

Chapter 4.4

Alien Species & Fisheries

Summary

ALIEN SPECIES

It is clear that alien species pressures are difficult to address within the conventional WFD model. This is largely a result of problems in determining the extent or nature of the pressure (establishing presence-absence, detecting impacts) and the lack of control options for many species. As such it is likely that the most effective approach to dealing with this pressure will be through the adoption of a range of measures, the exact nature of which will be determined by geographical and species specific factors. Due to the difficulties associated with controlling outbreaks of problem species it is widely acknowledged that 'prevention' should be afforded the highest priority in programmes addressing alien species issues. Where control or management is required and deemed feasible it is suggested that in the first instance this is targeted at the sites with greatest ecological importance eg WFD Natura 2000 protected areas.

The emerging Great Britain (GB) strategy for non-native species and the related work of the GB programme board will be important in defining the extent to which WFD obligations and ambitions drive work on alien species in marine and freshwater habitats. This GB level work and the initiatives falling out from it, is anticipated to deliver some of the key elements of a programme of measures for WFD e.g. risk assessment process, rapid response to new arrivals. The exact nature of the work required specifically for WFD will become clearer as this GB work progresses. However, the immediate statutory requirements of the WFD represent a significant opportunity for implementing some of the components of the GB strategy at an early stage.

In addition to a range of 'baseline' measures which are not WFD specific, and are rooted in the proposed GB strategy, there are three broad categories of measure which appear to be appropriate for implementation in the first round of River Basin Management Plans (RBMPs):

1) RBMP Forums

The establishment of an alien species forum within each River Basin District (RBD) is likely to be a very effective but low cost means of capturing and better coordinating existing efforts to monitor and control problem species within a defined geographical area. A detailed proposal for the structure and remit of these forums has been presented to the UK Technical Advisory Group (UKTAG) on the WFD by the Alien Species Group. It is envisaged that these forums could ultimately be integrated into any structures that emerge from proposals from the GB strategy. These forums would be responsible for setting targets and coordinating control at a local level and would need to be able to access resources to deal with alien species problems where an appropriate control mechanism has been identified. It is through this route that remedial work (to restore to good status) would be identified and prioritised. A priority for these forums in the first RBMP will be to scope and implement such remedial work in protected areas currently not meeting their objectives due to alien species.

2) Prevention & Monitoring

As a priority, measures should be put in place to prevent deterioration of high and good status sites. In practice this may require a dedicated monitoring and surveillance programme for water bodies since it may be the case that the recently established WFD monitoring is not able to specifically identify alien species impacts. A key component of

this preventative approach would be early and appropriate action on new arrivals/introductions. Funds will be required to support this early, emergency action.

3) R&D Programme

It is clear that action on alien species is compromised by a lack of understanding of the nature of alien species impacts on all elements of the ecosystem and a lack of appropriate, proven control techniques. At present funding for work of this nature is uncoordinated and there is no dedicated budget for such work. In order that existing alien species impacts can be adequately addressed in future rounds of the RBMP it is important that the necessary underpinning work is undertaken now. The work required can be roughly divided into two components: (i) determining and identifying impacts; (ii) developing new sustainable control/management techniques (including biocontrol options).

FISHERIES (as a biological pressure)

The pCEA Fisheries, Alien species and Biodiversity (FAB) working group examined the risks and impacts relating to fishing activity in so far as they are relevant to the meeting of WFD objectives. Most of the key pressures caused by fishing activity are morphological and these are covered where appropriate in the morphology chapter. The other key pressure caused by fisheries activity is direct biological pressure in the form of overstocking, weed cutting in freshwater bodies, the promotion of economically/recreationally important fish species and the introduction of alien fish species. By-catch can be an issue if some coastal fisheries.

The overstocking of bottom feeding fish such as carp can stir up lake sediments and cause turbidity, reducing light penetration and causing loss of plants and invertebrate animals. This pressure can usually be minimised by cessation of stocking (EA have powers to ensure this through the Salmon and Freshwater Fish Act) and allowing the remaining fish to be caught or live their natural lives. In more serious cases, the fish - or a good proportion of them - would need to be removed by netting or electrofishing. The farming and fisheries sectors may have to bear the ongoing costs of operating in more environmentally-sustainable ways.

Regarding the introduction of alien fish species, either deliberate or unintentional, by recreational or commercial fisheries, the EA have the powers to regulate the introduction of any fish into any controlled water under the Salmon and Freshwater Fish Act. The movement of alien fish species is already strictly regulated. It is suggested that the licensing and enforcement of alien fish species movements is fully WFD proofed.

Weed cutting is sometimes used to maximize the fishery potential of certain freshwater courses. This can have a negative impact on the natural ecology of the water bodies affected. However, the EA already have the powers to control this practice through their general water quality consenting activity. It is suggested that any consents issued by the EA fully take account of the need to meet WFD objectives.

Bottom and beam trawling can lead to species by-catch of bottom dwelling organisms. Mitigation measures such as the use of benthic release panels has been successfully adopted in some ports in SW England.

BIODIVERSITY BENEFITS

The FAB working group (FAB WG) also looked across the pCEA outputs to ensure that potentially cost-effective measures that would deliver wider biodiversity benefits as well as those relating to WFD objectives were captured. The group reached consensus that the WFD environmental standards being proposed by UKTAG would by themselves deliver improvements in biodiversity and therefore the key element to focus further effort on was morphological pressures. As such most of the biodiversity benefit outputs from the FAB WG have been included in the morphology chapter of this report. As such no costings for the biodiversity benefits are included in this chapter.

Biodiversity benefits - freshwater physical habitat

As a general principle, the group thought that the most cost-effective approach to restoring physical habitat was to reduce the existing pressure and allow the waterbody to recover through natural processes (“assisted natural recovery”). However, it was recognised that this approach would not be cost-effective everywhere. For example, natural recovery would take a very long time on low energy channels. Such channels would require a higher level of intervention.

(Note: in this report “restoration” refers to restoring the function and form of the water body *system*; the assumption being that by restoring natural processes, high quality habitat is formed).

Other principles that were proposed include:

- Restoration measures should *generally* start at top of catchment and work downstream
- In dealing with obstructions, measures should *generally* start at river mouth and work upstream
- The restoration of physical habitat should be in step with the management of other pressures. For example, there would be little point in restoring the physical nature of a polluted water body without also addressing water quality issues
- Given the uncertainties associated with physical restoration “adaptive management” should be adopted and R&D should be undertaken on measures of lower certainty

The following measures were identified as being generally cost-effective:

- Reducing maintenance where this allows a degree of natural recovery and does not jeopardise the use
- Protection of the riparian zone to allow the natural recovery of riparian vegetation and the channel (This includes the reducing stocking densities use of anti-livestock fencing of streams and lakes damaged by overgrazing). This might also be seen as a potential climate change adaptation measure as shading by riparian vegetation could reduce stream temperature.
- The addition of woody debris at selected sites could be considered where is it needed and re-colonisation by trees or tree planting is not practicable.
- Removal of impoundments or obstructions to fish migration or works to make them passable
- The screening of water intakes to prevent the ingress of fish

- Blocking grips and drains to restore upland wetland source areas and reduce flash flows.
- Selected small-scale channel restoration measures (including re-connection of backwaters and side channels) particularly on lower energy streams.
- Reduction of silt inputs through land management measures
- Removal of unnatural deposits of silt from selected shallow lakes
- Natura 2000 measures to restore “*favourable condition*” in the context of the Habitats and Birds Directive
- R&D to investigate the efficacy of these methods in delivering GES or GEP

Measures needing further exploration or are deemed ineffective

The use of instream habitat improvement devices and artificial riffles as measures needs further exploration. While two recent reviews and one scientific paper demonstrate that they seem to be ineffective, other scientists and many practitioners believe that they work.

It should be noted that there was insufficient time to consider all potential measures in detail.

It is considered that restoring heavily engineered and reinforced channels and the removal of major infrastructure such as bridges and large culverts, particularly those under buildings will be excessively costly.

As there was insufficient time available to undertake a systematic review of all possible measures, expert judgement supported by evidence to hand was used to identify the measures that were obviously cost-effective and those that were likely not to be cost-effective.

Wetlands

Floodplain pond and wetland restoration has the potential to lead to significant improvements in river ecosystems. However, at present there is insufficient evidence available to assess the cost-effectiveness of such restoration work on in-channel biological, water quality and hydromorphological parameters. This makes it difficult to recommend the immediate inclusion of pond and wetland restoration in the Programme of Measures. However, it is strongly recommended that further R&D is undertaken to investigate the benefits of such work for river ecosystems. A number of opportunities are currently arising for such work, including the Water Friendly Farming Landscapes project promoted by a consortium of NGOs and statutory bodies.

Catchment restoration delivered through community led partnerships

If catchment restoration funds are made available then they should be more cost-effective if partly applied through community partnerships. There are a number of key reasons for this:

- Such partnerships are highly effective at gearing-up funds by acquiring grants, donations and contributions in kind

- An involved local community will feel ownership of their river and are likely to act to maintain the improvements made
- They seem to have a lower costs of delivery due to smaller overheads

Natura 2000 sites in England

Prescribed morphological measures are available for aquatic Natura 2000 sites which have helped inform the estimation of potential costs and effectiveness. Further analysis is required to identify the proportion of the costs that are attributable to the Habitats and Birds Directives versus the costs associated with aquatic Natura 2000 sites that are attributable to the WFD from the introduction of the 2015 deadline.

A number of measures to restore the morphology of Natura 2000 river sites to *favourable condition* are outlined in Annex A. These include reconnecting backwaters, restoration of banks, erosion prevention, control of silt inputs and weir removal at a total cost of £31million by 2015. The costs to restore Natura 2000 lakes by 2015 would be an estimated £9.5 million. These costs are attributable to meeting the requirements of the Habitats and Birds Directive, although the 2015 deadline introduced by the WFD means that this cost cannot necessarily be spread over subsequent river basin planning cycles.

Some of the measures proposed for Natura 2000 sites might also need further R&D to ensure effectiveness and this R&D would inform future morphology measures applied elsewhere.

River Basin Biodiversity Frameworks

River Basin Biodiversity Frameworks (RBBF) are a mechanism to maximise the benefits of WFD measures for biodiversity. A GIS system is under development which will allow river basin planners to take account of opportunities to benefit biodiversity. This initiative is being taken forward by Environment Agency and Natural England.

4.7.1. Relevant WFD objectives

Direct biological pressure from fisheries (species manipulation; overfishing) can affect the attainment and protection of good ecological status for fish fauna (although fish fauna are not part of the normative definitions in coastal waters), macrophytes and phytobentos and benthic invertebrate fauna.

Alien species can also impact on the ecological status of surface waters. Whilst there is no explicit mention of alien species in the WFD the achievement of the ecological quality elements in the normative definitions of Annex V will be influenced by the presence or likely presence of invasive species.

UKTAG have classified alien species found in the UK in terms of their impact on native habitats and biota. This is essentially a risk assessment. Species are classified as **high impact** (alien species known to be invasive and documented as causing harm), **low impact** (a low probability of becoming invasive and field observations over many years have indicated low impact) or **unknown impact** (probability of becoming invasive is unknown and a full risk assessment is required). The listing is given in “Revised

classification of alien species according to their level of impact”, UKTAG, May 2007. (See UKTAG table in annex B).

High-impact species are likely to become established and cause problems in any habitat in which they appear. Their propensity to spread rapidly means that prevention is the only effective way of dealing with problems, as control is likely to be prohibitively expensive and or unsuccessful. “Unknown impact species” are to be treated no differently to high-impact species in accordance with a precautionary approach. However, it is envisaged that work will be undertaken to improve our understanding of such species and hence over time species on the ‘unknown’ list should be expected to move to either ‘high’ or ‘low’ impact lists.

The spread of North American signal crayfish *Pacifastacus leniusculus*, is an example that demonstrates that alien species will have an impact on ecological status in some water bodies. Its establishment in many water bodies in England and Wales has led to the widespread extinction of native crayfish populations. This has occurred not only through competitive exclusion but also through a fungal disease (crayfish plague) carried by signal crayfish and to which native crayfish are highly susceptible. Signal crayfish are also known to damage plant and invertebrate communities: in some rivers in the Thames catchment many larger invertebrate species have almost disappeared in some water bodies. There is currently little prospect of eliminating this species. The key measure will be to prevent its spread into new areas. A case for setting alternative objectives may be required for some water bodies where serious infestations already exist.

UKTAG has not yet formally agreed the principles for integrating alien species into water body classification but in brief the recommended classification principles proposed by the Alien Species Group of UKTAG can be summarised:

High status: no established alien species present (high and unknown impact lists);

Good status: no demonstrable and damaging ecological impacts from any alien species;

Implementing these principles will clearly require a means of determining with appropriate confidence the presence or absence of a particular species and also of detecting damaging impacts. Work is continuing to develop these aspects.

4.7.2 Extent and nature of pressure, trends and associated uncertainty

Direct biological pressure from fisheries

No risk assessment was undertaken for the direct biological pressures attributable to fisheries activity in the EA’s initial River Basin Characterisation exercise (morphological pressures were however identified).

Marine & estuarine commercial fisheries

In relation to the potential impacts from marine and estuarine commercial fisheries most of these are morphological in nature. However it could be argued that some are direct biological if they involve species by-catch. For example some trawling gear will also catch non target fish species. It should be recalled that by-catch of fish fauna is not caught by

the WFD since fish fauna as a quality element is only relevant for estuaries and freshwaters (fish fauna is not a WFD quality element in coastal waters).

However, species by-catch of bottom dwelling organisms is associated with some bottom trawling activity. In nearshore areas, mobile bottom fishing gear has effects on benthic habitats and communities. Trawling and dredging reduce habitat complexity. Repeated trawling and dredging result in discernible changes in benthic communities and productivity of benthic habitats. Fauna that live in low disturbance regimes are generally more vulnerable to disturbance by trawling. Fishing gear that disturbs the sediment surface can change sediment grain size distribution or characteristics. Suspended load and magnitude of sediment transport processes and direct alterations of habitat can cause species shift and general decline in abundance of some of the benthic organisms although the latter is considered a morphological pressure.

A review undertaken by the FAO in 2005 on the “Impact of trawling and scallop dredging on benthic habitats and communities” recognized the lack and difficulty of rigorous scientific analysis, the absence of long-time series, baselines, or reference areas, the difficulty and lack of real-scale experimentation, and the need for more and better documented investigations on bottom impacts of trawling.

With regard to pelagic trawls, which fish in mid–water for species such as mackerel, sprat and herring, these do not generally touch the bottom as they would easily be damaged under the wrong conditions. They can be a highly targeted method of fishing with the net only being deployed when a shoal of the target species is detected. As such the impact from this category of fishing is considered to be low in terms of the WFD.

For beam trawling, the gear in contact with the ground consists of two heavy sleds one at each end of the “beam”. The beam itself is about 80 cm off the bottom. The bottom of a beam trawl is nearly always hung with heavy chains designed to keep hard down on the ground. Depending on the target species and the type of ground this chain can take the form of a mat when targetting flatfish on rough ground, or the more “open” gear when targetting cuttlefish. A much smaller type of beam trawl without the heavy ground gear is used in shrimp fisheries such as those found in The Wash and in Morecambe Bay. By law beam trawls can never have an aggregate length greater than 9 metres (4.5 metres a side) inside the UK 12 mile limit. Beam trawls do take non-target organisms and as such can causes a direct biological pressure. The impacts can be mitigated through the installation of “benthic release panels” which have been successfully adopted in some ports in South West England.

Dredges, of which there are a wide variation, ranging from suction dredges used in some cockle fisheries to scallop dredges, may impact on the achievement of WFD objectives. However, their impacts are morphological in nature so are not covered in this chapter.

Longlines are seen as highly selective form of fishing (i.e. fish of a certain size). During hauling longlines could damage fragile structures such as coral but are generally low impact in UK inshore waters

Gillnets can also be highly selective but can have by-catch of cetaceans. Whilst this is an important issue such bycatch is not covered by the WFD.

Aquaculture

The majority of marine fish farming in the UK occurs in Scotland with production dominated by the cultivation of the Atlantic salmon. There is a small production of other species such as cod, and halibut. Fish are held in cages often located in sea lochs, and other sheltered areas. In recent years there have been concerns expressed over the environmental impact of this method of fish farming. Concerns include the effect of particulate matter from fish farms on the benthic environment under the cages, the enrichment of waters around fish farms resulting in phytoplankton blooms, the visual impact of cages, the long term effects of medicines, and antifoulants, and the transfer of disease such as sea-lice infestations between farmed and wild fish. Escapees from salmon farms may also pose a threat to wild fish by interbreeding or competing for habitat. Taking a broader perspective the use of industrial fishmeal and fish oils in artificial pelleted feeds used in both marine and freshwater fish farming has wider implications for marine ecosystems in many parts of the world. **The limited extent of marine aquaculture in England & Wales means that this pressure is excluded from the pCEA .**

Freshwater fisheries: commercial and recreational

Overstocking

Discussions within the FAB working group identified that managed fisheries particularly in lakes can be overstocked to such an extent that the ecology changes.

The overstocking of bottom feeding fish such as carp can stir up lake sediments, uproot plants and cause turbidity, reducing light penetration and causing loss of plants and invertebrate animals as well as in some instances encouraging the development of (ecologically and aesthetically) undesirable algal dominated sites.

Introduction of alien fish species

The release of fish into the wild (inland waters) has the potential to cause direct impacts on native fish stocks through competition, predation and hybridisation. Indirect impacts may occur through impacts on the aquatic habitat, or through the spread of piscine diseases. Because some native fish species have a naturally restricted distribution, for example barbel, release of these locally absent species can have adverse impacts on local biodiversity.

Fish are released into the wild both unintentionally (e.g. through flooding of fish farms' closed water systems) and intentionally (whether under authorisation of the Environment Agency or otherwise) for stocking purposes primarily for anglers' sport (coarse fish) or environmental reasons (salmon and trout). The stocking of species such as Pumpkin Seed by anglers is a good example of the issue. This species has now infested several catchments across England eg. the River Ouse in Sussex.

The trade in ornamental fish can also lead to releases of non native fish species. Previous Government policy has also caused problems for example when farm diversification grants encouraged the farming of signal crayfish.

Weed cutting

Weed cutting is sometimes used to maximize the fishery potential of certain freshwater courses. This can have a negative impact on the natural ecology of the water bodies affected.

Freshwater aquaculture

Concerning the issue of environmental impact of freshwater fish farming - the principal species in cultivation in England and Wales is **rainbow trout**. The abstraction of water and the quality of discharges are factors that may impact on the environment. The effect of escapees on the genetic integrity of wild stocks has been recognised as an area of concern, as has the accidental introduction of non-native species of fish. More extensive production systems for the culture of species such as common carp, are considered to have a lower environmental impact. Recent developments in high technology recirculation systems for the intensive production of tilapia and other warm water species again are likely to have a lower environmental impact.

Shellfish farming, primarily bivalve molluscs, is generally extensive and unlikely to have any negative environmental impacts. There is some evidence of non-native species of shellfish brought in to UK waters for farming, have escaped and established sustainable population.

There is little freshwater shellfish farming in the UK, although it is noteworthy that crayfish plague, a fungal disease that has contributed to the decline of the native crayfish was thought to have been brought into the UK with the American signal crayfish, a species introduced for aquaculture purposes.

Alien Species

Alien species pressures present a particular challenge to this analysis for a number of reasons:

- Alien species pressures and impacts are diverse and may act both directly and indirectly;
- There is generally a poor understanding of the impacts of alien species upon ecological status;
- There is uncertainty about how alien species will finally be considered within water body status classification;
- There is uncertainty about the effectiveness of many potential measures (particularly those relating to control or eradication);
- There is uncertainty about the extent and magnitude of many of the problems.

The risk assessment for Article 5 maps (RBC 1) is summarised in Table 1 below. The risk assessment was undertaken using the best available data on the distribution of the ten most problematic species and mapping the coincidence of species presence with water bodies. The risk assessment exercise was entirely dependent on the quality of data on alien species distribution. Such data are generally incomplete as there is a tendency for a

decline in recording effort as problem species become more widespread. The risk assessment should therefore be considered as a very broad indication of the scale of the problem and for some species is likely to be a significant under estimate of the pressure.

Species risk assessed for the Article 5 reports in 2005 and reported to the Commission in 2005 are:

- Australian swamp stonecrop
- Floating pennywort
- Water fern
- Parrot's feather
- Common cord-grass
- Japanese knotweed
- North American signal crayfish
- Zebra mussel
- Chinese Mitten Crab
- Slipper limpet

Table 1 Summary of Article 5 Risk Assessment for Alien Species (England and Wales, 2005)

	% water bodies at risk
Rivers	21
Lakes	9
Estuaries	37
Coasts	46

Trends in alien species as a pressure

The alien species pressure is likely to increase over coming years for a number of reasons:

- **Critical mass** – once established, eliminating most alien species (except in small, isolated water bodies) is usually impracticable. The potential for spread from one water body to another is considerable particularly for those species or situations where the vectors are largely outside of human control. A critical point may be expected where a given species is so widespread and invasive that further spread is inevitable, such a situation is already apparent for signal crayfish or *Crassula helmsii* in certain catchments.
- **Climate change** – warmer winters may ultimately remove the limitations on spread or reproduction of certain alien species.
- **Changing drivers** - some of the key drivers may increase, for example, harmonisation of EU fish import rules with third countries has made it easier to import fish alien to the UK. Furthermore, angling interest in large

non-native fish continues to increase creating demand for introduction so potentially problem species. Wider work on the GB Strategy will also help achieve WFD objectives and should act as the overall framework for any action on alien species under the WFD. The predicted IMO requirements should be taken into account. Baseline drivers are summarised in **Annex C**.

4.7.3 Apportionment and associated uncertainty

Fisheries - freshwater

Biological pressure from overstocking is associated with recreational angling and commercial fisheries/aquaculture. Weedcutting is associated with recreational angling and flood management. The introduction of alien fish species is associated with recreational and commercial fisheries as well as the ornamental pet trade.

Fisheries – estuarine and coastal

Biological pressure in the form of by-catch (excluding fish fauna in coastal water bodies) is caused by bottom fishing gear and beam trawls in nearshore waters. There remain uncertainties as to the impact these activities have in terms of meeting WFD objectives within the 1nm. Research is ongoing by Defra. The review of marine protected areas under the Marine Bill should also yield further information since some of the most sensitive sites will also be WFD n2k protected areas where they are within the 1nm.

Alien Species

Alien species introductions can be characterised as two separate processes: (a) initial introduction to a water body or geographical area, (b) secondary introductions arising from spread from initial site. Both processes generally involve a transport vector (human activity, birds, hydrological connectivity). It is difficult to make definitive links between a particular problem species and a sector because different sectors may be involved in these two different processes. For example, it is widely acknowledged that the highly invasive aquatic plant species *Crassula helmsii* has been introduced to many sites as either an escapee or deliberate introduction (often by well-meaning gardeners clearing out their ponds). However, the species is now so widespread across much of England and Wales that it is highly probable that new introductions are associated with transfer (by birds, anglers, boats etc.) from existing 'wild' populations rather than gardens or the horticultural trade.

These uncertainties about introduction routes and the historic nature of many introductions means that it is frequently difficult to identify the sectors contributing to a particular problem and even more difficult to apportion any responsibility between these sectors. Examples of sectors which may have contributed to particular pressures include:

- The horticultural trade has introduced the large majority of non-native invasive aquatic plants for pond and aquarium use.
- The majority of marine and transitional species, and some species that are able to survive in freshwater, arrived within ballast water, or as a contaminant of ship hulls.

- The five species of non-native crayfish were introduced to the UK, along with their associated diseases, with the endorsement of Government departments as part of a farming diversification strategy.
- Fish species have been introduced for ornamental and commercial purposes, accidentally spread during stocking of fisheries or inadvertently introduced as live bait for angling.
- Water supply (inter-basin transfer) e.g. Zander (*Stizostedion lucioperca*).
- Inappropriate management of waste, such as fly-tipping garden waste or soil contaminated with Japanese knotweed rhizome.

Figure 1 below has been taken from the JNCC publication 'Non-native marine species in British waters: a review and directory' (Eno *et al.*, 1997) and details the number of marine species that have entered UK waters through various methods of introduction and the approximate percentage of introductions through each method.

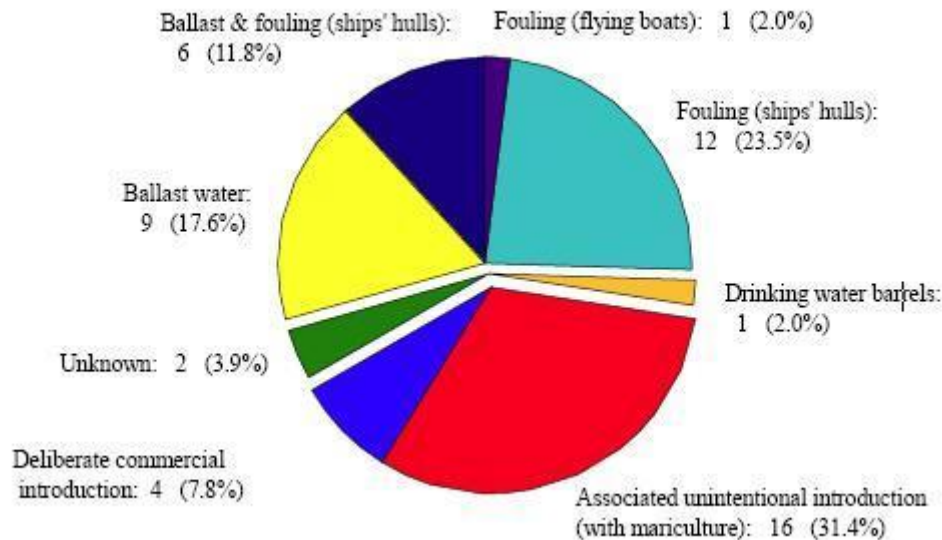


Figure 1: Probable primary methods of introduction of non-native marine flora and fauna found in British waters. Numerals indicate number of species involved, and the percentage of total introductions (Eno *et al.*, 1997).

4.7.4 Measures to meet WFD objectives under the four scenarios

There are two main groups of measures needed to meet WFD objectives in relation to direct biological pressure from fisheries and alien species.

They are:

- *Measures to restore ecological status,*
- *Measures to ensure no deterioration,* including:
 - those to prevent and control the introduction of alien species (licensing and regulatory activity, codes of practice etc)
 - Ongoing management of sites to keep already established invasive species in check. This may be on a statutory basis or voluntary.

Some measures can fall into more than one category. An example is those to reduce uncertainty. Where measures have little proven effect, we may wish to trial their use (potentially in Protected Areas where they are justified to achieve other objectives) and learn about their effectiveness to help justify future use. This supports the principle of Adaptive management, which combines management (based on the best *available* science), research, and monitoring so that robust learning takes place and actions can be modified or corrected through experience. Adaptive management is appropriate for dealing with morphological pressure where uncertainties are high and yet there is an imperative to take action.

Time and Spatial scales

As with many pressures the successful management of a water body in relation direct biological pressure and alien species will depend on the interplay of local and catchment scale pressures. If wider national strategies to prevent the spread of invasive are not put in place then local measures are likely to be ineffective.

Likely cost-effective measures for tackling biological pressure from fisheries

Overstocking

This pressure can sometimes be reduced by cessation of stocking and allowing the remaining fish to be caught and removed or live their natural lives. The EA have powers to require destocking under Section 30 of the Salmon and Freshwater Fish Act. In more serious cases, the fish - or a good proportion of them - would need to be removed by netting or electrofishing. The fisheries sectors may have to bear the ongoing costs of operating in more environmentally-sustainable ways.

Tackling alien fish species

The cost of restoring affected water courses can be significant. The cost of eradicating topmouth gudgeon from infected waters has been demonstrated in two exercises. Topmouth gudgeon were eradicated from an infected lake in the Lake District using rotenone in March and April 2005. The capital cost of the rotenone was approximately £6,500, and the man-power costs were estimated at over £31,00. Topmouth gudgeon were eradicated from an infected water in the West Midlands in 2006 and the capital cost alone was in the region of £20,000, with man-power costs estimated at over £20,000.

The most cost-effective measure is to prevent such releases in the first place. The EA have the powers to regulate the introduction of any fish into any controlled water under Section 30 the Salmon and Freshwater Fish Act and as such is already strictly regulated. It is suggested that the licensing and enforcement of alien fish species movements by the EA or other regulatory authorities is fully WFD proofed in the first River Basin Planning cycle.

Weedcutting

The EA already have the powers to control this practice through their general water quality consenting activity. It is suggested that any consents issued by the EA fully take account of the need to meet WFD objectives.

Aquaculture

It should be noted that in the UK there are a number of legislative mechanisms to reduce the environmental impact of fish farming, including regulations on the abstraction of water, the quality of discharge, control of non-native species, disease controls, and on the location of farms.

Defra regulates aquaculture through CEFAS. Here too escapes of rainbow trout have caused ecological problems to date. Escapes have occurred even where strict controls have been put in place eg due to flooding events. Again it is recommended that regulation is fully WFD proofed in the first planning cycle.

Likely cost-effective measures for alien species

Given the uncertainties associated with the extent to which alien species control or management might be required to meet good ecological status it is important to provide a framework within which decisions on alien species measures can be considered. For example, there are some introduced species that might not be expected to affect water body status but nevertheless it would be desirable to prevent such a species becoming established in sites at high status. Equally there are measures which are appropriate for different species at different times and in different locations; for example preventative measures are applicable to problem species known to have caused problems elsewhere. As the range of possible measures for alien species is broad and many approaches have not yet been widely applied there is the potential for a wide range measures and combinations of measures to be considered.

A suite of principles for alien species management should be outlined; it is anticipated that these will focus on *prevention, surveillance, early action* and *sustainable management techniques*. A decision framework is suggested as a means of aiding in the selection of the most appropriate measure for a given species or situation. A further principle that should be integrated into any programme of measures for alien species is that of objectives and action at an appropriate scale: from national initiatives through to action on an individual water body. One possibility is that these objectives could be set and delivered through alien species forums at the River Basin District (RBD) scale. These forums would be supported by a national framework and R&D programme (developing best practice for control approaches), the GB strategy and non-native species programme board. Table 2 provides examples of hypothetical targets for a given RBD based forum.

Table 2 Selected targets for a hypothetical alien plant management strategy (from Clarke, 2007)

Target	Comment	Control options
Eradicate parrot's feather from waterbody by 2008	Eradication may be feasible in areas where a species has only recently been recorded and the problem is relatively contained.	Targeted mechanical removal by spot spraying of regrowth or fragments with herbicide (repeated at regular intervals).
Reduce coverage of Australian swamp stonecrop by 50% in area X (by end 2008)	Where complete eradication is unfeasible it may be possible to reduce biomass to a level where the impact of the species is reduced and ongoing routine management is sufficient to prevent further spread (this is analogous to scrub or bracken control in terrestrial sites)	As above.
Prevent balsam from establishing within waterbody	Such targets are appropriate where a problem species is known to be established upstream or on land surrounding the waterbody. The strategy must include preventative measures as control is most effective and least expensive at the earliest stages of establishment.	Surveillance programme established (possibly making use of voluntary angling clubs etc.). Emergency response to reported colonisation.
Establish location of balsam populations upstream of waterbody or in adjacent areas (by mid 2007)	Monitoring and data collation is an essential part of the strategy and enables accurate risk assessment.	n/a
Control balsam within 50m of tributary Y (by 2008)	Control outside the waterbody should be prioritised with greatest effort focused on upstream areas and adjacent land.	'Handpulling' by volunteer groups followed up herbicide control by agencies/contractors.
Prevent floating pennywort establishing within river basin district	The strategy should also anticipate future problems and aim to 'hold the line' against species known to have invasive tendencies.	Surveillance programme established (possibly making use of voluntary angling clubs etc.). Emergency response to reported colonisation.

It is clear that any alien species related measures proposed for WFD implementation should be linked to the wider proposals in the emerging GB non-native species framework strategy (Defra, 2007). The 'GB strategy' is expected to determine the range of activity relating to non-native species and provide a framework within which a range of approaches (voluntary initiatives, education and awareness programmes, monitoring programmes and legislative changes) might be employed.

Measures proposed for the WFD should be presented within the same framework as that proposed by the draft GB strategy which can be summarised as:

- Prevention;
- Early Detection, Surveillance, Monitoring and Rapid Response;
- Mitigation, Control and Eradication;
- Building Awareness and Understanding;
- Legislative Framework;

- Research.

Practically, one measure/suite of measures could deal with more than one of these areas. It is suggested that alien species measures for WFD are applied according to a hierarchy:

1. **Prevent** future alien species problems and deterioration of high or good status water bodies due to alien species;
2. **Remove, reduce or mitigate** impact of alien species in sites currently not at good.

A common UK approach should ideally be developed and these proposals are being considered by UKTAG.

Baseline and existing legislative measures

For fisheries Sea Fisheries Committees have powers inside the 6nm to regulate inshore fisheries. By law beam trawls can never have an aggregate length greater than 9 metres inside the UK 12 mile limit. The EA have powers under the Salmon and Freshwater Fish Act to deal with freshwater fisheries pressures if needed such as overstocking and the introduction of alien fish species.

There are a number of legislative mechanisms in place to deal with some aspects of the alien species pressure.

The UK is bound by international agreements such as the Convention on Biological Diversity, the United Nations Convention on the Law of the Sea, The Convention on the Conservation of Migratory Species of Wild Animals (Bonn 1979), The Convention on the Conservation of European Wildlife and Natural Habitat (Bern 1979), the EC Birds Directive and the EC Habitats and Species Directive. All of these aim to protect biodiversity and endangered species and habitats, and include provisions requiring measures to prevent the introduction of, or control of, non-native species, especially those that threaten native or protected species.

In response to the growing concern about the increase in damage caused by non-native species, the International Maritime Organisation (IMO) member countries have agreed to develop a mandatory international Convention to regulate and control ballast water transfers.

The World Conservation Union, the IUCN (2000), regard damage by non-native invasive species as second only to habitat loss in terms of its damage to biodiversity. This is also recognised within the Convention for Biological Diversity, which requires consenting parties to manage invasive species within the conditions stated in Article 8.

The UK Government has completed a review of non-native species policy and has consulted on a draft strategy for non-native invasive species.

Baseline measures agreed and already funded to deal with aquatic alien species and so help meet WFD objectives are outlined in Annex C of this chapter.

MEASURES LIKELY TO BE MOST COST-EFFECTIVE

Scenarios of groups of measures

The scenarios provided here assume we know costs, effectiveness, and the extent of water bodies that require measures. Therefore changes only relate to disproportionate cost, uncertainty, timing and cost share.

Fisheries

For the fisheries biological pressures scenarios have not been devised since not enough information was available to the group to undertaken such an exercise. From the analysis undertaken for this chapter it is concluded that there are adequate control mechanisms to deal with those biological pressures from freshwater fisheries activity. These simply need to be 'WFD proofed'.

For the marine fisheries that cause biological pressure in the form of species bycatch it is as yet unclear whether the by-catch causes a significant risk in terms of meeting WFD objectives. Further research is needed. In the example of beam trawling trialling in SW ports has demonstrated that benthic release panels are an effective way of mitigating species by-catch allowing the escape of welks, small crabs, small fish and small crustacean. It is unclear whether the fitting of benthic release panels would need to be driven by the WFD to meet GES – it is unclear whether the by-catch affects the attainment of WFD objectives. However if it is assumed that the fitting of such devices was required as a mitigation measure then using the example of the port of Brixham, it is estimated that 6 beam trawls fish within the 1nm from this port. Assuming a cost of £300 for each boat to fit the panels the overall cost of taking mitigation measures for those boats operating out of Brixham would be £1,800 perhaps incurred every 2 years.

Another example of mitigation is the use of separator trawls in the Wash as a method of mitigation the impact of the shrimp fishery on juvenile fish.

Other more extreme measures could include curtailing fisheries activity in certain periods or closing fishing in certain sensitive areas altogether. Work being undertaken by Defra in the review of marine protected areas under the Marine Bill should yield further information of the risk posed by fisheries to ecological status. Powers also exist under the Habitats and Bird Directive to take action if required in Natura 2000 sites which if within the 1nm are also WFD n2k protected areas.

Alien Species

Broad assumptions for cost effectiveness analysis of alien species measures adopted here are:

- That restoration measures will only be needed in water bodies which, despite agreed non-WFD measures, are at risk of failing Good Ecological Status or WFD protected area objectives.
- That the presence of an alien species can be used to indicate a risk of failure – in other words that its presence will affect the ability to maintain and reach GES. This is an area of uncertainty and will rely on site specific assessments. UKTAG are currently considering classification rules for water bodies affected by alien species pressures.
- That to address the pressure from alien species, we may need to introduce measures both inside and outside the affected water bodies.
- The costs used are the 'best estimates' provided by the working group

There are a number of areas of uncertainty relating to the *unit cost* estimates derived by all working groups. Many of these relate to the need to understand and accommodate site-specific characteristics in often dynamic physical and biological systems, and the associated availability and adequacy of existing information.

Another major area of uncertainty with potential cost implications relates to mechanism gaps. Defra (jointly with Welsh Assembly Government and the Scottish Executive) has recently launched The Invasive Non-Native Species Framework Strategy for Great Britain which outlines ways in which to implement the three-pronged approach agreed under the Convention on Biological Diversity – prevention measures, early detection and appropriate action.

Where costs are listed they are for England only.

4.7.6 Costs of 4 scenarios

Scenario 1 – Higher certainty of achieving outcomes, no phasing- do all tried and tested technically feasible measures at once.

This scenario contains all of the WFD specific measures within the first RBMP. For this pressure there are some measures that are ‘tried and tested’ but these are not always failsafe in ensuring the prevention of entry of the alien species concerned.

The overall costs are c. £500k to £1million per annum (highly variable depending on the number of species and sites addressed) with a break down below in Table 3:

Table 3: WFD Specific Measures

Measure	Target Sector	Costs & (Effectiveness) [1 = low; 5 = high]
Ban/restrictions on the sale of known non-native species that affect WFD objectives using existing legislative mechanisms (eg review of ban on sale list)	Horticulture, Aquaculture, pet trade	Costs need to be assessed (5)
Research programme on management options	Operational (UK Govt/agencies)	250k p.a. (5)
Establish a coordinated early warning system based on monitoring programme with contingencies for rapid response control programmes	Operational (Govt/agencies + other funders?)	Surveillance/early warning: £50k pa. (5) Rapid response control/eradication: £5-100k depending of species/site (5)
Target known pathways of invasion and establish prevention measures, based on species that are already invasive in similar climates abroad.	Importations, horticulture, aquaculture, marine etc.	As above
Risk assessment analyses for species being introduced or likely to arrive		£1-3k per species (4)
Control Work – sustainable management of problem species	Varies	£? Varies according to species/site (variable)
Fish removal from isolated water bodies eg. via repeat netting		Fish removal = approx £30k (4)
Management forums – coordinated marine and freshwater Working Groups under GB Strategy Programme Board (National) and establish alien species For a at RBD level	All relevant co-delivers and stakeholders	National working group:£10k p.a. (3) RBD Forum: £5-10K p.a. for each RBD (4)
TOTAL		£500k to 1,000k

The most effective measures are associated with prevention of species colonising and establishing in aquatic ecosystems and are critical for safeguarding HES/GES. The largest proportion of these costs are likely to be associated with rapid response control/eradication which will vary depending on the aquatic species concerned and the characteristics of the site concerned. Costs might vary from a few thousand pounds where mechanical control could remove a small stand of an invasive plant to over £100k where invasive fish need to be removed from a water body. Recent *Ludwigia* control and topmouth gudgeon removal are good examples for cost estimates. This measure is likely to be most cost-effective if undertaken at the earliest possible stage of detection and will depend on a coordinated early warning system based on monitoring. Data is already collected e.g. through RHS type surveys, fisheries work, BRC etc. However, there is a need to collate these data and make them available to managers. GB programme board currently has feasibility project looking at options for such a scheme.

Costs associated with the ban or further restriction of the relevant aquatic alien species (for WFD purposes above and beyond what would happen without the WFD as a driver) has yet to be ascertained but are likely to include the horticulture, aquaculture and pet trade sectors.

In terms of restoration via control and sustainable management of alien species it is difficult to assess total likely costs (need to identify costs for the priority species most relevant for the WFD – UKTAG to advise) since these vary by species and site. Ongoing management at a given site (akin to bracken control or tree removal on terrestrial sites) may be sufficient to reduce biomass of problem species to a level at which there is no impact upon GES. Indicative costs for *Crassula* control at Brown Moss SSSI/SAC cost £90k originally for capital works but ongoing costs are thought to be £5k p.a. Early action would minimise initial capital costs.

The establishment of national level marine and freshwater working groups at under the GB alien species programme board has been put forward by the FAB working group. Its unclear whether this would happen anyway under the GB Strategy regardless of the WFD (a marine group has already been proposed) so it remains uncertain whether to attribute the estimated £10k pa running costs to the WFD. The establishment of an alien species forum for each River Basin District would have the benefit of engaging a wide range of stakeholders who may be controlling alien species (eg. angling clubs, wildlife trusts). The forum could work with the river basin district liaison panels in helping set targets for dealing with alien species and coordinating ongoing and proposed activity.

It is certain that further R&D and risk assessment is needed in order to understand the extent and nature of the pressure from aquatic alien species and their impacts on meeting GES under the WFD. This might be taken forward under the GB strategy. However restoration measures under this scenario would not benefit from R&D taking place from 2009-2015 and given the possible need to over-programme control measures that are certain to work (without trailing innovative measures) to meet WFD objectives measures may be expensive. However for those measures that are known to work rapid action in the first cycle may be more cost-effective in the long run.

Scenario 2 – Higher certainty of achieving outcomes, some phasing- do what is tried and tested and reasonable as soon as possible.

This scenario allows more flexibility on implementation. This ensures that objectives are likely to be met as a result of delivering most available measures, but the costs are spread over subsequent river basin planning cycles. All the measures identified in Scenario 1 would be deployed but restoration/control measures would be phased taking into account considerations such as affordability. This would be appropriate if some of the restoration measures for particular species/sites are high cost. The focus for the first RBMP would be on restoration/control measures which are necessary for aquatic Natura 2000 protected areas where the 2015 deadline is introduced by the WFD. Further analysis is required to ascertain how much of the costs in restoring these Natura 2000 sites should be attributable to the Habitats and Birds Directive and how much is attributable to the WFD from the introduction of the 2015 deadline. Other priorities for the first cycle would be for those water bodies that are SSSIs or BAP habitats or which have particular significance in terms of their biodiversity and ecology.

Under this scenario the prevention, R&D, risk assessment and establishment of national and regional forums measures would all be implemented in the first RBMP since all are highly cost-effective and are known to work. The national and regional forums would be able to determine the priorities and what measures should be phased at RBD level. Phasing would allow Regional Forums/EA/NE time to establish pilot areas to trial innovative restoration solutions and to build networks with landowners, users of the water environment (eg . anglers, amenity groups), volunteers from the general public and NGOs. The trialing of innovative approaches and building of networks would take place over the first cycle leading to more clearly defined and targeted restoration approaches for the second cycle. However control of species that are well understood would be implemented in cycle 1 since it is most cost-effective overall to act sooner rather than later. There is an assumption that WFD should drive control measures and there should be no waiting for external drivers to deliver objectives (including those for WFD) to a later timescale.

Scenario 3 – Lower certainty of achieving outcomes, no phasing- do all technically feasible measures at once, use innovative measures.

This would involve all measures in scenario 1 but with the immediate roll out of innovative restoration measures for those aquatic alien species which are less understood. Whilst some of the innovative measures will help deliver WFD objectives within the first cycle there is unlikely to be a guarantee of this given the limitations of data and current knowledge on how best to instigate control measures for some problem alien species. Some measures may lead to unintended ecological consequences if their potential impacts are not well understood or may simply prove ineffective. The ability to use the findings of R&D and monitoring data gained during the first planning cycle to inform the development of more effective measures and subsequent cycles is lost if this scenario is adopted.

There may be greater reliance on voluntary approaches over statutory ones involving partnership working coordinated by the national and RBD forums. These may prove very effective although the establishment of voluntary partnerships may vary from one part of an RBD to another and is dependent on goodwill from those concerned. The rush to implement as many as possible innovative approaches in the first cycle may lead to loss of goodwill from voluntary partners if efforts do not yield desired benefits and would have benefited from the results of R&D findings.

Scenario 4 – Lower certainty of achieving outcomes, with phasing - do what is reasonable as soon as possible. Implement innovative measures over a longer timescale.

Same measures as scenario 2 (phasing) except greater reliance on voluntary approaches. Important role for the national and RBD forums in coordinating and keeping track of voluntary partnerships. Important to ensure the effectiveness of innovative and piloted measures is monitored and assessed so that the most effective measures are promoted.

Preventative measures could also be phased again relying more heavily on voluntary approaches rather than legislative ones which would be informed by a coordinated early warning system.

Heavier reliance on non WFD actions to deliver WFD outcomes by 2027 eg. CBD, GB strategy.

May prove more costly overall since control measures have less urgency and species begin to take a permanent hold and as a consequence eradication is more difficult and time consuming.

4.5.7 Measures not considered: assumptions and justification

- *Measures to deliver other directives and obligations*- the impact of efforts in tackling alien species for Natura 2000 protected sites needs further analysis since these should not be attributed to the WFD except where the 2015 deadline introduced under the WFD prevents the phasing of measures which would otherwise be possible under the Habitats and Birds Directive. The same applies to domestic conservation obligations namely in aquatic SSSI and BAP sites.
- *Climate Change* – current and predicted climate change is likely to increase the risk from alien species. Further analysis is required to ensure any measures remain cost-effective having taken account of the predicted effects of climate change.
- *Site specific measures* - costings for restoration/control measures are very difficult to assess on a national level since they are highly variable depending on the species and site situation.

4.7.8 Measures to reduce uncertainty

There is a high degree of uncertainty in relation to the nature and scale of action which will be required to meet WFD objectives in relation to fisheries pressure and alien species. There are significant gaps in

- Understanding the exact location and extent of biological pressure from fisheries
- evidence of the extent and nature of alien species pressures, although RBC1 did risk assess the top 10 most impacting alien species.
- understanding the pressure/impact relationship and therefore the effectiveness of measures

4.7.9 Further considerations; costs, distributional trade-offs, uncertainty

Measures likely to be disproportionately costly

Eradication of certain established species using existing techniques eg. signal crayfish

4.7.8 Summary

For freshwater fisheries causing biological pressure it is concluded that the regulatory toolkit is capable of tackling this pressure if required. The regulatory framework needs to be 'WFD proofed'. There remains uncertainty over the location and extent of impacts from the beam trawling within inshore areas pressure in terms of meeting WFD objectives. If this pressure is relevant in terms of meeting WFD objectives it is recommended that forms of mitigation such as benethic release panels be extended to other parts of England where

relevant. The cost of fitting such devices is relatively low at £300 per boat and it is likely that this measure is very cost-effective measure.

Alien species pressures are difficult to address within the conventional WFD model. This is largely a result of problems in determining the extent or nature of the pressure (establishing presence-absence, detecting impacts) and the lack of control options for many species. As such it is likely that the most effective approach to dealing with this major pressure will be through the adoption of a range of measures, the exact nature of which will be determined by geographical and species specific factors.

The emerging GB strategy for non-native species and the related work of the GB programme board will be important in defining the extent to which WFD obligations and ambitions drive work on alien species in marine and freshwater habitats. This GB level work and the initiatives falling out from it, is anticipated to deliver some of the key elements of a programme of measures for WFD e.g. risk assessment process, rapid response to new arrivals. The exact nature of the work required specifically for WFD will become clearer as this GB work progresses. However, the immediate statutory requirements of the WFD represent a significant opportunity for implementing some of the components of the GB strategy at an early stage. Given the broad nature of the subject, the GB strategy is a framework strategy which is intended to provide a clear national focus on the subject of invasive non-native/alien species. In part it will deliver high level strategic mechanisms such as for example the Risk Analysis Panel and a coordinated data and surveillance centre; but it is also intended that it will enable other relevant programmes and projects to engage and align with the high level approach to achieve greater synergy and complementarity in tackling invasive species.

In addition to a range of 'baseline' measures which are not WFD specific, and are rooted in the proposed GB strategy, there are three broad categories of measure which appear to be appropriate for implementation in the first round of RBMPs:

1) RBMP Forums

The establishment of an alien species forum within each RBD is likely to be a very effective but low cost means of capturing and better coordinating existing efforts to monitor and control problem species within a defined geographical area. A detailed proposal for the structure and remit of these forums has been presented to UKTAG by the Alien Species Group. It is envisaged that these forums could ultimately be integrated into any structures that emerge from proposals from the GB strategy. These forums would be responsible for setting targets and coordinating control at a local level and would need to be able to access resources to deal with alien species problems where an appropriate control mechanism has been identified. It is through this route that remedial work (to restore to good status) would be identified and prioritised.

2) Prevention & Monitoring

As a priority, measures should be put in place to prevent deterioration of high and good status sites. In practice this will require a dedicated monitoring and surveillance programme for water bodies as current proposals for WFD monitoring are not designed to identify alien species impacts. A key component of this preventative approach

would be early and appropriate action on new arrivals/introductions. Funds will be required to support this early, emergency action.

3) R&D Programme

It is clear that action on alien species is compromised by a lack of understanding of the nature of alien species impacts on all elements of the ecosystem and a lack of appropriate, proven control techniques. At present funding for work of this nature is uncoordinated and there is no dedicated budget for such work. In order that existing alien species impacts can be adequately addressed in future rounds of the RBMP it is important that the necessary underpinning work is undertaken now. The work required can be roughly divided into two components: (i) determining and identifying impacts; (ii) developing new sustainable control/management techniques (including biocontrol options).

ANNEX A

Morphological measures to restore Natura 2000 sites (Rivers and Lakes in England).

(1) The pressures assessed as causing SAC **rivers** to be in 'unfavourable condition' are explored below. Measures to address these pressures need to be developed as part of a strategic plan for the whole SAC river. Such an approach is being piloted on the River Wensum SAC in Norfolk by Natural England, with the Environment Agency and the Wensum Internal Drainage Board. It is important to understand (i) the particular physical pressures on the river and (ii) what effects they are having on its hydromorphology and ecology. Natural England monitors the river ecology and commissioned an aquatic plant survey of the whole river. A geomorphological appraisal was undertaken which discovered that 67% of the river length was backed up from 14 structures. A range of measures to relieve the pressures were identified, as well as constraints and synergies (eg with the Fisheries Action Plan and the Catchment Flood Management Plan). The measures were then prioritised and costed. It was found that, without work on the impounding structures, insufficient hydromorphological functionality could be restored to achieve the Wensum's conservation objectives. Therefore, other measures such as channel narrowing and riparian rehabilitation (traditionally the 'bread and butter' of river restoration) were given a lower priority.

(2) The type of hydromorphological pressure - and appropriate restoration measures - will vary from river to river. For instance, there may be opportunities to reconnect canalised or embanked river stretches with the former course of the river or nearby floodplain features, particularly if the reasons for the modification no longer pertain. Natural England has estimated that the restoration of 90km of SAC river would

benefit from such solutions. However, it is important that such measures are carried out in the right places and are designed to fit in with a plan for restoring hydrological and ecological functionality for the river as a whole. On the 10 SAC rivers currently identified as requiring physical restoration, it is proposed to draw up strategic restoration plans, learning from the Wensum pilot and similar work on SSSI rivers. Measures would then be implemented following stakeholder consultation.

(3) These 10 rivers include upland, lowland and spring-fed chalk rivers - with a range of pressures. The effect of measures in these different situations would be monitored, and guidelines drawn up by Natural England and the Environment Agency for suitable measures on river water bodies more generally. This will add to our knowledge of cost effectiveness.

(4) The main hydromorphological pressure affecting SAC **lakes** is unnatural siltation. As well as dealing with the sources of silt (point-source and diffuse) measures may include removal of accumulated silt deposits, particularly in shallow lakes such as the Norfolk Broads. Natural England's condition assessment of lakes designated for conservation has identified lakes within only one SAC (5 of the Norfolk Broads) as requiring silt removal; in addition there are seven in the West Midlands Meres Ramsar Site. The costs are large, particularly of disposal of large quantities of silt. Experience in silt removal techniques has already been gained by the Broads Authority (working with Natural England and the Environment Agency) on some of the Broads and at Aqualate Mere Ramsar Site - two thirds full of silt mainly derived from the Shropshire Union Canal - for which a plan has been drawn up but not yet implemented.

(5) Overstocking of fish, such as carp, can also cause severe turbidity by stirring up of benthic sediments during feeding. This prevents light penetrating the water column and the loss of higher plants. Fish removal has been identified as a restoration measure for 3 SAC lakes and 4 Ramsar lakes. In all the lakes affected, it is thought that the sediment will stabilise without the need for mud pumping. In The Broads, it has been necessary to exclude fish after sediment removal (by isolating the Broad from the river) to allow re-establishment of plants and zooplankton which help to maintain clear water.

(6) The WFD has introduces the aim to objective of taking measures to meet the objectives of Protected Areas by 2015; this includes restoring Natura 2000 sites to favourable condition in this timescale. It is still under debate how the economic tests of WFD apply to such measures.

(7) Table 2 gives a summary of the costs of measures to restore river Natura 2000 sites and an indication of the effectiveness of these measures in restoring favourable condition. The total cost of restoring the morphology of these Natura 2000 sites is just under £30 million. (Data on 8 river SSSIs requiring physical restoration measures are given for information.)

(8) Table 3 gives a summary of the costs of measures to restore lake Natura 2000 sites and an indication of the effectiveness of these measures in restoring favourable condition. The total cost of restoring the morphology of these sites is about £9.5 million. The additional cost of restoring Ramsar sites (if relevant) is about £5.7 million. (Data on lake SSSIs are given for information).

(9) The attribution of these costs to different sectors is not clear, but potential funding sources are given for each measure in the tables. For prevention of silt entering rivers and lakes, it appears that regulation (eg Water Protection Zone) is potentially the most cost-effective approach, although it can be supplemented by Environmental Stewardship agreements or water company investment in sewage treatment through AMP.

Table 2 Restoration of Natura 2000 and SSSI rivers in England affected by hydromorphological pressures

Measure	Mechanisms	Effect.	Protected Areas	Cost	SSSI WBs	Cost	Funding sources
Removal or lowering of in-channel structures and barriers (eg weirs)	Capital projects	H	5 (35 structures)	£11m	8	£11m	Catchment (River Basin) Restoration Fund; National challenge fund - Defra; possible contributions from fisheries owners
Reconnection of canalised stretches to former course and floodplain wetlands	Capital projects	H	3 (90km)	£2m	3 (40km)	£3.5m	Catchment (River Basin) Restoration Fund; National challenge fund - Defra; possible contributions from fisheries owners
Restoration of banks using soft engineering and tree-planting	Local projects	M	4 (140km)	£12m	6 (200km)	£16m	Catchment (River Basin) Restoration Fund; S.15 management agreements on SSSIs; contributions from fisheries owners
Prevention of bankside erosion	Reduction of stocking density /removal of stock (HLS)	M	4 (50km)	£880k	3 (30 km)	£500k	NE grant-in-aid (CAP); NE staff costs
	Fencing to create buffer strip (HLS)	M	4 (50km)	£700k	3 (30 km)	£390k	NE grant-in-aid (CAP); NE staff costs
	Water Protection Zone	M	4 (50km)	£200k	3 (30 km)	£105k	EA grant-in-aid (staff costs)
	Purchase and lease-back of riparian land	H	4 (50km)	£1m	3 (30 km)	£550k	Catchment Restoration Fund; EA grant-in-aid; staff costs
Control or diversion of inputs of silt	CSF- Env Stewardship	M	2	£2m	7	£6.5m	NE grant-in-aid; NE/EA staff costs
	Water Protection Zone	H	2	£120k	7	£500k	EA grant-in-aid staff costs
	Capital project - block moor grips	M	2	£200k	0	0	HLS, NE grant-in-aid (CAP); water company AMP; NE staff costs
	Diversion of drainage /SUDs	M	3	£350k	4	£400k	HLS capital project (CAP); Highways Agency; local authority; EA budget; water companies AMP
	Settlement lagoons on fish farms and watercress farms	M	3	£600k	1	£100k	EA amendment of discharge consents; Code of Practice; costs fall to operators

Table prepared by David Withrington, Natural England; numbers from ENSIS remedies database. Refs. (1) River Wensum Restoration Strategy - Technical Plan. JBA Consulting for Natural England. 2007. (2) River Beult outline restoration plan. Royal Haskoning for English Nature. 2006

Table 3 - Restoration of Natura 2000, Ramsar and SSSI lakes in England affected by morphological pressures

Measure	Mechanisms	Effect.	Protected Areas	Cost	Ramsar lakes	Cost	SSSI WBs	Cost	Funding sources
Removal and disposal of accumulated silt	Capital works (eg as part of regional strategies - Broads, West Midlands Meres; Lake District Still Waters Partnership)	H	1 (5 Broads) (500ha)	£7.5m	7 (103ha)	£4.5m	2 (108ha)	£2.5m	Catchment Restoration Fund; National challenge fund - Defra; contributions from water companies where sewage inputs are involved.
Control or diversion of inputs	CSF- Env Stewardship	M	2	£250k	8	£650k	1	£120k	NE grant-in-aid
	Water Protection Zone	H	2	£85k	8	£150k	1	£35k	EA grant-in-aid
	First time rural sewage	H	1	£1m	1	£95k	2	£300k	Water companies AMP
	Diversion of drainage /SUDs	M	3	£350k	2	£100k	4	£400k	Highways Agency; local authority; EA budget; possible contribution from water companies AMP
Prevention of bankside erosion	Reduction of stocking density /removal of stock (HLS)	M	1	£100k	-	-	-	-	NE grant-in-aid
	Fencing to create buffer strip (HLS)	M	1	£20k	-	-	-	-	NE grant-in-aid
	Water Protection Zone	M	1	£20k	-	-	-	-	EA grant-in-aid
Prevention of turbidity	Fish removal (physical)	H	3	£75k	4	£220k	-	-	NE grant-in-aid: S.15 agreement
	Restriction on stocking	M	2	nil	4	nil	-	-	EA s.30 powers/discharge consents

Refs. (1) Review of lake restoration techniques and resource costs. Final Report to English Nature. 2003. Prepared by Royal Haskoning and Centre for Ecology & Hydrology. (2) Lake SSSI Conservation Strategy. Report to Natural England. 2007. Prepared by Econ.

ANNEX C – BASELINE MEASURES FOR ALIEN SPECIES

Policy baseline measures

Measure	Objectives of measure	Target sector(s)	Likely Environmental outcome	Effectiveness 1 low, 5 high
Salmon and freshwater Fisheries Act (Section 30)	To prevent introduction of fish into inland waters without EA consent.	Aquaculture/ fish suppliers; Angling groups. Consents per year (all species): 5000	Preventing the irreversible introduction of fish species	3
Import of Live Fish Act (1980), amended 1998 (ILFA)	To prevent the keeping or release of specified non-native fishes without a licence	Aquaculture/ fish suppliers; Angling groups.	Preventing the introduction of non-native fishes	3
Fisheries byelaws	To prevent removal of fish and use of fishing instruments in inland waters without EA consent	Aquaculture/ fish suppliers; Angling groups. Consents per year (all species): 3000	Preventing the illegal and unregulated transfer of fish between waters	3
EA Fisheries Strategy	To prevent further introductions of non-native fishes into fisheries in England and Wales	Aquaculture/ fish suppliers; Angling groups.	Preventing introduction of non-native fishes into inappropriate waters	2
Codes of practice (e.g. IFM)	To enable Fisheries Managers to better manage their fisheries and fish stocks	Aquaculture/ fish suppliers; Angling groups.	Sustainable fisheries based upon native species	1
Code of practice for the management of Japanese knotweed	To enable developers to manage knotweed on site, reducing the need to dispose of waste to	Development	Control of knotweed. Increased use of brownfield sites, due to reduced costs.	4

on development sites	landfill.			
FRM river management programmes	To manage aquatic and riparian habitat to prevent flooding	Operational	Eradication, containment or control of invasive species, particularly weeds	4
R&D programme	Research relevant to invasive species and their management	Operational	Better understanding of the impact of invasive species. Development of 'good practice' for management. Potential for classical biological control of some weed species	3
Biodiversity Action Plans	Protect and enhance UKBAP species and habitats. Includes some invasive species management.	Operational	Enhanced protection of species at threat due to non-native species.	4
NERC Bill	Environmental protection, including the aims relevant to invasive species described within Article 8(h) of the CBD.	Operational	Increased justification for invasive species management	2
Habitats Directive	Protect and enhance native habitats. Article 22 refers to regulating the release of non-native species. However, current Wildlife & Countryside Act 1981 of limited use for implementing	Operational.	Reference to invasive species management within the Directive	2

	Article 22			

Directive	Measure	Objectives of measure	Target sector(s)	Environmental outcome	Effectiveness. 1 is low, 5 high
Freshwater Fish Directive	Protect native fisheries	Protect and enhance our freshwater fisheries			
Plant Protection Products Directive		Determines what products can be used for plant management		Will influence what management options will be available for PoMs. May determine whether biological control can be used.	
Urban Waste Water Treatment Directive		To regulate levels of N and P in the water environment		Many plant invasive species are determined by the availability of nutrients and are therefore exacerbated by high trophic levels	
Convention on Biological Diversity (CBD), 1992	Conservation of biological diversity	To prevent introduction of, control or eradicate alien species which threaten ecosystems, habitats or species. Also addresses liability for damage caused by introductions	Member states		
The Bern Convention	Provides regional framework for the implementation of the Convention for Biological	Article 11(2) refers to the control of non-native species.	Member states		1

Directive	Measure	Objectives of measure	Target sector(s)	Environmental outcome	Effectiveness. 1 is low, 5 high
	Diversity				
The Bonn Convention	Conservation of migratory species of wild animals	Article V(5)(e) - strict control on exotic species. Article III(4)(c) Agreement of contracting parties on control of alien species	Member states		1
Convention on Wetlands of International Importance as Wildfowl Habitat (Ramsar Convention)	Covers the environmental, economic and social impact of invasive species	Resolution VII.14 – requirement to list, prioritise and assess the impact of invasive species. Also includes requirement for early recognition of new species and the sharing of this knowledge	Member states		1
IMO Convention on control of Ballast Water, which is at the detailed planning stage, with the intent for commencement of binding use by 2008.		discharge of ballast water will be prohibited within 200 nm of the coast unless rigorously treated.	Shipping		