Impacts of climate change on seabed wildlife in Scotland

Communities of sea anemones, lamp shells, fan worms and sea squirts, characteristic of sea lochs, respond to local conditions of shelter and may not be influenced by climate change.

Introduction

Climate change, as a warming of air and seawater temperatures, will result in increased diversity of seabed marine life in Scotland with adverse effects limited mainly to declines in abundance or loss of a small number of northern species. Changes to a minority of biotopes might occur in the long term but, significantly, they include some that are 'special' to Scotland including maerl and horse mussel beds. Some enclosed water biotopes may be adversely affected if de-oxygenation at the seabed occurs as a result of increased thermal stratification. The extent to which change occurs and the speed of change depends on a wide range of other factors, especially those affecting distribution of larvae and spores and the longevity of species in existing populations.

The nature of Scottish seabed wildlife

The marine flora and fauna of Scottish waters, excluding bacteria, non-lichenous fungi, viruses and Protista includes in the order of 8,500 species. About 230 of the 263 seabed biotopes (habitats and their associated communities) catalogued from around the Great Britian and Ireland are recorded from Scottish waters.

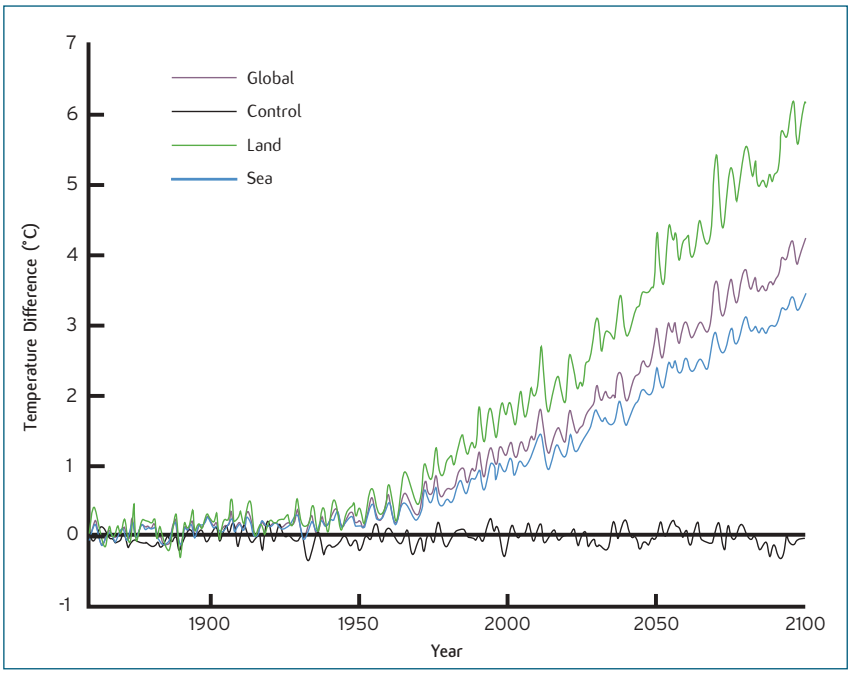
Scotland lies near the centre of the Boreal biogeographical region but with elements of Lusitanean-boreal flora and fauna from further south present off the western coasts and of Boreal-arctic species in Shetland. Many species reach either their northern or southern geographical limits in Scotland.

Many habitats and their associated communities are found only in Scotland or are especially well developed there. They include the deep, sheltered mud and rock communities of sea lochs, maerl beds and beds of horse mussels.

Expected change in the marine climate

The most recent predictions suggest that Scottish inshore areas will be subject to a progressive increase in temperatures over the next few years. By 2100, average air temperatures may be between 2 and 4°C higher than at present and seawater temperatures may be as much as 2°C higher than in 2000. Coastal water temperatures in Scotland have already risen by about 1°C between 1970 and 1998 and, in enclosed waters especially, the rise of inshore seawater temperature may be higher than the oceanic average.

In addition to increased air and seawater temperatures, increased storminess and alterations in major current patterns may occur as a result of climate change.



Actual and predicted changes in temperature for (from upper to lower lines) land, global, sea and 'unperturbed'. (Re-drawn from: www.metoffice.com/research/hadleycentre/pubs/brochures/B1998/index.html)© Crown Copyright.

The northern sea fan *Swiftia pallida* may decline in abundance and eventually be lost from Scottish waters.
(Photo: JNCC)

The southern sea fan *Eunicella verrucosa* may not reach Scotland from populations in Wales and Northern Ireland, despite warmer temperatures, because it most likely has a short-lived larva that would not cross the significant geographical barrier of the North Channel. Pink and white forms are illustrated.
(Photo: Keith Hiscock)

Predicting the effects of sea temperature changes on the seabed wildlife

The rate of geographical extension or reduction of distributional extent or change in the abundance of species at existing locations in response to increases or decreases in temperature are likely to be determined by:

1 Mobility of existing populations – can individuals swim, drift or walk or are they dependent on larval distribution?
2 Presence of viable populations for the production of larvae – some populations may not be reproductively viable and so not be a source for distributional extension.
3 Type of reproductive and dispersal mechanisms – benthic species which reproduce asexually or that have a benthic or short-lived larval/juvenile stage will extend their distributions less rapidly than those with long-lived planktonic propagules.
4 Survival of larvae in relation to water temperature – some larvae require high enough temperatures to develop to a final settlement stage; thus they will spread further north if those temperatures are achieved.
5 The presence of suitable habitats for settlement within the potential extension of range – according to mobility of dispersive stages.
6 The lethal temperature limits of adults – in the case of higher temperatures, some species might be killed by high temperatures whilst those that require a low temperature trigger to reproduce may fail.
7 Presence or absence of geographical barriers to potential spread.
8 The presence of favourable currents to enable spread.
9 Longevity of individuals in existing populations – if climate changes 'shuts-down' reproduction and therefore local recruitment, existing populations will persist until the end of their natural life span is reached.

Taking the various factors that might encourage or prevent change in distribution and abundance of seabed wildlife, a 'key' and a 'decision tree' have been prepared. Seven 'types' of species have been identified and examples of likely change are given in Hiscock *et al*. (2001) for 23 species.

Type A (northern volatiles) Species that currently have a northern distribution that are pelagic or demersal (such as plankton and fish) where the adults respond rapidly to temperature change and will 'retreat' northwards in concert with seawater temperature rise.
Type B (northern stables) Benthic species that currently have a northern distribution that will 'retreat' northwards but very slowly as individuals are long-lived and recruit irregularly.
Type C (northern retreaters) Benthic species that currently have a northern distribution that will decline in abundance and 'retreat' northwards rapidly (in 'concert' with isothermal changes).
Type D (southern volatiles) Species that currently have a southern distribution, that are pelagic or demersal (such as plankton and fish) where the adults will respond rapidly to temperature change and extend northwards.
Type E (southern stables) Benthic species that currently have a predominantly southern distribution that will expand northwards slowly or become more abundant within their present range.
Type F (southern gradual extenders) Benthic species that currently have a predominantly southern distribution that will expand northwards and increase in abundance at their current locations and in a sporadic way dependent on particularly favourable years for reproduction.
Type G (southern rapid extenders) Benthic species that currently have a predominantly southern distribution that will expand northwards at about the same rate as isothermal changes in sea or air temperatures providing that currents are favourable and there are no barriers to spread.

Populations of the exposed coast alga *Fucus distichus distichus* (which is only found in Scotland in Great Britain) are likely to persist at the locations where they currently occur as distribution is most likely determined by daylength rather than temperature.
(Photo: Ian Tittley)

Increased temperatures may lead to some enclosed areas becoming thermally stratified and the isolated bottom waters de-oxygenated leading to death of a wide range of fauna and colonisation by *Beggiatoa* bacteria.
(Photo: Keith Hiscock)

Significant effects of climate change are likely in only a few biotopes where the characteristic or keystone species are affected. Fifteen biotopes or biotope groupings that are considered to have climatically restricted distributions in or near Scotland and that might be affected by climate change have been identified. Some biotopes currently only occurring south of Scotland might develop and some present mainly or only in Scotland, including maerl and horse mussel biotopes may be adversely affected.

Tracking change

Targeted surveys are required now to establish baselines and wider recording schemes focussed on conspicuous, easily identified climate change indicator species should be initiated. Surveys will require both professional marine biologists and amateur naturalists to provide records of occurrence (or lack of occurrence) of selected species at set locations.

Extract from part of a species information page giving a prediction of likely change in the distribution of species as a result of temperature increase.

Chthamalus montagui

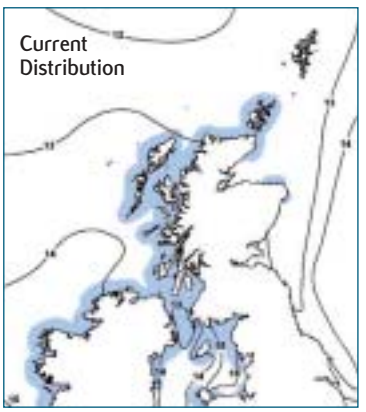
Common name
Montagu's punctate barnacle

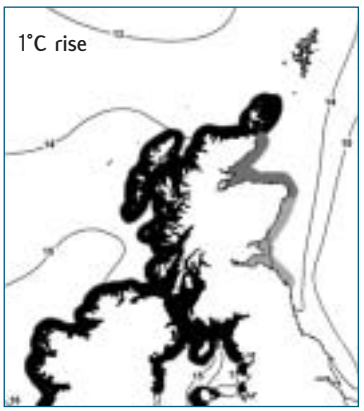
Current distribution
A southern species recorded as far north as Orkney. Rare on the east coast of Scotland.

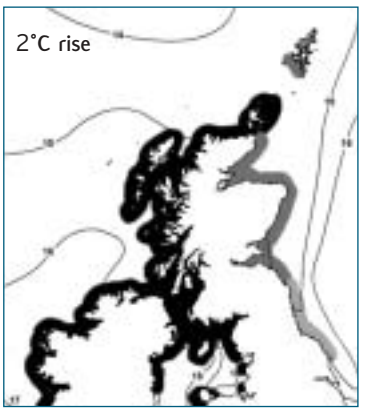
Prediction of future changes in distribution
Likely distribution assuming a 1°C (left) or 2°C (right) rise in summer seawater temperatures.

Summary
Abundance and occurrence will increase within the current geographical range of the species. Distributional range will extend down the east coast. Expansion of range will closely follow increase in summer temperatures.

(photo: Alan Southward)







Key ■ Annual breeding ■ Occasional breeding ■ Not breeding

List of species that may change in distribution and abundance as a result of increasing temperature in Scotland.

Southern species not currently recorded in Scotland but which may spread to Scotland	Southern species currently recorded in Scotland whose extent of distribution or abundance might increase		Northern species which may either decrease in abundance and extent or disappear from Scotland
Ciocalypta penicillus *	Axinella dissimilis *	Crassostrea virginica	Thuiaria thuja *
Haliclona angulata	Hemimycale columella	Cerastoderma glaucum	Swiftia pallida *
Gymnangium montagui	Phorbas fictitius	Gari depressa	Bolocera tuediae
Eunicella verrucosa *	Haliclona cinerea	Pentapora fascialis *	Phellia gausapata *
Aiptasia mutabilis	Haliclona fistulosa	Asterina gibbosa	Lithodes maia
Balanus perforatus *	Haliclona simulans	Paracentrotus lividus *	Tonicella marmorea
Maja squinado *	Alcyonium glomeratum *	Holothuria forskali *	Margarites helicinus
Osilinus lineatus *	Anemonia viridis *	Centrolabrus exoletus	Tectura testudinalis *
Patella depressa *	Aulactinia verrucosa	Crenilabrus melops	Onoba aculeus
Crepidula fornicata	Corynactis viridis	Ctenolabrus rupestris *	Colus islandicus
Tritonia nilsodhneri	Sabellaria alveolata	Labrus mixtus *	Akera bullata
Solen marginatus	Chthamalus montagui *	Thorogobius ephippiatus	Limaria hians
Phallusia mammillata	Chthamalus stellatus *	Scinaia trigona	Anomia ephippium
Scinaia furcellata	Hippolyte hunti	Asparagopsis armata	Thyasira gouldi
Chondracanthus acicularis	Palinurus elephas *	Bonnemaisonia hamifera	Leptometra celtica
Stenogramme interrupta *	Polybius henslowii	Naccaria wiggii	Leptasterias muelleri
Laminaria ochroleuca	Ebalia tumefacta	Jania rubens	Semibalanus balanoides *
Bifurcaria bifurcata *	Corystes cassivelaunus	Lithothamnion corallioides	Lithodes maia *
Cystoseira baccata *	Liocarcinus arcuatus	Mesophyllum lichenoides	Strongylocentrotus droebachiensis
Cystoseira foeniculaceus	Liocarcinus corrugatus	Calliblepharis ciliata	Cucumaria frondosa *
	Goneplax rhomboides	Kallymenia reniformis	Styela gelatinosa *
	Pilumnus hirtellus	Rhodymenia delicatula	Lumpenus lumpretaeformis
	Xantho incisus	Rhodymenia holmesii	Zoarces viviparus
	Xantho pilipes	Rhodymenia pseudopalmata	Lithothamnion glaciale *
	Tricolia pullus	Halurus equisetifolius	Phymatolithon calcareum
	Gibbula umbilicalis *	Sphondylothamnion multifidum	Callophyllis cristata
	Patella ulyssiponensis *	Drachiella heterocarpa	Odonthalia dentata *
	Bittium reticulatum	Drachiella spectabilis	Sphacelaria arctica
	Cerithiopsis tubercularis	Stilophora tenella	Sphacelaria mirabilis
	Melarhaphe neritoides	Halopteris filicina	Sphacelaria plumosa
	Calyptraea chinensis	Dictyopteris membranacea*	Chorda tomentosa
	Epitonium clathrus	Taonia atomaria *	Ascophyllum nodosum mackaii
	Ocenebra erinacea	Carpomitra costata *	Fucus distichus distichus *
	Acteon tornatilis	Cystoseira tamariscifolia	Fucus evanescens
	Pleurobranchus membranaceus	Codium adhaerens*	
	Atrina fragilis	Codium tomentosum	

* Species recommended for establishment of current distribution and abundance and to be considered in schemes for monitoring change.

Reference:
Hiscock, K., Southward, A., Tittley, I., Jory, A. & Hawkins, S. 2001.
The impact of climate change on subtidal and intertidal benthic species in Scotland.
Edinburgh, Scottish Natural Heritage (Survey and Monitoring Series).

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