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Criteria for identifying the critical environmental capital of the maitime zone

A discussion paper

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CRITERIA FOR IDENTIFYING THE CRITICAL ENVIRONMENTAL CAPITAL OF THE MARITIME ZONE: A DISCUSSION PAPER

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1. INTRODUCTION

1.1 This report presents the findings of a research project undertaken for English Nature by the Centre for Environmental Interpretation, the Manchester Metropolitan University. The report provides initial suggestions for a checklist of criteria which can be used to identify the Critical Environmental Capital (CEC) of the maritime zone. This research, and the philosophy underlying the use of CEC in achieving sustainable development, is both complex and implies a fundamentally new approach to environmental management. The report does not aim to provide a comprehensive account of ways in which CEC can be identified, rather it sets out a mechanism which can be tested and modified until it is ready for practical application.

2. BACKGROUND TO SUSTAINABILITY

2.1 In June 1992, at the United Nations Conference on Environment and Development, the UK Government approved the text of *Agenda 21: Programme for Action for Sustainable Development.* In doing so, Government agreed to a framework for global and national sustainability, including the protection of coasts and the sea. This has committed the UK to "integrated management and sustainable development of coastal areas, including exclusive economic zones".

2.2 Sustainable development seeks to improve the quality of human life without undermining the quality of the natural environment. For English Nature, 'environmental sustainability' means maintaining the environment's natural qualities and characteristics and its capacity to fulfil its full range of functions, including the maintenance of biodiversity (English Nature 1994a).

2.3 English Nature believe that 'sustainability' must become an overriding objective of all economic and social activities if irreversible environmental degradation is to be avoided. To achieve this in the maritime zone, the specific environmental conditions that exist here must be recognised. The maritime zone is defined as lying between either the landward limit of specifically coastal habitats or 1 km landwards of Highest Astronomical Tide, to the limits of territorial waters. This zone is a highly complex assemblage of habitats and communities governed by a range of dynamic natural processes. Limits to management are set by our incomplete knowledge of the marine environment. Achieving sustainability in the maritime zone therefore requires an approach which takes account of a great complexity of habitats and can accommodate the inherent dynamics of the environment. This approach must work within our present range of knowledge, but should also seek to extend that knowledge whenever possible.

2.4 Identifying and protecting those elements of the environment which are critical to its continued functioning is essential to sustainable development. These elements are called the Critical Environmental Capital (CEC). To protect CEC from damage or loss requires that these areas are first identified. This report presents a number of criteria which could be used to establish whether a site in the maritime zone is

CEC or not. The criteria are presented in a simple flowchart-type checklist that is eventually intended for practical use.

3. BACKGROUND TO CEC

3.1 English Nature (EN) have carried out extensive research on sustainability and how sustainable development can be achieved. In an informal discussion paper (English Nature 1992), EN explore a new approach to planning that is guided by environmental principles and takes place within certain limits to development. The setting of these "sustainability limits" is achieved by identifying the Critical Environmental Capital, which is formally defined as "those elements of the natural environment whose loss would be **serious**, or which would be **irreplaceable**, or which would be **too difficult or expensive to replace in human timescales**." So identifying CEC is dependent on judgements about whether the loss of a part of the environment is 'serious' , and on objective assessments of what is irreplaceable through natural regeneration, or beyond our technical or financial ability to reinstate Once identified, Critical Environmental Capital should be inviolable and should not be traded against any development or environmental project.

3.2 The challenge of using CEC lies in determining which elements of the natural environment qualify and which do not. To ascertain this we need to establish what can be replaced once lost and what cannot. This can be less clear in the marine environment than on land, where our ecological knowledge and experience is much better developed. Many coastal and marine communities are specifically adapted to change in a dynamic environment, and natural re-colonisation via the medium of the sea is commonplace. These factors, together with the complex range of habitats, conditions, natural dynamics and our incomplete knowledge present a considerable challenge to marine and coastal environmental managers.

3.3 Once established, the protection of a network of CEC, together with an environmental stock of Constant Natural Assets (see 6.5), should sustain the natural dynamics of the coast and its ecology. Maintaining the ecology of the maritime zone in a healthy state will also provide scope for ecological adaptation to future phenomena such as climate change. Equally importantly, it will provide future generations with a greater range of options in the way they value and exploit the environment, perhaps in ways we cannot foresee or predict.

3.4 It is important however, to recognise the limitations of using CEC in achieving sustainability in the marine environment. Fisheries policy and water quality are the two primary factors which will dictate the state of the marine environment. If we get these right, much else will follow. These issues are highly political and require national and international action beyond the scope of CEC.

4. SOCIAL AND ECONOMIC VALUE OF CEC

4.1 There are many factors that contribute to identifying CEC, and to determining what renders a habitat or community irreplaceable. 'Irreplaceability' can be measured in ecological, earth science and technical terms. But some elements of the environment can also be irreplaceable because of the social or economic value placed on them by local communities. For example, we may be able to re-create the biological community of a grazing marsh at another site, but the original site may be irreplaceable in terms of amenity value placed on it by the local community. Likewise, inshore waters may provide grounds for local shellfish industries, and although shellfish can be farmed, the particular shellfish community may make a significant contribution to the local economy. Economic dependency on natural resources is therefore an important component of "irreplaceability", as are social factors such as access and amenity.

4.2 The brief for our research limits this report to defining CEC through ecological, earth science and technical principles. Ways in which these could be linked to other irreplaceability factors like amenity, economy and social value will need close examination in future research. The application of the checklist we suggest in this report must work in tandem with a socio-economic approach because sustainability transcends the old barriers between the science of environmental management, and social and economic considerations.

5. A PRACTICAL DEFINITION OF CEC

5.1 A practical, working definition of CEC requires us to understand what we mean by 'serious loss', and what we mean by 'irreplaceable'. Irreplaceability can objectively be defined in two ways:

* by the natural recoverability, or resilience of a habitat or community;
* by man's ability to recreate it artificially or in concert with natural processes

'Serious loss' however is a value judgement. To make this judgement as objective as possible, we have interpreted 'serious loss' to also relate to those elements of the natural environment that cannot be recreated or will not recover naturally. This results in two broad principles for defining CEC: ecological criteria related to the natural ability of a community to recover if disturbed or destroyed; and criteria relating to our ability to apply a technological solution and re-create the community or natural feature artificially. These form the basis of a set of criteria, against which habitats, communities or natural coastal features can be assessed.

5.2 For the concept of CEC to be meaningful, a timescale needs to be set within which the criteria operate. For the maritime zone, where ecological systems can be very dynamic, a timescale of 25 years is proposed - or approximately one human generation span. A 25 year period is also suggested in *This Common Inheritance* as an appropriate timescale in which to aim for and judge sustainability.

6. ASPECTS OF DEFINING CEC

6.1 The role of key species

6.1.1 The resilience of a community, or its ability to regenerate after disturbance, is influenced by the behaviour of its constituent species. It would be very time consuming to consider all the species of a community when identifying CEC, and choices need to be made as to which species should be assessed. The approach we have taken to identifying CEC is based around an assessment of the qualities of 'key species'.

6.1.2 We suggest that, in ecological terms, there are certain 'key species' present within a community which provide the ecological basis for the existence and continued functioning of that community. These species exert a measure of biological control over their community, such that their loss would cause that community to dysfunction and disintegrate.

6.1.3 We have therefore defined key species as 'biologically structuring species that are vital to the ecological integrity of communities, and whose absence would cause the community to significantly alter, dysfunction or disappear'. Examples could include fucoids, barnacles and limpets on moderately exposed rocky shores; *Zostera* in eel grass communities; sponges and soft corals in some benthic communities (see appendix I for initial lists of candidate key species). There may also be some species which qualify as key species not in their own right, but because they are in vital symbiosis with other key species.

6.1.4 Key species refer only to sessile organisms (fauna and flora) and those mobile fauna which can move around only within the boundary of their habitat. Once migratory animals (such as sea birds) are considered, the exact relationship between that species and any one site becomes extremely difficult to tie down. It is also much more difficult to assess the level of biological control these generally higher trophic species exert on any single community. More research would be needed if sea birds or sea mammals were agreed to be ecologically critical to individual sites, communities and habitats.

6.1.5 Key species are thus not necessarily rare, or endangered, or in any other form threatened. The key species of recognised community types should be identified and agreed as far as possible at a national level. The National Vegetation Classification and the Marine Nature Conservation Review will provide an important reference point for this. Account will then need to be made for local and regional variation, and we suggest key species can only finally be identified on a site by site basis. There will generally be less than 10 key species for any community. The fewer the key species the easier it will be to use the checklist, but if this approach is to be thorough key species need to be carefully and objectively selected from the outset.

6.2 Artificial habitat and community re-creation

6.2.1 In many cases, the most important criterion in defining CEC will be our ability to re-create or replace habitats, communities or natural features. A habitat may qualify as CEC because we do not have the technological or financial means to re-create it.

6.2.2 Habitat re-creation brings with it considerable technical difficulties. Habitat re-creation, especially in the marine environment, will mostly be confined to establishing environmental conditions similar to those that were present before. While it may be possible to reintroduce or transplant some species into some habitats, much will rely on natural recolonisation. It is also doubtful whether an exact replica of the previous community could ever be created, even if the conditions of the new site exactly match those of the previous site. When technical solutions can provide conditions as close to the original as possible, every effort should be made to reinstate key species - but ultimately the composition of the biological community will depend on natural processes. In determining whether a site qualifies as CEC, the best available advice on re-creatability will be needed. This will almost certainly require extra research.

6.3 Coast protection/sea defence

6.3.1 CEC assessment should also examine the role a site plays in coast protection and sea defence. Saltmarsh for example can protect considerable areas of land from incursion and flooding by the sea. The loss of flood protection following destruction of an area of saltmarsh could prove critical, and the use of artificial solutions in their place can be financially unacceptable. The checklist will help identify natural coastal features that make a critical contribution to sea defence.

6.3.2 A related criterion is the function a site performs in natural coastal processes such as sediment transport, erosion and accretion. We propose the checklist should determine whether the loss of a site would cause significant deterioration elsewhere on the coast (leading to loss of natural sea defence and consequent flooding) and whether it would be possible to maintain this process artificially - for example by beach replenishment.

6.4 Financial considerations

6.4.1 The financial feasibility of habitat re-creation or engineered coast defence is important to recognise for both pragmatic reasons, and because of its inclusion in the original definition of CEC . The checklist therefore includes questions relating to financial feasibility. These must be put to the relevant funding bodies, and clearly there is an issue of responsibility - for example, should developers pay, or should public money be made available. There will be immediate project costs to be met, plus in many cases a management and monitoring commitment.

6.4.2 The financial acceptability of re-creating habitats or replacing natural coast protection with engineered solutions should therefore be assessed when identifying CEC. Formal guidelines will be required for those assessing CEC on whom to approach for answers to financial questions.

6.4.3 Financial criteria may be difficult to apply, but they need to be recognised as valid. It could be possible to broadly take account of them in other ways (such as through reference to national Government policy on coast protection/sea defence), in which case they could be removed from the checklist assessment of individual sites.

6.5 CEC and Constant Natural Assets

6.5.1 CEC is the most important classification of sites used to set limits to development - habitats, communities or features that cannot regenerate themselves or cannot be replaced once lost. There is also a second classification of sites of sub-critical importance. These communities, habitats and features are defined as Constant Natural Assets (CNA). CNA are those elements of the environment which individually can be sacrificed for development so long as compensatory action of equal worth is taken. These items are 'tradeable' against development and must be replaced if lost. A constant 'pool' of environmental resources (CNA) is thus maintained, within which individual items can be won and lost in equal measure.

6.6 Level of application of CEC

6.6.1 We consider that CEC can best be applied at a single habitat or community level. Setting boundaries of areas to be assessed for CEC will not always be clear-cut, but we believe individual communities or habitats provide the most convenient units for assessment, providing a less complex subject than larger sites covering several contiguous habitats or communities. For example, in an estuary individual areas of saltmarsh or mud flat could be assessed for CEC, rather than the entire estuary as single unit. Ecological transition zones present difficulties, and in this instance the two communities either side could be assessed for CEC. If the two communities are identified as CEC then the transition between them should also be protected.

6.6.2 We recognise there will be difficulties in accommodating the natural variation of communities within a single habitat. For example, within a saltmarsh, creek edges often have markedly different communities than the marsh flat, and there is also a transition from lower to upper marsh communities. It may never be possible to re-create the rich variety of all these communities within this habitat, but the major saltmarsh flat communities are more likely to be re-creatable, and in time the associated fringe communities and transitions may regenerate. Whoever assesses each site will need to decide on the importance of fringe communities, and then include them in the assessment as appropriate. This may need additional guidance from English Nature.

6.6.3 English Nature have provided an initial broad classification of habitats in the maritime zone into 20 nationally recognised types (Appendix 1). These could be adapted and refined according to regional variation in species' distribution.

6.6.3 We suggest this checklist is tested on these broad habitat types to identify potential candidate maritime zone communities. This could help to target and prioritise CEC assessment locally. We believe, however, that CEC can only be finally identified at a local level and within a local context.

6.7 Present and future value

6.7.1 We consider that CEC should generally be assessed on a site's present conditions and not on its potential future value. By definition, CEC is not creatable within a 25 year period. Where communities or habitats are degraded but offer a chance for reinstatement in future, CEC status must be withheld until the qualifying conditions are reached. Provision should therefore be made to re-evaluate CEC on a long-term basis, possibly on a 25 to 50 year timescale.

6.7.2 A possible exception is the role certain habitats may play in coastal defence. Given the threat of sea level rise, habitats such as salt marsh and grazing marsh have value for their potential future contribution to sea defence, even though they may not actually perform this role to a significant degree at present. Where natural processes are concerned, potential future roles in sea defence/coast protection could be considered as a qualifying criterion of CEC.

6.8 Relation to existing designations/notifications

6.8.1 Defining CEC is wholly independent of all existing designations and notifications. Although some argue that SSSIs and NNRs should automatically form part of CEC, we believe CEC should be assessed independently, and that <u>irreplaceability</u> should be used as **the** fundamental criterion of assessment. SSSIs and NNRs have historically been identified for nature and geological conservation, using broader criteria; whereas CEC is identified as a sustainability limit based on replaceability and uses purely ecological and technical criteria. It is important to recognise that nature conservation and ecology are not the same.

6.8.2 In sustainable development terms, we suggest it is the overall ecological health and earth science interest of the maritime zone that must be protected. An ecological community or geological exposure may be replaceable whether it is part of an SSSI or not. CEC and SSSIs should operate in tandem and may be mutually reinforcing (preserving biodiversity is the most important contribution of SSSIs and NNRs).

7. HOW CRITICAL ENVIRONMENTAL CAPITAL CAN BE APPLIED

7.1 Using a checklist of criteria, CEC can be identified by site managers or others with access to the relevant information. CEC is a tool that aids decision-making, and can be used both in a reactive way in response to threat, and in a pro-active way in resource planning.

7.2 CEC evaluation could, for example, feed into the environmental assessment process when new development is proposed, and could help inform the byelaw-making process. CEC may become a standard component of coastal and estuary management planning, and could be used by English Nature or any other agent responsible for managing the maritime zone.

7.3 English Nature have already taken the concept of CEC forward in their informal discussion paper (English Nature 1992), which contains suggestions on how the concept could be applied to the planning system. CEC could provide a basis for informed coastal planning, possibly resulting in a classification of the coast and limits to use.

7.4 English Nature propose that an initial desk study could be carried out to assess CEC on a national scale. This could be followed by more detailed regional assessment of sites, based on regional habitat classifications and incorporating regional variations. It may however prove difficult to identify particular habitats or communities as CEC on a national scale because CEC is largely dependent on its local or regional context.

7.5 The assessment of CEC will also point to future research. This research must be focused on those problems that are directly relevant to determining CEC - particularly on the 're-creatability' of specific maritime communities and habitats.

8. THE CHECKLIST OF CRITERIA

8.1 We have set out our checklist of criteria for assessing CEC in simple, easy-to-follow flowcharts. The flowcharts proceed through a series of questions about the site being assessed. These questions must be answered either yes or no, and lead on to either another question, or identify the subject as being CEC or not CEC. There is no ranking of criteria in terms of importance, nor is there a cumulative principle of classification, so that a site automatically becomes CEC as soon as it qualifies under a single heading. It is very important to consider the questions carefully, and to answer them correctly with as much informed advice as possible.

8.2 It will not be possible to answer some of the questions for some communities and habitats. In this instance, we recommend that expert advice be sought, and ultimately the precautionary principle should be applied. Guidance on the course to follow when questions are unanswerable will be needed. In may be that the identification of CEC will at some point in future be challenged in court. Identification will therefore need to be as thorough as possible.

9. THE CRITERIA

9.1 This section of the report sets out and explains the individual questions from the draft checklist. The checklist should be rigorously tested and will need refinement. We are aware of many potential criticisms that can be made in what is a vastly complex subject, but the purpose of this paper is to provide a starting point. Our main concern has been to rationalise and simplify the criteria and checklist as far as possible - with its end use primarily in mind. Some of the following questions relate directly to the preceding one, whilst others stand alone. This section should be read alongside the checklist flowcharts for reference, and to see how the questions relate to each other.

9.2 Species reproduction

The following criteria are centred on the life cycle of key species, and consider factors such as longevity, reproductive rate and population trends.

9.2.1 <u>What key species are present on site?</u>

This question establishes the key species of the site under assessment. An initial list of suggested key species has been produced for 20 broad maritime habitats. These are given in Appendix 2 and should be used for guidance only. Regional and local variation in species' distribution and habitat types should always be taken into consideration.

9.2.2 <u>Are any key species long-lived (25 years +)?</u>

Key species with life cycles greater than the 25 year timescale for assessing CEC should be identified.

9.2.3 <u>Do these species have reproductive rates such that generational turnover is 25 years or more?</u>

Key species with a long life span and slow generational turnover automatically qualify for CEC because they cannot be replaced within 25 years. This could include sea fans and corals for example.

9.2.4 <u>Is the population trend of any key species declining?</u>

Declining population trends for any key species is cause for concern. If a declining key species is lost from a site, this could have implications for the wider population as a whole. When identifying CEC it is important to consider the wider implications of potential loss of key species. We suggest that further discussion is needed on whether regional, national or international population data are most appropriate to this question. We believe regional trends are likely to be more important in ecological terms.

9.2.5 Can this decline be halted and reversed by human intervention?

If the population decline of key species can be reversed by human intervention then the site which supports them would not qualify as CEC. If the decline is likely to continue unchecked then the site is CEC. But for some species data on long-term population trends may not be available, or it may be difficult to distinguish genuine decline from cyclical behaviour with subsequent troughs and peak. Expert advice should be taken when considering population trends, and informed judgement should form the basis of decisions where data are unavailable. It may often be necessary to assume that decline will not be reversed - in accordance with the precautionary principal. Only when clear evidence is available that a declining population of key species is being recognised and action taken or planned to reverse it should this question be answered as non-CEC.

9.3 Species physical sensitivity

Different key species react differently to physical disturbance. Where species are also habitat-specific, physical disturbance of their habitat site is likely to have a greater long-term effect on population levels than for more generalist, opportunist species..

The JNCC Marine Unit are currently working on 'sensitivity tagging' different communities to different types of disturbance, and are taking individual species into consideration. Making available 'sensitivity indices' for key species and habitat types would be an obvious advantage to identifying CEC.

9.3.1 Are any key species habitat-specific?

Species are habitat-specific when they require specific conditions and certain environmental parameters in which to exist. Examples could include water quality, salinity, exposure to air or the presence of other biota as specific prey or symbiotes. Key species that are not habitat specific will not depend on any one site for their continued population fitness.

9.3.2 Are any of these key species particularly sensitive to physical damage, disturbance or pollution?

Some key species may be especially sensitive to physical damage, disturbance and pollution. Some species are extremely fragile and highly vulnerable to physical damage, such as sea fans and corals. Others are highly sensitive to pollution or disturbance. High sensitivity of key species means a site is more likely to qualify as CEC.

9.3.3 If the site is threatened by these impacts, could human intervention make good the resulting damage?

In identifying CEC, sensitivity and fragility only matter where there is a threat to a particular community or key species. If the community contains habitat-specific species that are sensitive to changing conditions, a reduction in environmental quality is likely to have an adverse effect. This should take into account those changes that do not occur directly on the site, but have an influence from further afield. Where it is not possible to make good the resulting damage the affected community or site should be classified as CEC.

[In practical terms, this may mean for example that a development with potential to cause critical pollution effects in key species in adjacent CEC should be opposed, when the site has been classified as CEC under this criterion.]

9.4 Island biogeography

Island biogeography is an ecological concept relating to the isolation of biological communities from one-another. The recolonisation of a disturbed community is dependant on the transfer of individuals from the nearest neighbouring colony. Whether this can happen or not is a function both of distance from the source of colonisation, and of the species' dispersal capacities. In the marine environment many organisms use water-borne propagules dispersed by current to spread their population, which can make it difficult to establish dispersal ranges.

These questions test the ability of key species to recolonise the site from the nearest neighbouring source. If they cannot, and we cannot apply a technical solution, the site qualifies as CEC.

9.4.1 Are any key species at the site isolated by physical space or barriers from their nearest neighbouring colony?

Recolonisation will only be a problem where a degree of isolation exists from the nearest neighbouring community.

9.4.2 Are those barriers impenetrable, or, is the nearest neighbouring source of recolonisation beyond the normal dispersal range of these key species?

Impenetrable barriers to recolonisation can be created by a distance greater than the normal dispersal range of the species, or by interjection of unsuitable environmental conditions, such as pollution, physical barriers or more subtle temperature or salinity changes.

If the nearest source of recolonisation is beyond the dispersal range, the key species will again be unable to recolonise the site.

9.4.3 Could recolonisation of key species be achieved by human intervention (technically and financially)?

In some cases it may be possible to artificially recolonise a site through transplantation, re-seeding, or releasing captive reared fauna. If a technical solution is not available for a biogeographically isolated site then it qualifies as CEC.

9.5 Earth science criteria

9.5.1 These criteria firstly test whether the role a coastal site plays in coast protection/sea defence is critical and cannot be substituted for by financially acceptable engineered solutions. The criteria take into account both present and potential future conditions, because given the threat of sea level rise certain sites may play a significant future role in coastal defence where they do not at present. These criteria also consider the role a site may play in maintaining coastal processes over a larger area through sediment transport. Defining CEC under these criteria is dependent on our technical ability to replace natural sea defence with engineered solutions, and our willingness to meet the financial cost of this work.

9.5.2 Does the site contain features that do or can potentially make a significant contribution to coast protection and sea defence?

This question establishes whether the site contributes to coast protection/sea defence at the current time or potentially in future; and whether this contribution is significant. What is or is not significant needs further definition, but we suggest it would relate to some critical role whereby the loss of the natural feature would lead to flooding and damage to land and property deemed worth protecting under national policy guidance.

9.5.3 Would it be technically and financially feasible to replace these natural features with engineered coast protection/sea defence?

If it is not feasible to substitute the natural contribution of a site to coast protection with artificial solutions, then the site qualifies as CEC. There is also an increasing recognition of the use of 'soft engineering' solutions to coastal defence problems. Saltmarsh and grazing marsh re-creation is being tested, and may sometimes provide cost-effective alternatives to 'hard engineering' on the coast. Estimating costs of providing alternative sea defences may be difficult, both for 'soft' and 'hard' solutions, and efforts need to be made to make these as accurate as possible.

9.5.4 Does the site play a significant role in natural coastal processes?

This question establishes whether the loss of the site would cause significant knock-on effects. Again a precise definition is needed of what would or would not be 'significant'.

9.5.5 Would it be technically and financially feasible to maintain these processes at the site artificially?

Defining CEC in this case again becomes a question of technological process and cost. While engineering solutions would appear feasible in many cases, the financial and political impacts of such a decision also need to be considered.

9.6 Technological factors

9.6.1 Where natural recolonisation or restoration of key species appear impossible, a technical solution may provide an alternative. The example of saltmarsh re-creation on Northey Island on the Blackwater Estuary in Essex has shown that it is possible to re-create this particular habitat. Re-creation is fraught with difficulty, and in many cases will be confined to re-establishing similar environmental conditions rather than installing relevant biota.

9.6.2 Should the site be destroyed, could the conditions that existed previously be reinstated/recreated at the same site, or at another available site in the same natural area - within a 25 year period?

This question establishes whether it is technically possible to re-create the conditions to support the habitat/community that has been lost. The habitat does not necessarily need to be re-created at the same site, but for macro-ecological reasons should be installed within the same 'natural area'.

9.6.3 Would key species be able to recolonise the site naturally? (refer to biogeography criteria)

If the right conditions can be created and the key species will recolonise unaided, the habitat and community is not irreplaceable and does not qualify as CEC.

9.6.4 Is it technically and financially feasible to restore key species at the same or an alternative site within a 25 year period?

Again, if it is possible through human intervention to restore key species to a site, then the community is replaceable and does not qualify as CEC. Habitat and community re-creation is a relatively new field and has only been successfully demonstrated in relatively few instances. These are largely confined to terrestrial areas such as salt and grazing marshes, although reef creation has also been demonstrated in the sub-tidal environment. Answering this question will require expert advice on the likely success of any restoration scheme, especially for those habitats yet to be (re-)created.

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 The concept of CEC could provide a practical basis for setting environmental limits to development. This research provides an initial checklist of criteria to assess whether components of the maritime zone should be classified as CEC or not.

10.2 The checklist will need further refinement and rigorous testing before it can be applied in the field. We have tried to promote an approach which is not too-complex and is capable of practical application.

10.3 We recognise the scope of our research has been fairly narrow. We wish to highlight the need to possibly incorporate assessments of the 'replaceability' of sites of nature conservation and earth science interest, landscape, amenity and economic value in identifying CEC. These are value judgements which we have avoided at this stage. CEC may or may not eventually encompass these, but the philosophy and practicality of their inclusion will need to be fully considered.

10.4 We recommend that further research is needed to assess the feasibility of habitat creation and restoration in the maritime zone. Guidance and contacts should also be provided to checklist users on sources of advice and existing data to help answer the checklist questions. It would be appropriate, for example, to compile all relevant ecological and earth science data on key species' population trends, reproductive behaviour, and coastal processes.

10.5 Our work poses a number of unanswered questions which would need to be addressed, such as 'what is a significant contribution to sea defence?' These are highlighted in the report.

10.6 The key species outlined in the report refer only to sessile organisms (fauna and flora) and those mobile fauna which can move around only within the boundary of their habitat. Once migratory animals (such as sea birds) are considered, the exact relationship between that species and any one site becomes extremely difficult to tie down. It is also much more difficult to assess the level of biological control these generally higher trophic species exert on any single community. The incorporation of sea birds and marine mammals into this checklist would need further discussion by specialist ecologists.

10.7 The approach outlined in this paper is universal and can be used by anyone with access to relevant information. We suggest a user's guide could provide the best means of promoting the checklist, and that workshops and training courses might also be necessary.

10.8 Taking the concept of CEC forward will rely on its potential ability to act as a sustainability limit for areas under development pressure. Deciding what constitutes CEC is only a first step - more crucial than that will be our ability to use that knowledge to ensure development and our use of the environment is sustainable.

11. ACKNOWLEDGEMENTS

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GLOSSARY OF TERMS

Island Biogeography

Island biogeography is a concept relating to the ecological isolation and distribution of 'island' communities. While it can literally refer to islands surrounded by water, it more often applies to 'islands' of habitat isolated from other areas by a 'sea' of unsuitable habitat. Woodlands separated by extensive wheat fields are a good example.

Constant Natural Assets (CNA)

Constant Natural Assets are those elements of the environment which individually can be sacrificed for development so long as they are replaced by compensatory action of equal worth. Unlike CEC, these elements are tradeable against development, provided there is no net loss of the resource and the overall pool of CNA is maintained.

Critical Environmental Capital (CEC)

CEC is defined as 'those elements of the natural environment whose loss would be serious, or which would be irreplaceable, or which would be too difficult or expensive to replace in human timescales.'

Key species

Key species are those species that, in ecological terms, provide the ecological basis for the existence and continued functioning of a community. We have defined key species as 'biologically structuring species that are vital to the ecological integrity of communities, and whose absence would cause the community to significantly alter, dysfunction or disappear'. Key species thus are not necessarily rare, or endangered, or in any other form threatened.

Natural areas

Natural areas are geographically defined areas delineated by a set of common features. They are usually determined by a combination of physical landscape characteristics, ecology and social factors, such as sense of community and 'belonging'. Natural areas are in many ways analogous to 'coastal cells', which divide the coast into 'Natural Maritime Areas'. These can provide convenient units for management.

Natural processes

Natural processes are those coastal phenomena such as sediment transport, erosion and accretion responsible for shaping the coast and underpin its dynamic qualities. It refers to geological/earth science processes only.

Appendix 1 Initial habitat breakdown and suggested key species/taxa for the maritime zone (common names are given where appropriate). This list is not intended to be exhaustive and will need to be adapted to suit the particular locality.

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1. Brackish Lagoons

The following species are characteristic:

Cerastoderma glaucum	cockle
Hydrobia ventrosa, Hydrobia neglecta	mudsnail
Clavopsella navis	hydroid
Edwardsia ivelli	sea anemone
Armandia cirrhosa	saline lagoon polychaete
Alkmaria romijni	polychaete
Gammarus insensibilis	amphipod
Littorina saxatilis lagunae	winkle
Victorella pavida	bryozoan
Zostera spp.	Eel grass
Ruppia spp.	Tassle weed
Potomageton spp.	
Phragmites australis	Common reed
Laminaria saccharina	Kelp
Filamentous green algae	

2. Chalk cliffs

Chalk cliffs are characterized by typical algae assemblages that are found at different sites. Some species only occur on chalk cliffs and need to be identified.

Piddocks/*Polydora*
Blidingia spp.
Chrysophyceae
Others as for intertidal rock

3. Dune wetlands

Primary vegetation of slacks:

Salix repens	Creeping willow
Holcus lanatus	Yorkshire fog
Potentilla anserina	Silverweed
Carex nigra	Common sedge
Carex flacca	Glaucous sedge

Hydrocotyle vulgaris	Marsh pennywort
Calliergon cuspidatum	Moss

plus animal species that keep these in check.

4. Coastal dunes

Primary vegetation:

Ammophilia arenaria	Marram grass
Elymus juncea	Sand sea couch
Leymus arenarius (northern)	Lyme grass
Festuca rubra	Red fescue
Carex arenaria	Sand sedge
Galium verum (calc.)	Lady's bedstraw
Galium saxatile (acid.)	Heath bedstraw
Agrostis capillaris	Common Bent
Tortula ruralis ruralis	Moss
Oryctolagus cuniculus	Rabbit
Hippophae rhamnoides	Sea buckthorn

5. Hard cliffs

Includes ledges.

Brassica oleracea	Wild cabbage
Armeria maritima	Thrift
Crithmum maritimum	Rock samphire
Spergularia maritima	Sea spurrey
Festuca rubra	Red fescue
Beta vulgaris	Sea beet
Atriplex hastata	Hastate orache
Stellaria media	Chickweed
Verrucaria maura	Black lichen
Yellow and grey lichens	

including the animal species that keep them in check.

6. Intertidal reefs (biogenic reefs)

Epiflora and epifauna and the species that keep them in check.

Particular species:

Sabellaria alveolata	
Mytilus edulis	mussel

7. **Intertidal sand and mud flats**

Epiflora and epifauna and the species that keep them in check, in particular:

Zostera spp.
Polychaetes (eg. *Lanice conchilega, Arenicola marina, Hediste diversicolor, Nephtys* spp.)
Amphipods (eg. *Talitrus saltator, Bathyporeia* spp.)
Bivalves (eg. *Scrobicularia plana, Macoma balthica, Cerastoderma edule*)

8. **Maerl**

Component species of maerl itself:

Phymatolithon calcareum
Lithothamnion coralloides
Lithothamnion glaciale
Lithophyllum dentatum
Lithophyllum duckeri
Lithophyllum fasciculatum
Lithophyllum hibernicum

9. **Maritime grassland (cliff tops and slopes)**

Primary vegetation which constitute the grasslands and the species that graze them, in particular:

Armeria maritima	Thrift
Festuca rubra	Red fescue
Holcus lanatus	Yorkshire fog
Daucus carota gummifer	Wild carrot
Plantago lanceolota	Ribwort plantain
Plantago maritima	Sea plantain
Plantago coronopus	Buck's horn plantain
Dactylis glomerata	Cocksfoot
Lotus corniculatus	Bird's foot trefoil
Hyacinthoides non-scripta	Bluebell
Prunus spinosa	Blackthorn
Pteridium aquilinium	Bracken

10. **Pelagic habitats**

Planktonic species, including phytoplankton, zooplankton and fish.

11. Rocky intertidal

Species that constitute sessile epifauna, and the species that keep them in check, in particular:

Fucoid algae (*Pelvetia canaliculata, Fucus spiralis, Fucus vesiculosus, Fucus serratus, Ascophyllum nodosum*)
Barnacles (*Semibalanus balanoides, Chthamalus* spp.)
Encrusting coralline algae
Limpets (*Patella* spp.)
Mytilus edulis
Laminaria digitata
Alaria esculenta
Himanthalia elongata
Red algal turfs

12. Rocky subtidal

Kelps (*Laminaria hyperborea, Laminaria saccharina, Laminaria digitata, Alaria esculenta*)
Echinus esculentus
Chitons
Encrusting coralline algae
Gastropod molluscs
Red algal turfs
Sponges (*eg Halichondria, Pachymatisma, Myxilla incrustans*)
Ascidians (*eg Dendrodoa, Morchellium, Clavelina*)
Hydroids (*eg Kirchenpaueria, Plumularia, Tubularia, Nemertesia*)
Encrusting and branching bryozoans (*eg Flustra foliacea, Pentapora foliacea*)
Anthozoans (*eg Alcyonium digitatum, Metridium senile*)
Brittle stars

13. Saltmarsh (not grazing marsh)

Primary vegetation and its grazers, in particular:

Spartina anglica	Common cord grass
Salicornia spp.	Glasswort
Aster tripolium	Sea aster
Puccinellia maritima	Common saltmarsh grass
Atriplex portulacoides	Sea purslaine
Limonium vulgare	Sea lavender
Juncus gerardii	Saltmarsh rush
Juncus maritimus	Sea rush
Elytrigia atherica	Sea couch
Suaeda maritima	Annual sea blite

14. Shingle structures

Only opportunistic species present, focus on primary vegetation and its grazers. In particular:

Crambe maritima	Sea kale
Rumex crispus	Curled dock
Glaucium flavum	Yellow horned poppy
Silene uniflora	Sea campion
Tripleurospermum maritimum	Scentless chamomile
Festuca rubra	Red fescue
Cladonia furcata	Lichen
Prunus spinosa	Blackthorn
Gammarid amphipods	

15. Strandlines

Mainly mobile detritivore species and primary vegetation, in particular:

Beta maritima	Sea beet
Honkenya peploides	Sea sandwort
Atriplex hastata	Hastate orache
Crambe maritima	Sea kale
Talitrus saltator	
Enchytraid oligochaetes	

16. Subtidal reefs (biogenic reefs)

Mainly sessile epifauna and flora and the species that keep them in check. In particular:

Modiolus modiolus
Sabellaria spinulosa
Serpula vermicularis

17. Subtidal sand and mud

Mainly infaunal species, in particular:

Zostera marina
Echinocardium cordatum - Ensis siliqua
Bivalves (*eg Spisula elliptica, Abra alba, Mya spp, Macoma balthica, Angulus tenuis*)
Amphiura filiformis

18. Subtidal shingle and gravel

Mainly mobile epifauna. In particular:

Modiolus modiolus
Opthiothrix fragilis - Ophiocomina nigra
Venerupis senegalensis
Mya truncata

19. Unprotected soft cliffs

Mainly primary vegetation and dominant infauna, in particular:

Tussilago farfara	Coltsfoot
Phragmites australis	Common reed
Festuca rubra	Red fescue
Festuca ovina	Sheep's fescue
Daucus carota gummifer	Wild carrot
Carex arenaria	Sand sedge
Arrenatherum elatius	Oat grass
Ligustrum vulgare	Privet
Clematis vitalba	Old man's beard
Rubus fructicosus agg.	Bramble

20. Zostera beds

Constituent species of eel grass.

Appendix 2 Checklist of criteria for identifying CEC in the maritime zone

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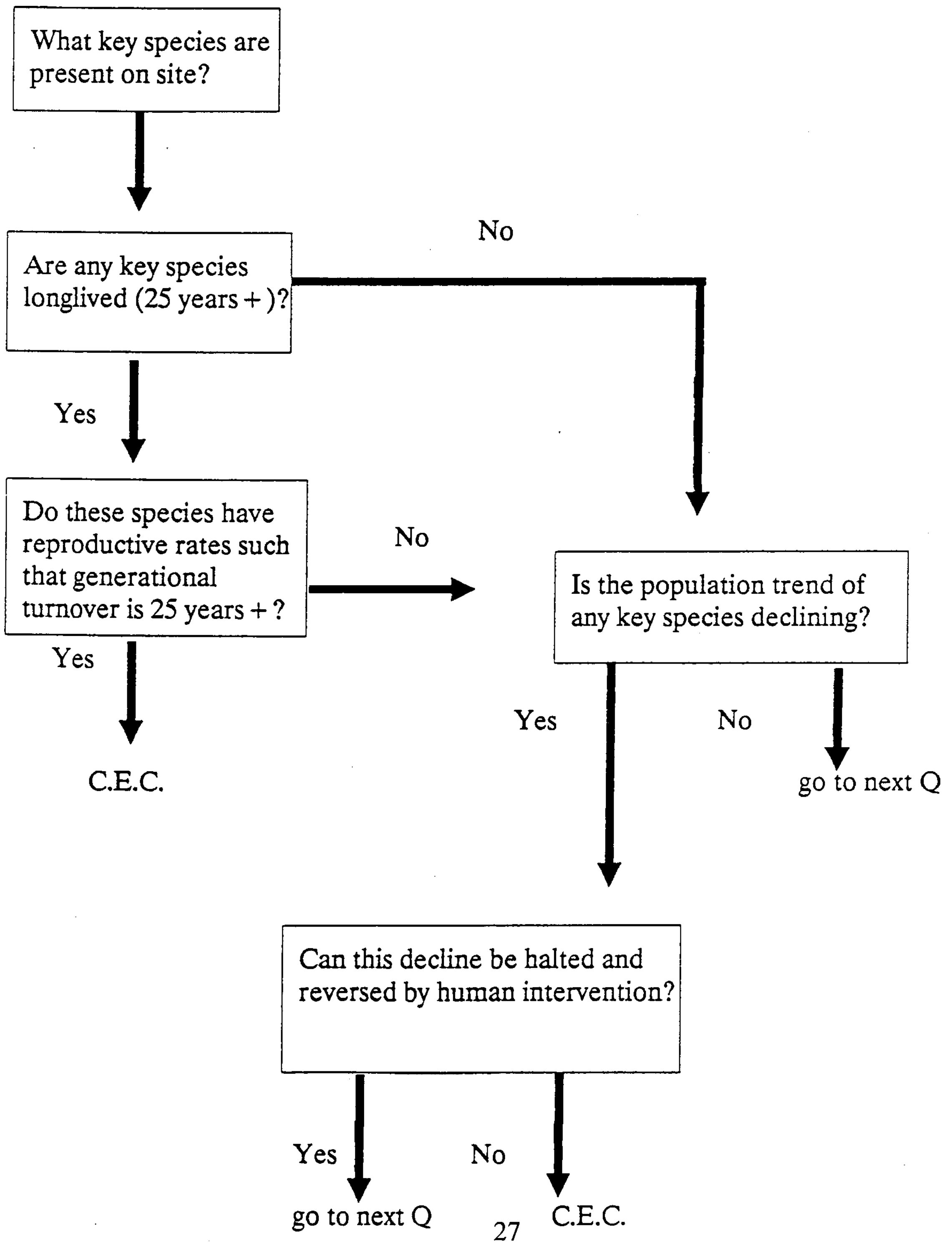
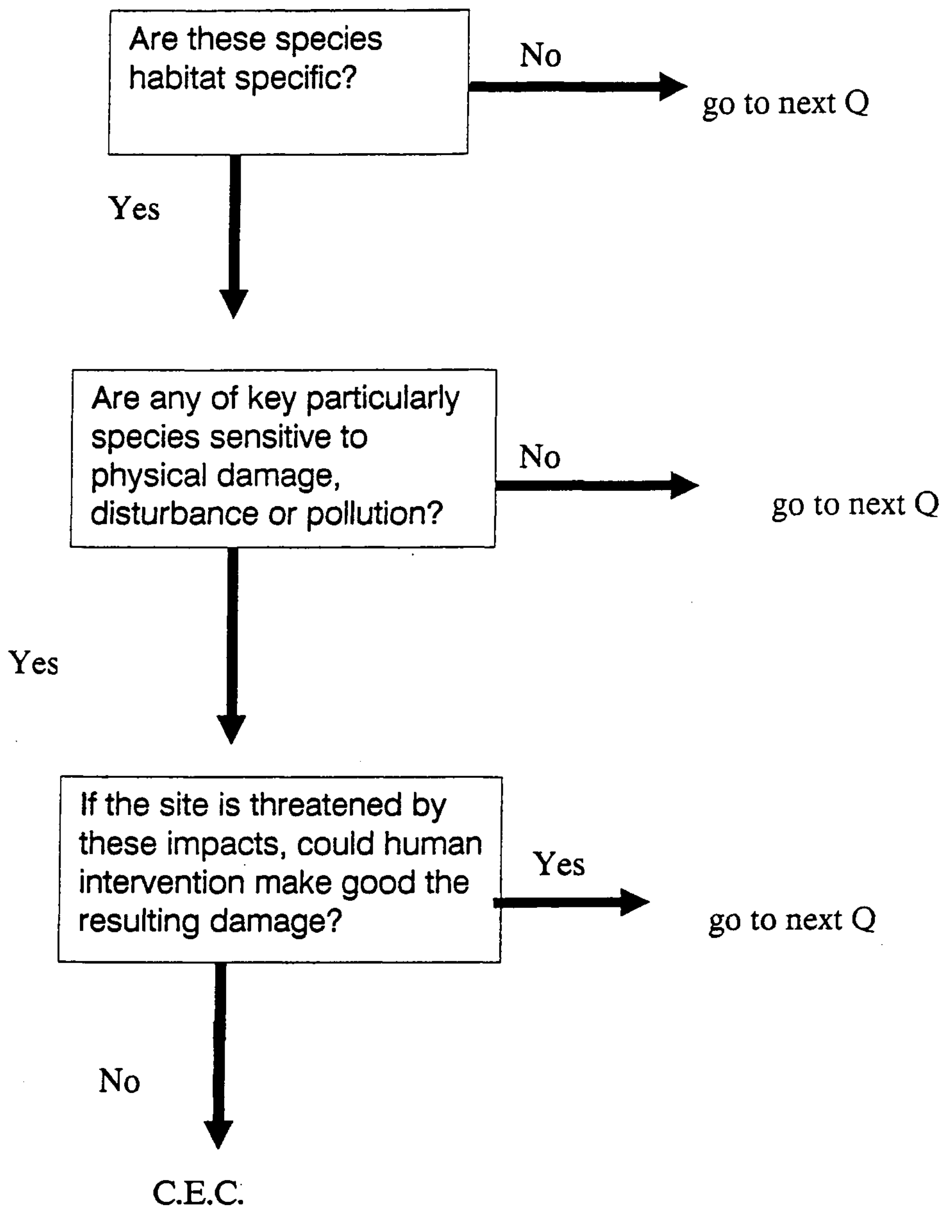
Species reproduction

These questions tests the ability of key species to regenerate and reproduce themselves.



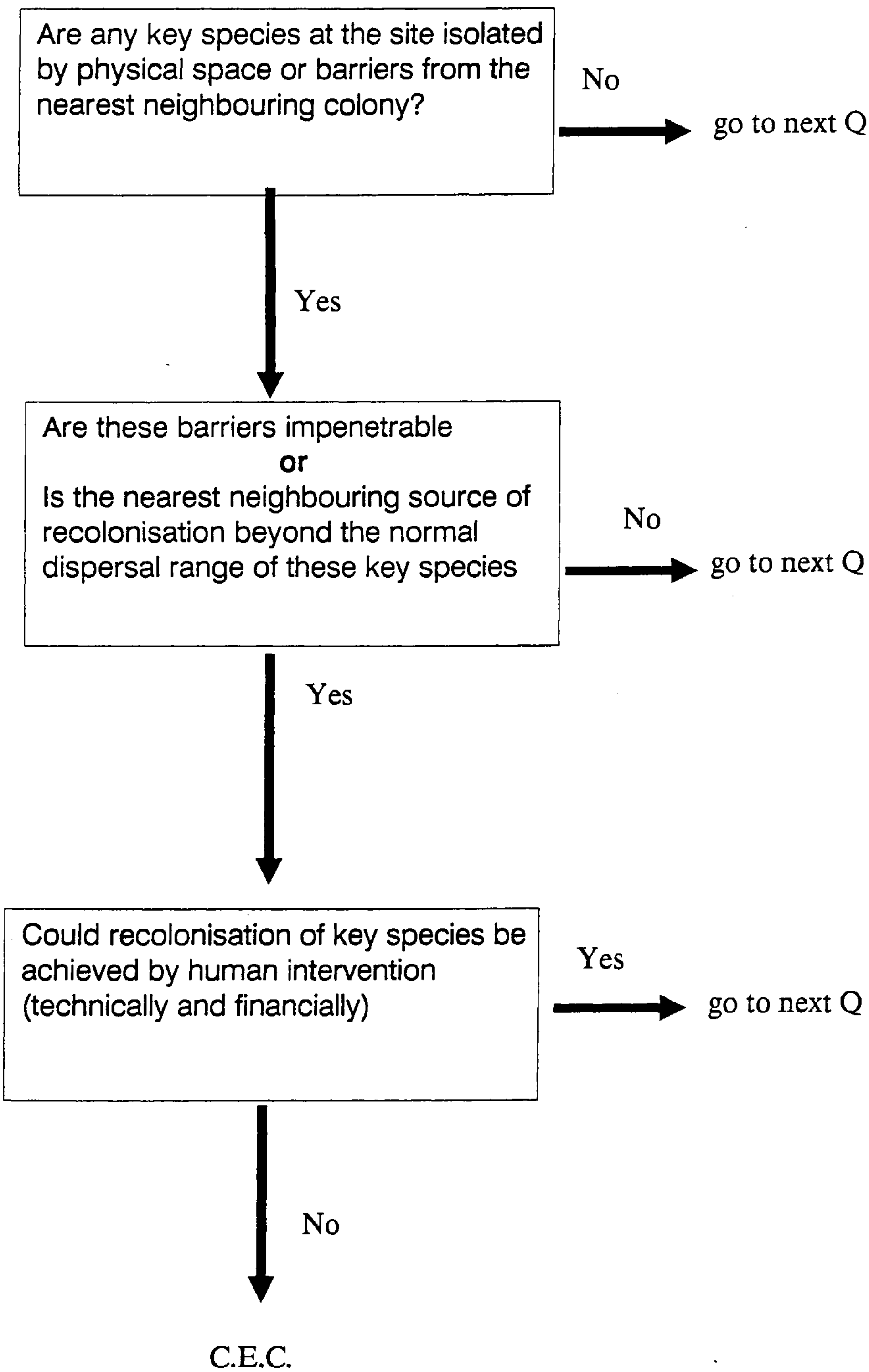
Species physical sensitivity

This page addresses the sensitivity of key species to physical disturbance, and the effect this may have on their fitness.



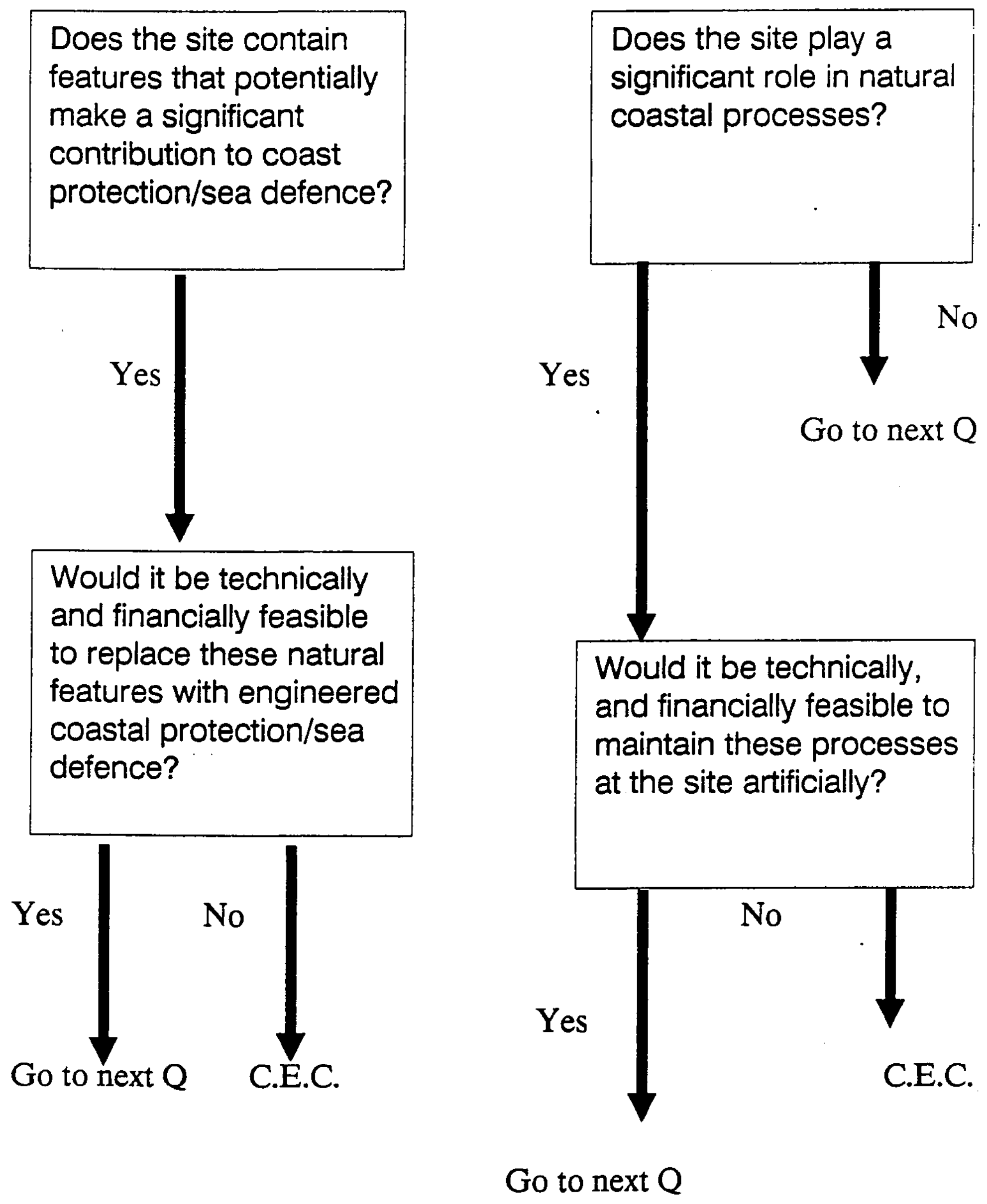
Island biogeography

These criteria relate to the ability of key species to (re)colonise a site



Natural Processes

These criteria relate to the role a site may play in coastal processes, in earth science interest, or coastal defence.



Technological factors : ecological restoration

These criteria consider whether it is technically and financially possible to restore a natural habitat/community artificially.