are mainly released at smolt stage. The life stage at which fish are released or escape determines the future migration pattern and survival of the salmon. This paper reviews this, with particular reference to Norwegian conditions.

Fish that are released or escape at smolt stage from a river, return with high precision to that system when mature, independent of stock origin (eg Carlin 1969). If smolts are released in the estuary, the straying rate will increase (Carlin 1955, Eriksson et al, 1981). If salmon escape at smolt stage from a marine locality, the adults will tend to return to the area from which they escaped (Sutterlin et al, 1982, Hansen et al, 1989a). These fish are not imprinted to (or have learned) the "home stream" and would therefore have no motivation to enter freshwater before they of physiological reasons have to (Jonsson et al, 1989, Lund & Hansen in prep.), but they will enter rivers and streams in the area to spawn. This lack of motivation might also result in a lower proportion of escaped fish among the spawners far upstream than in the lower part of the stream. When salmon are released or escape at postsmolt or adult stage, they seem to stray to rivers farther away from the site of release when mature (Hansen et al 1987, Hansen & Jonsson in prep). The reason for this could be that salmon are not able to imprint to cues used in homing throughout the whole year and/or at all life stages.

There are many factors determining the survival of salmon in nature. In particular, released salmon and escapees from fish farms have to pass through a number of "bottlenecks" before they are ready to spread their genes. To survive in the sea, the salmon must be physiologically and behaviourally fit for a life in sea water. Size, age and state of maturity of the salmon, and the time and site of release or escape are important factors determining the future fate of these fish.

Experimental releases of reared Atlantic salmon show that there is a seasonal variation in survival (Hansen & Jonsson 1989). Survival is much higher for those fish escaping at smolt stage in the spring than those escaping the following summer and autumn. However, survival will also improve with increased body size which will reduce the predation. Previous male maturity will reduce the number of migrating smolts (Hansen et al, 1989b), and therefore contribute in reducing the overall survival of a smolt group (Lundqvist et al, 1988).

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ANNEX 5

CAN THE FACTORS LIKELY TO LIMIT THE CROSSING OF WILD FISH AND FISH OF FARMED ORIGIN BE IDENTIFIED?

by
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When both native Atlantic salmon (*Salmo salar*) and fish which have escaped or been released from culture are present in a single drainage system they may not cross freely at spawning. Two categories of restraint can be envisaged. One category will limit contact through differences in the distribution of the two types of fish in the spatial framework of the catchment. The other category will restrain the interaction of fish of both types through behavioral or physiological incompatibility, even when they are present together in the same reaches of stream.

While native fish will disperse throughout a drainage system, escapes or releases may be confined to particular parts of the system. Lack of homing stimulus in opportunist entrants may impair migratory drive. Low motor capacity in recent escapes from culture may reduce migratory vigour. Both effects may be expected to confine farmed fish to the lower parts of catchments. When indigenous and non-native fish are present together, crossing may be limited by behavioral differences between the groups. The density dependent mortalities to which groups of wild fish are exposed are greatly reduced in culture. This may also result in lowered overall levels of aggression. The performance of cultured fish generally may be impaired because of this. In particular, many cultured males may not compete effectively with wild males in pairing with wild females.

In addition, both large and small adult males of the salmonid *Oncorhynchus kisutch* are more effective in competitive spawning than those of intermediate size. Gross (1985) considered this to result from disruptive selection for size at maturity. Cultured *S. salar* males may be disadvantaged in this way since they are often smaller than wild males at adulthood. Crossing will be reduced if farmed males spawn less with wild females than either large, dominant wild adults or sneaking wild parr (Hutchings and Myers, 1988).

Under other circumstances, normally dominant wild males may be prevented from crossing with smaller cultured females by their large size. Female choice of spawning site is in part determined by body size. The lesser flows and water depths likely to be particularly favoured for spawning by small cultured females may preclude the attendance of larger wild males. Cultured males may be reciprocally favoured because of their size-match with cultured females.

Any restraints to the crossing of wild and farmed fish which depend on alterations in the behaviour or physiology of cultured fish caused by the culture environment itself will only act in the first generation of escape or release. Even in this group, the strength with which the restraints may act will be dependent on the stage of life at which release has occurred. Early releases will revert most fully to the condition of wild fish.

However, physiological incompatibility based on genetic differences may limit crossing to an extent which is independent of stage of release. Heggberget (1989) described wide variation in the date of peak spawning in different rivers in Norway. Heggberget hypothesised that the differences were adaptive and a response to differences in over-winter temperature. Spawning early in streams where winter temperatures are low and later where temperatures are higher may result in the matching of the duration of egg incubation to optimum hatching date.

Spawning date may be determined by environmental cues which differ between streams before or as spawning takes place. However, to be of adaptive value in the context of Heggberget's hypothesis, any such cues must be predictive of over-winter temperatures. It seems unlikely that cues of consistent predictive value exist, at least in temperate regions of Scotland, where the same wide range of peak spawning dates exists. In Scotland, as in Norway, peak spawning date also appears correlated with over-winter temperatures but in many rivers peak spawning takes place in the transitional period when winter temperatures are becoming established. Peak spawning date is relatively fixed at single sites but the time at which water temperatures fall to winter levels is often weather dependent rather than seasonal. As a consequence, in single Scottish rivers, fish may spawn in different years at about the same date but over a relatively wide part of the normal temperature range.

The differences in spawning date identified by Heggberget probably therefore result from stock specific selection for spawning date itself. If the differences are genetic they may limit the crossing of escapes or releases from culture with native fish, through asynchronous sexual maturation.

Most of the factors listed above as possible limits on the crossing of wild and farmed fish of the single species *S. salar* might also be considered to be among those limiting the intergeneric crossing of brown trout (*S. trutta*) and Atlantic salmon. Yet such crossing can be demonstrated to occur. Salmon-trout hybrids can be identified electrophoretically particularly where trout have been introduced into the salmon's range (Verspoor, 1988) or where distribution of one or other species is patchy (Garcia de Leaniz and Verspoor, 1989). Since hybridisation between these species is occasionally quite common, it seems unlikely that any of the factors which may limit the intraspecific crossing of native and introduced salmon will prove to be of major or consistent significance.

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ANNEX 6

IS AQUACULTURE LIKELY TO AFFECT THE GENETIC INTEGRITY OF WILD POPULATIONS?

by
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Farmed Atlantic salmon ascending into a river with an existing wild population of salmon may potentially cause a genetic impact through ecological or reproductive interactions. Ecological interactions could cause a reduction in the numbers of wild fish in subsequent generations increasing genetic drift and reducing genetic variability. Ecological interaction could also cause selective pressures on wild populations to change and so change their genetic make-up. Whether a change occurs will be dependent on the specific nature of the interaction and the circumstances in which it occurs. In contrast, interbreeding will always have a genetic impact. However, its significance will be highly dependent on the degree of adaptively relevant genetic differentiation existing between the farmed and wild stocks involved.

A number of ecological interactions can be envisaged which might give rise to genetic change in the wild stock. The first is the introduction of a disease vector to which the farm but not the wild stock is resistant. Here the wild population would be reduced in size, at least short term and possibly for a large number of generations, until the vector disappears or the population evolves resistance. The second is interference with reproduction. For example, farmed fish may breed later and superimpose their redds on those of wild fish, or they may compete with wild fish for a limited amount of suitable spawning sites. This might both reduce numbers of wild fish the next generation as well as select for changes in spawning timing. Such specific changes may be immediately adaptive but also disruptive of the overall coadaptive nature of the existing gene complex. This could lead to a lower productivity in the longer term until selective pressures restore an optimal genetic make-up. Ecological interactions will also occur between the offspring of farm fish and those of wild fish. For example, with respect to territories and food. Unfortunately, few studies are available to shed light on the actual and potential extent to which ecological interactions might be adverse.

The impact of interbreeding between wild and farm salmon will be to introduce into the wild population genetic types which would normally be infrequent or absent. As the genetic make-up of wild populations will have been moulded by natural selection to provide the mix of genetic types which is optimal for long-term survival and maximum productivity, the new genetic types will on average be expected to be less well adapted. If so, then the productivity of the population will decrease until selection can restore an optimal genetic constitution for the population. This may take many generations. The degree of decrease in productivity and the time taken to restore it will depend on the extent to which the farm stock differs genetically. The genetic change caused by interbreeding may also result in short-term, or even permanent changes to the character of the wild population affected. Studies which have been carried out on interbreeding between salmonid stocks suggest that hybrids between native and hatchery fish will often do less well than native fish in the wild, for example, with regard to juvenile survival and probability of returning as an adult to the natal river to spawn.

Concern for adverse impacts of escaped farm salmon on wild salmon populations is justified based on our understanding of population genetics and on the evidence currently available. How concerned we should be is unclear but undoubtably the extent of any impact will be highly dependent on the numbers of farm salmon relative to wild salmon involved in the interactions which occur.

ICES Working Group on Introductions and Transfers

Dublin : May 1989

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Tentative Agenda for the 1990 Symposium on "Case Histories of the Effects of Introductions and Transfers on Aquatic Resources and Ecosystems" in Halifax for a two-day interval during June 10-17, 1990.

Allotted Time	Topic	Co-Conveners
1/2 day	GENERAL SESSION: ISSUES AND THEORETICAL CONCEPTS ON THE GLOBAL MOVEMENTS BY MAN OF MARINE AND FRESHWATER SPECIES Special Keynote Papers: * International Transportation of Marine and Aquatic Organisms by Man (J. Carlton) * Laws and Regulations Governing the Movement of Marine and Aquatic Organisms by Man (Speaker to be Chosen) * Genetic Engineering and the Introductions and Transfers of Genetically Modified Organisms (Speaker to be Chosen)	C. Sindermann (ICES) B. Steinmetz (EIFAC) W. Hershberger (WAS)

Allotted Time	Topic	Session Co-Chairmen
1/2 day	FISH INTRODUCTIONS AND TRANSFERS * Overview Paper (R. Welcomme) * Special Case History Papers (Speakers to be chosen)	A. Munro (ICES) R. Welcomme (EIFAC) . . . . (WAS)
1/2 day	INVERTEBRATE (ESPECIALLY MOLLUSCS AND CRUSTACEANS) INTRODUCTIONS AND TRANSFERS * Overview Paper * Special Case History Papers (Speakers to be chosen)	H. Grizel (ICES) or K. Westman (EIFAC) . . . . (WAS)

Allotted Time	Topic	Session Co-Chairmen
1/4 day	PLANT INTRODUCTIONS AND TRANSFERS * Overview Paper (I. Wallentinus) * Special Case History Papers (Speakers to be chosen)	I. Wallentinus (ICES) C. Cook (EIFAC) . . . . (WAS)
1/4 day	SUMMARY AND RECOMMENDATIONS * Brief Reports by Session Co-Chairmen and by Co-Conveners * Recommendations	Co-Conveners and Co-Chairmen

APPENDIX VIII

NEW SOURCES OF INFORMATION ON INTRODUCTIONS AND TRANSFERS

Meetings

A symposium entitled, "Human Influences on the Dispersal of Living Organisms and Genetic Material into Aquatic Ecosystems", chaired by Dr. A. Rosenfield, was held in Los Angeles in February 1989 as part of the World Aquaculture Society meetings.

A symposium entitled, "Exotic species in Large Lakes: Ecology and Impacts", is scheduled for June 1, 1989, as part of the 32nd International Association for Great Lakes Research Conference, at the University of Wisconsin -- Madison. The invasion of the Great Lakes, U.S.A./Canada, by European mollusks, crustaceans, and fish, as the results of ballast water discharge in the 1980s, is the major focus of the symposium.

Related Literature

Allmon, R.A., and K.P. Sebens. 1988. Feeding biology and ecological impact of an introduced nudibranch, Tritonia plebeia, New England, USA. Marine Biology 99:375-385.

The European sea-slug (nudibranch) Tritonia plebeia was first observed in Massachusetts, USA, in 1983, and is now known to have spread north to Maine. It is believed to have been introduced from Europe (perhaps by ballast water?)

Carlton, J.T. 1989. Man's role in changing the face of the ocean: biological invasions and implications for conservation of near-shore environments. Conservation Biology, in press.

Crowe, W.A. 1989. Status Report on the Japanese Scallop, Patinopesten yessoensis (Jay), with reference to the Proposal for Introduction into Irish waters; with a review of its Biology, Culture Techniques and Possible Consequences of Introduction. ICES CM. 1989/00 Introductions and Transfers of Marine Organisms. 18p.

Hengeveld, R. 1988. Mechanisms of biological invasions. Journal of Biogeography 15: 819-828.

McDonald, J.H., and R.K. Koehn. 1988. The mussels Mytilus galloprovincialis and M. trossulus on the Pacific coast of North America. Marine Biology 99: 11-118.

The well-known mussel Mytilus edulis is actually comprised of several distinct species: on the Pacific coast of the United States, these are M. trossulus (believed to be native) and M. galloprovincialis (believed to be introduced).

Minchin, D., C.B. Duggan & D. McGrath. 1987. Calyptraea chinensis (Mollusca: Gastropoda) on the west coast of Ireland: a case of accidental introduction?

J. Conch. 32 (5): 297-302.

Michin, D., and C.B. Duggan. 1988. The distribution of the exotic ascidian, *Styela clava* Hardman, in Cork Harbour. Ir. Nat. J. 22(9): 299-393.

Posey, M.H. 1988. Community changes associated with the spread of an introduced seagrass, *Zostera japonica*. Ecology 69: 974-983.

The Japanese eelgrass *Zostera japonica* accidentally introduced with oyster culture is now extremely abundant in bays from southern Oregon to British Columbia. It has had a strong impact on infaunal community structure.

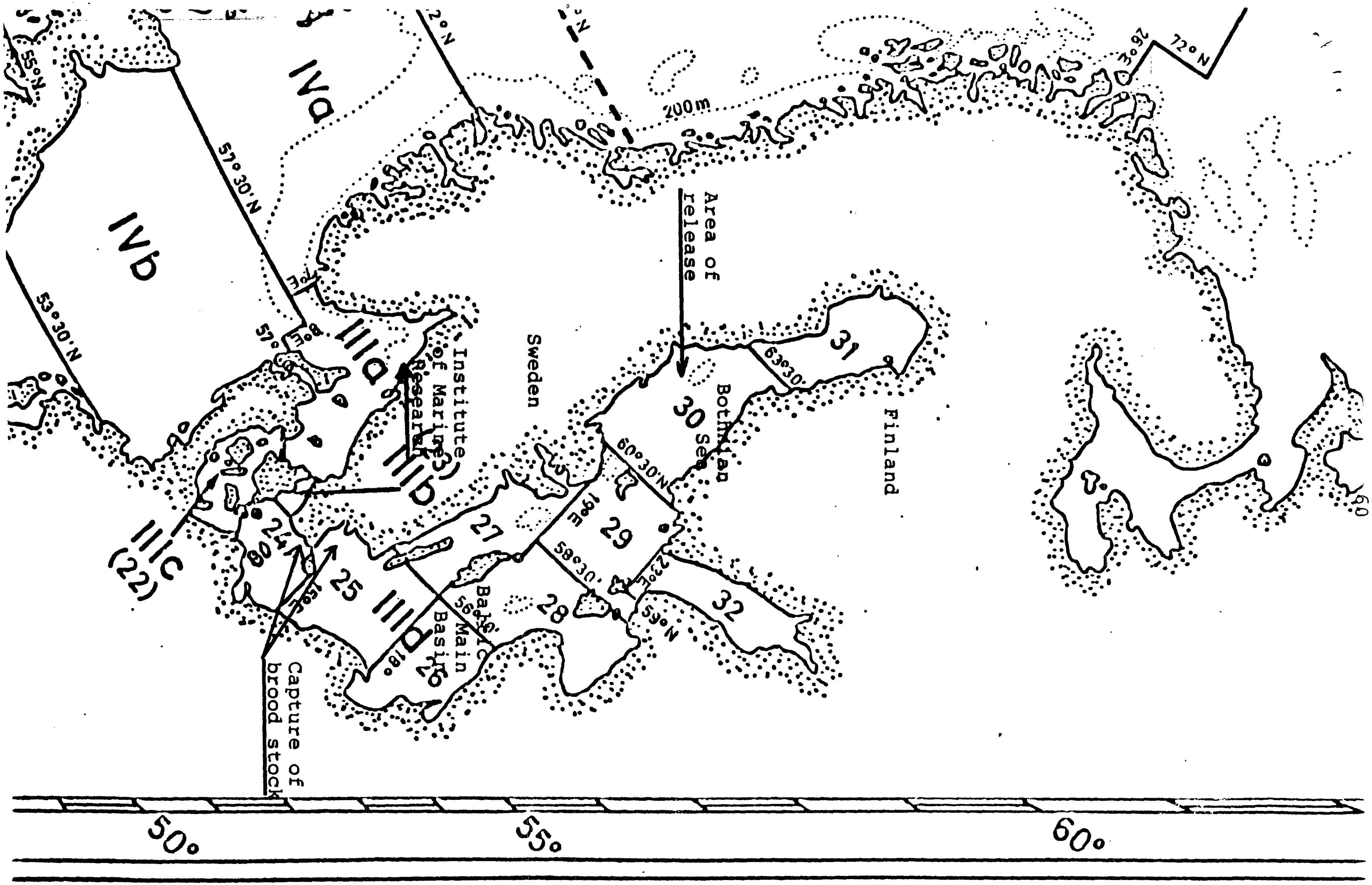

FIGURE 1. SWEDISH RESTOCKING THE BOTHNIAN SEA WITH COD.