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Appendices to the ICES Code of Practice (CoP) on the Introductions and Transfers of Marine Organisms (2005). Revised by WGITMO in March 2012.

Appendices A to D will be applied to all new introductions and transfers as required. The Appendices outline the details required for the Prospectus (Appendix A), Risk Review (Appendix B), Quarantine (Appendix C) and Monitoring (Appendix D). Appendix E shows a flowchart of all stakeholders involved and Appendix F presents a case study of the application of an older version of the ICES Code of Practice.

Note: The following three EC Regulations may also be consulted in combination with this document.

- **COUNCIL REGULATION (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture,**
- **COMMISSION REGULATION (EC) No 506/2008 of 6 June 2008 amending Annex IV to Council Regulation (EC) No 708/2007 concerning use of alien and locally absent species in aquaculture,**
- **COMMISSION REGULATION (EC) No 535/2008 of 13 June 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 708/2007 concerning use of alien and locally absent species in aquaculture.**

The content of these CoP Appendices are not meant to replace the requirements as set forth in the EC Regulations, but to represent the ICES/WGITMO views on this subject. Many European WGITMO members contributed to the development of these EC Regulations.

APPENDIX A - PROSPECTUS

The information provided with the Prospectus will be used to conduct the biological risk review (see Appendix B). To be scientifically valid, the information provided needs to be based on a thorough literature review. The prospectus also needs to include a contingency plan in case immediate eradication of the introduced species needs to be carried out. The proponent has to design an appropriate monitoring programme that will document impacts in the receiving environment.

Wherever possible, information is to be supported with references from the scientific literature, and notations to personal communications with scientific authorities and fisheries experts. Applications lacking detail may be returned to the proponent for additional material, resulting in a delay in assessing the proposal.

For some proposals, e.g. routine introductions/transfers, the information requirement may be reduced significantly. WGITMO should be consulted in such cases. It is possible that there may be concurrent proposals taking place or knowledge of a previous attempt in which case this information can be provided and so reduce the time and cost of this part of the project. As introductions are intended to cover a wide range of situations (aquaculture, fisheries, restoration of habitat, re-introductions of a similar population/species to replace expired populations, genetically modified organisms, biological control) all of the requirements made below will not necessarily apply and additional requirements may be necessary so as to reduce the risk of an unwanted impact and to protect the proposer from not having acted appropriately.

A) Executive Summary:

Provide a brief summary of the document including a description of the proposal, the potential impacts on native species and their habitats and mitigation steps to minimize the potential impacts on native species.

B) Introduction

1) Name (common and scientific and commonly used synonyms [genus and species]) of the organism proposed for introduction or transfer.
2) Describe the distinguishing characteristics, of the organism and how it may be distinguished from similar species in its area of origin and proposed area of introduction. Include a scientific drawing or photograph.
3) Describe the history in aquaculture, enhancement or other introductions (if appropriate) and the nature of the planned activities using the candidate species.
4) Describe the objectives and rationale for the proposed introduction, including an explanation as to why such an objective cannot be met through the utilization of an indigenous species.
5) What alternate strategies have been considered in order to meet the objectives of the proposal? What are the implications of a "do nothing" option?
6) What is the geographic area of the proposed introduction? Include a map.
7) Describe the numbers of organisms proposed for introduction (initially, ultimately). Can the project be broken down into different sub-components; if so, how many organisms are involved in each sub-component?
8) Describe the source(s) of the stock (facility) and genetic stock (if known).
9) Describe the frequency of the planned species movement for e.g. aquaculture purposes (is it planned to e.g. annually import this species from this source?)
10) Does the proposed quarantine facility require to be modified to an acceptable standard for the purpose of completing the introduction? Are there other holding facilities where the species may be held should this be necessary?

C) Life History Information of the Species to be Introduced or Transferred - For Each Life History Stage

1) Describe the native range and range changes due to introductions.
2) Record where the species was introduced previously and describe the ecological effects on the environment of the receiving area (predator, prey, competitor, and/or structural/functional elements of the habitat).
3) What factors limit the species in its native range.
4) Describe the physiological tolerances (water quality, temperature including, turbidity, oxygen, and salinity) at each life history stage (from early life history stages to adult, , and for reproductive development) including any resting stages).
5) Describe the habitat preferences for each life history stage including water depth, substrate types and adaptability to different habitats.
6) Describe the mode(s) of reproduction (including any asexual stages i.e. fission) and natural triggers and artificial means for conditioning and spawning. Duration of the larval phase?
7) Describe how the species becomes dispersed and is there any evidence of local or larger scale seasonal or reproductive migration(s).
8) Describe the feeding methods and food preferences for each life history stage. In case of algae describe the light and nutrient preferences.

9) Describe the growth rate and lifespan and extrapolate likely rates of growth in the introduced area based on information from its native range and where it has become introduced.
10) Describe the known pathogens and parasites of the species or stock including epibionts and endobionts. Are there specific taxonomic groups that pose a risk? Is it a known carrier of pathogens or life history stages of harmful stages? Will it act, in its new environment, as an intermediate host for unwanted species?
11) Describe the behavioural activities that result in modifications to habitat and that may result in interactions with other species. Are any other species required for the presence of the introduced species to be successful?
12) Describe the occurrence of the taxon in other regions (native and introduced): In what densities is the taxon found? Are mass occurrences reported? How frequently are findings of the taxon reported?
13) List nearest populations and indicate why the potential source population is being considered over other sources that may have disease free stock, for example.

D) Interaction with Native Species

1) What is the potential for survival and establishment of the non-native species should it escape? (This question applies to species intended for closed culture systems)
2) What habitat(s) will the introduced species be likely to occupy in the proposed area of introduction and compromise the existence of any protected species/species population? Indicate if the proposed area of introduction also includes contiguous waters).
3) With which equivalent native species will/could there be a niche overlap? Are there any unused ecological resources of which the species would take advantage?
4) What will the introduced species eat/consume in the receiving environment?
5) Will this predation/consumption cause any adverse impacts on the receiving ecosystem?
6) Will the introduced species survive and successfully reproduce in the proposed area of introduction or will annual stocking be required? (This question applies to species not in closed culture systems)
7) Can the introduced species hybridize with native species? Is local extinction of any native species or stocks possible as a result of the proposed introduction? Are there any possible impacts of the introduced species on the spawning substrata of local species?
8) Are there any potential impacts on habitat or water quality as a result of the proposed introduction?

E) Receiving Environment and Contiguous Watershed

1) Provide physical information on the receiving environment and contiguous water bodies such as seasonal water temperatures, salinity, and turbidity, dissolved oxygen, pH, nutrients and metals. Do those parameters match the tolerances/preferences of the species to be introduced, including conditions required for reproduction.
2) List species composition (the principal aquatic vertebrates, invertebrates and plants) of the receiving waters. Which of these are competitors with, or predators of the species to be introduced. Which of the species have a similar ecological function? Are any of these species known to be susceptible to the diseases and parasites found to affect the introduced species within its native range, the region from where the introduction will take place or elsewhere in its range?
3) Are any of the species in the receiving environment known to be susceptible to the diseases and parasites found to affect the introduced species in its native range?
4) Provide information on habitat in the area of introduction, including contiguous waters, and identify critical habitat. Which of those parameters match the tolerances/preferences

of the species to be introduced? Is the introduced species capable of modifying any of the habitats described?

5) Describe the natural and/or man-made barriers relied upon to prevent the movement of the introduced organisms to adjacent waters. . Include flow rates and direction of flow that might distribute the introduced species.
6) 5 Describe the substrate and bottom characteristics in the receiving area and compare with the preferred and tolerated environment in the area of origin.
7) Indicate what native or other already introduced species may be likely to compromise development of the proposed species introduction to native waters.

F) Precautions and Management Plan

1) Describe the management plan for the proposed introduction or transfer. This should include but not be restricted to the following information:
   a) details of the disease certification status of stock to be imported;
   b) Setting-up of an independent national scientific advisory team.
   c) disease monitoring plan proposed for the introduced stocks following introduction or transfer;
   d) precautions taken to ensure that no unnecessary associated biota accompany the shipment;
   e) who will be permitted to use the proposed species and under what terms and conditions;
   f) The nature of the pilot and pre-commercial phases including a contingency withdrawal plan;
   g) description of the quality assurance plan for the proposal;
   h) other legislative requirements and precautionary measures that need to be met for each phase of development.
2) Describe the chemical, biophysical and management precautions being taken to prevent accidental escape of any target as well as non-target taxa to recipient ecosystems. Provide details of the water source, effluent destination, effluent treatments, local drainage and proximity to storm sewers, predator control, site security, precautions to prevent escapes.
3) Describe contingency plans to be followed in the event of an unintentional, accidental or unauthorized liberation of the species from rearing and hatchery facilities or an accidental or unexpected expansion of the range deduced at the pilot or later stages. Also, describe a contingency plan to address the finding of a disease agent of significance (e.g., exotic disease agent to the area of introduction) and the disposal of fish mortalities in case of a disease outbreak.
4) If this proposal is intended to create a fishery, give details of the objective. Who would benefit from such a fishery? Give details of a management plan, and, if appropriate, include changes in management plan for species, which will be impacted.

G) Business Data

1) Provide the legal name of the owner and company, the aquaculture licence number and the business licence (if applicable) or the name of the government agency or department with a contact name, telephone, fax and email information.
2) Provide realistic indication as to the economic viability of the proposed project, having studied other similar projects.

H) References

1) Provide a detailed bibliography of all references cited in the course of the preparation of the risk assessment.

2) Provide a list of names, including addresses, of scientific authorities and fisheries experts consulted and listed in the information provided.
3) Include taxonomic identification literature.
4) Refer to web-pages and other sources of information for further information (further reading).

APPENDIX B: RISK REVIEW

INTRODUCTION

To evaluate risks associated with the introduction or transfer of aquatic organisms, it is necessary to assess the probability that a species will become established and the consequences of that establishment. The process addresses the major environmental components. It provides a standardised approach for evaluating the risk of genetic, ecological and disease impacts as well as the potential for introducing a "fellow traveller" or parasite that might impact the native species of the proposed receiving waters. This approach has been adapted from "Final Draft - Report to the Aquatic Nuisance Task Force - Generic Non-indigenous Aquatic Organisms Risk Analysis Review Process, Washington, DC, February 9, 1996 by the Risk Assessment and Management Committee of the U.S. Aquatic Nuisance Species Task Force".
The precautionary principle will be taken into account in the final outcome of the risk review.

At each of Steps 1, 2 and 3, the element rating and rationale for the rating should be recorded, based on the following criteria:
A **HIGH** rating means that the risk is likely or very likely to occur.
A **MEDIUM** rating means that there is a probability of negative impact.
A **LOW** rating means that the risk is considered to be insignificant.

> ***Note*: For the High and Medium category of risks, application of appropriate mitigation measures are required to lessen the risk to a Low rating. However, it is recognized that this may not be possible for all proposals.**
> ***Note*: Proposals will be approved only if the Organism Risk Potential is LOW or can be reduced to LOW through mitigation procedures.**

> ***The strength of the review process is not in the ratings but in the detailed biological and other relevant information statements that motivate them.***

Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process
Step 1 Determining the Probability of Establishment

Complete the following table and provide a brief rationale with appropriate references to support the rating given.

Element Rating	**Probability of Establishment (H, M, L)[1]**	**Level of Certainty (VC to VU)[2]**
Estimate of probability of the organism successfully colonizing and maintaining a population in the intended area of introduction[3]		
If the organism escapes from the area of introduction, estimate the probability of its spreading[4]		
Final Rating[5,6]		

Explanatory Notes

1. H = High, M = Medium, L = Low. Element ratings should be supported with data and references, including a rationale for the rating given.
2. VC = Very certain, RC = Reasonably certain, RU = Reasonably uncertain, VU = Very uncertain.

The level of certainty is intended to give an estimate of whether the element that is being rated is based on scientific knowledge, experience, or whether it is extremely subjective and based on “best guess”. Such uncertainties need to be taken into account when making a decision.

3. Characteristics within this element include: the organism coming in contact with an adequate food resource; suitability of habitat, encountering appreciable biotic and abiotic environmental resistance; and the ability to reproduce in the new environment.
4. Characteristics within this element include: ability for natural dispersion; estimated range of the probable spread; ability to use human intervention/activity as a means of dispersal, likely areas of further colonization. The areas of likely further colonization should be described, especially if they contain species of special interest (e.g., endangered species) or areas of concern (Marine Protected Areas).
5. The final rating for the **Probability of Establishment** is assigned the value of the element with the lowest risk rating (example: **High** and **Low** ratings for the above elements would result in a final **Low** rating).
6. The final rating for the **Level of Certainty** is assigned the value of the element with the **Lowest** level of certainty (e.g**. Very Certain** and **Reasonably Certain** ratings would result in a final **Reasonably Certain** rating).

Part 1 – Step 2 Determining the Consequence of Establishment of an Aquatic Organism

The “**Consequence of Establishment**” is assigned a single rating based on environmental impacts.

Element Rating: Estimate of magnitude of environmental impacts, if established.	**Consequences of Establishment (H, M, L)**[7]	**Level of Certainty (VC to VU)** [8]
Ecological impact on native ecosystems both locally and within the drainage basin.[9]		
Genetic impacts on local self-sustaining stocks or populations.[10]		
Final Rating[11,12]		

Explanatory Notes

7. See Note 1.
8. See Note 2
9. Ecological impacts that can affect the distribution or abundance of native species resulting from alterations in relationships such as predation, prey availability, and habitat availability. In assessing the ecological impacts of establishment, the assessors should take into consideration whether the non-indigenous stock i) enters or alters the habitat of indigenous species, ii) displaces indigenous species from optimal habitat, iii) affects the quantity, quality, and availability of food supply of indigenous species, iv) prey on other species of concern.
10. Genetic impacts which can affect the capacity of native species to maintain and transfer to successive generations its current identity and diversity. In assessing the genetic impacts, the assessors should take into consideration whether the non-indigenous stock i) encounters or interacts with species of concern, ii) affects the survival of local species, iii) affects the reproductive success of local species, or iv) affects the genetic characteristics of native stocks or species.

11. The final rating for the **Consequences of Establishment** is assigned the value of the element with the **highest** rating (example: **High a**nd **Medium** ratings for the above elements would result in a final **High** rating).
12. See Note 6.

Part 1 – Step 3 Estimating Aquatic Organism Risk Potential

The overall Risk is assigned a single value based on the **Probability of Establishment** and the **Consequences of Establishment.**

Component Rating	**Element Rating (H,M,L)**	**Level of Certainty (VC to VU)**
Probability of Establishment estimate[13]		
Consequences of Establishment estimate[14]		
FINAL RISK ESTIMATE [15, 16]		

Explanatory Notes:

13. As estimated in Step 1 - Use the "final rating level" and "final level of certainty", respectively
14. As estimated in Step 2 - Use the "final rating level" and "final level of certainty", respectively
15. Under "element rating " – The table above provides a guide for categorizing the final risk estimate
16. Under "level of certainty" - the final level of certainty for the **Final risk estimate** is assigned the value of the element with the **lowest** certainty level (e.g. a **Very Certain** and **Reasonably Uncertain** estimate for the probability of establishment and consequences of establishment, respectively, would result in an overall **Reasonably Uncertain** level of certainty).

Definition of **Overall Aquatic Organism Risk Potential**

HIGH = Organism(s) of major concern (major mitigation measures are required). It is advised that the proposal be rejected unless mitigation procedures can be developed to reduce the risk to Low.

MEDIUM = Organism(s) of moderate concern. It is advised that the proposal be rejected unless mitigation procedures can be developed to reduce the risk to Low.

LOW = Organism(s) of little concern. It is advised that the proposal be approved. Mitigation is not needed.

Note: It is advised that the proposal be approved as presented (no mitigating measures required) only if the overall estimated risk potential is LOW
Note: It is advised that the proposal be approved only if the overall confidence level for which the overall risk was estimated is VERY CERTAIN or REASONABLY CERTAIN.
Note: For an overall HIGH or MEDIUM risk, a second risk assessment needs to be conducted to determine whether the proposed mitigation procedures are adequate to reduce the overall risk to LOW.

Part 1 – Step 4 Completion of Risk Assessment Documentation
Specific Management Questions (Mitigation Factors or Measures)
Additional Factors and Notes

1. Mitigation measures could reduce risks to a low rating. Mitigation measures include but are not limited to the following:

   Reducing risk of genetic impact on local stock**:**
   - hold in containment facilities to prevent escape
   - use stocks genetically similar to stocks in receiving waters
   - sterilize organisms to prevent interbreeding with local populations

   Reducing risk of ecological impact on local ecosystems**:**
   - use local stock only
   - sterilize organisms to prevent natural reproduction and increase in population size
   - use species that cannot reproduce naturally in receiving waters
   - hold in containment facilities to prevent escapes

2 Are there any neighbouring jurisdictions to consult?

   If Yes – Has this been done?
   Is the neighbouring jurisdiction concerned?
   If Yes – Has the dispute avoidance mechanism outlined in Appendix II been applied?

Part 2 – Pathogen, Parasite or Fellow Traveller Risk Assessment Process
Step 1 Determining the Probability of Establishment

Complete the following table and provide a brief rationale with appropriate references to support the rating given.
Steps 1 to 3 must be carried out for each **hazard** identified in the hazard identification step (Appendix V).

Element Rating	**Probability of Establishment (H,M,L)** [17]	**Level of Certainty (VC to VU)**[18]
Estimate the probability that a pathogen, parasite or fellow traveller may be introduced along with the species proposed for introduction. Note that several pathways may exist through which pathogens or accompanying species can enter fish habitat. Each must be evaluated.		
Estimate the probability that the pathogen, parasite or fellow traveller will encounter susceptible organisms or suitable habitat.		
Final Rating [19, 20]		

Explanatory notes:
17. See Note 1
18. See Note 2
19. The final rating for the **Probability of Establishment** is assigned the value of the element with the **lowest** risk rating (e.g., a **Medium** and **Low** estimate for the above elements would result in an overall **Medium** rating). Note that the calculation of the final rating follows the multiplication rule of probabilities (i.e., the probability that a given event will occur corresponds to the product of the individual probabilities). Thus the final risk of establishment is assigned the value of the lowest individual probability estimate.

20. The final rating for the **level of certainty** for the Probability of Establishment is assigned the value of the element with the **lowest** level of certainty (e.g. a **Very Certain** and **Reasonably Uncertain** ratings for the above elements would result in a final **Reasonably Uncertain** rating).

Part 2 – Step 2 Determining the Consequence of Establishment of a Pathogen, Parasite or Fellow Traveller

Complete the following table and provide a brief rationale with appropriate references to support the rating given. The final rating of the Consequences of Establishment is assigned a single rating based on environmental impacts.

Element Rating – Impacts of establishment of a parasite, pathogen or fellow traveller on native species and/or aquaculture in the watershed.	**Consequences of Establishment (H, M, L)** [21]	**Level of Certainty (VC to VU)** [22]
Ecological impacts on native ecosystems both locally and within the drainage basin including disease outbreak, reduction in reproductive capacity, habitat changes, etc.		
Genetic impacts on local self-sustaining stocks or populations (i.e. whether the pathogen, parasite or fellow traveller affects the genetic characteristics of native stocks or species).		
Final Rating[23, 24]		

Explanatory notes:

21. See Note 1
22. See Note 2.
23. The final rating for the **Consequences of Establishment** is assigned the value of the element with highest risk rating (e.g. **High** and **Medium** ratings for the above elements would result in a final **High** rating)
24. See Note 20.

Part 2 – Step 3 Estimating Pathogen, Parasite or Fellow Traveller Risk Potential

The overall Risk is assigned a single value based on the **Probability of Establishment** and the **Consequences of Establishment.**

Component Rating	**Element Rating (H, M, L)**	**Level of Certainty (VC to VU)**
Probability of Establishment estimate[25]		
Consequence of Establishment estimate[26]		
FINAL RISK ESTIMATE [27, 28]		

Explanatory notes:

25. As estimated in Step 1 - Use " final rating for probability of establishment" and "final rating for the level of certainty", respectively.
26. As estimated in Step 2 – Use "final rating for consequences of establishment" and "final rating for the level of certainty", respectively.
27. Under "element rating" – refer to Table 1, which provides an outline for categorizing the final risk estimate.

28. See Note 20.

Definition of **"Pathogen, Parasite, Fellow Traveller Organism Risk Potential"**

HIGH	=	Organism(s) of major concern (major mitigation measures are required). It is advised that the proposal be rejected unless mitigation procedures can be developed to reduce the risk to Low.
MEDIUM	=	Organism(s) of moderate concern. Mitigation is justified. It is advised that the proposal be rejected unless mitigation procedures can be developed to reduce the risk to Low.
LOW	=	Acceptable risk - organism(s) of little concern. It is advised that the proposal be approved as presented. Mitigation is not needed.

Note: It is advised that the proposal be approved as presented only if all potential hazards (as defined in Step 1) for which the overall risk was estimated is LOW.
Note: It is advised that the proposal be approved as presented only if the overall confidence level for which the overall risk is VERY CERTAIN OR REASONABLY CERTAIN
Note: For an overall HIGH or MEDIUM risk, a second risk assessment needs to be conducted to determine whether the proposed mitigation procedures are adequate to reduce the overall risk to LOW

Part 2 – Step 4 Completion of Risk Assessment Documentation

Specific Management Questions (Mitigation Factors or Measures)
Additional Factors and Notes

Mitigation measures could reduce risks to a low rating. Examples of mitigation measures include the following:

Reducing risk of transferring accompanying pathogens, parasites and/or fellow travellers

- health inspection and certification
- pre-treatment for pathogens, diseases and parasites
- inspection for fellow travellers
- disinfection prior to discarding water in which the organisms arrived
- vaccination
- disinfection of eggs
- importation as milt or fertilized eggs only
- quarantine incoming organisms and use as broodstock, release F_1 progeny only if no pathogens, parasites or fellow travellers appear.

Table 1. How to Categorize the Final Risk Estimate[29]

Probability of Establishment	Consequences of Establishment	Final Risk Estimate
High	High	High
High	Medium	High
High	Low	Medium
Medium	High	High
Medium	Medium	Medium
Medium	Low	Medium
Low	High	Medium

Low	Medium	Medium
Low	Low	Low

Explanatory Notes

29. If there is no increment between the two estimates, the final risk estimate takes the value of the highest of the two probabilities (precautionary approach). For example, if the Probability of Establishment is High and the Consequence of Establishment is Medium, the Final Risk Estimate will be High. If the Probability of Establishment is Low and the Consequence of Establishment is High, the Final Risk Estimate will be Medium.

APPENDIX C: QUARANTINE

QUARANTINE

Quarantine is the separate holding, rearing, or both, of taxa in a facility or site, under conditions which prevent the escape or other movement of these taxa and associated organisms (i.e. disease agents, pathogens, epibionts) out of the location. Different periods of quarantine and security level may be required depending on the risk of introducing reportable disease agents or previously undetected disease agents of concern.

During the quarantine period, the taxon is held in a quarantine unit. To accomplish this, general principles which apply to all quarantine units for aquatic species are given below. The individual construction and approval of the unit and the length of the quarantine period. Further is there a need to build quarantine systems according to the species considered as some might have peculiarities remains with the operator and the jurisdiction into which the introduction or transfer takes place.

For the operation of an effective quarantine unit, the operators will need to take the topics below into account when constructing and maintaining the quarantine unit

Effluent and Waste Disposal

All effluent and wastes generated within a quarantine facility[1] should be treated in a manner that effectively destroys all disease agents, parasites, fouling organisms on oysters etc.

To ensure continuous operation and complete containment, quarantine effluent treatment systems should be equipped with fail-safe backup mechanisms to ensure continuous operation and complete containment

Treated effluent and waste may contain substances deleterious to the environment (e.g. active disinfectants). The discharge should therefore be disposed of in a manner that minimizes environmental impact.

Further information on disinfecting effluent and solid wastes are presented below (under heading of Disinfection).

Discharge of treated effluent and waste must comply with all other restrictions and regulations applicable to the facility (e.g., federal, provincial, municipal or other environmental legislation with respect to quarantine effluent discharge and waste disposal).

A detailed log of effluent and solid waste treatment should be prepared, listing the operational personnel responsible for treatments, timing and monitoring of the system is useful to monitor effective operation and act as a early warning system for possible failures. Details of the information that should be monitored are provided below (under heading of Record Keeping).

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[1] A quarantine facility is defined as land based facility or portion of a facility approved by the ITC where shellfish can be held in a manner which prevents the movement of shellfish or shellfish disease agents from the facility.

Physical Separation
Aquatic organisms held in quarantine must be separated from other organisms in a system to ensure containment of animals and disease agents, to prevent entry by birds and other animals, to prevent entry by unauthorised personnel and to prevent spills from contaminating surrounding areas. Water lines must be constructed such that there is no possibility of backflow from the quarantine areas to other animals or the environment.

Personnel
Access to a quarantine facility must be restricted to authorised personnel. Personnel working in the quarantine facility must ensure that footwear, hands, and any material used within the facility are disinfected before exit from the facility.

Equipment
Upon receipt all life-stages, tanks, water, shipping containers and equipment in contact with the taxon— including the transport vehicles — should be handled to ensure that there is no escape of the taxon or associated disease agents from the facility. All shipping and packing material must be disinfected or burned.

All equipment and supplies used within a quarantine facility must be disinfected in a manner that will effectively destroy disease agents before removal from quarantine. Protocols for effective management and disinfection must be approved by the WGITMO.

Mortalities and Disposal
Daily records of mortalities must be maintained and be available for inspection, where required.

All mortalities must be kept on site. No mortalities, body parts or shells, bones etc. can be discarded without approved treatment to ensure complete disinfection so that no body parts etc. may re-enter the aquatic environment. Where autoclave access is outside the quarantine facility, the organisms and associated solid waste can be chemically sterilised, or frozen prior to transport to the autoclave. Alternately, materials can be formalin fixed and then discarded in e.g. a landfill site.

The cause of mortalities must be determined in a timely manner. Mortalities should be reported immediately to the WGITMO in order to expedite protocols for examination of the affected animals. This may require that samples be collected or preserved for transportation to a laboratory in an approved manner.

Inspection and Testing
Regular inspections for reportable disease agents must be carried out as specified under the conditions of the licence for introductions or transfers.

If a reportable disease agent, or previously undetected disease agent, is identified in any life-history stage of animals in a quarantine facility, actions necessary to control the disease will be required. These actions may include destruction of all animals in the facility and disinfection of the facility.

If no reportable disease agent is detected in the animals during quarantine, a pathogen status report will be provided to terminate the quarantine requirement.

Following removal of all life stages of the taxon from the quarantine facility, further monitoring and testing of the taxon for reportable disease agents and imposition of additional restrictions may be required.

Duration
The required duration of quarantine will vary according to the aquatic taxon, seasonality of pathogens of concern, rearing conditions and reason for quarantine containment. The quarantine period will be specified on the licence for introductions or transfers that specifies quarantine as a condition.

RECORD KEEPING

All quarantine and isolation facilities and sites must maintain accurate records of the following:

- entry /exit times of personnel, all of whom should have authorization for access
- numbers of mortalities and method of storage or disposal
- effluent and/or influent treatments and monitoring of residuals
- any abnormal conditions affecting quarantine / isolation operations (power outages, building damage, serious weather conditions, etc.)

DISINFECTION

The general principles pertaining to disinfection of aquaculture facilities (hatcheries, holding facilities, land-based ponds, etc.) involve the application of treatments in sufficient concentrations, and for sufficient periods of time, to kill all harmful organisms which otherwise would gain access to surrounding aquatic ecosystems. Since the inherent toxicity of disinfectants prohibits safe use in open-water, or in flow-through systems, disinfection can only be applied with reasonable control within hatcheries, tank or isolated pond-holding facilities. All disinfectants should be neutralised before release into the surrounding environment and facilities based on seawater should deal with the residual oxidants produced during chemical disinfection.
A log of neutralisation of disinfection procedures and monitoring results is highly recommended for ensuring that neutralisation is adequate to prevent negative environmental impacts.

There is a wealth of detailed information on disinfection available from official and commercial organisations. New and improved products and protocols are being continuously developed and so it is not appropriate to provide detailed guidance here.

For example, The World Animal Health Organization (Office International des Epizooties) has provided information on the disinfection of aquaculture establishments (see: International Aquatic Animal Health Code, 2002, Office International des Epizooties 2002 - http://www.oie.int/fileadmin/Home/eng/Health_standards/aahm/2010/1.1.3_DISINFECTION.pdf). A list of some commercially available disinfectants approved for use in Australia by AQIS can be found on their website. (http://www.daff.gov.au/aqis/import/general-info/qap/aqis_approved_disinfectants_for_all_classes).

APPENDIX D: MONITORING

The purpose of the monitoring program is to verify that the introduction is performing according to the proposed prospectus for release of the organism. Thus, the monitoring needs to address issues related to three separate levels during the introduction process: 1) a "pre-baseline" review, 2) monitoring during pilot release phase, and 3) subsequent monitoring. The following is adapted from Managing Troubled Waters, the Role of Marine Environmental Monitoring, National Research Council, Washington, D.C. published in 1990.

The monitoring report must identify resources at risk.This information should have been included in the Prospectus (Appendix A). Information on select species most likely to be impacted (prey, competitors, potential species for hybridization) and/or physical alterations (changes in current light etc.) must be part of the pre-baseline review and must be re-visited in the subsequent two reports to ensure that the impacts were accurately predicted or if there were additional or different impacts.

The proponent should develop a conceptual model appropriate to each pilot project (e.g. use the *Patinopecten yessoensis* in Appendix F as an example) and highlight the issues of concern with an endpoint of acceptability or unacceptability, see Box 1 for some examples. The monitoring will result in caution levels and warning levels depending on the findings/results of the studies undertaken.

A caution level recognized during the monitoring phase may result in the need for additional studies to be carried out, with acceptable results, before the next stage of the introduction into the environment is acceptable.

A warning level: a decision from the regulatory agencies in the importing country is required before the project can proceed to the next step (e.g., further releases, or expansion of the project) or if the project is to be discontinued.

1. Establishment in nearby areas: the requirement is to monitor nearby areas at appropriate time frame after spawning.

2. Competition with other species for food/habitat: Laboratory studies are needed (e.g., re-circulating tank studies to examine behaviour, stomach contents and habitat preferences as juveniles and adults).

3. Spread of pests and diseases: The information on the presence of pathogens in the source population, the initial introduction phase, and/or the population investigated during the pilot release phase may lead to a caution level or a warning level, depending on the type of pathogen detected and the stage of the introduction.

4. Mass mortalities: Because the use of mass mortalities may be related to cultivation practices, the culture practice itself should be self-monitoring and part of the pilot project proposal. If mass mortalities occur, they should be examined for pathogens, pest, and diseases to elucidate whether a) there was an escape of a pathogen or whether b) it was a native causative organism likely to endanger the project. The caution level is an occurrence of a mass mortality in the field (and triggers an analysis of the reasons both environmental and potential surveys of pathogens). A warning level is the presence of pathogens (native or not) that would require a delay in continued culture until satisfied

that the disease/pathogen was not released. Thus no additional monitoring is needed if there are no mass mortalities.
The warning level comes into effect at any significant mortality event.

5. Potential for hybridization: Monitoring of spawning periods of native and introduced species. The caution level is (a) evidence of spawning outside the predicted range during the pilot project or (b) that there is evidence of hybridization with local species in lab studies. If there was hybridization in the lab then there is a warning level and a decision would be required before proceeding.

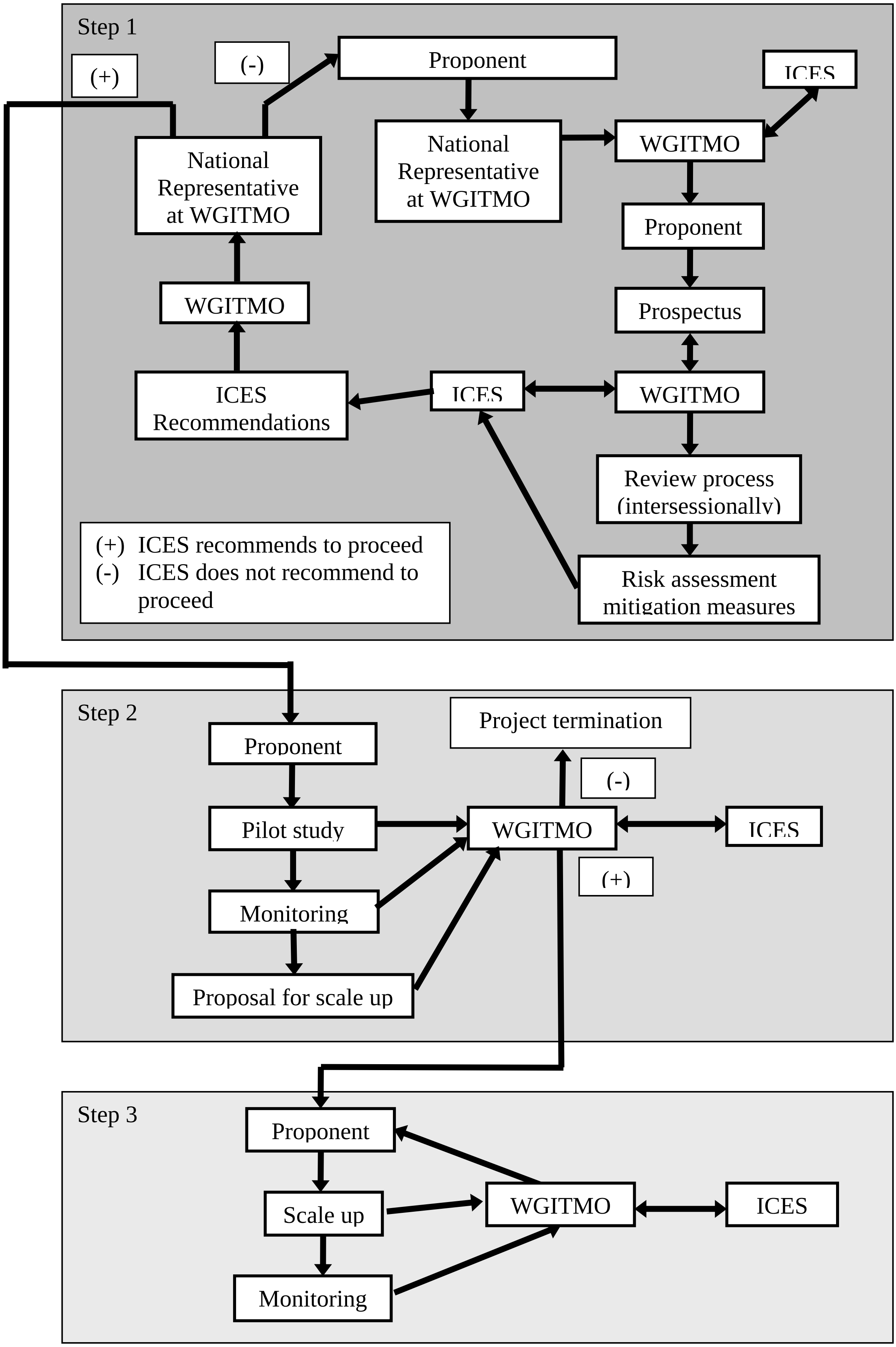
6. Ability to live in conditions of the receiving environment: this is based on known physiological information (taken from initial prospectus). Also, there should be water quality monitoring on a regular basis that examines (1) dissolved oxygen, (2) changes to benthos outside acceptable zone. The caution levels come into effect when a given level is exceeded (e.g., dissolved oxygen at the country level of acceptability (5-6 mg/L in MA), no shift to pollution tolerant species (e.g. capitellids, spionids etc.) outside modelled zone of impact as the caution level and additional monitoring to see if it is a transient occurrence or long term occurrence.

   The monitoring will be increased in scale to accommodate future expansion.

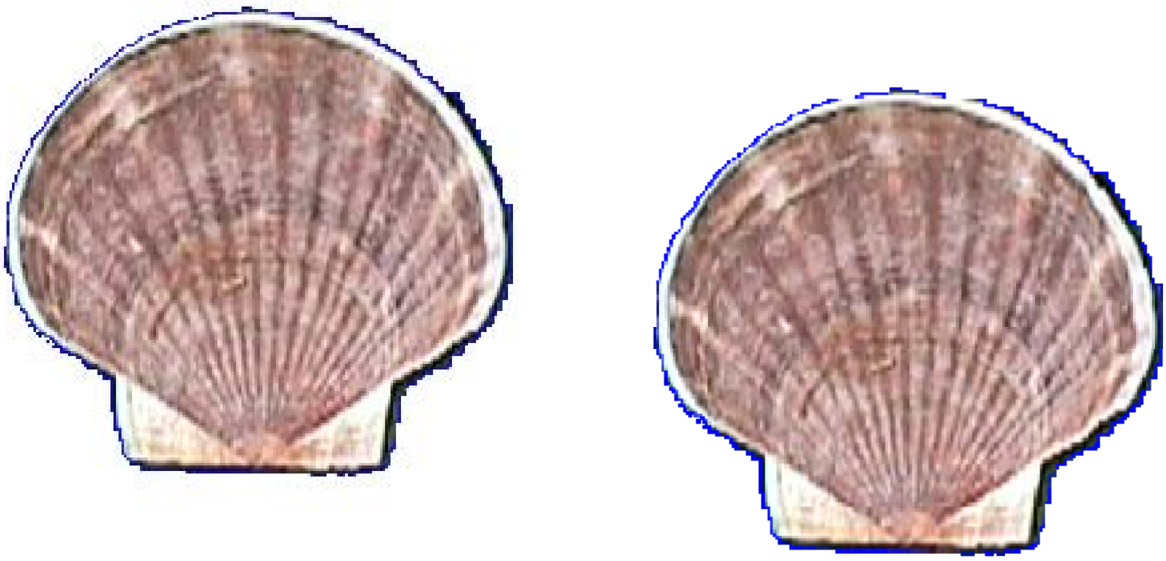
Box 1: Negative hypotheses that may aid direction for monitoring of an introduction.

1. The expected growth is not realised and so the species is unlikely to be profitably used.
2. The species appears outside intended area of introduction
3. The species will significantly alter normal trophic pathways
4. The substratum will be altered
5. The species becomes elusive to capture
6. The species is susceptible to native parasites, pests or/and diseases
7. The species is readily consumed by native predators
8. Reproductive development is not synchronised
9. Species is prone to translocation by natural vectors (i.e. storms)
10. The species acts as an intermediary host for a pathogen/pest
11. Consumers do not wish to purchase the intended product
12. Others?

APPENDIX E: FLOW CHART OF APPLICATION AND REVIEW PROCESS



APPENDIX F: A CASE HISTORY OF THE INTRODUCTION OF THE JAPANESE SCALLOP *PATINOPECTEN YESSOENSIS* FROM JAPAN TO IRELAND USING THE ICES CODE OF PRACTICE ON THE INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS



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and the

ICES Working Group on Introduction and Transfers of Marine Organisms

Introduction

The Japanese scallop, *Patinopecten yessoensis* (Jay) was introduced to Ireland following requests by an Irish fish and shellfish processor, the promoter, to cultivate the species on the south-east coast of Ireland. The earliest discussions took place in late 1988 at which time it was agreed to follow the procedure set forth in the revised ICES Code of Practice of 1988. Essentially the principles followed in this version of the Code appear in the 2002 version. The use of the Code was rigorously tested and was subsequently modified based on the experience of this introduction. Two meetings of the Working Group on the Introductions and Transfers of Marine Organisms (WGITMO) in 1989 and 1990 were required before the modified project was approved. Progress reports were submitted at following annual meetings of the WGITMO and continued until 1994.

In this account the case history is covered in two main parts:

1. Historical summary of the management of the introduction.
2. Response to concerns raised by the members of the ICES Working Group on the Introductions and Transfers of Marine Organisms.

Part I HISTORICAL SUMMARY OF MANAGEMENT OF THE INTRODUCTION OF THE JAPANESE SCALLOP FROM JAPAN TO IRELAND.

1988 –1989: Initial Discussions

In early 1989 a leading processor of fish and shellfish, the promoter, made a formal request for developing a Japanese scallop (*Patinopecten yessoensis*) aquaculture business on the Irish Coast. The project was first discussed with scientists of the Irish Department of the Marine (DOM), in November, 1988 at which time the ICES Code of Practice was adopted as the protocol for proceeding with the proposed introduction. The promoter’s initial plan was to introduce spat for direct release into the sea at a later stage following clearance from pathogens and parasites. However, the Code does not permit the release of the original broodstock imported. The spat would need to be cultured to maturity to produce an F1 progeny, which then could be released, and only if no parasites or pathogens were associated with this generation. Thus, based on the Code, the initial proposal to introduce spat following a short period of quarantine was rejected by the Irish Minister for the Marine, on the advice of the management team.

A further proposal based on the introduction of hatchery reared eyed umbonate larvae to quarantine, which at a subsequent time could be released to culture in the sea, was discussed. There was uncertainty about whether this would be permissible, because the larvae could be classified as the original import (i.e. comparable to brood stock) being released to the sea. This proposal was based on what had become at this time standard practice for the international transmission of the eyed unbonate larvae (the stage before settlement) of the Japanese oyster, *Crassostrea gigas*. Thus, the principle of transferring eyed oysters had already been established but the Irish DOM considered this an unacceptable approach for *P. yessoensis* unless these were to be used as broodstock. The ICES Secretary General was informed about the intended project to introduce the Japanese scallop to Ireland and the DOM sought the advice on this matter through the Working Group on Introductions and Transfers of Marine Organisms (WGITMO).

1989

At the WGITMO in Dublin during May 1989, the planned introduction of *P. yessoensis* to Ireland was described. A presentation was made by the proposer as to the reason for the introduction, based on economic projections and known ease of culture. The following documents were provided in advance of the meeting:

- Status report on the Japanese scallop, *Patinopecten yessoensis* (Jay) with reference to Proposal for introduction into Irish waters: with a review of its biology, culture techniques and possible consequences of introduction (17 pp) by William Crowe, Shellfish Research Laboratory, University College Galway.
- Status report on the Japanese scallop, *Patinopecten yessoensis* (Jay). Information relating to the biology, fisheries and cultivation of scallops, together with supporting documentation on:
    - i) *Patinopecten yessoensis* (39 pp) by William Crowe
    - ii) *Pecten maximus* (16 pp) by William Crowe
    - iii) Inspection and Certification (7 pp) by John McArdle, Fisheries Research Centre.

The WG members wished to discuss the project further with their national experts before comment, but did not oppose the introduction of adult broodstock to Irish waters provided that the correct quarantine measures were adhered to. A number of questions were raised:

1. Unexplained mass mortalities of scallops in culture in Japan
2. Genetic risk
3. Possible competition with other scallops
4. Possible introduction of other organisms with the scallops
5. Would Japanese scallops thrive in Irish waters?
6. Would Japanese scallops become established outside Irish waters?

These required further consideration and the DOM endeavoured to answer these questions for the 1990 WGITMO meeting. The subject was tabled as a special discussion topic for the 1990 meeting in Halifax, Canada. The advice provided by ICES, following the recommendations of the WGITMO, in the meantime was as follows:

The Department of the Marine of Ireland submitted to the ICES General Secretary a proposal for introduction of the Japanese scallop, Patinopecten yessoensis, *for consideration by the Working Group on Introductions and Transfers of Marine Organisms. The review determined that further information is needed before definitive advice can be developed on this proposed fisheries management measure.*

Background
The Working Group summarises relative information and points of concern, as follows:
1) 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.
2) The introduced species is expected to establish viable populations in Ireland.
3) 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.
4) Available information on environmental data and on inter-specific competition with native species is inadequate to enable full evaluation of the proposal.
5) Greatest detrimental impact is likely to occur mainly in ecological interactions; pathological problems via unwanted disease movements are possible; and genetic risks through hybridisation are expected to be low.
6) Late receipt of the proposal prevented consultative meetings within member countries.
7) 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 F1 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.*

1990 Assessing Information
In January-March 1990, letters of concern relating to the introduction were published in Irish national newspapers. A United Kingdom agency sought further clarification about the importation.. The DOM endeavoured to collate further relevant literature and carry out a risk assessment of such an introduction which included a study visit in Japan in March-April 1990. At the same time a quarantine facility was constructed under the supervision of the DOM by the promoter.

At the ICES WGITMO June 1990 Meeting in Halifax, Canada, additional support of information already presented in 1989 and from the study-visit in Japan to address the concerns endorsed by the ICES Council were made (see - Part II).

In addition further presentations included statements on the layout of the quarantine facility, procedures to be employed at this facility, health certification, histological studies and administrative matters and policy.

Following two days of discussion, WGITMO reported to the ICES Council:

The Department of the Marine, Ireland, has submitted to the Council a request for advice on the introduction of Japanese scallops, Patinopecten yessoensis, *to open waters of Ireland. Steps outlined in the ICES Revised Code of Practice have been followed meticulously by the Department. The following advice is offered by the Working Group to go forward to Council:*

The Working Group,
(1) does not oppose the continued development of Patinopecten *culture in Ireland, in the form of field trials that would assess their survival, growth, and gametogenesis in open waters pending verification of a pathogen-free F1 progeny and hatchery brood, including the stock destined for open release.*
(2) finds that upon careful examination of available scientific evidence assembled by Ireland, commercial-scale development of Patinopecten yessoensis *populations in the open sea will very likely lead to the establishment of natural (wild) populations and possibly their eventual (albeit slow) spread,*
(3) urges that Ireland should provide to the Working Group annual records of release sites, dates, and numbers as part of their national report, and carefully monitor the occurrence, extent, micro habitats, health and concomitant ecological relationships, if any, with native biota, of wild populations if such become established (with a particular focus on any competitive interactions with the native scallops).

While the appraisal of the proposal was in progress the DOM permitted the importation of the first broodstock consignment to the quarantine facility in April 1990 on the understanding that these, and their progeny, would remain in quarantine until such time as definitive advice on the overall proposal was received from ICES. It was necessary to import the broodstock at this time (their normal reproductive period), so that larvae could be produced at the quaratine facility because otherwise the project would be delayed a year. ICES, following the 1990

Statutory Meeting, informed DOM that they did not oppose the development of field trials subject to the condition that there would be status reports of the project presented to the WGITMO for review.

1991 Summary of Report to WGITMO

The main points in the following status report submitted to the WGITMO in June 1991 were:

- Histological studies, using 150 Japanese scallops produced in each batch of scallops at the quarantine facility, in the spring of 1990, showed no indication of disease or parasitic organisms. The scallops in quarantine were then released to the wild in pearl nets on longlines.
- Comparative growth between the native scallop *Pecten maximus* and the Japanese scallop, *P. yessoensis* of the 1990 year-class took place in pearl nets at the longline site at varying densities 20:40:80:160 per pearl net. Both species suffered shell distortions and interrupted growth and had high mortalities (*ca* 90%). There was poor growth with dense fouling of pearl nets from hydroids, tube-building amphipods, sponges and bryozoa. Some native scallop *Aequipecten opercularis* had settled on the outside of the pearl nets.
- Japanese scallops of the 1990 spawning, released to the sea did not show any indication of reproductive development.
- Twenty males and 51 female broodstock of *P. yessoensis* were imported in March 1991 from the same source as previous broodstock. These spawned and produced a settlement after 20-28 days, the higher survival and reduced larval period indicated a better condition than in 1990.

1992 Summary of Report to WGITMO

The 1992 report was as follows:

Three introductions of adult broodstock were brought into quarantine under the supervision of the Department of the Marine. Scallops were released from quarantine in September 1990 and were held in hanging culture near Carnsore Point on the south-east coast alongside native scallops (Pecten maximus). *Of this year class, 118 remain. Samples of these animals taken in April did not show any pathological condition or parasite loading.*

In March 1991 the quarantine facility was re-opened in advance of receiving 20 male and 51 female broodstock. The adults came from Utatsu Bay in Miyagi Prefecture, Japan - the same source as the 1990 introduction. There were five spawnings over a twenty-day period during March and April. All adults, after spawnings, were destroyed. Settlement of larvae took place 20-28 days after spawnings. In June there were noticeable mortalities of spat following strong south-easterly winds that caused large amounts of algal debris to accumulate on the shore close to the sea water intake. At this time scallop mortalities were high and the rate of growth declined. There was a vibrio infection of the mantle margin and all spat were then destroyed. On no occasion did scallops from the 1991 year-class leave quarantine.

There will be no importation of broodstock in 1992.

1993 Summary of Status Report to WGITMO

In 1993 the status report of the project to the ICES WGITMO was as follows:

Japanese scallops that survived their importation from Japan were introduced to a quarantine facility in Ireland during April 1990. Following spawnings all adult broodstock were destroyed. The surviving F1 generation, which cleared quarantine in September 1990, was expected to spawn during the spring of 1993. It will appear that spawning will now take *place during spring 1994. The surviving 75 scallops are held in lantern nets off the Wexford coast, SE coast of Ireland.*

There were no further importations in 1992 and none are planned for 1993 or 1994.

1994 Summary of Status Report to WGITMO
In 1994 the project was terminated, the longline holding the F1 broodstock was torn from its moorings in a storm. The longline was recovered but all of the scallops were dead.

Although the project ultimately failed, given different circumstances it could have been successful. The onshore quarantine laboratory was made secure in advance of any consignments and adult broodstock were imported close to breeding condition. Sufficient numbers of F1 individuals were produced but their subsequent culture in the sea on completion of quarantine requirements took place in an exposed area on the insistence of the promoter. On account of the exposed culture site there was entanglement and fouling of the long-line system and shell overlapping that resulted in high mortality. Servicing of the cultures could only take place when the sea-state was suitable, limiting the possibilities for practical management. Despite these difficulties, the procedure adopting the ICES Code of Practice was successfully carried out.

Part II RISK ASSESSMENT ON THE INTRODUCTION OF THE JAPANESE SCALLOP (*Patinopecten yessoensis*) TO IRISH WATERS

Introduction
The ultimate objective of introducing the Japanese scallop *Patinopecten yessoensis* to Irish waters was to develop commercial hanging culture. Initially its survival and growth in a pilot culture scheme would be compared with that of *Pecten maximus*, the main commercial scallop species in Ireland, to determine whether it was suitable for large-scale culture. Sites on the south and west coasts were selected for possible ongrowing following quarantine. All parent *P. yessoensis* were introduced to a quarantine facility on the SE coast of Ireland, under the supervision of the Irish Department of the Marine.

Introductions of larvae from Japan, intended to eventually act as broodstock, did not survive. Importations of adults took place in April 1990 and March 1991. These were spawned and the subsequent F1 generations settled. All adults were destroyed following spawning. The young scallops remained in quarantine until the F1 generation of the 1990 importation was released to the sea in September 1990. Those spat produced in the quarantine laboratory in 1991 were destroyed following a large mortality during a period of poor water quality. The surviving 2,500 spat of the 1990 spawning were to form the basis of a parental broodstock on which the project would depend.

The main contents of this document were presented to address concerns raised by the Working Group on Introductions and Transfers of Marine Organisms and subsequently by the Mariculture Committee of the International Council for the Exploration of the Sea (ICES) at 1989 meetings, and was reported in the following year. The preparation of the report is based on studies of the literature, a visit to Japan (to meet with biologists, oceanographers, pathologists and fishermen) and correspondence with internationally recognised scallop biologists, affiliated with the International Pectinid Workshop.

SUMMARY OF IMPACT HYPOTHESES

1. THAT JAPANESE SCALLOPS COULD BECOME ESTABLISHED OUTSIDE IRISH WATERS.

The scallops are to be cultivated in intensive hanging culture. Their growth and reproductive development will be monitored using spat released from quarantine. The project will proceed on a pilot programme in advance of becoming a commercial production with an option of withdrawing all cultivated scallops should any significant and negative effect be predicted or determined.

Japanese scallops once mature have the capability of spawning and small initial releases would provide a small inoculum with a low probability of the species becoming established. Increased production of scallops would undoubtedly increase this risk. In tandem ecological studies, including dredging of areas near the culture site should provide sufficient information on the extension of the cultured population to the wild. Because the conditions in Ireland are suitable for growth and reproduction, it is likely that the species will eventually become established in the wild. It is probable that a large source population is required before the establishment of a wild self-reproducing population becomes likely. The critical size of the source population required is not known, but will depend on local hydrographic conditions. For this reason a small adult biomass is recommended in pilot studies so that a full evaluation of scallop growth and reproductive development can be undertaken, to ensure that its expectations for culture can be realised.

In Japan the establishment of cultivation in new areas is thought to have produced some recruitment to the natural populations in nearby regions, but this has not been quantified. Larval numbers will clearly be dependent on population size, and in Mutsu Bay a direct relationship between spawning stock biomass and settlement onto collectors has been found to exist. Annual settlements are known to be highly variable in most scallop species, however.

2. THAT JAPANESE SCALLOPS MAY COMPETE WITH NATIVE SCALLOP SPECIES

It is not possible to determine the full interaction with other species in advance of an introduction; however, the study of scallop shell morphology does provide some basis for a reasoned argument in advance of an introduction. *P. yessoensis* has features intermediate between *Pecten maximus* and *Aequipecten opercularis.* For this reason it is considered that the range of *P. yessoensis*, once established in the wild in Europe, are unlikely to coincide with those of native scallops. Although there is some overlap with the ranges of other scallop species in Japanese waters there is no apparent competition. The Japanese *Pecten albicans*, which resembles *P. maximus*, has a geographical range just overlapping that of *P. yessoensis*, and has a preference for finer sediment.

It can be deduced from the Japanese literature that the larvae or settled spat of *P. yessoensis* are unlikely to compete with those of Irish pectinids, because spawning takes place in the early spring. However, there may be competition as juveniles or adults, where its distribution overlaps with that of other scallops, but this is not seen in Japan. Studies in tanks, and in the field, of *P. yessoensis* with European native scallop species would be required to determine the interactions, behaviour and sediment preferences as juveniles and adults.

3. THAT THE INTRODUCTION OF JAPANESE SCALLOPS MAY RESULT IN A SPREAD OF PESTS, PARASITES OR DISEASES.
Prior to introductions, *P. yessoensis* adults were selected by size and condition, and their shells scrubbed. The consignment was met on arrival at customs by an officer of the Irish Department of the Marine who brought the scallops directly to the awaiting and supervised quarantine facility. Following unpacking, all waste was burned and dead tissues buried in lime. Living scallops, and their remaining epibionts, remained in quarantine. Wastewater was treated by chlorination at 250 ppm with a minimum treatment holding time of 4.5 hours.

Following spawning all eggs were sieved, washed and separated from adults and their water. The original broodstock was then destroyed and the quaratine facility was operated until such time as the F1 or subsequent generations were devoid of known pathogens and parasites, determined by histology, and were in a healthy condition. These measures were considered sufficient to control and eliminate the risk of an introduction of known pathogens or parasites to the sea.

4. THERE WAS CONCERN OVER THE MASS MORTALITIES OF JAPANESE SCALLOPS IN CULTURE IN JAPAN.
There was no evidence of any direct pathological implication in scallop mortalities in Japan. Causes appear to have been one or more of the following, most of which arose from over-intensive cultivation:

a) Physiological stress arising from premature development or high sea temperatures,
b) Wave action, resulting in soft tissue damage from shell overlapping,
c) Oxygen depletion.

5. THAT JAPANESE SCALLOPS MAY HYBRIDISE WITH COMMERCIALLY IMPORTANT EUROPEAN SCALLOPS
In Japanese waters there are no known examples of hybridisation of *P. yessoensis* with any other pectinids with overlapping ranges. This scallop has a different shell morphology and is dioecious and is unlike European commercial species.

Further, hybridisation is unlikely because *P. yessoensis* spawns at lower temperatures (in the early spring) than *P. maximus*, which spawns from May to August. *A. opercularis,* which has a different chromosome number, has three periods of spawning - a small peak in January/February (in the Irish Sea), summer and autumn. *Chlamys varia* occurs within shallow bays and spawns at temperatures above 14°C.

For these reasons it was concluded that there was no predictable genetic risk.

6. THAT JAPANESE SCALLOPS ARE UNLIKELY TO THRIVE IN IRISH CONDITIONS
All indications are that conditions in Ireland are favourable, sea temperature ranges fall within the optimum range for the species, and all likely cultivation areas have appropriate salinities.

Main Account of the Risk Assessment of the Introduction of the Japanese Scallop, *Patinopecten yessoensis*, to Irish Waters.

Scallops were introduced to Ireland following strict adherence to the ICES Code of Practice in effect at that time. The 1988 Code was updated during the course of the introduction of Japanese scallops. Recommendations for some changes were made and subsequently contributed to the 1994 Code of Practice.

Species summaries of the three main scallop species in Irish waters are provided. These are distilled accounts of lengthy submissions made to the Working Group (Boxes 1-3) to enable comparison with the biology of the Japanese scallop (Box 4).

Following the study visit to Japan in March 1990 the following responses (below) in relation to the concerns expressed by the ICES Council in 1989 were addressed at the WGITMO meeting in Halifax, Canada in June 1990. In addition a description of culture methods and general conditions at the donor site was included. During this time adult *P. yessoensis* broodstock were imported to the prepared quarantine reception facility in Ireland (to produce spawnings in March/April – their normal spawning time) so that a years work was not lost.

CULTIVATION TECHNIQUES ON THE SANRIKU COAST, JAPAN.

Scallops were sourced from Utatsu Bay on the southern Sanriku coast in Miyagi Prefecture (Figure 1). In this region of intensive cultivation, the main species utilised from the sheltered shore to more open bay is generally in the following sequence:

Oysters Þ Ascidians Þ Undaria Þ Salmon Þ Scallops

Scallops are normally cultivated at the most open end of these bays sometimes 5-6km offshore over depths of 40-60m. Scallops are held on submerged longlines with marker floats that extend to the surface. The majority of the floatation is from subsurface floats; most of these were glass. As scallops grow and become heavier additional floatation is added. The longlines are arranged in rows, with corridors of 50-100m between them. Cultivation is extensive and activities in the production provide employment for most of the year.

Environmental conditions

Onagawa Bay lies adjacent to the area where the Irish consignments of scallops were sourced. Much of the environmental data from this area is based on studies made by students at the University of Sendai. Annual sea temperatures range from *ca* 6°-22°C, however, temperatures at the depths of culture range from 6°-20°C, with cooler and warmer temperatures inshore in winter and summer respectively (Misu, 1990; Arimoto, 1977). In Onagawa Bay, which gradually deepens to almost 50m at its entrance, sediments range from sandy mud to sand (Misu, 1990). Seasonal transects passing through the centre of Onagawa Bay were made to determine the distribution of nitrogen, silicates, phosphates and chlorophyll α together with temperature and salinity (Shibakuki, 1990). In spring silicates and phosphates are concentrated below 20m. Levels are low in summer but are well mixed throughout the water column in autumn and winter. Chlorophyll α levels were highest close inshore in spring and summer. The tidal range within this region is 1.8m (Uno, 1990).

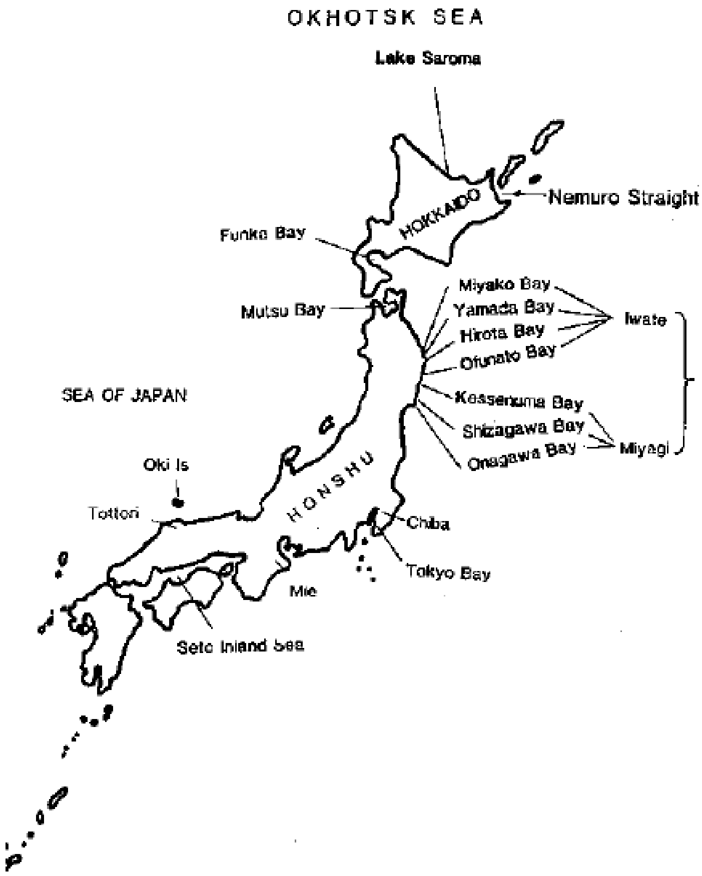

Figure 1. Location of Japanese localities referred to in the text.

Japanese scallop cultivation

The industry in Japan is totally based on natural spat settlements. The main areas of cultivation are Mutsu, Funka, Saroma, Tenora and Sanriku districts (Figure 1). No laboratories currently rear *P. yessoensis* larvae apart from some small experimental studies on the Sanriku coast, although efforts were made to produce hatchery reared spat to stabilise production in the 1960's and early 1970's when there were large fluctuations of natural settlements (Imai, 1967). Hatchery production was expensive and was discontinued when natural settlements became more reliable (Sanders, 1973).

In Miyagi Prefecture more than 70% of the seed used in culture is obtained by placing collectors locally. Larval occurrence and spat production have been studied by Sasaki *et al.* (1984). Settlement takes place over the period May-June and the spat are removed from the collectors in July-August once they are *ca* 10mm shell height. At some localities on the Sanriku coast there are two separate appearances of larvae in the plankton (end of May-first week of June, last week of June first week of July in 1984 (Sasaki *et al.,* 1984)). The source of these settlements is not known. There is a local and natural unexploited population below the longline culture areas. It is not clear whether both cultured and natural scallops provide larvae that settle within these areas, but it is considered likely. Scallops in culture may spawn in advance of those on the sea-floor and this could account for the two peaks of larval abundance appearing in the plankton.

Scallops spat when removed from collectors are transferred to pearl nets at densities ranging from 40-100 per net. A second grading to a larger meshed pearl net takes place when scallops are 30mm+ shell height, when densities are reduced to 15 *per* net. The mesh floors of these pearl nets were not as fouled as their upper surfaces. In was noticed that *Polydora* can be found on shells of this size (pers. obs.).

Importations of scallops from Northern Hokkaido to the Sanriku coastline have not taken place. However, scallops for hanging culture, once about 6cm, are imported from Funka and Mutsu bays. The exact quantities imported are not known because fishermen do not wish to disclose their suppliers. Transfers normally take place in December, six months following settlement. Scallops are transported in boxes lined with sacking soaked in seawater. The consignments are held at 2°to 4°C in temperature controlled containers. Transportation times are usually planned so that scallops are not held out of water more than 10 to11 hours. Funka Bay scallops, that are not used in hanging culture, normally go for sowing culture in the Othotsk Sea and the Nemura Straight. The majority of the Mutsu Bay scallops are transferred to Iwate Prefecture. Here scallop production is greater than in Miyagi Prefecture.

After nine months scallops can be large enough for sale. This market for small scallops has developed as a result of the large quantities being reared with insufficient capacity for growing them on to a larger size. These small scallops tend to be slower growing or may have sustained some damage while handling and are usually sold entire. The better quality and larger scallops continue to be ongrown, those that exceed 6cm in shell height are ear (auricle) drilled and hung in vertical arrays from longlines. Ear hanging culture takes place at depths of 10-39m, on dropper lines spaced approximately 1m apart suspended from a subsurface buoyed horizontal line. Scallops are fixed to the dropper lines in pairs using 1mm diameter monofilament line, or barbed plastic tabs. In the more exposed areas shells can be lost due to wear of the monofilament. Scallops using this system normally develop with a greater shell volume (are more globose) with thin shells.

Those not cultured in this way are held within subsurface lantern nets at stocking densities of about 10 per level until they reach a size of 100mm shell height. However, fishermen are inclined to overstock using 13-15 individuals per level. Scallops generally grow more rapidly when held in suspended culture (Figure 2). In the Sanriku region there are few areas where scallops are sown on the sea floor.

Scallops are normally marketed following two years of culture, although some may require to be ongrown a further year. This depends on local conditions and cultivation densities. Growth in the Miyagi district (Figure 1) is the fastest known in Japan. This is due to the extensive period of warmer sea temperatures resulting in optimal growth. Mortalities do, however, take place once temperatures exceed 21°C.

The method of cultivation is intensive; many longline systems are installed within suitable ongrowing areas. Fishing vessels in these areas use hydrojet propulsion to avoid entanglement with the surface marker floats. The equipment used for working the longlines is highly specialised and consists of rollers and lifting gear on shallow drafted, low gunwhale vessels.

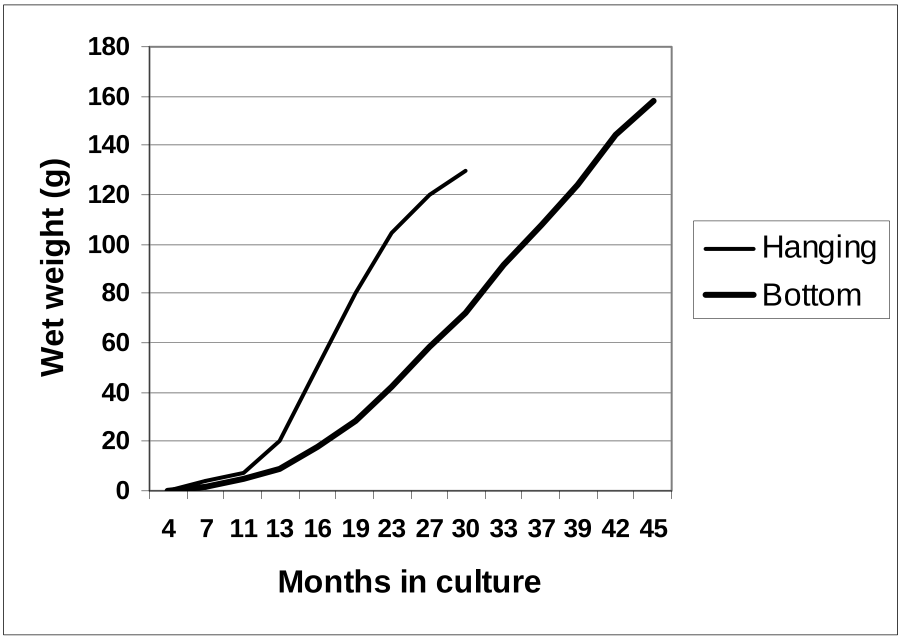

Figure 2. Comparison of growth for scallops held in hanging culture with those sown on the sea floor (based on Imai, 1967).

MASS MORTALITIES OF SCALLOPS IN CULTURE

In Japan scallop losses have taken place at most production sites, and also in the warmer water areas outside of their natural range where experimental cultivation trials took place. Extensive histological studies at main cultivation sites (when there have been high mortalities) have not indicated any pathological cause. The most likely explanation for these mortalities would appear to have been physiological stress due to over intensive cultivation. Saito (1984) suggested diseases as being one of a number of possible contributory causes of decreased production in Hokkaido following the dramatic twelve-fold expansion in production over the years 1971 to 1977. During this period annual production rose from less that 6,000 metric tonnes to 70,000 metric tonnes. No evidence is adduced, however, to support this hypothesis. No further information relating to diseases was available during the 1990 visit to Hokkaido. Although mortalities still occur from time to time, the levels of losses that took place since 1972 have not been repeated. The following possible explanations for high mortality were offered.

Cultivation technique

Long exposure to air:

Scallops, as they grow larger, need to have their cultivation density reduced and placed in containers with progressively larger mesh sizes. This reduces fouling, enhances water flow and thereby promotes growth. During this grading process the scallops are exposed to the air. There is a apparently a great variability in stock survival between different family units who cultivate scallops in close proximity to each other according to the handling they receive. For example, in Saroma Lake adjacent units have had >50% mortality and <10% mortality (Hayashi, 1988). Some cultivators handle their stock at sea to reduce aerial exposure and return them to the water as soon as possible. Survival under these circumstances is greater. Those who bring their stock ashore to grade expose the scallops for longer periods and these scallops have higher mortalities (Hayashi, pers. comm.)

Exposure to sun and rain:

Scallops handled in the early morning in the warmer months avoid being exposed to high solar radiation and at a time with cooler air temperatures. Scallops handled in this way have a lower mortality (Anon., 1980). Survival is greater when tarpaulins are used as a sunshade or as a shelter to deflect rain. Once sea temperatures are high, >20°C, handling is normally avoided.

<u>*High density cultivation:*</u>
High-density cultivation has continued to result in high mortality. In Funka Bay large interconnected longlines are owned by a fishermen's co-operative, and sections of this are allocated to family units. Because of the limited space available each family produces as much as possible from the apportioned area. Ear hung scallops are usually hung in groups of three, where optimally there should be one or two, and correct densities in lantern nets are exceeded. Such overstocking results in reduced growth requiring a longer cultivation cycle, poorer quality scallops with significant losses (Hayashi, pers, comm.).

High-density culture in pearl and lantern nets may result in deformed shells, more importantly this can lead to additional mortality. Many die from shells overlapping ('biting'). The ventral (leading) edges of the overlapping shells may penetrate and cut the soft tissues within the shell cavity. Small scallops of 15 to 30mm shell height are particularly vulnerable; because at this size they can gape widely. This was a serious problem 15-16 years ago in Hokkaido when densities of 300-600 scallops were held within each pearl net, when normally two hundred 3mm shell height individuals would be stocked (Hayashi, 1988). The effects of density on growth have been well described by Querellou (1975) and Ventilla (1982.). The optimum density for cultivation is considered to be 50%-66% shell surface area to cage floor area (Anon., 1980).

<u>*Incorrect drilling of cultured shells:*</u>
Scallops can be drilled through the shell auricles ('ears') to take a monofilament which is then attached to a vertically arrays of hanging dropper lines suspended from a horizontal subsurface longline. Incorrectly drilled shells often perish. Mortalities of 10% are frequent. Losses from this source are accepted because of the lower overall capital cost of this method of cultivation. Higher losses occur in areas of wave exposure. Currently there is about 2% shell distortion among drilled shells (Sasaki, pers. comm.).

Physiological Stress
<u>*Abnormal sexual development:*</u>
Scallops grown in the Miyagi and Iwate Prefectures grow more rapidly, and females can mature during their first year, unlike the populations in Mutsu Bay and Hokkaido. In warmer waters abnormal sexual development in scallops of less than one year can take place (Osanai, 1975). Development may be incomplete and so result in only partial spawnings at the normal time of spawning. This is followed by partial adsorption of the remaining sexual products.

Reproductive cells are formed during a decline of sea temperature in the autumn. Throughout the coldest period maturation takes place and spawning occurs with a sea temperature rise, usually in March-April in Iwate and Miyagi Prefectures. Should scallops be held at a low temperature for insufficient time they will enter the spawning period without full maturation, and this may explain the presence of sexual products found during summer months, as was found in Yamada Bay, Iwate Prefecture (Mori & Osanai, 1977). At higher temperatures the maintenance of gonadal tissue is greater (Mori, 1975). These conditions impose stresses that may result in mortality, particularly if exposed to additional handling.

Mortalities of 30 million scallops (>50%) were recorded in Yamada Bay in 1972, and similar mortalities were recorded for Ofunato and Hirota bays (Figure 1). The following year mortalities in these bays in Miyako Bay, all in Iwate Prefecture, were as high as 90%. In Miyagi Prefecture high mortalities were recorded during 1972 and 1973 in Kessenuma and Shizagawa bays. Scallops that were dying usually had a deformity and browning of the shell margin and pallial atrophy (Mori, 1975). Mortalities occurred in other years but this was not quantified. More recently mortalities have declined considerably as a result of modified longline systems and reduced culture densities.

Stress arising from high sea temperatures:
P. yessoensis is a cold water species tolerating temperatures from -2° to 21°C. Once temperatures exceed 21°to 24°C physiological stress results in reduced growth and often death. Mortality increases in those cases where scallops become exposed to additional stress, such as high-density cultivation.

Trial cultivation in Chiba and Mie Prefectures and the Seto Inland Sea (Yamamoto, 1977) showed high losses once summer temperatures attained 23°C (Koike, pers. comm.). In Mutsu Bay once temperatures attain 23°C, mortalities were normally noted. In many areas, at the southern end of this scallops range, mortality could be reduced by suspending them in deeper water to avoid those periods when there were high temperatures in the near-surface water.

Effects of high density:
High densities result in poor growth, competition for food, and greater fouling. Slow growing scallops may become overgrown by fouling organisms; this may lead to distorted growth of the shell and death.

The effect of wave action on scallops in hanging culture.
Scallops ongrown on longlines may be subject to strong vertical movements, particularly near the sea surface at exposed localities. Under these conditions, when scallops tap each other, shell margins and mantle tissues can become damaged, commonly resulting in shell chipping, mantle retraction and death. Mortality from this source has been significantly reduced with a redesign of longlines and culture of scallops at greater depth. There is also some indication that poor food availability as well as effects of wave action, termed "vibration", result in high mortalities (Mori *et al.*, 1974).

Oxygen depletion of the water column
Pseudofeces, waste matter and fouling organisms that descend to the seabed in areas of intensive off-bottom cultivation can result in a high organic loading, particularly in those areas where there is low dispersion. Locally the redox-discontinuity layer can appear at the sediment surface and the bacterial flora can produce sulphurous gases causing environmental deterioration (Anon., 1980). These conditions are also known to occur beneath both mussel rafts, in the rias of Spain, and salmon farms, in northern Europe (Pearson & Gowan, 1990).

Local events, such as the collapse of an algal bloom, may result in oxygen depletion causing mortality in the benthos. In Japan, sheltered areas with large accumulations of detritus can have poor growth and high mortalities. This can be controlled, in part, by moving in rotation the position of the cultivation units, to avoid continuous accumulation of waste so providing an opportunity for recolonisation of the sediments by benthic organisms (Anon., 1980).

GENETIC RISK

Absence of hybrids in Japanese waters:

There are no known hybrids between *P. yessoensis* and other scallop species found within its range. These include *Pecten albicans, P. sinensis, Chlamys swiftii, C. farreri nipponensis* (Kijima pers, comm.).

Different chromosome numbers:

P. yessoensis has 19 chromosome pairs, three of which are acrocentric, whereas in *P. maximus* there are the same number of chromosomes but 14 of these are acrocentric (Beaumont & Zouros, 1991). *A.. opercularis* has 14 chromosome pairs (Rasotto *et al.*, 1981) or 13 (Beaumont & Gryffydd, 1975). Recombination with European species is very unlikely. In Japan both *P. albicans* and *Chlamys farerri* have 19 chromosome pairs.

Scallops morphologically different:

P. yessoensis is morphologically different from other European pectinids. In addition this species is dioecious unlike the two main northern European commercial species *P. maximus* and *A. opercularis*.

Different spawning periods:

The expected spawning period of *P. yessoensis* in Irish waters (March and April) is unlikely to overlap that of *P. maximus*. In many coastal areas of Ireland spawning of *P. maximus* occurs form May to August (Gibson, 1956), except perhaps on occasions within the Irish Sea where spawning has been recorded over a sea temperature range of 7.2° - 13.7° C (Mason, 1958). *A. opercularis* spawn predominantly in the autumn, with smaller spawning peaks in the early spring and summer (Paul, 1978), mainly outside the anticipated spawning time of *P. yessoensis*. The opportunity to hybridise, should this for some reason be possible, is thereby considerably reduced.

COMPETITION WITH OTHER SPECIES IN JAPAN

Scallops that overlap the range of P. yessoensis:

The range of *P. yessoensis* overlaps other pectinid species, but only at the edge of its range or habitat (Figure 3). *Chlamys swiftii, C. nobilis, and C. farrei nipponesis* are normally found attached to stones and usually in shallower water, and here *P. yessoensis* is seldom encountered. *P. albicans and P. sinensis* infrequently overlap the range of *P. yessoensis*.

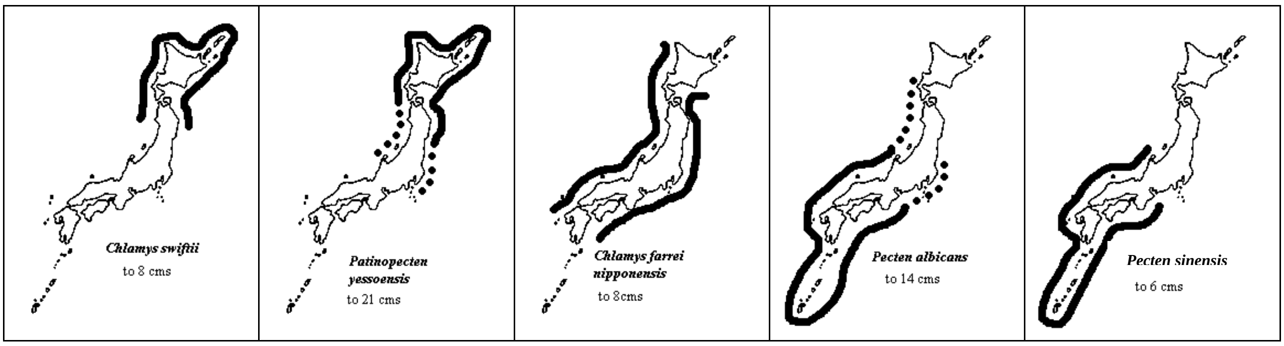

Figure 3. Distribution of the principal scallop species that overlap the distribution of *Patinopecten yessoensis.*

Patinopecten yessoensis in Japan*:*

P. yessoensis is found naturally in Northern Honshu and Hokkaido. Off Hokkaido it is found to depths of 60m, mainly on gravels (0.5-4mm diameter) in areas of swift water movement. The gravels in these areas are often well polished. These same areas are also sown in rotation, using scallops from culture, (Hayashi, 1988) with densities of up to 6-7 scallops per square metre.

In the partially enclosed Mutsu Bay, scallops occur on finer sediments. The chosen sowing areas consist of a community which includes *Echinocardium cordatum* and *Lepidopleurus assimilis*, both of which are used as biological indicators for sediment suitability. These sediments of sand, silt and gravel must have a silt (<0.1mm diameter) composition of less than 30% (Yamamoto, 1968). Higher levels of silt are unsuitable and in such areas scallop growth and survival are reduced. Settlement in muddy or silty areas normally result in high mortalities of spat, and so explain the absence or low numbers of scallops in these areas, Densities of less than six per square meter are needed to obtain 200g scallops in 3-4 years (Aoyama, 1989).

Pecten albicans in Japan:
P. albicans , a commercial species in the Sea of Japan on the west coast of Honshu, has a preference for sand and sandy mud. It normally occurs at depths of 30-80m (Ayama, 1986). It is cultivated in Tottori Prefecture and the Oki Island. Landings have been variable depending on recruitment of good year classes. Currently, production is stabilising as a result of cultivation. Attaining 100mm in its third year (maximum size, 140mm), it is cultivated in a similar way to *P. yessoensis* (Kunizou, 1986). *P. albicans* is very occasionally found on the east coast of Japan where it occurs northward to Tokyo Bay, where occasional sporadic year classes recruit. Overlapping of its range with *P. yessoensis* is not known on this coast (Koike, pers comm.).

Pecten sinensis in Japan:
P. sinensis attains 60 mm shell height, and has a similar geographic distribution to *P. albicans* within Japan, occurring in shallows where there is fine sand.

COMPETITION WITH OTHER SPECIES IN NORTHERN EUROPE

Likely range overlap with main European species:
Pecten maximus ranges from Norway to the Canaries (Figure 4) but is exploited from Spain to Norway from the lowest tidal level to depths of 180m. It is found on all Irish coasts particularly within shallow bays (Figure 5). *P. maximus* is found on a wide range of sediments, from soft mud to coarse gravels, although there would appear to be a preference for sandy mud (Minchin, 1984). These substrata and greater depth range represent a wider distribution than has been described for the Japanese scallop. Should *P. yessoensis* become established in Irish waters, it is expected that it will overlap the range of *P. maximus*. However, it is unlikely that their ranges would coincide. *A. opercularis* is also found over a wide range of substrata, but is more frequently associated with muds and sands to depths of 46m (Mason, 1983).

Figure 4. Distribution of *Pecten maximus* in Europe (Minchin, 1984).

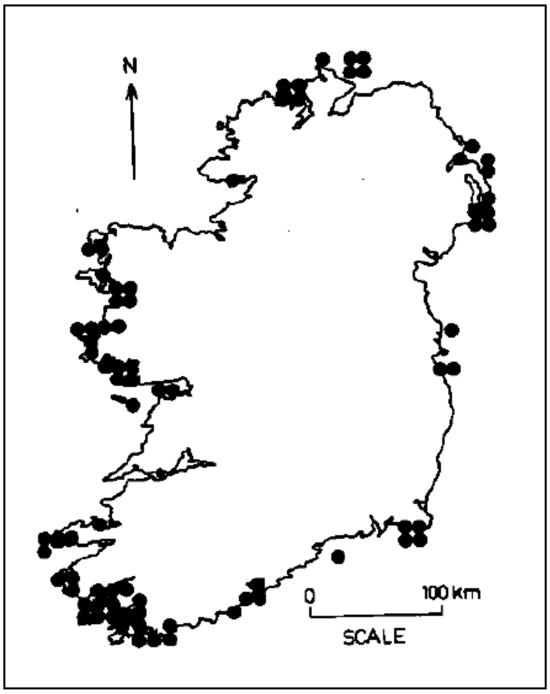

Figure 5. Distribution of *Pecten maximus* in Irish water (Minchin, 1984).

Likely behaviour in European waters:
Shell shape provides some indication of behaviour among pectinids (Gould, 1971). The shell of *P. yessoensis* differs from that of *P. maximus* and *A. opercularis*, yet has some similarities. *P. maximus* recesses within a pit in the sediment, and normally has a thick layer of sediment covering the upper (left) flat valve so that the upper surface of the shell lies flush with the level of the surrounding sediment. In *P. yessoensis* recessing also take place, but within shallow pits and some sediment can cover the left valve. *P. maximus* has an overlapping lower curved (right) valve, an adaptation for a deeper recessed mode.

A. opercularis has a biconvex shell without shell overlap, and, like *P. yessoensis*, is an active swimmer. The Japanese scallop has characteristics common to both of the aforementioned species and lives for a similar length of time. For these reasons *P. yessoensis* may be expected to become dispersed over a similar depth range with a preference for coarser sediments.

Chlamys varia is principally found in shallow water bays. It attaches with a byssus throughout its life and like the Japanese *Chlamys* species is unlikely to be found in areas where free swimming scallop species are found. It is capable of detaching the byssal mass and then swimming and subsequently secreting new byssal threads. Swimming seldom takes place, and then usually as an escape response to sea-stars.

P. maximus and *A. opercularis* coexist in European waters with overlapping ranges without apparent detriment. It is expected that *P. yessoensis* would behave in a similar manner should it become established. The only likely competition is expected to be for food, and this may not be significant when compared with the biomass of other filter feeding organisms present.

POSSIBLE INTRODUCTION OF OTHER ORGANISMS

Introduction of algal cysts

Distribution of algal blooms in Japan:

In Onagawa Bay and the Sanriku coast, close to the region of the source population of scallops to be introduced to Ireland, movements of coastal and oceanic water masses into the Bay determine the phytoplankton successions. The dominant species were diatoms, mainly composed of *Chaetoceros radicans* and *Thalassiosira decipiens* in May changing to *Nitzschia seriata* (now *Pseudonitzschia seriata*) and *Rhizosolenia fragilissima* in July. In October *Asterionella glacialis* and *Skeletonema costatum* predominated (Hashimoto, 1990). In Hashimoto's study in 1989 dinoflagellates did not consist of more than 1.5% of the marine algal counts. Arimoto (1977) who examined the same bay in 1974 and 1975 did find small numbers of *Prorocentrum micans* in the late summer, and recorded the presence of *Dinophysis ovum* and *D. homunculus var. tripos* during the summer and autumn.

On the Sanriku coast DSP has occurred close inshore, and scallops (as well as other species) sampled in the summer of 1976 and 1977 were found to be contaminated (Yasumoto *et al.*, 1978). The organism responsible is thought to be a *Dinophysis* species. Seed collection areas that supply Miyagi Prefecture with some of the scallops used in the suspended cultivation to the adults do have problems with DSP contamination. Species found associated with this problem are *Dinophysis fortii* and *D. acuminata*, although *D. norvegica, D. rotundata* and *D. mitra* were all recorded in Funka Bay, Hokkaido, in 1989 (Hayashi, 1989). In Mutsu Bay, Honshu, DSP contamination is also known (Yasumoto *et al.*, 1978); principally caused by *D. fortii*, which can be present from March to October/November (Satoh, pers. comm.). DSP is known to have occurred in this area since 1976, and there were serious outbreaks over the period 1978-1980 (Ventilla, 1982). This species does not appear to interfere with the growth of scallops, and sales can take place provided the hepatopancreas, in which the toxin accumulates, is removed. PSP contamination is not known from the Miyagi Prefecture, but is known in Funka Bay, an area that has sent scallops for adult cultivation on the Sanriku coast. The problems in Funka Bay are serious and sales of scallops can be restricted for most of the year. The causative organisms are *Alexandrium (Protogonyaulax) tamarense*, which was first recorded in the autumn of 1988, and *A. catenella* (Hayashi, 1989). Scallops are contaminated from May to October, and restrictions on sales of fresh meat for some localities can extend for as much as 290 days.

Treatment of used water in the Irish quarantine facility:

All water was filtered in stages down to 5μm and then treated with ultra-violet light before being used within the quarantine facility. All water introduced to the quarantine area was contained. In the unlikely event of all tanks being damaged the quarantine area had a bund to contain all spilt water so that it could then be treated in the way intended. Sterilisation of all used water was by means of an injected solution of sodium hypochlorite. Wastewater was contained within a 500 gallon drainage tank which when filled to a predetermined level activated a pump. The pump was linked to the hypochlorite injection system. The treated water was then held within a series of tanks at 250ppm chlorine before being neutralised at the point of discharge. The required treatment to destroy algal cysts is not presently known, but the precautions were considered to be adequate at the time for treatment. The tanks also acted as settlement traps and will have contained particles for longer than the minimum residence time of 40 hours. Procedures to ensure correct management of the quarantine area are laid down in Table 1.

Control of the introduction of non-native organisms

Shell fouling organisms:

There is considerable fouling of the shell surface of scallops held in hanging culture. Arakawa (1990) describes fouling in the hanging culture of the Pacific oyster, *Crassostrea gigas*, in Japanese waters. He describes 45 species that attach to the shell; the same species are likely to be found on the shell surface of scallops. In Utatsu Bay, colonial and solitary tunicates, hydroids, bryozoa and mussels were the principal fouling organisms seen. Scrubbing the shells prior to transportation can control the majority of these species.

Parasites and diseases of scallops;

First described in 1971 in Mutsu Bay in sown scallops was a rhizocephalan-like parasite to become known as *Pectenophilus ornatus* (Nagasawa *et al.,* 1988). This parasite attaches in the region of the gill or adductor muscle and is claimed to impede growth. It is presently widely distributed in Mutsu Bay and is also found on the Sanriku coast. It can infest all scallops in a locality and can result in marketing problems (Elston *et al.,* 1985). This species cannot be transferred to the F1 generation using standard quarantine procedures; all scallop parent stock will be destroyed following spawnings.

Branchial rickettsiales-like infections are known in *P. yessoensis* and *Tapes japonica* and have been implicated in myodegeneration and mortality (Elston, 1986).

Table 1. Procedure used for operating quarantine area:

1. The quarantine area was clearly indicated with a notice. Restricted regions within the compound were indicated, a health and safety statement was on display and included the following matters:
- *Labelling of electrical switches and fuses according to function.*
- *Low level warning alarm for chlorination injection system.*
- *Spring closures on hatchery doors*
- *Handwashing facilities at entry/exit point of hatchery*
- *Separate broodstock and larval culture areas*
- *Separate equipment for use with each tank*
- *Intruder alarm system*
- *An established daily opening up and closing procedure*
- *Identification and notification of trip points, wet areas, obstructions, and unguarded equipment, hazardous chemicals and sharps.*

2. Only authorised personnel were permitted entry to the hatchery, all non-operatives signed a logbook on arrival. Visitors wishing to gain access to the facility required prior approval from the proposer and the Irish Department of the Marine.

3. White coats (regularly laundered as for hospital clothing) were worn by all entering the hatchery.

4. Boots were provided for on site use in the hatchery and compound area. Separate footwear was used for work outside of the compound area.

5. Both boots were bathed in a disinfectant solution (with a colour indicator) within the footbath before entry/leaving the hatchery area.

6. Hands were washed frequently with disinfectant soap, especially after handling broodstock, or between working separate scallop bins.

7. Equipment entering or leaving the hatchery was disinfected using absolute alcohol, in a 100ppm solution of chlorine, or by being autoclaved.

8. All rubbish was regularly removed to the compound and burnt.

9. Non flammable materials were soaked in chlorine and buried.

10. All organic material (dead broodstock, larval cultures) was soaked in chlorine and buried in lime.

11. Smoking and eating within the hatchery area was not permitted.

12. The main gate to the compound perimeter fence was either kept locked or overseen.

13. Regular inspections of:
- *all running pumps*
- *Sea-water pump house for flooding*
- *chlorine and metabisulphite tanks for levels*
- *sandfilter tanks*

- *flowmeters and UV indicator lights*
- *temperature, salinity and pH in larval and broodstock tanks*

14. Working procedures:

- *Chlorine levels in the waste treatment system were measured thrice daily at points of entry to the waste tanks and at the point of discharge.*
- *Assist in the hatchery practice, under the supervision of the hatchery manager, and be familiar with the hatchery purpose and routine.*
- *A diary of observations, measurement and hatchery operations.*
- *Aquire and prepare samples of material for histological study.*

LIKELY PHYSIOLOGICAL EXPECTATIONS FOLLOWING TRANSFER

Time of spawning in Irish waters:

In Japan development of the gonad begins once sea temperatures fall below 10°C, and it is important that at least two months of temperatures below 10°C are maintained (Matsutani, pers. comm.). Sea temperatures below 10°C are found about Irish Coastal areas (Figures 6 & 7, from Irish lightship records), and those regions within shallow bays may be expected to have lower and higher temperatures, more closely corresponding to air temperatures. With a rise in sea temperature spawning commences, and lasts approximately one month with no further subsequent spawning until the following year. This is unlike the native European species, which in Irish waters have a number of spawning periods throughout the year, but principally over the period late spring to autumn. In *P. yessoensis* the time of spawning depends on the geographical locality, those farther north spawning later. Spawning at the southern end of the range, in Miyagi Prefecture, takes place in March/April (Sasaki, pers comm.) and in Posjet Bay in the Soviet Union in late May to August (Golikov & Scarlato, 1970). Expectations of spawning in Ireland would coincide with a steady rise in sea temperature in March/April.

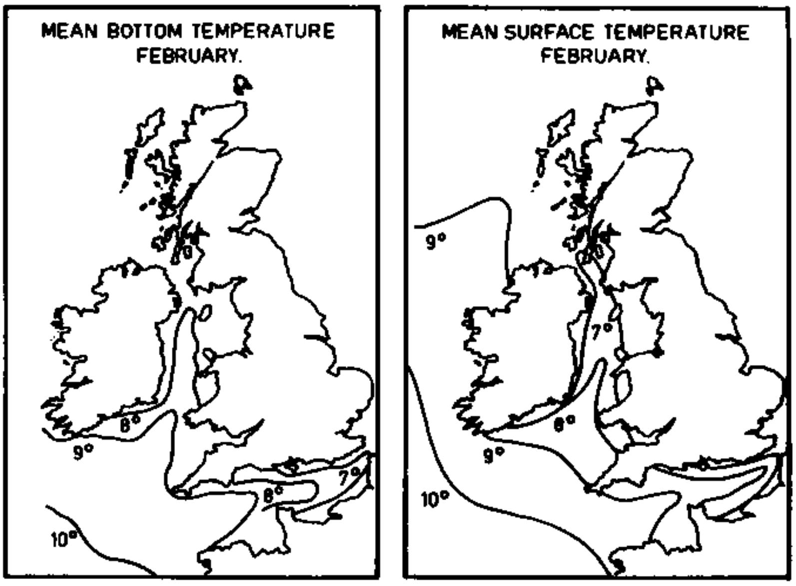

Figure 6. Mean bottom and surface sea temperatures for February about the Irish coast.

Growth of scallops in Irish waters.

The temperature for optimal growth in *P. yessoensis* is 15°C (Figure 8) and at some localities in Japan the depth of cultivation is adjusted to coincide with these temperatures (Sanders, 1973). Hanging culture on the Sanriku coast for most of the year is well suited for the growth of this species (Figure 9). Throughout the range of *P. yessoensis* in Japan there is a greater range of sea temperature, -2° to 24°C, but scallops are probably very seldom exposed to a full temperature range this great (Figure 10). It is very unlikely that sea temperatures will rise as high in Irish waters even inshore. The highest bay temperatures at the sea surface that have been measured in Ireland have been 21°C in August (Minchin, 1984). Lowest sea temperatures in Ireland are probably about 2°C in shallow bays during periods of sustained cold in late winter, and *P. yessoensis* can clearly function in Japan at these temperatures. Conditions in Irish waters would appear to be optimal for good growth rates for *P. yessoensis*.

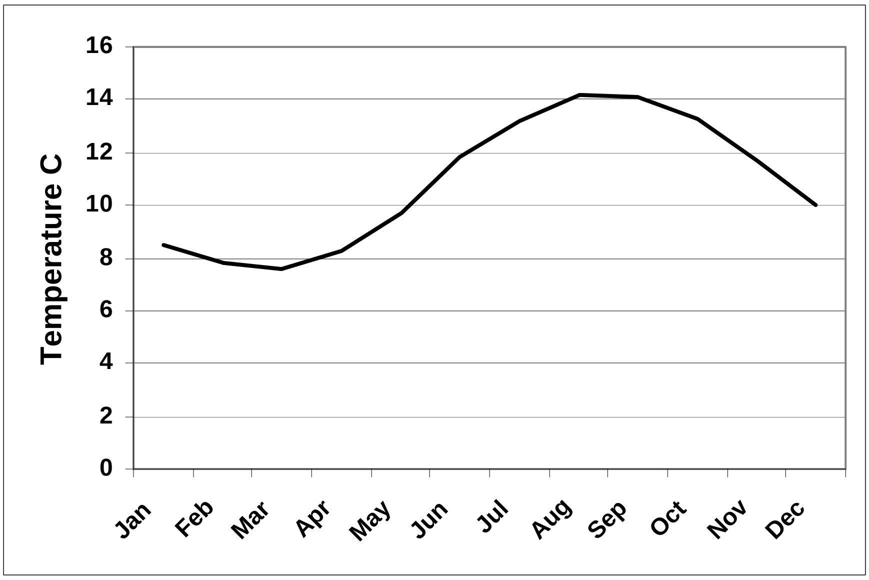

Figure 7. Mean sea surface temperature for the SE coast of Ireland close to the quarantine station at Carne, Co Wexford.

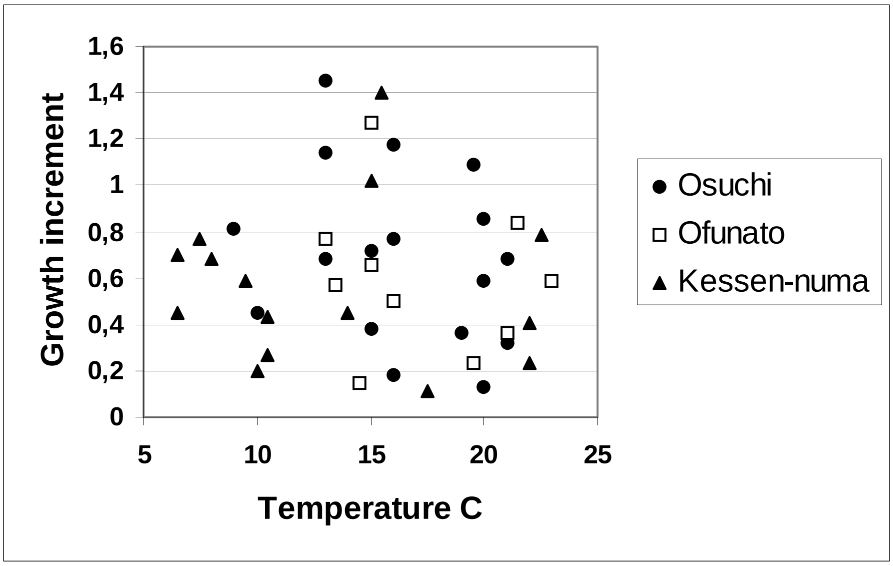

Figure 8. Optimal temperatures for the growth of *P. yessoensis* over a wide range of environmental conditions (based on Muller-Fuega & Querellou, 1973).

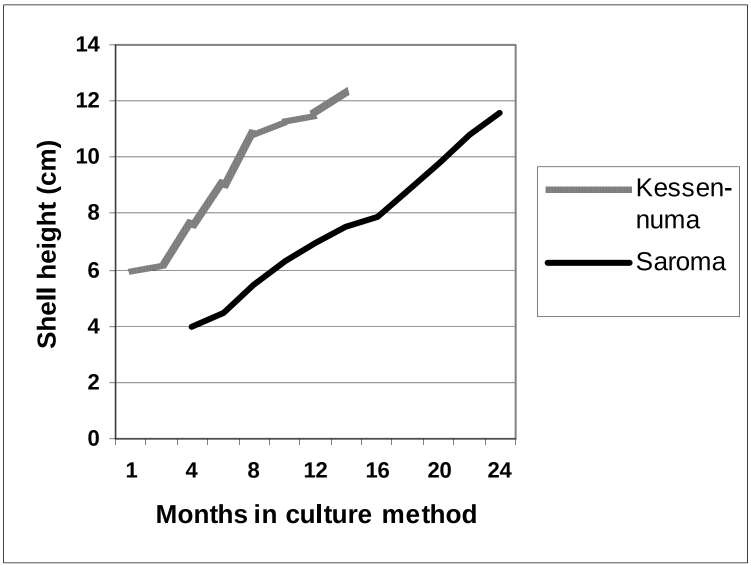

Figure 9. Full known range of growth, from ear-hanging culture (Kessen-numa Bay in Honshu – to the south) to pocket-net culture (Saroma Lake a shallow water lagoon on the north coast of Hokkaido – to the north) (provided by R. Sasaki).

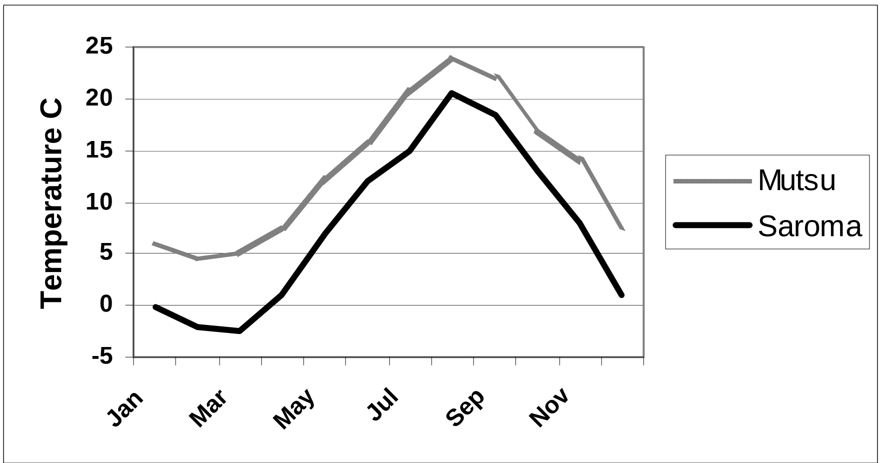

Figure 10. Sea surface temperature ranges for Mutsu Bay and Saroma Lake covering the range of the main production areas (based on Ventilla, 1982).

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BOX 1. *Pecten maximus* (L.), the great scallop, escallop, coquille Saint Jacques

Distribution: Northern Norway to the Azores, Madeira, West Africa and the western Mediterranean. Principally in areas of sandy mud to muddy sand but also occurs on muds to coarse gravels. Experimental introductions to Japan and Chile.

Depth range: Known to be exposed at low water spring tides to depths of 180m, most usually at depths of 3-45m.

Habit: Attaches at settlement with byssal threads, which can remain until about 4-13mm. Capable of swimming/recessing once 6mm. Adult scallops lie within depressions on the sea floor with sediment covering the upper valve. Can orientate to current flow.

Reproduction: A protandrous hermaphrodite spawning from late spring to early autumn. In Irish bays this is normally over the period May to September at temperatures of >13°C. A number of spawnings can take place within the same population during the year.

Larval Development: Larvae occur from April to September. Laboratory studies indicate a planktonic duration of 16-33 days at 15-20°C. Settle at 190-260μm, depending on temperature. .

Settlement: Commercial settlements known from Mulroy Bay and the West coast of Scotland. Collected on onion bag type collectors, settlement time is predicted by examining the size of larvae in the plankton. Settlement takes place June to September principally on hydroids and algae.

Growth: Exceptionally attains 215mm shell length, however, those of 180mm are considered large. Commercial size is 100mm, normally exceeding this size within three to four years. Depth, food available, sea temperature and density influence growth.

Longevity: Known to live to 22 years, most fished populations have some specimens exceeding 10 years.

Diseases and parasites: Diseased animals are seldom encountered. The coccidian, *Pseudoklossina pectinis*, has been found in scallop kidneys in France. Copepod symbionts frequent. *Odostomia* frequently associated with scallops in some populations.

Predators: The blenny *Blennius gattorugine*, anenome *Anthopleura ballii* and small sea stars feed on ‘0’ group scallops. Green crabs (*Carcinus maenas*); swimming crabs (*Liocarcinus spp.*), hermit crabs in shallow water feed on juveniles. The edible crab *(Cancer pagurus*), crawfish (*Palinurus elephas*), sea stars (*Asterias rubens, Marthasterias glacialis*) feed on adults. There is a swimming response to sea stars.

Competition and other interactions: Organotin leachates have resulted in settlement failures in some areas. Occasionally during prolonged cold winters scallops become torpid and die. Scallops can concentrate a toxin resulting in amnesic shellfish poisoning (ASP) if eaten.

Fisheries: Range from shallow bays to offshore areas. In depths of less than 5m they may be collected using a pole-net. Dredges of different designs either single light frames (in shallow water) or in gangs with heavy chain bags and sprung teeth (in deep water) are used. In some bays, where regulations permit, scallops are collected to depths of 25-30m by diving. Densities of up to $2.33m^{-2}$ are known but seldom exceed $0.6m^{-2}$ within established fisheries. Fisheries inshore normally take place during the winter and offshore during the spring and summer.

Aquaculture: Currently under development, limited by available natural spat collections. Hatchery production is small, except in France and Norway. Intensive cultivation of all later stages in cages, nets, ear hanging culture and ranching. Extensive ranching is possible but there can be extensive predation due in part to thinner shells arising from their earlier intermediate culture.

Main references: Brand *et al.* (1980); Gruffydd & Beaumont (1972); Minchin (1992); Mason (1983); Le Gall *et al.* (1988); Paul *et al.* (1981).

BOX 2. *Chlamys (Aequipecten) opercularis* (L.), the queen scallop, princess scallop, petoncle blanc.

Distribution: Northern Norway to the Mediterranean and Adriatic seas, generally ranges on the western coast of Europe from 30-70°N. Found over a wide range of sediments from muds to coarse gravels, may be found on coarser sediments than *Pecten maximus.*

Depth range: From 2 -180m, more usually 3-45m.

Habit: Can remain bysally attached to 2cm. Readily swims when disturbed. Not normally known to recess but has been found within shallow depressions, lies on the less convex valve. Can occur in large concentrations.

Reproduction: A hermaphrodite with a proximal white testis and a distal red ovary. About the Isle of Man there would appear to be two main spawnings in spring and autumn, but spawning spans over the period January to October. Spawns at temperatures 7-11°C. Probably a 'dribble' spawner.

Larval Development: Little is known of larval duration as the species is difficult to culture. Spawning requires careful management and in relation to its precise sexual cycle.

Settlement: Commercial settlements known from the west coast of Scotland. Collected on onion bag type collectors, settlement is monitored by examining plankton samples. Settlement takes place February to October principally on hydroids and algae. Settles at 210-260μm.

Growth: Attains 95mm shell height. acceptable to the market once 55mm, attaining this size in culture after 14-18 months.

Longevity: Known to live to 11 years.

Diseases and parasites: Diseased animals seldom encountered. The ciliate *Licnophora auerbachi,* has been found attached to the eyes.

Predators: Young individuals are consumed by plaice and cod, swimming crabs (*Liocarcinus spp.*), hermit crabs in shallow water; edible crab *(Cancer pagurus*). It has a swimming response to sea stars *Asterias rubens, Marthasterias glacialis*.

Competition and other interactions: Byssogenesis can be influenced by the insecticide

Endosulphan. Can occur as a significant fouling organism on fish netting resulting in hand laceration. Presence of amnesic shellfish (ASP) poisoning can influence fishing effort.

Fisheries: Principal fisheries are in The Faroes, western Scotland, Irish Sea and La Manche. Exploitation varies because sporadic recruitments can result in pulse fisheries in some regions. Can exceptionally attain densities of up to $1000m^{-2}$ on the Scottish west coast, precise measurements of 5.7^{-2} have been made. A variety of gear is used in their capture including beam trawls, spring dredges, rock hopper trawls.

Aquaculture: Cultivated in Scotland under the name 'princess scallop'. It grows rapidly to consumer size when held within suspended cages. The market is limited as the species has a relatively small meat and reproductive organ. Cultivations have been dependent on natural settlements.

Main references: Mason (1983); Paul (1980 & 1981); Broom (1976).

BOX 3. *Chlamys (Mimachlamys) varia*, variegated scallop, black scallop, petoncle noire.

Distribution: Ranges from North Sea (Denmark to Britain), Ireland, Mediterranean Sea to Senegal in west Africa. Found on coarse sediments attaching to shell, gravel, stones and bedrock.

Depth range: Attains greatest densities in shallow waters of fully marine sheltered inlets. Exposed at low water spring tides to depths of 40m, more usually occurring at depths of less than 20m.

Habit: Attaches at settlement with byssal threads, which remain throughout life. May be found within crevices, beneath stones and inside paired shell remains, often on shell banks, frequently where oysters *Ostrea edulis* naturally occur. Juveniles often cryptic.

Reproduction: A successive hermaphrodite functioning either as males or females can change sex following spawning. Spawns during May to September. Spawning is triggered by 1-2°C fluctuations, associated with spring tidal movements or prolonged periods of sunshine at temperatures exceeding 15°C. Requires 318-359 day degrees to the first spawning and 271-308 to the second spawning on the west coast of Ireland.

Larval Development: At 18°C settles after 25 days. .

Settlement: Commercial settlements of up to 50,000 spat per collector have been obtained in the Rade de Brest, France and several thousands in Lough Hyne, Ireland, in onion bag type collectors. Natural settlement takes place June to September on shells, stones and algae.

Growth: Exceptionally attains 105mm shell length, specimens of 70mm are considered large. French commercial size is 35mm, normally attained in two years.

Longevity: Known to live six years.

Diseases and parasites: Diseased animals seldom encountered. Some *Odostomia* sp. have been seen associated with adults. The ciliate *Licnophora auerbachi* is rarely found on the eyes.

Predators: Small scallops preyed upon by the blenny *Blennius gattorugine*. Juveniles fed upon by green crabs (*Carcinus maenas*) and swimming crabs (*Liocarcinus spp.*). Adults fed on by sea stars (*Marthasterias glacialis* and *Asterias rubens*) to which it has a swimming response.

Competition and other interactions: Organotin antifouling leachates have influenced larval survival in some areas.

Fisheries: Occur within shallow bays, none are known in deep water. Collected by hand picking at lowest tides or by dredges. Densities of up to 28^{-2} in Ireland and 3.2^{-2} in France.

Aquaculture: Cultivation to the adult does not presently take place due to the relatively low value of the market product. Collected spat on collectors are ranched in Rade de Brest. It is tolerant of a wide range of conditions and handling. Only experimentally produced in the hatchery.

Main references: Burnell (1991); Conan & Shafee (1978); Shafee (1980).

BOX 4. *Patinopecten (Mihuzopecten) yessoensis* (Jay), Japanese scallop, Hotategai.

Distribution: From the south Kurile Islands and southern part of the Sea of Othotsk to Sakhalin Island, North Korea, northern Japan south to Tokyo Bay and China north of 39°N. Found on a wide range of sediments but most frequent on coarse sands and fine gravels. Introductions to: Canadian Pacific and Atlantic coasts (in culture); Denmark (failed); France (in storage); Ireland (discontinued).

Depth range: 0.5 to over 50m.

Habit: Attaches at settlement with byssal threads to algae and hydroids until 6-10mm. Juveniles and adults recess in shallow depressions.

Reproduction: It is a dioecious species, spawning coincides with a rise in sea temperature following the lowest winter temperatures in Mutsu Bay. This is between March and May at temperatures of 6-8.5°C.

Larval Development: Larvae exist within the plankton 15 days at 17-19°C, 22-35 days at 7-13°C and may remain for 40 days. Larvae concentrate at different horizons at varying states of the tide and time of day. Larvae appear late March to the end of June in Mutsu Bay reaching densities of 4,600m^{-3}. They attain 230-286μm at settlement.

Settlement: Settlements greater in coastal gyres and in regions with slow flow rates. In Mutsu Bay optimum settlements in March-June, in Hokkaido from May-June, in Posyet Bay in June-July and Vostock Bay in July-September. Optimum settlements normally at 6-16m.

Growth: Sown scallops attain commercial size in 2.5-3.5 years in Mutsu Bay, longer in cooler northern regions. Can attain 6cm within a year in hanging culture and 10cm in two years. Sown scallops attain 150g in three years.

Longevity: Known to live to ten years.

Diseases and parasites: The shell boring worm *Polydora ciliata* can weaken the shell and result in severe mortalities. The copepod *Pectinophilus ornatus* infects the gills and adductor muscle and impairs growth.

Predators: In bottom culture and fisheries *Asterias amurensis* can result in up to 90% mortality. Crabs, cottid and hexagrammid fishes are predators.

Competition and other interactions: Unexplained mortalities may be due to oxygen depletion in relation to stratification of the water column, poor husbandry and high-density cultivation. Algal blooms influence the marketing of scallops due to DSP and PSP. Mortalities are known arising from sudden temperature changes and high temperatures, high turbidity, prolonged exposure in air and from storms causing strandings.

Fisheries: In Mutsu Bay the fishery was subject to pulses of abundance probably due to local hydrographic conditions. Presently most fisheries are under management by enhancement. Maximum production is 1200gm^{-2} with up to 6 scallops m^{-2} from sowings of 50-250 spat m^{--2}.

Aquaculture: Developed in 1963-64 using mesh bag collectors in Mutsu Bay and landings resulting from this rose to 47,000mt in 1974, but declined to 16,000 in 1977 due to high mortalities. With guidance from state laboratories 35,000mt were produced in 1982. This form of culture is also practised on Hokkaido, in Korea and Federated Union of Soviet States.

Main references: Aoyama (1989); Ito *et al.,* (1991); Kasyonov (1991); Ventilla (1982); Yamamoto (1977).