Marine Climate Change Impacts Partnership

Topic

Non-native species

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Executive summary

- New marine life is arriving into our waters both by migration, range extension, and human **introduction**.
- The number of species of non-indigenous flora, fauna and algae is increasing in marine habitats and some are causing major ecological changes.
- Distributions of some non-native species are currently limited by water temperature.
- Warmer UK waters over the last three decades are facilitating the establishment of some of these species.
- Future temperature increases could enable a wider range of species to invade and become established, replacing current native species.

Full review

What are non-native species

Non-native species can be classified as fauna, flora or unicellular organisms that have been introduced from outside their natural range and have become established in UK waters. Some of these species can be considered to be invasive if they spread rapidly and cause economic or environmental harm, or harm to human health. In general, non-indigenous species are becoming increasingly common in marine habitats, and are causing major ecological changes on both local and global scales (Ruiz et al., 1997; 2000).

Full Review

Unfortunately, evidence and models of the effects of climate change on invasive spread are rare. However, climate change has been proposed to affect marine invasions in a number of ways. Firstly, warm-water indigenous species may expand ranges to the warming higher latitudes and out-compete cold-adapted species through their greater growth and recruitment (Carlton, 2000; Stachowicz et al., 2002). Secondly, climate change may alter primary **trophodynamic** regimes and oceanography, indirectly facilitating invasions (Carlton, 2000; Hulme, 2005). Thirdly, successful invaders tend to be more resilient to disturbances than native species, and thus climate change could combine with other stressors to allow invaders to out-compete native species (Rogers & McCarty, 2000).

In the UK, many of our marine invasive species are thought to be limited in distribution by water temperature. It is likely that increasing water temperatures will further facilitate the spread of these species within the next decade. Examples of invasive species which may be affected by increasing temperatures include:

- The barnacle, *Elminius modestus*, which can grow rapidly and withstand higher temperatures than native *Balanus* species. Low water temperature is likely to restrict northwards spread of this species; *Elminius* increased considerably in abundance in the Clyde following the warm summer of 1959 (Barnes & Barnes, 1960).
- The slipper limpet, *Crepidula fornicata*, which may spread if water temperatures rise; minimum winter temperatures may be important in limiting the development of large populations in the North of Britain (Minchin *et al.*, 1995).
- The Jap weed, *Sargassum muticum*, which has spread rapidly along the entire Channel coast (Hiscock & Moore 1986), the east coast up to Suffolk and has also now been found on the west coast of Scotland. Ideal conditions for growth are 25°C; increasing temperatures could facilitate its spread northwards.
- *Bonnemaisonia hamifera* and *Asparagopsis armata* are red algae that are likely to be limited in distribution by water temperature (Eno

et al., 1997). Other Rodophyta species such as *Antithamnionella ternifolia* and *Polysiphonia harveyi* are very tolerant of temperature changes, and may out-compete native species.

- Many estuarine species which have been spreading rapidly through Britain, such as the Chinese Mitten Crab, *Eriocheir sinensis* (Herberg et al., 2005), the zebra mussel, *Dreissena polymorpha* (Aldridge et al., 2004) and the Asian clam, *Corbicula fluminae* (pers.obs). There is certainly some evidence that zebra mussel larvae are developing more rapidly than historically documented, which could be related to climate change (Elliott, 2005)

More worryingly, with sufficient water warming, it is even possible that some of the more notorious global warm-water invasive species may enter British waters, such as the Northern Pacific Sea Star (*Asterias amurensis*), Caulerpa Seaweed (*Caulerpa taxifola*), and the American Comb Jelly (*Mnemiopsis leidyi*). Of particular concern for future invasions are non-indigenous marine plankton such as the shellfish-poisoning dinoflagellate, *Gymnodinium catenatum* (Minchin & Eno, 2002). However, due to the problems in predicting rates of range expansion and long-distance dispersal events, it is very difficult to anticipate when, and indeed if, any of these invaders will arrive.

Natural variability vs human induced climate change

Empirical work in marine invasion emphasizes the effects of spatial heterogeneity, temporal variability, other species, and evolution on invasions (Hawkins et al., 2003). Many factors can affect the successful establishment of the species, such as the presence of predators, availability of unfilled niches, and the presence of food (Eno et al., 1997, Hawkins et al., 2003). However, evidence remains scarce regarding the past effects of directed environmental change on invasive spread. Indeed, it is possible that few, if any, of the introductions to the UK to date are a consequence of climate change. Introductions have been an ongoing process; more than 60 species of mostly red algae, polychaete worms, crustaceans and molluscs have been introduced over the last century.

Relative importance of climate change to other human pressures

There is little doubt that most invasive species reach new localities by anthropogenic dispersal such as deliberate **introduction**, fouling on the bottom of ships, or through the release of organisms in ballast water (Ruiz *et al*, 1997, Eno *et al.*, 1997). More than 50% of the introductions to the UK are believed to have originated from fouling on ship hulls or ballast water and the remainder in association with deliberate introductions of shellfish for mariculture. Further, the international transport of organisms on the hulls of vessels may increase in the future due to the introduction of a ban on Tributyltin

(TBT) antifoulants. However, there is also a growing body of evidence that most aspects of global climate change favour the successful establishment of invasive alien species (Dukes & Mooney, 1999; Carlton, 2000; Stachowicz *et al.*, 2002).

Current debate

There is considerable debate regarding the effects of climate change on marine invasions in the UK, largely because of a lack of comprehensive studies that would inform opinion. This lack of studies probably reflects the fact that the impacts of invasive species in the UK marine environment have not proved to be as detrimental as those reported from elsewhere in the world.

Theoretical work has shown that invasive species' spread is a far more complex process than classical models have implied, because long-range dispersal can rapidly enhance range expansion. Many attempts to model the effects of climate change have often used "climate envelopes" to predict future changes in species distribution. Such models often predict that climate change may reduce the suitability of current habitat, and these threats are most likely to be felt by species of limited dispersal ability (Hulme, 2005), i.e. non-invasive species. For many species, effects may be indirect and result from changes in the availability of natural resources and mutualistic and antagonistic interactions between species (Hulme 2005).

Regional Variations

A report by Eno *et al.* (1997) summarizes the distribution and invasive characteristics of 51 non-native species in British waters. These include 15 marine alga, five diatoms, one flowering plant and 30 invertebrates. There are generally no common patterns in the distribution of the invasive species, but there do seem to be more invasive species on the south and west coasts of Britain, especially in the Solent (Zibrowius & Thorp, 1989) and along the Essex Coast (Utting & Spencer, 1992). This could be due to a number of factors such as more shipping and therefore more vectors for the transport of non-native species, proximity to areas from which species could spread, monitoring effort and differences in water temperature between the north and south of the country. Rates of spread vary between species, with 16 out of 51 species having spread to much of the British Isles within 50 years. Most species originated from similar latitudes to the UK, especially the east coast of the USA (mainly fauna) and the Western Pacific (mainly flora). It is likely that most species made the journey to Britain via deliberate introduction (often in association with mariculture), or with transport on ships hulls, or in ballast water. The UK also often supplies Ireland with invasive marine species (Invaders of Ireland are summarized in: Minchin & Eno, 2002).

From a Scottish perspective it is clear that some species are able to spread northwards and become established in colder waters. For example, ten marinas in Scotland were recently surveyed for seven non-native species (*Caprella mutica, Eriocheir sinensis, Perophora japonica, Styela clava, Codium fragile subsp. tomentosoides, Sargassum muticum* and *Undaria pinnatifida*) known to be established elsewhere within the UK (Ashton *et al.*, 2006). Seven of the marinas had one or more of the selected species and only three of the selected species were not found (*E. sinensis, P.japonica and U.pinnatifida*). It is worth noting that the Jap Weed (*Sargassum muticum*) is spreading particularly quickly around Scotland (Harries *et al.*, in prep) and may become a nuisance in many more harbours and shallow waters in the future.

Confidence assessments

'What is already happening' - Medium

We would suggest a **medium** level of confidence regarding "what is happening now". This applies to non-native species overall as the information available in the UK is moderate, and consensus is also only moderate.

'What could happen in the future' – High

However, we would allocate a **high** level of confidence as to future effects; there is a growing body of evidence from the rest of the world that climate change can facilitate marine invasions, and the potential risks from new **introductions** in the future are both high and potentially disastrous.

Knowledge gaps

One of the major problems of assessing the potential impact of climate change on non-native species is the lack of knowledge regarding where many of the species are established. There has been no full scale base-line survey of the presence of non-native species in the marine environment so the current distribution of many species is not known.

There is an urgent requirement for monitoring of the range of and effects of climate change on, established invaders. Only then can detailed risk assessments and contingency plans be prepared for future invaders. Further, the question of how climate change will interact with other ecological pressures (such as invasive species or habitat fragmentation) to create synergistic effects also needs to be considered (Sutherland *et al.*, 2006).

Commercial impacts

Commercially, some economically important species have been introduced, but some associated pests and parasites adversely affecting native species have also been unintentionally introduced. Control methods, where applied to nuisance species, are fairly ineffective and no non-native marine species have yet been successfully eradicated from British waters. Of the species deliberately introduced for aquaculture, only a few bivalve molluscs have become established in the natural environment beyond the confines of their cultivation. For example *Crepidula fornicata* has become a dominant mollusc in estuaries on the south coast and especially in the Solent, outcompeting oysters.

The Pacific oyster, *Crassostrea gigas*, is an important invasive species in its own right because it is extensively cultivated in Scotland. Cultivation of this species is controlled in that it occurs in containment (i.e. on trays or in bags) and is only allowed to go ahead after a consultation process. It is assumed that the low temperature of Scottish waters would mean that this species would be unable to establish itself. There has been no successful spat fall recorded in Scottish waters although maturation of the gonad and the occasional release has been noted but not settlement or establishment of populations. As this species has become established in other countries such as the Netherlands and Germany as well as areas in the south of the UK there is potential for an increased risk of the species becoming established in Scotland as water temperatures increase. This could lead to the out-competition of native filter feeders (Eno *et al.*, 1997) and the extensive modification of estuarine habitats.

The **introduction** of non-indigenous marine plankton via ballast water can also have a considerable ecological and economic effect on regional systems (Edwards *et al.* 2001). Some of these species can form Harmful Algal Blooms (HABs) and as a consequence of regional climate warming it is thought that many more non-indigenous species may become established in the future (e.g. *Gymnodinium catenatum*)

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